

This book is written for professionals in developing countries, for occupational safety and health specialists, production engineers, managers and trade union representatives. The book links occupational safety and health with production and productivity, showing the positive relationship between good and safe working conditions and sustainable high productivity. The book makes use of research results, and is intended to be used in connection with training activities, but does not concentrate on research or training. The focus is action for change to eliminate or reduce risks at workplaces.



# OSH for Development

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Edited by  
Kaj Elgstrand  
Nils F Petersson

Royal Institute of Technology

# OSH for Development

Occupational Safety and Health for Development

Editors

Kaj Elgstrand & Nils F Petersson



**ROYAL INSTITUTE  
OF TECHNOLOGY**

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# Introduction



# Introduction

*Kaj Elgstrand & Nils F Petersson*

## AIMS AND CONTENTS

### Aims

This book is written for professionals in developing countries, for occupational safety and health specialists, production engineers, managers and trade union representatives working to improve working conditions and eliminate risks for occupational accidents and diseases.

The origin of the book lies in the international training programmes in Occupational Safety and Health & Development, sponsored by the Swedish International Development Cooperation Agency (Sida), initially managed by the Swedish National Institute for Working Life, and later by the Royal Institute of Technology in Stockholm. The majority of the authors have been engaged in several of these eleven training programmes. These programmes were largely based on action oriented development projects carried out by the participants. The theoretical content given by the lecturers aimed to prepare and assist participants to manage their action oriented projects. During these training programmes we lacked a basic text outlining the principles of occupational safety and health and ways to take action to improve occupational safety and health in developing countries. This book has the ambition to fill this gap.

The contents of the book are focused on the prevention of occupational safety and health risks. Actions and developmental processes at enterprises and workplaces have the highest priority. Activities at national and international levels are also included in relation to their importance for action at enterprise level.

Efforts to foster development of occupational safety and health (OSH) traditionally deal with the study of risks through scientific or other investigations. The results are then documented in reports or articles. When knowledge exists about safety and health risks, information is disseminated in the form of written or oral information, and/or through training activities. This book makes use of research results, and is intended to be used in connection with training activities and programmes but does not concentrate on research or training. The focus is action for change to eliminate or reduce risks for occupational accidents and diseases.

Besides dealing with OSH issues, the book also links OSH with production and productivity, showing the positive relationship between good OSH and the creation and maintenance of sustainable high productivity.

The authors use examples of ways that basic knowledge can be used for practical action and evaluation. The reader is not expected to read this book from start to finish but to consult parts of it when confronted with practical problems in working life. We hope that the book will help readers to find their own solutions to practical problems, solutions that relate to individual workers limitations and possibilities.

### Structure and contents

The book is structured into 13 sections, most of them containing several chapters. In total there are 47 chapters.

The following part of this introductory section deals with a number of basic concepts. What is occupational safety and health (OSH)? What is meant by development, and how is it related to OSH? What is meant by hazards and risks, and why is prevention such a key concept within OSH?

Section 2 outlines the historical development of the risk concept. The current OSH paradigm is described, and the need for a new OSH paradigm is discussed.

Sections 3 to 7 deal with workplace hazards and how to eliminate or reduce them. Section 3 focuses on manual work including basic work physiology, food and nutrition, musculoskeletal disorders and workplace design and evaluation. The prevention of physical risks is covered in Section 4 including accidents, heat and cold stress, noise, vibrations, radiation, electrical and fire risks and an introductory chapter on risk and risk control. Section 5 covers the prevention of chemical risks including pesticides, solvents, gases, dusts, metals and skin disorders. There are special chapters on risk assessment and control, and epidemiology. Sections 6 and 7 deal with the prevention of biological and psychosocial risks, respectively.

Development of work and enterprise survival is discussed in Section 8. Work organisation, learning at work, managing understanding, gender integration, and strategies for change and team work are highlighted.

In Section 9 the overall practical issues related to child labour, gender and work, and migrant workers are discussed.

Organisation of OSH at enterprise level is discussed in Section 10, dealing with informal sector and small enterprises, management and participation, and occupational health services.

National planning issues are highlighted in Section 11, related to the role of social partners, education and training, and supervision and control.

Section 12 gives a global perspective on OSH including globalisation and working life, the global situation concerning work related injuries and diseases, and international governance and partnerships.

The final section is a summary and reiteration of the book's orientation towards practical actions for the prevention of risks and the development of work, working environment and productivity.

### Overlapping

There are overlaps in the content of various chapters and sections. We consider this to be an advantage. It enables independent study of different chapters and furthermore, where there are different statements on the same issues in various parts of the book, they serve as a reminder that different views exist.



## BASIC CONCEPTS

### Occupational safety and health

Problems of occupational safety and health (OSH) have been present since the emergence of human work. The recognition that work is risky to life, safety and health was heightened in the eighteenth and nineteenth centuries as the Industrial Revolution occurred in Europe. Public concern about these problems led to legislation and special agencies set up to protect workers safety and health.

The scope of occupational safety and health has gradually broadened from the diseases or injuries attributable to work to the nature of work itself, the wider work environment, and workers' wellbeing. OSH is divided into a number of specialities related to particular problems and applications within physiology, psychology, sociology, ergonomics, medicine, hygiene, work safety, toxicology, epidemiology amongst others.

Occupational health is sometimes represented as a superior concept to occupational safety, however, we prefer to use the term occupational safety and health as this better reflects safety *and* health as factors of equal importance. Occupational safety and health is defined in ILO convention no. 155 (1981) that provides scope and definitions, principles of national policy, and suggestions for action that should be undertaken at national and workplace level.

The widely used abbreviation *OSH* for "occupational safety and health" is used in the title and throughout this book. The assumption is "safety first", meaning the priority should be the prevention of accidents to avoid fatalities and injuries, followed by health issues. It is common for engineers to think this way about OSH.

The abbreviation *OHS* is also used sometimes. The abbreviation has two distinct meanings. One is "occupational health and safety", sometimes preferred by physicians instead of

"occupational safety and health" as they are trained to address illnesses or health problems rather than safety problems. They consider "health" to be the overall concept that also includes safety. The other meaning of the abbreviation OHS is "occupational health services". This book uses OSH for "occupational safety and health" and OHS is generally used for "occupational health services".

### Development

The concept of development is used in different disciplines from biology, technology and other natural sciences, to philosophy and social sciences. This book addresses some of the issues concerning human development in relation to living standards and quality of life, with special emphasis on working conditions and working life. The concept of development is often used to convey a particular meaning, i.e. a general move in a positive direction, synonymous with improvement. On the other hand the concept of change is often portrayed as being devoid of value judgments. Development is often characterized as "man made" while evolution is more dependent on uncontrolled forces working on a longer term basis.

Development theories have been commonly associated with the concept of underdeveloped or developing countries. Development was earlier considered to be a process following certain natural and thereby predictable principles but over time more attention was given to the problems that complicated the process, which in turn stimulated interventions by governments. The effects of colonial heritage were emphasised so the rich industrialised countries were considered to have a special responsibility. During the 1980's the main tendency was to play down the effects of a colonial background as an explanation for the poverty of "the third world" instead blaming the corruption, autocratic ways

and erroneous economic policies of third world regimes. The North-South dialogue changed character. Instead of giving development aid to compensate for a historical exploitation, which had deprived the former colonies of resources and distorted their economic structures, the industrialised countries started to give economic assistance that imposed conditions for a process of adjustment to the rules of a deregulated world market. “Structural adjustment” aimed to impose liberalisation and macro-economic balance.

A new tendency in the activities of international funding agencies, i.e. the World Bank, International Monetary Fund and regional development banks, has recently emerged as these agencies have started to look beyond economics, currency markets and capital flows. Consideration of social issues and strengthening of public institutions are now seen as important measures for promoting development. At the Okinawa Summit in July 2000, the leaders of eight major industrialised democracies (G8) and the European Commission President underlined that health is the key to prosperity. The final communiqué of the summit states that good health contributes directly to economic growth whilst poor health drives poverty – health is wealth.

A new era of globalisation has reshaped markets over the last fifteen years. Deregulated flows of capital, and increased exchange of knowledge and work forces between countries have occurred rapidly, posing both serious problems and new possibilities for societies. Since late 2008, the character of the current era of globalisation seems to be changing. The global integration of the world economy is in retreat. The movement of goods, capital and jobs is going into reverse. Industrial production is falling, factories are closing and trade is slowing down. Unemployment worldwide is on the rise. Popular opinion backs more state regulation. So far (May 2009),

this has mostly taken the form of pouring public money into banks and selected industries notably the auto industry.

While it is accepted that global economic growth will be needed during the 21st century, more attention must be paid to the structure and quality of that growth to ensure that it is directed to supporting human development, reducing poverty, protecting the environment and ensuring sustainability.

### **Occupational safety and health for development**

During the last decades, the positive relationship between OSH and productivity has been highlighted in many countries and international organisations. This has partly come about because of increasing difficulties to convince the employers with the traditional arguments of decency, like “production should finance the costs for OSH activities”, “health for all”, “workers should not only be provided with work but also with safe and healthy work”, etc.

The difficulties to convince employers in developing countries to improve OSH may be connected with the structural adjustment programmes initiated by the international funding agencies. These programmes increased the pressures on enterprises to become more competitive on the global market and so money spent on OSH is seen as a cost without obvious benefits. Increasing unemployment in industrial countries results in the same difficulties.

These difficulties may also occur because OSH demands appear to be endless, complex and disturbing production. Workers never seem to be safe and healthy even though changed technology is making a lot of work lighter and easier to perform. There are a lot of rules about how to deal with OSH risks that appear to be more effective in preventing production

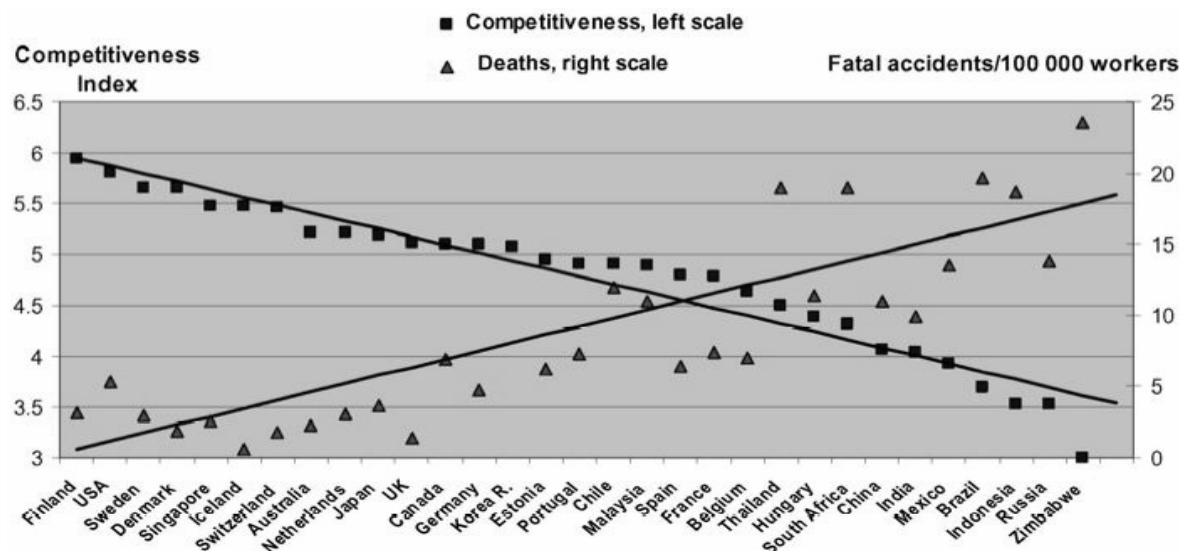


Figure 1.1. Fatal occupational accidents and competitiveness index for 31 industrialised and developing countries. Source: World Economic Forum; ILO/Safework, 2002.

improvements rather than OSH risks. A focus on repeated measuring and monitoring is not enough to solve OSH problems.

Until relatively recently many OSH specialists viewed “production”, “productivity” and “effectiveness” as dirty words of no concern to them, because engineers dealt with these issues. OSH experts, many of them physicians, were the “good guys” who cared only for the safety, health and well-being of workers while production engineers, managers were the “bad guys”, squeezing profit out of the workers without consideration.

Now there is a move to integrate occupational safety, health and production in order to improve the safety and health of workers and to increase productivity at the same time. Productivity, effectiveness and OSH can be of common interest for workers, employers, owners of industry and wider society. This positive relationship between productivity and safety is illustrated in Figure 1.1. Countries with high competitiveness index tend to have low number of fatal occupational accidents.

The positive relationship between OSH and development is emphasized in a statement by the former UN Secretary-General, Kofi A. Annan (1997):

“The world of work will continue to undergo dramatic changes. Already, we see growing demands for flexibility mobility and productivity. As we look to the future, we must always remember that human being are not servants of economies. Rather, economic development and production must serve men and women. Occupational safety and health is a crucial means towards that end. As an essential component of the United Nations Charter’s vision of ‘social progress and better standards of living in larger freedom’, it is and must remain a high priority on the international agenda.”

### Categorising countries

As this book is oriented towards occupational safety and health specialists in developing countries, the terms “developing countries” and “industrial countries” are often used, however, this does not mean that the two terms are well defined or that other terms cannot be used.

There are many alternatives: developed and underdeveloped countries; North and South countries; countries belonging to the First, Second and Third World; poor and rich countries; high, middle and low income countries are just some of the most common categorisations of countries. While some terms are better defined than “developing” and “industrial” countries most of them are not.

For the purpose of this book we believe that the simple categorisation in developing and industrialised countries, favoured by the UN organizations, is practical.

We are also well aware that the existing 200 countries in the world represent a continuum in relation to all the important parameters like health, economy, industrial development, population and country size. How can a country of 1 billion inhabitants be placed in the same category as a country of 10 000 inhabitants? How to categorise a country of 200 million inhabitants that includes both highly industrialised activities alongside a large sector of non-mechanised agriculture?

### Hazards and risks

A *hazard* may be defined as a substance, agent or physical situation with a potential to cause an effect in terms of ill health, injury or damage to a human being, animal, property or environment. The presence of a harmful chemical (even if it is not used), or an uncovered hole in a floor are examples of a chemical and a physical hazard.

Hazards can also be of biological or psychosocial nature.

The term *risk* expresses the likelihood of an event to occur and its severity. The term hazard expresses a quality, while risk expresses a quantity. The concepts of hazard and risk are often used without distinction, sometimes causing confusion.

The ultimate aim of occupational safety and health work is to eliminate hazards and risks and if this is not possible, to reduce them.

Figure 1.2. shows a number of concepts used to define and manage the risks of occupational accidents and diseases.

The first step in a risk assessment is the recognition and definition of a hazard, i.e. hazard identification. The second step is to estimate the magnitude of the risk (risk rating) so priorities for action can be set. A number of different methods exist for hazard identification and risk rating, some of which are discussed in this book. Risk evaluation includes not only hazard identification and assessment of the magnitude of the risk, but a judgment as to whether the risk is tolerable or not.

The term risk analysis is sometimes used synonymously with risk assessment but risk analysis is a broader term as it may include an analysis of the consequences of the risks.

Risk communication is the exchange of information about the detection of hazards and risks and how they can be dealt with. Risk communication may also consider public perception of risk and the assessment of a risk by individuals (risk perception).

### Prevention of risks

Risk prevention has long been a well known concept within occupational safety and health. It is often emphasized that actions to improve

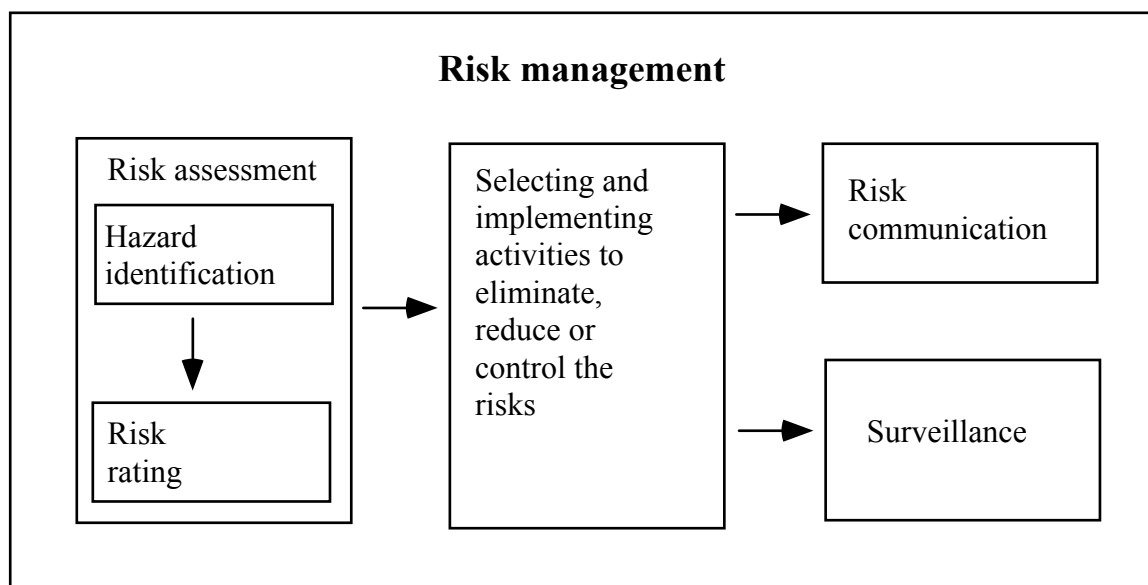


Figure 1.2. Basic concepts related to risk management.

working conditions and work environment must firstly focus on prevention of accidents and diseases. However, “prevention” is attributed with a number of different meanings, depending on the context.

In medicine prevention is generally used in three different contexts. *Primary prevention* seeks to prevent diseases and injuries from occurring e.g. through immunization, adequate nutrition, or elimination of toxic substances from production. *Secondary prevention* aims to detect and treat any disease at the earliest possible time in order to reduce the more serious consequences of disease e.g. screening for occupational asthma. *Tertiary prevention* attempts to reduce the progress or complications of an established disease through therapy and rehabilitation e.g. x-ray investigations to control silicosis.

This book focuses on the prevention of occupational accidents and diseases through the elimination or reduction of risks. If this is not fully successful, control measures, such as in-

spections, registration and analysis of accidents, and/or health examination, have to be taken. If control measures are not fully successful, workers have to be protected through the use of collective protection such as general ventilation or protective barriers, or of personal protective equipment (PPE) such as ear plugs or dust masks. The use of PPEs should not be seen as a readily acceptable and first stage solution, but as a measure to be applied only when prevention and control of risks have failed. PPEs should only be used as a temporary intervention, not as a permanent method of dealing with hazards and risks.

Preventive actions can be taken at a number of levels in society, from the national to the local level. Action at national level is important, e.g. introduction of new legislation supported by information and training activities. Although such actions are discussed throughout the book, the main focus is on direct actions at workplaces and within enterprises.



The most efficient and least expensive ways to prevent risks are achieved through the appropriate design of production and organisation of work. Risks can also be most effectively prevented when machines, tools, furniture and chemical substances are selected and purchased. These preventive actions apparently lie within the responsibilities of purchasers, production engineers and managers. The knowledge of OSH specialists should be integrated with the work of those responsible for the design of production systems, work and workplaces, and those who purchase machines, tools etc.

### Who is the culprit?

It is common to hear that occupational accidents or diseases are caused by someone making an error, i.e. by a “human factor”. Such an expression is mere nonsense as work is created by humans, performed by humans and controlled by humans. Evidently 100% of occupational accidents and diseases are caused by human factors.

Depending on professional background, we may fall into the trap of using a single cause to explain an occupational accident or disease. A worker may say that an accident was caused by stressful working conditions, while a manager may see it as caused by a careless worker. An engineer may understand the same accident to be caused by a technical failure while a labour inspector may consider it as a consequence of

rule violation. A statistician may see an accident as a random occurrence while someone else may see it as bad luck. Such single-minded approaches are not conducive to understanding accident causation and prevention.

Basic human errors are not made by the worker (the “end-user”) but by those who have designed the layout of workplace locations, work processes and workplaces, as well as by those who select and buy furniture, machines, chemical substances and tools. Those responsible for the organisation of work, and for the maintenance of machines and tools also play a role in prevention. To start by blaming a worker for an accident does not allow a real understanding of what has happened and why, and is not helpful for the prevention of future accidents.

Designing the work environment and production technology so that safety and health risks are eliminated or reduced to a minimum, places the main responsibility for a safe workplace on the employer. A manager or an occupational health physician may regard the provision of personal protective equipment (PPE) such as breathing masks, gloves, and helmets as prevention. If a worker doesn’t use the protective equipment, he can be blamed for the accident regardless of existing possibilities to prevent the risks. This view of prevention totally blocks any real prevention by elimination or minimisation of the risks.

# History and future

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# Historical development of the risk concept

*Gideon Gerhardsson*

## FROM HAZARD TO RISKS

The terms hazard and risk, are often interchanged, however, there is a difference. The term hazard includes all kinds of unwanted events, both natural and manmade while the concept of risk also embraces efforts to reduce the number and severity of unwanted events in other words risk implies some ambition to master uncertainty. For example, the most spectacular project to master uncertainty the Apollo moon landing in 1969. In a speech on July 29, 1969, the day of the first man landed on the moon, Jerome Lederer, Director of the Manned Space Flight and Safety for NASA, declared:

“ This nation was built on risk. Personal risk in tackling the wilderness, financial risk in business, risks in exploring the scientific unknown, enormous engineering risks, management risks. We shall continue to take risks of greater magnitude than in the past. But the consequences of failure are becoming less permissible. The political, social, as well as economic and personal risks that now accompany our ventures can have enormous repercussions when failure occurs. Growing risk factors require a more comprehensive approach to hazard management than our wealth and isolation have permitted in the past ..... In order to accomplish our goal, we must develop a sensitivity to the severity of risk-taking, so

that we reflect it to our people in decisions that we make and actions that we take.”

This chapter follows the long road from philosophies of risk to concepts of well-being as these visions have appeared in the curative and preventive strategies of their time.

## Fatalism was the core

The history of humankind dates back more than four million years. The quest for survival and subsistence was evolved through labour to gain control of the natural environment. More hostile natural environments concealed numerous hazards, most of most of which were considered to be inevitable hazards, i.e. fatalism was the core belief. Magic, mysticism, trial and error, were the first tools employed to manage the risks from hazards. The hardest types of work were based on slavery, which was prevalent in many parts of the world, including China, Egypt, Greek, and India. Slaves represented a cheap and inexhaustible supply of labour and workers' health was not an issue. New technologies were developed in the Asia-Pacific Region, particularly in China and India, before they were developed in Europe, but the concept of managing risks connected to working conditions came first from Europe.

### Population density as a risk factor

As societies became more settled there was growing concern about human health, particularly on the conditions of those dwellers in congested areas, but not particularly focused on labourers. The learned Greek, Hippocrates, 460-370 B.C., the father of medicine was concerned as was the Roman scholar Pliny the elder, 23-70 A.D., the author of the classical “*Historia Naturalis*”. Pliny the elder is also credited as the first person to speak of a protective mask against dust. There were earlier pronouncements about “prevention being better than cure”, and the idea was even put into practice. The Yellow Emperor of China, Huang Di, from the Shang Dynasty, 1500-1040 B.C., stated:

“Hence the sages did not treat those who were already ill; they instructed those who were not yet ill. To administer medicines to diseases which have already developed and to suppress revolts which have already developed is comparable to the behaviour of those who begin to dig a well after they have become thirsty, and of those who begin to cast weapons after they have already engaged in battle”.

Galen, 129-200 A.D., a Greek born physician and medical writer living in Rome, observed the great danger faced by miners but did not include occupational accidents and diseases. The influential Arabian physician Avicenna, 980-1037 A.D., wrote five volumes about the theoretical and practical medicine of his time. While he wrote with great clarity and detail he had little to say about work-related hazards. Such hazards were minor compared to others in society such as the increasing appearance of epidemic diseases which presented much greater threats. There were two major epidemics during the Middle Ages. The Black Death raged in Europe from the 1340s, killing one quarter of the world's population. The Great Plague of 1665 wiped out twenty percent of the population of London;

both epidemics were widely attributed to supernatural influences.

Early textbooks dealing with health, accidents, and diseases recommended that practices, rules and regulations remain the same rather than taking a creative approach. There was a marked resistance to change.

### The expansion of man-made hazards

The Renaissance, rooted in Italy in the 1300s, opened the doors to exploration, experimentation and new visions. Manufacturing of various goods escalated but new technologies initially caused great fear of unemployment. For example, in 1397, the use of a device that automatically pressed pinheads was banned in Cologne. During the Luddite riots of 1811-12 in England some 1 000 stocking frames and 80 lace machines were destroyed by workers. Those accidents and diseases that were reported were generally accepted as “fate”.

Georgius Agricola, 1494-1555, was a German mineralogist, scholar and physician who is considered to be the father of geology. In his book “*De Re Metallica*”, published in 1556, he described accidents and diseases among miners and also recommended a number of preventive measures. He also believed that there were harmful devils and dwarfs living in the mines.

Another mixed product of the Renaissance was the Swiss medical thinker Aureolus Philippus Theophrastus Bombastus von Hohenheim, more known as Paracelsus, 1493-1541. His interest in astrology and the occult did not preclude his famous chemical experiments. He saw the human body as a chemical laboratory and attributed lung diseases to toxic air in mines and metal melting plants. His textbooks on health were regarded as the established knowledge on the subject for two centuries.

The London surgeon, Percivall Pott, 1714-1788, gave the first description of an occupational cancer, scrotal cancer, called the “chimney sweeps cancer”. This was the first occupational link to cancer but it was many years before preventive measures were taken to protect chimney sweeps. The British chemist Sir Humphry Davy, 1778-1829, was more influential. He investigated mine explosions and developed the miners’ safety lamp that saved many lives. Accidents impacted more than diseases.

The Italian physician Bernardino Ramazzini, 1633-1714, is called the father of Occupational Health. His classical *De Morbis Artificum Diatriba* was published in 1700. Ramazzini examined the conditions of work and hazards of the most important occupations of his time. He also proposed preventive measures and asked physicians to routinely include the question about what trade patients worked in when making a diagnosis. His book was compulsory reading at numerous medical universities around the world over for 200 years but was poorly applied in practical, hands on medicine.

The British physician Charles Thackrah, 1795-1833, devoted his life to the study and prevention of the occupational hazards of industrialism. His systematic observations of 128 trades in Leeds, England, played an important part in the formulation of later factory and health legislation.

Despite the increasing knowledge of occupational hazards that was gained in the first half of the 18<sup>th</sup> century, little was done to safeguard workers.

The Age of Enlightenment was a philosophical movement that developed in France, Britain and Germany during the second part of the 18<sup>th</sup> century. Rationalism and Science were leading ideas. The French philosopher and essayist Denis Diderot, 1713-1784, signed the monumental

“Encyclopédie”, announced as the key to human progress under the banner of “Rationality” but even here labourers’ health was a minor issue.

### Growing awareness

The first industrial revolution, 1700-1850, developed from a combination of technology, improved power sources (steam from the 1780s and electricity from the 1800s), new materials, and improved long distance transportation. The number of wage earners expanded to form a class of its own, the “working class”.

In 1841 Great Britain had a total population of 18 350 000. Three million were engaged in trade and manufacturing. 1.5 million were employed in agriculture and in mining, see Figure 2.1.1, and 750 000 in quarrying and transport. There was a total of 5 250 000 employers and employees at a time when London had less than 2 million citizens.

The economic theory of Capitalism, based on private ownership and free enterprise, was gaining momentum. In the middle of the 1800s the rest of the world looked at England as the major centre of capitalism and the place that the risks to workers were observed and defined over time.

The greatest sociological study in the 19<sup>th</sup>-century of working and living conditions in London was undertaken by Henry Mayhew, Figure 2.1.2, and published as *London Labour and the London poor* (2 076 pages in four volumes) in 1861-62. His aim was “to publish the history of people, from the lips of the people themselves-giving a literal description on their labour, their earnings, their trials and their sufferings, in their own unvarnished language”.

Mayhew invented oral history a century before the term was coined. He walked hundred of miles through London streets in the 1840s and 1850s and gathered thousands of pages of testimony. His findings first appeared as a series



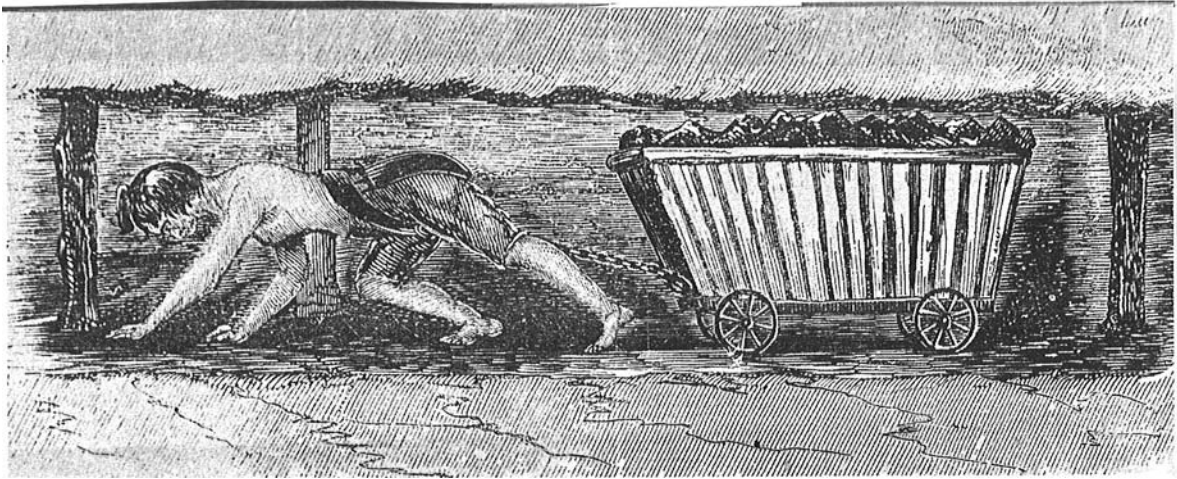


Figure 2.1.1. A female coalminer in 1840. “I have a belt round my waist, and a chain passing between my legs, and I can go on my hands and feet”.



Figure 2.1.2. Henry Mayhew, London, 1861.

of articles in the Morning Chronicle in 1849-50. The English writer W.M. Thackeray 1811-1863 wrote: "Mayhew provides us with a picture of life so wonderful, so awful, so piteous and pathetic, so exiting and terrible, that readers of romances own they never read anything like to it".

The hazards inherent in the society, "the total social fabric", Mayhew pleaded, could be identified, measured, and evaluated in series of comparisons. As a first approach he arranged the population into four different groups: a) those that will work, b) those that cannot work, c) those that will not work, d) those that need not work. He stated that under one or other section of this four part division, every member of not only the English community, but of other civilised states, could be accounted for – those who were rich, poor, industrious, idle, honest, dishonest, virtuous, vicious.

However, there were so many branches of industry with the division of labour so minute and various, that it seemed impossible to reduce them into any workable system. Mayhew was assisted by various statistics that increasingly were being collected. In 1827, M. Payon had tested a classification of labourers into five major divisions, arranging the crafts according to their origin: chemical, mechanical, physical, economical, and miscellaneous. In 1834, M. Dupin proposed a classification that was found to work better than earlier classifications. He viewed humans as: a locomotive animal, a clothed animal, a domiciled animal etc. By tracing individuals through their various daily needs and activities, Dupin arrived at a classification in which all crafts were placed under nine headings, according to their contributions to society.

### Who are real workers?

Mayhew used broad definitions. He applied the title "worker" to all those who did anything to earn their living, who performed any act considered worthy of being paid for by others, without regard to the question of whether such labourers tended to increase or decrease the aggregate wealth of the community. All persons doing or giving something in return for any kind of comforts were defined as "self-supporting individuals". An informative comparison was made between living and working conditions of three groups of non-workers: a) incapacitated or those not allowed to work, b) those who were indisposed or choosing not to work, and c) independent and privileged non-workers. These non-workers included people diametrically opposed to each other from the very rich to the very poor, from the honest to the dishonest.

Mayhew noted that the circumstances governing the classification of commercial trades were totally different from those regulating the division of other types of work. However, distinct sets of workers were required, according to the specific demands of trades. From his main groupings Mayhew pictured society as a living organism moving from the whole to the parts. He made a systematic outline of the health and safety conditions of all his groups and subgroups of workers and non-workers.

### Charity agencies

According to Mayhew, the support or aid offered by charity is a main social resource in a capitalistic society so he also mapped out charitable activities. In the 1850s, some 530 charitable societies in London spent 2 million pounds annually. Mayhew grouped them as: a) curative, b) preventive, c) repressive and punitive, and d) reformatory. The curative agencies were mainly based on societies promoting Christian knowl-



edge and city missions. Preventive agencies worked with issues such as home hygiene, the provision of free drinking water, and public improvements of conditions of the working classes, including the employment of women. Among the repressive and punitive agencies, suppression of vice dominated the agenda, but prevention of cruelty to animals was also observed.

Mayhew comments upon many favourable and unfavourable factors in society. “The path of man, even of a man on the highway to heaven, is never one of perfect safety”. As to those people far away from the highway to heaven, Mayhew devotes many pages to beggars whom he illuminates as a catalogue of victims caused by the process of industrialisation, including children, women, and injured men. A striking example were the beggars who appeared on the streets after a disaster including shipwrecked sailors, injured miners, burnt or maimed tradesmen. “A man who has lost both arms, or even one, is scarcely in a position to earn his living by labour, and is therefore a fit object for charity”.

Charity, however, can be misused. After a serious coal mine accident, injured miners swarmed into London in such numbers “that one might suppose the whole of the coal-hands of the north had been blown south by one explosion”. Numerous others pretending to be beggars join the victims. The real miners, Mayhew notes, are very charitable and don’t think it shameful to seek aid from their betters when they really need it.

Burnt and maimed tradesmen were another group of beggars often showing bloody coverings over leg and arm sores. While such sores can be faked, ill health and accidents in workplaces often ended in street begging. Henry Mayhew maintained his fighting spirit and claimed that the wealth produced in a society must be properly shared. He concluded:

“The poor will never cease from the land. There always will be exceptional excesses and out-breaks of distress that no plan can have provided against, and there always will be those who stand with open palm to receive, in the face of heaven, our tribute of gratitude for our own happier lot. Yet there is a duty of the head as well of the heart, and we are bound as much to use our reason as to minister of our abundance.”

### Registers and statistics enter the scene

Mayhew considered earlier events that foreshadowed or confirmed his own observations. As early as 1506 Torella proposed the periodic examination of prostitutes as a measure for the control of venereal diseases. At the beginning of the 18<sup>th</sup> century, Howard set forth a plan for reform of prisons and hospitals. In England in particular, registers of births and deaths, and of statistical methods, were launched in the 17<sup>th</sup> century. In Germany Johann Peter Frank produced his Magnum Opus in social medicine: *The System of Comprehensive Medical Policy* in 6 volumes, with 3 supplements, from 1784.

In 1887, Conrad published his work *Contribution to the Study of the Effect of Social Conditions and Occupations on Mortality* based on data of the town of Halle for 1855-1874. His work preceded epidemiology. He divided recorded deaths into two age groups, one with deaths of those up to 5 years of age and one over 5 years of age. He found that in both groups almost 90% of the cases were related to poverty.

Several mortality and morbidity studies published later confirmed that social position affected mortality. A Danish demographer, Westergaard, analysed the life expectancy for the nobility and for the rest of the population in England during 1800-1855. He found that the Aristocrats could expect a longer life expectancy than the rest of the population.

### Risks and human nature

Second to the belief that all events were determined by fate and were therefore inevitable, comes the concept of inherent “human nature”. Humans are naturally accident prone or gambling risk takers so to master hazards was to master human nature. Numerous early studies included the “accident-prone personality”.

*Holism and evolution* was a striking book written by J.C. Smuts, 1870-1950, published in 1926. The author was an English born South-African statesman who tried to bridge the gaps between matter, life and mind. He indicated the need to reform all three concepts. However, one condition prevailed, and he stated that the parts should be interpreted from the whole, not the other way round. The mind should not be studied as a distinct phenomenon but as a universal process, i.e. a holistic approach must be taken. His ideas were not taken seriously for many years.

The founder of behaviour psychology, the American scientist, J. B. Watson, 1878-1958, made his main contributions during 1910-1920. His thesis was that environmental factors ruled behaviour. He studied the behaviour of animals and people in the “real world”, in their own surroundings. According to the British philosopher Bertrand Russell, 1872-1970, Watson’s achievements equated to Aristotle. Prediction and control of behaviour were his two prevailing issues. Behaviourism used external signs to keep track of the individuality. Watson studied how subjects responded to different stimuli. He transformed his findings into “learning curves”. He characterised basic behaviours that normally last over a life-time as “the habit equipment” that included disturbances and maladjustments of behaviour that could be corrected. Individual expectations could be manipulated.

Watson’s message was challenging because behaviourism meant that people could be programmed or reprogramed to understand the principles of their own behaviour. His idea that it was possible to condition consumers to buy anything, was successfully exploited commercially, particularly in the US, but was not used as a tool to change the behaviour of people at risk. However, Watson and an American Professor of Experimental Psychology, B. F. Skinner, 1904-1990, are revisited in what is currently called “program learning”. Watson was given remarkable publicity in both west and east but he did not trigger substantial new activities on hazard abatement.

### RISKS CONCEPTS ARE CHILDS OF POLITICAL SYSTEMS

The British industrialist Robert Owens, 1771-1858, was a front runner of modern socialism in Great Britain suggesting a number of social reforms in the 1820s. Two German socialists, Karl Marx, 1818-1888, and Friedrich Engels, 1820-1895 highlighted the basic incongruity of capitalism: the contradiction between the social nature of the process of production and the private capitalist method of appropriation. According to Engels and Marx, socialism offered political conditions for human development through the abolition of private ownership and exploitation and by giving all citizens equal political and legal rights and duties. Appropriate science could be transformed into a directly productive force so production would gradually become the technological embodiment of science. Everyone had a duty to serve in a socialist society – “he who does not work shall neither eat”.

Academics in the Union of the Soviet Socialist Republics, recognized three stages in the evolution of the interrelationships between science and production. During the first stage dated

from the emergence of scientific knowledge to the industrial revolution of the late 18<sup>th</sup> century, science mainly developed in accordance with its internal laws. There was no direct connection with either production or technology except some through some haphazard influence.

The second stage spanned almost two centuries, separating the first and second industrial revolution. Large-scale mechanised industry transformed production by replacing obsolete methods through the conscious application of science and scientific data.

The third stage in the historical evolution of science and work began when scientists, industrial workers and engineers cooperated directly. Science has become a cornerstone of modern technology and production processes. Common risk factors can be eliminated or substantially reduced. According to official Soviet statistics, the rate of industrial injuries and accidents fell by more than 75% between 1928-1975. However, detailed data were not presented.

It became imperative to find what conditions could achieve a reasonable balance whereby nature could be developed in accordance with the needs of human culture. Humans rule nature. “Labour is, in the first place”, wrote Marx, “a process in which both Man and Nature participate, and in which man of his own accord starts, regulates, and controls the material reactions between Himself and Nature”.

Waste and pollution could be brought under control by closed-cycled technologies, however, a switch to closed-cycle technology would involve much greater consumption of energy. The Soviets felt that the energy problem could be solved by using controlled thermonuclear processes.

### The Club of Rome

The Club of Rome was initiated in 1968 by the Italian industrialist Aurelio Peceri, 1908-1984. The Club of Rome was a private group of 100 independent specialists from more than fifty countries. They looked at the contemporary predicament of mankind and focused on the consequences of population growth, standards of living, and geographical boundaries. Using computers they tried to structure a world model based on system dynamics. In 1972 they plotted a first course from exponential growth into global equilibrium, coordinating a number of subsystems: social, technical, economic and political. In an evaluation in 1992 they noted that implementation of their most urgent global recommendations had not even started.

The statements of the Club of Rome were the subject of much attention in the capitalist world. By applying what they called “System Dynamics” the world of growth with increasing risks could gradually be transformed to a world of equilibrium with low risks.

### No state of equilibrium

Soviet scientists, however, were arguing against the Club of Rome calling the recommendations in *World Dynamics* and *The Limits to Growth* (1972) “unrealistic”. This publication stated that the only way to safeguard humankind from a future catastrophe and to establish a “state of world equilibrium” was to limit the open-ended growth of all parameters: population, production, consumption, and pollution.

An unrestricted capitalistic system, directed by the market, is mainly based on the principle of one-time use of natural resources. This type of production uses only part of extracted primary materials and the rest is converted into waste. Capitalists said that the demand for a zero growth rate was also unrealistic theoretically as

it is impossible to halt economic development but the socialists claimed that economic development was stimulated by a centrally planned economy. Soviet researchers made a distinction between growth and development of an economic system. Growth describes the increase in the system's productive potential. Development, on the other hand, reflects the ability of an economy to accomplish specific programs in a flexible way.

### Metapotential

In socialist terms, one of the most important factors in the development of an appropriate economic system was preparatory technological measures. The extent to which the production systems already in use produced discharges, or produced zero discharge, served as an index for this. As such an index the metapotential (MP), describes the ability of an economic system to realise long-term development programs. Determination of preferred growth rates expressed in MP terms presumes measuring of the MP elements in value terms. Four aspects had to be considered:

- 1) Economic potential reflects the total production of a nation
- 2) Scientific and technological potential includes education, science, and management
- 3) Human potential embraces the size of the population, its physical and mental health, and creative activity
- 4) Ecological potential reflects the boundaries of possible expansion of production.

Changes in any of the four elements should be appropriately balanced in the three others. Politically, the scientists' models were used as impressive arguments against Western concepts but in practice there was little implementation.

### RISK PERCEPTION AND RISK MEASUREMENT

Up to the middle of the 19<sup>th</sup> century in all industrialized or industrializing countries, action programs and legislative measures were largely based on classical risk concepts. Although the basic conditions of work were had been outlined a long time before, e.g. by Mayhew, among others, human health and productivity were dealt with separately. Multidimensional risk concepts including damage, injury, and material losses only appeared in the later part of the 1900s. Risk aversion was defined as the actions taken to control holistic risk patterns, including risk estimation and risk evaluation.

As a rule risk prevention does not eliminate the risks but reduces them to a defined "acceptable" level. There were no arguments about whether workers should be protected but the costs of protection were a decisive issue. Two types of studies were referred to for guidance on this issue, cost-effective and cost-benefit calculations. However, no data for damages or benefits were credible enough to determine political decisions.

While cost-effectiveness studies can indicate the cheapest way to achieve an agreed level of protection, such studies are complicated. Most cost-benefit equations take time to prepare but political decisions must be made quickly and decision makers must combine hard data with subjective value judgements. This includes ranking results in a priority order and making rational decisions (but often based on intuition). There is uncertainty not only about facts but also what people think about those facts and uncertainties about future consequences. New risk patterns may require detailed multidisciplinary studies e.g. involving biochemistry, physiology, genetics,

behavioural science, or epidemiology. The time available is a critical factor.

All industrialised countries have gradually established statistical systems for rating both serious and less serious accidents, e.g. the frequency and the incidence rates (injuries divided by worked man-hours) of injuries that cause disability. These statistics are excellent indicators within a country, but cannot be used directly for wider comparisons as recording and reporting systems and practices differ greatly from one country to another.

At the factory level, quantitative information is usually collected through recording the number of accidents, near misses, rates of absenteeism, and occupational hygiene measurements. In larger companies or health centres, statistical reports also include workers' medical records.

### Predictive technology

The Apollo Mission to land a man on the in 1969, involved some 20 000 national and international companies employing more than 350 000 people in the construction and assembly of 15 000 000 component parts. While there were great possibilities for accidents or failures due to human error a flight system was produced that proved to be more 99.9% reliable. It is possible that one of the greatest benefits achieved by the space programs was the safety related measures that were utilized to ensure the success of these great ventures. At all stages of conception, design, manufacture and operation, the man-machine-environment-equipment subsystems were considered to be interrelated and interdependent components of the overall system.

The enormous potential for catastrophic loss led to the development of a new safety discipline that came to be known as "Systems Safety Engineering". The application of new predictive techniques to determine the probability of com-

ponent, sub-system or system failure at all stages of a system's life cycle enables management to make decisions that could correct control problems a system becomes operational. Product safety engineering will be more commonly applied in future.

### Retrospective and prospective epidemiology

Epidemiology is an important tool for the study of risks. Epidemiology is a non-experimental science that studies disease through observations of disease phenomena in population groups. Thus, in case-control studies a group of individuals afflicted with a particular disorder is selected along with a control group free from the disorder. Differences between the two groups are then compared on issues such as in lifestyle, diet, working conditions, and environmental factors. This type of study is sometimes referred to as a "retrospective" study because the presence or absence of a predisposing risk factor is determined from some time in the past.

Cohort studies are more reliable and costly. They involve subjects in a large population who are questioned in detail about their habits and environment. The entire study population is followed for years or decades to see who get sick and who doesn't, to identify what diseases they suffer from and what factors may be different between the study groups. This type of study is referred to as a "prospective" study because it looks forward from exposure to the possible development of disease. Since the 1950s epidemiologists have succeeded in identifying a number of long term diseases such as cancer caused by smoking and asbestos.

### DRIVING FORCES

During the first half of the 20<sup>th</sup> century, there were some important supporters for society's responsibilities for Occupational Safety and



Health (OSH). The international Permanent Commission on Occupational Health (now the ICOH), was founded in Milan in 1906 driven by the fact that 10 000 workers were killed in the construction of the St Gotthard and Simplon tunnels in Switzerland. To prevent a repetition, international cooperation was required at all levels. The International Labour Organization (ILO) was created in 1919, and the International Social and Security Association (ISSA) in 1927. The World Health Organization (WHO) was founded in 1948. These bodies all co-operated to collect, elaborate and distribute research findings, field experiences, and rules and recommendations. The British Health of Munitions Workers' Committee (1915-18) established the first fatigue research board in the world. Scientists were invited to study work-related fatigue, particularly in women's work, in controlled experiments on the shop floor. In 1950 the ILO/WHO introduced a new health concept, widening the old 'health as the absence of illness', to a more positive one: 'the promotion and maintenance of the highest degree of physical, mental, and social well-being of workers in all occupations'. The behavioural sciences were acknowledged. However, all the conventions, recommendations and standards issued by these global organizations are still not universally applied, (nor are later EU directives).

"Think globally and act locally" was a slogan introduced in 1992 with the UN Agenda 21 on Environment and Development. Agenda 21 mirrored current demands and future goals. Level 4 of Agenda 21 means that physical, psychological, ethical and existential needs should be integrated at local community level. This is, of course, easier said than done.

Preliminary work outlined different scenarios. Good progress had already been made in terms of legislation. The 1970s were golden years in

many industrialised countries for the working environment. The Commission of the European Community (CEC) published in 1985 five comprehensive volumes on the law and practice of occupational health in the Member States. The scope and content of occupational health legislation and non-statutory measures has been examined in detail and extensive annexes cite the full text of numerous documents, from statutory requirements down to guidance notes. Comparisons between countries were a major feature.

"Quality based benchmarking" (comparison with the best available practice) has been treated warily in OSH although quality based production has gradually replaced mass production. The birth and growth of various quality based methods that have developed over the years has been put into perspective by John Butman in 1997. He emphasises the important differences between static and dynamic strategies. Advanced quality production cannot succeed in companies with pronounced internal tensions. Numerous other volumes address the question of quality production. A highly influential management guru is Peter F. Drucker. Two of his books published in 1987 and 1992 have a particular bearing on OSH management. Other pioneering writers on new management strategies are Michael Hammer and James Champy who suggest that continuous quality improvement is not always enough; in some instances a radical redesign of a whole corporation is needed.

Support for OSH is always lagging behind the many changes in priorities and perspectives that occupy governments, employers and trade unions. Classical tripartite relations are weakening in some countries and new arrangements are unclear in the current age of irreversible globalization. It is not easy to update OSH measures in a globalised world lacking traditional 'responsible employers' and 'collective workers' of the past.

## COMPANY BASED OCCUPATIONAL HEALTH SERVICES

Historically it is possible to discern the broad evolution of medical practice, commencing with witch-craft and folk medicine, through to sanitary improvements and public and occupational health. This development has been marked by an advance from an empirical to a scientific approach.

At the beginning of the 20<sup>th</sup> century, Germany was the pioneer of national health services that stimulated similar developments in the other countries of Western Europe. A national health service was introduced in Great Britain in 1912. The United States later became leaders in the expansion of company based health and safety programs.

Company occupational health services led to the development of techniques and practices

such as the placement of workers through job selection and job analysis, pre-employment and periodic medical examinations, medical and biological screening and monitoring, caring for the health of both workers and executives, preparation for retirement and occupational hygiene measures including the definition of maximum allowable exposures to chemicals, dust, fumes and gases, and workload.

### Increasing complexity

Expanding and changing industrial technology has resulted in environmental changes of increasing complexity, Figure 2.1.3. Sanitary problems such as bacterially contaminated air, water, and food have now been largely replaced by chemical pollution and other hazards.

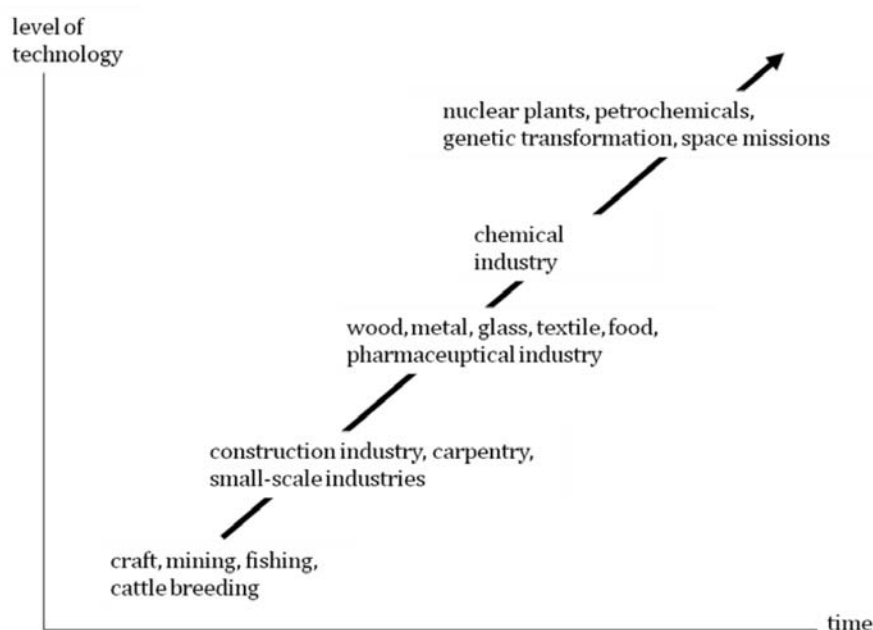


Figure 2.1.3. Levels of technology and production. Every level is related to its special set of hazards and risks. Based on data from Galli E. & Wennersten R.: Understanding Safety (Swedish National Institute for Working Life, 2003).

The idea that humans are part of the overall ecosystem is an important fundamental concept for current preventive work. Potential sources of disruption to an ecosystem must be given due consideration. Decisions on the localisation and operation of industrial plants, production planning, transportation and the end use of products are all potential threats to the ecosystem. The prevention and technical aspects of hazard elimination requires the monitoring of work processes, the working environment and the surrounding outdoor environment. Integrated strategies covering these three issues have only been seriously considered since the 1990s.

The growth of OSH during the first part of the 1900s differed between countries according to needs. In Italy, occupational medicine grew out of clinical medicine; in France, out of legal medicine; in the United Kingdom out of protective legislation; in the United States, out of industrial hygiene; in the socialist countries, as a part of public health; and in Sweden, out of a tripartite cooperation. The development of occupational health from medical diagnosis and cure to comprehensive prevention has followed a long and crooked path. An important step was the introduction in 1950 of a broader scope for occupational health by the ILO and WHO that included the concept of human “well-being”, distinct from human disease. In most European countries, the general principles of health and safety at work in the 1980s were maintained through legislation.

### CASE SWEDEN

Sweden is a large country with a small population of 9 million. Four million people are in employment. The industrial history of Sweden is relatively short but Sweden has made some remarkable contributions to the development of occupational safety and health in Europe.

The changes of Swedish working life illustrate the impact of new technologies and the strong forces behind current trends including the inherent resistance of people to changes. In 1880 Sweden was a poor farming country that had become an advanced industrialized society by 1950. In 1980 Sweden was considered to be an established industrialized country in contrast to the newly industrialized countries such as Korea and China.

Historically, Sweden is unique because early on the Swedish Employers' Confederation (SAF) and the Swedish Trade Union Confederation (LO) formulated operational rules governing cooperation in each sector of the economy. The two organizations created joint tools of cooperation and employed their own specialists to implement their shared objectives. Initially, serious instability in the labour market, immediately after the turn of the century, was instrumental in forcing this decision on the parties. A series of disputes, strikes, and violent conflicts of interest characterized the labour market in Sweden throughout the 1920s and 1930s. Proposals for coercive legislation to stabilize conditions were put forward in several government study papers and parliamentary bills introduced by the political parties. In this situation, SAF and LO elected to ward off government interference by securing industrial peace through the negotiation of voluntary agreements in the private sector.

The most important document was the 1938-agreement to maintain industrial peace, the Saltsjöbaden Agreement (named after the place where it was signed), with the prime purpose of safeguarding production and employment. Wage agreements negotiated by both sides at the central level were to be binding at the local level throughout the period of validity of the agreement. In a series of corollary agreements, the negotiating parties formulated their community



of interest in three fields: industrial health and safety, occupational training, and arbitration.

Following a series of council and committee meetings and later agreements, the two sides did not merely secure opportunities for promoting constructive and mutual cooperation, but also secured funds to engage the services of qualified external experts. This move in turn necessitated the employment of in-house experts. The SAF engaged its first medical adviser in 1939 and the LO in 1964.

The relationship of working environment factors to health was subdivided into five main categories: level of activity (physical and mental); physical impact (noise, vibrations, radiation, electromagnetic fields, climate); chemical impact (fumes, gases); biological impact (micro-organisms); social impacts.

### Agreements

The voluntary guidelines from the labour market parties in the private sector for risk prevention and occupational training were efficient tools for application on the shop-floor.

The following three agreements help to illustrate the transition from risk to well-being:

- The Development Agreement (1982)
- The Equal Opportunity Agreement (1982)
- The Work Environment Agreement (1983)

The Development Agreement identified that the development and promotion of efficiency and security of employment in private companies as issues of common interest to companies and employees alike. The parties to this agreement expressed their desire to promote the efficiency, profitability, and competitive ability of private companies. They also agreed to create conditions favourable to the maintenance of employment levels, job security and satisfying and

meaningful job content. As in other quality programs, the active participation of all employees was needed. Work and the work environment should be structured to reflect the statutory and negotiated requirements for a good working environment. The organization of work and the tasks allotted to an individual employee should be designed to ensure that the work was as interesting and stimulating as possible. An employer was required to account for factors motivating the introduction of new technology and to list the technical and financial consequences including the impact on employment and the environment. In many cases, this process required the participation of skilled experts.

The Equal Opportunity Agreement set out the objectives and guidelines for the promotion of equal employment opportunities. The agreement stated that the promotion of equal opportunities for men and women were an important objective for both salaried staff and wage earners.

The Work Environment Agreement contained the rules governing activities related to the work environment, guidelines for company health programs and an agreement on occupational training. The agreement stated that a corporate health program should consist of a technical and medical section, both giving special emphasis to psychosocial questions. Staff employed in company health programs should take a scientific approach and utilise proven experience of the workplace under the supervision of a joint industrial safety committee or company health program committee. Emphasis was placed on preventive action. Rigorous precautions must be taken to assure the impartiality of company health programs. Issues related to interpretation of the terms “scientific approach” and “proven experience” was referred to a national level scientific committee for resolution.

In addition to the establishment of clearly defined objectives for their joint sphere of operations, the negotiating parties at the central level of the labour market allocated material resources and staff to realise these objectives. The parties also pursued their own separate activities within the frameworks laid down by the negotiated agreements and guidelines.

The tripartite philosophy that dominated in Sweden up to the 1970's, meant that new legislation should be based on tested, practical experience. Directives from authorities were expected to confirm proven experiences from the shop floor. In the 1970s, direct legislation, not based upon tripartite agreements, appeared as a presumed speedier tool.

### Revised law

A major revision of the law went into force in 1974. Safety delegates were given the authority to temporarily stop jobs that were judged to be acutely dangerous. Factories with less than 50 workers could now, when needed, be ordered to organize a joint safety advisory committee with members representing employers and workers (prior to that time a company had to have a minimum of 50 workers). In 1978 further amendments tightened up existing regulations and set more ambitious targets. The authorities policed more thoroughly and executed harder sanctions. Inspectors had to enforce written directives and were not permitted to give advice in matters where written directives were lacking. Lawyers joined the staff of all districts of the inspectorate.

The 1974 Act signalled the route to the 1976 law on codetermination, which marked the official end of the Saltsjöbaden Agreement. While confrontation became stronger, the labour market parties maintained their cooperative spirit in important health matters.

Eventually, increased efforts by the labour market parties to enrol small companies in OSH proved successful. In 1988, 80% of the Swedish working population of four million employees had access to organised occupational health services. Some 10 000 people, including safety engineers, occupational hygienists, physicians, nurses, physiotherapists, behavioural scientists and others, were employed in occupational health services.

### EVOLVING OPTIONS

There is a close connection between technology and social progress. Historically, humans were hunters and gatherers for 50 000 generations. They then became hunters and farmers for 500 generations and then farmers and artisans for slightly more than 200 generations. Industrial workers started to receive earnings 10 generations ago.

The industrialisation era with urbanisation, mass production and cheap, long-distance transport radically changed human life. In the early stages of industrialisation, attempts were made to maintain old tools and strategies from the self-sufficient society. It took time to realise that the new sources of power, and new machines and materials created new skills, techniques and organisation. Currently, massive efforts are being made to project outdated strategies from the old industrial society into the future. However, such attempts are a repetition of the mistakes of the past.

Since the 1960s, humankind has passed through a paradigm shift into the knowledge-based society. Knowledge (rather than minerals or wood) is now the main capital of a developed economy, and knowledge creates new tools and strategies that were not available in the old industrial society. Our generation is the first to experience a knowledge based society, that is

continuously changing. Individual and collective learning is the most urgent issue in the short term.

Many individuals and organisations study the changing aspects of the world situation. The earth is limited in size and there are many problems associated with many subsystems: demographic, industrial, agricultural, etc. Models of ecology are now being used in order to explain the interactions between various systems and to find preventive measures. Industrial activities impact on both the natural and the social environment and workers' health cannot be separated from community health.

The first industrial revolution created a quantitative increase in mass-produced products, new markets on distant continents and increases in output that were quantified in terms of volume. Society gradually started to consume on a large scale (for good or evil...). The current technological revolution is quite different in character because it is principally concerned with quality and progress is measured by quality.

In the knowledge-based society, multinational production is essential for economic success.

The challenge for management is to organise enterprises that function on both global and local markets. Multinational trading requires complex systems for global production, product development, supply technology, finance, and distribution.

Modern information technology advances through the increasing use of artificial intelligence, intelligence amplification and virtual thinking. Knowledge systems using such resources now solve production and productivity problems and are helpful for research and education. The knowledge base of an expert system is readable and easy to modify and are highly interactive. For example, if a number of health and safety standards are changed in a plant with 30 000 production standards, an expert system will quickly identify the need for appropriate changes of all affected operative standards in the plant.

In theory, new technology gives us more alternatives than earlier technologies permitted so it should be possible to make both large and small organizations more agreeable for humans.

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## A new OSH paradigm is needed

*Tom Dwyer & Kaj Elgstrand*

The ‘Great Western Paradigm,’ founded by Descartes, would come to be associated with far more than just science; it would become associated with ‘modernity’ and would carry the spirit of reason into all the nooks and crannies of Western life. The new paradigm met with extraordinary success as its rationalising power helped build the wealthiest nations ever seen. Through science and education, came the highest average levels education and knowledge distribution known in human history. This system, allied with an economic system, became the largest producer of wealth in the history of the world, achieved through a general process that sought to crush traditions and all other imagined obstacles to the spread of reason. The idea of reason was exported, by imposition or by imitation, as though it were universally applicable.

One reason for the spread of the paradigm was the increasing capacity of scientific activity to explain and to be applied thereby transforming the world. As science grew, its diverse languages became increasingly esoteric and distant from citizens. Science contributed to the concentration of power into the hands of people who had no role in producing it, especially the leaders of large corporations and nation states. A darker side of the modernisation process became

visible as human hands created destructive powers and an ecological imbalance hitherto unimagined in the history of the world. From the late 1960s there was increasing questioning in the West about the role of science and about type of society it had played such an important role in producing. Such questioning was symbolised by the ‘doomsday clock’ which graphically portrayed the likelihood of nuclear war and inspired the anti-nuclear bomb movements. Rachel Carson’s book *Silent Spring* published in 1962 and the Club of Rome’s 1972 report *The Limits to Growth* fed a growing ecological consciousness. The ‘small is beautiful’ concept emerged in opposition to mass production and large monopolies. Diverse forms of modern domination: colonial, cultural, monopoly capitalist, and male were increasingly denounced. The very idea that universal principles of reason were being applied in all forms of social and economic life in the West was contested. Various counter culture and liberation movements, ranging from feminist to the ecological movements, profoundly affected many parts of the World, particularly in the industrialised countries.

## THE BIRTH OF THE INDUSTRIAL OCCUPATIONAL SAFETY AND HEALTH PARADIGM

Information relating to diseases of miners and to workers in dangerous trades can be found already in the sixteenth century. In the middle of the century, Agricola and Paracelsus wrote on the subject of miners' diseases and accidents. In 1700 came the classical work of Bernardino Ramazzini, the Father of Occupational Medicine, *De morbis artificum diatribe* (Diseases of Workers). He made a striking addition to the Hippocratic art: "When a doctor visits a working class home he should be content to sit on a three-legged stool, if there isn't a gilded chair, and he should take time for his examination; and to the questions recommended by Hippocrates, he should add one more – What is your occupation?" In summary, Ramazzini's pioneering work saw a worker's profession as a key factor in ill health.

With the rise of industrial society the causes of misfortune came to be blamed on human agents and, in the case of work accidents in mines and large industrial plants, specifically on owners. The notions of responsibility, cause and prevention that emerged were closely linked to the development of science, technology and a legal system that sought to respond to the problems of an industrial age. Such measures combined to form the dominant paradigm of safety and health at work that is closely linked to the Great Western Paradigm. The world was separated into the world of things (objects) and the world of thinkers (subjects), concepts that were eventually translated into 'unsafe conditions' and 'unsafe acts' in the field of industrial safety.

In order to prevent disease and injury it was seen to be necessary to intervene and apply preventive measures. As a consequence govern-

ment and private sector institutions developed in the form of specialised professional groups, and enforcement agencies whether public (e.g. factory inspectorates) or private (e.g. insurance company inspectors and rules). In addition a series of scientific, technical and administrative milieus grew, as their members built scientific and professional societies (nationally and internationally), specialist journals, training, conferences and formed pressure groups. In some cases an international agenda guides the implementation of OSH measures most particularly by multinational corporations and large firms adopting international 'best practices', or when governments implement international standards. These are the means by which the paradigm has come to be a part of the reality of life for workers, professionals, civil servants, trade unionists and employers in many corners of the globe.

## PARADIGM FORMATION AND COMPONENTS

It took over a century for the current industrial OSH paradigm to acquire its form. This time lag is particularly visible in the case of industrial accidents. Sir Humphrey Davy invented the first modern work safety equipment in 1815, i.e. the mine safety lamp that still bears his name. In 1931 when Heinrich's book *Industrial Accident Prevention* was published, it was considered by many to be the 'safety man's bible', and its publication marks the consolidation of the safety component of the paradigm. The book's important contribution was to systematise an engineering-based theory of prevention inspired by a rationalising perspective similar to that developed for industry by F. W. Taylor. The book also helped to transform safety engineering into a distinct sub-discipline. Institutions were built up in areas such as industrial medicine, industrial hygiene and human factors engineer-



ing. Heinrich's theory defended the idea that 85% of accidents are caused by unsafe acts and 15% by unsafe conditions. The idea of 'unsafe acts' opened up a space for the application of psychological knowledge, and for the notion that accidents were due to the failings of subjects. Many attempts to determine the cause of accidents and illness sought to relieve employers of legal responsibility for what was happening to their workers. However, the foundation members of what later became the British 'Society of Occupational Medicine' in 1935, "were anxious to distinguish their approach from that of practitioners involved in assisting employers with compensation claims. From the start they were keen to transform their interests into improvement and extensions of industrial health practice for the benefit of the employees, the enterprise and themselves." In other words they had a vision of prevention that they saw as technical and neutral.

The industrial OSH paradigm emerged from a long process. The earlier *laissez faire* approach to accident prevention and health protection was seen to produce death and injury among workers, (children, adults, women and men), and this perception was particularly acute in Great Britain, the country considered to be the cradle of industrial society, especially in the coal mines and manufacturing. However, some employers, who can be characterized as traditional capitalists, defended a *laissez-faire* approach to all workplace and economic issues and were opposed to government intervention. Other employers, defined as industrial capitalists, had a quite different approach, believing that investment in the improvement of working conditions could yield higher levels of productivity. The worst excesses of rampant *laissez-faire* capitalism, such as child and women's labour, were widely seen to be degrading and unhealthy, accidents and the

resulting social unrest were broadly criticised. It was in such a context that legislation designed to produce healthy and safe working conditions gradually won out in the British Parliament, and the *laissez faire* approach lost out to the industrial approach. Gradually the government set up inspectorates to guarantee that legislation was obeyed. This change from a *laissez faire* to an industrial model received employer support from the mid 1800s. For example, in 1864, Mr. E. Potter, Britain's and the world's largest calico printer, told the Social Science Association that "the Factory Acts were opposed by many of us as economically unsound and as an unjust interference with the rights of labour and capital. They have been soundly beneficial." The British model, which concentrated principally on mining, manufacturing and later construction, gradually spread to many countries. At the very end of the 19<sup>th</sup> Century, workers, particularly those in Western European coal mines, mobilised and achieved political influence, contesting the degree to which managers implemented healthy and safe work practices and demanding participation in the process. As a result a limited degree of worker participation in safety and health came into law firstly in Belgium and subsequently in other countries.

By the end of the 19<sup>th</sup> century the payment of adequate compensation to the victims of injury and illness gradually started to become an accepted principle of the system. Notable progress on this issue was made by Chancellor Bismarck in Germany, and his initiatives were widely copied. In many cases limited legal responsibility for compensation of illness and accidents was transferred to employers, who in return were generally freed from criminal responsibility. Many countries also sought to guarantee quick and efficient medical attention to victims, thereby guaranteeing rehabilitation and a reduction



in the potential damage resulting from illness and injury. In other words, the social problems of unregulated capitalism were transformed into administrative problems, to be dealt with by specialist State or private bureaucracies.

By the early 20<sup>th</sup> century the key elements of the industrial OSH paradigm were coming into place in the most advanced democratic and industrial countries, concepts and institutions that would later spread to many points of the globe.

The disciplines of industrial medicine and engineering were applied through armies of specialist professional practitioners who dealt with working conditions. Also a particular focus developed on men engaged in physical activities associated with industrial work. Industrial psychology was employed to combat illness and accidents seen to be caused by malingering and unsafe acts. Training, regulations, incentives and penalties were developed to channel behaviour in desired directions. Specialised education emerged in universities, and on a mass basis through technical courses.

In general, the technical and economic development of a country determines the overall health status of its population and promotes safety and health. The average health status of the world population has improved considerably during the last 50 years. WHO has estimated that life expectancy at birth in the world population has increased from less than 50 to more than 65 years, since 1950. So, the question becomes why bother with occupational safety and health? Surely if technical and economic development continues, the safety and health of the population will improve? Well, firstly there are great health variations both between and within nations, variations that, as argued by Lindstrand et al in *Global Health* (2006), “remain very unfair by any standards of morals and justice”. Secondly, the inequality referred to applies to public

health in general. Communicable diseases (such as malaria, tuberculosis and HIV/AIDS), under nutrition or over nutrition are major health concerns in most countries of the world. However, the main concern of this chapter is occupational safety and health for the working populations. It is estimated by ILO and WHO that 250 million occupational accidents, resulting in more than 300 000 fatalities, and 160 million new cases of work-related diseases, occur every year. Besides the loss and suffering for individuals and enterprises, these injuries and diseases constitute serious impediments to industrial and economic development. An unhealthy workforce is not a productive one and as we have already seen this was a historical motivation for the development of industrial health services in most of the industrialised countries. Over time industrial health services came to be organised along general lines compatible with specialist industrial safety services, i.e. in line with the industrial OSH paradigm.

This “industrial OSH paradigm” can be summarised as follows:

- Accidents and diseases due to work can and should be avoided. The health of workers should be promoted.
- Prevention is the preferred action.
- The employer has the main legal responsibility.
- Workers and government should cooperate with the employer to achieve OSH.
- Injured and diseased workers must be rehabilitated and compensated. In cases of fatalities the family should get economic support.

The implementation of these five components requires the application of science and practical experience, resource allocation, organisational infrastructure, competence and training, legal and regulatory systems, control and supervision.

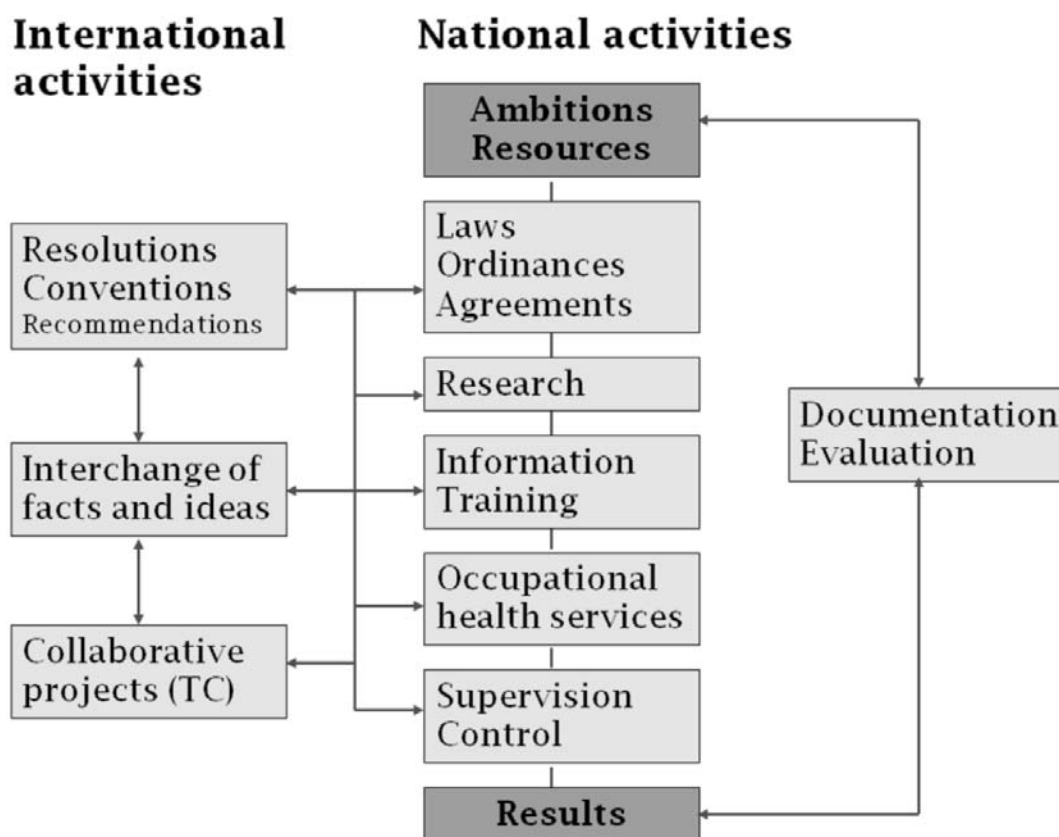


Figure 2.2.1. Overview of occupational safety and health activities at national and international levels.

A general description of how the industrial OSH paradigm operates in both industrialised and developing countries is given in Figure 2.2.1.

The industrial OSH paradigm spread because of its association with the idea of modernity and progress. It is accepted as being legitimate because it can be seen to have successfully reduced accidents and illness. Legislators have transformed its key ideas into laws, and these have been enforced in a manner seen to be equal for all employers. Both trade unions and employers' representatives have adhered to the paradigm, the former because it guarantees rights for injured and ill workers and their dependents,

and the latter because legal responsibilities are limited in exchange for adhesion. We have also seen that there has been strong professional activity developed in the area, it legitimates itself when its technical skills are seen to be applied in a neutral manner. The languages of prevention, rehabilitation and eventually of rights to compensation have come to be accepted in most countries.

#### THE UNDERMINING OF THE PARADIGM

Currently the industrial OHS paradigm is increasingly contested. We have identified four specific reasons for this state of affairs.

### Failures and constraints

A growing series of research results questioned the all-encompassing nature of the dominant paradigm, particularly in relation to prevention. This questioning reflected rising accident rates and concerns about ill health in a number of countries in the 1970s, particularly in the United Kingdom and the United States. In the U.K. a major review of the international research literature by Hale and Hale concluded in 1972 that gross deficiencies surrounded existing notions of accident prevention and causation. They claimed that a great deal more research was required into the effectiveness of prevention techniques, and “radically new theories are needed”. Major industrial disasters in Seveso, Bhopal and Chernobyl pointed out that the paradigm was inadequate to prevent major accidents in certain highly complex industries.

Workplace health issues also brought up new agendas and challenges. In some cases, health problems already known about by researchers became broader public issues as work changed. Repetitive strain injury (RSI) mushroomed as the service sector computerised, to become an epidemic and major drain on compensation funds in many countries. New illnesses, especially AIDS, made the rigid separation between work and non-work related health seem dangerously artificial. Growing workforce mobility also made it much harder to establish causal relationships between the exercise of a particular profession in a particular workplace and ill health.

### Development of production and work organisation

Investment in knowledge, knowledge production, storage and transmission, gradually replaced investment in the division of labour and in machinery as the central process for generating economic growth in the wealthy nations.

Many writers endorsed the hypothesis that a new basis for a productive society was being built. To differentiate this new society from the industrial society that had gone before, it was referred to by some as a ‘post-industrial society’. The OSH paradigm assumed that product and labour markets were relatively stable, that people held their jobs for lengthy periods, that productive activities would be increasingly concentrated in large enterprises and that controls would be increasingly vertical. The combined forces of globalisation, the rise of information or post-industrial society and the reorganisation of work to generate greater efficiency, challenged the validity of the industrial OSH paradigm’s underlying assumptions. Thus the forces that had resulted in management hierarchies and centralisation of enterprises gave way to enterprises that increasingly subcontracted out non-core activities, flattened hierarchies, made production activities leaner, and where the physical content of much work in industrialised countries was reduced as core activities became increasingly intellectual in nature. In many cases the division of labour lost its regional and national dimensions to become more global, particularly in the case of manufacturing and certain types of service jobs.

Beyond the workplace new sources of power and new cultural patterns emerged, representations of productive activity changed, certain social conflicts consequently lost their force or became increasingly institutionalised (e.g. between capital and labour in the industrialised countries) and social conflicts emerged around new themes (e.g. ecology, women’s movement, rights of cultural minorities). One significant new site of conflict emerged and is expressed in that fact that considerations relating to ‘risk’, and its avoidance, had become central concerns in the running of modern complex societies.

### Restricted application of the OSH paradigm

It was gradually understood that the application of the OHS paradigm had been highly restricted. It treated only a small number of all the workplaces in the world and the model was particular rather than universal, there was enormous inequity surrounding its operation.

In a recent review of the challenges posed to OSH by globalisation, Jorma Rantanen says: “At present, only a minor percentage, according to an optimistic estimate, about 10–15% of workers in the world are covered by adequate occupational health and safety services, labour inspection, and social security systems.” The figure is definitely optimistic when it comes to occupational health services. If these services are to be preventive, which is a major requirement according to the ILO’s convention on occupational health services, it may be questionable to say that even 5% of the workers in the world have access to such services. Some important industrialised countries still have significant contingents of workers who are not covered. This particularly comes about where economic decentralisation occurs, the informal economy expands and legal regulation of work consequently weakens.

Labour inspection is mainly organised for the formal sector, which means that the majority of the world’s working population has no contact at all with such inspectorates.

At the same time economic globalisation has made it increasingly difficult to maintain full time, properly contracted employment and previous levels of hourly wages, particularly in the unskilled manufacturing sector of the industrialised economies. As a result men and women in these countries work longer and longer hours, sometimes in a variety of part time jobs.

However, the increasingly global nature of manufacturing can lead to new OSH problems in developing countries, as regulatory structures

and professional skills available are unable to guarantee standards for the increasing numbers of workers employed in the manufacturing and construction sectors. In many cases adult and child labourers being subjected to extremely unhealthy and/or degrading working conditions and, in extreme cases, to slavery (one only needs to read Charles Dickens or Karl Marx to discover parallels with industrialising 19<sup>th</sup> century Great Britain). In addition, many work processes that hark back to pre-industrial times still survive in developing countries little touched by the OSH paradigm. With increasing frequency such processes are integrated into the supply chains of modern industries. For example, this is the case for impoverished rural workers who make the charcoal used to produce the pig iron that supplies Brazil’s modern steel mills, and for many sugar cane cutters who are essential to the country’s bio-fuel programme. OSH is unregulated in both subsistence work and in work that is a part of many local or international supply chains – for many workers, the paradigm simply does not apply.

### Political developments

The social partners build the current OSH paradigm upon cooperation and contributions from workers, employers and government. During the last 30–40 years, a series of political developments have greatly influenced the balance of power between these partners in many countries. Employers’ influence has been strengthened at the expense of weakening influence of workers and governments. These developments are described and discussed in Naomi Klein’s *The Shock Doctrine*. Klein argues that events including Pinochet’s 1973 coup in Chile, Thatcher’s wars in the Falkland (Malvinas) Islands and against the Coal Miners Union in 1982 and 1984–85 respectively, the massacre at Tianan-

men Square in Beijing in 1989, the economic shock therapy applied in Russia in 1991-94, the 1997-98 financial crisis in Asia, the 1999 NATO attacks on Belgrade, the attacks of September 11 2001 in New York, the invasion of Iraq in 2003, and the aftermath to the Hurricane Katrina in New Orleans in 2005, were either intended to or used as pretexts for extensive privatisation and government deregulation, followed by deep cuts in social spending. The British geographer David Harvey systematically links many of the changes identified by Klein to a process of neo-liberal managed 'creative destruction' of the existing regulatory features of the capitalist economic system. In essence, policies were promoted with the aim of separating economics from politics, political and regulatory control, i.e. various controls over economic activity were reduced or abolished in the name of prosperity and economic growth. The overall result, Harvey argues, has been increasing inequality and "deregulation that allowed the financial system to become one of... fraud and thievery. Stock promotions and Ponzi schemes... the promotion of debt incumbency that reduced whole populations, even in the advanced capitalist countries, to debt peonage – to say nothing of corporate fraud, the dispossession of assets such as the raiding of pension funds and their decimation."

While defending neo-liberal policies governments decreased their involvement in certain areas of social policy by simultaneously reducing taxes and delegating public tasks and services to the private sector. This has led to the constriction of coverage of services in the areas and sectors in which the market was alleged to be unable to provide sufficient incentive to deliver services. While occupational safety and health was not a direct focus during these events it was one of the many social casualties.

### CONSIDERATIONS RELATING TO THE DEVELOPMENT OF A SOCIAL OSH PARADIGM

In Thomas Kuhn's seminal book *The Structure of Scientific Revolutions*, he states that the anomalies produced by research undertaken within a given paradigm accumulate. This opens up the way for a scientific revolution whereby a new paradigm is founded, one that permits the knowledge accumulated under the old paradigm, especially including the anomalies discovered, to be integrated into a new body of theory. Of the four features associated with the undermining of the industrial OSH paradigm only the first (Constraints and failures) and the third (Restricted application of the OSH paradigm) correspond to Kuhn's anomalies. In contrast to the world of the natural sciences upon which Kuhn built up his model, the world where OSH knowledge is applied is both produced and changed by social action. This is the reason why the paradigm itself is also undermined by the social action of human subjects and not simply the social action of scientists as seen in processes of investigation and the construction of scientific consensus (as in Kuhn's case). The social world is different to the world investigated by natural sciences since natural objects of investigation do not themselves have a capacity to modify their own nature and their relations with other objects through actions based on reflexive and rational thought about the consequences of one course of action instead of another. What we human beings see as relevant in determining our own actions may change from one moment to another, from one situation to another, from one historical period to another. For this reason theories of social action must have a capacity to deal with context, and with human reflexivity.



It is impossible to think about a renewal of thought and action around OSH in an isolated manner, it must be placed within a wider vision of historical change, one that integrates considerations of economic, political and cultural factors, as well as new intellectual horizons.

However, human beings always adapt elements of the present as they seek to orient their actions towards the future. Individuals may do this during face-to-face interaction, or governments may seek to channel human action through administrative regulations, taxes or incentives that highlight desirable or undesirable activities. The history of OSH as depicted earlier was the history of governments moving from treating accidents and illness at work as a private matter, to making them a public responsibility through regulations and compensation insurance and by building institutions to reorient activities. Now climate change has become a major issue, there is much debate around how to reorient action, which centres on regulation on the one hand and the development of a system of carbon credits on the other.

The *laissez faire* approach mentioned earlier is a precursor for what is now called the consensus based assessment approach, a methodology that permits employers to calculate the benefits of the risk of infrequent accidents and illnesses against the costs that might arise should these occur; investment decisions are based on estimates of potential savings. The ideology of deregulation which has dominated the most recent period has played an important political role since it was defended by those who saw it as more rational and economically effective than the industrial OSH approach constructed around the need for regulation. The eventual adoption of neo-liberal economics as a guide to policy development, (Klein's description of the 'shock doctrine' reinforces such a view of social

policy), is one where the market is seen as the supreme form of rationality where life is evaluated in monetary values; more valuable lives are calculated to be worthy of more investment than less valuable ones.

At the other end of the scale is a systemic approach to safety and health that is, as we saw earlier, a product of the rise of a knowledge economy or a post-industrial society. This approach uses systems theory as a basis for the identification and analysis of hazards in order to design a system that eliminates the possibility of accidents or ill health occurring. It seems to have been very successful when products and machinery have specific safety and health considerations 'designed into them'. The key idea is that scientific and technical knowledge should be applied so as to eliminate all potential physical dangers and hazards. With respect to safety it is frequently developed on an ad hoc basis, project by project, and such cases can become extremely expensive. However, in some specific types of activities including space travel, nuclear power generation, and genetic engineering, safety becomes a supreme value. Serious accidents such as those at Three Mile Island and the Challenger crash associate negative effects and the development and application of systems safety. Hyper complex organisations have blind spots built into their operation because the theories used to think about them are incomplete, ironically such organisations come to be 'designed' in such a way that the negative consequences of their regular operation become 'normal' (to use Charles Perrow's idea of 'normal accidents').

It is in such limited cases that the social element, traditionally excluded from design solutions, has come to be seen as fundamental incorporating the idea that it is essential to consider 'human factors' in both the design and operation. Theoretical advances are currently occur-

ring at a micro level in the workplace, the level at which we believe a new paradigm is being developed.

We have earlier outlined a number of reasons why the industrial OSH paradigm has been partially discredited. Furthermore, from September 2008 onwards, the lack of proper regulations has been seen to lie at the very heart of the economic collapse that started in the USA and is now affecting countries all over the world (May 2009). One result of this collapse is that currently dominant models of social and economic policy will increasingly be contested. Such questioning liberates us from the past and demands that we think creatively to find new ways forward; in our view this means to discover a social paradigm.

### A SOCIAL PARADIGM – MACRO LEVEL CONSIDERATIONS

We now move to examine a proposal for the development of a social paradigm within which policy development can be framed at both a macro level and at a micro level in the workplace. In so doing, we briefly enter into the realm of philosophy and economics, seeking to go beyond the Great Western Paradigm. We don't expect that there will be wide agreement on what is written here but the times require creativity and reflection. However, before entering into an examination of a social paradigm it may be useful to recall Adam Smith's statement, made 250 years ago, about the powerful role of non-profit values. While stating that "prudence" was "of all virtues that which is most helpful to the individual", Smith went on to argue, "humanity, justice, generosity, and public spirit, are the qualities most useful to others".

### Rethinking justice

It is clear that large parts of the world's working populations are not covered by the industrial

OSH paradigm, creating unjust and unequal life chances for different groups of people. In order to produce a conceptual response to the injustices of modern life, where never before in the history of humanity has such opulence existed alongside such massive poverty and degradation, one to the 20<sup>th</sup> century's most important political philosophers, John Rawls, elaborated a theory of distributive justice. His theoretical framework can help us think about the underlying wisdom for arriving at new institutional arrangements capable of reducing such injustices. In *The Theory of Justice* Rawls seeks to establish the basis of a just social contract. He begins by constructing a fictional state, an original position, where individuals are free and alone, and need to define the rules of a future society. Their job is to define these rules without any advance knowledge of the place that each will occupy so no individual can choose the rules as a function of their personal interests because these are unknown. In such a hypothetical situation each individual could imagine him/herself ending up in the worst condition possible when eventually allocated his/her position in the social hierarchy. Thus, knowing the risk of ending up at the bottom of society, there is a tendency for people to imagine rules that would make such a position less intolerable. From here onwards it is possible to imagine that individuals, placed in such a fictional situation, would seek the most just and equitable system possible. Rawls' imaginary system is constructed in terms of two principles, equal liberty and difference. The principle of equal liberty defends the right of access to a range of fundamental freedoms. The principle of difference determines that inequalities are permitted to exist under certain circumstances: first, that people have equal chances of moving into coveted positions in the society; second, the society must help its least favoured members to

reach the best possible situation, i.e. to be able to improve their position within society. Rawls' formulation permits inequalities to be seen as a part of society, on the condition that the less favoured have a perspective of social mobility and are included in the social system through redistribution policies. In this way Rawls' political philosophy breaks the traditional tie made between freedom and inequality; freedom and equality can go hand in hand because there is a system of distributive justice. We believe that it is possible to adapt this reasoning so that unequal exposure to risks (a fundamental inequality) could be rectified through appropriate social arrangements, enabling new thinking about prevention, rehabilitation and compensation.

Nobel prize winning economist, Amartya Sen, has engaged in a fertile dialogue with John Rawls and an important part of his thinking centres on the question of development. He conceives that it is best to see the prime goal of development not in terms of expanded material wealth but, rather, in terms of expanding degrees of freedom, and diminishing types of 'unfreedom'. 'Unfreedom' reduces peoples' capacity to act autonomously on the basis of their own values and reasoning. Sen's book *Development as Freedom* sets out this approach. He focuses especially on the roles and interrelationships between a range of instrumental freedoms (e.g. economic opportunities, political freedoms, personal security, social facilities, guarantees about knowledge and transparency) and institutional arrangements (e.g. public discussions, state, political parties, markets, legal systems) that can serve to guarantee freedom. In Sen's words "a very elemental freedom: the ability to survive rather than to succumb to premature mortality" can be seen as an important dimension of development.

The writings of these two authors don't specifically examine OSH but they encourage us to think afresh about such issues and their relationship to justice, freedom and development. Sen writes "Individual freedom is a quintessentially social product, and there is a two way relation between (1) social arrangements to expand individual freedoms and (2) the use of individual freedoms not only to improve the respective lives but also to make the social arrangements more appropriate and effective." It can be visualised that if OSH institutions were to refocus so as to place work within a development perspective that could be seen as an expansion of freedom. A perspective designed to promote social justice (in a sense theorised by Rawls) would necessitate three types of change: institutional, workplace change (i.e. to improve the lives of workers) and changes in the way that experiences and reflections from the workplace contribute to the modification of institutions.

### Developments at the workplace

The Achilles' heel of systemic safety is that highly complex systems designed and operated to the highest standards can fail (e.g. the Three Mile Island incident, the Challenger crash and Bhopal). In each of these cases information could not be processed accurately or in sufficient time to prevent the disastrous event. Such rare events cast a shadow over the viability of any project that seeks to plan and eliminate risks to health and safety from the design of a complex system. The shadow cast by these events has led to the birth of a new social paradigm that embraces participation and management. This new paradigm allocates a space for workers to have access to information, and to discuss and act in relative freedom, in other words, to act as subjects.

A number of North American researchers in organisational psychology and management



have asked a very important question about how work can be safely executed in complex systems. Weick and Sutcliffe's book *Managing the Unexpected* builds upon earlier research that examines the notion of 'safety culture' to explain the paradox already observed, that planning for safety can also create conditions for disasters. They develop the idea that certain types of organisations, specifically those that deal with extremely complex and potentially dangerous materials and situations, have fewer accidents than expected. This is because they create a state of "mindfulness" among managers and workers that transforms their organisations into high reliability organisations such as air traffic control, hospital emergency departments, hostage negotiating teams and nuclear powered aircraft carriers.

All staff, including both workers and managers, must be capable of dealing with the unexpected in order to guarantee performance. However, the 'unexpected' is by definition unplanned, it upsets routines, threatens and potentially destroys organisations. Organisational cultures typically impose powerful blinkers that impede vision beyond certain horizons therefore, when something unexpected occurs, human beings lack the capability to deal with it. The authors propose that it is necessary to develop the human side of any enterprise, particularly to create a 'mindful infrastructure' among workers and managers so that they can safely manage potentially destructive surprises and guarantee safe operation. It is important to note that their view has been carefully built up on the basis of case studies and inductive theorising. The authors isolate five processes that contribute to a state of 'mindfulness': "(1) preoccupation with failures rather than successes, (2) reluctance to simplify interpretations, (3) sensitivity to operations, (4) commitment to resilience, and (5) deference to

expertise, as exhibited by encouragement of a fluid decision-making system."

The social system and the people that make up an enterprise are seen as a solution rather than a problem. Even though complex organisations have hierarchies and people are placed in unequal positions, this must not become a barrier to performance. The social system needs to be organised in order to channel activities towards safe operation, and this occurs only under specific circumstances. This conception of what is necessary for safety (but not health) is very different from most of the approaches formulated since the industrial revolution.

However, these authors assume that workers and managers are committed and submitted to the goals of their organisation and society. In other words they are not free in the sense given by a more abstract definition of freedom as elaborated by Sen or in terms of a more theoretical and sociological definition provided by Alain Touraine in his book *A new paradigm for understanding today's world*. For Touraine the subject is formed in the will to free oneself from the forces, rules, and powers that stop us from being ourselves, forces which try to reduce us to being an element in their system and that seek to take over our activity, and everyone's intentions and interactions.

### **Traditional participative approaches to workplace management**

We saw earlier that the industrial OSH paradigm introduced limited official recognition of participation as a result of struggles by workers for autonomy from the imposition of excessive dangers and insufficient management adherence to rules and regulations beginning in Belgian mines in 1897. The participation of workers was officially recognised as relevant to improving safety and health in the workplace. This ap-

proach expanded its influence, particularly in the mining sector in Western Europe, and was later taken up by accident insurance companies in the USA. Later, participation came to be seen, particularly due to influential research conducted by the socio-technical school of the Tavistock Institute, as a pre-condition for higher levels of productivity in situations of workplace change. In the post World War II climate a small number of Western European industrial enterprises embarked on participative strategies seeing them as the key to safer, more efficient and trouble free production.

Lessons drawn from the Tavistock research were taken to Norway and implemented in industries, later they were applied in some Swedish industries. Although Swedish ergonomists had tried to persuade enterprises to employ participative approaches, it was not until production engineers used the methods themselves that they could see their benefits e.g. in Volvo Kalmar and Uddevalla. In the 1970s, changed legislation and policies, supported by training, empowered workers' representatives in Sweden to take an active part in the planning and supervision of production and safety and health at work.

By the 1980s such approaches had spread into various sectors and were being studied by a range of academic disciplines in both the technological and social sciences. An increasing number of forms of workplace participation were observed and came to be defended as part and parcel of successful safety and health programmes. By the 1990s John Wilson, a leading British ergonomist, postulated that access to workers' views, as expressed in participative strategies, could be seen as a "framework and a foundation for ergonomics." He built up his case through reference to a series of classical themes found in the literature on participation, includ-

ing considerations as to the roles of knowledge and power in decision-making processes.

In France an approach called 'activity ergonomics', pioneered by Faverge and developed by Alain Wisner, sought to systematically capture worker knowledge and orientations when designing interventions to improve productivity and the quality of working life. Much later Wisner developed a more complex notion which he called 'anthropotechnology'. Wisner was aware that technology transfers were associated with many difficulties, and that traditional ergonomics (a part of the industrial OSH paradigm) was unable to deal with these. He had observed that when technology and operating principles established in one national setting were introduced into a new setting (typically into a developing country) marked by working populations with different anthropometric measurements, culture, or economic, climatic and political systems, they did not perform as well as expected. Wisner was one of the earliest researchers to see that the industrial OSH paradigm had limited effectiveness in non-Western societies, that there was not 'one best way'. Basing his analyses on case study research he illustrated how ergonomics could achieve a more complete view of the complex questions involved if it incorporates history, geography, anthropology, sociology and some currents of the cognitive sciences into its reflections. While his traditional methodological proposal remained, he took the view that it was essential for ergonomics to renew itself and to refer to the cited disciplines in so doing. Therefore the barriers between research and intervention would have to be broken down in order to produce an understanding of the complexities of technology transfer, to increase productivity and to minimise undesired effects.

Participative strategies seem to require a subtle balance from those who manage and

coordinate them. There must be a balance between being focused but open to change, being both flexible but disciplined, and being able to combine technical expertise with a readiness to listen to workers and seeking to understand their visions of solutions. In other words those who choose participative strategies must be capable of playing a complex role that includes facilitating, consulting, educating and supporting. Such requirements are a long way from those traditionally demanded of prevention personnel. Successful participative strategies imply that superiors must listen to, give freedom to and respect subordinates, such strategies dissolve the rigid separation between subject and object at the heart of the Great Western Paradigm.

Paradigm development implies social theory development. Paradigms are necessary because they provide useful and coherent ways to think in a systematic manner about how various types of actors could act in a array of situations. We have gone from the industrial OSH paradigm (a product of the Great Western Paradigm) that helped organise thinking all around the world to a new situation where such thinking is seen as inadequate. It is necessary to develop a new paradigm that provides a clear view to actors at all levels in society about how to confront the challenges that lie ahead. It is our bet that it will be a paradigm that incorporates a capacity to deal with a complex view of the world incorporated with reflection about strategies designed to combat injustice/inequity in the face of differential probabilities of death, injury and ill health.

At this point in time we believe that the high reliability organisations and socio-technical approaches described above, along with other new knowledge and thinking, can contribute to the development of a theory of prevention. Our focus on prevention in this chapter comes from the belief that this is a logical starting point

for paradigm development in this area. From a social science perspective the subjectivity of actors who have a certain freedom to opine and to act (in democracies), in spite of the inequalities of the power structures in which they are immersed, appears likely to constitute a key reference point in theory construction. In keeping with our times theory will be built up inductively, with strong reference to the complexities of working life. However, we must refer to an additional element that is virtually ignored in the high reliability organisation literature but that is included in the socio-technical school literature, i.e. the dynamics of power relations within organisations. Some of the literature points to the importance of autonomy in permitting workers to refuse known risks. Other research highlights that money or rewards should not be used to entice people into working in situations that they know are risky. There is also a substantial body of literature that discusses the necessity to have knowledge about tasks that potentially threaten health and safety. As such these factors appear as vital for the exercise of freedom and in the formation of conscious and autonomous subjects, in this way they are compatible with the views of Sen and Touraine.

The question is how is such knowledge, once consolidated, capable of influencing the establishment of new institutions that will be able to overcome the problems observed with the deregulated *laissez faire* or consensus-based assessment approaches and the industrial OSH paradigm? For example, how can it be guaranteed that the focus of institutions move to where there is most need, to the majority of the world's working population that appears to have been untouched by the industrial OSH paradigm?

Firstly, a series of policy related questions for OSH related institutions would emerge. For example, what policies would permit those who

currently work in the unhealthiest jobs to have less unhealthy jobs in the future? What policy measures can be developed to make up for a life of suffering faced by those who have reduced life chances? What are the roles of modern information technologies to make people more aware of the risks they face? What can be done to reduce these risks? Under what conditions of knowledge and life can risk-taking be compatible with freedom? What mechanisms can guarantee the minimum of ‘unfreedoms’ for victims and their dependents?

Secondly, investigation would need to focus on the workplace. People need to have sufficient liberty and guaranteed access to relevant knowledge as well as institutional support that permits them to consciously, and as freely as possible, make decisions relating to the dangers around them. In such a way development, when it is seen in terms of providing greater freedom, permits people to make crucial decisions necessary to live long and healthy lives, particularly working lives. We have seen that in diverse types of workplace an approach to safety is being built that unites freedom, knowledge, and transparency. We believe that some core issues of an OSH paradigm are being worked out in such an approach.

### **Cultural change and a social paradigm**

Edgar Morin’s critique of industrial civilisation has had a strong influence on the macro-level dimensions of this text and some of his most recent writing seeks to put humans back into the

centre of politics, (seen as both a means and an end), to promote good living instead of well being. Similarly the work of Henri Bartoli seeks to place humans at the centre of economics (rather than vice versa), constituting a necessary step to overcome two ills of contemporary living: individualism and solitude. Only then will it be possible to regenerate education, renew work, to turn solidarity into a living reality and to seek to live based on principles of good living.

One factor that was observed to undermine the industrial OSH paradigm was that industrial development was concerned principally with material well-being that led to large parts of working populations suffering the constraints and ‘unfreedoms’ of threats to their lives and health. This is inequitable and deserves consideration in any new approach. However, as we saw, the anomalies identified within the industrial OSH paradigm and in the systemic safety approach have resulted in a variety of distinct perspectives that emphasise how the interaction of human and technical systems varies from one situation to another. It is essential to free up human capacity building in order to avoid costly and damaging results.

Currently we don’t have the knowledge and clarity of vision that would permit us to talk of a new social paradigm. Rather, the final section of the chapter should be seen as bringing together a set of theoretical reflections, capable of being applied to examine many different questions and contexts, ones associated with the building of new practices.

### SUGGESTIONS FOR FURTHER READING

Dwyer, T. 1991. *Life and Death at Work*. New York, Plenum.

Advances the theory that workplace accidents as being produced by systems of social relations. It examines both the history of contemporary OSH institutions, and reports on workplaces studies to defend this notion, which with dominant theoretical approaches about workplace accidents.

Elgstrand, K (ed). 2006. *Anthology on Industrial Development. OSH & Development No. 7*. Accessible at [www.ufa.se](http://www.ufa.se)

13 articles on industrial development and how it relates to components like transport, telecommunication, the concept of time, environment, income distribution, culture, human rights, nutrition, health, accidents, democracy and globalisation.

Heinrich, H. W. 1959. *Industrial Accident Prevention*. New York, McGraw Hill. (4th edition)

This pioneering book applies Taylorist engineering oriented management theory to industrial health and safety issues, particularly those associated with safety. Considered for many decades in the anglo-saxon world as 'the safety man's bible' it is of great historical interest.

Klein N 2007. *The Shock Therapy*. Penguin, 2007.

In this extensive book, Klein is analysing the economic and political developments in the world during the last 40 years. She focuses on dramatic and violent events that have been utilised for great economic transformations. These events and the shock they have caused to societies and nations, have been exploited for privatization of enterprises by govern-

ments, dictators and international monetary agencies like the World Bank and IMF. Government deregulations have been linked to the privatizations, and in many cases been followed by deep cuts to social spending. A similar message is given in a shorter and more academic article by David Harvey: *Neoliberalism as Creative Destruction*; *The Annals of the American Academy*, AAPSS, 610, March 2007.

Lindstrand et al. 2006. *Global health – An introductory textbook*. Studentlitteratur.

The book provides an overview of the global health situation related to the concept of human development and the factors that determine the public health of the populations in different countries.

Perrow, C. 1984. *Normal Accidents*. New York, Basic Books.

This book produces a typology of accidents and demonstrates how complex systems come to be designed so that accidents are a 'normal' (even if undesired) consequence of their operation.

Rantanen, J. 2008. *Challenges Posed by Globalization to Ethics in Occupational Health*. Newsletter of the International Commission of Occupational Health, Vol. 5, No. 3, December 2007.

An overall analysis of the role of occupational health and safety in a globalising work life.

Rawls, J. 1971. *A Theory of Justice*. Cambridge, Harvard University Press.

One of the major works of political philosophy of the 20<sup>th</sup> Century, this book lays out a highly original theory of redistributive justice.

Sen, A. 1999. *Development as Freedom*. Oxford, Oxford University Press.

The 1998 Nobel Prize in Economic Sciences defends a redefinition of development in terms of its capacity to produce human freedom and to reduce lack of freedom.

Touraine, A. 2007. *A New Paradigm for Understanding today's World*. Cambridge, Polity Press.

A simply written book by one of the world's most influential sociologists, which sets out the basis for a new paradigm, one built to help understand today's world and centred around the idea of the subject.

Weick, K. E. and Sutcliffe, K. M. 2001. *Managing the Unexpected*. Jossey-Bass.

This book sets out to answer the question as to how an organization should prepare for and manage itself so as to guarantee high performance, especially when unexpected forces push towards failure.

Wisner, A. 1985. *Quand voyagent les usines*. Paris, Syros.

The foundations of an 'anthropotechnological approach' to ergonomics designed to reduce human suffering and productivity loss associated with technology transfer to developing countries.





# Manual Work

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## Basic work physiology

*Ewa Wigaews Tornqvist*

Demands for energy vary largely between different occupations. The energy consumed during light sedentary office work may be 50 % more than the energy used while resting, Figure 3.1.1. Physically demanding jobs such as those in forestry or construction work, may increase energy consumption by 500 %. Humans are designed for mobility and physical activity and physical activity requires energy. Skeletal muscles are unique when compared with all other tissues because their metabolic rate can vary more than any others meaning that human energy requirements mainly depend on the level of muscular work. The energy expenditure required for extremely heavy short term physical activities may increase by 10-20 times and in some top athletes, up to 30 times.

Various physical work tasks place different demands on specific capabilities. For some tasks the energy yielding processes (aerobic and anaerobic) are of primary importance, while other tasks put high demands on the neuromuscular function (strength and technique). For some tasks psychological factors (attitudes and motivation) are of major importance. There can be many reasons why a job or work task may be stressful and tiring but no work can be performed without energy production, neuromuscular function and a willingness to perform the work.

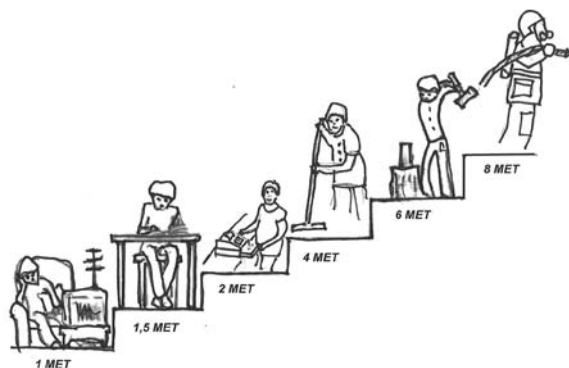


Figure 3.1.1. Energy expenditure at rest and during different work tasks expressed as multiples of the resting metabolic rate, METs. One MET is equivalent to the metabolic energy expenditure of sitting quietly which for an average adult is approximately 3,5 ml of oxygen \* kg body weight<sup>-1</sup> \* minute<sup>-1</sup> or 4,2 kJ (1 kcal) \* kg body weight<sup>-1</sup> \* hour<sup>-1</sup>. From Ainsworth, B et al, 1993.

### HEAVY WORK

In this chapter the term heavy work refers to any activity that calls for great physical exertion characterised by high-energy consumption and high strain on respiratory and cardiovascular functions. As soon as physical work is performed the body makes adjustments and adaptations that affect almost all organs, tissues and fluids. The most important adjustments are:

1. Deeper and more rapid breathing.
2. Increased heart rate, accompanied with an initial rise in heart stroke volume (up to approximately 40% of the maximal aerobic capacity).
3. Dilatation of the blood vessels in the organs involved (muscles and heart), but constriction in other blood vessels that diverts blood supply to those organs and tissues that need more oxygen and nutrients i.e. mainly the working muscles.
4. Rise in blood pressure by increasing the pressure from the main arteries into the dilated vessels of the working organs and tissues in order to speed up the blood flow.
5. Increased supply of carbohydrate (glucose and glycogen) into the blood from the liver.
6. Rise in body temperature and increased metabolism. The increased temperature speeds up the chemical reactions of metabolism which increases the conversion of chemical energy into mechanical energy.

Energy consumption and cardiac capacity limit the performance of heavy work and these two functions are often used to assess the severity of a physical task.

Mechanisation has reduced occupational physical activity; heavy work is becoming rarer in industrial countries but is still widespread in developing countries. Occupations that are generally regarded to involve heavy work include construction, agriculture, iron and steel industries, the armed services, fishing, forestry, mining and wharf labour. Some occupations with predominantly female workers, including cleaning, nursing, elderly and home care, also frequently involve heavy work.

A major target for ergonomists in developing countries is the achievement of high levels of ef-

ficiency for heavy work tasks while ergonomists in many industrial countries are seeking ways to increase physical activity and variation in sedentary occupations. In the industrial world continuous sedentary work, often combined with monotonous and static work postures, increased stress, and lack of physical activity, has increased static loads (especially on the neck and shoulders) leaving many organs in the body “under used”. Sedentary life styles have increased the risk of negative health outcomes, such as neck and shoulder disorders, obesity, cardiovascular diseases, diabetes and osteoporosis. However, jobs that can be categorised as physically heavy, and that lead to overload, still exist in industrialised countries e.g. in the construction industry, small scale farming and home care.

### PHYSICAL WORK PERFORMANCE

The ability to perform physical work depends on the ability of a muscle cell to transform the chemical energy in fuel into mechanical energy that can be used for muscular work. Fuel uptake depends on the amount, nature and quality of the food ingested and on the frequency of meals. The ability to transform fuel into useful energy depends on the capacity of the service functions that deliver fuel and oxygen to the working muscles, Figure 3.1.2.

If nutrition is adequate, the capacity for oxygen uptake is of primary importance to liberate sufficient energy during prolonged heavy dynamic work that engages large muscle groups. Such work implies a high load on respiratory and cardiovascular functions and the individual strain depends on the proportion of an individual's maximal aerobic capacity that is utilized. The maximal aerobic capacity is defined as the highest oxygen uptake that can be measured in an individual, and can only be obtained during dynamic work with large muscle groups (e.g.

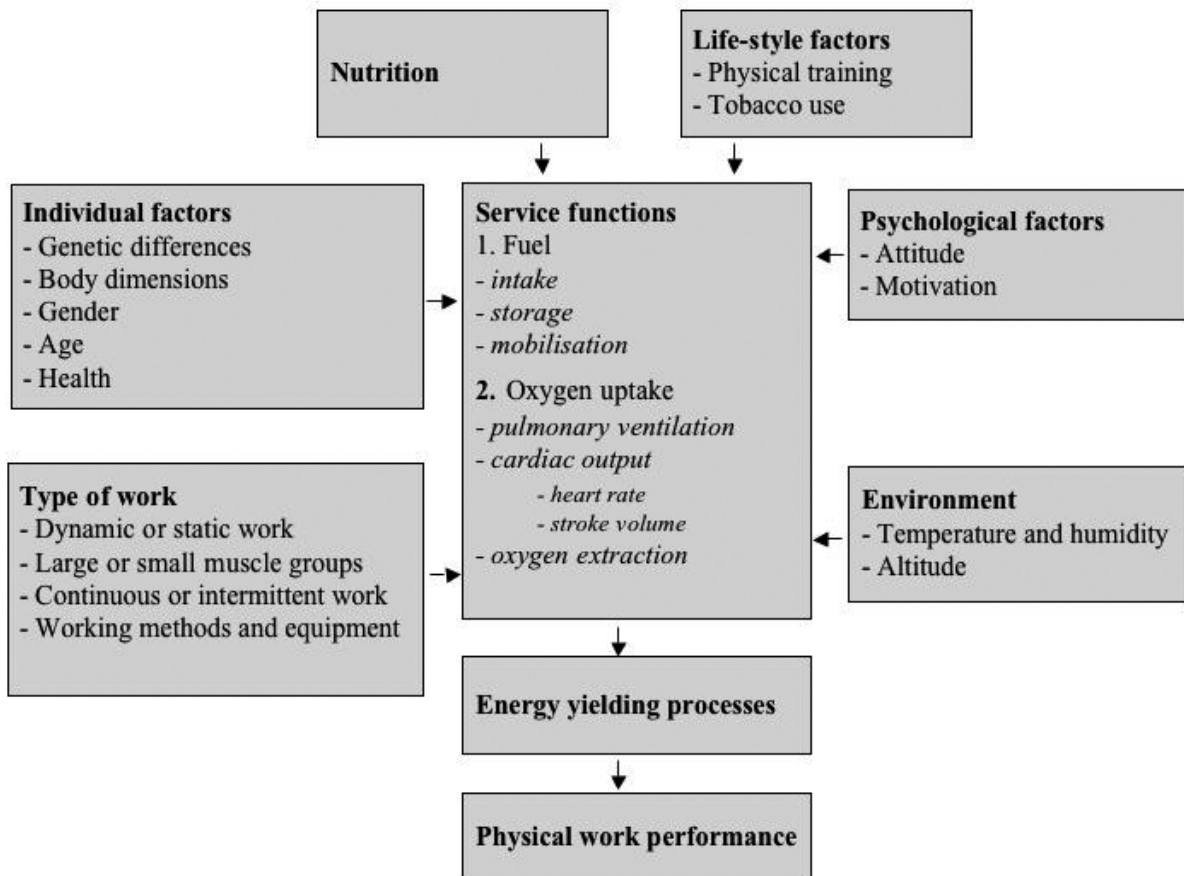


Figure 3.1.2. Factors affecting physical work performance; modified from Åstrand, P-O et al, 2003.

running or bicycling). This capacity varies largely between individuals. If sufficient nutritional supply is provided, genetic factors play a major role for the inter-individual variability - up to 70 % may be explained by genetic factors. Individual factors, e.g. gender, age, and health, as well as life-style factors, e.g. physical training, are also of importance, see Figure 3.1.2. In addition, the type of work to be performed (dynamic or static work), the environmental conditions (temperature and humidity), and psychological factors (attitude and motivation) also interact in a complex way to affect work performance.

Oxygen uptake increases in a linear fashion with increasing energy demands, Figure 3.1.3.

The amount of energy liberated when 1 litre of oxygen is consumed is approximately 20 kJ (20.2 kJ at rest and 20.6 kJ at work). The amount of oxygen consumed, i.e. oxygen uptake ( $\dot{V}O_2$ ), is determined by the cardiac output [heart rate (HR) \* stroke volume (SV)] and the extraction of oxygen from the arterial blood, i.e. the difference in oxygen content between arterial and venous blood.

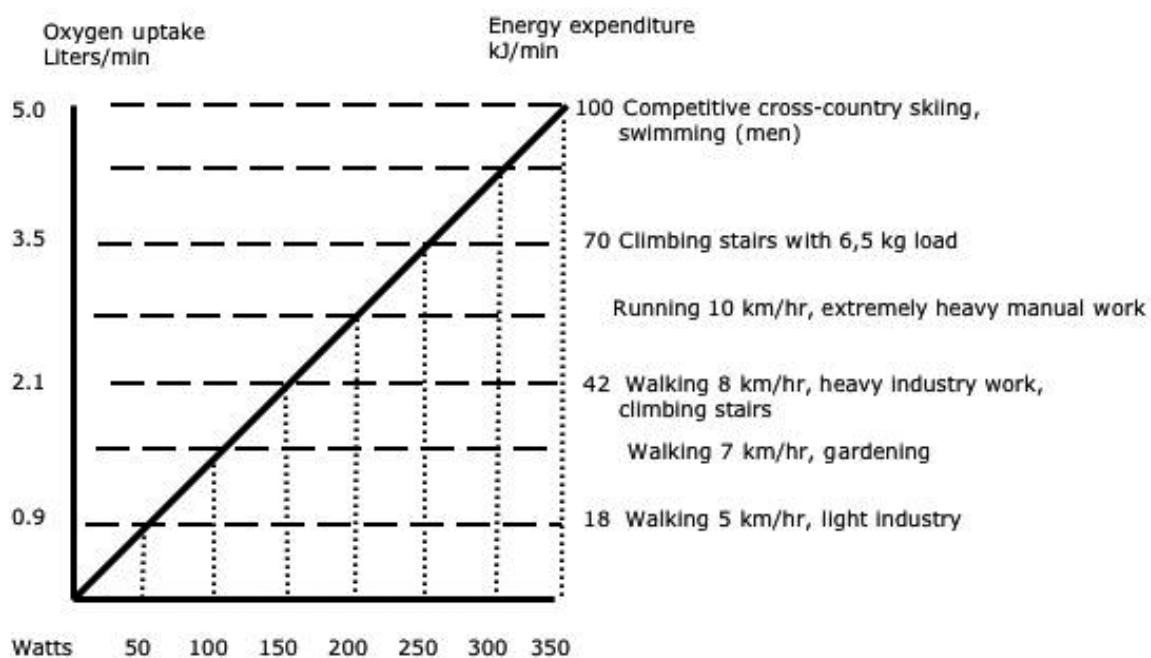


Figure 3.1.3. Cycle ergometer work and corresponding oxygen uptake (l/min) and energy expenditure (kJ/min) at different work loads (Watts); modified from Åstrand, P-O et al, 2003.

Among healthy individuals, only cardiovascular functions, (not respiratory functions), are decisive for  $\dot{V}O_{2\max}$  and the stroke volume is normally of primary importance.

### ENERGY SUPPLY

Physical work requires energy. For an average adult the energy requirement during rest is approximately 4.2 kJ per kg body weight and hour. During light sedentary office work the daily energy requirements is approximately 11-12 MJ for a 75 kg man and 8-9 MJ for a 55 kg woman. During extremely heavy manual work such as forestry or mining work, the daily energy demand may increase to 20 MJ.

We eat a variety of nutrients in food but only the carbohydrate, fat and protein content can yield energy for muscular work. However, the

choice of fuel for the exercising muscle is mainly limited to carbohydrate and fat, whereas protein is mainly used for building new cells and replacing parts of old cells as long as the energy supply is adequate. The relative proportion of energy yield from carbohydrate and fat, respectively, depends mainly on the following factors:

1. Type of work: duration and intensity
2. State of physical training: trained or untrained subjects
3. Diet: high or low carbohydrate diet

### Type of work

Provided an individual has a normal mixed diet, carbohydrate (glucose and glycogen) and fat contribute equally to their energy supply during rest and short-term light to moderate physical

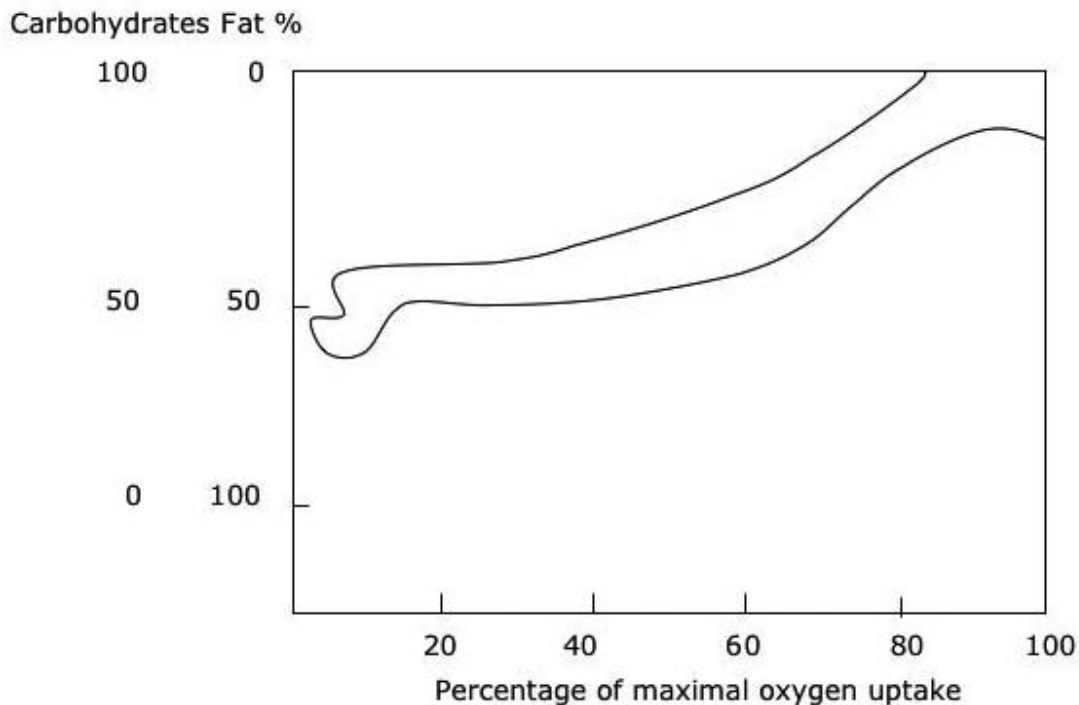


Figure 3.1.4. The percentage contribution to the energy yield of fat and carbohydrate related to the oxygen uptake in percentage of the subject's maximal oxygen uptake. Prolonged exercise, endurance training and diet can markedly modify the relative contribution; modified from Åstrand, P-O et al, 2003.

work/exercise, Figure 3.1.4. As the work continues the relative contribution of fat gradually increases. 60–70% of energy can be derived from fat during moderately heavy work/exercise that can be endured for 4–6 hours (including rest pauses); compared with 50% during short-term work.

With increasing work/exercise intensity there is a gradual change toward a greater proportion of energy yielded from carbohydrate, Figure 3.1.4. The energy efficiency is about 10% higher for carbohydrate compared with fat consumption, so the energy production per unit of oxygen consumed is higher when carbohydrate rather than fat is consumed. Carbohydrate contributes to nearly 100% of the energy supply used during very heavy or near maximum work/

exercise. During such heavy work the oxygen supply is inadequate and energy is liberated by *anaerobic* oxidation that can only proceed as far as the production of lactic acid allows.

### State of physical training

The ability to use fat as a fuel depends on the body's capacity to transport oxygen and therefore the proportion of energy yielded from fat at a given workload depends on the workload intensity in relation to the individual's  $\dot{V}O_{2\max}$ . Because physical training increases  $\dot{V}O_{2\max}$ , it also increases the ability to utilize fat as a source of muscular energy. During prolonged exercise at a given workload it is a distinct advantage to be able to use more fat, because fat stores are definitely larger than carbohydrate stores. In



addition, a physically trained individual utilizes a lower proportion of their maximal oxygen uptake when work is performed at a given sub-maximal workload and less lactic acid is formed.

## Diet

Adaptation to a high fat and low carbohydrate diet results in lower muscle glycogen content and a higher rate of fat oxidation during exercise. Such adaptation can spare muscle glycogen and, since muscle glycogen storage is essential for endurance performance, it is possible that adaptation to a high fat diet potentially could enhance endurance performance. However, since the consumption of a low carbohydrate diet decreases the glycogen storage in both muscles and liver, the training intensity may be compromised in those adapted to a high fat diet.

## Aerobic and anaerobic metabolism

When oxygen supply is adequate, energy is released by *aerobic* oxidation of (mainly) carbohydrate and fat with the end products being water and carbon dioxide, see Figure 3.1.5a.

When oxygen supply is inadequate, energy is released by *anaerobic* oxidation where carbohydrate is oxidized in the absence of oxygen and lactic acid is formed as the end produce, Figure 3.1.5b. The concentration of lactic acid in the body is closely correlated with muscle fatigue.

The concentration of lactic acid in blood increases exponentially with increasing workload, Figure 3.1.6. During dynamic work with large muscle groups, e.g. running and bicycling, the formation of lactic acid starts to increase markedly when the workload corresponds to approximately 50 % of an individual's maximal aerobic capacity. If work continues at this intensity, lactic acid will accumulate in the muscles and blood with increasing muscle fatigue and pain arising because of the reduced pH. More lactic acid is

produced at corresponding  $\dot{V}O_2$  during work that includes static postures (compare blood lactate concentration during skating and bicycling in Figure 3.1.6).

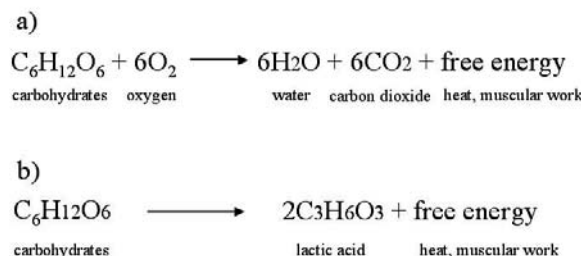


Figure 3.1.5. A simplified formula of what happens when carbohydrate is oxidised during dynamic muscular work when oxygen supply is adequate (a). The carbohydrate (stored in the muscles and the liver) are oxidised with the help of oxygen which enters the body via the inhaled air and is then transported by the blood to the muscles (and other organs). The end products are water and carbon dioxide, and free energy for muscular work. The same end products are formed when fat (and protein) is oxidised. This process is called aerobic, as it occurs in the presence of oxygen. During very heavy work or during static work that impairs the blood flow, and thus decrease oxygen transport, the oxygen supply may be inadequate. In such situations the energy needed for muscular work is supplemented by a process where carbohydrate (not fat) is split without the presence of oxygen (b). Lactic acid is created as the end product. When too much lactic acid is accumulated in the muscles fatigue and pain will make it impossible to continue the work allowing oxygen to break down the lactic acid accumulated.

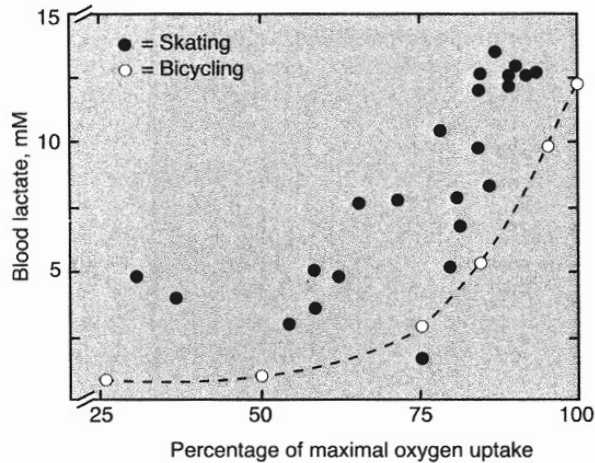


Figure 3.1.6. Blood lactate concentration and corresponding work load expressed as percentage of the individual's maximal oxygen uptake during bicycling and speed skating. At corresponding oxygen uptake, more lactic acid is produced during speed skating than during bicycling. This is due to the more purely dynamic work during cycling compared with speed skating where the static load on mainly the thighs is quite evident (knees constantly bent deeply). During bicycling the blood lactate concentration starts to increase markedly at approximately 50 % of maximal oxygen uptake; from Åstrand, P-O et al, 2003.

### Work efficiency

Only part of the chemical energy in food is transformed into mechanical energy for muscular work; the rest is liberated as heat. This heat production makes it possible to keep a relatively constant body temperature around 37°C although environmental temperatures are often lower. Under the most favourable conditions during dynamic muscular work with large muscle groups, 30 % of energy expenditure is transformed into “productive” mechanical work and the remaining 70 % is transformed into heat. However, work efficiency during most work tasks is lower than 30 % because energy is

wasted on “unproductive” static or dynamic load such as work in awkward postures and/or efforts to hold and support things.

Activity	Efficiency, %
Shovelling in stooped posture	3
Shovelling in normal posture	6
Using a heavy hammer	15
Going up and down stairs without load	23
Cycling	25
Walking on the level without load	27
Walking uphill on a 5° slope without load	30

Examples of factors that influence work efficiency are working methods, design and maintenance of tools and other equipment. To optimise efficiency it is important that work equipment is properly maintained (e.g. keeping cutting tools sharp) and fits individuals of varying sizes. Examples of individual factors that influence efficiency are body dimensions, e.g. length of lever arms, and working techniques such as speed of movements, postures and neuro-muscular coordination.

### FACTORS AFFECTING PHYSICAL WORK PERFORMANCE

#### Nutrition

In many developing countries nutritional and health status are important limitations for worker performance. Under-nourishment and malnutrition reduce worker performance especially in manual or semi mechanised work demanding high energy, e.g. in the construction industry, agriculture, iron and steel industries, the armed services, fishing, forestry, mining and wharf labour. In addition to individual suffering, it is very expensive for an industry to have under-nourished workers. It has been suggested that under-nourishment is as important as heat

stress for explanations of low productivity in tropical countries. The rapid population increase in many developing countries in combination with the negative effects of under nourishment on productivity makes it very difficult for some countries to come out of the problematic situation. The energy reserves necessary for production gets smaller and smaller relatively seen at the same time as an increasing production is a remedy for this problematic situation. A rational arrangement to supply meals to workers engaged in heavy manual tasks might be a decisive factor to increase production in some developing countries.

### Dynamic or static work

Contractions that cause changes in muscle length are called *dynamic* contractions and include situations where the muscle tension is developed during shortening (concentric contraction) as well as during lengthening (eccentric contraction) of the muscle. Both types of dynamic contraction occur regularly in daily life, e.g. when lifting a cup of tea the biceps works concentrically and when replacing the cup the biceps works eccentrically to slow down the movement and prevent breaking the cup.

When the muscle doesn't vary in length, and no movement takes place, the contraction is *static* (or *isometric*). Static contractions play an important role in stabilising and maintaining joint positions such as staying upright when standing. The primary function of antigravity or postural muscles is to adjust to gravity and maintain postures, e.g. the trunk muscles. These muscles have a high percentage of muscle fibres with primarily aerobic metabolism, (often called slow twitch fibres), so they have better endurance compared with muscles that have a higher percentage of fibres with primarily anaerobic metabolism, (often called fast twitch fibres), e.g.

arm muscles. There are inter-individual differences in the proportion of slow and fast twitch muscle fibres in specific muscles, partly due to both genetic factors and how the muscles are used.

Blood circulation is often impaired during static contractions causing inadequate oxygen supply that increases the *anaerobic* metabolic process and the formation of lactic acid. In addition, reduced blood flow impairs the transportation of metabolites from the muscle resulting in considerable increase in the concentration of lactic acid and muscle fatigue.

Long periods of static work increase the risk of muscular pain and disorders. Static muscular load is an important problem in working life as work-related static postures often involve muscles that are not primarily postural muscles.

Purely dynamic work is unusual in working life as work tasks generally consist of both dynamic and static muscle contractions. For example, work with elevated arms or sideways movements, e.g. carpentry work, painting, cleaning and repair work, entails static load mainly on the shoulder muscles. Work efficiency and  $\dot{V}O_2$ max is markedly reduced during such work tasks. When nailing at different heights,  $\dot{V}O_2$  is relatively constant whether the arms are elevated or not but productivity (nails/min) and work efficiency is lower when nailing in a ceiling compared with work at bench height, Figure 3.1.7. The heart rate, blood pressure and the concentration of lactic acid in blood is also higher.

### Large or small muscle groups

$\dot{V}O_2$ max cannot be obtained when only small muscle groups are used e.g. only approximately 70 % of  $\dot{V}O_2$ max is reached during maximal effort using only the arms. At a given sub-maximal workload,  $\dot{V}O_2$  and cardiac output are about the same whether small or large muscle groups are

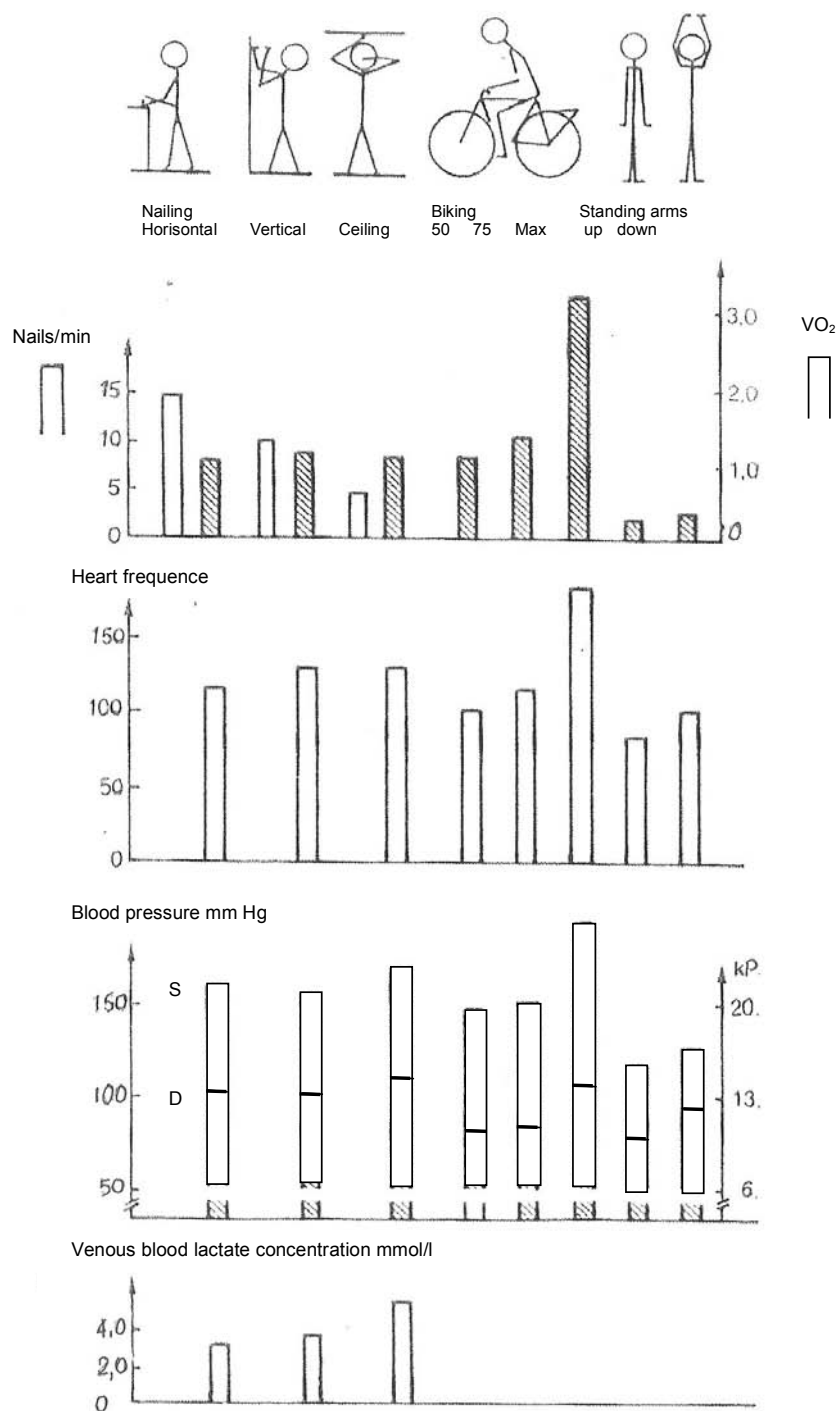


Figure 3.1.7. Productivity, heart rate, blood pressure and venous blood lactate concentration during nailing with different arm postures, during bicycling and during standing with the arms hanging down and above the head, respectively. Although, the oxygen uptake was approximately 1 l/min during nailing at all three postures the productivity was markedly reduced (5 compared with 15 nails/min) when nailing in the ceiling compared with at bench height. Work efficiency was thus decreased. During bicycling at 50 Watts and during nailing in the ceiling the heart rate was approximately 100 and 130 beats/min, respectively, although the oxygen uptake was the same. Both the systolic (S) and the diastolic (D) blood pressure was also markedly higher during nailing in the ceiling compared with bicycling at corresponding oxygen uptake. The blood lactate concentration was higher the higher the arm posture. Note the increase in heart rate and blood pressure just by lifting the arms above the head; modified from Åstrand, I, 1990.

used, however, heart rate and blood pressure are significantly higher. The lower work efficiency during work with small muscle groups is further reduced when the work is combined with static postures, see Figure 3.1.7.

### Continuous or intermittent work

When it is possible to influence work pace, frequent pauses can allow the performance of extremely heavy work with less physical strain without reducing productivity. Figure 3.1.8 shows the heart rate of a worker who is moving 30 kg iron pigs from a machine to a loading platform.

The heart rate is approximately 150 beats/min at the end of a work cycle when 14 iron pigs are carried continuously before pausing. The pauses were 1.5 times longer than the working period. When the worker reduced the number of iron pigs carried before pausing, but still kept the pause duration 1.5 times longer than the working period, the heart rate was reduced. When carrying 4 iron pigs before pausing, i.e. taking 14 short pauses, the heart rate decreased to 110 beats/min. Thus, the shorter the work period the lower the heart rate although productivity remained constant. After 13 minutes 56 iron pigs had been carried in all cases. When the number of iron pigs carried before pausing was further reduced the heart rate decreased further but the work process felt jerky and irregular.

Similar results have also been shown in the laboratory during bicycling and running. Both heart rate and the concentration of lactic acid in blood were lower over a shorter work period. Interestingly, provided the work period was short, the pause duration did not influence the reduction in heart rate or blood lactate concentration if the pause duration was above a certain minimum. The conclusion is that the work period should be as short as possible while the pause

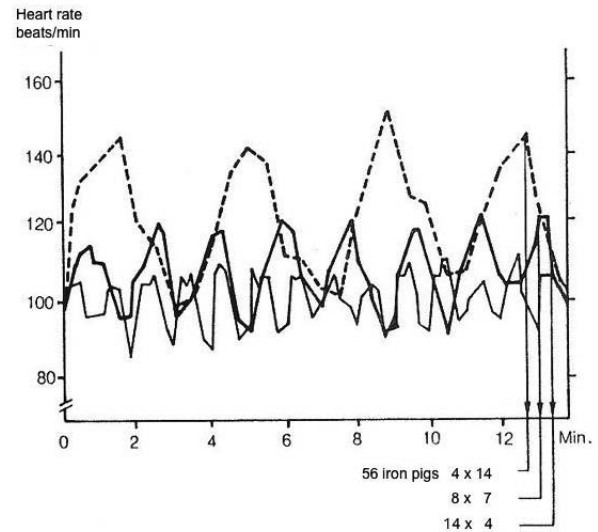


Figure 3.1.8. The heart rate of a worker who is moving 56 heavy iron pigs from a machine to a loading platform. When he carried 14 iron pigs continuously and then took a pause, continued to carry 14 iron pigs and then paused again etc, his heart rate was approximately 150 beats/min at the end of the work cycle (dotted line). The pause duration was 1.5 times the working period. When he reduced the number of iron pigs before pausing, keeping the pause duration 1.5 times the working period, his heart rate was reduced. When he took 4 iron pigs before pausing, thus he took 14 short pauses, his heart rate decreased to 110 beats/min (thin solid line). Thus, the shorter work period the lower the heart rate although the productivity remained constant; from Åstrand, I, 1990.

duration is less critical because during short periods of heavy work, the oxygen demand is probably covered by oxygen bound to myoglobin in the muscle cells. During the pause the myoglobin is quickly loaded with new oxygen so work can continue with aerobic energy supply as long as the work periods are not too long. If the work periods are extended, anaerobic energy supply will take over and lactic acid will accumulate.



Frequent micro pauses are recommended when it is possible to influence the pace of heavy work. Work pace that is set by machines means that it is not always possible to influence the work-pause pattern but these principles should guide work organisation to reduce physical strain.

However, apart from these short pauses, it is important to have longer rest pauses and breaks needed for physical and mental recuperation, water and food intake and social relations.

### Working methods and equipment

Working methods and the design and maintenance of work equipment influence the levels of physical strain and productivity, Figure 3.1.9 and 3.1.10 a and b. For optimal efficiency working methods should minimize “unproductive” static

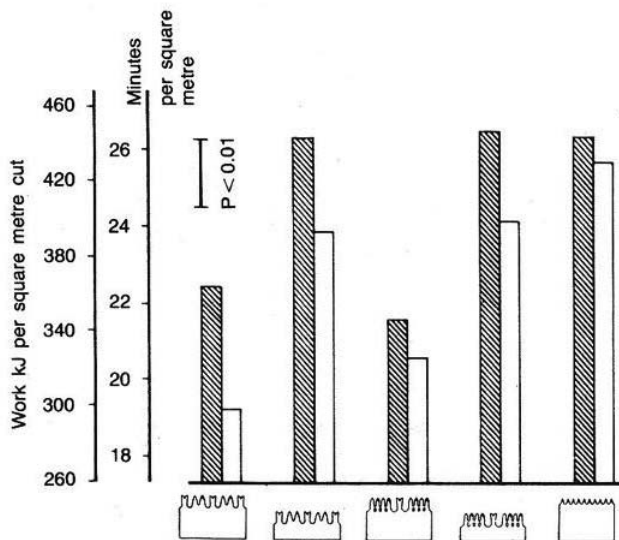


Figure 3.1.9. Energy consumption and productivity during work with five different types of saws. The shaded columns represent the average energy consumption per square meter of cut surface and the white columns show the average time needed to saw one square meter. The vertical marker ( $P < 0.01$ ) indicates a difference in energy consumption that is statistically significant; from Kroemer, K H E and Grandjean, E, 1997.

and dynamic efforts, and engage large muscle groups for heavy manual work tasks. It is important that work equipment fits individuals of differing sizes and is maintained properly, e.g. keeping cutting tools sharp. It is frequently possible to decrease physical load by easy measures.

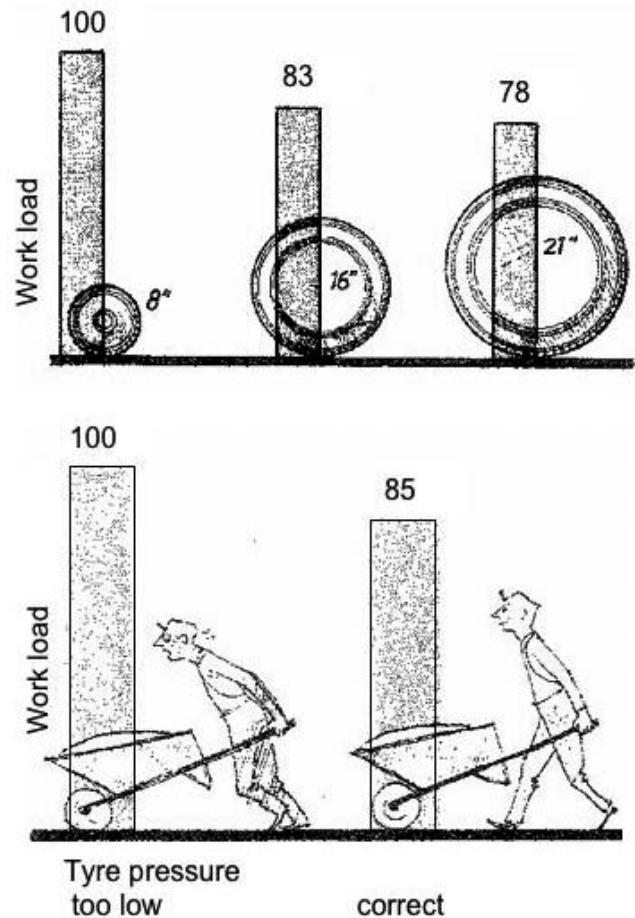


Figure 3.1.10. With a constant load and transport speed the oxygen uptake is lower when the wheel-barrow has larger compared with smaller wheels (a) and when the tyre pressure is higher (b). The oxygen uptake during the most unfavourable conditions is set to 100 and the more favourable conditions are expressed as percentage of the most unfavourable conditions; modified from Hansson, J-E, 1970.

## PHYSICAL TRAINING

Physical training may be defined as any repeated physical activity that improves or maintains endurance, strength, mobility and coordination. One important goal of physical training is the achievement of physical condition and a level of fitness that surpasses that required for everyday work. Physical training activities must be of sufficient intensity, frequency and duration while allowing enough time for recovery and adaptation between training sessions. The effects of physical training are very specific with regard to the particular functions that are being trained. For example, workers required to do heavy manual work will benefit from training that increases their oxygen-transporting functions to enhance maximal aerobic power and endurance thus reducing relative load and fatigue. To date there is no scientific evidence showing that heavy manual occupational work has any positive effects on work performance. On the contrary, some studies suggest that heavy occupational work may accelerate the age related impairment of physical capacity probably because the load in occupational work is not optimal regarding intensity, frequency and duration. Most importantly, there is not optimal time for recuperation to allow for central and peripheral adaptation that results in a training effect.

A general rule for training to increase aerobic capacity requires the engagement of large muscle groups, i.e. walking/jogging, bicycling and swimming. For an average sedentary person to improve their aerobic capacity, a training intensity corresponding to 50-60 % of the individuals maximal aerobic power, (a moderate degree of breathlessness), for a minimum of 30 minutes (not necessarily continuous although the periods should not be shorter than approximately 10 minutes) is sufficient for a training effect. The activity should be performed regularly on most,

if not all, days of the week. For most people, the more vigorous and prolonged the activity is, the greater the training effects and health benefits, provided that the increments in activity level are not too abrupt. The improvement of aerobic capacity is greater in cases where the level of physical fitness is lower before training. Maximal training effect is generally achieved after approximately 6-8 weeks, Figure 3.1.11. During periods of inactivity, e.g. due to illness or bed rest, aerobic capacity declines quite rapidly. It is important not to increase training intensity too quickly to avoid overloading tendons and ligaments. Although maximal training effects regarding aerobic capacity are normally reached within 8 weeks, it takes several months before ligaments and tendons strengthen markedly.

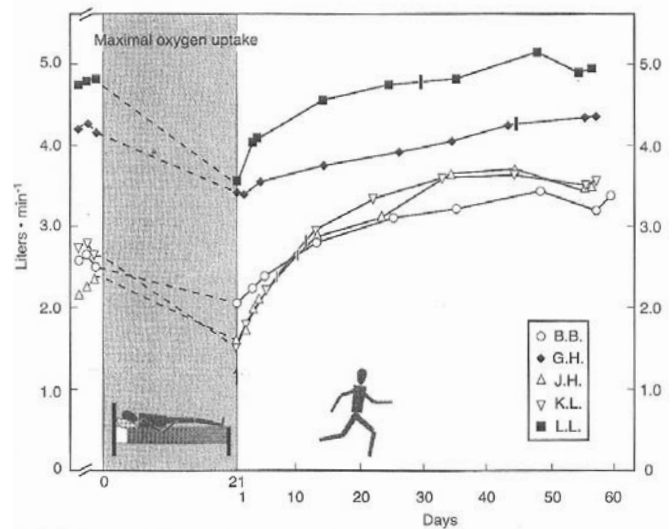


Figure 3.1.11. Changes in maximal oxygen uptake before and after bed rest in five individuals at various intervals during training. Vertical bars mark the time during the training period when the maximal oxygen uptake had returned to the control value before bed rest; from Åstrand, P-O et al, 2003.



Central circulation generally limits the maximal oxygen uptake during work that engages large muscle groups. Training of aerobic capacity improves central circulation by increased stroke volume. The heart rate, and physical strain, decreases at a given sub-maximal workload, Figure 3.1.12. As maximal cardiac output (due to increased maximal stroke volume), and maximal

aerobic uptake increases, the maximal workload that could be performed also increases. In addition there is improvement of peripheral circulation in the muscles engaged in training. This improvement increases the oxidative capacity in the working muscles allowing the oxygen to be more effectively utilized, i.e. the arterio-venous difference increases.

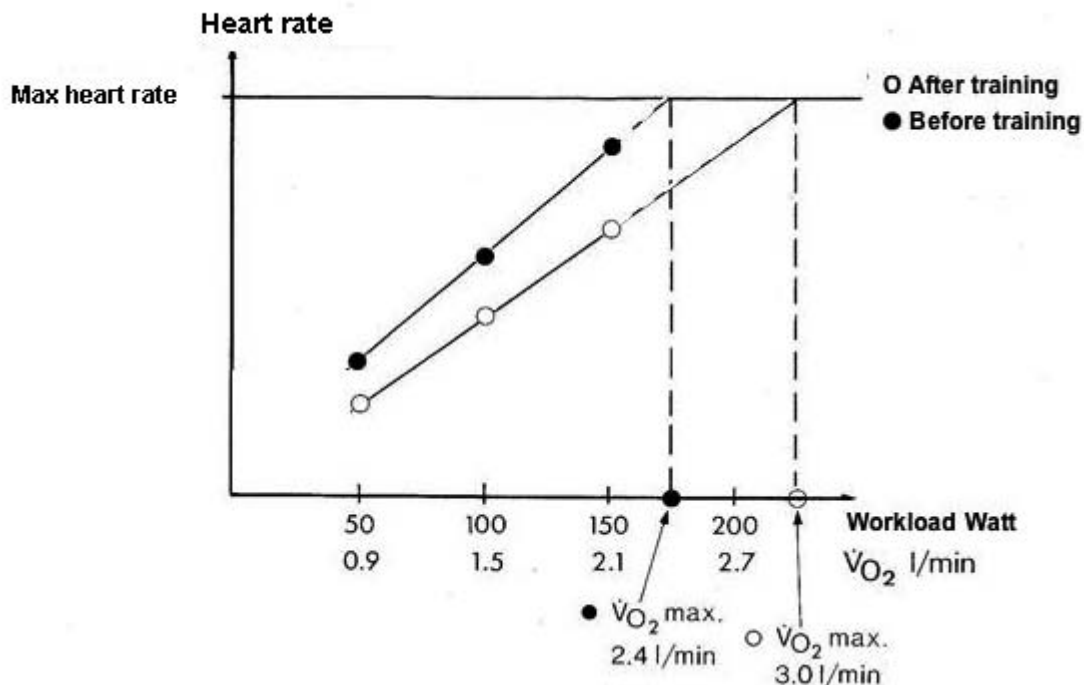


Figure 3.1.12. Individual work-load - heart rate relationship for a subject before and after aerobic capacity training. Heart rate was measured at three sub-maximal intensities and the line extended to maximal heart rate. After training his maximal oxygen uptake had increased from approximately 2.4 to 3.0 l/min\*. The heart rate on a given sub-maximal load, expressed in Watts or oxygen uptake ( $\dot{V}O_2$ ), is lower after training, thus the strain during work is reduced. The reduced strain may also be demonstrated by expressing a certain load in percentage of the individual's maximal aerobic uptake. A work task requiring an oxygen uptake of 1 l/min represents 42 % of the subject's maximal oxygen uptake before training and 33 % after training.

\* Note, that the values are based on a linear relationship between oxygen uptake and heart rate up to maximal heart rate, although the heart rate increase with increasing oxygen uptake generally levels off somewhat close to maximum. Therefore the estimated maximal oxygen uptake is probably slightly underestimated.

As heavy manual work generally includes lifting, carrying and pushing/pulling objects, muscle strength training and training in lifting techniques is also important to reduce fatigue and the risk of accidents from overload and over exertion. Muscular strength may increase markedly through strength training. Muscle strength may increase by 20-40% during the first 6-8 weeks of strength training with heavy loads. This “initial” training effect is due to a nervous adaptation resulting in more effective recruitment of muscle units. If training continues for more than 2-3 months, further adaptation takes place by increases in the muscle fibre area. Muscle fibres may increase their size by 100% or more after several years of training so when neural and muscular adaptation are taken together, muscle strength may increase 150-200%.

### Tobacco use

Smoking and other forms of tobacco use can cause acute effects on the cardiovascular system. Nicotine decreases peripheral blood circulation, increases heart rate and blood pressure and influences hormone excretion. Tobacco smoke contains up to 4 % carbon monoxide that has an affinity to haemoglobin that is approximately 225 times the affinity of oxygen to haemoglobin. The presence of even small amounts of carbon monoxide can markedly reduce the oxygen transporting capacity of blood and work capacity. At a given sub-maximal  $\dot{V}O_2$ , the heart rate may be 10-20 beats/min higher after smoking 1-2 cigarettes; the heavier the work, the greater the difference between smokers and non-smokers.

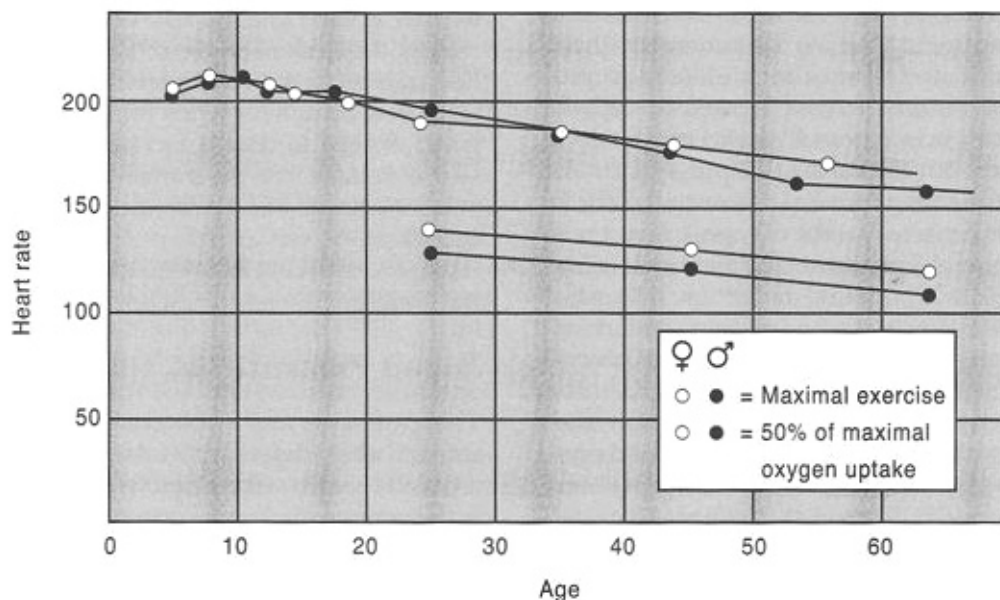


Figure 3.1.13. The decline in maximal heart rate with age, and heart rate during a sub-maximal work load. Mean values from 350 subjects. The standard deviation is approximately  $\pm 10$  beats/min in all age groups; from Åstrand, P-O et al, 2003.

### Gender and age

The maximal heart rate is on average the same for men and women, but varies considerably between individuals. The maximal heart rate decreases with increasing age, Figure 3.1.13. The relative load and physical exertion on the body that is working with a given heart rate, is therefore generally higher in older subjects (when compared with younger subjects).

The  $\dot{V}O_{2\max}$  for an adolescent female is on average 65-75% of that of a male, see Figure 3.1.14. This is partly due to differences in size. When weight is taken into account women reach on average 75-85% of the male's  $\dot{V}O_{2\max}$ , which is mainly explained by the woman's greater proportion of fatty tissue having lower energy consumption.

$\dot{V}O_{2\max}$  increases during childhood and adolescence and generally reaches its maximal value at 18-20 years of age, followed by a gradual decline, Figure 3.1.14. At the age of 65 the  $\dot{V}O_{2\max}$  is about 70% of the value for an average 25 year old; the average  $\dot{V}O_{2\max}$  for a typical 65 year old man is the same as that of a typical 25 year old woman.

Women's maximal muscle strength is lower than men's, Figure 3.1.15. This difference between men and women varies according to the muscles involved. For example, the maximal strength of a female's leg muscles is, on average, 65-75% of that of a man. The same figures for trunk and upper arm muscles are 60-70 and 50%, respectively.

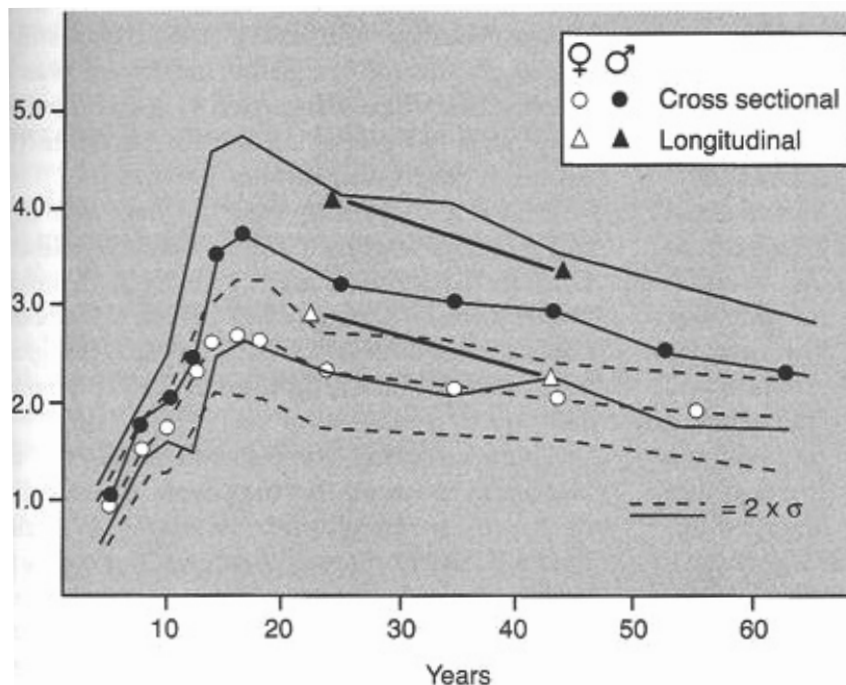


Figure 3.1.14. Mean values for maximal oxygen uptake in 350 female and male subjects 4 to 65 years of age. Included are values from a group of 86 students trained in physical education and data from a follow-up study of 35 female and 31 male students from the same group; from Åstrand, P-O et al, 2003.

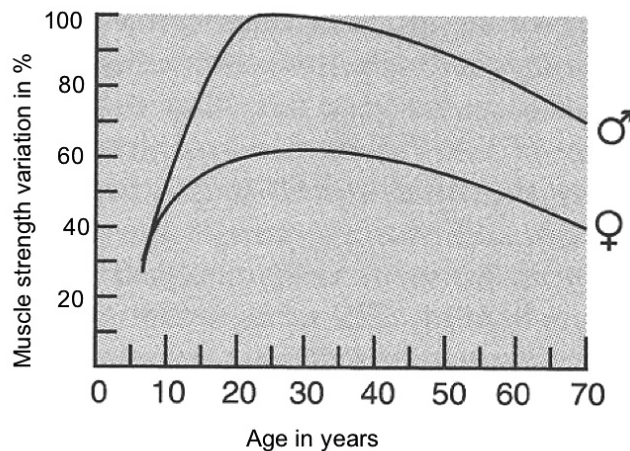


Figure 3.1.15. Changes in maximal isometric strength with age in women and men; from Åstrand, P-O et al, 2003.

Maximal muscle strength in men is usually reached around the age of 20, (a few years earlier for women), followed by a gradual decline. The strength of an average 65 year old is 75-80% of an average 20-30 year old. The rate of decline with age is somewhat greater for the leg and trunk muscles compared with the arm muscles.

### Temperature and humidity

Heat stress increases cardiovascular load and decreases work performance and productivity. The heart rate accelerates due to increased skin perfusion to enhance the transportation of heat from the working muscle to the skin that then boosts evaporation of sweat taking heat from the body. When high temperature is combined with high humidity, work performance and productivity are reduced even more since evaporation is hampered. Prolonged heat stress leads to loss of body fluid (hypohydration) through increased sweating that in itself further increases the heart rate and reduces work performance, especially endurance. At a hypohydration corresponding

to 1% of the body weight, there is already a measurable decrease in performance. Heart rate increases with approximately 10 beats per % of hypohydration and body temperature increases approximately 0.2° C per % of hypohydration making it very important to replace water loss. Water should be drunk frequently, in greater quantities and much more often than indicated by feelings of thirst. 5-8 litres needs to be replaced during a normal shift of moderate or heavy work.

Various physiological changes, (i.e. acclimatisation), takes place during prolonged exposure to heat, especially during the first week of exposure, that help individuals adapt to better endure heat stress. The heart rate and body temperature at a given sub-maximal load will decrease while sweat production increases. The salt content in sweat also tends to decrease.

Heat stress not only impairs the capacity for the performance of heavy work but also impairs capacity for precision work, intellectual tasks and decision making, potentially leading to risk taking and accidents. Therefore it is of considerable practical importance to minimise heat stress by organisational, technical and behavioural preventive measures.

In a cold climate heavy manual work is most problematic before the muscles have been warmed up as blood circulation and nerve conductivity is reduced in cold tissues resulting in reduced musculoskeletal function and work performance. There is also an added risk of injuries in cold tissues. Reduced nerve conductivity means that fast and precise work is difficult to perform if the hands and fingers are cold. Cold hands also increase the risk of accidents during manual handling since muscle strength and coordination is reduced. Appropriate clothes are important to keep individuals warm in a cold climate, however, warm and heavy clothes may

have a negative impact on work performance as they may reduce mobility and increase energy demands because of additional weight.

### Altitude

Physical work performance is reduced at high altitudes. The oxygen pressure of inhaled air decreases with increasing altitude, from approximately 100 kPa (760 mm Hg) at sea level to approximately 70 kPa (525 mm Hg) at 3 000 metres altitude, Figure 3.1.16. During acute exposure, i.e. without adaptation to high altitude,

pulmonary ventilation and heart rate at sub-maximal workloads increases compared with that at sea level, to compensate for the low oxygen pressure in arterial blood. Work at a given workload at high altitude requires more effort and endurance is reduced.

Beside maximal cardiac output,  $\dot{V}O_{2\max}$  depends on the maximal oxygen extraction from the blood. During maximal work at sea level almost all oxygen is extracted from the blood passing the active muscles so the lower oxygen content in arterial blood at high altitude cannot

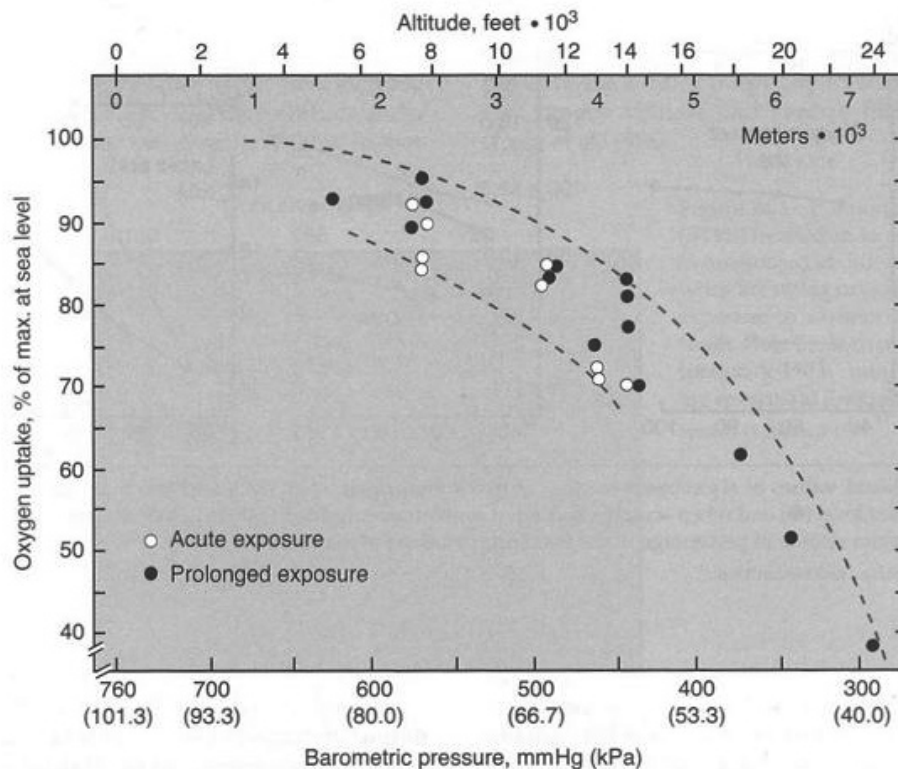


Figure 3.1.16. Reduction in maximal oxygen uptake in relation to barometric pressure.  $\circ$  = data from acute exposure,  $\bullet$  = data after various periods of acclimatization. In principle, the maximal oxygen uptake during acute exposure to reduced oxygen pressure decreases at the lower part, within the dotted lines; during acclimatization, it is shifted toward the upper part of the field; from Åstrand, P-O et al, 2003.



be compensated for by more effective extraction. The maximal cardiac output remains the same at high altitude as at sea level but the maximal aerobic capacity decreases in proportion to the decreased arterial oxygen content, e.g. at an altitude of 4 000 metres, the reduction in maximal aerobic capacity is approximately 30% in non-acclimatised subjects, see Figure 3.1.16).

During prolonged exposure to high altitude, various physiological changes, (i.e. acclimatisation), occur to compensate for the reduced oxygen pressure in the inhaled air. A further increase in pulmonary ventilation takes place during the first days of exposure and the heart rate at sub-maximal levels gradually decreases at a given oxygen uptake. At a later stage of acclimatisation, the same or even lower heart rate levels as at sea level are attained. The maximal cardiac output decline gradually at high altitudes but the haemoglobin concentration increases so that the content per litre of arterial blood can be the same in an acclimatised person at 4 500 metres as at sea level. There are also gradual morphological changes in the tissues, e.g. increased capillary density, increased myoglobin content and modified enzyme activity. The initial reduction in maximal aerobic capacity will gradually decrease and at an altitude of e.g. 4 000 metres, the reduction in aerobic capacity is approximately 15% in an acclimatised person compared with 30% in non-acclimatised subjects, Figure 3.1.16.

### Fatigue

Fatigue is a multifactorial condition that is a common and important constraint in work. Subjective symptoms of fatigue range from slight feelings of tiredness to complete exhaustion. Although there are objective symptoms indicating disturbances in the balance and feedback systems to keep equilibrium of body substances and processes (homeostasis), very little is known

about these changes. Fatigue has been defined as a state of disturbed homeostasis, attributable to both work and the work environment, which may imply both subjective and objective symptoms and reduce work performance. Sometimes fatigue occurs together with pain in various parts of the body so fatigue and pain should be regarded as warning mechanisms for overexertion.

Fatigue may be physical or psychological (mental). Both forms of fatigue can be caused by heavy physical work and normally occur with reduced work performance. If fatigue is to be reduced and work capacity restored, work must be discontinued or the workload lightened to allow recovery.

Physical fatigue can be *local* or *general*. *Local* or muscular fatigue may occur during and after intensive use of a specific body region, e.g. the shoulder when working with lifted arms. The physiological factors responsible for fatigue may be of mechanical, metabolic (e.g. depletion of energy and accumulation of lactic acid) or electrophysiological origin. *General* fatigue may occur after long duration of heavy work with large muscle groups, e.g. manual forestry and agriculture work or aerobic capacity training when there is increased blood lactate concentration and accelerated heart rate. General fatigue can also be associated with hypoglycaemia (reduced blood sugar concentration) after prolonged sub-maximal work or hypo hydration in heat-exposed workers who do not consume enough water during their working shift. General fatigue may also be a symptom of disease.

Psychological fatigue may be caused by a disturbed central nervous control. Typical symptoms are impaired sensory and motor function, impaired intellectual and decision making capacity and slower information transmission. Situations that may cause psychological fatigue are prolonged work requiring high mental con-

centration and attention, heavy physical work, monotonous work and environmental factors such as noise, improper lightening and uncomfortable climate.

The prevention of fatigue requires to be organised in such a way that there are variations in workload, workers have the possibility to influence their workload and work pace, and that enough time is allowed for rest breaks for recuperation.

### Workload in relation to work performance capacity

Prolonged work can be classified according to severity of workload and cardiovascular response for a group within a certain age range.

Workload	$\dot{V}O_2$ , l/min	HR, beats/min
Light work	up to 0.5	up to 90
Moderate work	0.5-1.0	90-110
Heavy work	1.0-1.5	110-130
Very heavy work	1.5-2.0	130-150
Extremely heavy work	over 2.0	150-170

The figures refer to average 20-30 year olds and are only general classifications because of the large individual variation in ability to perform physical work.

The strain on an individual is, however, highly dependent on the individual's  $\dot{V}O_{2\max}$ . In general, an individual's experience of a specific workload and their perception of exertion is more closely related to heart rate than to  $\dot{V}O_2$  during work because heart rate not only reflects the actual workload but other factors that influence work performance.

Because maximal aerobic capacity varies greatly between individuals, a workload that is easy for one worker can be quite exhausting for another. Generally, work requires more exer-

tion for women and elderly persons than men and younger individuals, although there are large variations within gender and age groups. E.g. two workers who carry a heavy load uphill, require an energy expenditure corresponding to an oxygen uptake of 2 l/min. One worker has a  $\dot{V}O_{2\max}$  of 6 l/min and the other's is 2 l/min. The first worker uses 33 % of his  $\dot{V}O_{2\max}$  whereas the second worker is using 100 % of his  $\dot{V}O_{2\max}$ . The lactic acid concentration during dynamic work, e.g. bicycling, increases markedly at 40-50% of maximal aerobic capacity (the lower value for untrained subjects), see Figure 3.1.6.

However, occupational heavy work generally includes manual handling operations with static work and work with small muscle groups, (as in the above example of the two workers carrying a heavy load uphill) that reduce work efficiency. During mixed physical work, including manual handling operations, the upper limit for the maintenance of homeostasis and prevention of the accumulation of lactic acid and fatigue over an 8-hour workday is approximately 30-35% of  $\dot{V}O_{2\max}$ , the lower value for untrained subjects. Consequently, the first worker in the example given above can work all day without marked fatigue whereas the second worker becomes exhausted after only a few minutes. It is meaningless to express individual workload in absolute values, i.e. as  $\dot{V}O_2$  in l/min (or comparable measures) so workload should be expressed as a percentage of an individual's  $\dot{V}O_{2\max}$  i.e. the ratio between the load and capacity.

International Labour Organisation (ILO) has suggested 33 % of  $\dot{V}O_{2\max}$  as the highest acceptable average load during an 8-hour work shift. If this cannot be achieved by organisational and/or technical preventive measures ILO recommends decreased working hours.



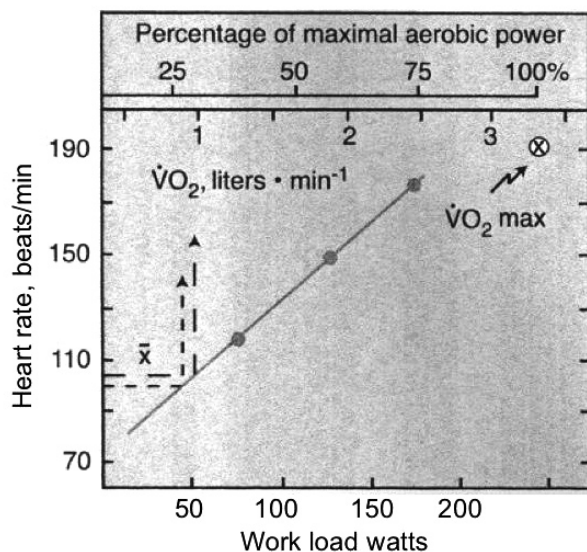


Figure 3.1.17. The individual relationship between the heart rate at different sub-maximal workloads and the predicted corresponding oxygen uptake. The measured maximal oxygen uptake ( $\dot{V}O_{2\max}$ ) is used to construct another parallel scale, which shows the load expressed as percentage of the individuals maximal oxygen uptake (aerobic power). The weighted mean of the continuous recording of the heart rate, e.g. during 2 different work days, is then used to approximate average oxygen uptake during work as well as the load expressed as percentage of the maximal aerobic power; from Åstrand, P-O et al, 2003.

A worker's  $\dot{V}O_{2\max}$  can be determined by direct measurements of oxygen uptake at maximal work or can be estimated on the basis of heart rate measurements from sub-maximal tests. Workload can be assessed either by measurement of  $\dot{V}O_2$  during the actual work or by indirect estimation of  $\dot{V}O_2$  by heart rate measurements. There is normally (within certain limits), a linear relationship between  $\dot{V}O_2$  and heart rate in a given individual, see Figure 3.1.17. However, there is a steeper rise in heart rate with in-

creasing workload; the higher the ambient temperature and humidity, the greater proportion of static to dynamic effort and the smaller/fewer muscles involved, Figure 3.1.18. Emotional factors such as nervousness and apprehension also increase heart rate at rest and during work at light to moderate workloads.

Although the workload/heart rate relationship can be established for a specific individual (individual calibration), heart rate can only be used to estimate workload under certain conditions. These conditions require that roughly the same large muscle groups are engaged in the calibration assessments as in the measured work task, and the proportion of static to dynamic work, ambient temperature, emotional stress and other factors that affect work performance must be the same. Heart rate can easily be monitored continuously during a whole workday with small, comfortable ambulatory heart rate monitors.

Maximal heart rate declines with age. A heart rate of 130 beats/min for an average 25 year old man roughly corresponds to 50% of his maximal aerobic capacity, however, the same cardiovascu-

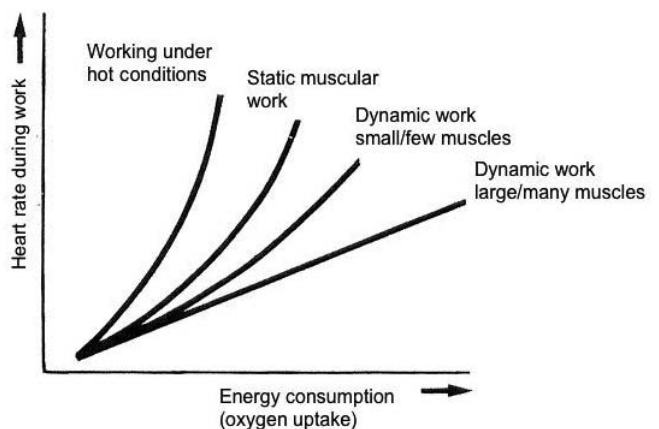


Figure 3.1.18. Increase in heart rate during different working conditions; from Kroemer, K H E and Grandjean, E, 1997.

lar strain and feeling of exertion is experienced by an average 65 year old man at a heart rate of 110, Figure 3.1.13. Maximal heart rate also varies considerably between individuals within the same age group. Therefore, the cardiovascular strain and degree of physical exertion is best expressed as an increase in heart rate from resting level as a percentage of the heart rate reserve (HRR); the heart rate reserve is the difference between maximal and resting heart rate of a subject. A heart rate of 130 beats/min corresponds to 50% of the HRR for a person with a maximal heart rate of 200 and a resting heart rate of 60 beats/min:

$$(130-60)/(200-60) * 100 = 50\%$$

whereas the same heart rate corresponds to about 70% of the HRR for a person with a maximal heart rate of 160 beats/min:

$$(130-60)/(160-60) * 100 = 70\%.$$

During prolonged heavy work the body temperature can be used as a measure of relative workload. Body temperature increases in a linear way with increasing workload, at least up to an energy demand of about 75% of an individual's maximal aerobic capacity. However, it takes approximately 40-50 min before the increase in body temperature levels off to a steady value. At 50% of an individual's maximal aerobic capacity, body temperature will reach approximately 38°C, see Figure 3.1.19.

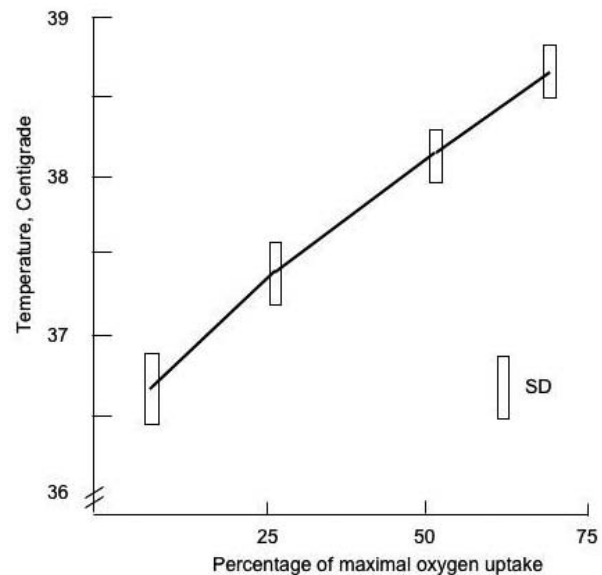


Figure 3.1.19. Average body temperature (measured in rectum) in relation to oxygen uptake in percentage of the individual's maximal oxygen uptake. Seven subjects were exercising for 60 minutes on a bicycle ergometer. To the left are data obtained at rest. SD=standard deviation; modified from Åstrand, P-O et al, 2003.

If workload is not too high, the oxygen uptake during an actual work situation can also be estimated from measurements of pulmonary ventilation as there is a linear increase in pulmonary ventilation with increasing oxygen uptake up to an oxygen uptake of about 1.5-2 l/min, Figure 3.1.20.

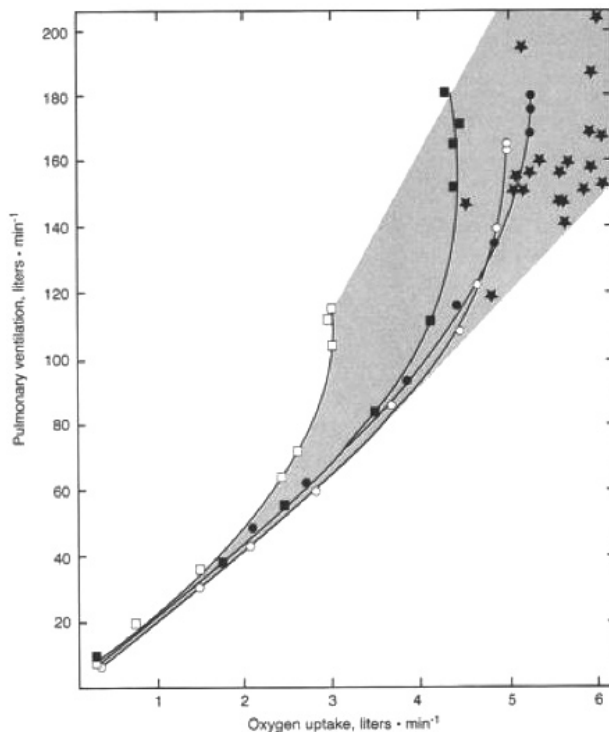


Figure 3.1.20. Pulmonary ventilation at rest and during 2-6 min of exercise (running or cycling). Four individual curves are presented. Several rates of exercise gave the same maximal oxygen uptake. Individuals with maximal aerobic uptake of 3 l/min or higher usually fall within the shadowed area. Note the wide scattering at high oxygen uptakes. \* = individual values from top athletes measured when maximal oxygen uptake was attained. At oxygen uptake values up to 1.5-2.0 l/min the relationship is linear and thus, oxygen uptake may be estimated from values of pulmonary ventilation; from Åstrand, P-O et al, 2003.

Oxygen uptake, heart rate and in some cases body temperature and pulmonary ventilation, are suitable and valid measures for assessing the general magnitude of physical load and strain, (i.e. energetic and cardiovascular load), but these measures are not suitable for measuring localised muscular strain. The load exerted on specific

muscles can be assessed by electromyography (EMG). The same principle of relating load to individual capacity also applies for localised muscular loads because only a certain percentage of the maximal strength can be taxed before local fatigue develops.

### EFFECTS OF HEAVY WORK

Heavy work may lead to undesirable acute and/or long-term effects. Acute effects such as overstrain and fatigue impair sensory and motor control as well as perceptive and cognitive functions. In turn, these effects can lead to poor co-ordination, and awkward working movements and postures in handling operations that may increase the risks such as over-exertion injuries and musculoskeletal disorders. Additionally, workers who have developed fatigue at work may have difficulties managing their non-occupational duties leading to social problems. Heavy work has been associated with negative long-term health effects such as increased risk of coronary heart disease, back, neck and shoulder pain and osteoarthritis. Studies also suggest that heavy occupational demands may accelerate the age-related deterioration of physical capacity, contrary to the positive effects of physical training on physical capacity. The main reason for the difference in effects between high physical activity during leisure time (e.g. aerobic training) and occupational activities is probably that the load in occupational work is not optimal in intensity, frequency and duration. Most importantly, there may not be sufficient time for recuperation to allow central and peripheral adaptation that results in a training effect.

### MEASURES TO PREVENT HEAVY WORK

It is very important that workers are allowed to influence the pace of work and the frequency of pauses particularly if elderly workers are to be

able to work until normal retirement age. However, high physical demands are unpredictable and difficult to avoid in some occupations, e.g. in fire and rescue services so it is important that such workers maintain a high physical capacity by regular physical training. Consideration should also be given to possibilities to enlarge the range of work tasks to also include less physically demanding tasks that allow physical recuperation. During very heavy work tasks micro pauses can also markedly reduce work strain without reducing productivity. Physical load may also be markedly reduced by increasing work efficiency. The use of technical aids, improved working methods, better design and maintenance of work equipment and tools can greatly reduce physical load and increase productivity.

The extent of physical strain should be appropriately investigated before new work methods, equipment and tools for manual work are introduced. These measurements should include both assessments of energy and cardiovascular demands (e.g. oxygen consumption, pulmonary ventilation, heart rate) and neuromuscular demands (e.g. muscular load, awkward postures, repetitive movements and local pressure) as well as psychological factors (e.g. motivation and satisfaction).

## SUGGESTIONS FOR FURTHER READING

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# Food, nutrition and work

Leif Hambræus

## What is nutrition?

The process whereby living organisms utilise food for maintenance of life, growth, the normal functioning of organs and tissues, and the production of energy.

The science and study of the reaction of the body to intake of food, the variation in the diet, and to other factors of pathological or systematic significance.

(Definition according to WHO/FAO/IUNS 1974)

## NUTRITION IN TRANSITION

In most countries there is an ongoing change in dietary habits and food availability. In the affluent societies the transition from hunting and gathering to agriculture took thousands of years, and industrialisation about two centuries. This transition now occurs in the low-income countries (LIC) over a few decades. The concept of malnutrition which means “wrong nutrition” has a wider meaning today. The role of malnutrition in public health perspectives is no longer only a question of “undernutrition” i.e. lack of energy and/or nutrients, often referred to as “malnutrition minus”. It also refers to effect of over-consumption of energy and certain nutrients, overnutrition or “malnutrition plus” leading to obesity and cardiovascular disease.

Severe protein-energy malnutrition, e.g. kwashiorkor and marasmus, has decreased during the last two to three decades as well as most vitamin deficiencies under “normal” conditions in LIC. However, on the same time some vitamin deficiencies now reappear as a result of environmental stress situations in refugee populations.

Although undernutrition, i.e. lack of energy and nutrients, still is a dominant nutritional problem in LIC, changes in urbanisation and socio-economic development also lead to shifts in

the nutritional situation as a result of changes in diet composition and physical activity characterised as *nutrition transition in development*. Obesity and cardiovascular diseases are now rapidly increasing in LIC, “the nutrition transition”, and the diet-health situation more and more polarised in all countries. Thus the diet-health relation is valid for all types of societies and both malnutrition plus (pattern 4 and 5 below) and malnutrition minus (pattern 1 and 2 below) occur in all societies, i.e. in LIC as well as in affluent societies, and represent a great public health concern. Nutrition transition in development could be described as “a question of over-eating and/or under-exercising”.

The following five broad patterns have been described in nutrition transition (Popkin):

### 1. Collecting food (hunting and gathering).

The diet in pattern 1 is characterised by a varied diet comprising plants and low-fat wild animals and the nutritional status characterised as robust with low body fat percentage but fewer nutritional deficiencies. This is typical of the rural low-density population with low life expectancy with high mortality essentially as result of infectious disease but few epidemics.

### 2. Famine (from acute to chronic lack of food)

The diet in pattern 2 is characterised by a monotonous cereal-based diet and the nutritional status is deteriorated especially within the vulnerable groups, i.e. children



and women, with low fat intake, occurrence of nutritional deficiencies and wasting and stunting. High infant and maternal mortality, low life expectancy and epidemics and endemic diseases follow famines.

### 3. Receding famine

The diet in pattern 3 is still less varied although more fruits, vegetables and animal products occur, and a few starchy items form the staple food. The nutritional status is still dominated by mother and child health problems, especially during weaning. However, there is a slow mortality decline and population growth although infection and parasitic infestations are common.

### 4. Degenerative disease typical of urban population

The pattern 4 is typical of affluent societies with increased urbanisation with a diet rich in empty calories from high fat intake, especially animal fat, sugar and processed foods with less fibre. This leads to increased prevalence of obesity and osteoporosis. Fewer jobs with heavy physical activity together with increased mechanisation in jobs as well as households increase the risk of obesity. Life expectancy is high but chronic diseases, e.g. cardiovascular disorders (CVD) and cancer, increase while infectious diseases decline.

### 5. Behavioural changes

The pattern 5 comprises behavioural changes as result of increased health promotion and lead to a diet with less intakes of fat and processed foods, and increased consumption of fruits and vegetables. This in combination with an increased leisure exercise to combat physical inactivity in job and household reduces the body fat content, as well as risk of developing obesity and osteoporosis. This results in high life expectancy and reduced CVD.

An illustrative presentation of the changes in the health panorama and its relation to socio-economic

development can be found in the World Health Chart on internet (<http://www.whc.ki.se>) As most of the effects on health panorama are related to the nutritional status of the individual, this also indirectly illustrates the public health perspectives on the linkage between socio-economy and nutrition.

## NUTRIENTS IN FOOD

All food contains a mixture of nutrients. The nutrients can be grouped into energy-yielding and essential nutrients and comprise macronutrients *and* micronutrients.

### Priority of nutritional needs

Under normal conditions the body gives priority to cover its energy needs, which can be covered from any of the energy-yielding macronutrients (carbohydrate, fat, protein and alcohol). Thus the *energy need* is essentially a matter of the amount of food needed, i.e. a *quantitative* aspect on the dietary intake.

When the energy intake via the diet, i.e. *exogenous energy*, does not meet the energy need, energy is released from mobilisation of energy-yielding substances stored in the body (glycogen in liver and muscle; fat from subcutaneous and adipose tissue) but also from breakdown of tissues, essentially skeletal muscle, where muscle protein is used as energy source through gluconeogenesis. Thus energy deficit results in muscle catabolism.

Energy yielding nutrients <i>Macronutrients</i>	Essential nutrients <i>Macronutrients</i>	<i>Micronutrients</i>
Carbohydrate	Water	Trace elements
Fat	Essential fatty acids	Vitamins
Protein	Essential amino acids	
Alcohol	Minerals i.e. calcium	

Figure 3.2.1. Grouping of nutrients.



The *nutrient needs* refer to the specific need of certain nutrients, i.e. protein, trace elements and vitamins but also water, leading to *qualitative* aspects on the dietary intake. The requirement of essential nutrients, i.e. protein, minerals, vitamins, is essentially related to fat-free mass and to little extent to the extent of physical exercise. Thus nutrient requirement is related to age, sex and body size and refers to a specific need of certain nutrients.

Protein plays a two-fold role. There is (i) a *specific nutritional role* as source of essential amino acids for protein synthesis i.e. building up, repairing and maintaining tissues; as well as (ii) a *non-specific role* as an energy-yielding nutrient. If energy needs are not met, protein will be used as energy source, no matter if protein needs are increased and not met. If more protein is consumed than specifically needed for protein turnover, which is the case in most affluent societies, the surplus is used as energy source since protein can not be stored in the body. It is consequently not possible to discuss energy and protein requirements separately. This is of special relevance when discussing nutritional problems in relation to physical performance.

### Energy density

The energy density of the food refers to the amount of energy per weight or volume. The energy density of fat-rich items is higher not only as fat has a higher energy value than carbohydrate and protein (38 kJ vs. 17 kJ per g), but also because fat-rich food items have lower water content. Most concentrated energy sources in the diet are oils which contain 100% fat, while butter, margarine and lard contain about 80% fat, some low-fat spread as low as 40% or even 25%. Water constitutes the remaining percentage.

### Nutrient density

Nutrient density refers to the amount of essential nutrients, i.e. protein, vitamins, minerals, per energy unit (joule or kcal). Food items with a high-energy content usually have a low nutrient density. Thus high-fat, high-sugar containing food items result in a low nutrient density of the diet.

### The concept of empty calories

Components which are rich in fat and refined sugar have a high energy density while they on the same time have a low content of essential nutrients, i.e. protein, trace elements, vitamins. They contain what is sometimes called "*empty calories*". A high consumption of such products may be an easy and sometimes cheap way to cover the energy needs. However due to their low nutrient density there is a great risk to overconsumption of energy leading to obesity before the needs of the essential nutrients are met. The problem of a high intake of empty calories is typical of the fat and sugar rich diet in affluent societies.

### Consumption of energy-yielding macronutrients

With the aid of national food balance sheet data on 85 countries Perissé and collaborators already in 1969 made an attempt to identify the general trends of consumption patterns as a function of income. They could show that although the protein energy percent (E%) was almost the same in low-income countries and affluent societies, the amount of fat and refined sugar constituted much higher E% in the diet of affluent societies leading to increased energy density and reduced nutrient density. Although more than 30 years has passed since then, the same tendency in energy percentage distribution between ma-

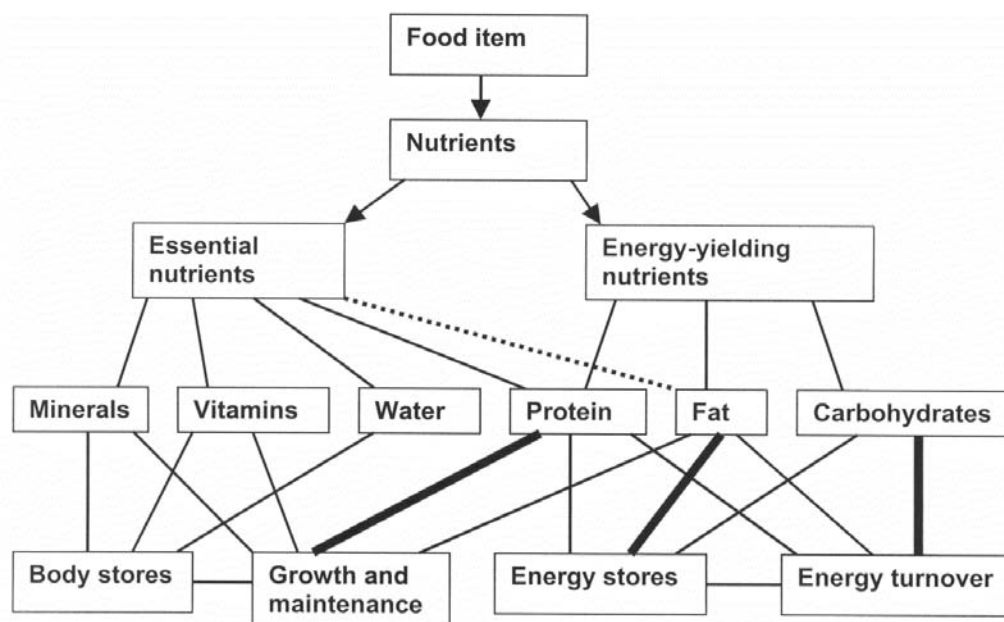


Figure 3.2.2. Schematic presentation of nutritional role of essential and energy-yielding nutrients. Bold lines refer to the major roles of protein, fat and carbohydrate. Dotted line indicates that there are only a few essential fatty acids.

cronutrients occurs in rich and poor in affluent societies as well as in low income-countries.

Complex carbohydrate sources (cereals, tubers) represent the major energy source (about 70%) amongst the poor, especially in LIC, while the fat consumption is low (less than 10%). In the affluent societies fat constitutes 35-40% of the energy intake, while the intake of complex carbohydrate only represents about 30-40%. Refined sugar may constitute up to 17%.

Figure 3.3.3 illustrates the interesting fact, which is often not fully realised, that the energy in the diet derived from protein in the poor in LIC represents 10-15 E% and is similar to that in high-income groups. This leads to the following two very essential conclusions:

1) The higher protein intake in high-income groups is not due to a higher protein concentration in the food *per se* but to the fact that the total energy consumption is much higher.

### Units of energy

The old unit used in energy studies was the calorie, which referred to the energy needed to raise the temperature 1 degree Celsius (from 14.5 to 15.5) in 1 g of water. This unit is still used in nutritional science, especially kcal (=1,000 calories) in biological systems, sometimes referred to as Calorie (with capital C).

Today Joule is used in most scientific papers dealing with energy as it is an SI unit.

To convert between calories and joule:

1 kcal = 4.186 kJ

1 kJ = 0.239 kcal

2) The high prevalence of protein deficiency in low-income countries is essentially due to a too low total intake of food (i.e. energy), and not primarily due to a low protein content in the food *per se*. The latter misconception has for a long time lead to action programs for protein and amino acid enrichment of food.

### The grouping of food items

Many systems have been used throughout the years to group various foods in relation to nutritional perspectives. Sometimes five groups

are used: fruits and vegetables, meat, fish and milk; cereals; sugar and fat. Other systems use 3 groups: body building foods, energy-yielding foods and protective foods.

The food square system was introduced as a way to group food items from a combination of nutritional and practical perspectives. It comprises four sectors:

- 1 staple food items
- 2 protein supplements
- 3 vitamin and mineral supplements
- 4 energy supplements

### Example

The energy density of vegetable oil is high, e.g. soy oil which contains 3.8 MJ (900 kcal) per 100 g. The energy density of potato is much lower, being 315 kJ (75 kcal) per 100 g. This is due to the fact that soy oil is almost pure fat, whilst potato, which is one of the highest energy-yielding crops per acre, contains almost 80% water. On the same time the nutrient density of vegetable oil is very low, with exception for its content of fat soluble vitamins, but high for potato, which contains both protein, vitamins and minerals in balance with the energy content.

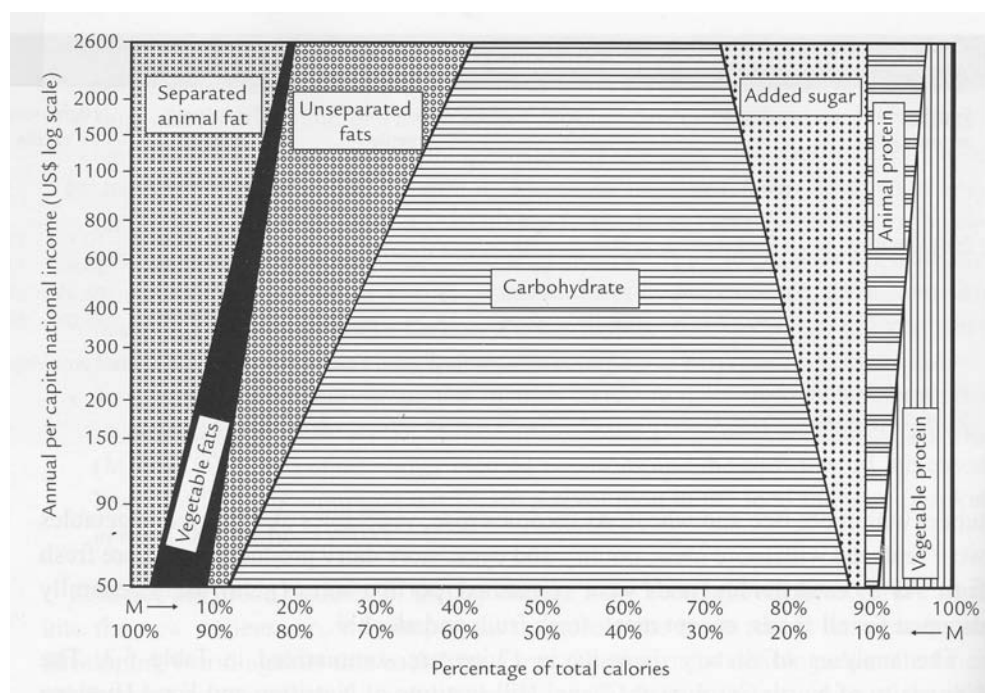


Figure 3.3.3. Structure of the diet and income (country-level sources of energy, 1962).

***Case study: Food and nutrient intake in male adolescent Kenyan runners***

A 2-week nutritional survey on 12 representative athletes, adolescent male Kenyan runners, showed a diet very high in carbohydrate (71 energy%) and low in fat (15 energy%) while the total protein intake (12 energy%) was still above the recommended daily intake according to FAO/WHO/UNU. The energy intake was mainly derived from vegetable sources (90%) with maize and kidney beans as staple foods constituting 81%. The diet met recommendations for endurance athletes for total protein and most essential amino acids as well as carbohydrate intake even though based on a small range of food items.

(Ref Christensen et al, Brit J Nutr 2002; 88; 714-717)

**CONCLUSIONS**

The balance between energy-yielding food items is a central problem in low-income countries as well as in the affluent societies. The following conclusions can be drawn:

1. A diet which is adequate to cover energy needs of an individual will also meet the needs of most essential nutrients if the content of empty calories is low.
2. It is not the quality of food per se that leads to malnutrition in low-income countries, but the fact that the amount of food is too small. The solution of the malnutrition problem is consequently not primarily to change the dietary habits but to increase the availability of food.
3. The high intake of fat and refined sugar in the diet of affluent societies, e.g. “empty calories”, where they constitute more than 50% of the energy intake means that the intake of essential nutrients is almost the same as in low-income countries despite the fact that they have almost double the energy intake. If the diet in low-income countries had the same relative amount of empty calories, their nutrition situation would have been much worse.
4. The food consumption pattern of high income groups in combinations with a too low energy intake is deleterious to their health and thus affluent societies as well as low income countries the dietary habits play an essential role for public health.
5. For people with low access to food or low energy needs there is a risk that the diet might not provide enough essential nutrients, e.g. iron, unless
  - A. The consumption of food items with high nutrient density is increased
  - B. Food items are fortified;
  - C. Food supplements are used
  - D. Physical activity is increased as this leads indirectly to increased food intake to meet the extra energy needs. The same diet may then cover the nutrient needs despite a low nutrient density as the need of essential nutrients only to a very little extent is increased at higher energy turnover.

The reason for the introduction of this system was that too little importance had been given to the staple food as source of both energy and essential nutrients and too much emphasis to animal products as sources of protein. The basis in this grouping is the staple food, which contains the major and cheap part of the diet in most cultures and which also constitutes the major source of both energy and essential nutrients. Depending of which type of staple food that is available there is a need to supplement with food items from the other groups in order to increase the intake of protein, energy and minerals and vitamins.

#### Example

How to use the food square system to plan a diet to supply the total nutrient needs of a 9-months-old child

<b>Group 1</b> <b>- Staple food</b> Cereal: 40 g wheat flour	<b>Group 2</b> <b>- Protein supplement</b> 15 g chick peas
<b>Group 3</b> <b>- Vitamin-mineral supplement</b> 25 g dark green leaves	<b>Group 4</b> <b>- Energy supplement</b> 10 g vegetable oil

### Nutritional characteristics of various food groups

**Cereals** (wheat, rice, maize, corn, rye, and oats) constitute the major energy source in most diets in affluent societies as well as low income countries. The water content is usually low, but the dietary fibre content high, which leads to low energy density. Carbohydrate, essentially starch, constitutes about 80 % of the energy and protein 10-15 %. The protein quality is not optimal due to low lysine content.

Cereals are the essential source of most B-vitamins, especially in whole meal and also contain minerals and trace elements but these can be lost during milling to flour. Wholemeal also contains antinutrients, phytin and tannins, which reduce the bioavailability of minerals and trace elements.

**Roots and tubers** (cassava, potato, and yams) have a higher water content than cereals which leads to low energy density, but the energy yield per acre in agricultural production is high. The protein content may be low, only 2 weight%, but energy wise it represents around 10 energy%. Potato has a relatively well balanced protein constituting about 11 energy %, while cassava is extremely low in protein which constitutes only 2 energy %. Some roots and tubers are rich in vitamin C and those with an orange colour contain carotenes, a pro vitamin A. The mineral content is about the same as in cereals but they contain fewer antinutrients.

**Legumes** (cowpea, common beans, groundnut, and soy bean) are rich in protein which constitutes about 20% both in relation to weight and energy content; some of them are also rich in fat (groundnut, soy bean). Legumes contain a number of antinutrients (e.g. antitrypsin activity in soy bean and lectins in brown beans) which necessitates cooking for long time in order to inactivate them. The legumes are good sources of B vitamins.

**Nuts and oil seeds** (peanut, rapeseed, and sesame, sunflower) are especially energy rich and have a low carbohydrate and water content giving them a high energy density. They are usually good sources of B-vitamins but are low in vitamin A and C. The mineral content can be high especially iron and calcium. Nuts are essential sources of calcium for those who do not have access to dairy foods.

## Chapter 3.2

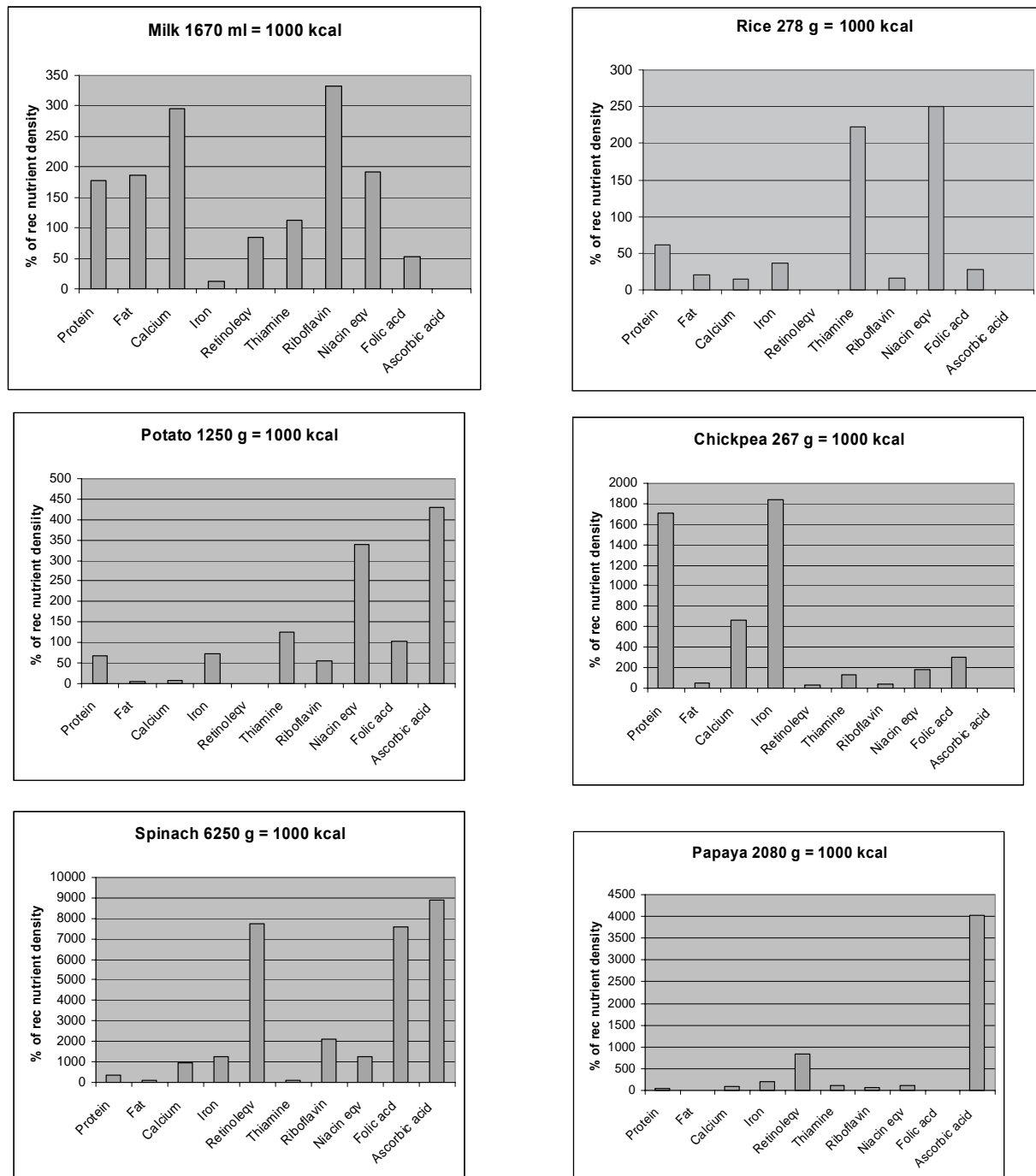


Figure 3.2.4. Nutrient profiles of various food items based on nutrient density.  
The values refer to per cent of recommended nutrients per 1000 kcal.



**Vegetables and fruits** (amaranths, tomato, onion, banana, citrus, papaya, mango, and guava) have high water content and low fat content and consequently a low energy density. The protein energy percent may be about 5 %. They are good sources of vitamins and provitamins and dark leaves also of folate and iron.

**Animal products** (milk, meat, fish, and egg) are usually expensive products in most LIC. Animal products contain almost no carbohydrate and the energy density varies with its fat content. The protein content is usually high and the protein quality high. They are also good sources of most vitamins and minerals and trace elements with a high bioavailability. Dairy products are extremely good calcium sources.

**Fats and sugars** (coconut, oil palm, rape seed, sesame, beet sugar, and cane sugar) have a high energy density but low nutrient density. They contain no protein and play a little role as source of vitamins with two exceptions: the high content of beta-carotene in red palm oil, and vitamin E in vegetable oils.

### Nutrient profile

The nutritional density for various food items can be illustrated by the nutrient profile. This refers to the nutrient content of various foods per energy unit, expressed as per cent of the recommended intake of that specific nutrient per energy unit for the consumer. Thus the nutrient profile differs for a food item in relation to the intention of its use. The nutrient profile of cereals when used for a 1-3-year-old child differs from that when used of an adult male. However, in this way it is easy to illustrate the nutritional characteristics of the various types of foods. The following figure illustrates the nutrient profile of some food items (cow's milk as well as food items of vegetable origin (rice, potato, chickpea, spinach and papaya) used in the diet of adults.

However the nutrient profile should be evaluated in relation to the amount to be consumed when covering the energy needs. Please observe that due to differences in energy density the amount that contains 1000 kcal varies considerably between the food items. In this example 1000 kcal is found in 1.7 kg of milk; 0.3 kg of rice; 1.3 kg of potato; 2.4 kg of carrot; 0.3 kg of chickpea; 6.3 kg of spinach and 2 kg of papaya.

The energy and nutrient content per weight or volume is given in food tables. Most food tables have to be somewhat region specific because environmental factors interfere with the quality of the product. Furthermore one has to know whether the values refer to crude products or the edible part of the product and if they are raw or prepared.

### *Two alternatives of meal composition*

The two alternatives in Figure 3.2.6 and 3.2.7 may to some extent illustrate the differences in a meal in an affluent society versus that in low income countries. It shows that it is no problem to cover the same energy intake in a vegetarian meal as in a mixed meal based on vegetable and animal products. However, the protein amount is only 2/3 and the calcium content only half in the vegetarian diet meal. The role of sesame milk as calcium source as alternative to dairy products in the mixed diet is also illustrated.

Figure 3.2.8 illustrates the amounts of nutrients when 100 kcal is consumed of various potato products. Thus 100 g of boiled peeled potato contains the same energy as 18 g potato chips but has a negligible amount of fat, while more than 50% of the energy is derived from fat in potato chips.



	Protein	Fat	Calcium	Iron	Retinoleqv	Thiamine	Riboflavin	Niacin eqv	Folic acid	Ascorbic acid
Milk	178	186	295	12	84	112	333	191	52	0
Rice	62	20	15	36	0	222	16	250	28	0
Potato	67	5	8	74	0	125	56	340	102	430
Carrot	76	9	130	59	8000	203	136	383	213	456
Chickpea	1710	47	668	1840	27	133	44	183	300	0
Spinach	372	116	969	1250	7750	105	2090	1250	7580	8900
Papaya	39	8	83	210	833	103	69	119	0	4034

Figure 3.2.5. Nutrient content in per cent of recommended amount per 1000 kcal in various food items.

Source	Total gram	Energy kJ	Protein gram (E%)	Fat gram (E%)	Carbohydrate gram (E%)	Iron mg	Calcium mg	Vit C mg
Milk 3%	200	494	7 (24)	6 (45)	9 (31)	0.2	226	1.2
Bread (wheat/rye)	35	409	2 (9)	1 (10)	19 (81)	1.8	9	-
Margarine	20	624	-	16 (100)	0	-	-	-
Cheese	20	272	7 (44)	4 (54)	0.3 (2)	0.1	187	-
Apple	100	272	0.2 (1)	0.6 (8)	15 (91)	0.3	7	10
Total		2071	16 (14)	28 (50)	43 (36)	2.4	429	11.20

Figure 3.2.6. A mixed meal, in an affluent society, comprised of one glass of milk (200 ml), one slice of wholemeal bread (35 g) with margarine (20 g) a slice of cheese (20 g) and an apple (105 g) has a total energy content of 2071 kJ.

Source	Total gram	Energy kJ	Protein gram (E%)	Fat gram (E%)	Carboh gram (E%)	Iron mg	Calcium mg	Vit C mg
Rice	40	600	3 (8)	0.2 (1)	32 (91)	0.3	10	-
Chickpea	22	340	5 (23)	1 (10)	13 (67)	1.5	33	-
Spinach	19	20	0.2 (15)	0	1 (85)	0.1	5	4
Sesammilk	100	300	2 (11)	6.4 (78)	2 (11)	1.6	111	-
Oil	15	564	-	15 (100)	-			
Clementine	150	225	0.8 (7)	0.2 (3)	12 (90)	0.4	40	50
Total		2049	11 (9)	22.8 (41)	60 (50)	3.9	199	54

Figure 3.2.7. A vegetarian meal, in low income countries, composed of 40 g rice, 22 g chickpea, 19 g spinach, 100 g sesame milk, one clementine (150g) and 15 g vegetable oil has a total energy content of 2049 kJ.

	Raw potato	Boiled potato	Pommes frites	Potato chips
Amount (g)	124	104	30	18
Protein	2.2	1.7	1.3	1.0
Fat	0.6	0.6	5	6
Carbohydrate	21	22	12	11
Energy %				
Protein	9	7	5	4
Fat	5	5	45	54
Carbohydrate	86	84	48	44
Iron	1.4	0.7	0.4	0.3
Vit C	13	7	-	-
Thiamine	0.05	-	-	-
Niacin Eqv	1.8	1.3	-	-

Figure 3.2.8. Nutrient content per 100 kcal in various potato products. The figure illustrates that product development in affluent societies does not always lead to better products from the nutritional point of view. This also explains why dietary changes in affluent societies such as when boiled potato is substituted by potato chips lead to increased energy and decreased nutrient density in the diet.

### Change in dietary habits in Sweden

Blix classical studies of the dietary habits in Sweden showed that the nutrient density was the same in high-energy consumers, e.g. lumber jacks, and low-energy consumers, e.g. female office clerks. This indicated a potential risk of deficient intake of essential nutrients in low-energy consumers.

On the same time analysis of the change in life style and dietary habits during the 20th century showed a decrease in total energy turnover of about 30% in the Swedish population during the last 40 years and a simultaneous increase in energy density in the diet as a result of intake of empty calories, i.e. fat and refined sugar. As shown in Figure 3.2.9 the peak in fat intake occurred during the 1950's.

The result from studies on dietary habits motivated a campaign for better eating habits, and the Swedish National Board of Health and Welfare established an Expert Committee on

“Diet and Exercise” to formulate recommendations. The “Diet and Exercise” campaign which was started in 1971 and the uniqueness of this campaign was that dietary habits were discussed together with exercise habits from a public health point of view. The campaign also included a close collaboration between the health sector, athletic organisations, food producers and food industry in the campaigns as well as the use of health promotion in marketing food.

Despite all these efforts, nutritional perspectives on food production and agricultural policy in Sweden are meagre. The interest from the National Board of Health and Welfare for nutritional problems have deteriorated and the responsibility for nutrition and food policy has been taken over by the Food Administration and the Public Health Board, but with less resources and collaboration with athletic organisations and the food industry. Interestingly when the Diet and exercise campaign, which was unique inter-

## CONCLUSIONS

There are many ways to cover the nutrient and energy requirements by a combination of various food items. The essential point is to keep a certain nutrient density in the diet by combination of foods which makes it possible to cover the nutrient needs without leading to any malnutrition problems due to too low or too high intake of energy or certain nutrients. This calls for a certain basic knowledge of the nutritional value and characteristics of various food items. The more monotonous diet and lower physical activity as in a sedentary life, the greater is the risk to develop malnutrition problems. A mixed diet in combination with less sedentary life minimizes the risk to develop nutrition deficiencies and deleterious effects on health.

nationally ended, the United States started its program “Dietary guidelines for the Americans 2000” by stressing the ABC:s : Aim for fitness, Build a healthy base and Choose sensibly.

Also in an international perspective the impact of nutrition perspectives on food and agriculture policy is still very limited. UN-conferences in Rome 1974 (World Food Conference), 1992 (International Conference on Nutrition) and 1996 (World Food Summit), all have ended in recommendation to all countries to establish a national food policy. The 1974 conference rec-

ommended that all countries, affluent as well as low-income countries, need to establish a food and nutrition policy. This was further stressed in the 1992 conference which also called for a plan of action for food and nutrition policy. Interestingly in 1996 conference it was stressed that the food availability for the individual is not only a question of nutritional requirements but also a political question of human rights.

One of the reasons for the problems to get an impact of nutritional perspectives on food policy is that it interferes with agriculture and indus-

	1886-95	1896-1905	1906-15	1920-29	1930-39	1950-59	1989	1997
ENERGY kcal	2331	2708	2954	3036	3114	2825	2057	2116
PROTEIN g	63	74	81	82	87	73	75	82
FAT g	49	66	78	94	111	120	84	82
PROTEIN E%	11	11	11	11	12	11	15	16
FAT E%	20	23	25	29	33	39	36	34
CARBOHYDR E%	69	66	64	60	55	50	47	47

Figure 3.2.9. Nutrient and energy intake in Swedish population during 100 years.

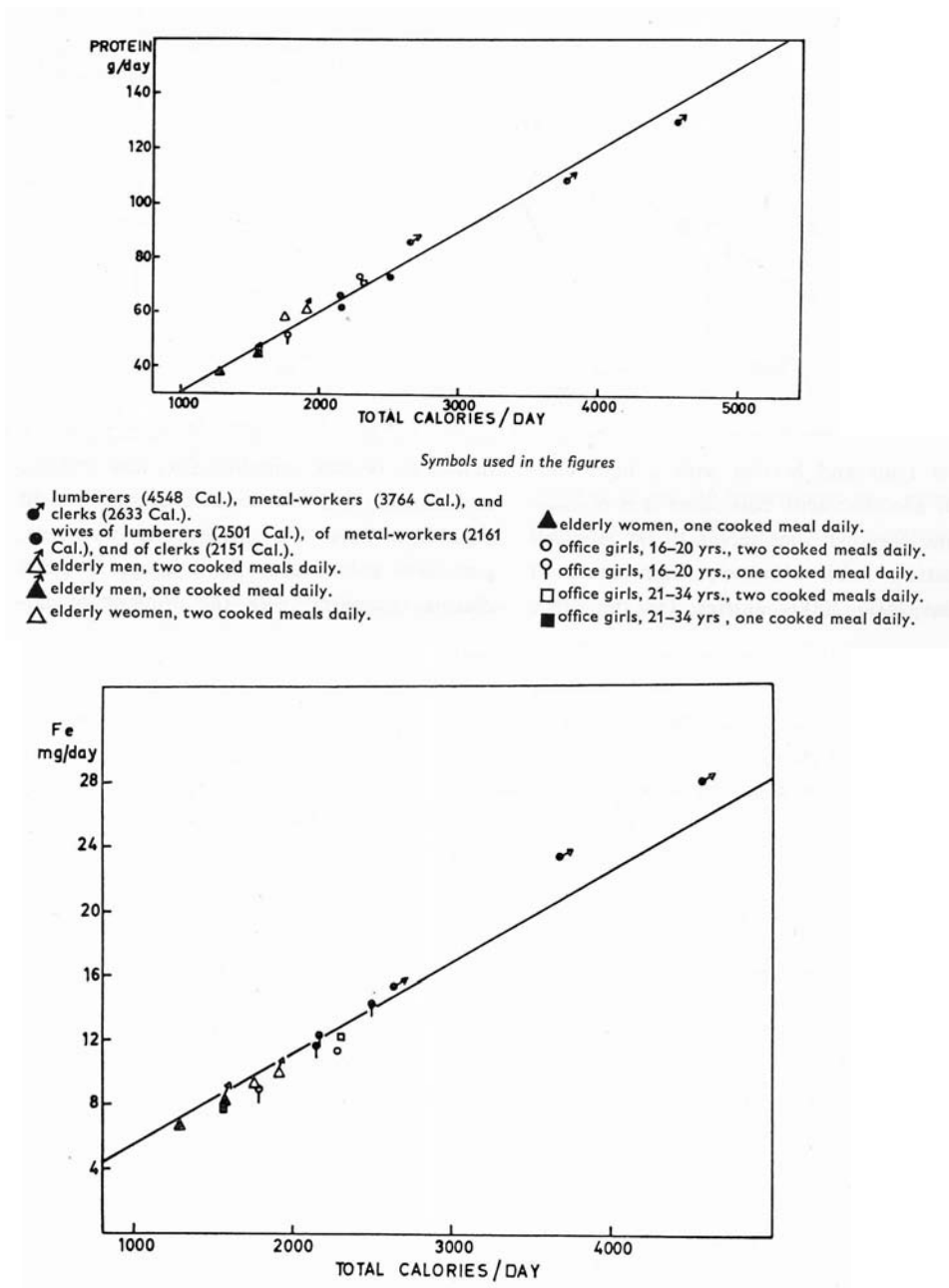


Figure 3.2.10. Relation between energy intake and some nutrients in Swedish population.

trial interests. Agriculture production and food industry are considered as positive factors and the consumer needs unfortunately as negative factors from national economy point of view. We are in the public health sector still fighting to get politicians and the market to recognize a healthy population as a human capital of at least the same economic value as industrial production. Without a good health there are no workers in the factories and the production per capita limited. Optimal nutrition is the key for productivity and socio-economic development in all societies.

### ENERGY TURNOVER

#### Energy balance and body composition closely related

The priority of dietary intake is to guarantee a normal body composition and body function. It is estimated that cell mass constitutes about 55% of the body weight and the extracellular tissue 30% and fat 15%, respectively, under normal conditions in a healthy adult man. Water is an essential component constituting about 73% of the fat free mass. Body fat is related to age and sex, which must be taken into consideration when the data are analysed. The fat content is also of importance for the endocrine (hormonal) function, especially in females. A body fat content less than 17% is assumed to be affiliated with disturbed menstruation.

Changes in body fat not only reflect energy balance, but also indirectly protein balance, which is influenced by the energy balance, and thereby secondarily also water and electrolyte

balance. Changes in body composition are consequently of great interest from the nutritional point of view. The body fat content is the major indicator of the nutritional status of the individual and consequently most methods to study body composition comprise methods to evaluate body fat.

From the nutrition point of view the problem of energy is essentially related to the balance between *energy intake* via the diet and *energy expenditure*, which comprises energy costs of body maintenance and function as well as physical work. As the body gives priority to cover its energy need and this can be covered from carbohydrate and fat as well as from protein, the energy turnover cannot be discussed separately from protein turnover.

This means that energy deficit leads not only to a mobilisation of energy stores but indirectly also has an impact on protein turnover and body function. Consequently methods to analyse energy balance are essential to evaluate the metabolic and physiological complications in all situations.

#### Energy store in the body

The immediately available energy source in the body is in the form of ATP and creatine phosphate. However as indicated in the table, from a quantitative point of view, they only constitute a negligible amount and at energy deficit the energy substrates stored in the body have to be mobilised almost immediately. Based on calculations of the available energy stored in the body,

## CONCLUSIONS

There is still an urgent need to get a better response from the politicians to recognize the impact of malnutrition, both over- and undernutrition, on public health and productivity in the population in both affluent societies and low income countries.

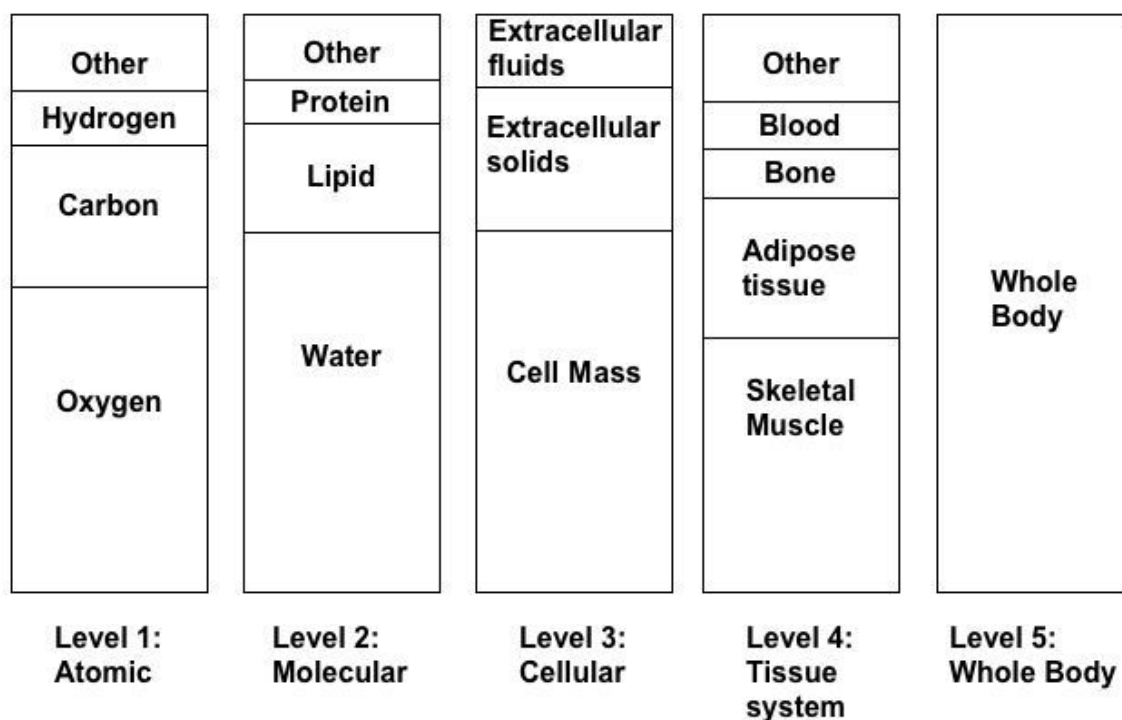


Figure 3.2.11. Various levels in compartmentalisation of the body composition.

see Figure 3.2.12, a normal person may survive 6-8 weeks without food.

Please observe that although the adipose tissue represents the biggest energy store, body protein constitutes a substantial fraction of the total energy store in the body.

The body gives priority to use carbohydrate as energy source. However, blood glucose only represents a minor role and while liver glycogen is available for total energy turnover in the body, muscle glycogen is only used as energy source in the same muscle and not for energy use in other muscle groups.

Body fat constitutes the dominant energy source in the body. However, the amount of fat in the cell membrane, often referred to as essential fat, is not mobilised during fasting state.

Energy source	Amount Content (kg)	Energy (MJ)	covers energy need during basal metabolism (hrs)
ATP	0.0005	0.002	
Creatine phosphate	0.015	0.006	
Carbohydrate	0,6	8.5	6-12 hrs (Liver glycogen)
Protein	14	32	10-12 days (only 50% can be used)
Fat	10,5	390	20-25 days

(The values refer to a male body weight 70 kg, body fat 15%, and 200 g protein/kg)

Figure 3.2.12. Energy store in the body.



Although the total protein content in the body might correspond to 20% of the weight only about 50% of the body protein, essentially skeletal muscle protein, can be mobilised as energy source.

During energy deficit leading to a negative energy balance the following stages can be observed in the change in mobilisation of endogenous energy:

Phase	Dominant energy source	Time span
1	Nutrient absorption in gastrointestinal tract	1–6 hours
2	Glycogenolysis	Day 1–3
3	Gluconeogenesis	Day 1–7
4	Ketosis (lipolysis)	After 3–4 days
5	Reduced gluconeogenesis Increased utilisation of ketone bodies in the central nervous system	After > 2 weeks

Figure 3.2.13. Mobilisation of energy in the body.

During the first hours after eating, the energy from food intake dominates as energy source. After this the first immediate available energy is derived from the carbohydrate sources, blood glucose, liver glycogen and muscle glycogen. Almost simultaneously the body starts to mobilize energy from protein breakdown resulting in gluconeogenesis. It is first at a later stage that the large energy store in the body, fat in the adipose tissue, is mobilised, ketosis and lipolysis. Please remember that the central nervous system uses carbohydrate as energy source and that it takes some time until it has converted to use ke-

tone bodies at energy deficit. This is one of the reasons why a negative energy balance already at an early stage leads to disturbances in protein turnover and muscle catabolism. Protein catabolism then secondarily results in disturbances in the electrolyte and endocrine balance, as they are regulated by hormones, which are proteins.

**The concept of BMI (Body Mass Index)**

Under normal conditions the best indicator of energy balance is a constant body weight. Daily variations in body weight are essentially influenced by changes in body water content, which is explained by the fact that water constitutes about 60-65% of body weight or about 73% of the fat free mass. However, in a longer perspective, the body weight indicates changes in fat stores in the adipose tissue and to a less extent by changes in muscle mass.

Based on this the concept of BMI as indicator of obesity was introduced. This is also known as Quetelet’s index and calculated as follows:

Body weight in kg / (height in meter)<sup>2</sup>.

BMI is used as indicator of total body fat, which is related to the risk of disease and sudden death. The score is valid for both men and women but it does have some limits. As increased muscle mass may also give rise to overweight and high BMI-values, it means that there is a risk to overestimate body fat in athletes and people with increased muscle mass. On the other hand BMI values may underestimate body fat in older persons with a lower muscle mass than the reference person.

### Classification of obesity by BMI

The BMI is often used in medical examinations as a health indicator and for risk evaluation of individuals in preventive health care. The following ranges are given using BMI score as indicator of the nutritional status of an individual.

Age (years)	Desirable BMI range
19-24	19-24
25-34	20-25
35-44	21-26
45-54	22-27
55-64	23-28
> 65	24-29

Figure 3.2.14. Desirable ranges of BMI with age.

	BMI
Underweight	< 18.5
Normal	18.5-24.5
Overweight	25.0-29.9
Obesity	> 30

Figure 3.2.15. BMI scoring.

The differential diagnosis between obesity and increased muscle mass as cause of high BMI values calls for analysis of total body fat using more specific methods. This is of certain interest for risk evaluation in individuals with high BMI values.

### Occurrence of obesity

As indicated in Figure 3.2.16 obesity represents a problem in affluent societies as well as low-income countries during the last decade

It is obvious that problems of obesity and dietary excess represent an increasing challenge for most societies where urbanisation increases. This could be described as a result of over-eating or under-exercising per se or in combination.

Country	Men	Women	Year
England	15	17	1995
Czech Republic	16	20	1988
Finland	14	11	1991/3
Netherlands	8	8	1995
Sweden 1988/89	5	9	
Iran 1993/94	3	8	
Kuwait	32	44	1994
Cyprus 1989/90	19	24	
Mali	1	1	1991
Mauritius	5	15	1992
Tanzania 1986/89	1	4	
South Africa black	8	44	1990
USA	20	25	1991
Brazil	6	13	1989
Australia	12	13	1989
China	0	1	1991
Japan	2	3	1993
Samoa (urban)	58	77	1991
(rural)	42	59	1991

Figure 3.2.16. Prevalence of obesity (BMI > 30) in the last decades.

Figure 3.2.17 shows the trends in prevalence (%) of underweight and obesity in female adults in a middle-income country such as Brazil. It illustrates the effect of nutrition transition during 1975 to 1997 and the occurrence of regional differences.

The figure illustrates that there is a trend to reduced underweight and increased obesity in both the poorest and the richest. The southeast region is however of special interest as not only obesity is more prevalent in the poorest than the richest in 1997, there is also an increase in underweight in the poorest from 1989 to 1997, and a decrease in overweight in the richest. These

## CONCLUSIONS

The best indicator of energy balance is a constant body weight.

Calculation of BMI is of great help as indicator of body fat for risk evaluation of obesity but has its limitations.

In short term perspectives changes in body weight are not reliable indicators of energy stores. Since fasting leads to mobilization of glycogen, which contains 2.7 g water per g glycogen, only 30% of weight changes of the immediate weight loss indicate changes in energy stores.

In long time perspective weight changes are better indicators of energy stores, as there is no water stored with fat in adipose tissue almost all weight changes are due to mobilisation of fat from the adipose tissue during nitrogen balance.

During energy deficit there is always an increased protein catabolism essentially from muscle catabolism initially.

changes might be due to rural-urban migration and changes in the socio-economic conditions.

### The energy equation

According to the first law of thermodynamics energy in must balance energy out, which leads to the following equation:

$$E_{\text{diet}} + E_{\text{store\#1}} = E_{\text{urine}} + E_{\text{faeces}} + E_{\text{miscellaneous}} + E_{\text{work}} + E_{\text{heat}} + E_{\text{store\#2}} + E_{\text{body temperature change}}$$

The energy intake side of the equation comprises the chemical energy bound in the food consumed (dietary intake) ( $E_{\text{diet}}$ ) and available in body stores ( $E_{\text{store\#1}}$ )

The energy “losses” comprises not only real losses from the body by excretion of components in urine and faeces but also components that represent the costs of metabolic turnover and the conversion of chemically bound energy from one energy source to another as well as to mechanical ( $E_{\text{work}}$ ) and thermal energy ( $E_{\text{heat}}$ ).

The equation also comprises the changes in body energy stores (i.e. glycogen in muscle and liver, fat in adipose tissue, protein in the muscles ( $E_{\text{store\#2}} - E_{\text{store\#1}}$ ) as well as in body temperature ( $E_{\text{body temperature change}}$ )

When the energy intake is higher than energy losses, the surplus is stored as energy reserve,

which may include a conversion between various forms of chemically bound energy (see below). An energy imbalance may also result in changes in body temperature.

### Conversion of energy intake via the diet to metabolisable energy

The energy content of foods is released during oxidation of the organic compounds protein, fat, carbohydrate and alcohol. Of practical importance is however to differ between the *chemically bound energy* which is released as a result of complete oxidation, and the *metabolically available energy* which takes into account the energy losses during synthesis and catabolism i.e. due to absorption ratio, costs for transport and storage, and excretion of waste products.

Thus the energy value of food items in absolute terms is not directly the same as the metabolically available energy. In order to estimate the metabolically available energy the energy content of food ( $E_{\text{diet}}$ ) should be reduced by the energy losses in urine and faeces:  $E_{\text{urine}} + E_{\text{faeces}}$ . Thus, although the physical energy value of protein is 23.6 kJ per g the metabolically available energy is only 17 kJ, since the metabolic cost of using protein as energy source is substantial, due to the costs of gluconeogenesis as well deamina-

Region and income group	Underweight BMI < 18.5			Obese BMI > 30		
	1975	1989	1997	1975	1989	1997
Brazil	13	8	7	6	11	12
Northeast region	16	10	8	4	8	13
25% poorest	18	11	10	3	5	8
25% richest	12	6	6	7	10	15
Southeast region	11	5	5	8	14	12
25% poorest	14	6	9	6	11	14
25% richest	7	4	3	8	14	9

Figure 3.2.17. Underweight and obesity prevalence in adult females in Brazil and its regions.

tion and urea excretion secondary to protein oxidation. This is a further reason for the waste of resources to use dietary protein as energy source in the diet.

The Atwater factors refer to the metabolisable energy (carbohydrate and protein 17kJ, fat 38 kJ) and were introduced in order to help to estimate energy intake from data obtained at chemical analysis of food constituents.

	<b>kJ/g</b>	<b>kcal/g</b>
Protein	17	4
Fat	38	9
Carbohydrate	17	4
Alcohol	29	7

Figure 3.2.18. Metabolisable energy.

### Are all calories “equal”?

Energy balance comprises the conversion of energy in various forms with different efficiency. “Man is built for carbohydrate oxidation”. Converting energy from protein means a substantial loss of chemically bound energy. Changes in the use of various substrates for energy store or utilisation may have an impact on energy regula-

tion (homeostasis) and result in various efficiency in energy utilisation as indicated in the example below:

Figure 3.2.20 shows that starting from the same energy substrates, based on glucose and a fatty acid (palmitic acid), the metabolism can be performed in two different ways, via direct oxidation (alternative 1) or in two steps (alternative 2) where part of the glucose is first converted to fat through lipogenesis and oxidised at a later stage. Interestingly the final production of energy differs depending on which metabolic way that is chosen. It is still not known to which extent and why the body can select the metabolic pathway, but this might have an impact of different tendency between individuals to become obese. Thus “inefficient” metabolic interconversion leaves 6% less energy available to perform other metabolic or physical work or to be stored in the adipose tissue! Consequently not only the type of energy substrate but also the choice of metabolic pathway, is as essential as the total energy intake for optimal energy balance, i.e. less risk to develop obesity.

Alternative 1	Alternative 2
<i>Oxidation in 1 step</i> $18 \text{ C}_6\text{H}_{12}\text{O}_6 + 2 \text{ C}_{16}\text{H}_{32}\text{O}_2 + 154 \text{ O}_2$ $\rightarrow 140 \text{ CO}_2 + 140 \text{ H}_2\text{O}$ $\text{RQ} = 0.91^*$ 906 moles ATP generated	<i>Oxidation in 2 steps</i> 1) $9 \text{ C}_6\text{H}_{12}\text{O}_6 + 8 \text{ O}_2$ $\rightarrow 2 \text{ C}_6\text{H}_{12}\text{O}_6 + 22 \text{ CO}_2$ $\text{RQ} = 2.75^*$ 12 moles ATP generated 2) $9 \text{ C}_6\text{H}_{12}\text{O}_6 + 4 \text{ C}_{16}\text{H}_{32}\text{O}_2 + 146 \text{ O}_2$ $\rightarrow 118 \text{ CO}_2 + 118 \text{ H}_2\text{O}$ $\text{RQ} = 2.75^*$ 840 moles ATP generated
* calculated respiratory quotient ( $\text{CO}_2 / \text{O}_2$ )	
<b>Conclusion:</b> Difference in generation of ATP 906 vs. 852.	

Figure 3.2.20. Efficiency in energy conversion differs depending on metabolic pathway used  
Example: Oxidation of glucose and palmitate (9:1) (cited from Simonson & DeFronzo, 1990).

Energy turnover in the body is based on oxidation

The release of energy in the body comprises an oxidation of the chemical components which leads to heat production, thermogenesis. The following forms of thermogenesis occur during the energy turnover in the body:

1. **Basal thermogenesis** Basal Metabolic Rate (BMR) refers to the energy needed for the basic function of the body, i.e. keeping body temperature, heart and lung function as well as the chemical processes in various metabolically organs that keep us alive, i.e. liver and kidney. BMR is measured under standardised conditions of thermal neutrality (around 25°C) when the body is at complete rest and not moving but awake. It is usually measured in the morning just after the individual has been awake. The lowest metabolic rate is usually recorded during sleep in the early morning (between 3.00 and 5.00 AM) and called sleeping metabolic rate (SMR). The amount of energy needed for maintaining the basal metabolic rate (BMR) in order to keep an individual healthy varies with the person's age, weight, and sex as it is related to the amount of active cell mass. Differences in body composi-

tion will consequently have an effect on energy needs. Changes in body temperature increases BMR with 10% per centigrade.

2. **Thermogenesis due to physical work**  
Any form of physical activity and muscular work, i.e. the conversion of chemically bound energy to mechanical energy, leads to heat production. The efficiency of the energy conversion to mechanical work in the muscles is calculated to be about 25%, i.e. equivalent to what is reported for a two-stroke engine. It seems to be the same for all, no matter if they are well trained or not. Better technique may however call for less muscle work in some individuals to perform physical work.

3. **Dietary induced Thermogenesis (DIT)**  
DIT (earlier called specific dynamic action, SDA) refers to heat production due to the oxidation of various chemical compounds in the liver as well as increased circulation of blood in the digestive tract. Maximal effect of DIT is observed about 6 hours postprandial. DIT usually represents 5-15% of the energy content of the substance, depending on the relative amounts of energy-yielding substrates.

4. **Environmentally induced Thermogenesis**  
Environmentally is essentially related to ther-

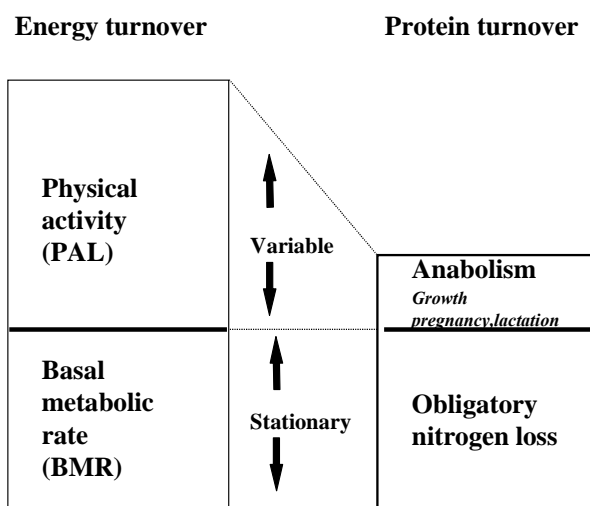


Figure 3.2.21. Stationary and variable parts of energy and protein turnover.

moregulation of the body. Optimal clothing can reduce the effect of the environment. However it is not only a problem of energy losses in a cold climate but also the cost of cooling at high temperature during sweat production.

### Energy and nutrient turnover

The energy turnover is based on essentially two compartments: the need to keep the basal metabolism and the energy needed for physical activity. During phases of growth and anabolism the energy costs of synthesizing tissues, e.g.

protein synthesis, and energy stores, e.g. fat and glycogen, should be added. The basal metabolic rate represents a stationary phase, which does not vary from day to day. The addition for physical activity may vary considerably from 0.25 to 20 times BMR (when lying continuously for survival or during short time heavy physical activity, respectively).

The turnover of essential nutrients, i.e. protein, minerals and vitamins, also comprises two compartments, one stationary phase which is related to the maintenance of various tissues,

Age	Men MJ/24hrs	Women Kcal/24hrs	MJ/24hrs	Kcal/24hrs
0-3	0.255W - 0.226	60.9W+54	0.255W - 0.214	61.0W - 51
3-10	0.0949W+2.07	22.7W+495	0.0941W+2.09	22.5W+499
10-18	0.0732W+2.72	17.5W+651		
19-30	0.0640W+2.84	15.3W+679	0.0615W+2.08	14.7W+496
31-60	0.0485W+3.67	11.6W+879	0.0364W+3.47	8.7W+829
>60	0.0565W+2.04	13.5W+487	0.0439W+2.49	10.5W+596

Figure 3.2.22. Calculation of BMR based on age, sex and body weight (W). Source: FAO/WHO/UNU 1985.



and a variable phase which is related to periods of anabolism, i.e. during growth, convalescence, pregnancy and lactation when new cells are formed. The stationary phase is by far the dominant part.

BMR, which is related to fat free mass (FFM), will be rather stable from day to day and can be calculated by means of equations based on empirical data.

The 2005 report from FAO/WHO/UNU developed new equations for predicting energy expenditure in infants and boys and girls and reported 18-20 per cent lower energy requirements for boys and girls under the age of 7 years, 12 and 5 per cent lower values for boys and girls, respectively, between 7 and 10 years of age, and 12 per cent higher for adolescent boys and girls when compared to the values given in the 1985 report. No changes were suggested for the equations given for adults.

During some periods in life energy is needed for building new tissues, i.e. growth. This comprises not only the energy stored in the tissues but also the energy costs for synthesis and building up new tissue. This is especially commented in the 2005 version of the energy requirements.

### The concepts of BMR factors and PAL levels

The total energy turnover comprises basal metabolic rate (BMR) as well as the energy needed for daily life. Based on large population studies, equations have been established in order to calculate BMR with reasonable accuracy based on anthropometrical data (weight, length, age and sex) (FAO/WHO/UNU, 1985). In order to calculate the total daily energy needs, information of life style of the individual must then be known, i.e. time spent on various forms of activities (sleeping, sitting, walking, household work) in addition to basic anthropometric data (age,

### Exercise

Calculate your own BMR by filling in your data below and use the accurate equation

Sex      Male/Female

Age      ..... Years

Weight      ..... Kg      Equation used:

Result      MJ/Kcal

sex, height and weight) for calculation of BMR.

In the 1985 version of the international energy and protein requirements (WHO/FAO/UNU 1985) the daily energy requirement of man expressed as multiples of BMR (BMR factors) was first introduced.

Various activities in daily life as well as during various forms of physical activities should be expressed as multiples of BMR, often characterised as BMR-factors (FAO/WHO/UNU, 1985; James & Schofield, 1990), PAR (physical activity ratio) or MET-values (MET = metabolic energy turnover) (Ainsworth et al, 2000). In this case the BMR or MET-factor multiplied by the minutes of physical exercise times BMR (expressed per minute) gives the total energy turnover for that specific activity (FAO/WHO/UNU, 1986).

The total energy turnover (ET) per 24h can then be calculated based on BMR with the addition of energy for various physical activities based on intensity and duration throughout the day. The total energy turnover (ET) in relation to BMR *per 24 hour* is an indicator of the *Physical Activity Level* (PAL) of the individual, thus expressing the life style. This concept of lifestyle includes physical activity during work as well as during leisure time.

Category	PAL value
Sedentary or light activity lifestyle	1.40 – 1.69
Active or moderately active lifestyle	1.70 – 1.99
Vigorous or vigorously active lifestyle	2.00 – 2.40*

\* PAL values > 2.40 are difficult to maintain over a long period of time

Figure 3.2.23. Classification of lifestyles in relation to the intensity of habitual physical activity or PAL (FAO/WHO/UNU 2005).

*Sedentary light activity lifestyles* occur in those who are only occasionally engaged in physically demanding activities during or outside working hours (PAL around 1.55). Active or moderately active lifestyles refer to individuals with sedentary occupations who spend a certain amount of time in moderate to vigorous physical activities (PAL around 1.75). *Vigorously or vigorously active*

*lifestyles* refer to those who are regularly engaged in strenuous work or strenuous leisure activities for several hours a day.

The 2005 report also stresses that extremely low energy expenditure (i.e. PAL=1.27 in the 1985 report) allow for survival but are not compatible with long term health and that food supply should satisfy a PAL of 1.40, i.e. the lower limit of sedentary lifestyle, also in short-term relief interventions.

To calculate a person's daily energy need, his or her BMR value should be multiplied with the relevant PAL value.

Figure 3.2.24 shows the changes in energy turnover in a male subject with age during his active working period. The y axis refers to MJ per 24 hours and the columns illustrate total energy turnover with age as a result of differences in body size and body composition and how this has an impact on total energy turnover related to various physical activity levels with age, using the WHO equation. The values refer to a nor-

### Examples of daily energy needs (24 hrs) = BMR x PAL

#### Example I:

A 33-year-old woman weighs 55 kg. She does housework and cultivates her fields. She has a heavy physical activity level so her PAL is 1.82. Her BMR is calculated to be 1308 kcal/day (5.47 MJ) and her daily energy needs are:

$$5.47 \times 1.82 = 9.96 \text{ MJ (2380 kcal)}$$

Please note that according to statistics she does not “work” although she has a high PAL

#### Example II:

A 25-year-old man, weighing 60 kg who usually has a moderate PAL level (1.78) is biking 2 hours at a speed of 15 km per hour (MET=4.0). This leads to a total energy turnover of 4 times BMR during these two hours and will increase his PAL level from 1.78 to 1.97

$$[(22 \text{ hrs} \times 1.78 + 2 \text{ hrs} \times 4)/24 = 1.97]$$

mal healthy male with office work but keeping his fitness by regular training during life making it possible for him to participate in strenuous endurance activities (300 km bicycle races) up to the age of 60. From his body size data his BMI can be calculated and shows an increase from 18.9 at the age of 15 to 24.2 at the age of 60. The increase is partly due to increase in weight but also to a slight reduced height with age. The

weight change is essentially due to increased body fat while the muscle mass may even have decreased at least during the last decade. Thus the fat free mass, which is metabolically active, has probably decreased both in relative and absolute amounts. However, this is taken into consideration when BMR is calculated as the equation based on total body weight is different for various ages.

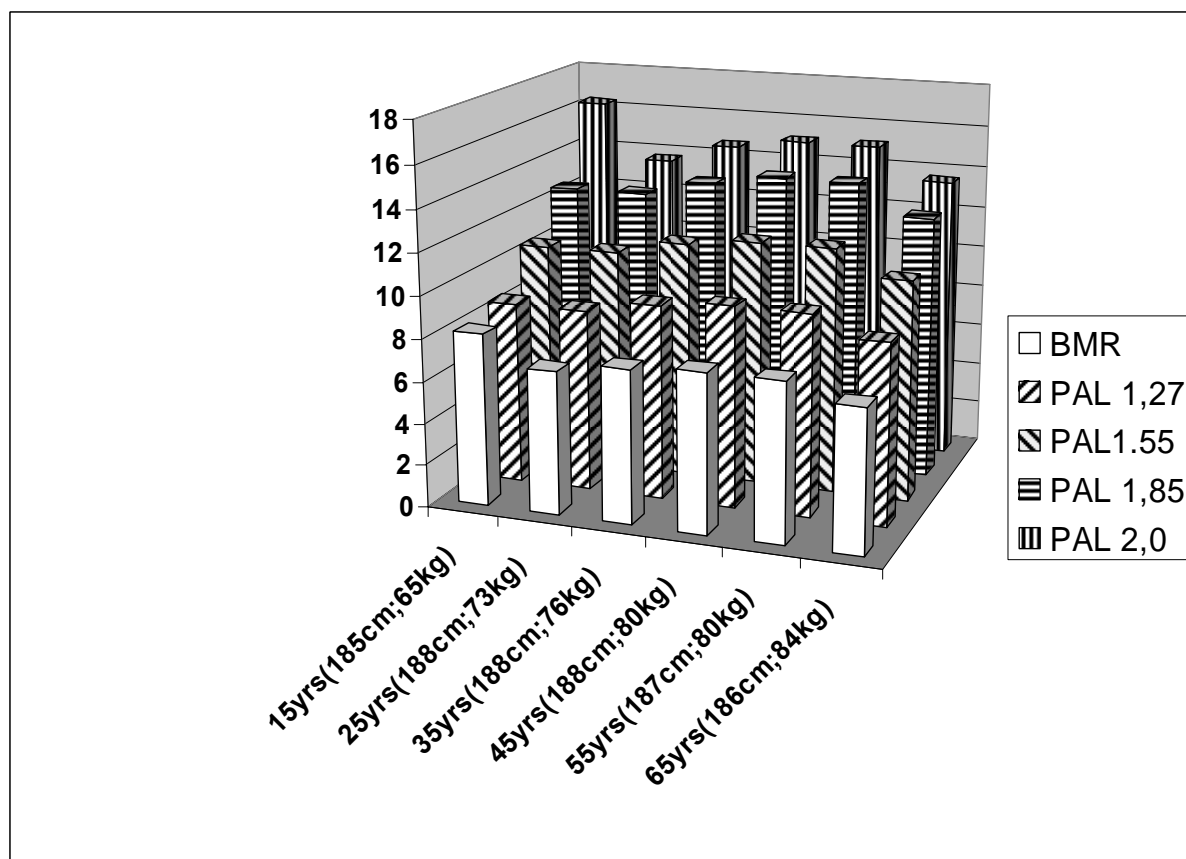


Figure 3.2.24. The effect of weight and physical activity with age in a male subject on total energy turnover.

<b>Males</b>		<b>Females</b>	
<b>Activity</b>	<b>BMR-factor</b>	<b>Activity</b>	<b>BMR-factor</b>
Sleeping	1.0	Sleeping	1.0
Lying and sitting quietly	1.2	Lying and sitting quietly	1.2
Standing	1.4	Standing	1.5
Walking slowly	2.8	Walking slowly	3.0
-“- uphill	4.7	-“- uphill	4.6
Office work	1.3	Cooking	1.8
Sitting weaving	2.1	sweeping house	3.0
Sharpening axe	1.7	Washing dishes	1.7
Tailoring	2.5	Washing clothes	3.0
Carpentry	3.5	Fetching water from well	4.1
Driving lorry	1.4	Grinding grain	3.8
Bricklaying	3.3	Bakery	2.5
Feeding animals	3.6	Laundry work	3.4
Milking cows by hand	2.9	Weeding	2.9
Loading manure	6.4	Harvesting root crops	3.1
Cutting sugarcane	6.5	Picking coffee	1.5
Cutting trees	4.8	Cutting fruit from trees	3.4
Fishing by spear	3.3		
Sawing by hand	7.5		
Pedalling rickshaw	7.2-8.5		
Mining, shovelling	5.7		
Jungle march	5.7		

Figure 3.2.25. Gross energy expenditure in specified activities (from WHOFAO/UNU 1985).

In Figure 3.2.25 a number of BMR-factors are listed to exemplify the increase of energy turnover in relation to BMR for various activities. The reader can find a more complete list in the WHO/FAO/UNU publication of 1985. The corresponding BMR-factors during various sport activities (in this case called MET-factors) have been published by Ainsworth and collaborators, the latest version in 2000.

For more detailed information of BMR-factors for various activities the reader is referred to publications by FAO/WHO/UNU 1985, 2005 and Schofield et al 1990.

### International reports on energy requirement

Energy and protein requirements have been analysed throughout the years and several international reports from FAO and WHO have been published, the latest in 2005. There have been

some changes in the approach throughout the years. In 1949 it was stated that if a person was in good health and energy balance, i.e. neither over nor underweight, then he/she is consuming food according to his/her energy requirement. In the 1950-57 edition the energy requirements were based on estimates of energy expenditure and the energy needs of a group is represented by the average of the individuals in that group. The energy requirement of a reference man or woman constituted a baseline for the assessment of energy needs of a population in general. The 1973 edition of the report stressed that the estimates should be based on individuals rather than groups and the concept of reference man or woman was rejected. The 1985 edition of FAO/WHO/UNU report on energy requirement stated that the actual energy intake in populations in developing as well in developed coun-

tries might not necessarily be optimal. BMR was introduced as a conceptional framework and the concept of BMR-factor of PAR (physical activity ratio) was introduced. The 2005 edition further stressed the different requirements for populations with various lifestyles and levels of habitual physical activity already from the age of 6. New values for infants, children, adolescents, and for additional energy during pregnancy and lactation were introduced. Interestingly the 2005 report on energy requirement also included recommendations for levels of physical activity required to maintain fitness and health.

The 2005 report also stresses that the term “lifestyle” is preferred to “occupational work” and the 24hr PAL should not be based on physical effort demanded by occupational work but on the total life style including activities in spare time, i.e. discretionary physical activities. Earlier differences in PAL and PAR values for men and women in the 1985 edition of the recommendations were rejected as BMR values are already gender specific, which consequently indirectly are corrected for when PAR-values are converted into energy units by multiplying with BMR.

## ASSESSING ENERGY AND NUTRIENT BALANCE

Are requirement and recommended daily allowances equivalent to optimal nutrition? For each nutrient there is a range of intakes from minimal requirement to prevent nutrient deficiency diseases to toxic levels. Somewhere in-between is what is defined as *optimal intake*. According to the original definition, requirement refers to the minimal nutrient intake needed in order to prevent nutritional deficiency diseases. As this may differ between individuals according to a statistical normal distribution the mean value of minimal requirement is used and called Estimated Average Requirement (EAR). The recommended dietary allowance (RDA) is defined as the mean of requirement for a special population group (EAR) + 2 standard deviations, thereby covering 97.5% of the need of a normal population. The Upper Limit (UL) refers to the level above which toxic effects may occur. For most nutrients there is an upper limit although the safety margin may be very great. Figure 6 also indicates where an adequate intake (AI) is. With

## CONCLUSIONS

The concept of BMR-factors makes it easier to calculate the energy turnover in various individuals as it takes in consideration the cost of energy in relation not only to the activity per se but also in relation to the body size and composition.

It is essential to recognize that the concept of lifestyle does not only include special physical activities due to more or less athletic performances but a continuous analysis of the daily activities throughout 24 hrs, i.e. number of hours sleeping, sitting, walking doing household activities in addition to energy costs during working hours and specific physical activities during leisure time.

Please note that at sedentary life with office work and much sitting, still the PAL-value is around 1.5. As BMR can be calculated from an individual's age and sex it is thus easy to make an estimate of the daily energy needs at sedentary life by using multiplying the BMR value with 1.5. Any intake below that value will lead to energy deficit, indicated by weight loss.

A dietary energy intake below 1.5 times BMR in an individual who has a constant body weight thus indicates that there are methodological problems in the dietary assessment.

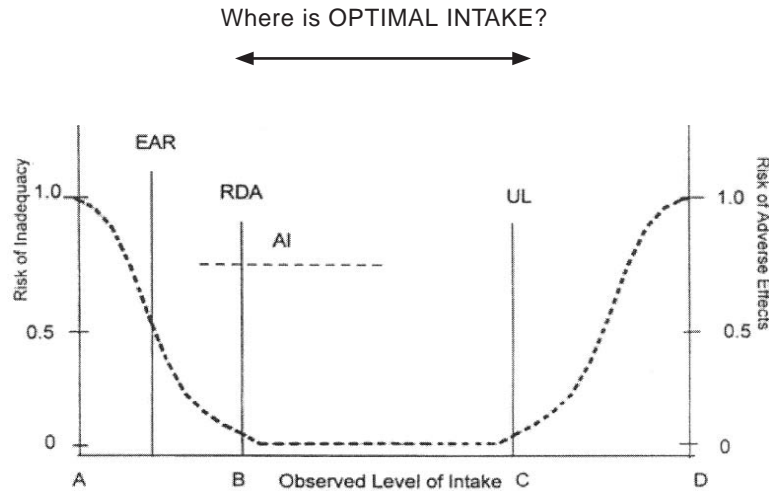


Figure 3.2.26. Schematic illustration of the relation between requirements optimal intake. Dietary Reference intake (DRI); Recommended Dietary Allowances (RDA); Estimated Average Requirement (EAR); adequate intake (AI) and tolerable upper limit (UL).

respect to energy intake there is little margin for effects of too low or too high intakes. Energy deficit leads to metabolic disturbances while overconsumption of energy leads to obesity and its clinical consequences. For most other nutrient however there is a safety margin as changes can be balanced by increasing or reducing body stores which have no effects on the metabolism under normal conditions.

However, a better distinction between the concepts “requirement” and “optimal intake” of nutrients is urgently needed. The mere fact that a more optimal restitution post-exercise is reached at a higher nutrient intake does not necessarily mean that there is an increased requirement as such in order to counteract any potential nutrient deficiency. This further accentuates the need to differentiate between various activity periods, whenever discussing the concept of nutritional perspectives on nutrient turnover

and its relation to physical activities and work performance.

Based on the concept of BMR and PAR it is obvious that there is a direct relation between the energy intake and energy balance on the one hand and that energy restriction will have a direct impact on physical performance and work capacity. It is only when the basic metabolic energy needs are covered that energy will be available for physical work. The most effective way of increasing work capacity of the labours is consequently to guarantee optimal energy intake in relation to work performance.

The cost of increasing work capacity in an individual leading to an increase of the PAL value from 1.70 to 2.00 in a 60 kg 25 year old man means an additional need of about 500 kcal (2.1 MJ). This investment of extra 18% of his daily energy turnover (corresponds to 4 glasses of milk, 100g potato chips or 80 g chocolate



## CONCLUSIONS

The impact of over- and under nutrition differs between energy-yielding nutrients and essential nutrients. It is still somewhat difficult to give the exact values for requirements for various nutrients as there is a biological variation between individuals. Consequently all requirement data are based on a statistical analysis of a normal distribution in individuals.

To obtain energy balance is of special concern since over- and underintake immediately leads to metabolic disturbances. For most other essential nutrients a slight positive balance can always be compensated for by increasing the stores without any metabolic disturbance.

bars) converts him into a vigorously active and probably also more healthy young man. The cost-benefit for the employer of food subsidies in preventive health care systems for the workers is thus obvious.

### Assessing energy balance

Energy occurs in the biological system in the following forms:

1. chemical energy
2. mechanical energy
3. physical energy
4. electrical energy
5. radiation energy

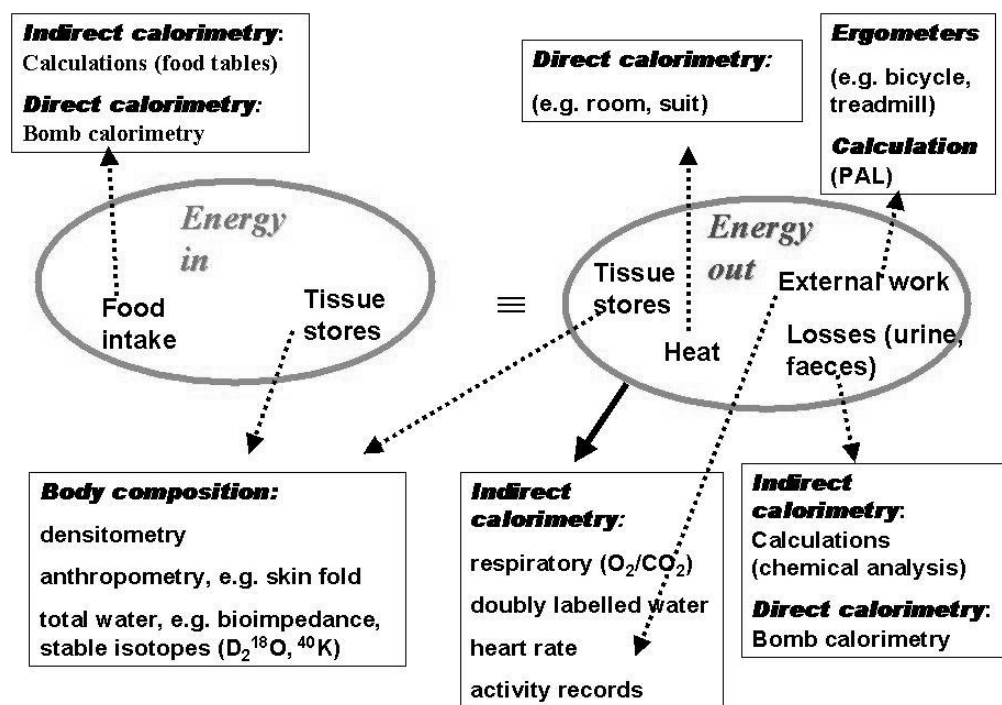


Figure 3.2.27. How to study the energy balance equation; schematic illustration of various compartments in analysis of energy balance in man.

Before analysing the methodology regarding energy balance studies it is essential to remember that energy turnover is following the first law of thermodynamics, i.e. energy cannot be lost, neither produced. The whole problem of energy balance is a question of conversion between various forms of energy. This also means that all studies on energy balance must include methods, which can analyse various forms of energy.

Methods for energy turnover studies are usually referred to under the term calorimetry. This is in many ways an inaccurate terminology as calorimetry refers to measurement of heat (calor=heat, metry=measure). However, most methods of today do not measure heat production as such, but indirect results of energy turnover, often called indirect calorimetry, which of course is also inaccurate, as it is still not a measure of heat production.

### Direct calorimetry

Direct calorimetry refers to the assessment of heat production as a result of oxidation of substrates during energy turnover. In food and excretes this can be made using bomb calorimetry, and in man and animal by means of calorimeter rooms or calorimeter suits.

The heat production is the summary of the following parameters:

- 1) Changes in body temperature;
- 2) Losses through expiration of water through skin and respiratory system

- 3) Conduction, (heat losses through skin)
- 4) Convection, (radiation from body surface).

### Indirect calorimetry

Indirect calorimetry is based on measurement of oxygen consumption and carbon monoxide production as indirect indicators of the oxidation. Using double-labelled water technique changes in water production as indicator of oxidation is also used for measurement of energy turnover. Measurement of heart beat frequency and physical activity by means of ergometer equipment and activity diary are other examples of indirect calorimetric methods.

Indirect calorimetry is usually easier to perform under field conditions but has its limitations as well. First it only gives information about total energy turnover, but in combination with direct calorimetry there is a possibility also to study more in detail changes in substrate oxidation in the regulation of energy turnover.

### Assessing dietary intake

There are several forms of methods used for studies on dietary intake, both retrospective and prospective, based on anything from personal interviews, records, and use of food frequency questionnaire to double portion technique. Each of them has its pros and cons. There is no single golden method for estimation of the dietary intake without error, and the goal of the study is of utmost importance when selecting the optimal method for dietary assessment. Furthermore,

<b>Energy intake</b>	<b>Energy turnover in man</b>	<b>Nutritional Status</b>
Assessment of dietary intake using recall and record methods	Calculation of BMR based on anthropometrical data Heart frequency recording Activity recording (diary) Mobile respiratory calorimetry Doubly labelled water	Anthropometrical data (weight, height, skinfold)

Figure 3.2.28. Indirect calorimetric methods for assessment of energy turnover adapted for field studies.

different types of errors have different effects in analysis and interpretation. Consequently, data collected by means of one dietary assessment aimed to study the intake of one nutrient may not necessarily be as valid to evaluate the intake of another nutrient.

### Validation of dietary assessments

Dietary assessments will almost without exception result in an underestimation of energy intake. Energy turnover should consequently be based on studies of energy expenditure based on calculated BMR with the addition for the cost of physical activity. The energy equation fulfils the

first law of thermodynamics, e.g. energy cannot be created nor destroyed, and it can only be transferred from one form to the other. Available energy from energy intake must balance energy turnover if bodyweight is stable and body composition unchanged during a certain length of time. Thus an objective and reliable reference to validate obtained data on dietary intake can be based on a comparison between the observed or registered energy intake (EI) and the theoretical calculations of energy turnover based on calculated BMR with the addition of a relevant PAL factor.

Method	Coverage	Advantage	Disadvantage
Dietary history	All food items or selected items	Long-term perspectives of dietary habits Individual data	Time consuming Skilled interviewer needed Memory demanding Quantitative data difficult to obtain Variations in dietary habits lost
24h recall	All foods	Relatively rapid and simple Can be repeated Individual data	Selection of interview day critical Quantitative data difficult to obtain Skilled interviewer needed
Food frequency Questionnaire (FFQ)	Only listed food items	Rapid and simple Easy to computerize Large groups covered by mail	Restricted number of food items Memory depending No direct contact with interviewer
Food records	All foods	Individual data Intake during various days Quantitative data	Selection of day critical Dietary intake may be affected Needs resources Time consuming Collaboration necessary
Double portions	All foods	Exact data on nutrient content possible (not depending of accuracy of food tables)	Dietary intake may be affected Resource demanding Collaboration necessary

Figure 3.2.29. Summary of various methods for dietary assessments.

<b>Step</b>	<b>Procedure</b>	<b>Example</b>			
1.	Collect antropometric data (Age and sex, body weight, height)	Female, 21 years, weight 57 kg; height 171 cm			
2.	Verify that bodyweight has not changed = energy balance	Stable body weight			
3.	Calculate energy intake (EI) From dietary assessment	8936 kJ			
4.	Calculate BMR according to FAO/WHO/UNU 1985 equation	5585 kJ/24hr or 233 kJ/h			
5.	Analyse physical activity from training report and life style (hours of sleep, sitting, walking etc)	<i>occupation</i>	<i>hrs</i>	<i>BMRfactor</i>	<i>Energy (kJ)</i>
		Sleep	10	1	2330
		Work 8 hrs (laundry work)	7	3.4	5545
		Training (biking 30 km/h)	1	12	2796
		Sitting, Reading, TV	1	1.3	303
		Walking	1	2.5	583
		Household	2	2.5	1165
		Misc.	2	2.5	1165
6.	Calculate total energy turnover (ET) using BMR-factors (see step 5)	ET = 13887 kJ			
7.	Calculate PAL factor based on ET (step 6)/BMR(step 4)	ET/BMR = 2.4			
8.	Compare estimated EI from dietary assessment (8936 kJ) with				
	a. estimated BMR (5585 kJ)	EI/BMR = 1.6			
	b. estimated ET from theoretical calculations of BMR and PAL	EI/ (BMRxPAL): 0.64			

Figure 3.2.30. How to validate dietary assessment by comparing energy intake (EI) and energy turnover (ET) based on BMR and PAL including one practical example.

Comments: The EI/BMR-ratio is 1.6, e.g. only covers the normal energy turnover in an individual with a sedentary life style. This is quite different from her PAL according to life style and training record (2.4). If the dietary assessment is right there is consequently no room for physical training and her activity record is wrong. If on the other hand her physical activity record is right, the recorded energy intake represents only 64% of calculated ET (8936kJ vs. 13887kJ). This means a serious negative energy balance, which will affect body weight and body composition. If bodyweight is stable a more probable explanation is an under-evaluation of dietary intake. Please note that 1 h intensive training represents about 50% of the energy turnover at her work. If this training was exempted her PAL would be reduced to about 2.1.

The most probable explanation is that the registered dietary intake has been too low or that the registration was not performed under the same conditions as the physical activity registration if the body weight is kept constant. In this case only limited conclusions regarding the dietary intake can be drawn.

### PHYSICAL PERFORMANCE AND NUTRITION

The relation between dietary intake and physical performance can be divided into four different aspects:

- Dietary habits in order to keep optimal nutrition (energy vs. nutrient balance)
- Dietary intake before a physical performance (loading phase)
- Dietary intake during performance (compensatory phase)
- Dietary intake immediately after a performance (recovery phase).

Increased physical activity is essentially a question of increased energy turnover, while the turnover of essential nutrients is usually not related to energy turnover to such an extent that there is a need for increased intakes. To what extent the intake of essential nutrients is a valid problem is mainly due to two other factors: (i) is there energy balance? and (ii) is the diet nutritionally balanced?

The principle behind any dietary advice in relation to work performance is that energy need

should be covered and fluid losses compensated, as well as that all essential nutrients, i.e. vitamins, minerals, fatty acids, are consumed in adequate and *balanced* amounts. The meal pattern should also be adjusted to the daily schedule.

### Substrate utilisation during muscle work

The effect of physical exercise is not only related to energy turnover as such. Physical exercise also has an impact on substrate utilisation and may help the individual to balance his/her body composition, metabolic regulation and homeostasis.

Muscle activity leads to increased energy turnover and substrate oxidation in the muscle tissue.

Figure 3.2.31 illustrates the oxidation of carbohydrate, fat and protein during 24 hours and the effect of physical exercise (indicated by whole line) at fast and feeding (indicated by the striped line). The two figures show the substrate utilisation at normal protein intake, e.g. 1 g per kg body weight and at a high protein intake, e.g. 2.5 g protein per kg body weight. The relation between the non-protein energy sources, carbohydrate and fat, being the same in both cases.

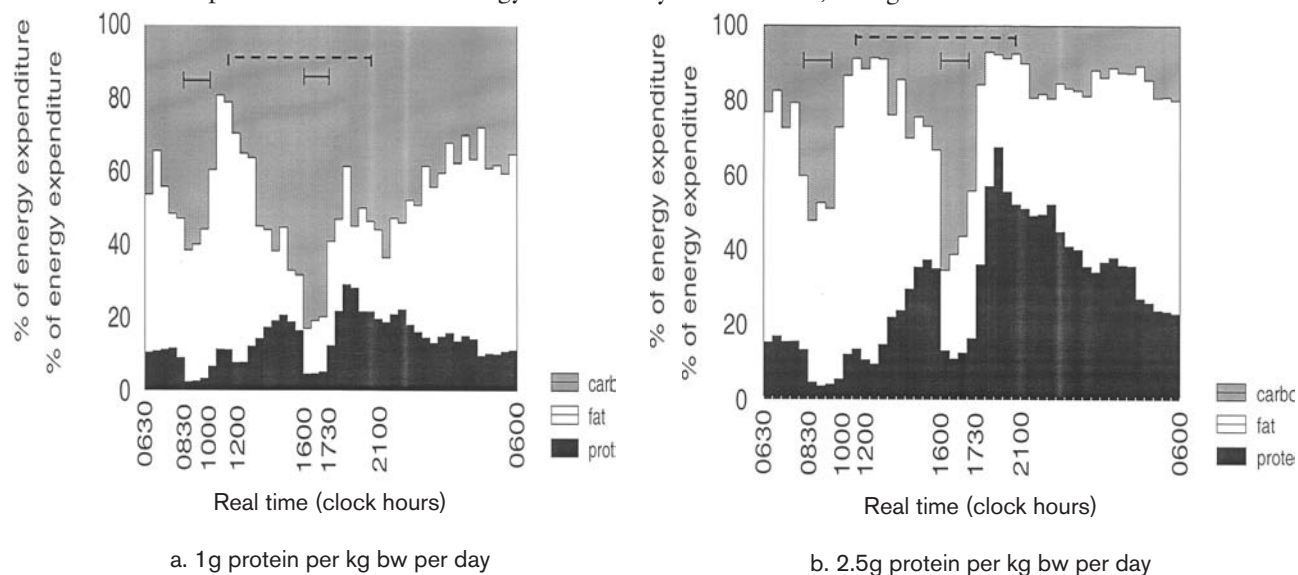


Figure 3.2.31. Effect of physical work on substrate utilisation at normal and high protein intake at energy balance (Forslund et al, 1999). The line indicates physical activity (biking 100W during 180 minutes). The striped line indicates food intake similar portions every hour during 9 hours).

During physical activity (indicated by whole lines), which was performed on a bicycle ergometer, in a fasting state and during eating (continuous meal intake indicated by striped line), the carbohydrate oxidation increased on both diets, while the protein oxidation decreased. Thus although protein oxidation is increased during muscle activity the relative proportion of protein as energy source is decreased. This illustrates the wellknown fact that carbohydrate is the substrate of choice during physical exercise, and that muscular work does not lead to a relative increase in protein oxidation. Although exercise leads to increased oxidation of all energy substrates, the relation between carbohydrate, fat and protein oxidation is different when fasting and feeding. The diagrams illustrate that during fast, fat oxi-

dation is high while during feeding most energy is covered from carbohydrate.

By comparing the figures one can also see that a higher protein intake leads to increased protein oxidation, which is due to the fact that protein can not be stored to any extent in the body and the overconsumption must be balanced by increased oxidation. Thus there is no advantage with a high protein intake for the protein balance. Please note that at high protein intake the relative contribution of carbohydrate is reduced and from fat increased. Thus it seems as a high protein intake leads to increased fat oxidation and reduced carbohydrate oxidation. This might partly explain why high protein intakes in some dietary prescriptions for reducing body weight may have an impact on body fat.

## CONCLUSIONS

Before drawing any conclusions between recorded dietary intake and potential health risks both in retrospective and prospective aspects, the data obtained from dietary assessments must be validated. The easiest way to do this is to analyse the life style of the individual in order to estimate the relevant PAL-level and to calculate the BMR of the same individual. In case the individual has a constant body weight, she or he can be assumed to be in energy balance and if the total energy turnover per 24 hr indicates a PAL-value lower than 1.6 in a sedentary individual there has most probably been an underestimation of the dietary intake. Please note that most methods for dietary assessment show an underestimation of about 25-30% for various reasons as commented above.

### Metabolic stress secondary to physical work

Physical stress will have an impact on metabolic turnover both on a short-term as well as on a long-term perspective. In both cases increased energy turnover, which is not balanced with an increased energy intake, leads to energy deficiency and secondarily a metabolic stress. This should be compared to our knowledge that malnutrition also leads to a metabolic stress syndrome as a result of catabolism and tissue damages. Similarly, a too high-energy intake also

leads to malnutrition, and the development of a metabolic syndrome and obesity. There are also indications that too high intake of certain nutrients will stress the metabolic turnover and lead to an impaired immune defence.

It is not only a physical but also a psychological stress that may lead to metabolic disturbances. Thus a psychological stress has been related to disturbed magnesium and zinc turnover and deficiencies of magnesium and zinc related to irritability, aggressiveness and lack of concentra-



tion. The mental stress has been suggested to be involved via the sympathetic nervous system in the pathophysiology of the characteristic insulin resistance or metabolic cardiovascular syndrome in young men.

Chronic stress, whether psychological and/or physical, exerts an intense effect upon body composition, which in turn, significantly affects longevity and survival of the organism.

Stress is followed by specific endocrine abnormalities followed by accumulation of intra-abdominal, visceral fat masses and insulin resistance, which may end in the development of a metabolic syndrome.

### **Effect of shift work on energy and nutrient requirement**

A specific metabolic stress from the nutritional point of view occurs in shift workers. An increasing number of individuals have irregular working hours. This affects their meal pattern. The human body has an endogenous circadian rhythm for body temperature and endocrine regulation. There is however still only limited knowledge on how the body reacts metabolically to changes in the meal pattern and food intake especially during night shifts.

Several studies have shown that shift workers have problems to keep a normal eating schedule

which leads to problems such as anything from loss of appetite to diarrhoea and obstipation. As a result they are at high risk for developing gastrointestinal problems, e.g. ulcer, as well as obesity and heart disease. It is typical that shift workers especially during night work consume more snacks and eat more fast food and sweets, drinking coffee and exercise less.

Most data indicate that altered dietary habits should be encouraged in shift workers. In most cases however it is recommended to schedule regular meals, to cut back on highly seasoned foods and fried foods and fast food high in fat. Several healthy small meals/snacks throughout the shift instead of larger meals have been recommended and the increased use of light meals including fruits and vegetables, low fat dairy products.

### **Impact of energy and nutrient intake on physical performance**

Subnormal levels of one or more nutrients in body fluids can not be taken as an indicator that there is a nutrient deficiency which calls for food supplements, unless the energy needs are covered. Several studies indicate that subnormal levels of nutrients can be restored by means of a well-balanced diet consumed in adequate amounts to cover energy requirement.

## **CONCLUSIONS**

Analysis of substrate utilisation indicate that there is no need whatsoever of an increased protein intake during hard physical activity or high work load as in heavy industry. The essential factor is that the dietary intake covers the energy need at an increased work load in order to counteract a catabolism in the body. A normal diet comprising 12-15 energy per cent protein is sufficient to cover the protein needs.

During hard physical work load leading to a high energy turnover, an increased dietary intake of energy is essential. As long as this is covered by conventional diet, the nutrient density is of minor importance. However at less energy turnover e.g. at office work and a sedentary life, there is a need to have a higher nutrient density.

Food supplements may be motivated in order to increase body stores and thereby physical capacity, e.g. carbohydrate loading, or to compensate subnormal plasma levels of certain essential nutrients, e.g. vitamin and mineral supplements. The use of supplements to increase psychological capacity, e.g. B-vitamins against anxiety, branched-chain amino acids against central tiredness, has also been reported but is controversial.

Several nutrients have been described to be associated with physical working capacity and available data indicate that physical fitness and working capacity may be affected by subclinical forms of vitamin and iron deficiency.

Iron nutrition is a classical example of the importance of nutritional status on oxygen uptake and physical work performance. Viteri and Torun in their classical paper in 1974 could show not only that iron deficiency anaemia significantly reduced physical work capacity but also that haemoglobin values above normal borderline values increased physical capacity. The increased oxygen transport capacity of increased haemoglobin had a direct impact on physical capacity, a factor that has been used in doping among athletes, i.e. the use of erythropoietin. As the uptake of inorganic iron in the diet is increased by ascorbic acid, intake of both iron and vitamin C may stimulate haemoglobin synthesis and thus have a positive impact on work per-

formance, especially in those who are at risk to develop iron deficiency anaemia. However, the effect of iron nutrition on physical performance is exclusively related to the haemoglobin value, which is responsible for the oxygen transport, and not related to the iron store in the body, illustrated by serum ferritin. Except for iron there are no indications that mineral supplementation may enhance physical performance.

Excessive dietary intake of certain minerals and trace elements may impair the balance of other minerals due to interaction in the intestinal absorption, e.g. zinc intake above 50 mg per day impairs copper and iron metabolism, and high iron supplementation impairs the uptake of other minerals, e.g. zinc. A high protein intake has also been reported to be deleterious for the calcium, phosphorus, zinc and copper requirements.

Vitamin supplementation may restore performance capacity in subclinical and clinical vitamin deficiencies but supplementation with quantities above recommended doses has not been shown to improve physical performance. Under normal conditions a mixed diet will cover all needs for mineral and vitamins when energy needs are met.

In general, the effects of the diet supplements mentioned have not been well-examined neither for possible positive qualities nor for toxicity, side effects and long-term effects.

## CONCLUSIONS

The metabolic stress during intensive physical activity or high work loads are essentially due to the fact that the increased energy needs are not covered in the diet. This leads to increased catabolism and secondarily to changes in the endocrine response and water and electrolyte balance.

### Optimal fluid intake

During physical activity fluid is lost depending on the degree of work intensity, temperature and humidity of the surroundings. A general guide is to consume 1000 ml per 1000 calories expended.

Studies have shown a tendency to drink too little (involuntary dehydration) since increased thirst during physical activity does not appear until too late. Even a dehydration of 1-2% of body weight reduces performance because of compromised temperature and adjustment of

cardiovascular regulation. It is therefore very important to drink at least as much fluid as lost.

### PRIMARY AND SECONDARY MALNUTRITION

Disturbances in the nutritional status lead to ill health and complications as well as increased susceptibility to various diseases. This is partly due to the fact that deficiencies of many specific nutrients may impair the immune response. This does not only lead to increased susceptibility for

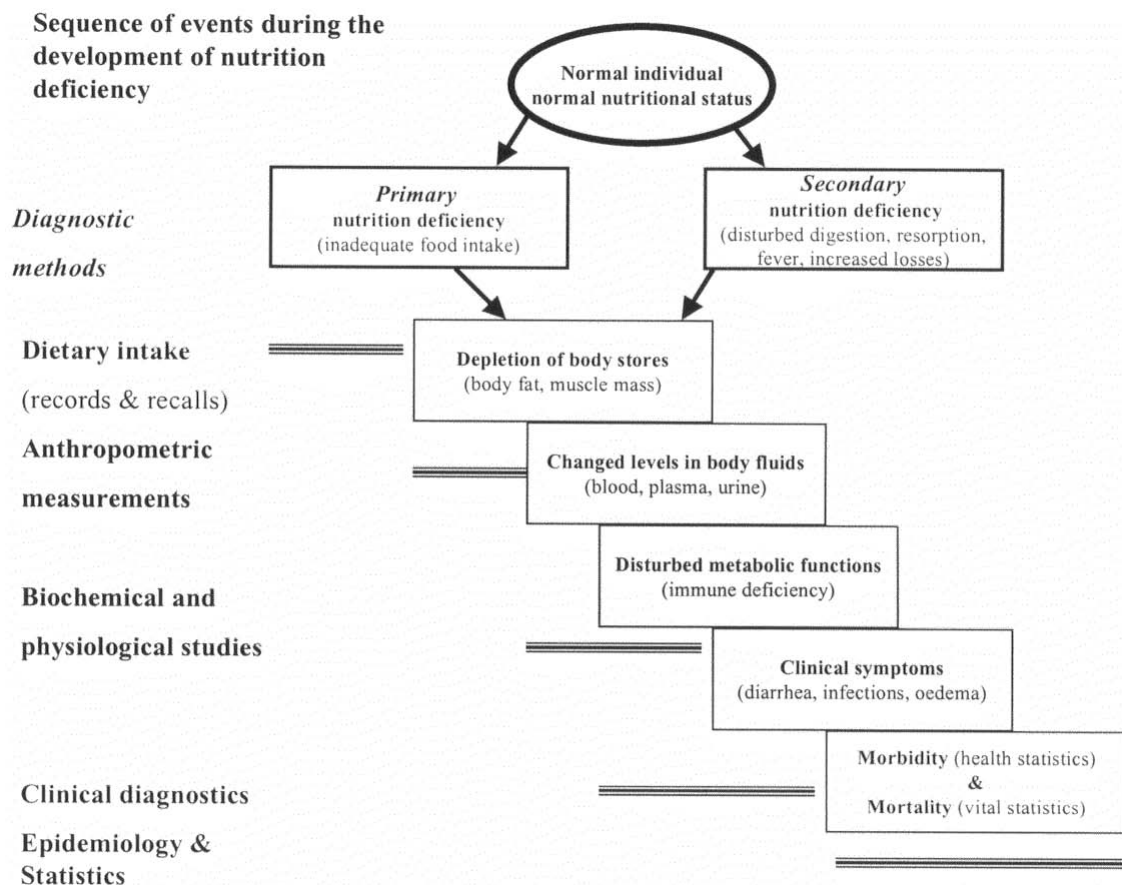


Figure 3.2.32. Sequence of events during the development of nutrition deficiency. The lines indicate at which stages the various diagnostic methods can be used.

infections but also to less than expected response to immunisation and antibiotic treatment. Deterioration of the nutritional status in a subject may be the result of two different forms of malnutrition: *primary malnutrition* and *secondary malnutrition*. Primary malnutrition refers to the situation where the nutrient requirements are not met by the diet. This is consequently mostly seen in subjects who have to rely upon the environment or other persons, i.e. the young child and the elderly, but also individuals depending on catering systems, i.e. prisoners, hospital patients, or as a result of famine. Secondary malnutrition refers to the situation where any disease or pathological conditions disturb the intake and metabolism of the nutrients, i.e. gastrointestinal diseases, or due to increased losses, i.e. surgical wounds, burned patients, vomit and diarrhoea, or needs, i.e. infections with high fever, or blood losses, i.e. malaria or hook worms. Although primary and secondary malnutrition differs with respect to their aetiology, the sequence of events is the same as illustrated in the figure below. This figure also illustrates at what stages in the sequence of events that the various diagnostic tools may be helpful.

### Macronutrient and micronutrient malnutrition

The word malnutrition is also used for both macronutrient deficiencies and micronutrient deficiencies. A woman with anaemia due to iron deficiency may be said to be malnourished. But most commonly the word malnutrition will be used for a macronutrient deficiency, which means that a person is consuming too little energy for her needs and will therefore lose the body stores of energy (=lose weight). Lack of dietary energy may also lead to micronutrient deficiencies and in children it may impair growth. Disease susceptibility will also increase.

	<i>Adults with macronutrient deficiency</i>	<i>Children with macronutrient deficiency</i>	<i>Adults with micronutrient deficiency</i>	<i>Children with micronutrient deficiency</i>
Wasting (thin)	Yes	Yes	No	No
Susceptible to disease	Yes	Yes	Yes	Yes
Impaired growth	No	Yes	No	Yes
Specific vitamin or mineral deficiency	Usually	Usually	Yes	Yes

Figure 3.2.33. The effects of macro- and micronutrient deficiencies in adults and children.

### Type I and Type II nutrients

Golden in 1996 suggested grouping of nutrients with respect to their effect on the nutritional status and the sequence of events during deficiency.

Type I	Type II
<i>Vitamins</i>	Essential aminoacids
Thiamine, riboflavin	Nitrogen
Cobalamin, folic acid	Sulphur
Pyridoxine	Water
Ascorbic acid	Sodium, potassium
Retinol, tocopherol	Magnesium
<i>Minerals</i>	Zinc
Iron, copper	Phosphorus
Calcium	
Manganese, selenium	
Iodine	

Figure 3.2.34. Examples of Type I and Type II nutrients.

*Type I nutritional deficiencies* lead to the classical concept of events where the deficient intake is compensated for by mobilizing the potential resources in tissue stores. This leads to a successive reduction in tissue concentrations until a critical level is reached and metabolic disturbances occur which result in more or less characteristic symptoms and signs.

*Type II nutritional deficiencies* are less easy to diagnose. As they all represent essential nutrients they are needed for a normal growth and development. However, a deficiency will result

in a non-specific catabolism of the tissues leading to growth failure in the growing individual. In adults there will be no characteristic changes in tissue concentrations as the catabolism of tissue will result in the fact that other nutrients will be released, metabolised and excreted as well, secondary to the catabolic state. This has led to a number of misinterpretations. The lack of confirmatory tests of an inadequate intake of the Type II nutrients has probably led to an underestimation of their nutritional importance.

### The malnutrition-infection complex

As both 'inadequate dietary intake' primary malnutrition and 'diseases' (secondary malnutrition) contribute to undernutrition, the phrase 'malnutrition-infection complex' has been proposed to avoid to accuse only one of the causes of the condition. Another way to express the relationship is the use of the concept 'undernutrition-overdiseasing'.

The most important mechanisms for the impact of infectious diseases on the nutritional situation are:

- Disturbed appetite leading to anorexia
- Decreased intestinal function, producing malabsorption
- Fever, which increases the energy need, e.g. 10% increase of energy turnover per centigrade.

Characteristics	Type I	Type II
Tissue level	variable, of diagnostic use	tissue level fixed
Use	in specific pathways	ubiquitously used
Physical signs	characteristic	non-characteristic
Growth response	late or never	immediate
Body stores	depleted	no bodystores
Response to diet	buffered	direct
Excretion	little control	homeostatic control
Relation to other nutrients	not interdependent	affects each others balance

Figure 3.2.35. Characteristics of the Type I and Type II nutritional deficiencies.

- Catabolic effects of microbes leading to tissue degradation
- Production of immunological proteins, which increases the nutritional needs
- Decreased circulating concentrations of micronutrients.

The most important mechanism for impact of undernutrition on the infectious susceptibility is due to the fact that it leads to disturbed protein turnover including reduced synthesis of immune globulins and reduced immune response to microbes and parasitic infestations.

When looking at vital statistics, for instance child mortality, there is the same problem of separating a 'food cause' from a 'disease cause' because often both a disease and a primary undernutrition have contributed the death of a child. Often the child had an infection, for instance diarrhoea, and at the same time he or she became undernourished. So when the child dies, is it due to the diarrhoea or due to the undernutrition? Because health staff often collects the data for vital statistics they will often tend to report the medical problem, in this case the diarrhoea. In a recent work it was estimated that in 49% of the deaths malnutrition was a major contributing factor leading to the death of the child.

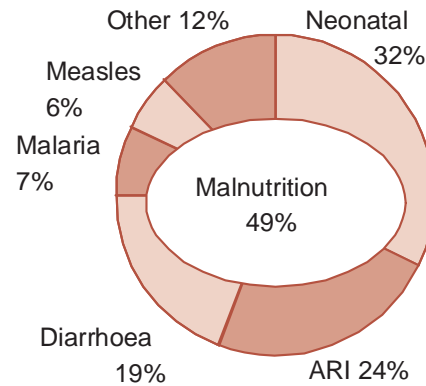


Figure 3.2.36. Of the 10.4 million deaths among children under 5 years of age in 1995, it is estimated that 5.1 million (49%) of these were precipitated by undernutrition (WHO 1999). ARI = acute respiratory infection.



**SUGGESTIONS FOR FURTHER READING**

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## GLOSSARY

### Abbreviations and Definitions

<b>BMI</b>	Body mass index, used as indicator of overweight and calculated as follows: Body weight in kg / (height in meter) <sup>2</sup> . Also known as Quetelet's index
<b>BMR</b>	Energy turnover when the individual is in supine position under standard conditions of rest, fasting, immobility, thermoneutrality and mental
<b>CVD</b>	Cardio-vascular disease
<b>DIT</b>	Dietary induced thermogenesis
<b>DRI</b>	Dietary reference intake
<b>EE</b>	Energy expenditure
<b>ET</b>	Energy turnover
<b>FAO</b>	Food and Agricultural Organisation of the United Nations System
<b>LIC</b>	Low income countries
<b>PAL</b>	Total energy expenditure (TEE) for 24 hours as a multiple of BMR. In adult man and non-pregnant, non-lactating woman, BMR times PAL is equal to TEE or daily energy requirement
<b>PAR</b>	The energy cost of an activity per unit of time (usually a minute or an hour) expressed as a multiple of BMR. Also called BMR-factor or MET-value.
<b>RDA</b>	Recommended dietary allowances
<b>TEE</b>	Total energy expenditure. i.e. energy spent on average in a 24hr period by an individual or group of individuals
<b>UNU</b>	United Nations University
<b>WHO</b>	World Health Organisation of the United Nations System
<b>Direct calorimetry</b>	Methods to estimate heat production by measuring temperature changes using sealed and insulated chambers or equipments, i.e. calorimeter rooms, calorimeter suits, bomb calorimeters
<b>Indirect calorimetry</b>	Methods to measure energy turnover by indirect methods. i.e. chemical analysis of food and using conversion factors; registration of oxygen consumption and carbon dioxide production as result of oxidation which gives energy; registration of heart frequency which is related to energy turnover
<b>Energy density</b>	amount of energy per weight or volume
<b>Gluconeogenesis</b>	synthesis of glucose from non-carbohydrate precursors, i.e. amino acids from protein breakdown and glycerol from triacylglycerols
<b>Nutrient density</b>	amount of essential nutrients, i.e. protein, vitamins, minerals, per energy unit (joule or kcal).
<b>Malnutrition minus</b>	undernutrition, i.e. too low intake of energy and/or nutrients leading to nutrition and energy deficiency states
<b>Malnutrition plus</b>	overnutrition, i.e. too high intake essentially of energy, leading to overweight and obesity and its complications (e.g. cvd, diabetes)
<b>Quetelet's index</b>	see BMI



# Musculoskeletal disorders

*Eva Vingård*

## INTRODUCTION

This chapter briefly describes the musculoskeletal system and a number of disorders that can affect it. There are a number of work-related factors of physical and psychosocial origin, including repetitive, forceful and heavy work, static or awkward postures, mechanical stress and vibration, that result in adverse outcomes for the musculoskeletal system. The chapter concludes with an appendix that describes models for the assessment of work postures, manual handling and physically monotonous, repetitive work.

## BACKGROUND

The human body is designed for motion and an appropriate mixture of movements, loads and recovery is needed to sustain bodily functions. The skeleton, muscles, tendons and ligaments form the musculoskeletal system and these structures must be flexible, stable, strong and supple in order to function satisfactorily. The capacity of this system varies widely between individuals, and is influenced by age, sex, nutritional status, fitness level, existing disorders and experiences such as injuries. Particular care must be taken if the musculoskeletal system is frequently subjected to excessive loads or subjected to loads for

long periods. In extreme positions, e.g. bending, the joints are more likely to be injured and muscles are less able to work in a coordinated way. Awkward positions may give considerable load to certain parts of the body, Figure 3.3.1.

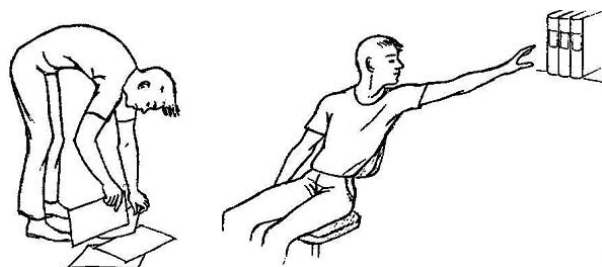


Figure 3.3.1. The weight of parts of the body (e.g. the arms), can be a heavy load.

Musculoskeletal pain, dysfunction and disorders are very common in all countries, regardless of their level of development. In parts of the developing world where nutrition is poor, diseases that affect musculoskeletal structures are common in both childhood and adult life, and people are exposed to heavy loads in both their occupational and domestic life. However, such problems are overshadowed by other risk factors which have

a more acute effect on health and life. A musculoskeletal disorder can cause lifelong pain and considerable loss of function and quality of life. In industrial countries, musculoskeletal disorders are the most common cause of long periods of sickness absence and early retirement.

The predominant symptom associated with musculoskeletal problems is pain. Pain is defined by the International Association for the Study of Pain, (IASP), as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage”. The definition says that the pain is experienced and as such, is subjective and impossible to measure and question in an objective way. Underlying the basic concept of mechanical, neurogenic or pain of unknown origin, there is an individual quality which gives psychological and emotional colour to the experience of pain and the way it is endured. The interpretation of pain differs between individuals and cultures. In Sweden, pain is the most common reason for individuals to seek medical treatment. However, the health care system often has very little to offer to cure pain, a situation that frustrates both the patient and the caregiver. In some societies, pain is an everyday phenomena that is given little attention in the health care system.

The causes of musculoskeletal pain and diseases are many and varied. Physical and psychosocial loads at work play important roles in the development of pain, disease and disability. The assessment and classification of exposures are important when investigating and judging potentially harmful factors. A harmful external exposure (e.g. exposure to a toxic chemical), can usually be measured, but exposures that affect parts of the musculoskeletal structure, e.g. tendons, muscles or joints, are more difficult to identify and vary from individual to individual.

To lift 15 kg is very easy for a strong young man but more strenuous for an older women.

In many developing countries lifting and handling heavy loads are still the main problem. In more industrialised countries, lifting and handling methods have been improved and loads have become lighter, but repetitive and static loading is still problematic. Even if manual lifting and handling is made easier, very little is gained in the prevention of musculoskeletal pain and disorders if the pace of work is increased and made more repetitive.

### PREVENTION

Primary preventive measures, i.e. measures to eliminate potential risk factors, are vitally important for both individuals and society. Prevention of musculoskeletal disorders is of interest to a number of international organisations including the ILO (International Labour Organization), which recognises musculoskeletal disorders as a work-related condition. International meetings on the prevention of musculoskeletal diseases have been arranged by the ICOH (International Commission on Occupational Health) and the IEA (International Ergonomics Association). The ISO (International Standardization Organization) has produced guidelines, recommendations and limits for different types of exposure, e.g. hand and arm vibration. The EU has also published information on prevention.

The avoidance of musculoskeletal disorders partly depends on the knowledge of employees about the correct way to perform a task. Training in work techniques is important when new employees are hired or when changes are made to work processes. Sufficient time should be reserved for an employee to practise appropriate, safe working postures and movements, to learn to handle equipment and working aids, and to learn how to collaborate on tasks which

are difficult to perform single-handed. Instruction may sometimes also be needed on the use of controls and technical aids. A simple checklist can be a useful means of ensuring that nothing is overlooked.

Employers need to check that routines for instructions, information, etc. are relevant, adequate, and regularly updated. It is also necessary to check that instructions are complied with.

To ensure satisfactory preventive work, the interaction between different factors within a work system should be considered. For example, the introduction of work techniques which reduce unsuitable movements, positions and physical factors such as vibration, can also reduce mental stress and create variety and stimulation.

### **Pain and disorders of the low back and neck**

Patients complaining of low back and neck pain very often have no identifiable pathological or anatomical disease. Pain and/or poor muscle function do not show up in blood tests, on x-ray or through other examinations. While some rare disorders such as spinal infections, spinal malignancy, compression fractures and sciatica can be diagnosed, many other back problems cannot be diagnosed. However, patients suffering pain should not be neglected. The progression from pain to ill-health and incapacity is also likely to depend on cultural and economic factors. Most scientific studies indicate that self-reported pain over different periods, (i.e. currently, during the recent past or over a life time), is the outcome variable against which different exposures are measured. A clinical examination can sometimes, but not always, provide further information.

The chosen outcome for a study obviously reflects the identified risk factors, e.g. the outcome for a clinically verifiable condition such as a ruptured disc. The outcome for a diagnosed condition is likely to be completely different from that

for back problems which develop into general pain syndromes. Furthermore, the causes of pain and disease in the low back and neck are complex and multi-factorial, potentially caused by a multitude of risk factors from heavy physical loads to unsatisfactory psychosocial conditions at the workplace. Most studies which have investigated the connection between workplace factors and low back or neck disorders are cross-sectional studies. This means that the exposure and pain/disorder is measured at the same time. The causal chain is thereby hard to evaluate. This makes it difficult to draw any reliable conclusions and connections, but it would seem to be a reasonable assumption as many studies indicate the same trend.

The vast majority of studies are unable to accurately show the level of exposure and the time required for pain or ill health to emerge. This means that arbitrary judgements are made about what is considered to be *harmful* and what is *harmless*, and non-linear relationships become uncertain and difficult to define precisely.

There are very few intervention studies. The authors of a systematic survey of studies carried out before 1994, detected a trend that showed an improvement in the biomechanical conditions at the workplace also improved health with regard to musculoskeletal disorders. Changes in production systems may also have a positive effect, although health variables are seldom fully investigated and followed up in studies.

Physical factors associated with low back pain include different types of vibration that affect the whole body, frequent bending and twisting, manual handling such as lifting and carrying, and pushing and pulling. Those at greatest risk appear to be workers in extreme work environments, e.g. nurses, construction workers, and farmworkers. In Sweden for example, blue-collar



workers of both sexes have more problems than white-collar workers.

### Awkward working postures

Working in a *heavily bent, twisted or extended* position can require the body to handle unsuitable loads, which stress the joints and force them to work close to their outer limits, see Figure 3.3.2. Poor working conditions require workers to adopt poor working postures, e.g. work above shoulder height requires extreme wrist flexion. If awkward movements such as bending or stretching are prolonged or recurrent, the risk of injury increases.

There is considerable risk of injury if the work posture demands *bending, twisting and/or extension* at the same time, particularly for *manual handling operations*. The body is also put under great strain if work is performed in the same position for a long time because of static loading of muscles, even if the work position is not extreme. These stresses are further aggravated if the task also involves material handling. Musculoskeletal disorders can easily occur if the body has to bend or twist suddenly and without control, (e.g. to regain balance).



Figure 3.3.2. Work postures involving bending, twisting and extending always entail risk.

### MANUAL HANDLING

Manual handling mainly refers to the transfer of loads, with one or more employees exerting muscular force to lift, deposit, push, pull, roll, carry, hold or support an object or person. The traditional concept of manual labour involved a great deal of lifting, carrying, pulling, dragging, etc. Manual handling is still required for such tasks as stocking shelves, handling and sorting bundles of paper, loading machines or mixers with raw materials, helping and moving hospital patients, pushing and pulling trolleys, serving food and drink and moving heavy outdoor play equipment. Other tasks may involve the use of considerable physical force to use an object rather than to move it. Examples include the use of hand-held machinery or tools such as chain saws; the operation of controls with heavy resistance; bricklaying or spray painting; steering a vehicle; the control of work processes with buttons, levers and pedals; opening swing doors by kicking or nudging. In some situations, the most hazardous factor is the degree of precision required for the handling rather than the actual force needed. Figure 3.3.3 shows examples of manual handling or the exertion of physical force.

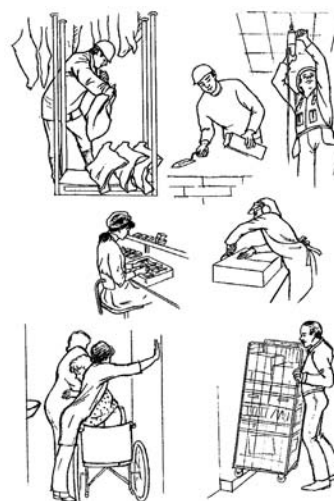


Figure 3.3.3. Various forms of manual handling and exertions of physical force which can be harmful.

Heavy manual handling primarily involves a risk of overloading the lumbar region of the spine but there is also a risk to the arms and shoulders, particularly when bad work postures are adopted. There is a risk of knee injuries when lifting with the knees heavily flexed or when carrying heavy loads on stairs or on uneven, unsteady or hard surfaces. In addition, the heart, circulation and lungs are put under strain during heavy lifting and carrying. Work of this kind requires both strength and fitness, but can still be hazardous even for strong and fit workers.

Acute overloading of joints, muscles and tendons very often occurs when manual handling deviates from normal procedures. Accidents of this kind can occur, for example, when health-workers move a patient who doesn't move as expected; when handling a container whose centre of gravity has changed because the contents have shifted; when making a sudden movement to recover balance after a slip or trip. In such situations, the impact of the load can greatly increase compared with normal conditions. Advance planning for the best way to perform a lifting or moving operation is very important.

### Lifting and carrying

Most operations to transport people, materials, equipment or goods can be performed on wheels, at moderate expense. This is particularly important for transport over long distances. Stairs are normally unsuitable for use as regular transport routes as carrying of heavy or awkward loads on stairs entails a severe risk of acute musculoskeletal disorders and other accidents.

The risks from lifting and carrying depend on a number of factors including: what is lifted, how and where the lifting is done, who is lifting or carrying. It is very difficult to define an absolute limit value for any single factor, e.g. the maximum permissible weight of a load, however,

there is sufficient scientific evidence and experience to support practical recommendations on how this kind of work can be assessed. The Appendix to this chapter contains a model for the assessment of lifting operations, focused on two main factors, the weight of the load and the distance between the body and the centre of gravity of the load when the lift is performed.

For many years there have been efforts to reduce the risks of back problems caused by lifting through instruction in correct lifting techniques, i.e. lifting with the back straight and the knees bent, however, ensuring that this instruction is put into practice has been problematic. Current knowledge and experience emphasises the following instructions as most important measures to prevent back injuries:

- avoid heavy lifting if possible, and use technical aids whenever possible
- make sure that the load is held close to the body
- avoid lifting and twisting simultaneously.

### Lifting people safely

Manual lifting of people can be largely avoided if the workplace premises are spacious, well planned and equipped with sufficient, appropriate and readily available equipment.

When trying to solve a lifting problem through the use of technical aids, it is important that there are clear instructions and that staff are trained in the use of the aids in the specific situation they are used in. Training is especially important for techniques used to transfer people who need assistance in a variety of situations. Staff assisting people need to know how to cope with unforeseen events such as patient falls. Lack of space or shortage of time can force a staff member into a difficult handling operation and awkward work posture. It is important that there

is adequate and properly planned space and appropriate time allocated for tasks such as moving patients to and from the toilet, between a wheelchair and bed, and helping patients to change position in bed.

### Pushing and pulling

Pushing and pulling means moving an object, with all or part of its weight resting on an underlying surface such as a floor, or with the object suspended, e.g. from a trolley. The force needed to move and keep an object in motion depends on the weight of the object and the amount of friction and the gradient between the object and the underlying surface. It is necessary for a worker to get a foot-hold, i.e. to have good friction between his/her shoes and the walking surface, in order to exert strong force on the object. In other words, it is desirable to have low friction between the object and the underlying surface but high friction between an individual and the walking surface.

### Repetitive work

*Monotonous, repetitive physical work* characteristically involves the performance of a single or small number of tasks that require the operator to repeatedly use the same movements for a considerable part of the working day. The work cycle time is often very short and the task is a small part of a rapid, flow line sequence. While this kind of repetitive work is often considered to be “light” work, it can cause considerable pain and tension in the neck.

*Closely controlled* work means that the employee has little or no chance of influencing factors like the pace of work, the sequence of tasks, the setting of deadlines for completion of work, methods for performing work or the timing of breaks and recovery periods. *Restricted work* means that it is difficult for the employee to

leave their workstations, even for short periods, without service or output being disrupted.

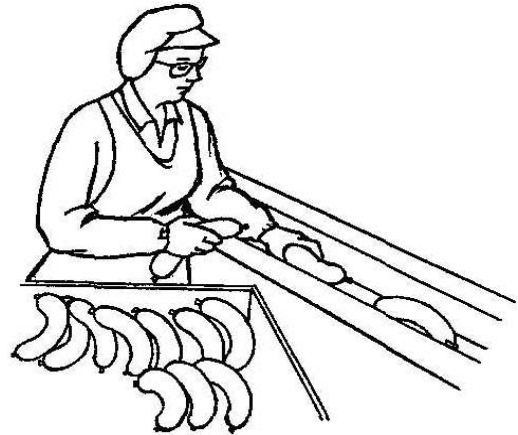


Figure 3.3.4. A physically monotonous, repetitive job.

Typical situations of the types of work listed above are assembly lines, checkouts, data entry, some types of laboratory work, mass catering, loading and unloading in semiautomatic systems, (Figure 3.3.4) and punch press work. Drivers may also experience monotonous work if they drive the same routes all the time. Some forestry work involves the use of machinery which is particularly physically monotonous and repetitive, but which also requires a high standard of precision.

Repeated performance of the same movements gives rise to a constant, uniform load. The object that is being handled may weigh very little but the weight of the arms themselves is sufficient to impose an unsuitable load on muscles and joints. This can lead to the gradual appearance of serious injuries that are slow to heal.

The appendix contains a model which can be consulted for the identification and assessment of physically monotonous, repetitive work.

### Manual work and the process of industrialisation

The long-term, overall influence of the process of industrialisation on health and safety of the human population is positive. Increased industrialisation creates economic wealth that amongst other things improves working conditions and the safety and health of the working population. One such development is that heavy manual work has diminished when production is mechanised and computerised. On the other hand, the process of mechanisation and other forms of technical rationalisation of work do not always result in light physical work and comfortable working environments. The process can for instance give an extreme load on small muscle groups when repetitive and static loads are introduced instead of heavy dynamic loads engaging the entire body. There is still need for concern about the musculoskeletal safety and health of man and women at work.

The mechanisation, automation and computerisation may lead to many unfavourable work arrangements. What is ideal for machines, is not always ideal for the workers who operate them or whose work is paced by the machines. But man can sustain inadequate arrangements of climate and ventilation, illumination noise, et cetera, and by applying uncomfortable body positions man can even handle badly designed machines and working equipment. He can also perform monotonous or extremely heavy tasks. This type of "adaptation" of man to work may be anatomically, physiologically and psychologically necessary in the work situation, but when frequently repeated, it brings adverse effects to the efficiency of work as well as to the safety, health and well-being of man.

Swedish work physiologists and ergonomists have been researching forestry labour for about 60 years, and have been able to show the development of this labour. These studies show that:

- mechanisation and productivity has increased
- whole-body work load has decreased
- the "ergonomic quality" of machines and tools has improved.

But in spite of the above:

- occurrence of low back pain has been constant
- shoulder-neck disorders have increased.

Some of the reasons for this health development may be found in that:

- productive work time duration has increased
- work load variation has decreased.

As industrialisation, computerisation and globalisation of markets are developing, working life all over the world is changing. The traditional ergonomic problems related to heavy manual work, musculoskeletal disorders, design of tools and machines et cetera today exist simultaneously with problems related to the human-computer interface (call-centres, control rooms et cetera), reliability, road safety and other issues where cognitive and organisational aspects of work is dominating.

## SYMPTOMS AND DISORDERS

### The shoulder region

The structures round the shoulder and shoulder joint can be affected by inflammatory conditions and the incarceration of tendons under the bone. The muscles of the rotator cuff, (supraspinatus, infraspinatus, teres minor and subscapularis), are the most commonly affected. These muscles are used for lifting and rotating the shoulder and arm. Trapped tendons of the supraspinatus muscle under the bursa may cause a painful condition, (an “impingement”), and the long tendon of the biceps muscle attached at the shoulder may also become inflamed. Other inflammations of the bursa, are also common. The symptoms of these disorders are pain and restricted movement in the shoulder joint.

A number of factors are often linked to the development of symptoms and disorders in the shoulder region. The first factor is work posture where the arms and hands are raised above 60 degrees. These disorders are exacerbated if a worker uses a tool such as a welding unit or drill. Many studies have also shown a connection between highly repetitive work and disorders of the arms, neck and shoulders. However, awkward working postures often occur in conjunction with work with raised arms so the effect of repetitive work is not as easy to assess separately.

### Epicondylitis (tennis elbow)

Epicondylitis is an inflammation in the tendons of the lower arm muscles attached to the epicondyle bones of the elbow, often referred to as “tennis elbow”. The connection between physical loads at work and epicondylitis is difficult to ascertain because of insufficient knowledge, however, work situations where both repetitive work and heavy tasks occur at the same time, seem to be most risky. Where repetitive or heavy

work is the only risk factor, the connection is less clear and needs further investigation.

### Carpal tunnel syndrome

Carpal tunnel syndrome is an incarceration of the median nerve in the carpal tunnel at the wrist. Symptoms of carpal tunnel syndrome are tingling and numbness in the hand, (especially at night), as well as pain and weakness in the hand, accentuated by movement. The nerve conduction velocity is reduced in the median nerve measured over the carpal tunnel. Carpal tunnel syndrome commonly occurs in connection with diabetes, hypothyreosis (changed function of the thyroid gland, resulting in low or no production of thyroid hormones), diseases of the connective tissue, and pregnancy. A number of workplace exposures are connected with the development of carpal tunnel syndrome but the connection between exposure to vibration is the best researched and documented. Highly repetitive work using the arms and hands for a long period can also result in clinical carpal tunnel syndrome. There is no definite evidence to confirm that exposure to high levels of bending and stretching in the wrist, or to loads with a forceful grip, can alone result in a carpal tunnel syndrome.

Most of the risk exposures do not occur singly, and combinations of exposures are more harmful than a single exposure. Combined exposures to work which is repetitive, requires non-neutral positions of the wrist, and all exposures to vibration present a high probability of causing carpal tunnel syndrome.

### Osteoarthritis

Osteoarthritis is a partially degenerative joint disease and is the most common condition affecting the joints. Age is the strongest risk factor, although it is unclear whether the age-related changes are primarily biochemical or mechani-



cal. Osteoarthritis can be divided into a primary form with no known predisposing factors, and a secondary form where the osteoarthritis arises as a result of an anatomical defect, injury, developmental disorder, infection or physical load. The disease primarily affects the cartilage in the joint, but the underlying bone surfaces can also be affected resulting in a stiff and painful joint. The main joints affected are the large ones such as the knee and hip, and the joints of the fingers and hand.

The knee joint consists of two joints, the tibiofemoral joint between the femur (the thigh bone), and the tibia (the shin bone), and the patellofemoral joint between the patella and the femur (the thigh bone), and the tibia (the shin bone). Great force is exerted on the knee joint during movement and weight bearing.

Many studies have established a clear connection between osteoarthritis and work requiring crouching, kneeling or bending. Heavy work is also strongly suspected to be a risk factor for the development and early emergence of osteoarthritis.

The hip joint is one of the largest in the body. It has a weight-bearing function and must be flexible and able to bend, stretch and rotate. Osteoarthritis is unusual in young people but those with a congenital hip disorder or who have suffered an infection in the joint, e.g. tuberculosis, can develop osteoarthritis, particularly if they are also exposed to heavy loading during their working life.

A number of studies from different countries, using a variety of methodologies, show a connection between early development of osteoarthritis of the hip and farming work, although the exact nature of the exposure is unclear. Some studies have shown that generally heavy work (mainly heavy lifting, jumping or movement between different levels), can cause osteoarthritis of the hip.

## REDUCING EXPOSURE

If the risks of injuries from harmful physical loads are to be reduced, a full assessment of the work situation must be undertaken. Physical and/or technical measures taken alone are seldom sufficient unless the work is completely mechanized. The main concern should be reduction of repetitive tasks and limits on the length of time individual employees spend on this type of work, measures which are likely to necessitate some form of organizational change. If the organisation of work is altered through job rotation, job diversification and job enhancement, employees have more scope to influence their own work arrangements and timing of breaks, increasing the opportunities for variation, participation and personal development.

- *Job rotation* generally means that employees alternate between different tasks of a similar nature. If job rotation is introduced, it is important that it leads to a meaningful variation in workload. Job rotation often has only a limited effect on reducing harmful physical loads.
- *Job diversification/enlargement* means a number of tasks as combined, e.g. supplementary duties, such as maintenance and cleaning, are added to an existing job or employees are allotted a bigger share of the flow line sequence. Job diversification typically lengthens the work cycle.
- *Job enhancement/enrichment* gives employees a wider range of duties requiring a variety of skills and qualifications, e.g. through the addition of a number of tasks including work planning, inspection of work output or customer contacts.

As regards limits on the amount of time an employee spends on physically monotonous, repetitive work, the distribution of working sessions



throughout the day has an important bearing on the risk of musculoskeletal disorders. This type of work should be performed in short spells, spread out over an entire shift and continuously interspersed with other work, breaks and rest intervals.

If physically monotonous, repetitive work is automated or changed, care must be taken to ensure that no “residual tasks”, (e.g. filling or extraction of production material), are created at either the beginning or the end of fully or semi-automated systems.

In some occupations, (e.g. orchestral musicians, data-entry operators), static loading of the neck region can cause acute and/or chronic pain. There is also evidence of a connection between forceful, dynamic work tasks such as the use of handheld tools, affecting the neck and arms.

There is also a connection between low back and neck problems and psychosocial factors such as high demands, combined with factors such as low control, job strain, lack of job satisfaction, stress, bad relationships with co-workers and superiors, monotony and dull work content. Most of these psychosocial exposures occur together with harmful physical loads. It is difficult to distinguish the degree of harmfulness from any individual other risk factor but a combination of exposures often leads to the highest risks of ill health, as is the case for both low back and neck disorders.

The ability to influence the arrangement and conduct of one's own work is an essential prerequisite for individual wellbeing and development potential. Influence over planning, working arrangements and methods, the timing of work and breaks, the pace of work and the procurement and use of working aids, helps to prevent musculoskeletal disorders.

Social interaction with management and fellow employees at the workplace has proved to play an important part in the occurrence and sub-

jective experience of disorders. Good job control means, (amongst other things), the ability:

- to alternate between different tasks,
- to alternate between sedentary and standing work,
- to take short breaks for recovery when needed,
- to choose or adapt the pace of work,
- to get help from others when necessary,
- to be involved, (on the strength of one's own experience), in the procurement of new equipment and the introduction of new working methods.

Some types of pay systems, such as piecework or incentive pay systems, can lead employees to use very poor and unsafe work techniques because they feel under pressure to exceed their physical and mental limits in order to earn more money. It is essential that pay systems put a premium on quality and general competence rather than on product quantity and specialization.

#### **Work using hand-held machines, hand tools and controls**

Hand-held machines and tools commonly contribute to musculoskeletal disorders of the hands, wrists, arms and shoulders. Vibration is a major risk factor, e.g. from the use of chain saws, grinders, hammers and drills. Other risks depend on the design and use of machinery and tools which are not always adapted to suit people with small hands and limited muscle power, particularly women.

The use of hand-held machines or tools often demands both strength and precision. Where high standards of precision are required, as for example in the case of a dentist or watchmaker, static workloads can be hard to avoid. In such cases, it is important to have functional tool design and frequent opportunities to rest.

To minimize the risk of musculoskeletal disorders, employers should provide their employees with hand-held machines and hand tools that:

- permit appropriate grips, are adapted to the requirements for force and precision with good friction and with the gripping force properly distributed over the hand, so as to avoid unsuitable concentrated pressure, e.g. with no sharp edges,
- will fit different sized hands,
- can be used with either hand,
- permit a neutral positioning of the wrist and arm (the position of the hand when relaxed and resting on a table) whenever possible,
- afford good vision and easy access to the item being worked on,
- are equipped with a trigger with a reasonable control resistance for force,
- vibrate as little as possible,
- are as light as function permits,
- are well balanced.

The use of controls (such as foot pedals), mainly occurs in work situations involving mobile machinery or vehicles but may also be used at stationary workstations. It is important that controls are designed and positioned to suit employees' physical characteristics such as body size and strength. This applies to both manually operated controls and to pedals and other controls operated by the feet or legs.

## THE FUTURE

It has been known for centuries that hard labour causes pain and discomfort, however, the concept of work-related musculoskeletal disorders was not recognised as an important occupational health problem in the industrialized world until the 1970's. The causal chain between various physical and psychosocial exposures is still de-

bated even after the veritable explosion of studies published in the 1980's and 1990's. There is a lack of high quality scientific research on the situation in low income countries where the problems are likely to be greatest. The 1983 edition of the ILO Encyclopaedia of Occupational Safety and Health had no references to musculoskeletal disorders but the 1998 edition includes about 400 references on the topic. This example illustrates the changing approach to musculoskeletal problems when the pain, discomfort and disability are considered to result from poor working conditions. It is possible to prevent injuries and is a legitimate concern for workers safety and health.

Heavy workloads are now less common in high income countries but still exist in some sectors such as the construction industry, small scale farming and home care. Sectors including mining, transport work, and forestry have been mechanised, however, other problems arise as work is increasingly mechanised and computerised. Higher technical skills are needed and there is an increase in monotonous, static work postures and stress, all factors that can cause musculoskeletal disorders. As production and work are transferred to poorer countries with lower wages and less developed safety regulations, more work-related musculoskeletal disorders will appear in the poorer countries.

Occupational health and safety managers in developing countries need to be aware of this problem because it is likely that musculoskeletal pain and disorders are substantial burdens to the workforce. Improvements to ergonomic and psychosocial conditions at the workplace are important ways to improve the health status and the well-being of all workers in all societies.

The Appendix on the following pages is originally published by the Swedish Work Environment Authority ([www.av.se](http://www.av.se))

## APPENDIX

### MODELS FOR THE ASSESSMENT OF WORK POSTURES, MANUAL HANDLING AND PHYSICALLY MONOTONOUS, REPETITIVE WORK

#### Background

There has long been a need for practical, systematic and simple methods for the identification and assessment of ergonomically hazardous jobs or situations. These models should make it possible to obtain an initial indication as to whether or not a certain job or operation entails physical loads dangerous to health, and give a basis for remedial action.

#### Assessment model principles

The connections between work and the risk of musculoskeletal disorders are often relatively complicated so these models have been simplified for practical use. The models only consider some of the characteristics of one type of load so they cannot be used as exact load limit values. But, they should offer sufficient guidance for practical changes to existing workstations or for planning new workstations and jobs.

Due to their simplified nature, an uncritical application of the models may result in overestimates and/or underestimates of the actual risks. A comprehensive assessment would require more factors to be taken into account and for more accurate models to be used which would call for a thorough knowledge of ergonomics.

The models are based on a triple-zone system (red, yellow and green), for easy identification of working conditions which are *clearly hazardous* or which entail *negligible risks*, as the case may be.

#### Models for the assessment of sedentary, standing and walking work postures

The following is an assessment model to help identify unfavourable work postures. (N.B. It

is impossible to identify the degree of harmfulness of *individual* work postures, because of the difficulty of segregating individual postures.) Frequently, there is a single or small number of common work postures with poor ergonomics, e.g. postures used every day or work requiring extreme working positions. The model is designed to assess such postures. When these postures have been identified, reference to the chart will allow you to see the classification for the postures in question, (*red, yellow or green*) for one or more parts of the body.

In principle, identification of only one posture in any square (red or yellow), is sufficient for application of the suggested remedies. The greater the number of assessments appearing in a red field, the greater the need for remedial action.

The parts of the body used in the model, are points to observe but are not necessarily the parts of the body that are injured. For example, “unstable underlay” (underlying surface) in the model means a risk of back disorders rather than a risk of leg ailments.

The model uses a “full” working shift of 4-8 hours per day. Reference to “a significant part of the shift” means that the work posture occurs with either no, or very short interruptions, for more than half the shift. “Intermittently” means that, in total, the identified work posture alternates with other work postures for less than half the shift.

N.B. The model does not take account of the level of exertion required for the job. Any of the yellow or green jobs can turn red if high levels of exertion are required.

The length of exposure to risk is always important in assessments. No work posture which can be assumed naturally is intrinsically dangerous to health, but any posture may become risky if it is assumed too often or for too long.



The colours in the models have the following meanings.

**Red field = unsuitable**

The work loads are of such magnitude and character that *all or most of the employees* risk developing musculoskeletal disorders in the short or long term.

Conditions ought normally to be remedied immediately so as to eliminate or reduce the risk, unless there are special reasons for deferring action. Reasons of this kind may, for example, be that there are very great practical difficulties involved in rapidly remedying the deficiencies which entail risks, or that specially chosen employees have acquired special knowledge of the risks and skill in avoiding them.

**Yellow field = evaluate more closely**

The work loads are of such magnitude and character that *a not insignificant number of employees* risk developing musculoskeletal disorders in the short or long term.

More exact investigations and assessments are needed in order to decide conclusively the degree of risk involved. It is above all time factors (tempo, frequencies, duration etc.) which may require closer investigation.

**Green field = acceptable**

The work loads are of such magnitude and character that *only one or two employees if any* risk developing musculoskeletal disorders in the short or long term.

Where the majority of employees are concerned, then, the loads do not present any risk of injury. A certain amount of caution can, however, be recommended where special risk groups (e.g. pregnant women, minors or employees who have recently been ill) are concerned. General measures are not normally needed, but individual ones must be taken where necessary.

## Sedentary, standing and walking work postures

	Red	Yellow	Green
SITTING	One of the following occurs <b>during a significant part</b> of the shift	One of the following occurs <b>inter-mittently</b> during the shift	The following applies for a <b>significant part</b> of the shift
Neck	<ul style="list-style-type: none"> <li>- bent, with no freedom of movement</li> <li>- twisted, with no freedom of movement</li> <li>- bent and twisted simultaneously</li> <li>- freedom of movement severely restricted</li> </ul>	<ul style="list-style-type: none"> <li>- bent, with no freedom of movement</li> <li>- twisted, with no freedom of movement</li> <li>- bent and twisted simultaneously</li> <li>- freedom of movement severely restricted</li> </ul>	<ul style="list-style-type: none"> <li>- central position, with freedom of movement</li> </ul>
Back	<ul style="list-style-type: none"> <li>- bent, with no freedom of movement</li> <li>- twisted, with no freedom of movement</li> <li>- bent and twisted simultaneously</li> <li>- freedom of movement severely restricted</li> <li>- no backrest</li> </ul>	<ul style="list-style-type: none"> <li>- bent, with no freedom of movement</li> <li>- twisted, with no freedom of movement</li> <li>- bent and twisted simultaneously</li> <li>- freedom of movement severely restricted</li> </ul>	<ul style="list-style-type: none"> <li>- free movements possible</li> <li>- well-designed backrest</li> <li>- option of changing to standing position</li> </ul>
Shoulder/arm	<ul style="list-style-type: none"> <li>- hand at or above shoulder height</li> <li>- hand beyond forearm distance, unsupported</li> </ul>	<ul style="list-style-type: none"> <li>- hand at or above shoulder height</li> <li>- hand beyond forearm distance, unsupported</li> </ul>	<ul style="list-style-type: none"> <li>- working height and reach adapted to task and individual</li> <li>- good arm support</li> </ul>
Legs	<ul style="list-style-type: none"> <li>- insufficient leg room</li> <li>- no support for the feet</li> <li>- freedom of movement severely restricted</li> <li>- leg-operated pedal work*</li> </ul>	<ul style="list-style-type: none"> <li>- insufficient leg room</li> <li>- no support for the feet</li> <li>- freedom of movement severely restricted</li> <li>- leg-operated pedal work*</li> </ul>	<ul style="list-style-type: none"> <li>- free leg space</li> <li>- good footrest</li> <li>- seldom leg- or foot-operated pedal work*</li> <li>- option of changing to standing position</li> </ul>



	Red	Yellow	Green
STANDING/ WALKING	One of the following occurs <b>during a significant part</b> of the shift	One of the following occurs <b>intermittently</b> during the shift	The following applies for a <b>significant part</b> of the shift
Neck	<ul style="list-style-type: none"> <li>- bent, with no freedom of movement</li> <li>- twisted, with no freedom of movement</li> <li>- bent and twisted simultaneously</li> <li>- freedom of movement severely restricted</li> </ul>	<ul style="list-style-type: none"> <li>- bent, with no freedom of movement</li> <li>- twisted, with no freedom of movement</li> <li>- bent and twisted simultaneously</li> <li>- freedom of movement severely restricted</li> </ul>	<ul style="list-style-type: none"> <li>- upright posture, with freedom of movement</li> </ul>
Back	<ul style="list-style-type: none"> <li>- bent, with no freedom of movement</li> <li>- twisted, with no freedom of movement</li> <li>- bent and twisted simultaneously</li> <li>- freedom of movement severely restricted</li> <li>- unstable or sloping underlay</li> </ul>	<ul style="list-style-type: none"> <li>- bent, with no freedom of movement</li> <li>- twisted, with no freedom of movement</li> <li>- bent and twisted simultaneously</li> <li>- freedom of movement severely restricted</li> <li>- unstable or sloping underlay</li> </ul>	<ul style="list-style-type: none"> <li>- upright posture, with freedom of movement</li> <li>- option of changing to seated position</li> </ul>
Shoulder/arm	<ul style="list-style-type: none"> <li>- hand at or above shoulder height</li> <li>- hand at or below knee height</li> <li>- hand more than <math>\frac{3}{4}</math> arm's length from body</li> </ul>	<ul style="list-style-type: none"> <li>- hand at or above shoulder height</li> <li>- hand at or below knee height</li> <li>- hand more than <math>\frac{3}{4}</math> arm's length from body</li> </ul>	<ul style="list-style-type: none"> <li>- working height and reach adapted to task and individual</li> </ul>
Legs	<ul style="list-style-type: none"> <li>-insufficient room for legs and feet</li> <li>- unstable underlay</li> <li>- sloping underlay</li> <li>- leg- or foot-operated pedal work*</li> </ul>	<ul style="list-style-type: none"> <li>-insufficient room for legs and feet</li> <li>- unstable underlay</li> <li>- sloping underlay</li> <li>- leg- or foot-operated pedal work*</li> </ul>	<ul style="list-style-type: none"> <li>- freedom of movement on non-slip, even and level underlay</li> <li>- no leg-operated and seldom foot-operated pedal work*</li> <li>- option of changing to seated position</li> </ul>

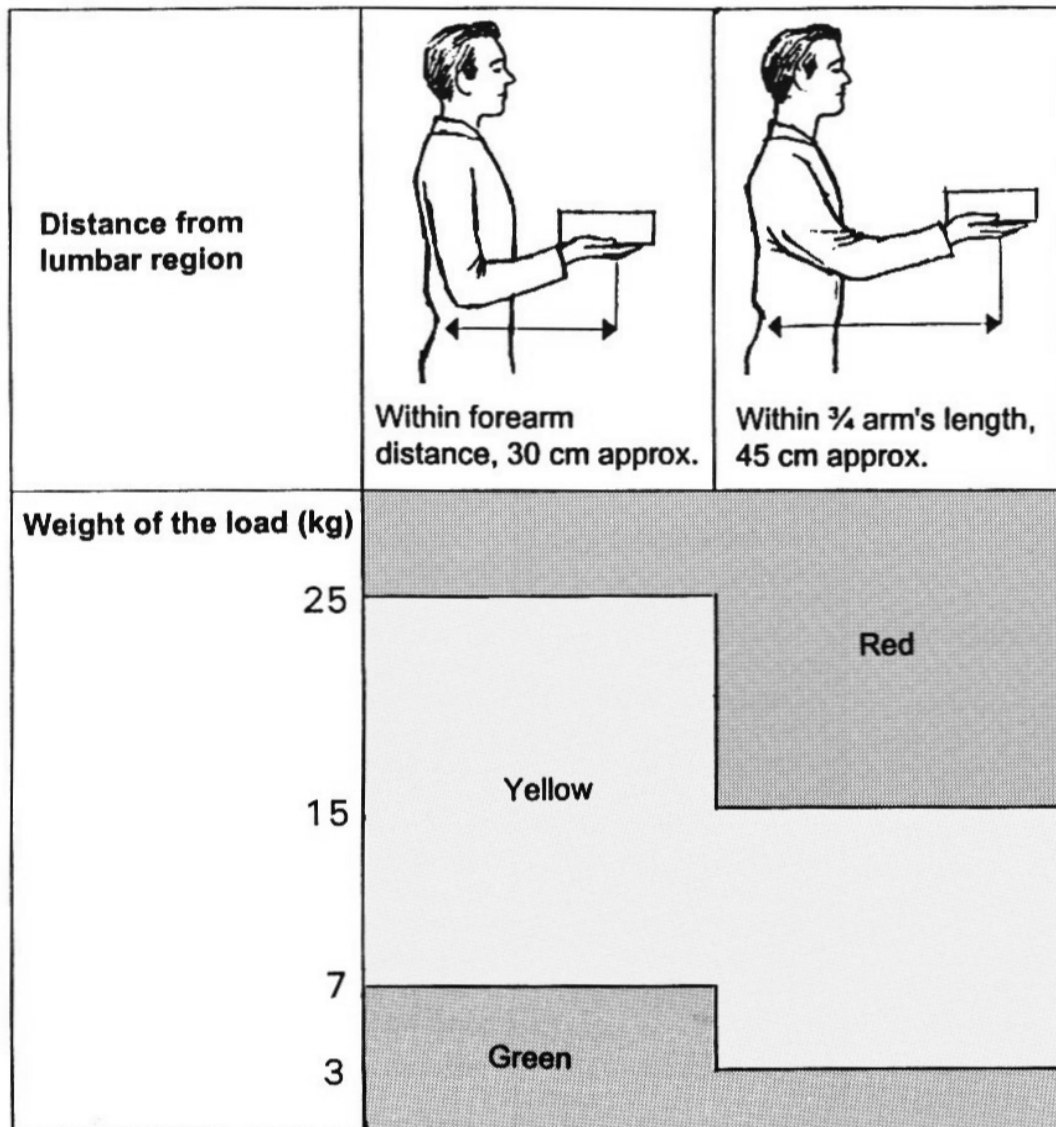
\* Leg-operated pedal work = the brake or clutch pedal of a motor vehicle

\* Foot-operated pedal work = the accelerator pedal of a motor vehicle



### Model for assessment of lifting work

The following model for the assessment of lifting work concentrates on two main factors: the weight of the load and the distance in front of the body, of the centre of gravity of the load. This means that other important factors (e.g. the frequency, duration, height, and ease of lifts), are not included in the model so supplementary assessments will be needed. This model is valid for both sexes.



Model for assessment of a symmetrical lifting operation in the standing position, using two hands and under ideal conditions. Horizontal distance = the distance between the lumbar region and the centre of gravity of the burden when lifting.

## Model for assessment of pushing and pulling work

Force is measured in Newton's [N] using a dynamometer.

Force [N]	Red	Yellow	Green
Starting	>300	300-150	<150
Continuously	>200	200-100	<100

This model refers to good ergonomic conditions, i.e. a symmetrical two-handed grip, properly designed handles positioned at a suitable height and good ambient conditions. If, for example, the object is to be moved over a long distance, the operation is repeated frequently or for a long time, the grasping height deviates considerably from about elbow height, then the values in this model should be correspondingly reduced. The same applies if the work is done using one hand only. Several of the conditioning factors in the assessment model for lifting work are also applicable to pushing and pulling work.

One conclusion that can be drawn from this model, is that handling of loads weighing in excess of 25 kg is unsuitable in the majority of cases.

### Important factors influencing assessment of risk

The following are the most important of the many factors which should be taken into account in the assessment of risk, especially if the first assessment comes in the yellow field. The greater the number of "aggravating" factors, the lower the recommended maximum weight will be compared with ideal lifting conditions.

#### Questions about *tasks*:

- is the work: performed for a long period? frequently? under time pressure? controlled by a machine? are employees allowed to take breaks when required?
- does the job: require the trunk to be bent or twisted? require the trunk to be both bent and twisted?
- is the load carried over a long distance?
- does the handling require precision?

#### Questions about *the object*:

- is the object: difficult to grasp? possible to be handled close to the body? large? unwieldy? warm? cold? sharp? wet? smooth?
- is the object: fragile? unstable? mobile or liable to shift (e.g. a sack of potatoes)?

#### Questions about "*the workplace*":

- is the workplace of sufficient size (e.g. have sufficient headroom)?
- are there obstructions in the workplace (e.g. stairs or poorly stored materials)?
- is the floor/underlay slippery, uneven, sloping or unstable?
- are climatic conditions satisfactory?

#### Questions about *the person doing the lifting*:

- does the employee have sufficient physical capacity (e.g. muscular strength, aerobic capacity or body control)?
- does the employee have sufficient knowledge about safe work techniques? Is the employee using this knowledge, applying adequate lifting techniques? is the employee wearing suitable clothing and/or footwear?

### Model for identifying and assessing physically monotonous, repetitive work

The following assessment model can be consulted for the identification and assessment of physically monotonous, repetitive work. A final assessment of risk should always include *the total time* devoted to the work and *how it is spread out* over the day.

	Red	Yellow	Green
<b>Work cycle</b>	The work cycle is repeated several times a minute for at least half the shift	The work cycle is repeated several times a minute for at least one hour of the shift <i>or</i> many times an hour for at least half the shift	The work cycle is repeated a few times every hour.
<b>Work postures and working movements</b>	Constrained or uncomfortable work postures and movements.	Limited scope for changing work postures and movements.	Well-designed work-place. Good possibilities of varying work postures and movements.
<b>Job decision latitude</b>	The work is completely controlled by something else or by other people.	The work is partly controlled by something else or by other people. Limited possibilities of influencing the way in which the task is performed.	Good possibilities of adapting the work to one's own ability. Influence on the planning and arrangement of work.
<b>Job content Training/ competence requirements</b>	The employee performs an isolated task in a production process. Short training phase.	The employee performs several tasks in a production process. Job rotation can occur. Training for several tasks.	The employee takes part in several tasks or in the whole of the production process, planning and instruction included. Continuous competence development.



**Aggravating factors:**

- work that requires a great deal of physical exertion, precision or speed of movement,
- working with objects that are heavy and difficult to grasp,
- a reward system that pays a premium for quantity rather than quality, e.g. piecework,
- a production process that is subject to frequent and unexpected disruptions that employed cannot control, and
- poor social relations and social support at the workplace.

*Assessment*

*The work cycle* is the predominant factor. If this is found in a *red* field, the work is judged to be physically monotonous and repetitive which is harmful. Remedial measures should be taken very promptly. The risk of negative effects further increases if one or more of the other factors also come in a red field. If the work cycle is found in a *yellow* field, conditions should be evaluated more closely. If one or more other factors appear in a red or yellow field, the work is rated as unsuitable and measures should be taken. If the work cycle is judged to come in the *green* area, the work is no longer assessed as physically monotonous and repetitive. Where other factors are concerned, working conditions improve as one moves towards a green field. Aggravating factors must always be included in a total assessment.

*Explanation of the model*

The diagram is based on a full working shift, which is usually 8 hours a day.

**Work cycle:** The duration of a work cycle is commonly defined by industry as the time that elapses from the time the machining/processing of an object starts until the same operation is

repeated with the next object. It is not unusual for the same working movements to be repeated several times within a working cycle of this kind, i.e. for the “technical working cycle” to consist of several “kinetic cycles”. If kinetic cycles are not clearly distinguishable, the “technical” working cycle can be used as a starting point. Fingers and wrists can cope with a higher frequency of movement, without suffering injury, than elbows and shoulder joints so serious attention should be taken if these larger joints are used for work.

**Work postures and working movements:**

Reference is made to the assessment model for strenuous work to aid the assessment of work postures. When assessing working movements, attention must be paid to which parts of the body are used.

**Job decision latitude:** The concept of “job decision latitude” relates to the level of control a worker has over their work procedures. For example, individuals sitting at a conveyor belt are unable to influence the speed of the machine and are therefore controlled by someone else. If employees are confronted by long queues of customers, they can experience mental stress that limits their job decision latitude. Piecework implies an element of self-determination, in that the employee can decide how much they will produce, however, in practice, piecework often has the opposite effect as there are always minimum requirements for output.

**Job content and training/competence requirements:** Job content refers (at least in part), to possibilities to see the “whole” production process and how an individual contributes to that process. High quality job content means that employees recognise that work tasks of different character clearly belong together, e.g.

because their job content includes elements of planning, implementation and inspection. Employees with high quality jobs are able to use and develop their competencies/skills

There are jobs with conspicuously limited job content where the only stimulus is the volume of product an individual can produce and/or the associated incentive pay. The mental stimulus connected to being ‘good at the job’, i.e. fast, actually endangers physical health because the load on the body increases with rising perform-

ance while time for breaks and recuperation diminishes.

Training/competence requirements refer to the induction, introduction and subsequent training needed by employees in order to do a job. More complex tasks cater to the physical, mental and creative capacities and needs of employees. Jobs with high quality job content usually require longer training and continuous competence development.

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# Workplace design and evaluation

*Roland Kadefors*

## WORKPLACE DESIGN DEFINITIONS AND LIMITATIONS

This chapter examines the design of the immediate environment in which a person works, i.e. a workstation, defined as the “combination and spatial arrangement of work equipment, surrounded by the work environment” (International Standard, ISO /DIS 6385). According to the same source, “work equipment” is defined as “tools, including hard- and software, machines, vehicles, devices, furniture, installations and other components used in the work system”. These definitions underline the fact that workplace design needs to take all the relevant factors into account in order to ensure that workers’ health is adequately protected.

This chapter on workplace design principally addresses “manual work”, focusing on design that aims to avoid physical strain and exposures that cause pain and discomfort in the musculoskeletal system. However, in practical design situations there will always be specific factors that have to be taken into account. For instance, in the design of a manual assembly system, it is essential to consider not only the physical layout of the workstations along the production line, but also the organisation of the work system. The distribution of work tasks between successive workstations in such a system defines important ergonomic characteristics such as

cycle length, repetitive tasks, autonomy, and the arrangement of work and rest time.

Stress can be imposed by poor work organisation and may also increase the risk of musculoskeletal pain syndromes, but this chapter does not address psychosocial factors, including mental stress, explicitly.

## CREATING NEW WORKPLACES

The design of workplaces is a critical task in ergonomics. A well-designed workplace not only increases the health and wellbeing of operators but also improves productivity and product quality. Conversely, poorly designed workplaces are likely to cause or contribute to the development of health problems or chronic occupational disorders, as well as to problems with maintenance of desired product quality and productivity. It is surprising that there is a widespread lack of awareness internationally among technical personnel, supervisors, and managers responsible for workplaces with respect to the importance of workplace design. However, there is a growing trend in both developed and developing countries, that emphasises the importance of ergonomic factors in the increasing demand for product quality, flexibility and precise delivery schedules, all demands that are not compatible



with a conservative view the design of work and workplaces.

As mentioned above, this chapter focuses on physical factors but workplace design cannot be practically separated from the organisation of work, (as illustrated by the design process described later in the text). The quality of the end result relies on the implementation of three key factors: ergonomic knowledge, integration with productivity and quality demands, and participation.

Workplaces are meant for work and any workplace design process must recognise that a specified production goal has to be achieved. Industrial designers, (often production engineers or others at middle management level), develop an internal vision of the workplace and then start to implement this vision through their planning media. The process is repetitive, starting with a crude first attempt and gradually refining the solutions. It is essential that ergonomic aspects be taken into account as the work progresses.

The design process needs a structure that ensures that all relevant aspects are considered, e.g. traditionally through the use of checklists that contain a series of variables that should be taken into account. An example of such an exhaustive checklist concerning workplace design, the Ergoweb, is presented in Figure 3.4.1. The website [www.ergoweb.com/resources/reference/guidelines/fittingjob.cfm](http://www.ergoweb.com/resources/reference/guidelines/fittingjob.cfm), has checklists covering task analysis, hand tool analysis, material handling, and computer workstations. However, general purpose checklists tend to be voluminous and difficult to use as often only a small part of a checklist is relevant for a specific design situation. In addition, some variables will be more important than others.

### THE WORKPLACE DESIGN PROCESS

The workplace is usually part of a work system, but while it is not possible to address the

whole methodology relevant to systems design, it is valuable to consider the process for work systems design as recommended in the international standard “Ergonomic principles in the design of work systems” (ISO 6385:2004). This standard emphasises the need to devote attention to “the human, the social and the technical requirements during the design process”.

In this context, we concentrate on the “workstation and workspace” aspect of design, as it relates to musculoskeletal strain.

### Steps in the process

In the workplace design and implementation process, there is a need to inform users and to organise the project in such a way that there is full participation by users thereby improving the quality as well as increasing the chance that employees will fully accept the final result. A participatory approach should always consider the following steps, see Figure 3.4.2.

However, in many cases, only some of these steps are actually included in the workplace design. There are a variety of reasons for this. For example, if the workplace is of standard design, such as for work with Visual Display Units (VDUs), some steps may be excluded but in other cases, the exclusion of some steps may result in an unacceptably lower quality workplace. This may occur when there are overly stringent economic or time constraints, or because of lack of knowledge or insight at management level. Another situation arises when a new workplace is created from scratch and there are no employees to involve so the ergonomist needs to articulate the potential demands of the end users of the workplace. Views on potential user demands can then be sought from experienced professional practitioners.

<p><b>Workstation checklist</b></p> <p>A “no” response indicates potential problem areas that should receive further investigation.</p> <ul style="list-style-type: none"> <li>• Does the working space allow for a full range of movement?</li> <li>• Are mechanical aids and equipment available?</li> <li>• Is the height of the work surface adjustable?</li> <li>• Can the work surface be tilted or angled?</li> <li>• Is the workstation designed to reduce or eliminate bending or twisting at the waist?</li> <li>• Is the workstation designed to reduce or eliminate reaching above the shoulder?</li> <li>• Is the workstation designed to reduce or eliminate static muscle loading?</li> <li>• Is the workstation designed to reduce or eliminate extending the arms?</li> <li>• Is the workstation designed to reduce or eliminate bending or twisting the wrists?</li> </ul>	<ul style="list-style-type: none"> <li>• Is the workstation designed to reduce or eliminate raised elbows?</li> <li>• Is the employee able to vary posture?</li> <li>• Are hands and arms free from pressure from sharp edges on work surfaces?</li> <li>• Is an armrest provided where needed?</li> <li>• Is a footrest provided where needed?</li> <li>• Is the floor surface flat?</li> <li>• Are cushioned floor mats provided for employees who are required to stand for long periods?</li> <li>• Is the chair or stool easily adjustable and suited to the task?</li> <li>• Are all task requirements visible from comfortable positions?</li> <li>• Is there a preventive maintenance program for mechanical aids, tools, and other equipment?</li> </ul>
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Figure 3.4.1. A workplace design checklist. Source: Ergoweb.

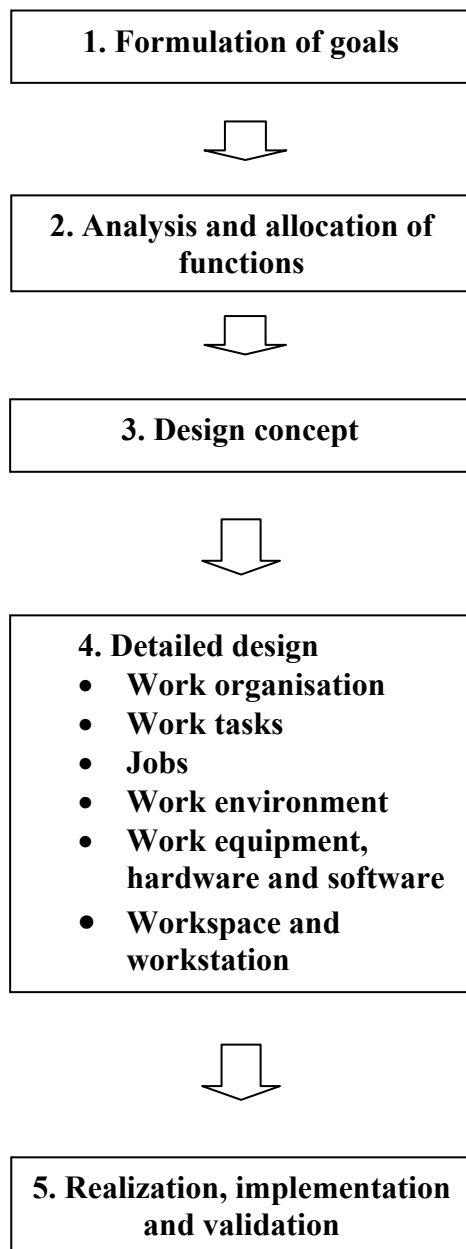


Figure 3.4.2. A work system design process, adapted from ISO 6385:200.

### Identification of technical demands

The planning phase specifies the end product of the work to be carried out in the workplace. In large organisations, there is frequently a gap between design and production so wherever possible, it is useful to integrate ergonomics into the early phases of product development. This possibility is significantly more likely to eventuate if production and design are part of the same company or group.

Small companies commonly deliver to a large company or local workplaces are part of a larger chain of workplaces, so there is often little possibility to influence design. Nevertheless, in all cases, information on ergonomic problems should be fed back to the designers for consideration. It may also be necessary to take account of productivity losses and quality problems as poor ergonomics often goes together with poor production performance.

### Collection of user specified demands

It is relevant to identify users of the workplace as any member of the production organisation who may be able to contribute qualified views on the design of a new workplace. This includes workers, supervisors, production planners and/or engineers, as well as safety stewards and members of the health care organisation. Experience shows clearly that these actors all have unique knowledge that should be used in the process.

The collection of specific demands from users should meet a number of criteria:

*Openness.* All points of view should be noted without criticism being expressed in the initial stage of the process.

*Non-discrimination.* Viewpoints from every category should be treated equally at this stage of the process. Special consideration should be given to the fact that some people may be more

eloquent than others so there is a risk that they may silence other participants.

*Development through dialogue.* There should be an opportunity to adjust and develop demands through a dialogue between participants of different backgrounds. Prioritising should be part of the process.

*Versatility.* The process of collection of specific user demands should be reasonably economical and not require the involvement of specialist consultants or demand extensive time contributions from participants.

The above criteria may be addressed by using a methodology based on Quality Function Deployment (QFD). User demands may be collected in a session, typically 10-15 minutes, involving a mixed group of actors (not more than 8-10 people). All participants are given a pad of removable self-stick notes. They are asked to write down all relevant workplace demands using a separate slip of paper for each. Aspects relating to work environment and safety, productivity and quality should be covered. At the end of the session, each participant is asked to read out his or her demands and to stick their notes to a board that everyone in the group can see. The demands are grouped in natural categories, for instance, concerning lighting, lifting aids, production equipment, reaching requirements, and flexibility demands. After completion of the round, the group is given the opportunity to discuss and to comment on each set of demands, with respect to relevance and priority. The convenor takes notes and makes a report that is used as the basis for subsequent design stages.

This way of working can be applied in any situation (service organisations and manufacturing companies alike), where there is an existing production organisation.

The set of user specified demands collected in a process such as the one described above,

forms a basis for the development of a workplace specification. It is essential that these demands are expressed in terms that will help the users, i.e. that they express function rather than only specifying technical characteristics, e.g. users might demand that a tool fits in an operator's pocket.

QFD techniques are not the only approach for collecting user demands. Another method for structuring user demands on the choice and/or development of hand tools is "A Good Tool – Check Yourself", see Figure 3.4.3. This is a very useful method when there is a choice to be made between different tools, (or other products), and in particular, to motivate the purchase of a more expensive tool with better ergonomic properties. End users may be interviewed by using this guide, and interview results can be then combined and presented. This process articulates end user views and helps to increase awareness of the importance of ergonomics in the organisation.

**A GOOD HAND TOOL – CHECK YOURSELF**

1. What do you think about the size of the tool?

Very good		Rather good		Neither good nor bad		Rather Bad		Bad	
10	9	8	7	6	5	4	3	2	1

a) Too bulky? yes no

2. What do you think about the weight?

Very good		Rather good		Neither good nor bad		Rather Bad		Bad	
10	9	8	7	6	5	4	3	2	1

a) Too heavy? yes no

3. What do you think about the balance?

Very good		Rather good		Neither good nor bad		Rather Bad		Bad	
10	9	8	7	6	5	4	3	2	1

a) Too much forward imbalance? yes no

b) Too much backward imbalance? yes no

4. What do you think about the size of the handle?

Very good		Rather good		Neither good nor bad		Rather bad		Bad	
10	9	8	7	6	5	4	3	2	1

a) Too long? yes no

b) Too short? yes no

c) Too thick? yes no

d) Too slim? yes no

5. What do you think about the form of the handle?

Very good		Rather good		Neither good nor bad		Rather bad		Bad	
10	9	8	7	6	5	4	3	2	1

a) Too round? yes no

b) Too angular? yes no

6. What do you think about the surface of the handle?

Very Good		Rather good		Neither good nor bad		Rather Bad		Bad	
10	9	8	7	6	5	4	3	2	1

a) Good structure? yes no

b) Isolated against cold/heat? yes no

7. What do you think about the usefulness of the tool?

Very good		Rather good		Neither good nor bad		Rather bad		Bad	
10	9	8	7	6	5	4	3	2	1

a) Can it be used with two hands? yes no

b) Is it comfortable to use? yes no

8. What do you think about the efficiency of the tool?

Very good		Rather good		Neither good nor bad		Rather bad		Bad	
10	9	8	7	6	5	4	3	2	1

9. What do you think about the appearance of the tool?

Very good		Rather good		Neither good nor bad		Rather bad		Bad	
10	9	8	7	6	5	4	3	2	1

a) Is the form OK? yes no

b) Is the colour OK? yes no

b) Is the tool easy to recognise? yes no

10. What do you think about the service and maintenance of the tool?

Very good		Rather good		Neither good nor bad		Rather bad		Bad	
10	9	8	7	6	5	4	3	2	1

Figure 3.4.3. A checklist for selection and evaluation of handtools.

### Prioritising and demand specification

With respect to the specification process, it is essential that different types of demands are considered according to their respective importance. This avoids the need for all aspects to be taken into account in parallel, which may make the design process complex.

It may be difficult to devise a priority scheme that will serve all types of workplaces equally well but if it is assumed that manual handling of materials, tools or products is an essential aspect of the work to be carried out, there is a high probability that aspects associated with musculoskeletal load will be the top priority. The validity of this assumption can be checked when user demands are collected. Relevant user demands may include work tasks associated with muscular strain and fatigue, reaching, poor visibility, and ease of manipulation.

It is essential to realize that it is not possible to transform all user demands into technical specifications. Some demands relating to more subtle aspects of work such as comfort, may be highly relevant and worthy of consideration in some, but not all, situations.

Tool problem category	Problem weight	Tool 1	Tool 2
Causes accidents?	5		
Causes musculoskeletal pain or disorders?	5		
Uncomfortable?	3		
Used many times during a work shift?	2		
Low materials quality?	1		
Ineffective?	1		
Gives poor product quality?	1		
Unattractive, ugly?	1		
Sum			

Figure 3.4.4. Guide for prioritising in a workplace design situation. Example: choice between two hand tools.

An example of a prioritising guide used in “The Swedish Hand Tool Project” is shown in Figure 3.4.4. This guide was developed to support the decision about which one of two alternative tools should be prioritised. The weight factors for each tool were added together and compared.

### Technical and user term specification

The technical specification of a workplace is based on the prioritised technical and user demands. This document could be given to the appropriate person responsible for implementation or could form the basis for a tender. The transfer of user specifications to technical specifications is sometimes easy, but may also be complicated. For instance, if workers in a sewing factory need to see what they are doing, adequate lighting is required. On the other hand, demands to be able to work without getting back pain require more detailed consideration if technical solutions are to be found. While this is a very reasonable demand, there may be a number of solutions such as the possibility for individual adjustment of the height of chairs and tables or a degree of mechanisation to alleviate heavy or sustained lifting.

## WORKPLACE EVALUATION

### Evaluation methods

With respect to physical workload, there are basically three methods used to evaluate existing workplaces,

- direct measurement,
- expert observation,
- subjective assessment.

Direct measurement is particularly useful in relation to workspace evaluation to address questions such as the distances that operators can see and reach, and whether work can be carried out in the optimal working zone. Figure 3.4.5 outlines optimal working zones in relation to stat-



ure (typical for males and females), for standing work. Figure 3.4.6 shows recommended measures for sitting work. Even though the average height of populations varies between different countries, it is possible to normalise and apply the recommendations to individual cases.

Figure 3.4.7 gives examples of the stature of men and women in different countries. This gives a basis for adaptation of the recommended measures to conditions in an individual country. However, it should be noted that part of these data are 20 years old or more and the average stature has increased by 10 mm or more per decade so it is advised that the stature of the population be checked before designing a workplace. Such information can be found for instance in military conscription statistics.

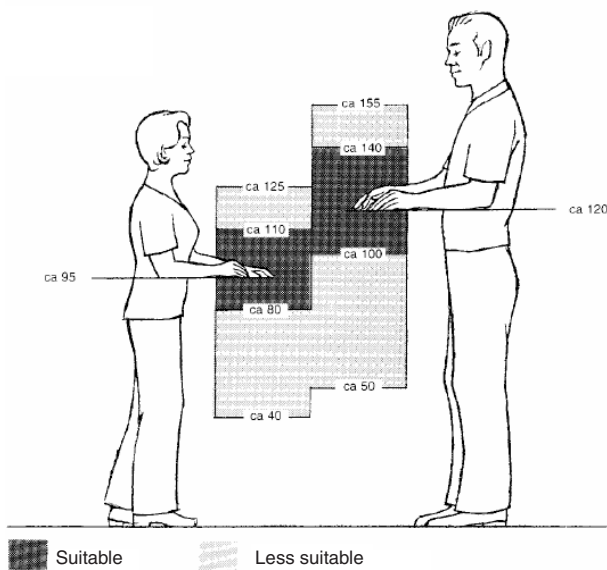


Figure 3.4.5. Suitable working heights for a large and small person respectively. 95 per cent of Swedish men are smaller than the man in the drawing, and 95 per cent of Swedish women are bigger than the woman. In normal instances, the most suitable working height is on a level with the employee's elbow. (Measurements are in centimetres).

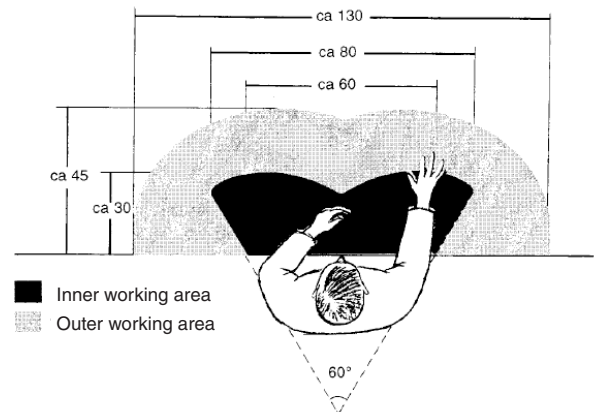


Figure 3.4.6. Working areas for the hands. (Measurements in centimetres).

There are many methods for *expert observation* of work e.g., the use of checklists and structured observational guides. An example of an ergonomic analysis instrument is RULA (Rapid Upper Limb Assessment), which makes assessment based on specification of body posture, handled load and repetition. It can be used online by visiting [www.rula.co.uk](http://www.rula.co.uk)

Expert observation methods are best suited for analysis of static or repetitive work carried out in relatively short cycles. Variable work observation methods tend to be too time consuming for work with long cycles because it is often necessary to analyse several operators carrying out the same job before conclusions can be drawn. Individual factors such as stature or working techniques, may significantly influence the ergonomic workload. Expert observation can also be facilitated by video filming work or through analysis away from the production line.

In ergonomic evaluations of existing workplaces, it is reasonable to make use of subjective assessment by taking account of the experience of the workers carrying out tasks. Questionnaires and interviews may supply extremely use-

Country	Men	Women
Brazil (industrial workers; 1989)	(1595)1700(1810)	-
Hong Kong (industrial workers; quoted 1996)	(1585)1680(1775)	(1455)1555(1655)
India (agricultural workers; 1989)	(1540)1620(1700)	-
Sri Lanka (workers; 1987)	(1535)1640(1745)	(1425)1525(1620)
Sweden (16-84 years; 1998)	1790	1655
U.S.A. (19-60 years; 1989)	(1647)1756(1867)	(1528)1629(1737)

Figure 3.4.7. Stature in some countries in adult men and women (millimetres).  
(5th percentile) 50th percentile (95th percentile).

ful information on the physical workload conditions, at low cost. The inclusion of self-reported assessments is based on a general view (with some scientific support), that reported high levels of pain and discomfort during work imply an increased risk of occupational disorders in the musculoskeletal system in the long term. Within the context of ergonomics, the subjective views of users provide a relevant basis for workplace design, on the grounds that pain and discomfort imply a poor correlation between work demands and capacity. Consequently, the productivity and quality of work is likely to be improved, which is consistent with a participatory approach to ergonomics.

An example of a widely applied instrument for collecting subjective responses to workloads is the body map included in Figure 3.4.8 (the so called Nordic Questionnaire). Subjects are asked if they feel pain or discomfort anywhere in the body, and if so, to indicate on the map which part of the body is painful or uncomfortable.

In addition to location, the degree of pain or discomfort is also of interest. A useful instrument for severity assessment is shown in Figure 3.4.9. Subjects are asked to identify the number on the scale that best describes their pain or discomfort.

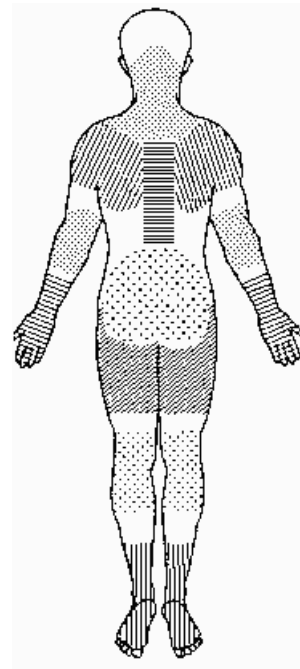


Figure 3.4.8. Body map from the Nordic Questionnaire.

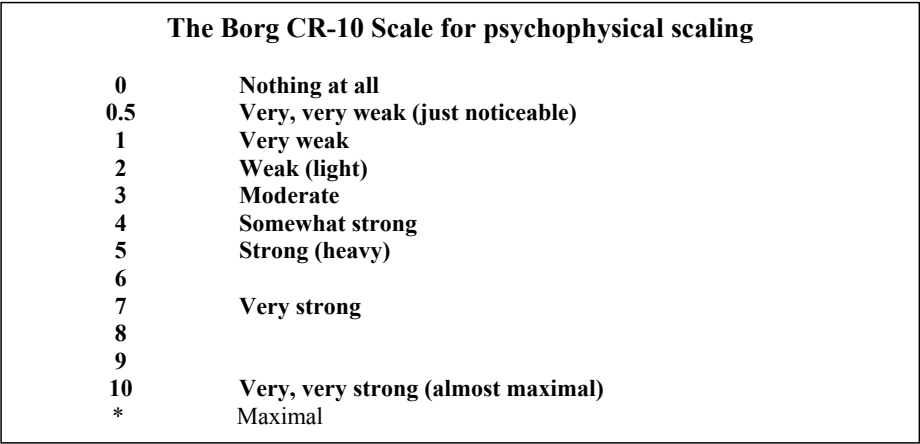


Figure 3.4.9. A scale for subjective reporting of perceived exertion, pain or discomfort.

Maximum allowable holding time (minutes)

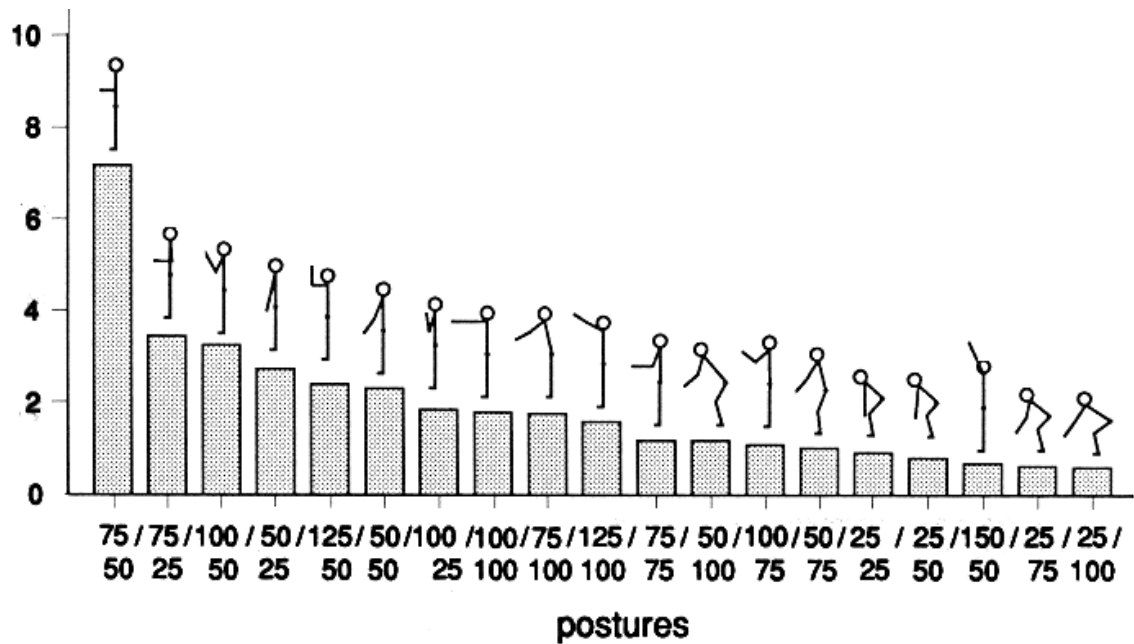


Figure 3.4.10. Maximum allowable holding time in minutes, in various body postures. A posture is defined by the vertical hand position (working height expressed as the percentage of shoulder height in upright standing position) and the horizontal hand position (working distance expressed as the percentage of arm reach). For instance, “125/100” means a posture where there is full arm reach and where the hands are 25 percent above shoulder height. Adapted from Ringelberg and Koukoulaki: Risk Estimation for Musculoskeletal Disorders in Machinery Design.

### Examples of useful guidelines: static posture

Specific guidelines to support expert assessment exist for musculoskeletal strain, in particular static posture and heavy materials handling.

In terms of postures for static work, recommendations may be based on 20% of the maximum time that a person should maintain a certain posture. This level is chosen so as to avoid “strong discomfort” (score 5 according to Borg’s rating scale, Figure 3.4.9). Figure 3.4.10 shows the estimated maximum duration that should be allowed without taking a rest, for 19 different standing body postures and arm positions. These measures correspond to 20% of maximum endurance time. It should be noted that in this instance, the load is not aggravated by the handling of materials, tools etc. but consists only of the body itself so if weight is added, the time will be shortened. These recommendations are applicable for both one- and two-handed operations.

### Examples of useful guidelines: manual lifting

The Swedish Ordinance (AFS 1998:1, Ergonomics for the Prevention of Muscular Disorders) provides relevant guidelines for manual two-handed lifting. As in Figure 3.4.5, the distance between the hands and the body is taken as a determinant, but here the weight of the load is a variable. A model for assessment of two-handed lifting tasks is shown in Figure 3.4.11. Here, the maximum acceptable load ranges between 15 and 25 kg depending on the position of the hands relative to the lumbar region of the body.

The allowable load may be compromised because the lifting is very frequent, or if twisting occurs, etc. A number of such factors are covered in the more complex NIOSH Model for Manual Lifting. In the “Applications Manual

for the Revised NIOSH Lifting Equation”, an equation for maximum recommended weight in manual lifting is presented. This equation takes into account the following mediating factors: horizontal distance, vertical lifting height, lifting asymmetry, handle coupling, and lifting frequency. In this way, the 23 kg maximum acceptable load limit, based on biomechanical, physiological and psychological criteria under ideal conditions, may be modified substantially to take account of the specifics of the working situation. The NIOSH equation provides a base for evaluation of work and workplaces involving lifting tasks. However, there are limitations to the usefulness of the NIOSH equation: only two-handed lifts may be analysed, and the assessment is strictly based on loading of the lower back, without taking the load on e.g. the arms and shoulders, into account.

The basic form of the equation is,  

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM,$$
 where:

RWL = Recommended Weight Limit

LC = Load Constant (23 kg)

HM = Horizontal Multiplier

VM = Vertical Multiplier

DM = Distance Multiplier

AM = Asymmetric Multiplier

FM = Frequency Multiplier

CM = Coupling Multiplier

All the multipliers HM through CM are  $\leq 1$ . This means that while the maximum recommended mass under optimal conditions is 23 kg, it will almost always be compromised and set to a lower value. The multipliers are calculated on the basis of the characteristics of a given task. This instrument can be downloaded from [www.cdc.gov/niosh/docs/94-110](http://www.cdc.gov/niosh/docs/94-110).

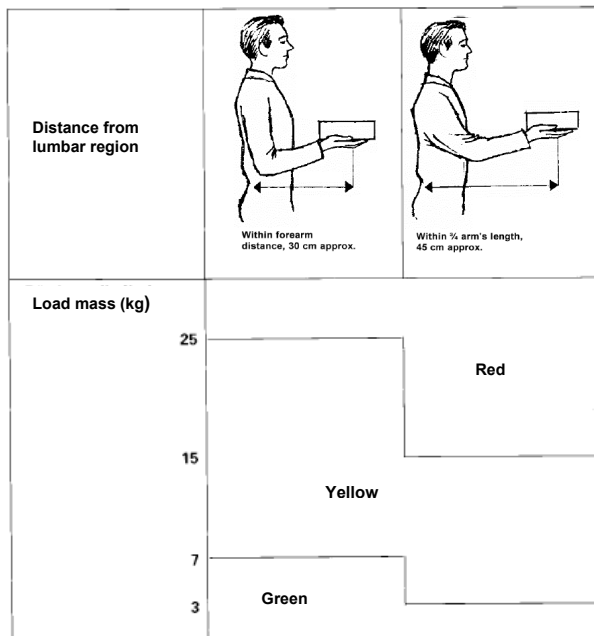


Figure 3.4.11. Acceptable (green), conditionally acceptable (yellow) and not acceptable (red) loads in two-handed lifting.

### Examples of useful guidelines: handling of tools and smaller objects

In line with the above reasoning, there is a set of basic ergonomic variables relating to musculoskeletal load that need to be taken into account as a priority in the design process, in order to reduce the risk of Cumulative Trauma Disorders (CTDs). These disorders are pain syndromes localized to the musculoskeletal system, which develop over long periods of time as a result of repeated stresses on a particular body part. The essential variables are,

- muscular force demand;
- working posture demand;
- time demand.

With respect to *muscular force*, criteria setting may be based on a combination of biomechanical,

physiological and psychological factors. Muscular force is a variable that is calculated through measurement of output force demands, in terms of handled mass or required force for an operation e.g., operation of handles. Peak loads connected with highly dynamic work may also have to be taken into account.

*Working posture* demands may be evaluated by mapping (a) situations where the joint structures are stretched beyond the natural range of movement; (b) particularly awkward situations, such as kneeling, twisting, or stooped postures, or work with the hand above shoulder level.

The *time demands* may be evaluated on the basis of mapping (a) short cycle, repetitive work, and (b) static work. It should be noted that evaluation of static work may not be exclusively concerned with maintenance of a static work posture or the production of a constant output or force over lengthy periods of time; from the point of view of the stabilizing muscles, particularly those in the shoulder joint, seemingly dynamic work may also have a static character which may make it necessary to consider lengthy periods of joint mobilization.

In practice, a working situation is deemed to be acceptable or not depending on the demands placed on the part of the body under the highest strain.

It is important to note that the above variables must be considered jointly, not separately. For instance, demands for high force or lifting the arm above shoulder level may be acceptable if they occur only occasionally, but combinations of these basic variables must be considered.

Setting criteria for ergonomics is complex, since different exposure variables are very much interrelated. For example, standing in an awkward working position to tighten a screw with a screwdriver may be quite acceptable if the task occurs occasionally but it is not acceptable if

*Force*

- Low force demand: two-handed handling of objects less than 1.0 kg weight
- Medium force demand: two-handed handling of objects between 1.0 and 4.0 kg weight
- High force demand: two-handed handling of objects exceeding 4.0 kg weight

For one-handed handling, divide figures by 2.

*Posture*

- Low postural demand is where the posture is straight upright standing or sitting and where hands are in optimal working zones; joint angles are neutral
- Medium demands are in standing straight or sitting when hands are outside optimal working zone; joints are deviated
- Working positions implying high postural demand are those with elevated arms, twisted or forward flexed positions, and kneeling positions; joint angles are in extreme deviation:

*Time*

- Low time demand: less than 30 minutes exposure per day
- Medium time demand: between 30 minutes and 4 hours exposure of work with work-rest quotient/cycle  $<1$
- High time demand: between 30 minutes and 4 hours exposure of work with work-rest quotient/cycle  $>1$ ; or more than 4 hours exposure per day

required frequently. However, if a work task can be carried out in an optimal working position, a higher degree of repetition may be acceptable. In general, independent consideration of force, posture and time is insufficient.

In the Cube Model, sub-cubes are denoted A, CA or NA depending on the acceptability of combinations of demands. Definitions are according to the “European Safety of Machinery – Human Physical Performance Standard” document:

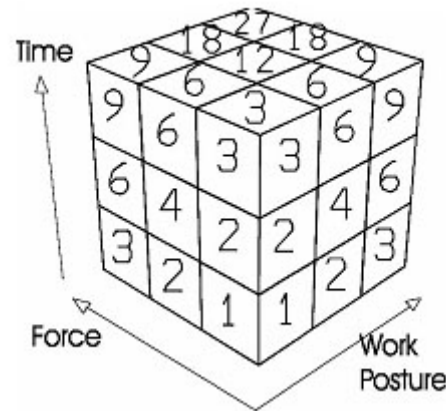


Figure 3.4.12. The cube model for ergonomic evaluation, taking into account force, posture and time aspects concurrently. Scores  $<5$ : A, acceptable situations; scores  $\geq 9$  NA, not acceptable, scores between 5 and 9 CA: conditionally acceptable, depending on, e.g., the user population.

- Acceptable (A): the health risk is considered to be low or negligible for nearly all healthy adults. No action is needed.
- Conditionally Acceptable (CA): there is an increased health risk for some or all of the user population. The risk must be analysed together with contributing risk factors, followed as soon as possible by risk reduction (i.e., redesign) or if that is not possible, other suitable measures.
- Not Acceptable (NA): the health risk is unacceptable for any part of the user population.

Acceptability is not only based on evaluation of the risk of acquiring musculoskeletal disorders; several instruments also give consideration to the level of perceived discomfort as illustrated in Figure 3.4.9, where situations imposing “strong discomfort” according to the Borg score 5 (or higher), are termed “always unsafe” and are unacceptable.



Activity	Force (N)
Power hand grip	250
Sitting posture, one arm:	
Pushing upwards	50
Pushing downwards	75
Pushing outwards	55
Pushing inwards	75
Pushing	
– with trunk support	275
– without trunk support	62
Pulling	
– with trunk support	225
– without trunk support	55
Whole body work, standing posture:	
Pushing	200
Pulling	145
Pedal work, sitting posture, with trunk support:	
Ankle action	250
Leg action	475

Figure 3.4.13. Force capacity in optimal working conditions (general population).

### Examples of useful guidelines: force capacity

The force capacity varies greatly depending on the direction of action. Figure 3.4.13 gives force capacity limits according to the European Safety of Machinery Directives. It should be noted that these values may differ depending on local conditions in an individual country. However, for a mixed user population no work should require effort exceeding these force capacity levels.

### A workplace design example: manual welding

Welding is an activity that frequently combines high demands for both muscular force and manual precision. The work has a static character when welders do no other tasks other than welding. The work environment is generally hostile, with a combination of exposures to risk factors such as high noise levels, welding smoke, and optical radiation.

This example shows what is needed to devise a workplace for manual MIG (Metal Inert Gas) welding of medium size objects in alloyed steel (up to 300 kg), in a workshop environment. The workplace needs to be flexible to cope with a variety of objects to be manufactured and there are high demands for productivity and quality.

Additional technical specifications include:

- Value adding welding work (arc time): 3 hours/day.
- Time per welding joint: 2-5 minutes.
- Weight of the welding gun package: 3.5 kg.

Using the cube model approach, the following classifications can be made:

Force variable. The handled mass implies *high force demand*.

Postural strain variable. The postural strain depends on the workplace layout and is dependent on design.

Time variable. The welding work implies *medium time demands*, on the condition that there is provision for variation of activity, for instance by object and tool handling, inspection, grinding, etc, between welding tasks.

The Cube Model assessment means that if the welding work is carried out in a position implying high postural demands, (e.g. working overhead or kneeling), the work situation is unacceptable. However, if the postural strain can be reduced by positioning of the welding object to achieve low or moderate demands, then the work situation is *conditionally acceptable*. Ways to arrive at an acceptable situation include the introduction of support for the welding cable, a lighter welding gun, and work organisation that

allows the welder to rotate to other jobs without static loading, for instance plate work or work with automated equipment.

Based on the results of the first stages of the design process, an acceptable workplace for welding can be established. Welding work also requires precautions against other hazards including welding fumes and noise.

In a practical design situation, various compromises may have to be made due to various

constraints, (e.g. economic or space) but adequate measures do not necessarily imply high costs. In practice, the achievement of acceptable solutions nearly always requires a combination of technical and organisational measures. Licensed welders are hard to come by and they represent a considerable investment so keeping a qualified welder on the job is beneficial for all parties involved: welder, company, and society.

### SUGGESTIONS FOR FURTHER READING

Ergoweb 2004, [www.ergoweb.com/resources/reference/guidelines/fittingjob.cfm](http://www.ergoweb.com/resources/reference/guidelines/fittingjob.cfm).

This site contains ergonomic checklists covering a wide range of applications.

Ringelberg, J.A. and Koukoulaki, Th., 2002, Risk estimation for musculoskeletal disorders in machinery design – Integrating a user perspective. European Trade Union Technical Bureau for Health and Safety (ISBN 2-930003-41-3)

This report consists of a compilation of different instruments for criteria setting and practical risk analysis.

Safety of machinery: Ergonomic design principles. Part 1: Terminology and general principles. EN 614-1:1995. CEN, European Committee for Standardization, Brussels Ergonomic Principles in the Design of Work Systems. ISO 6385. International Standards Organisation.

These standards outline general principles for ergonomic design.

Pheasant, S., 1996, Bodyspace. Anthropometry, Ergonomics and Design. 2nd ed. Taylor and Francis, London.

Contains a chapter on anthropometry in population groups from different parts of the world. It also outlines the principles for taking body measures.

Putz-Anderson, V. (Ed.), 1988, Cumulative Trauma Disorders. A Manual for Musculoskeletal Diseases of the Upper Limbs. Taylor and Francis, London.

This manual summarises the different sorts of clinical conditions that may be attributable to exposure to manual work. It also gives substantial advice on measures at the workplace to alleviate risks.



# Prevention of physical risks

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# Risk and risk control

*Lars Harms-Ringdahl*

## CONCEPTS OF RISK AND SAFETY

### Risk and related terms

The word risk has no universally accepted definition. It is used in a variety of contexts and in many senses. However, most definitions have two characteristics in common:

- A negative outcome – unwanted consequences or losses, e.g. an accident or some kind of disease.
- An uncertainty – an outcome (e.g. an accident) that may or may not happen

A general definition of risk is the possibility of an event or situation with undesired consequences. In everyday speech, its meaning shifts according to context. A high risk may refer to the seriousness of the consequences of an event that might occur or, to the high probability that an event will occur or, to a combination of the two. The term risk may also be used when outcomes are uncertain. In some contexts probability aspects are pronounced, and the risk is then defined as a combination of the likelihood of an occurrence of a hazardous event and the severity of injury.

The terminology and ways of thinking about risk vary between different scientific disciplines

and applications which makes the issue rather confusing and inconsistent. One option to clarify the issue is to make a division according to the context.

### Technical and economic systems

In the context of technical systems, the primary interest is in the reliability, i.e. the probability that the system will work as intended. In reliability applications, the term risk is used in a more narrow sense. Risk is a combination of the frequency, or probability, of occurrence and the consequences of a specified, hazardous event.

The term hazard is often used to denote a possible source or cause of an accident, injury or damage to people's health. "Source of risk" has been proposed as an alternative term. Harm is physical injury or damage to health, property or the environment.

For an economist, risk can refer to the possibility of losing money or that the actual return on an investment could be negative. In this type of application, there is often a statistical perspective on "risk".

### Occupational arena

For risks related to the workplace, the focus is usually on potential harm to workers. Here,



traditions from medicine exist in parallel with different types of technical concepts. Figure 4.1.1 gives a general (and abstract) model related to problems at the workplace.

The top row indicates a number of potential “sources of harm” that can negatively influence employees. The second row shows “mechanisms” that can result in negative effects, such as injuries, diseases and psycho-social effects.

One of the mechanisms is defined as “event”, used to indicate something that happens quickly. Traditionally, the focus has been on unintended events, often called accidents. During recent years, the scope has been broadened to include intended events such as violence at the workplace. There are three classes of events:

- *Accident* – an unintended event.
- *Intentional violence* from a person at the workplace, and
- *Suicide* which can be caused by factors at the workplace.

Occupational injuries can occur in a variety of ways. In general, they can be divided into three categories:

- Occupational accidents—accidents occurring in the workplace.
- Occupational diseases—harmful effects of work (not due to accidents), such as silicosis, metal intoxication, muscular and skeletal disorders, and hearing loss.
- Commuting accidents—accidents occurring on the way to or from the workplace.

Negative psycho-social effects are included in the above model as they are of increasing interest at the workplace.

An “occupational accident” is a sudden and unexpected event that leads to the injury of a human being in the course of their work. Generally, the course of events is rapid, only lasting seconds, but some accidents, such as those involving toxic gases or cold temperatures, may require several hours of exposure before causing an acute injury.

An accident is an undesired event that causes damage or injury. In the medical tradition, the term injury is often preferred to “accident”. An “incident” or “near accident” is an undesired event that almost causes damage or injury. The term “major accident” usually refers to a large

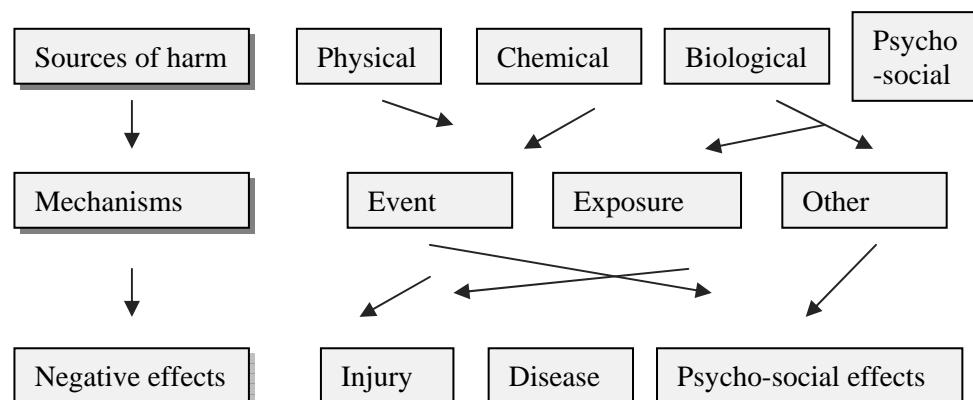


Figure 4.1.1. Simplified model of negative outcomes at the workplace. The arrows in the right section are only indicative.

scale accident in a chemical plant or large facility such as an oil refinery.

The time scale for occupational diseases is much longer compared to accidents, e.g. it can take 25 years for silicosis or asbestos disease to manifest in exposed workers.

### General concept of risk

It is important to notice that the diversity of ways in which the concept of risk is used constitutes a problem. This chapter uses the term in the general sense, “the possibility of an undesired consequence”.

Peoples’ perception of risk is another matter to be considered. The interpretation of information about hazards and how risks are controlled concerns both decision makers as well as the behaviour of people at risk. Which risks should be considered large enough to require actions? Such questions have become a branch of psychological study.

Research on risk perception started in the 1970’s. One common theme is the study of how people rank different types of risks, which is compared with statistical data about the risks.

### Safety, security and health

Definitions of “safety” are complicated by a number of alternative meanings. A system or device may be described as safe if it is free from energy and factors that might cause harm, e.g. a machine can be said to be in a “safe state” if there is no energy stored or supplied which can cause injury. One definition refers to a “safe system” as one free from obvious factors that might lead to injury of a person or damage to property or the surroundings. However, in practice this state is not obtainable.

Safety should be seen as a value judgement. A machine or action is regarded as safe if the level of risk of being injured is considered to

be acceptable. The judgement then concerns the significance of the risk, what level of risk is acceptable and who makes the judgement. The acceptance of risk depends on judgement and experience about how hazards are controlled. Acceptance of risk may also be related to the degree of trust in the person or organisation in charge of the situation.

The term security also has several meanings. One application of security concerns measures taken as a precaution against intentional actions such theft, espionage or sabotage, as distinct from safety concerns about unintentional events such as accidents.

Other meanings are closely related to safety, for example, being free from danger, anxiety or fear. Social security and insurance are also associated with safety, (sometimes referred to as a “safety net”), as they offer help when accidents or illness occur.

Another positive term related to the workplace is “health” which is defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

It is meaningful to see these aspects in combination. The management procedures to achieve these qualities have many elements in common. Also environmental aspects can be included. It is especially common to talk about SHE-management, where SHE stands for safety, health and environment.

### CAUSES OF ACCIDENTS

Explanations for why accidents occur show large variation, there is no uniform, universally applicable theory. It is common to look for the “the cause” of an accident but this kind of thinking regards an accident as the product of one event and one cause. However, research has long shown that a number of “causes” and factors lie behind each accident.

Depending on the person's role in the company, he or she may pick the explanations found most useful. E.g. the foreman can blame the worker who made a mistake, while the union may criticise the company for inadequate safety equipment. Views also differ between types of production and industry and depending on the state of technical and social development.

Explanations on the cause of accidents can also be based on the level of technical development of the workplace. For accidents that occur during traditional, manual work, it is common to look for human error or defective tools as the cause, as initially it may appear that only a small number of people are involved. In a sophisticated industrial installation, a large organisation and intricate equipment is usually involved, which makes it necessary to examine more complex relationships in order to find the cause of accidents.

The drawback with simple explanations which only consider a selected part of the total situ-

ation is that they may prevent problems from being effectively solved. Explanations and theories are useful, especially when they provide sufficient insight into why accidents occur and how they can be prevented.

Figure 4.1.2 gives a schematic view of explanations about the cause of accidents and how explanations change over time. There are five main overlapping categories:

- 1) The major problems are technical failures and malfunctions. Technical solutions would help.
- 2) People and human error cause accidents and problems in the workplace. Initially the focus was on errors by workers, but later, it was considered that managers also make mistakes.
- 3) The socio-technical perspective takes more of a systems approach, considering the interplay between people, equipment and organisational factors. People make errors because of poor adaptation of technical equipment and inadequate work organisation.

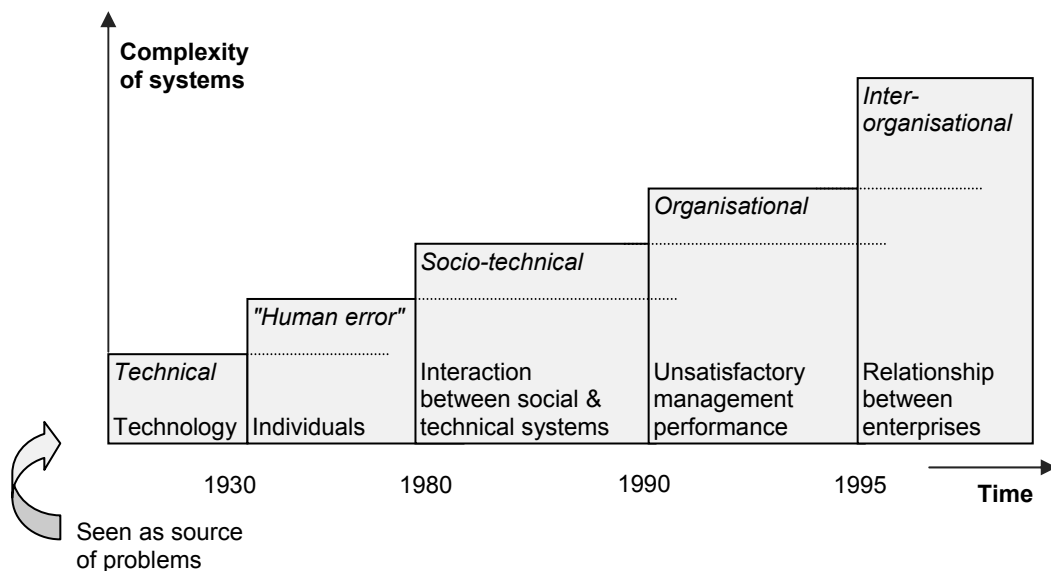


Figure 4.1.2. Schematic diagram of different explanations for the cause of accidents and how such explanations have changed over time. The time scale is only indicative, as different explanations of causes overlap.

- 4) Accidents and problems occur because of unsatisfactory company management of daily work, long term planning and design of production and work.
- 5) Hazards can be caused by organisational changes when a production process is divided between several enterprises. The division of tasks and responsibilities might be defective or incomplete, causing hazards. The defects have their roots in outsourcing, organisational changes, pressure from other companies, etc.

Explanations 3, 4 and 5 focus on traditional workplaces, where it is assumed that employers are responsible and are willing and able to try to prevent injuries. In other situations, workers need to take care of themselves as well as they can.

### Assumptions about the cause of accidents

The above text has given a number of explanations related to different assumptions and situations. Figure 4.1.3 gives a summary of parameters defining different situations. In Group A, the situation is related to a well organised and large company, while the Group B is much more informal.

A specific company or organisation may have parameters in both groups at the same time. For example, while a company has a formal safety management system, frequent changes allow improvisation and informal safety action to play a more prominent role.

Standards for risk analysis and risk management usually make an implicit assumption that there is a Group A situation. On the other hand, small and medium sized companies have most of the parameters in category B.

Parameter	Group A	Group B
Accidents	major consequences, infrequent	minor consequences, occasional
Organisation size	large, complex	small, simple
Regulation	precise, strictly enforced	general
General management	structured, formal	informal
Safety management	formal safety management system	informal
Economy and resources	good	poor
Stability	constant	frequent change

Figure 4.1.3. Parameters of management and risks divided in stereotypes A and B. Group A stands for a well organised large company, and Group B for the other extreme.

When discussing advanced safety features, it is easy to be trapped by stereotypical thinking related to Group A. Ideas about safety management systems, (or more broadly, Occupational Safety and Health Systems), including risk analysis and other tools, often assume a type A-situation exists.

In many practical situations, it is essential to be aware of the distinctions made in Figure 4.1.3. One example can be a fancy management system which is suggested. If the approach is based entirely on assumptions, a basic question is if it can be useful also in the actual situation.

### RISK CONTROL

There is a large spread in application areas and need for efficient approaches to prevent diseases, accidents and injuries. On one side there are uncomplicated types of production, where minor accidents dominate and safety is managed in a fairly relaxed way.

On the other side, industries with major hazards have high demands on more sophisticated approaches for prevention. For example, nuclear installations, aviation companies, and large chemical industries, are often associated with rigorous safety management systems because of their potential for major accidents and loss of life. Several independent, technical barriers are often in use so if one fails, the remaining barriers should give satisfactory protection. Technical solutions are often combined with organisational measures, such as maintenance programs that can increase the reliability of the technique and increase protection. One example is the (so called) Seveso II Directive of the European Union, which regulates safety management systems, risk analysis, and emergency plans in large chemical installations.

### Approaches and tools on risk control and accident prevention

There are a number of different approaches for risk control and accident prevention.

- Company management and responsibility
- Methods such as feed-back systems, risk analysis, etc.
- Workers' participation and involvement
- Intervention by authorities (such as inspectorates), insurance companies, etc.

A life cycle perspective on production systems could also be added considering different phases such as:

- a) Specifications
- b) Design procedure
- c) Operating the system
- d) System changes
- e) Termination, when the production is closed down and the equipment disposed.

A number of principles and methods can be applied at workplaces in order to make working conditions safer and healthier:

- 1) Conscious and safety-oriented planning procedures will support safe workplaces and production systems.
- 2) Application of established design principles.
- 3) Risk analysis to identify hazards in the system.
- 4) Safety inspections.
- 5) Incident studies such as collection of information from near accidents.
- 6) Accident investigations.
- 7) Feedback procedures between employees and managers that identify and give information about problems and hazards.
- 8) Statistical tools can be used to collect and analyse information on accidents and health problems.

The principle for many of the tools is to identify problems and hazards, and the result is used for correction of the system. However, the cost of remediation may reduce interest in carrying out improvements.

The first two approaches listed above, try to find a safe solution from the beginning of the design of the production system and workplace. Risk analysis and inspections might identify problems before accidents occur or health problems are manifest.

Incident studies and accident investigations give information about specific safety deficiencies at the workplace. Effective and appropriate feedback procedures can allow this information to be used to correct problems.

Larger companies commonly collect and analyse information about occupational accidents and diseases in order to show the relative frequency of accidents and diseases. This information can be used for comparison with

other companies and national mean values and can also help to identify dangerous job tasks and places where many accidents occur. Results can be used when setting priorities and identifying areas which need more effort.

Epidemiology is generally defined as the branch of medicine that studies the causes, distribution, and control of disease in populations. Epidemiological methods can also be applied to accidents and injuries. Occupational epidemiology has been defined as the study of the effects of workplace exposures on the frequency and distribution of diseases and injuries in the population; it is an exposure-oriented discipline with links to both epidemiology and occupational health and uses methods similar to those employed in general epidemiology.

### The management approach to OSH

Most legislation and approaches to OSH are based on the principle that the employer or company operating the workplace are responsible for safety and health at the workplace. There are many regulations and management systems that describe what employers should do on OSH.

One definition of risk management, based on the technical reliability standard states:

“Risk management is the systematic application of management policies, procedures and practices to the tasks of analysing, evaluating and controlling risk.”

In some industries the word “safety” is preferred, e.g. this definition related to major accident sites:

“Safety management may be defined as the aspect of the overall management function that determines and implements the safety policy. This will involve a whole range of activities, initiatives, programs, etc., focused on technical,

human and organisational aspects and referring to all the individual activities within the organisation, which tend to be formalised as Safety Management Systems (SMS).”

Both these definitions require companies to have policies on risk/safety management, a “top down” approach that is in line with both quality and environmental standards. However, as these definitions are based on the existence of policy, there can consequently be a problem if safety management policies are lacking. The definitions are also normative, (stating how work shall be done), which may be acceptable in high risk industries, where such practices are common and compulsory, but will be problematic in smaller enterprises.

While many companies, especially small companies, do not have a formulated policy, they may have OSH management to deal with hazards. It is also clear that there can be management which is not “systematic” so there a more comprehensive and simple definition is required. A simple definition is suggested below:

“Safety management is a way of managing the hazards (safety risks) of a company.”

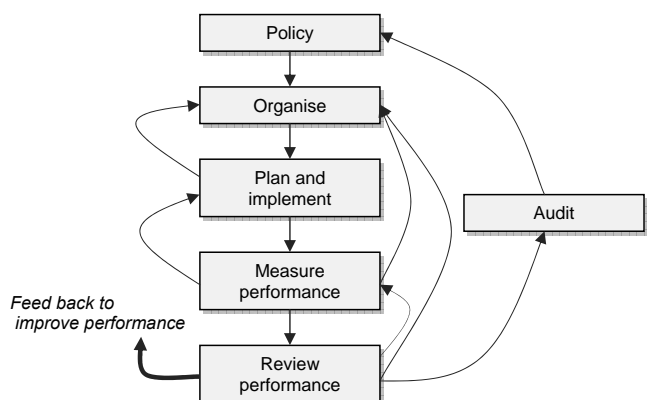


Figure 4.1.4. Examples of elements in OSH management.



Many ideas and advice exist on effective safety management, even for less formal companies. An example of health and safety management (developed from the Health & Safety Executive in UK), is shown in Figure 4.1.4. The model contains seven key elements.

- 1) The policy should express the general intention, aims and approaches, in relation to occupational safety and health issues at the company.
- 2) Organising for health and safety is the process of designing and establishing the responsibilities and relationships that form the social environment within which work takes place. More simply stated: “Organising is having an effective management structure and arrangements in place for delivering policy.”
- 3) Planning is essential for effective implementation of OSH policy. Planning requires the allocation of human and financial resources, and the setting of precise goals. A number of other activities are also related to planning including design of rules, accident investigations, and risk analysis.
- 4) Measuring is an essential aspect of maintaining OSH-performance. The implementation of plans needs to be checked to ascertain whether a company complies with standards. Accidents, incidents, and health problems need to be monitored.
- 5) During the review process judgements are made about the adequacy of performance and decisions about improvements and other changes are made.
- 6) Feedback is an essential element in all parts of management systems. Managers and workers need information about activities, accident rates, etc, to enable them to take effective and positive action.

- 7) Auditing is a structured process of collecting independent information on the efficiency, effectiveness and reliability of a total OSH management system. Corrective actions may also be proposed if necessary.

The feedback of information and problems can take many forms from formal, written reports to informal discussions between individuals. Person to person communication may be a very important source of information in both formal and informal systems.

### RISK ANALYSIS

Risk analysis is a useful tool to systematically identify hazards and problems at the workplace, even if no accidents have occurred (a proactive approach). The term “safety analysis” is often used as an alternative.

Within the technical field of reliability there is a standard from the International Electrotechnical Commission, which states that:

“Risk analysis is the systematic use of available information to identify hazards and to estimate the risk to individuals or populations, property or the environment.”

This standard also gives a number of alternative terms with similar definitions, namely probabilistic safety analysis, probabilistic risk analysis, quantitative safety analysis, and quantitative risk analysis. The terms “probabilistic” and “quantitative” mean that the results are based on numerical calculations, estimates of probabilities and (occasionally) consequences. Other terms defined in this standard are:

“*Risk estimation* is the process used to produce a measure of the level of risks (a part of risk analysis).”

*“Risk evaluation is the process in which judgements are made on the tolerability of the risk (based on the risk analysis).”*

*“Risk assessment is the overall process of risk analysis and risk evaluation.”*

The term risk analysis is used in many different applications, e.g. in toxicology, environmental studies, financial considerations, and insurance. However, here the definitions might be different.

In the chemical industry, risk analysis is the preferred term for all types of methods while in the nuclear industry, safety analysis appears to be more commonly used. The term is used in many other applications as well, for example:

*“Safety analysis is a systematic procedure for analysing systems to identify and evaluate hazards and safety characteristics.”*

### Job safety analysis

“Job safety analysis” is a simple example of a safety analysis method. Attention is concentrated on the tasks performed by a person or group in the workplace in order to identify the hazards related to the task, and to find appropriate means to reduce the risks. Basically the method is focused on accidents, but it may also be useful in identifying other hazards such as exposure to chemicals.

The analysis procedure in Figure 4.1.5 consists of four main stages, plus a preparatory and concluding stage; it is recommended that each stage is completed in sequence.

Preparation includes defining the job tasks to be analysed, and gathering information about the job. Job instructions are often useful. It is beneficial to involve a team of people from the workplace which may include someone familiar with the job analysis method, a supervisor, and a person who performs the job and knows its potential problems.

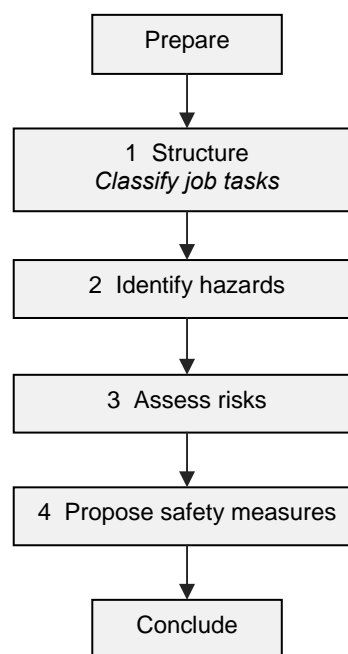


Figure 4.1.5. Main stages of procedure in Job Safety Analysis.

In the structuring stage of the analysis, a suitably detailed list of the different phases of the work is prepared. Useful basic material consists of standard job instructions. However, these should be regarded only as a starting point and should not be assumed to be complete or correct. It is also important to take account of exceptional or rarely performed tasks. The following items should be considered:

- Standard job procedures.
- Preparations and finishing of work.
- Peripheral and occasional activities, such as obtaining materials, cleaning, etc.
- Corrections of disturbances to production that might arise.
- The job as a whole, including how it relates to descriptions, planning and other tasks.
- Maintenance and inspection.
- The most important types of repairs.

During the identification of hazards, each item on the list is gone through one at a time. A number of questions are related to each item, including:

- What types of injuries can occur?
  - Pinch/squeeze injuries or blows, moving machine parts, objects in motion or at height
  - Cuts, pricks, stabs, sharp objects
  - Falls, work at height
  - Burns
  - Poisoning
- Can special problems or deviations arise in the course of the work?
- Is the task difficult or uncomfortable?
- Is the task usually done differently to the prescribed procedure? Are there incentives to deviate from regular procedures?

It is advantageous not to only restrict the analysis to accidents. Contact with chemicals, ergonomic problems, etc. may also be included, which may increase the benefits of the analysis and produce a more integrated approach to OSH.

In the third stage of the analysis, each hazard or problem that has been identified is assessed. A variety of approaches to classification and risk assessment may be utilised as the method itself does not prescribe what kind of assessment should be made.

Safety measures are proposed in the next stage of the analysis, focused on the hazards assessed as the most serious. Such measures may apply to:

- Equipment that aids workers to carry out their tasks
- Organisation of work
- Work routines and methods (Can the work be carried out in a different way?)

- Elimination of the need for certain tasks
- Improvements to job instructions, training, etc
- Planning how to handle difficult situations
- Safeguards on equipment
- Personal protective equipment.

An analysis concludes with a summary of results. In simple cases, the record sheet may be used to report the results. The list of job tasks and the record of the analysis may also be used to produce an improved set of job instructions.

This method of job analysis is easy to learn and simple analyses can be conducted with minimal preparation and effort. But, if the work to be analysed is more extensive or involves a lot of variation, a more formal application of the method may be needed which might require the assistance of experienced people.

One advantage of the method is that it is based directly on ordinary job tasks that are easy to visualise and on commonly accepted ideas about safety and regular safety work. This makes it easy to teach the method and to make it acceptable for direct use by job supervisors and work teams. However, the fact that the method is based on standard thinking about safety matters may also be a disadvantage because it makes it harder to avoid having a blinkered view on the work involved.

### **Relationships between safety management and risk analysis**

It is hard to define general relationships between accident investigations, risk analysis, and safety management because of the variety of application areas and concepts. However, there are many interesting and essential relationships and aspects between these methods.

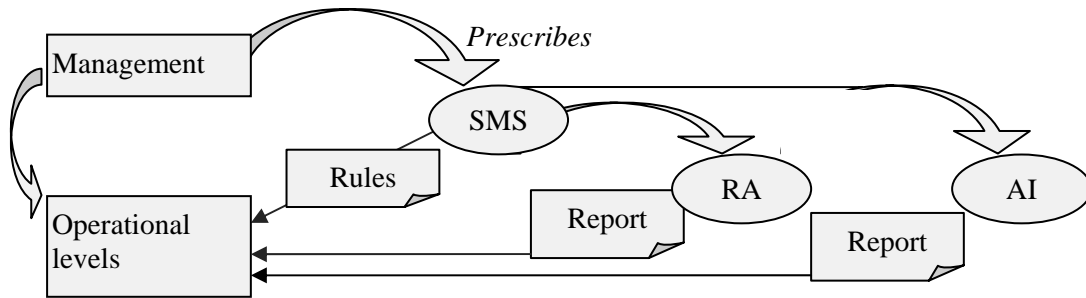


Figure 4.1.6. Elements and relationships in a “Group A” company.

In this type of situation, the SMS prescribes when and how risk analysis (RA) and accident investigations (AI) shall be done. These activities produce reports with observations and recommendations. (The figure does not show the feedback to the SMS from audits, RA and AI.)

Of course there is also great variability in this type of situation. (The following example concentrates on the AI aspects, but much of the reasoning also holds for RA.) In principle, the SMS defines what is done in the AI, and how the information should be used. The aim may be to produce a report about the course of events, recommendations, and who is to be responsible for remedying the situation. This report then goes to the manager responsible and is used to inform others.

Accident investigation (AI) can also be regarded as a learning process. This widens the scope of the investigation and can influence conceptions about feedback loops and what can be done to improve the system.

Figure 4.1.7 illustrates a number of relationships which can appear in a learning type of AI. It is assumed that a specific event is being investigated, and that the AI will raise a number of questions. Some comments on the numbered links in the figure:

- 1) The investigator may scrutinize the investigation process itself, especially earlier investigations which might have disregarded particular problems.
- 2) There are a number of interesting mutual links between AI and RA (further developed below).

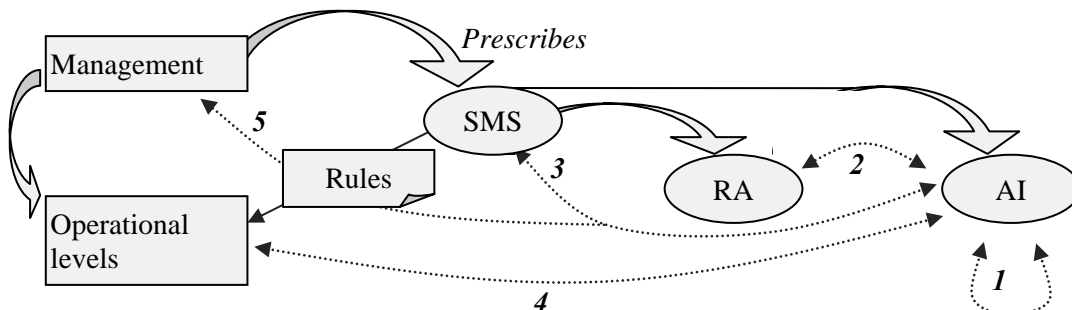


Figure 4.1.7. Links in a “learning process” type of accident investigation in a “Group A” company.

- 3) *The links between the SMS and AI.* In one direction, the SMS gives directives about how and when AIs are performed. A key question is how an accident could occur despite the SMS and whether SMS instructions could be improved. A basic question is whether an AI is allowed to scrutinize the SMS and its role.
- 4) *The links between AI and operational management.* An AI examines the role of both operators and line management. However, they should all share a mutual interest so that all those involved can learn and benefit from the both the AI findings and the fact finding process itself.
- 5) *Company management.* The role of leadership of a Group A company is an essential consideration. While a top-down approach usually dominates, bottom-up communication could be equally important. It is necessary to establish whether a critical and meaningful investigation will be permitted.

In Group B companies (as defined in Figure 4.1.3), many of these links might be broken because a formal procedure may be nonexistent or ineffective. However, it should not be forgotten that informal management systems are also very important but, if they are not defined, it is hard to know if they are efficient from an OSH perspective.

### PERSPECTIVE ON INSURANCE

Insurance systems all over the world are regulating the costs and consequences of work related injuries and ill health.

There are a number of stakeholders related to occupational insurance, all of whom have a particular perspective and interest:

- For *employees* insurance can offer improved social security by compensating for accidents and ill health caused by work.
- *Trade unions* represent employees interests in order to get good working conditions, and to ensure that employees are covered by insurance. (Solidarity and justice are keywords.)
- *Employers* usually pay insurance premiums that are often compulsory through legal requirements and/or formal agreements with trade unions.
- *Insurance companies* may be public or private, and their main task is financial and economic oriented.
- *Society as a whole* is supposed to provide the framework for the insurance system,

### Role of insurance

OSH insurance has different characteristics both between and within countries. The role of insurance varies according to a number of factors:

- a) Whether insurance is compulsory or voluntary.
- b) Whether it is a supplement to other insurance, or offers complete coverage.
- c) Whether insurance covers all, or only some, employees and which OSH-aspects are covered.
- d) Whether causal connections between ill health and work can be proved beyond doubt, or whether such connections cannot be excluded.
- e) If the insurance have blame-free conditions, or negligence of the employer is regulated in the rules for the compensation.
- f) If the insurance have blame-free conditions related to the worker's actions.

The major role of occupational insurance is to mitigate the economic consequences for employees when preventive OSH actions have failed and lead to injuries and ill health, i.e. to provide social security. This is universally recognized as a basic human need that contributes to greater social justice. It is an advantage for employees when they have a right to compensation rather than something they have to make strong claims for.

Insurance also reduces the economic risks for employers. Traditionally, small insurance premiums have been paid in order to avoid having to pay out large sums in damages. In some countries, insurance has conditions attached that prevent further claims being brought to court. In situations when OSH insurance is not compulsory, a company can demonstrate care for its' employees by offering free insurance, (as is often seen in employment advertisements).

One role of insurance is that it offers a clearly defined process about how compensation should be dealt with. Insurance companies are responsible for handling this. A major task is communication and payment of compensation to those who have suffered work related injuries or ill health. Another vital task is the collection of premiums and financial planning.

Insurance companies may be involved in prevention work to a greater or lesser extent. A basic service is the provision of statistics on accidents and ill health for use in general planning. Insurers may play a more active role and develop their own expertise in order to give advice and support to their customers.

In a number of countries, the size of insurance premiums are set according to the level of risk in the company - companies with more injuries must pay more. The insurer can give incentives and penalties by their choice of premium related to statistics from a specific company. Another

way of setting premiums can be through the use of a set of indicators for the quality and efficiency of the prevention program at a company.

### Dilemmas and problems

Even if insurance seems a quite straight forward approach, a number of dilemmas and problems exist. The advantages and disadvantages of different insurance solutions have been debated but there have not been any broad scientific investigations of "best practice". These are complicated issues, the following discussion is only indicative.

The first dilemma concerns both employers and employees who get injured and is related to responsibility and morality. When an employer has an insurance based on conditions that free them from blame for negligence, and which has a fixed premium, it may reduce the economic motivation for preventive work. This disadvantage may be offset by the fact that workers don't have to argue to get compensation.

In insurance situations where guilt and negligence are more dominant, conflicts are more likely to arise when a person or company needs to be blamed. For example, there can be disputes about whether a victim has been inattentive or violated a safety rule, and therefore questions arise about whether they should be paid compensation. Another possibility is that employers can be accused of being neglectful in their OSH management, and face damage claims.

Another dilemma concerns the level of strictness of the cause and effect relationship, especially in the case of occupational diseases. A medical assessment tries to establish whether a particular disease is caused by circumstances at a specific workplace, however, this is complicated by the fact that many diseases take a long time to develop. If an affected person has changed workplace, the question arises about where the responsibility should be placed. If the person has



changed workplace, the question is where the “responsibility” should be placed. With a rigid insurance policy this can be an essential problem for the sick employee. There have been arguments that this kind of policy is unfair and difficult to handle for the “weak” part.

A further concern is the ownership structure of insurance companies. There are three principal forms of ownership:

- *Public organisation*, usually coupled to social security
- *Mutually owned and controlled company*, e.g. by associations of employees and employers, usually based on a “not for profit” arrangement; if profits are made, they are used to reduce fees or funded by the company.
- *Private company* which has commercial agreements with employers. Any profits belong to the owners of the company.

All three types of organisations may exist side by side in a country. Each type of structure has both advantages and disadvantages. One advantage with public insurance is that it has the potential to take a more holistic perspective on occupational injuries and diseases based on the idea that such injuries and diseases are a societal problem.

Where the market has several private insurance companies, employers can take advantage to find lower premiums. On the other hand, competition may lead to some insurance companies going out of business, and possibly failing to fulfil their obligations towards employees suffering long term illness or disability.

The long term perspective needed for consideration of occupational diseases creates a dilemma for the insurance system as it may take twenty years from the exposure until the symptoms are observed. It is argued that long term perspectives on insurance solutions are absolutely essential.

## SUGGESTIONS FOR FURTHER READING

Surveys of basic concepts and of perceptions of risk can be found in the following publications:

Andersson, R. and Menckel, M., 1995. On the prevention of accidents and injuries - a comparative analysis of conceptual frameworks. *Accident Analysis and Prevention*, Vol. 27. pp. 757-768.

Harms-Ringdahl, L. 2004. Relationships between accident investigations, risk analysis, and safety management. *Journal of Hazardous Materials*, Volume 111, pp.13-19. (<http://www.irisk.se/english>)

Sjöberg, L., 2002. Perceived information technology risks and attitudes. *Stockholm School of Economics*, Stockholm. ([http://swoba.hhs.se/hastba/papers/hastba2002\\_005.pdf](http://swoba.hhs.se/hastba/papers/hastba2002_005.pdf))

The following textbooks give descriptions of risk analysis and the principles behind, and the IEC-report is an international standard related to risk analysis.

Harms-Ringdahl, L., 2001. *Safety analysis - Principles and practice in occupational safety* (Second edition). Taylor & Francis, London, pp. 320.

Kjellén, U., 2000. *Prevention of accidents through experience feedback*. Taylor & Francis, London.

IEC (International Electrotechnical Commission), 1995. *Dependability management – Risk analysis of technological systems* (IEC 300-3-9). IEC, Geneva.

Principles for safety and health management are given in the references below. The first two are on a general level and contain basically the same approach. The two last are illustrates how large chemical plants are supposed to be managed.

ILO (International Labour Office), 2001. *Guidelines on Occupational Safety and Health Management Systems*. ILO, Geneva (<http://www.ilo.org/public/>)

Health & Safety Executive, 1991 *Successful health & safety management*. Health & Safety Executive, London.

European Commission, 1996. *The Seveso II directive – Council Directive 96/82/EC on the control of major-accident hazards*. (see e.g. <http://europa.eu.int/comm/environment/seveso/>)

Papadakis, G.A., and Amendola A., (eds), 1997. *Guidance on the preparation of a safety report to meet the requirements of council directive 96/82/EC (Seveso II)*. Joint Research Centre, European Commission. Luxembourg. (<http://mahbsrv.jrc.it/GuidanceDocs-SafetyReport.html>)



# Accidents

*Carin Sundström-Frisk*

## INTRODUCTION

Chapter 4.1 deals with the theories, structures, concepts and risk control. This chapter focuses on the prevention of occupational accidents through safety management, giving extra attention to the role of human behaviour.

Effective accident prevention at enterprise level demands an appropriate management system, and a range of realistic, multi-faceted safety measures that creatively match safety problems and preventive strategies.

This chapter outlines and discusses the following safety organization activities:

- the formation of policies that reflect intentions and goals
- the creation of a structure and plan that provides appropriate means, personnel, and training to implement policy
- the establishment of routines for identification and monitoring of hazards
- the creation and continuous update of plans for the implementation of remedial actions (technical, educational and organizational)
- the initiation of routines for monitoring and checking corrective actions

- the establishment of communication channels
- the creation of emergency preparedness routines

## A multi-dimensional phenomenon

Accidents cover a broad variety of phenomena ranging from *traditional, everyday accidents* that affect few people and often cause only minor damage, to *major accidents* that can kill or injure many people, destroy nature and even affect future generations, e.g. as in Bhopal and Chernobyl. While the majority of occupational accidents are relatively minor, occupational accidents also cause a very large number of fatalities. Globally, some 250,000 men and women lose their lives through occupational accidents per year (2001) including 12,000 children. Each year, workers suffer approximately 270 million occupational accidents that lead to absence from work for three or more days. The activities with the highest rates of fatalities are construction, mining, agriculture, forestry, fishing and transportation. According to European statistics the most common type of event is falls.

The global distribution of injuries due to accidents, according to data from by the Inter-

national Labor Organization (ILO), is shown in Figure 4.2.1. The numbers are estimates based on reports from regions that have reasonably accurate accident records. Conclusions about differences between countries must be drawn with caution. Data on accidents are not available from all countries and where there is data they are not fully comparable due to differences in definitions, recording and notification systems. The motivation to report accidents varies according to the types of incentives built into compensation and social security systems.

In developing countries information about accidents in important sectors such as the agriculture and the informal sector is not available or limited. These sectors cover more than 50 % of the world's active employment.

Under-reporting of injuries is a worldwide phenomenon, however, the more severe the accidents the more reliable the figures. This means that fatalities are the most reliable category, best

suited for comparisons. Injury statistics usually only include insured workers but the majority of employees in developing countries are not covered by insurance so under-reporting is believed to be higher in these countries.

As can be seen from the figure 4.2.1, the estimated fatality rate in the non-industrialized regions is at least double that of the established market economies. The number of reported fatal occupational accidents, especially in Asia and Latin America, is increasing. For example, between 1998 and 2001, fatal accidents at work rose from 73 500 a year to 90 500 in China, while there were nearly half a million work-related deaths in 2001. In Latin America, fatal accidents moved from 29 500 per annum in 1998 to 39 500 in 2001. According to ILO analysis, rapid economic expansion lies behind these figures. The construction industry has a disproportionately high rate of recorded accidents.

World bank region	Economically active population (million)	Fatal accidents (thousand)	Accidents causing 3 or more days absence (million)	Estimated numbers of fatalities per 100,000 workers
Established Market Economies (industrialised countries)	419.5	16 000	12.0	3.8
Central and Eastern Europe and Central Asia	183	17 500	13.5	9.6
India	444	40 000	30.5	9.1
China	740.5	90 500	69.0	12.2
Other Asia and Islands	415.5	77 000	58.5	18.5
Sub Saharan Africa	279.5	53 500	40.5	19.1
Latin America and the Caribbean	219.0	39 500	30.0	18.0
Middle Eastern Crescent	135.0	18 000	13.5	13.3
<b>Total</b>	<b>2 837</b>	<b>251 500</b>	<b>268</b>	<b>10.5</b>

Figure 4.2.1. Global estimates of occupational accidents based on data from International Labor Office, 2001 ([www.safework@ilo.org](http://www.safework@ilo.org))

Differences in accidents between industrialized and developing countries are ascribed to differences in the types and number of risk exposures and differences in production systems. Poorer knowledge and awareness of hazards, paired with a lack of compensation based systems and legal control systems, also contribute to the differences.

Accident prevention is motivated by both human and economic factors. In addition to human suffering, there are considerable economic losses

associated with injuries. The economic costs for occupational accidents include four main areas: cost for prevention, workers compensation, health care, and production losses. The distribution of costs between individuals, companies and societies is related to systems for workers compensation, insurance and general social security. National compensation systems are generally focused on ensuring security for injured individuals rather than on prevention.

Research and official statistics describe and characterize occupational accidents in different ways including the:

- number of persons injured
- number of persons injured related to exposure data e.g. number of work hours,
- the type of injury (fractures, spruces, soft tissue injuries)
- severity of the injury (fatalities, disabling and minor injuries etc)
- type of event (falling, collisions, cuts, explosion, fire, hit by moving objects etc)
- type of hazardous energy (e.g. chemical electrical, thermal, mechanical)
- sector of working life and size of enterprise
- type of production technology (level of automation and complexity)
- type of work tasks (from manual work to demand on higher cognitive activities)
- stationary or mobile work conditions (e.g. industrial production contra construction work)

### External influences

A company operates within a context where legal, economic, political and social prerequisites form the basis for what should and can be achieved. Decisions about how to run a business safely are affected by factors such as the pressure from public awareness and public opinion, the market, the power of trade unions, the efficiency and power of labour inspection, and incentives imbedded in insurance policies. Companies are

subjected to severe environmental pressures in a global, dynamic, and competitive society. Rasmussen and Swedung illustrate the external influences in a model, see Figure 4.2.2. Information flow and a chain of influences from high societal decision makers to the company shop floor level are shown. The model illustrates the interaction among actors and decision-makers at different levels of risk control, in a context of rapid societal change and technical development



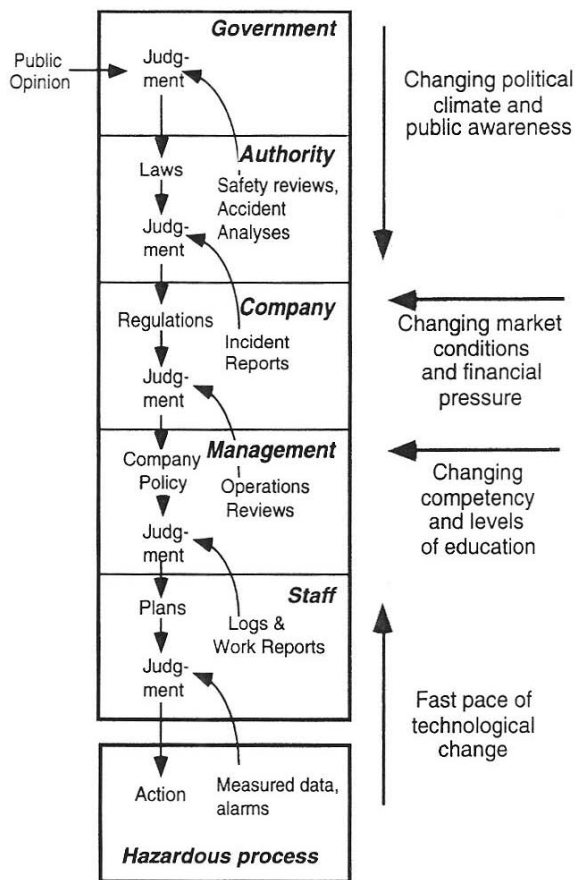


Figure 4.2.2. Hierarchy of factors influencing safety work at the company level. Source: Rasmussen and Svedung, 2000.

The figure illustrates that many levels of decision making are involved in the control of hazardous processes. Effective prevention at company level thus relies on a proper co-ordination of decision makers at all levels to ensure that everyone is working in the same direction.

### Why do accidents occur?

The way we look at accidents and their causes directs the choice of preventive strategies. Strategies will vary according to those causes that we choose to pay attention to.

Inadequate investigations of accidents will result in wasted effort and money spent because the wrong causes will be addressed.

Already in 1964 the legendary, safety scientist Haddon concluded that “Virtually any bystander in any sort of accident seems to have his own theory of its cause and its prevention”. Explanations vary between persons and over time. Different types of bias predominate depending on the position of the person attributing the cause. An external observer is more prone to explain other person’s behaviour (generally a failure) by referring to permanent personality traits of that person. A person who has been involved or injured in an accident may perceive own failure as something resulting from a specific situation and as a temporary deviation from the normal behaviour.

Explanations vary between stakeholders. Workers or their trade union may indicate that accidents are caused by factors beyond a workers own control, such as non-ergonomic machinery and tools, poor maintenance, stress, deficiencies in planning, and other bad working conditions. Employers regard accidents as events that result from carelessness, negligence and improper behaviour of workers, including violation of safety rules and non-compliance with working instructions. Economic, legal and ethical issues can all provide reasons for the attribution of blame.

Causes of accidents are more or less visible depending on number of cases available for analysis. A single accident may seem totally unique and random but when many accidents are aggregated and analyzed over time, common elements and basic causal patterns emerge and randomness partially disappears. Only then do indirect causes such as safety routines, bonus pay systems, work schedules, design of tools, or work organization become visible

Perceptions and explanations for accidents have changed over time. Historically, there was a pre-dominant culture where accidents were seen to result from a single cause, namely worker carelessness. Today causation is related to interaction between human behaviour and the physical and organizational context of the workplace. It is accepted that accidents often result from a number of causes, including indirect causes. New categories of actors receive attention. Previously the behaviour of the person exposed to a risk, normally a worker, was the primary focus but now there is more emphasis on management and organizational behaviour. This approach enlarges options for preventive measures and increases the probability for root causes to be addressed.

A more systematic analysis of accidents emerged when accidents were no longer regarded as “fate” or an “act of God”. Human performance then came into focus and accidents were seen to be caused by human failure (“act of man”). The theory of accident proneness emerged assuming that some individuals were uncoordinated, careless or born with a personality trait that made them more likely to have accidents. This idea made it very easy to blame the victim and to consider their misfortune to be their own fault. This attitude made it easier for some employers to resist the provision of compensation and demands on safety measures as it was presumed to be pointless to improve work conditions as accidents would inevitably occur to accident prone persons. The only possible way to reduce injuries was to get rid of these people.

The search for an “accident prone profile” generated considerable research. Two conclusions can be drawn from this research. Firstly it is doubtful that a permanent individual disposition for being involved in accidents exists, and even if it did, it would only account

for a small number of accidents. Secondly, all individuals may become temporarily prone to accidents due to certain bad work conditions or because of personal life events such as grief, divorce or illness.

Accidents are often explained by the so-called “human factor”. The other main explanation, “technical failure”, gives the impression that technology lives a life of its own without human intervention; however, technical failures are generated by humans somewhere in the chain of events prior to an accident. The decisions and behaviour of managers, supervisors, and designers also determine risk levels in a workplace. A designer who neglects ergonomic principles will create machines, tools and systems that are not adapted to users increasing the risk of inducing human errors. A manager who buys badly designed products will increase workplace risks. The same goes for a supervisor who fails to intervene when unsafe work methods are used to speed up production, or when maintenance staff gives priority to production at the expense of safety. These errors, remote in time and space from an accident event, are defined as *latent or indirect errors*. The error that triggers a risk is called an *active error* or direct cause. Deficiencies in knowledge, skills and motivation among all those involved in remote operations will contribute to the potential risk, but the person who triggers the risk, normally a worker, will often be held to be morally and/or legally responsible.

For example, when an operator makes a mistake (defined as an active or direct error) he/she is personally blamed. When a latent error causes an accident, responsibility is depersonalized and the event described as a technical or organizational failure. Earlier mistakes remote in time and space from an

accident often become the cause of the active errors made by front-line personnel.

Now the focus has been enlarged to include latent, indirect causes as well as active, direct causes. Companies in the front line of safety and risk management emphasize ideas such as “safety culture” and “organizational performance” as the basis for accident prevention. Organizational characteristics and context are taken into account. Issues such as leadership styles, communication, norms and sanction systems are all regarded as determinants of the risk level of a company.

The role of senior managers becomes critical as they more or less consciously communicate the safety culture of the company through their personal behaviour and management practices. Workers’ behaviour is a reflection of a company’s safety culture. Human errors are seen as the results of an interaction between individual, situational and organizational characteristics that shape human performance and account for variations in capacity and performance.

### **SAFETY MANAGEMENT**

#### **Organization and policy**

Preventive work requires an organizational structure that articulates clear responsibilities and systematic routines for identification and handling of safety issues. Responsibilities related to safety should be made clear to all concerned, including top and middle management, first line supervisors, maintenance departments, purchasers, planning departments and operating staff. The necessity to merge production and safety questions becomes more obvious.

When responsibility is allocated it is also necessary to allocate appropriate resources. Questions to be considered include - which function is responsible for taking care of specific

areas? What safety issues need to be addressed to cover all risks? What cooperation between various staff members is required? To ensure that knowledge from all levels in the company is used in the search for good preventive strategies, there must be arrangements for joint labour-management efforts. These two parties should have regular meetings to review problems and to find measures to correct unsafe working conditions. The resources required to ensure practical safety operations will obviously vary with the size of an organization and the nature of its activities and risks, but, all organizations must be systematic and truly proactive. Safety prevention measures based on urgent, half-baked measures taken in panic after dramatic events tend to be costly and unsustainable.

A policy document defining company intentions, goals and implementation methods concerning safety is a good start. Such a document should include a commitment to comply with current applicable legislation and standards. It should be communicated to everyone concerned, including employees and be based on realistic, obtainable objectives that everyone understands. Sometimes there are accusations that policy documents are no more than bureaucratic pieces of paper loaded with empty clichés and no binding promises. However, if adequately elaborated, they have a clear function as they give all those concerned something to refer and relate to. Policies also offer the opportunity to identify double standards, e.g. the gap between what is said and what is done.

#### **Identification and monitoring hazards**

The identification of hazards and risk characteristics define targets for a prevention program. This is not a one shot activity but a continuous process. Knowledge about accident risks may be

generated by more or less sophisticated methods, demanding different levels of resources and expertise. Three different methods in the risk-identification process will be described here: learning from earlier events by accident reporting and investigations, identification of potential risks by safety analysis and safety checks.

### Learning from earlier events

The reporting and investigating of accidents generates knowledge about hazards at the worksite and identifies weaknesses in the safety management system. Involving workers in discussions on these events will increase workers' awareness of risks. Reports and discussions on near accidents will give information about risks related to defined situations and experiences about the way hazardous events have been avoided by recovery operations. Discussions about near accidents are generally less emotionally charged and more open to constructive analysis of causes, because nobody has been injured.

The need for formal reporting routines depends on the size and type of an enterprise. Knowledge about an injury due to an accident in a small enterprise will soon reach management by informal channels but a large company needs formal accident reporting routines to provide management with information.

To establish a reporting routine there is a need to *be explicit about its purpose and goal*. Workers must be given good reasons as to why they should report. Clear information about the fact that data will be used for prevention rather than punishment must be given. In order to encourage the reporting of events it is also necessary to ensure that there are more incentives to report than disadvantages. If workers are likely to be blamed or punished for an accident, their willingness to report will be much reduced. If

there is "something in it for me" the reporting is more likely to take place.

To improve reporting habits the following activities are recommended:

*Give clear definitions (with examples) of what type of events to report.*

The use of drawings and videos is recommended.

*Use a simple reporting formula that is easily available. Ensure easy access to computers if a computer based routine is used.*

If a work force has problems with literacy, writing or reading, a reporting formula can be designed using signs, symbols and illustrations and the possibility to answer questions by marking fixed answers instead of writing free text. Pre-printed formulas usually offer a mix of standardized questions that include both preset response alternatives and opportunities for written descriptions. Reporting procedures may be on computer.

The report may serve as a first step in a more detailed analysis. An in depth investigation is a systematic and more elaborated method to ensure that all contributing factors are identified, and might require teamwork with safety professionals and other experts such as chemists, working together.

*Train workers how to complete reporting forms.*

The main purpose of a reporting regime is to get information about the chain of actions and causes of the accident or near accident event. Repeatedly questioning "why" until a root cause has been identified is a simple but effective way to analyze what caused an event.

An accident investigation should cover the following data and activities:

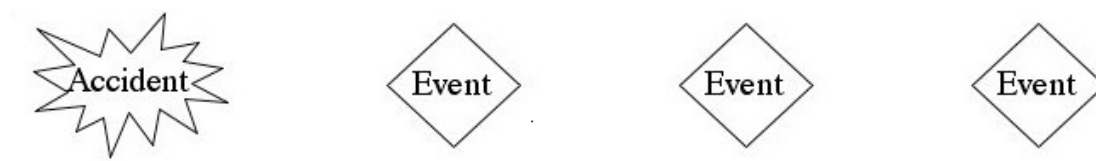


Figure 4.2.3. Timeline for a sequence of events.

#### *Background data*

information about *where and when* the event occurred, what *type of activity* or work task was involved, *type of injury*, the *sex and age of the injured person* and *physical objects* involved.

#### *A description of the factual sequence of events*

a description is facilitated by a flow chart that graphically depicts a “time-line”. The analysis must not only describe the last event but work backwards in the chain of events, like reversing a film sequence, see Figure 4.2.3.

Data is collected by interviews and technical observations at the worksite.

Drawings and photos help to support memory and make a common picture of the event. The sequence of events should be presented without subjective value judgments and premature speculations about causes.

#### *A systematic search for direct and indirect causes*

This should preferably be based on a “MTO perspective” (M for man, T for technique, and O for organization), that ensures all types of

contributing factors are taken into account. For each human failure contributing to the event, further analysis should be performed asking why the actual behaviour took place. All behaviour must be understood in context. The tendency to primarily ascribe an accident to the personality of an injured person must be avoided in favour of looking for conditions that produce human errors and risk-taking behaviour.

To perform a systematic and complete data collection when investigating into accidents .a checklist or observation structure is a helpful and practical way to ensure that all contributing factors are considered. An example of such a structure is the

TRIPOD DELTA observation schema, based on the TRIPOD accident model. (TRIPOD was developed by James Reason for Shell Company and TRIPOD means three feet. It refers to the three-part structure on which the accident model is based: general failure types, unsafe acts and negative outcomes.)

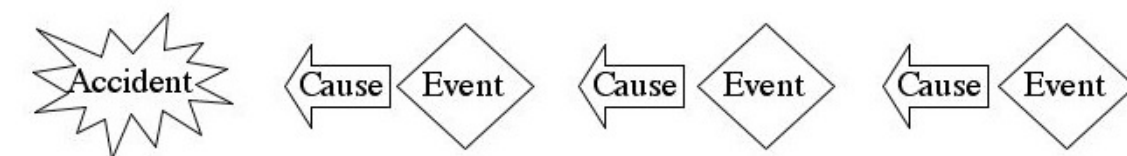


Figure 4.2.4. Chain of causes. Causes added to each event.

Basic risk factors or failure types according to the TRIPOD investigation schema.

- 1 **DESIGN**  
A poor plant layout or a non-ergonomic design of tools equipment (user-unfriendly)
- 2 **HARDWARE**  
Material failure due to poor quality or aging, suitability or availability of tools, equipment and components
- 3 **MAINTENANCE MANAGEMENT**  
Failures in the system aiming at maintaining inadequate performance of maintenance tasks and repairs
- 4 **HOUSEKEEPING**  
No or insufficient attention given to routines for keeping the plant tidy and clean, and for dispose of waste
- 5 **ERROR ENFORCING CONDITIONS**  
Poor design and poor working conditions (e.g. heat, noise, awkward working positions, shift schedules that produces adaption problems, or a remuneration system that promote rule violations
- 6 **PROCEDURES**  
Insufficient quality or availability of procedures, guidelines, instructions and manuals
- 7 **TRAINING**  
Insufficient or inadequate knowledge, skill or awareness due to poor training
- 8 **COMMUNICATION**  
Ineffective communication of necessary information between the various sites, departments or employees of a company or with the official bodies
- 9 **INCOMPATIBLE GOALS**  
The situation in which employees must manage the conflict between safety and productivity, or between safety and individual goals, such as saving time and money
- 10 **ORGANISATION**  
Shortcomings in the organization's structure, organization's philosophy, processes or management strategies resulting in warning signals being overlooked, and inadequate or ineffective management of the safety issues
- 11 **DEFENCES – BARRIERS**  
No or insufficient protection of people, material and environment against the consequences of operational disturbances



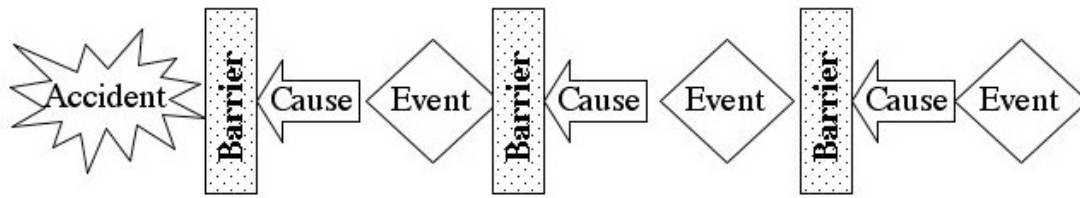


Figure 4.2.5. Barriers in the sequence of events.

The last point in the TRIPOD DELTA schema refers to the analysis of deficiencies in safety barriers such as machine guarding, inadequate work procedures, and management support. A barrier analysis addresses the following aspects:

- barriers that were in place and how they performed
- barriers that were in place but not used
- barriers that were not in place but were required
- the barrier(s) that, if present or strengthened, would prevent the same or similar accidents from occurring in the future.

#### *Proposals of remedial measures*

Well reasoned and realistic suggestions for remedial measures can be identified if there is a scrupulous matching of problems and potential measures that address both indirect and direct causes. The potential effects of suggested measures must be assessed in order to avoid the creation of new risks.

#### **Identification of future risks**

With hindsight injuries usually appear to have been easy to prevent but they are harder to imagine before they happen. There are analytical tools developed to support the process of looking for risks that may cause accidents in

the future. Some of these methods are highly sophisticated and require computer modelling such as fault tree analysis, hazard operability studies or human error analysis. These methods calculate probabilities, sometimes based on data banks, and demand expertise to perform. They are mainly used in high-risk systems such as nuclear plants, aviation, military systems, and process industries, and may include economic losses, production losses, cancelled deliveries, losses of public opinion and environmental damage.

In industries where minor accidents are the main problem, less complicated techniques are used. A two step model is normally applied, starting with a rough selection and analysis of which risks need to be further addressed. A simple and cheap method is to use a brainstorming session to ask group members to come up with plausible scenarios about what could happen with what consequences by asking “What would happen if....?”

Involving workers in a risk analysis procedure creates an excellent opportunity for learning for both safety professionals and workers. It might also create curiosity and engagement among exposed workers thereby increasing safety consciousness. A risk analysis session offers a good opportunity to teach workers about risks, and how to detect and cope with them.

## Safety checks

A widely used method for risk identification is the safety check (safety round, safety inspection), where the work place is physically inspected and screened by a group.

A safety check can be general, addressing all types of risks, or focused directly on a specific problem, area, work tasks or piece of equipment. Common issues for general safety checks are housekeeping, maintenance of machinery and equipment, physical safety devices, emergency exits, and the availability, maintenance and use of personal protective equipment (PPE).

Directed inspections normally generate deeper knowledge. They focus on a specific type of event such as fire, explosions, working at height, traffic injuries, or on technical components as lifting equipment, scaffolding ladders, or machinery. Incident and accident reports may serve as a basis for selecting the targets.

Some members of an inspection group should preferably take part only occasionally to ensure that inspections are performed with new eyes that reduce the risk of becoming blind to defects.

Safety checks can be performed with or without a checklist. The use of lists can help to remind those inspecting of important items or dimensions to focus on, but it may also impair the creativity required to find new risks. There are standard checklists for use on safety inspection rounds. For example, if there are many cut and squeeze injuries in a workplace, an inspection checklist might focus on mechanical risks such as:

*shear points:*  
where objects with sharp edges come together, cutting body parts

*sharp points and edges:*  
physical objects, sharp enough to puncture or cut a person's skin

*catch points:*  
objects with sharp corners or rough surfaces capable of snagging skin or clothing, or potentially pull a person into another hazard e. g. getting caught between moving machine parts

*squeeze points:*  
points where human body parts could be squeezed between moving objects

*moving and falling objects:*  
objects in motion with sufficient kinetic energy to cause injury.

## Record keeping and feedback

A monitoring system is necessary to keep track of the safety status of an enterprise and to follow up on any measures that have been taken. Records from incident and injury reports can be kept and accident statistics aggregated. However, record keeping has no value per se so if information generated from reports is not forwarded to those in control of the risks, they are useless documents. Routines for feed-back and information must be established to ensure that critical knowledge reaches those concerned e. g. production planners, maintenance staff, purchasers of equipment, training officers and exposed workers.

## PLANS FOR REMEDIAL ACTIONS

A plan for implementing safety measures should be developed based on information from accident investigations, risk analyses, and safety checks. No decision about actions should be taken before a thorough analysis of the problem is completed as the matching of problems and safety measures is crucial in order to get a good

result and to avoid spending money and resources in vain.

There are three mistakes to avoid when looking for appropriate remedial actions:

### *Inadequate or incomplete attribution of causes*

The tendency to stop an analysis too early and focus only on direct causes leads to a choice of preventive efforts with limited value. Inadequate analysis of reasons for human errors misdirects strategies for behaviour change. The wider the analysis, the greater the number of available strategies.

### *Wrong lesson learned*

Feedback of information from incidences and accidents is a key element in efforts to prevent their recurrence. The implicit assumption behind this strategy is that learning by experience and from mistakes will generate knowledge that benefits accident prevention. While this often is the case, it is not always what happens. One event may result in different people learning different lessons, primarily for less serious events such as a near accident or a minor injury. While one person may learn to be more cautious, another person may feel that he has controlled the outcome and don't need to change his behaviour. Reports on "lessons learned" from individuals who have been involved in accidents report vary from extremes such as perceiving *less* risk after an accident, to a total refusal to perform the same work task again. People usually change their behaviour temporarily, reverting to the same pre-accident behaviour after a while. Furthermore, it is of interest to know who is learning what: a decision-maker with power to take preventive action, or a worker with no control over root causes. Because of this, there is a need to identify circumstances that facilitate and support learning that benefits prevention.

### *Inadequate analysis of work place and work organization characteristics*

It is important to understand why people create their own way of managing risks instead of following expert recommendations or orders from management. The reasons are usually found in analysis of the individual "costs" associated with adopting safer behaviour.

These costs compete with those for action to promote safe behaviour and may totally counteract the safety promotion efforts. These costs have to be identified and "disempowered" for a safety program to have an effect. For example, payment on a piece work basis can reward time saving and risk-taking and can more strongly influence behaviour than a safety information campaign. A supervisor, who accepts – or rewards an employee for using unsafe work methods in order to increase production, also communicates the attitude that unsafe work practices are ok.

Any action plan must be a living document that is continuously updated to deal with new risks that will always arise. Employees should be consulted and involved whenever safety activities are developed in order to increase the probability that suggested actions will be accepted and implemented by those in charge. Consultation also guarantees more realistic proposals as employees normally have more knowledge about the informal infrastructure and work procedures than safety professionals. They know what measures are reasonably acceptable when completing a work task.

A time schedule and staffing plan that assigns responsibility for each remedial action completes an action plan.

## **HADDON'S PRINCIPLES**

Preventive measures can be divided into passive or active. Passive measures are those that func-

tion without human intervention, regardless of the skill or motivation of people involved, e.g. a fence, an airbag, sprinkler system, light curtain, or machine guard. Passive measures eliminate or modify harmful energies or separate the human body from them. They are effective because they function in situations of acute risk, regardless of human behaviour and regardless of the capacity and risk perception of actors involved. For example, they are effective with all types of workers from novice to experienced, tired or alert, strong or weak, educated or ignorant, cautious or careless. On the other hand, active measures such as education, training and motivational approaches aim to equip a worker with the ability to cope with risk by being attentive, skilled, knowledgeable, and risk conscious.

Passive measures should be the first choice as human capacity varies over time and everyone makes errors sometimes as the main focus of attention is normally directed towards a work task rather than at the risk.

In 1970 Haddon published his principles for accident prevention where safety strategies are related to sources of damaging energy. He conceives an accident as an unintended release of energy resulting in an injury. Consequently the ideal is to channel energy away from the individual or to minimize the amount of energy that

can be released in an unintended way (a passive approach). Ten strategies are divided into three groups related to energy source, barriers, and to the vulnerable target. Haddon's structure for controlling energy release is a useful framework for how to think about the problem.

#### **Haddon's principles:**

##### Strategies related to the energy source

- 1 Prevent build-up or accumulation of energy
- 2 Modify the qualities of the energy
- 3 Limit the amount of energy
- 4 Prevent uncontrolled release of energy
- 5 Modify rate and distribution of the released energy

##### Strategies related to barriers

- 6 Separate in time or space the energy source and the target
- 7 Separate by physical barrier

##### Strategies related to the vulnerable target

- 8 Make the target resistant
- 9 Limit the injury or damage (counter damage)
- 10 Stabilise, repair and rehabilitate the victim

Haddon's ten principles are illustrated in Figure 4.2.6.

<i>Type of strategy</i>	<i>Rotating machinery (Circular saw)</i>	<i>Toxic chemical (Oil Vapour) and mist from drilling mud in shale shaker</i>	<i>Motor vehicle (Car traffic)</i>
Prevent build-up	Eliminate use of circular saw by ordering pre-cut pieces of wood	Eliminate oil in mud by using water based mud	Avoid car driving
Modify the qualities	Modify saw blade teeth	Use of low toxic oil	Softening of hard objects in the cabin
Limit the amount	Limit rotational speed	Smaller evaporation area	Speed limits
Prevent release	Design of start button which prevents accidental start	Not applicable	Sanding and salting of roads
Modify rate and spatial distribution	Emergency stop	Ventilation	Cars with shock absorbing zones, safety belts
Separate in time or space	Automatic sawing machine	Remote control	Separate lanes for meeting traffic
Separate by barriers	Machine guarding	Air curtain	Cars with safety cage
Make the victim more resistant	Eye protection	Respirators	Helmet
Counter damage	First aid	Not applicable	First aid
Rehabilitation	Depends on type of injury	Depends on type of illness	Depends on type of injury

Figure 4.2.6. Application of Haddon's strategies on three examples of damaging energy.  
Source: Kjellén U. Prevention of accidents through experience feedback.

## Safety engineering

Safety engineering includes measures concerning equipment, workplaces and the physical environment. Safety engineering targets two goals: the elimination or reduction of exposure to damaging energies and the reduction of probability of human errors.

### *Design of tools and machinery*

It is much easier and normally more cost-effective to eliminate or reduce exposure in the design of a new machine than it is to modify an old machine. The same goes for tools and work equipment. Machines and tools should be designed taking both safety and operational reliability into account. Machines that stop frequently create irritability and stress in users provoking human errors and risk-taking behaviour. Poor design of tools demands more attention from the user and generate human errors.

If safety cannot be built into the basic design of machines and equipment, some type of safeguards must be installed, such as shielding against rotating parts of machinery or lockouts that allow operators to switch off the power. Detailed recommendations on machine safety are given in the EU Machine Directive.

Poor design of tools and machinery provokes human error; that is increases the probability for unintentional behaviours such as slips and mistakes. The safety philosophy in high-risk activities such as nuclear power stations, process industries, and aviation, adopts a “forgiving” perspective. Basic design of production systems and the interface between humans and processes allow for normal human errors and deviations to take place without disastrous consequences.

The insight and acceptance of human beings as creatures with high but fluctuating capacity should be transferred to safety engineering in “normal-risk activities”.

An example of “forgiving” design in normal settings is a knife furnished with a parry guard – the user might slip, but there is no injury thanks to the parry.

### *Layout of workplaces*

Poor layout of workplaces and workstations contributes to many accidents. If there are many sharp points and edges the risk of cuts or squeeze injury is obvious. If working areas are too narrow or confined, awkward work positions cause strains. Bad housekeeping increases the risk of accidents.

One of the most common tasks associated with injury is material handling. The risk can be reduced by transporting materials on pallets or in containers or by using lifting devices like cranes or elevators. The layout of workplaces is particularly important where workers and heavy transport share the same access paths. The selection of appropriate transport equipment, such as forklifts, is important when trying to prevent accidents.

### *Occupational hygiene conditions*

Physical conditions such as bad lighting, dust, noise, and hot climate impair human performance and hinder the ability of workers to detect risks or control an event. A well-lit workplace with a diffuse light source is generally safer than a dimly lit workplace. Glare or excessive shadow tends to make the workplace less safe despite higher levels of illumination. Noise may hide signals from warning devices, and/or disturb communication at the workplace.

## Organizational measures

It is widely understood that if safety management is to be truly effective it must become part of the culture and everyday business practice of an organization. A good safety culture is fostered in organizations with open communication, that



integrate safety and production planning and that understands safety as a management task.

### *Work routines, safety rules, and instructions*

Furnishing workers with appropriate equipment is only a beginning because if instruction and training on the safe operation of the equipment is not given, the safety effect is reduced. Written instructions usually reflect the thoughts and language of the designer or manufacturer. Instructions must be designed using ergonomic principles that are adapted to suit the attitudes and reading abilities of users. English instructions are of little use to non-English speakers. When introducing new equipment or practices hands on demonstrations and training should be compulsory.

Second hand equipment and machinery bought or donated from other countries should be furnished with instructions and guidelines in the workers own language. The same goes for warning signs.

Safety rules are necessary when risks cannot be eliminated by technical measures but they must be compatible with efficient work practices, otherwise they will probably be violated. If rules delay a work operation or place new demands and extra loads for a worker, they may resist applying the rule.

There might be reasons for not using PPEs other than lack of knowledge or poor awareness about risks, e.g. PPEs are not provided, are poorly designed, or workers are not given adequate information and training about their use and maintenance. In addition, PPE sometimes creates substantial problems related to physical load, heat stress and restrictions of movement. In this way the “cost” of prevention is shifted to the worker who must pay for the enhanced safety by expending more energy, lowering their comfort, and losing productivity.

### *Maintenance and housekeeping*

A crucial element for a safe workplace is the organization of maintenance activities, as many safety problems result from poor or inadequate management of maintenance and housekeeping. Damaged machinery and tools creates new hazards. Disturbances in the production flow due to bad maintenance give rise to improvisations. that create acute risk situations. Bad organisations of keeping and storing tools and equipment and poor housekeeping reduces availability and produces stress. Accident risks can occur due to the work situation and conditions of maintenance work itself. Management include physical design of the workplace, planning of the activities, timing, ensuring sufficient trained personnel, defining responsibilities, and investing in adequate hardware.

### *Safety audits*

An action plan will be pointless if it is not implemented. Plans and suggested measures have to be carried out and evaluated. Audits are systematic examinations that assess whether activities at the floor shop level have been properly implemented.

### *Emergency preparedness*

When accidents occur there must be clear routines and an established organization for taking care of injured people. The type of injury suffered depends on the type of energy that caused the injuries: electricity, fire, chemical substances, and/or mechanical force. Emergency procedures and equipment should organization cover first aid, special equipment such safety showers, first aid kits, and equipment for emergency calls, and training of all personnel. In cases of severe trauma, there may be a need for debriefing of personnel who may suffer from post traumatic effects.

### Addressing human behaviour

The promotion of safe behaviour is a challenging task particularly when established unsafe working practices need to be replaced by safer practices. The greater the perceived benefits of unsafe behaviour, the greater the resistance to change - this maxim applies equally to employers and employees behaviour. It is possible, however, to influence human performance. It requires general knowledge of factors shaping risk perception and risk behaviour and a familiarity with organizational prerequisites such as safety culture, behavioural norms and the informal sanction systems that operate within individual workplaces.

The “human factor” in accident causation almost always carries negative connotations. In fact, humans are extremely reliable when you take into account the immense quantity and variety of actions they perform. However, there are limitations to consider:

- human capacity varies over time depending on workloads and stressors
- there are other immediate human basic needs to satisfy that compete with the need to avoid injuries
- humans are more prone to choose behaviours that are known to give immediate satisfaction (e.g. saving time), in favour of behaviours that might reward in the future (e.g. complying with a safety rule)
- humans rely more on their own experience than on information about unsafe acts given by safety experts. “I have used this work practice for years and never had an accident, so this won’t happen to me”

Taking the above factors into account means that engineering measures should be considered

prior to choosing a behaviour directed strategy to accident prevention. Engineering measures, such as eliminating or modifying exposure to harmful energy source or setting up barriers between the human body and an energy source, are effective as they function regardless of the capacity and risk perception of the individual involved. It is more efficient to put up a fence to prevent people from falling into a hole in the ground than to put up a warning sign saying “Caution!” It may be easier to get people to use personal protective equipment by making the PPE comfortable and easy to use rather than by describing how dangerous it is not to use PPE.

Traditionally, the problem of incorrect behaviour has been addressed by legislative or information strategies only, often with less effect than hoped for. A need to reinforce such strategies for instance by motivational techniques has been demonstrated and today multi-method programs are recommended. There is also a shift from focusing on attitudes to focusing on behaviour because there is no perfect correlation between reported attitudes and behaviours. The very same person who believes that it is important to use scaffolding when working at height might never the less work at height without adequate scaffolding. In other words, even if a change in attitude is reported, one cannot take for granted that behaviour will be affected.

Methods to promote safe behaviour range from the use of force to willing participation. The methods used to influence behaviour tend to be chosen because they appear to be effective rather than because they have empirically demonstrated effects. To avoid basic mistakes when choosing a promotion strategy for safer behaviour, three critical questions should first be considered.

- What category of human behaviour is to be addressed?

- Whose behaviour is to be affected?
- How to deal with unsafe behaviour?

*What category of human behaviour is to be addressed?*

Different types of behaviour demand different strategies to shape performance. Behaviours that are critical for safety can be summarized in two categories: unintentional mistakes and calculated risk-taking. Unintentional mistakes are unplanned acts such as slips, lapses or errors due to inadequate knowledge or misdirected attention. On the other hand, calculated risk-taking takes place when a person decides to behave in an unsafe manner despite knowledge of the risk e.g. by dismantling a safety device.

Everybody makes unintentional mistakes and great efforts have been made trying to understand how and why they occur. A vast number of factors deteriorate human performance increasing the probability for mistakes e.g. noise, heat, bad ergonomics, poor design, stress, fatigue, and inadequate training. These factors must be targeted in the search for appropriate strategies to reduce the effects of human error.

Limitations related to human capacity should be considered. There are inherent human characteristics that put *absolute limits* on our abilities, e.g. reaction time, physical strength, perception and cognitive functions. If there are demands for actions that go beyond these human capacity limits, any individual will fail regardless of their ability or motivation. For example, it is impossible to look in two directions simultaneously or to deal with too much information at the same time. The adaption of the demands of a situation to suit human capacity is the only way of dealing with these limitations.

In addition to universal limitations there are *individual differences* in capacity, inherited and/

or acquired. Strategies that consider individual limits are selection, supportive devices, and training. For example, bad eyesight is compensated by spectacles, and heavy workloads can be reduced by using lifting devices.

*Capacity limits may fluctuate* due to external and internal stressors and over time. This means that while people are able to perform a task on one occasion, they cannot perform the same task at another time. Reaction time and cognitive skills vary related to stress, fatigue, alcohol intake, noise, heat etc. The elimination or reduction of these stressors might be necessary to moderate such behavioural fluctuations.

Calculated risk-taking refers to planned behaviour. Examples of risk-taking at management level include the intentional neglect of safety regulations during designing, planning, and staffing. Examples of risk-taking by front-line personnel include an intentional neglect of safe work practices, non-use of PPE, and dismantling safety devices.

Explanations for risk-taking vary from biologically based theories (the born sensation seeker) to psycho dynamic causes (self-destructive needs, warped perception of reality); however, it is more common to see risk-taking as a result of a learning process. Most people have a positive experience of risk-taking with no resulting injury. On the contrary, unsafe acts are rewarded by immediate benefits of faster, less strenuous work that aids production. Basic needs outweigh the need for self-preservation, e.g. the need to make money outweighs the need for safety.

A positive experience of risk-taking that doesn't result in injury can create the false impression that we can control risk situations. The idea that "it-won't-happen-to-me" is strengthened, and important risk information is regarded as being valid only to others, not to ourselves.

Safe behaviour means not making unintentional errors and not deliberately taking risks. To behave safely requires knowledge, skills and motivation.

Knowledge provides a basis for anticipating hazardous sequences of events, and selecting adequate coping strategies. Knowledge is required about:

- the work process
- the types of hazards to be expected
- the cues that indicate the presence of a hazard
- how to cope with hazards
- own behavioural limitations

Knowledge is not enough. An actor must also have the capability to perform any necessary action. If a situation demands action beyond workers capacity they will fail regardless of the extent of their knowledge.

Besides knowledge and capability additional motivation may be required to get people to take the necessary action. A person may know what to do and be able to do it, but for some reason simply doesn't want to. Correct and safe behaviour must reward a person in one way or another otherwise the behaviour will not take place.

The three dimensions are interrelated; for example, knowledge and ability might serve as motivators. If you are motivated you are likely to look for knowledge and resources to foster your ability. The reason for separating the three dimensions outlined above is that once the causes for a specific unsafe act have been identified, it is easier to select strategies to shape performance.

*Whose behaviour is to be affected?*

Normally the behaviour of front line personnel is initially focused upon but there are other im-

portant actors who create risks at the workplace. These actors include supervisors, production planners, designers etc whose risk-taking behaviour is often the indirect causes of accidents e.g. a manager who intentionally gambles on safety by neglecting safety standards when equipping the workplace or training workers. The commitment, attitude and behaviour of top management towards safety issues are the critical factors in a good safety culture.

*How to deal with unsafe behaviour?*

Unsafe behaviours are often "naturally" rewarded as they are followed by gains in time, money, comfort and increased production. These rewards are reinforced by arrangements such as bonus pay, promotion and other kinds of recognition. Such reward systems should be identified and modified so they don't compete with efforts to encourage safer behaviour. A single approach to promote safer behaviour is normally not enough. A combination of methods that support and reinforce each other is recommended. Seven strategies for improving safety performance are summarized below.

*Information*

Information about risks and their consequences is meant to increase the desire to avoid hazardous situations and to the adoption of self-protective behaviour. A considerable part of the acquisition of knowledge and skills comes about through unorganized, non-intentional learning processes in everyday work settings. For this reason, planned information endeavours have to compete with contradictory signals that occur in everyday life. The way people perceive risks from this "learning from experience" must be taken into account when designing information programs on risk.

### *Rewards for safe behaviour*

Safer acts and changes in risk perceptions can be achieved through the use of external “artificial” rewards or incentives. This can be the case independent of the risk perception of an exposed individual as a behaviour is adopted to get a reward rather than to avoid an accident. This behaviour change can be sustained even after the reward is removed.

Award programs based on a comparison injury statistics between departments or companies are controversial as they may cause under-reporting. They also place the emphasis on the worker rather than on the responsibility of the employer to provide a safe working situation. Award programs where a specific safe behaviour is monitored are reported to be more successful.

### *Compelling*

Efforts to change behaviour are normally more effective and long lasting if they rely on positive consequences instead of negative. In some cases, there is not sufficient time for an individual to voluntarily internalize a safe behaviour so behavioural rules are made compulsory. Management insist on strict adherence to the rules and when rules are violated negative sanctions follow.

Technical arrangements and product design can also be means for enforcing specific safe behaviour, e.g. by making it impossible to enter a danger zone while a moving machine part is in operation.

### *Training*

Training may be necessary for the acquisition of specific skills and safe practices. Many accidents occur when there have been changes in work and working conditions (new work tasks, new machinery, and new production methods) so such changes should be accompanied by safety training. Newly hired workers and those given new work tasks should be given “hands-on train-

ing” and practical exercises in how to cope with accident risks.

### *Design measures*

Facilitating the adoption of safe behaviour can be achieved by educational, engineering and organizational measures. Beside education and training in safe practices, good ergonomic design facilitates and promotes safer behaviour, and reduces human errors. A comfortable, light, or ventilated helmet is more likely to be used rather than a heavy and uncomfortable one. Safety guards that aid production are more likely to be used than devices that obstruct production.

### *Participation*

In general two sources of knowledge have to be exploited to create relevant and realistic promotion programs, i.e. the expert knowledge of safety professionals and the knowledge of workers exposed to the actual risks about informal structures, work practices and behavioural norms. Involving workers activates risk consciousness and increases the probability of behaviour change as we are more inclined to accept and implement decisions that we have been involved in making.

### *Behaviour based safety*

BBS or “Behaviour Based Safety” refers to a wide range of programs using behaviour analysis principles and positive feedback mechanisms to change unsafe behaviour.

BBS identifies behaviours required to carry out tasks safely, provides training and facilitating, and organizes for observation, feedback & reinforcement the targeted behaviours.

The causes behind unsafe behaviour, such as noncompliance with safety rules, are analyzed and the information used to redesign the workplace, equipment, organization, safety rules, and/or work tasks to facilitate the use of safe behaviours.



Safe behaviours are taught and positive feedback given to those who perform the requested behaviour. These programmes have been widely applied and reported successful in scientific evaluations. The use of behaviour modification principles to promote safer behaviour has also generated controversy, mainly due to observed tendencies to focus only on workers behaviour rather than on conditions that shape human performance.

### MAJOR ACCIDENTS

Accidents range from minor incidents that cause minor or no injury to large-scale accidents resulting in many fatalities and injuries and cause large scale damage to public health, the environment and economic losses. Much of what this chapter has been said about the prevention of accidents is applicable to component failures in enterprises of varying size, with variable accident risks. This part of the chapter focuses on the nature and occurrence of major accidents including the systematic prevention of such accidents.

According to the ILO convention no. 174 of 1993 on “Prevention of Major Industrial Accidents”, the term major accident means “a sudden occurrence - such as a major emission, fire or explosion - in the course of an activity within a major hazard installation, involving one or more hazardous substances and leading to a serious danger to workers, the public or the environment, whether immediate or delayed.” The OECD defines a major accident as one that causes the death of five or more people, causes injuries to 25 people and/or the evacuation of 400 people. The terms ‘major accident’ and ‘major risk’ have been widely used in the literature, by health and safety professionals and by the media. Public understanding of the terms generally refers to an accident or risk that has become a catastrophic force whose consequences

affect workers, communities, the general public, the environment, and potentially, future generations.

Major accidents can, and do, happen in high-risk sectors of working life such as the chemical industry, nuclear plants, public transport systems, the airline industry, space shuttles, mining operations, and shipping.

The globalization of the last 20-30 years has seen the exchange of technology between industrialized and developing countries, subcontracting, and outsourcing, as well as an increase in the transport of toxic and explosive substances within and between countries. These developments have contributed to the spread of risks for major accidents to most countries of the world whereas before 1970, major accidents occurred mainly in the industrialized countries where the greatest number of large industrial plants was found. There has been a considerable increase in the number of accidents in developing countries since 1970. The countries of Asia and Latin America had the greatest number of fatalities. Between 1960 and 1970, India, Mexico and Brazil adopted similar development models: intensification of economic growth at the cost of enlarging their overseas debt, increase of participation by multinational enterprises in the industrialization process, and heavy state intervention in their economies. During the 1980's these three countries experienced some of the most serious chemical industry accidents that ever have happened, namely at Union Carbide in Bhopal, India; Pemex in México and Petrobras in Brazil.

Perrow makes a distinction between component failures and system accidents. Both types of accidents start with component failures, (e.g. in a valve or by an operator error), but in system accidents “multiple failures occur which interact in ways unanticipated by systems designers and by those trained to operate them, whereas in



component failures, single or multiple failures are anticipated and comprehensible”. Perrow defines system accidents as those that occur in systems with ‘tight coupling’ where a failure in one point of the system will have consequences for the rest of the system.

So, how can system errors and accidents in high-risk technologies be prevented? That question is answered in the vast number amount of technical and scientific literature available.

On the next page, an example is presented based on the ILO Convention and the Seveso Directive.

Actions to be taken by enterprises where major accidents may occur.

The list of actions is based upon two documents: ILO's convention no. 174 of 1993

On 'Prevention of Major Industrial Accidents', and the Seveso Directive (Seveso II)

of 1996 on "Control of Major-accident Hazards Involving Dangerous Substances".

The enterprise has to have a Policy and a Safety management system, for major accident prevention. The policy and the management system shall include the following components:

#### Organisation and personnel

The employer is responsible for providing means to ensure the abilities and skills to the personnel involved in the management of major hazards. Personnel who perform or control work affecting safety shall be given clear roles and mandates by the management. Contractors shall receive information and training to be aware of the hazards.

#### Identification and evaluation of major hazards

The employer shall have a system for identification and evaluation of hazards emanating from activities, production and handling of materials.

#### Operational control

The procedures and instructions for safe operation of the plant, processes and equipment shall cover both normal circumstances (incl. test running and maintenance) and special circumstances (like emergencies). The procedures shall be developed in cooperation with the workers concerned. Training on the procedures shall be given.

#### Management of change

There shall be procedures for planning and controlling all changes having an influence on the major accident hazards (processes, materials, staff, etc).

#### Planning for emergencies

Procedures for emergency cases shall be in place, including training of key persons.

#### Monitoring performance

The employer shall monitor the safety performance and compare with the objectives defined. The monitoring shall be both proactive (preventing risks) and reactive (when a hazard is detected).

#### Audit and review

An audit shall be carried out by persons independent from the management, and its result be used to improve the hazard prevention system. An audit compares the system in place with the defined system, while a review is more fundamental and may be extended to consider modification of the policy or the defined system.

Besides what is said in the ILO convention about the enterprise (employer) obligations to prevent major accidents, the convention also states the obligations of the workers and governments.

## SUGGESTIONS FOR FURTHER READING

### International conventions and standards

Machinery Directive 98/37/EC.

Provides the regulatory basis for the harmonisation of the essential health and safety requirements for machinery at European Union. The manufacturer is responsible for verifying whether a particular product falls within the scope of the Machinery Directive. A revised Machinery Directive - Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, - will be applicable from 29<sup>th</sup> December 2009. [http://www.sis.se/DesktopDefault.aspx?tabName=@DocType\\_97&Doc\\_ID=45557](http://www.sis.se/DesktopDefault.aspx?tabName=@DocType_97&Doc_ID=45557)

SIS OHSAS 18 001: 2007 International Standard Organization, Geneva.

OHSAS 18001 has been developed to be compatible with the ISO 9001 (Quality) and ISO 14001 (Environmental) management systems standards. The (OHSAS) specification gives requirements for an occupational health and safety (OH&S) management system, to enable an organization to control its OH&S risks and improve its performance. In addition to the standards themselves, *The OHSAS 18000 Toolkit* includes a whole range of supporting items and materials. These are designed to assist not only in understanding the standards, but in implementation. <http://18000.drkeyboard.com/18000standards.htm>

Convention no.174 of 1993. International Labor Organization. Prevention of Major Industrial Accidents.

Available as Pdf -file on

[http://www.unitar.org/cwm/publications/cbl/synergy/pdf/cat3/ilo\\_agreements/convention174/convention174/convention174\\_en.pdf](http://www.unitar.org/cwm/publications/cbl/synergy/pdf/cat3/ilo_agreements/convention174/convention174/convention174_en.pdf)

Directive 96/82/EC (The Seveso Directive) 1996. Control of Major-accident Hazards Involving Dangerous Substances.

European Council [http://ec.europa.eu/environment/docum/01624\\_en.htm](http://ec.europa.eu/environment/docum/01624_en.htm)

### Websites

European Agency for Safety and Health at Work <http://osha.eu.int>

The aim of the Agency is to provide the European Community bodies, the Member States, the social partners and those involved in the field with the technical, scientific and economic information of use in the field of safety and health at work. Best practises in OHS work are presented in relation to different problem areas covering both safety and health issues.

International Labour Organization:  
[www.ilo.org](http://www.ilo.org)

### Textbooks

Geller S. Keys to behavioural based safety. ABS Consulting, 2000.

Describes experiences from different ways to work with BBS and their prerequisites and traps in practical applications

Kjellén U. Prevention of accidents through experience feedback. Taylor and Francis 2000. New York.

This book gives a comprehensive insight in accident prevention theory and practices. It covers a wide range of approaches and could be used as a book of references .

Perrow C. Normal accidents – Living with High-Risk Technologies, Basic Books. 1999. 2nd edition. Princeton University press, Princeton USA.

This is a seminal contribution to the understanding of causes and consequences of modern high-tech industrial accidents. Due to systems complexity and “tight couplings” Perrow perceives accidents as nearly inevitable consequences of the way the launch industrial ventures. Based on a number of real cases he describes what could have been done to prevent unfortunate occurrences.

Reason J. Human error. Cambridge University Press. New York. 2000.

Explores the nature of human error and its relation to stress, ergonomics and other external performance shaping factors. Based on knowledge from the cognitive sciences error management techniques are outlined. Despite a academic style this is reading not only for human factors specialist but also for reliability engineers and risk managers. Familiarity with concepts and theories from the cognitive sciences facilitates the reading.

Reason J. Organisational Accidents. Ashgate 1997.

A systematic organizational approach to safety replacing hitherto piecemeal approaches. The book uses four linked case studies to reach the

organizational outlook. It explains the concepts of Organisational Accidents and Human Error and includes practical guidance to error management.

Ridley J and Pearce D *Safety with Machinery* 2005 Second edition. Elsevier. London.

This book provides a basic grounding in machinery safety and covers safeguarding philosophy and strategy, typical hazards, risk assessment and reduction, guarding techniques, ergonomic considerations, safe use of equipment and plant layout. All types of safeguards are discussed – mechanical, interlocking, electrical / electronic / programmable, hydraulic, pneumatic. Target groups are engineers involved in machinery design, purchasing and maintenance, health and safety professionals, students and employee representatives.

### Articles and reports

Rasmussen J & Svedung I (2000) *Proactive Risk Management in a Dynamic Society*. Karlstad, Sweden: Swedish Rescue Services Agency.

Sklet, S. Methods for accident investigation. (2002) Norwegian University of Science and Technology, NTNU Trondheim.

Describes 15 established and commonly used methods for in depth accident investigation,

Galli E. A sociological approach to major chemical accidents.(1999) Internal report IDC 1999:2, Swedish National Institute for Working Life.

Based on an example from a petrochemical industry in Brasil. Galli characterises major accidents as socially produced errors. The report can be obtained through [ester.g@uol.com.br](mailto:ester.g@uol.com.br)



# Heat and cold stress

*Ingvar Holmér*

Thermal conditions, either hot or cold, effect human health, functioning and performance. Effects vary from subjective annoyance to death. Diminished human performance can result in increased accident risks and significant productivity losses.

Effective prevention requires elimination or reduction of exposure to extreme thermal conditions by technical and organisational means combined with measures to strengthen individual resistance.

## EXPOSURE TO HEAT AND COLD

Many developing countries have a tropical or desert climate with daytime air temperatures well exceeding 30 °C. Conditions are worsened by the presence of intense solar radiation and high humidity. In certain workplaces additional heat from industrial processes further aggravates the local thermal climate.

Indoor climatic conditions vary throughout the world depending on geographical and economic factors. In industrialized countries where most buildings are ventilated, air temperatures in dwellings and offices are usually in the range 20–25 °C. In tropical and hot countries the prevailing indoor temperature in buildings with

natural ventilation may be well in excess of 30 °C.

Problems related to cold stress are found in countries which have cool to cold seasons. All countries have cold stores and rooms, in which people work temporarily at temperatures as low as –25 °C.

Many categories of workers are exposed to both hot and cold conditions, e.g. in agriculture, forestry, building and construction.

## ADJUSTMENTS TO THERMAL EXTREMES

*Heat stress* results when there is excessive thermal load that the body cannot get rid of. *Cold stress* is a result of excessive, unbalanced loss of heat from the body.

The primary strategy applied to cope with abnormal thermal conditions, (hot or cold) is a behavioural one. For example, exposure to hot or cold is avoided or shortened, activity is reduced, clothing is put on or taken off, or heat radiation is shielded. Over time people have survived and adapted to cold and hot environments. Specific local climatic conditions are often the basis for the development of people's thermal preferences.

When behavioural adjustments are insufficient, automatic physiological adjustments



take over to facilitate the maintenance of heat balance and a stable and controlled body core temperature. *In response to heating*, superficial blood vessels are dilated and peripheral blood circulation enhanced. In addition, sweat glands are activated allowing for evaporative cooling of the skin.

*In response to cooling*, vessels constrict and redirect peripheral circulation to deeper vessels, e.g. those in the extremities. Excessive cooling results in shivering, an involuntary muscle contraction primarily producing heat.

The purpose of behavioural and physiological adjustments by the body is to control heat exchange with the environment. The same amount of heat must be emitted to the environment to ensure heat balance and a stable body core temperature. The cost of adjustment to thermal extremes is an increasing strain on the human body that compromises the body's ability to work and function properly. When the capacity of the thermoregulatory system is exceeded the body is unable to cope with the conditions. Indirectly, failure to adapt degrades human performance, resulting in productivity losses and an increased risk of occupational accidents.

### INDIVIDUAL FACTORS

Tolerance of heat and cold largely depend on individual factors such as physical fitness and health status. Cardiovascular disease, impaired renal function, obesity, poor health status (infections, tropical diseases, etc.), and alcohol and drug abuse are contributing factors to increased thermal intolerance. Poor physical fitness related to physical exhaustion, dehydration, and starvation makes people more susceptible to the effects of heat and cold stress.

### RISK ASSESSMENT

A series of international standards have been developed for assessment of thermal environments. They describe strategies, measurements and methods for evaluation of thermal conditions and the associated risk of adverse effects. The philosophy adopted in the strategy is that simple, quick and practical methods should be used for the first estimation of thermal conditions. Preferably, these methods should be easy to use and be understood by workers themselves at the workplace. This approach is more likely to engage all workplace partners as initial costs are small and controllable.

Only when assessment becomes complex, difficult or ambiguous, expertise should be consulted to define more reliable and accurate methods to deal with thermal stress.

Appropriate international standards on both heat and cold stress are quoted and briefly described below. The given information should be sufficient for a first screening of thermal problems in the workplace and for advising on more complex methods of evaluation.

ISO standards are internationally agreed documents describing procedures and methods for example for evaluation of properties of products or machinery but also of thermal conditions of the workplace. Standards must be purchased from the national standardisation body, but may be borrowed at major libraries in the country. Experts and consultants that are engaged for more complex evaluations must be familiar with and trained in the use of the standards. The relevant ISO standards are:

ISO7243, Hot environments – Estimation of the heat stress on working man, based on the WBGT-index.

ISO7933, Hot environments – analytical determination and interpretation of thermal stress using calculation of predicted heat strain, PHS.

ISO9920, Ergonomics – Estimation of the thermal characteristics of a clothing ensemble.

ISO11079, Ergonomics of the thermal environment – Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects.

ISO13732, Ergonomics of the thermal environment – Assessment of human responses to contact with surfaces. Part 1 – Hot surfaces.

ISO13732, Ergonomics of the thermal environment – Assessment of human responses to contact with surfaces. Part 3 – Cold surfaces

ISO15265, Ergonomics of the thermal environment: risk assessment strategy for the prevention of stress or discomfort in thermal working conditions

ISO15743, Ergonomics of the thermal environment – Working practices for cold environments

## HOT ENVIRONMENTS

### Heat exchange

In a hot environment, sweat evaporation becomes the ultimate determinant of successful thermal adjustment. Heat losses by convection (warming of air) and radiation decrease with increasing air temperature. At high air temperatures of 35 °C or more, and/or in the presence of heat radiation, the body may gain heat by radiation and convection. This can be compensated only by increased sweat evaporation. In warm and humid climates, conditions for sweat evaporation are worsened and effective heat transfer reduced. A dry, hot environment is often better tolerated than a warm, humid environment.

Heat production at rest is approximately 100 Watts, but may rise to more than 500 Watts during heavy work. At high air temperatures, such high work rates may require a sweat production

of 1 l/h or more, equivalent to a cooling rate of 680 Watts if it evaporates at the skin surface.

Clothing complicates the heat transfer process. Efficient sweat evaporation requires clothing to be permeable to the passage of water vapour so the water vapour resistance of clothing material is critical. Warm weather clothing is often open and porous. Protective clothing may compromise vapour transfer and worsen evaporative cooling of the body.

### Effects of heat

Initially, deviations from normal climatic conditions cause subjective discomfort and complaints. This is the predominant problem in office buildings and similar environments.

Depending on the severity of the heat stress, the effects on humans vary from subjective annoyance, performance degradation, fatigue and exhaustion to heat injuries. The risk of severe and irreversible effects rises with increasing thermal stress. Figure 4.3.1 lists different effects associated with heat stress.

tissue and body heating
discomfort/pain
mental performance, vigilance and arousal impaired
cardiovascular load – increased heart rate – orthostatic intolerance, fainting
fluid imbalance – dehydration
reduced work capacity – increased workload – decreased endurance
heat injuries – heat stroke – heat collapse – heat exhaustion – heat cramps – heat rashes

Figure 4.3.1. Effects associated with heat stress in humans.

The increased cardiovascular load experienced during heat stress compromises the capacity for physical work. Significant water losses due to sweating aggravate the physiological strain. A given workload requires more effort (e.g. higher heart rate), and endurance is reduced. Pooling of circulatory blood in lower extremities makes a person more susceptible to fainting.

*Heat stroke* is a severe condition caused by high core temperatures and failure of adequate thermoregulatory responses. Damage to vital organs may occur and eventually result in death. Immediate body cooling is necessary. *Heat collapse* may result from cardiovascular failure, due to the inability of the body to maintain adequate circulation, cardiac work and central blood pressure. *Heat exhaustion* is caused by physical fatigue due to dehydration and insufficient muscle blood supply. *Heat cramp* is localized to muscle tissues, caused by uncompensated salt loss through sweating.

Repeated exposures to heat may cause the body to develop positive functional adjustments (acclimatisation). With daily repeated sessions of physical work, sweating and circulatory adjustment becomes more efficient, thus enhancing thermoregulatory control. The ability to sustain physical work under hot conditions is greatly enhanced when preceded by a 7–10 day acclimatisation period. During this period the person is gradually exposed for a couple of hours to more and more severe heat stress.

In many developing countries working and living conditions are such that workers may be more or less fit to work in hot climates, however, health and nutritional status and access to drinking water are decisive factors. Family conditions and transportation are other factors that may affect the overall physical capacity of an individual.

In order to prescribe acceptable working conditions, various effects can be used as risk

criteria. Medical effects are commonly used. People should not be injured at work, however in heat and cold fatigue and exhaustion may be more relevant risk criteria as they directly interfere with work ability. Work must be stopped if people become fatigued or exhausted. For office work, thermal sensation and discomfort reactions are relevant criteria for assessment. The relationship between thermal conditions (stress level) as defined by the climatic factors, and the specified effects (strain) must be known for the setting of limit values.

Effects on mental performance such as reduced vigilance and arousal, indirectly affect motor performance and increase the probability of human error. Figure 4.3.2 shows the number of unsafe and erratic behaviors as reported by an observation team visiting industrial workplaces with different ambient temperature conditions as measured by the WBGT index. Deviations from optimal climatic conditions, (around 20 °C WBGT), increase the frequency of erratic behavior.

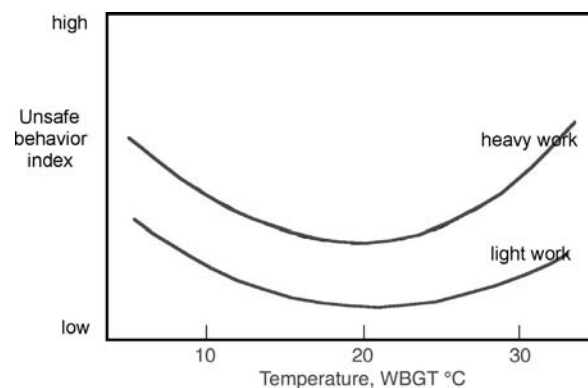


Figure 4.3.2. Deviations from optimal, climatic conditions increase the frequency of unsafe behaviour. Modified from Ramsey et al. J. Safety Research, 1995.

Productivity is strongly dependent on thermal conditions, in particular during physically de-

manding work, Figure 4.3.3. Up to a certain temperature thermal stress can be compensated for and work capacity is relatively well maintained. As soon as heat stress becomes overwhelming, workers become exhausted and can only sustain work output by taking frequent, intermittent breaks to recover.

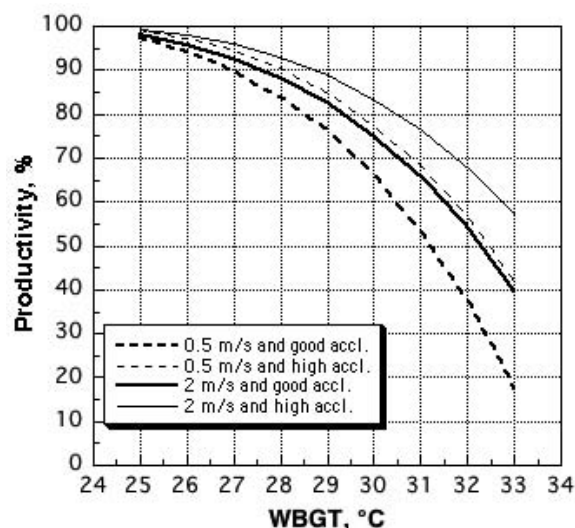


Figure 4.3.3. Productivity loss (in percentage) in hot mining work, modified from Axelsson, Scand J Work Environ health, 1974.

Losses at minor heat stress expressed by WBGT are small, but they increase exponentially at higher temperatures principally because physiological strain and heat exhaustion develop and call for reduced work pace and frequent pauses for recovery. Acclimatisation of workers and better ventilation improve conditions.

The graph in Figure 4.3.3 was derived from experiences in the mining industry, primarily in hot and humid conditions. Such conditions can also apply to other types of manual work, such as agricultural, forestry, building and construction work in similar climates.

### Observation checklist

The most apparent and immediate risk factors are listed in Figure 4.3.4. The figure provides a checklist for quick assessment of thermal risk factors and their severity.

How do you perceive the risk of adverse effects associated with the following factors?	0 – no risk 1 – small risk 2 – high risk
air temperature	
humidity	
thermal radiation; sunshine	
air movements	
work load	
clothing, protective equipment	
contact with hot surfaces	
other factors (specify)	
The severity of each risk factor is estimated from 0-2: 0 – no risk 1 – small risk (conditions should be improved when appropriate) 2 – high risk (conditions should be improved immediately)	

Figure 4.3.4. Checklist for observation of thermal risk factors in hot environments (modified from ISO 15265).

ISO 15265 och ISO 15743 provide numerous examples of simple, preventive measures that can be immediately applied at low cost, without consulting external expertise. As previously mentioned, external expertise for the risk assessment is only needed when conditions cannot be solved the easy way.

More accurate and complex risk assessment requires an expert to undertake detailed measurements to quantify thermal stress. The important climatic factors to consider for both cold and heat stress are listed in Figure 4.3.4. These factors need to be quantified by measurement or estimation before the evaluation can be done.

### Measurement of heat stress

When measurements are required, several indices are available for the assessment of heat stress.

WBGT (ISO 7243) provides a screening method that reasonably estimates thermal effects. PHS is an analytical index that more accurately determines the conditions for heat balance.

The WBGT (Wet Bulb Globe Temperature) index has long been used world-wide and is an empirical index based on measurements of globe temperature ( $t_g$ ), natural wet bulb temperature ( $t_{nw}$ ) and air temperature ( $t_a$ ). It is calculated by the two formulas shown below. The globe temperature is measured with a sensor placed inside a 5-15 cm hollow, black sphere, preferably made of copper or aluminium. Measurement time is at least 10-20 min for equilibrium (shorter for the small globe). The natural wet bulb is measured with a 0.5x2 cm cylinder-type sensor that is fully covered with a cotton cloth extending a few cm outside the sensor area on both sides. The cotton cloth must be fully wet and must not dry out during measurements. Measurement time is approximately 5-10 minutes.

WBGT is recommended as a screening index for the identification and control of potential places, times and conditions for adverse heat effects.

$$WBGT = 0.7 t_{nw} + 0.3 t_g$$

$$WBGT = 0.7 t_{nw} + 0.2 t_g + 0.1 t_a \text{ (outdoors with solar load)}$$

The *recommended exposure* limits as defined in ISO 7243 are illustrated in Figure 4.3.5. The limits are activity dependent. For high work rates conditions may quickly become strenuous, in particular during continuous work. Since most continuous work (1 hour average) falls in the low to moderate category, the limit values to apply are in the range 26-30.

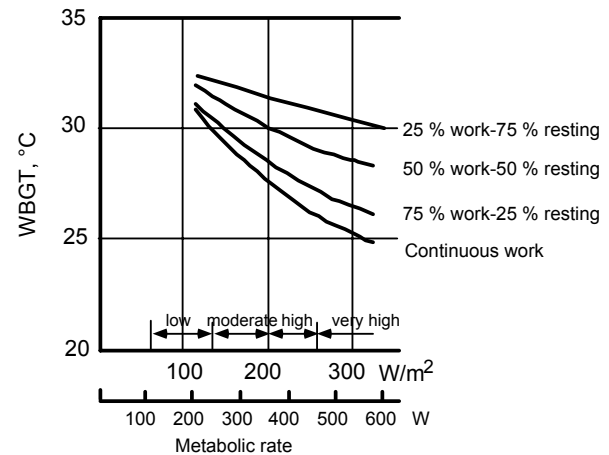


Figure 4.3.5. Recommended limit values according to ISO 7243 for continuous and intermittent work-rest regimens (redrawn from ISO 7243). Values refer to 1 hour time weighted averages.

Examples of WBGT-values for some industries in Thailand and Tanzania are given in Figure 4.3.6. A comparison of the values and the graph shows clearly that all the workplaces frequently exceed these values.

Industry	Thailand	Tanzania
Ceramics factory	20-33	--
Steel factory	21-37	25-37
Glass factory	27-34	27-37
Corrugated sheet factory	--	27-31
Agriculture	20-32	--
Construction site	22-30	25-30

Figure 4.3.6. Examples of measured WBGT in workplaces in two countries. Values from Tanzania are calculated from tabulated values for globe and natural wet bulb temperature.

In general, internal heat loads in the building add to the ambient climatic conditions since most such workplaces has no mechanical ventilation. In the furnace area of a steel plant located in a dry hot climate, the WBGT is predicted to



vary between 28–44 °C for the air temperature range of 20–35 °C (from Emes et al. *Am Ind Hygiene Assoc J*, 1978).

The WBGT index may be sufficient for most routine assessments but when more accuracy is needed, expertise should be sought and the PHS-index (Predicted Heat Strain) should be used (ISO 7933). This method is based on a heat balance calculation which considers all the relevant climatic and individual factors. Core body temperature increases are predicted for given conditions that allow determination of appropriate exposure times when risk criteria are exceeded. The method also allows simulation and calculation of the effects of various preventive measures, rendering it suitable for cost-benefit analysis.

Another international standard provides data on surface temperatures of different materials that can be safely touched by bare hands without risk of burns (ISO 13732). In particular, metal surfaces at temperatures above 45–50 °C may result in burns after a few seconds on contact with unprotected skin.

### Prevention of heat stress

Technical measures to reduce exposure, e.g. shielding of radiant heat, reflective panels or cooling arrangements at the workplace, will improve conditions for body heat balance and reduce heat stress. In addition, organisational measures such as work rotation and adequate breaks can be used to reduce and control the heat stress of individual workers. Solar radiation is a common source of heat load in outdoor work. The human body may absorb up to 100 W of incident radiation on a clear day. This solar load can be less than 50 W if white and loose-fitting clothing is worn. Working in the shade is preferable.

Heat radiation can easily warm surrounding surfaces creating new sources of low temperature infrared radiation. Shielding is most effective close to the radiation source. Shields can be insulative or reflective. Surfaces towards the radiation source must be clean and polished for effective reflection.

Increased convection (air speed), e.g. through the use of large fans, improves cooling of the body by enhanced sweat evaporation. The positive effect is greatest when air temperature is below or close to skin surface temperature (around 35 °C). This measure is particularly useful in warm and humid environments.

Workers must be provided sufficient amounts of potable water that should be drunk frequently, not only due to thirst. Salt tablets are required when heat stress prevails for long periods perhaps even during leisure or at night time. The provision and drinking of water is crucial to maintaining work ability over a working shift. Studies have shown that productivity of agricultural and forestry workers was strongly dependent on the availability of drinking water. The costs involved to provide clean water at remote work places may easily be repaid by longer periods of productivity. A person working at a medium to high rate loses about 1 l/h or 5–6 litres during a working shift, which must be balanced by frequent intake of water and salt throughout the working shift.

Protective clothing may be needed for certain jobs. This type of clothing often greatly reduces heat loss, in particular that due to sweat evaporation. Control of work and rest pauses are essential in order to prevent rapid increases in body temperatures. Use of an ice-vest underneath clothing is a cheap and simple method for the reduction of heat stress in hot industries. Special equipment for the provision of cool air or liquid cooling under clothing is available.



Education and training of workers, foremen and employers is an essential component of an effective and functional risk management program.

Measures that reduce thermal stress without compromising performance and productivity are more likely to be accepted by both employers and employees.

<b>Technical measures</b> <ol style="list-style-type: none"> <li>1. increased circulation of air increases evaporation and convection at air temperatures below approx. 35 °C</li> <li>2. shielding of radiant heat</li> <li>3. reflective panels</li> <li>4. provision of shade from sunshine</li> <li>5. cooling of indoor air by compressor or evaporative cooling systems</li> </ol>
<b>Organisational measures</b> <ol style="list-style-type: none"> <li>1. provide breaks for recovery and cooling</li> <li>2. improve methods and equipment to reduce work rate</li> <li>3. rotate workers between work and workplaces</li> <li>4. avoid work at peak temperature of day</li> <li>5. instruct workers for pair wise observation for heat symptoms (buddy system)</li> </ol>
<b>Individual measures</b> <ol style="list-style-type: none"> <li>1. provision of drinking water for frequent replacement of sweat losses</li> <li>2. salt tablets</li> <li>3. light, loose clothing</li> <li>4. protective clothing               <ul style="list-style-type: none"> <li>– reflective garments must be clean and glossy</li> <li>– thick, insulating garments for short extreme exposures</li> <li>– check compliance of special protective equipment</li> </ul> </li> <li>5. microclimate cooling               <ul style="list-style-type: none"> <li>– compressed air</li> <li>– liquid cooling</li> <li>– ice vests or similar</li> </ul> </li> </ol>
<b>Other measures</b> <ol style="list-style-type: none"> <li>1. inform, train and educate workers on heat effects</li> <li>2. health controls at employment and at regular intervals</li> <li>3. acclimatisation programs</li> </ol>

Figure 4.3.7. List of actions that can be taken to reduce or prevent heat stress.

## COLD ENVIRONMENTS

In cold environments the large temperature gradient between the body surface and the environment facilitates convective and radiative heat losses. The combination of wind and low temperatures provides significant cooling power and may represent a major risk factor in cold workplaces but in most situations there is no need for evaporative cooling. In fact, it is strongly recommended to avoid sweating in cold climates in order to keep clothing dry and warm. Clothing is a significant factor for control of heat balance. The build-up and variation of insulative layers allows adjustment of convective and radiative heat losses according to the needs of the wearer.

### Adjustments to cold stress

If behavioral measures are insufficient to maintain heat balance, peripheral circulation, in particular to the extremities, is reduced in order to conserve core body heat. With more pronounced tissue cooling, core temperature drops and evokes compensatory heat production by shivering (involuntary muscle contractions).

### Effects of cold stress

Early responses to body cooling are discomfort and annoyance. In particular the onset of shivering is perceived to be extremely unpleasant and serves as a strong alert for intervention. Vasoconstriction leads to lowered heat input and a drop in temperature, particularly in the hands and feet. Pain is perceived at finger skin temperatures around 15-20 °C and numbness (sensory loss) at 7-8 °C. Tissue freezing occurs at skin temperatures below 0 °C. When temperature drops in the hands and feet, function and performance deteriorate. Manual dexterity is affected, e.g. precision work is affected at finger skin temperatures around 20-25 °C, and gross

muscular performance at finger temperatures below 15 °C. Vasoconstriction also contributes to increased blood pressure. High ventilation rates means that cold air may irritate the airway mucosa eventually leading to inflammatory reactions.

Profound body cooling results in hypothermia, a condition that severely affects the ability to function and perform. With deep body cooling there is an imminent lethal risk.

tissue and body cooling
thermal discomfort, pain
mental performance, vigilance, arousal impaired
cardiovascular load – increased blood pressure
respiratory effects – mucosal irritation,
neuro-muscular performance and work capacity reduced – manual function and dexterity impaired
cold injuries – hypothermia – local cold injuries – freezing injuries – non/freezing injuries

Figure 4.3.8. Effects associated with cold stress in humans.

### Cold stress assessment

As a first step a simple checklist can be used to observe the workplace. The checklist can be used by a supervisor, a specially trained worker or any other person familiar with production and workplace conditions.

One example of a checklist is given in Figure 4.3.9.

How do you perceive the risk of adverse effects associated with the following factors?	0 – no risk 1 – small risk 2 – high risk
air temperature	
wind	
contact with cold surfaces	
water, liquids, moisture	
cold protective clothing	
protection of head, arms and feet	
interference with protective equipment	
other factors (specify) .....	
For each factor a risk level between 0-2 is estimated: 0 – no risk (no action needed) 1 – low risk (conditions should be improved when appropriate) 2 – high risk (conditions should be improved immediately)	

Figure 4.3.9. Checklist for observation of thermal risk factors in cold environments, modified from ISO 15743.

For many conditions classified as 1 or 2, appropriate measures should be applied and evaluated. These measures may be suggested by the workers themselves or see the examples in figure 4.3.11. When appropriate measures cannot be found or are insufficient, an expert should be asked to undertake measurements and evaluation of the conditions.

### Measurements of cold stress

A more detailed evaluation of cold stress requires assessment of the following effects:

- whole body cooling
- local cooling
  - extremity cooling
  - wind cooling
  - contact cooling
  - respiratory cooling

Whole body cooling is evaluated using a heat balance calculation to determine the required clothing insulation for defined criteria (levels of strain). The value is called the IREQ-index (Insulation REQuired) (ISO 11079). When available clothing provides sufficient insulation, exposure time is infinite. With less thermal insulation, a recommended exposure time to prevent body cooling is calculated. Figure 4.3.10 gives an example of exposure times for light work. Each curve represents a defined level of clothing insulation (from 1 to 4 clo). The clo-value for an ensemble can be obtained from tables in the standard, or from ISO9220. The clo-unit provides a simplification of the more complex SI-unit – 1 clo =  $0.155 \text{ m}^2\text{°C/W}$ . Typically a 2-layer long-sleeved clothing ensemble provides 1–1.5 clo, a 3-layer ensemble 1.5 to 2.5 clo and a 4-layer ensemble 2.5 to 4 clo. Cold protective clothing must also provide air impermeable outer layers when protection against wind is required.

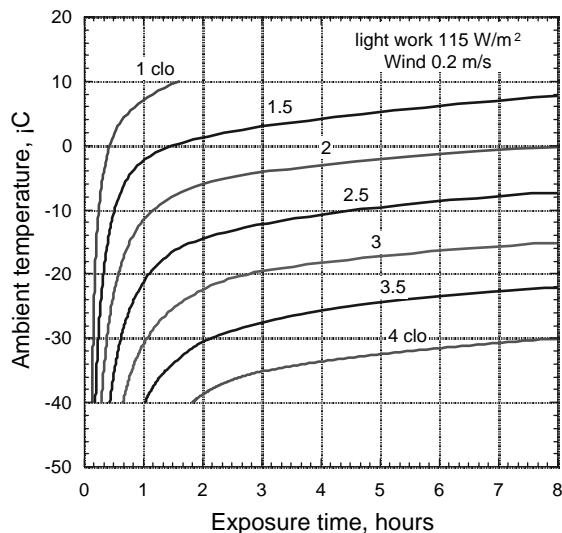


Figure 4.3.10. Exposure time at various air temperatures for clothing ensembles with different insulation values (see text). Curves apply to light work and no wind, modified from ISO 11079.

It is clear from figure 4.3.10 that work in a cold store at  $-25 \text{ °C}$  can continue for long time but only with an ensemble providing more than 3.5 clo. If the ensemble used by the worker is 2.5 clo, the appropriate working time should be less than 1 hour.

Wind increases heat loss in cold environments. The head and the extremities are particularly vulnerable and tissues may cool rapidly. The face is often unprotected so the risk of developing frostbite is imminent at temperatures below  $-20 \text{ °C}$  at 10 m/s and below  $-30 \text{ °C}$  at 2 m/s or more.

The most prevalent risk factor in cold work is extremity cooling, in particular cooling of the hands and fingers. Measurement of finger skin temperature provides an easy measure of the risk. At finger temperatures below  $15 \text{ °C}$  exposure should be interrupted and hands allowed to warm up.

Contact cooling can be evaluated on the basis of surface temperature and the properties of contacted material. Metals are dangerous to handle with bare skin at temperatures below  $0 \text{ °C}$ . Frostbite may occur within a few seconds if the surface temperature is lower than  $-5 \text{ °C}$ .

At very low temperatures significant cooling of the airways may take place. The use of simple filter breathing masks improves heat retention through respiration and helps to reduce respiratory symptoms.

### Prevention of cold stress

Similar basic principles apply to the design of preventive measures for both hot and cold work. Technical and organisational measures can be applied to improve heat balance by affecting conditions for heat exchange, heat production during work, and the time and intensity of work. Individual measures are designed for similar purposes, for example by the use of protective

clothing for reduction of physiological strain. The capability for an individual to cope with thermal stress is improved by training, education and medical surveillance.

The key element to protection from cold is adequate, insulative clothing that must be flexible so that the actual insulation can be adjusted to variations in climate and work intensity. Sweating should be avoided at all times. Sweat evaporation is very inefficient in cold environments and most sweat will accumulate in clothing layers. Wet and moist clothing is not only uncomfortable but also threatens body heat balance as insulation by the clothing reduces. Body cooling may accelerate during subsequent periods of light work or rest.

Workplaces should be shielded against wind and precipitation. Wind increases convective heat losses and wind penetration into clothing greatly reduces its insulative capacity. Accordingly, the outer layer of clothing must be highly windproof.

Cold outdoor work conditions are often unpredictable due to changes in weather. Careful advance planning is needed and alternative procedures should be scheduled. Sudden weather changes during the day also justify alternative action plans. Coverage of specific areas or even complete workplaces, (e.g. building sites), has become common and may pay off the extra costs because weather conditions are controlled.

The human head is highly susceptible to heat loss and should be properly protected, particularly in windy conditions. If the body gets hot during intensive work, the bare head and bare hands, may eventually lead to significant heat loss.

Hands and feet are highly susceptible to cooling due to their remote location from central heat sources. In particular the available energy for peripheral heating is limited when the rate

of work is slow so the temperature of hands and feet gradually falls. Adequate gloves or boots may sometimes be insufficient to prevent this drop but only slow down the cooling rate. Fingers, toes and face are the most frequent locations for injuries from cold.

Due to the bulk and weight of protective clothing against cold, physical work becomes more cumbersome and strenuous. Compared to more temperate climate conditions, the pace of work is reduced and productivity is lower.

In very cold workplaces (below  $-10^{\circ}\text{C}$ ), even the best protective clothing against cold may be insufficient, particularly when the work rate is low, see Figure 4.3.10. In that case work must be organized so that acceptable periods of cold work are interspersed with breaks for warming up and recovery. Many countries enforce regulations of this kind for work in cold stores ( $-25^{\circ}\text{C}$ ). Suitable work rest regimens can be determined on the basis of ISO 11079.

Measures that reduce thermal stress without compromising performance and productivity are more likely to be accepted by both employers and employees.

<b>Technical measures</b> <ol style="list-style-type: none"> <li>1. provide protection against foul weather</li> <li>2. provide wind breaks</li> <li>3. provide local heating</li> <li>4. insulate against cold ground</li> <li>5. tools, equipment and machinery <ul style="list-style-type: none"> <li>pre-warm or keep warm <ul style="list-style-type: none"> <li>– insulate knobs, handles and bars</li> <li>– must allow operation with gloves</li> </ul> </li> </ul> </li> <li>6. insulate cold surfaces</li> </ol>
<b>Organisational measures</b> <ol style="list-style-type: none"> <li>1. allow more time per task</li> <li>2. reduce time in the cold</li> <li>3. provide breaks with warm up facilities</li> <li>4. reduce work in light and stationary work</li> <li>5. avoid coldest part of the day (morning)</li> <li>6. use buddy system</li> </ol>
<b>Individual measures</b> <ol style="list-style-type: none"> <li>1. clothing <ul style="list-style-type: none"> <li>– optimize insulation</li> <li>– avoid bulky and stiff materials</li> <li>– check compliance of special protective equipment</li> </ul> </li> <li>2. insulation <ul style="list-style-type: none"> <li>– flexible and adjustable</li> <li>– minimize needs for sweating</li> <li>– avoid moisture in clothing</li> </ul> </li> <li>3. Micro climate heating <ul style="list-style-type: none"> <li>– use heated vest, gloves or socks</li> <li>– use pocket heaters for hands etc.</li> </ul> </li> <li>4. provide double glove system for warmth and dexterity</li> <li>5. provide footwear with insulation against ground and anti-slippery sole</li> <li>6. adjust work rate</li> <li>7. provide warm food and drink</li> </ol>
<b>Other measures</b> <ol style="list-style-type: none"> <li>1. inform, train and educate workers on cold effects</li> <li>2. health controls at employment and at regular intervals</li> <li>3. allow for gradual adaptation to work</li> </ol>

Figure 4.3.11. Examples of preventive measures applicable to cold work.

## SUGGESTIONS FOR FURTHER READING

Parsons, K. C., 2003, Human thermal environments. (Taylor & Francis, Hampshire, UK).

Comprehensive and up-dated textbook for learning and understanding the interaction of humans with the thermal environment.

Detailed presentation of assessment methods, in particular ISO standards, and preventive measures.

Holmér, I. 2001, Assessment of cold exposure International Journal of Circumpolar Health 60: 413-422.

Describes a systematic step by step strategy for assessment of the various types of effects in cold work.

ILO Encyclopedia of Occupational Health, 1998, Stellman, J. (ed.). Heat and Cold, volume 2, pages 42:1-55, ILO Geneva.

Thorough presentation of problems of heat and cold work. Description of methods for assessment and preventive measures.

# Noise

*Ulrik Sundbäck*

Mechanization of work through the use of machines is a predominant factor in the process of industrialization. Mechanisation results in an increasing number of noise sources at work-places, in homes and in the general environment.

Noise can be defined in different ways but the most simple and frequently used definition is that “noise is unwanted sound”.

Millions of workers are constantly exposed to very high noise levels in a variety of industries including manufacturing, transport, mining, construction and chemical processing. High noise levels have three main effects, i.e. it is harmful to health, hinders speech communication and is annoying. Noise-induced hearing loss is the highest reported occupational disease in many countries and occurs in both developing and industrialised countries.

## EFFECTS OF NOISE

Noise causes physical, psychological and social effects. Noise can be annoying but the most serious adverse effect resulting from exposure to excessive noise is permanent hearing loss caused by damage to the sensory organs of the inner ear.

Noise not only damages hearing but can also influence cardiovascular functions such as blood pressure and heart rate and cause stress

and other psychological effects. Noise can also interfere with communication, cause tiredness and reduce efficiency. Interference with speech communication can be an accident risk because warning signals are less audible.

We are rarely exposed to a single, isolated sound but usually exposed to a variety of sounds, often referred to as “background noise”. If the frequency components of background noise are sufficiently loud compared with those of the sound we wish to hear, sound reception and intelligibility of speech may be impaired or masked.

## NATURE OF NOISE

### The ear

The human ear consists of three main parts: the outer or external, middle and inner ear. The outer and middle ear both collect airborne sound waves and conduct them to the fluid-filled inner ear. The outer and middle ear transform mechanical vibration signals into neural impulses which then transfer acoustic information to the brain.

The inner ear has two separate systems: semi-circular canals that are primarily related to balance and the cochlea, primarily related to hearing.

The fluid-filled cavity of the cochlea is divided into two longitudinal canals by the basilar



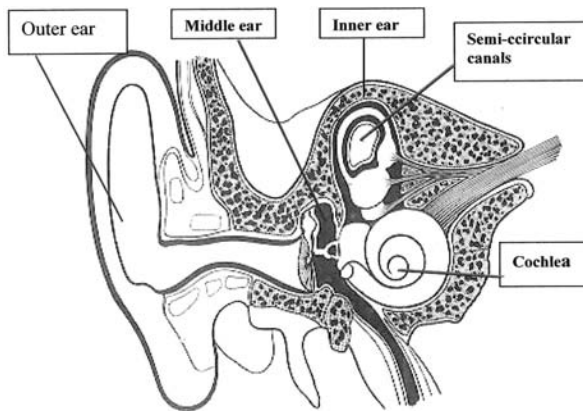


Figure 4.4.1. The human ear.

membrane. When sound enters the outer ear and is transferred to the inner ear, the fluid disturbance passes through the canals and causes different parts of the membrane to vibrate. There are thousands of hair cells on the basilar membrane and these register the vibration and transform it into nerve impulses that are transmitted to the brain. When a person is exposed to high sound levels, there is a risk that these very fine hair cells will be destroyed. This risk is especially high if a person is exposed to high sound levels over a long period of time, e.g. for those working in a very noisy environment. Unfortunately, when the fine hair cells die they cannot repair themselves, resulting in permanent hearing damage.

### dB and $L_p$

A main quantity used to describe noise is the size or amplitude of the pressure fluctuations. The most quiet sound a human ear can detect has an amplitude of  $20 \mu\text{Pa}$ , (approximately 5 000 million times less than normal atmosphere pressure), but the human ear can also tolerate sound pressures more than a million times higher than normal atmospheric pressure. If noise were

measured in Pa, very large numbers would be required, so, (in order to avoid this), the decibel (dB) scale is used.

The decibel is not an absolute unit of measurement but a ratio between a measured quantity and an agreed reference value. The dB scale is logarithmic and uses the hearing threshold of  $20 \mu\text{Pa}$  as the reference level – defined as 0 dB. When the sound pressure in Pa is multiplied by 10, 20 dB is added to the dB level.  $200 \mu\text{Pa}$  corresponds to 20 dB and  $2000 \mu\text{Pa}$  corresponds to 40 dB and so on.

The mathematical definition of sound pressure level,

$$L_p = 10 \log \left( \frac{p^2}{p_0^2} \right)$$

$L_p$  is sound pressure level, dB,  
 $p$  is the measured value in Pa  
 $p_0$  is the reference sound pressure, which has a value of  $20 \mu\text{Pa}$ .

The advantage of using the dB scale is clearly seen in Figure 4.4.2.

On the left, the sound pressure is shown in the Pascal unit, (Pa),  $0.0001$ – $100$  Pa and on the right, the pressure is shown in decibel, dB,  $0$ – $140$  dB.

### What we hear

Sound is defined as any pressure variation which can be heard by the human ear. The number of pressure variations per second is called the frequency of sound and measured in Hz. A young person has an audible range of frequencies from  $20$  Hz to  $20$  kHz.

The audible range of hearing in terms of sound pressure level starts from threshold of hearing at 0 dB and ends at the threshold of pain which can be over 130 dB.

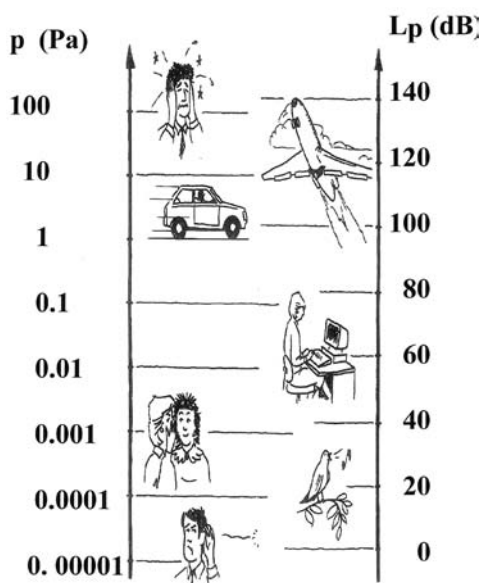


Figure 4.4.2. Sound pressure level.

While an increase of 6 dB represents a doubling of the sound pressure, an increase of about 10 dB is required before the sound is perceived to be twice as loud. The subjective loudness of a sound is determined by several factors, one of which is the fact that the human ear has a non-linear frequency response. The ear is most sensitive to sounds with frequencies between 2 kHz and 5 kHz.

The distinction in sensitivity to different frequencies is more pronounced at low sound pressure levels.

### Inaudible sound

Inaudible sound also exists. Sound with frequencies below the hearing range is called infrasound. Sound with frequencies beyond the range of hearing is called ultrasound.

### ALLOWABLE NOISE LEVELS

“Allowable” noise levels at a workplace are a question of level and duration and refer to levels related to health risks.

Sound from a noise source usually fluctuates and is not constant over a period of time.

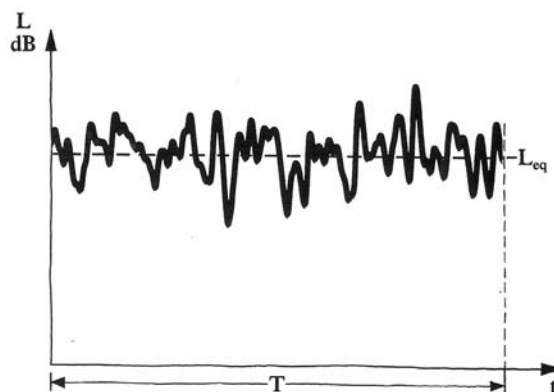


Figure 4.4.3. Fluctuating noise.

In order to determine the health risk caused by fluctuating noise, it is necessary to measure the average value, equivalent value  $L_{eq}$ , of the noise. The equivalent level,  $L_{eq}$  is an electronically calculated mean RMS level which integrates all the energy in a signal measured over a certain time period –  $t$ .  $L_{eq}$  can be considered to be the continuous noise with the same total acoustic energy as the actual fluctuating noise measured over the same period of time.

The mathematical definition of  $L_{eq}$

$$L_{eq} = 10 \log_{10} \frac{1}{T} \int_0^T \left( \frac{p(t)}{p_0} \right)^2 dt$$

$T$  is the total measurement time

$p(t)$  is the instantaneous sound pressure

$p_0$  is the reference sound pressure, 20  $\mu$ Pa

Most often, the instantaneous sound pressure is A-weighted so the unit of  $L_{eq}$  becomes dB(A).

For steady, continuous noise, a good correlation has been demonstrated between the risk of hearing damage and A-weighted sound level measurements so this unit is now universally employed when rating noise for this purpose. But, the duration of exposure also has to be considered in addition to the noise level.

Noise “dose” is defined as the A-weighted equivalent noise level, (the A-weighted  $L_{eq}$ ), to which a person may be subjected for a working day of 8 hours, or a working week of 40 hours, before there is a significant risk of permanent hearing loss. The allowable dose varies slightly between countries but is usually 85 or 90 dB(A).

“Allowable” exposure to noise is a question of level and duration; a high level of noise is acceptable as long as it is compensated for by periods of low levels. This trade-off between noise level and exposure time, creates the main divergence of opinion between different standards but both ISO and OSHA specify a halving rate, i.e. they specify a rise “q” in noise level for each halving in exposure time, see Figure 4.4.4.

This means that if the criterion level is 90 dB(A) in both cases (ISO and OSHA), ISO will allow an exposure of 93 dB(A) and OSHA an exposure of 95 dB(A), for 4 hours a day if the remainder of the day is spent in an area where the noise level is below 80 dB(A). If the exposure is reduced to 2 hours, ISO will allow 96 dB(A) and OSHA 100 dB(A).

The following example illustrates the  $L_{eq}$  for a full working day. The operator spends 1 hour in a workshop where the noise level is 100 dB(A) and the remainder of the day in an office, with a noise level of 80 dB(A). The  $L_{eq}$  for the 8 hour working day will be approximately 91 dB(A) which means that the operator is exposed to the same risk of hearing damage as if the opera-

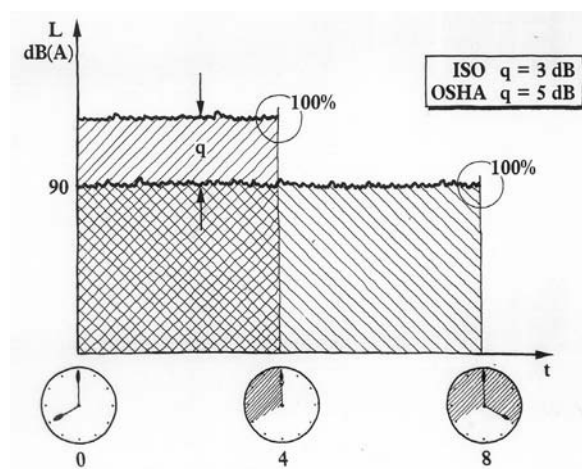


Figure 4.4.4. Halving rate.

tor had spent 8 hours in an environment with a noise level of 91 dB(A).

### Masking

The sound of interest to us normally occurs with several other sounds, usually referred to as background noise. This combination of sounds may impair or mask the reception of sound, especially the intelligibility of speech, if the frequency components of the background noise are

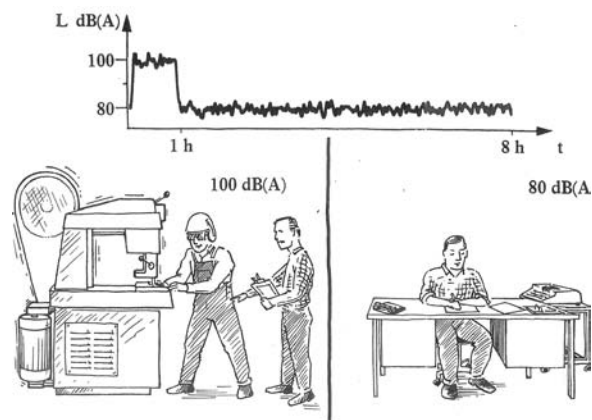


Figure 4.4.5. Example of  $L_{eq}$

sufficiently loud compared with the sound we want to hear. The following is an example of the “masking” phenomenon. If someone is exposed to a pure tone of 1000 Hz, the result will not only be a masking of any signal at 1000 Hz but a shift in the threshold of hearing for the whole range around 1000 Hz. This reduction in hearing ability may result in the loss of important information.

Masking is not solely restricted to pure tones but occurs with all types of noise, pure tone, narrow band, or wide band.

### Annoyance

Low-level sound can be annoying or disturbing even if it won't cause hearing damage. The level of annoyance depends not only on the quality of the sound but on our attitude towards it as illustrated in Figure 4.4.6. Some members of a theatre audience listening to a performance can have their enjoyment of the show destroyed by even a very low level of noise from another member of the audience.

## MEASUREMENTS

### Audiometry

Permanent hearing damage is mainly caused by excessive exposure to high noise levels. Audiometry is an important way to check whether dam-



Figure 4.4.6 Annoyance.

age has already occurred but should not replace work to reduce harmful noise levels.

The essential issue in the fight against noise induced hearing loss, is the assessment of exposure to noise. Hearing loss can occur immediately after exposure to extreme sound levels such as explosions, but more generally results from constant exposure to noise over a long period of time. Harmful noise levels do not always cause pain, so usually there is no immediate reaction or complaint from exposed workers. Unfortunately, by the time someone realises their hearing is severely impaired, it is too late to do anything about it.

If a workplace hearing protection programme is to be successful, it is important to know how noise levels are distributed throughout a work-site. Authorities often request a noise map from companies suspected to have excessive noise levels. The data for a noise map is obtained by the use of sound level meters.

Different noise sources emit sounds of varying frequencies but the total range of hearing is limited by the threshold of hearing and the threshold of pain. The normal range for music and speech extends from approximately 100 Hz

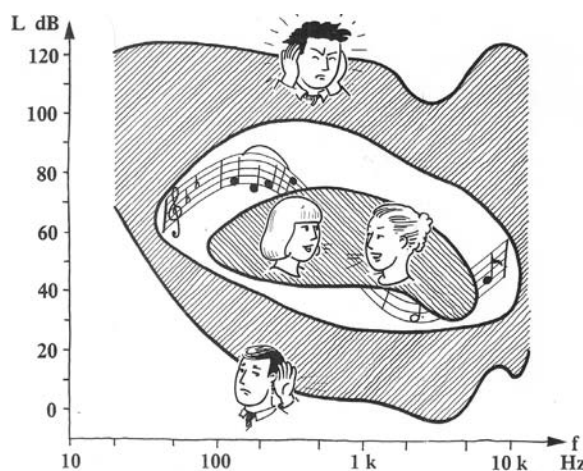


Figure 4.4.7. Hearing range.



to a few kHz. The range for normal speech has the shape of a “banana”.

The threshold of hearing shifts because of masking from background noise or hearing impairment. A part of the normal range of speech is cut off, which reduces the understanding of spoken information, see Figure 4.4.8.

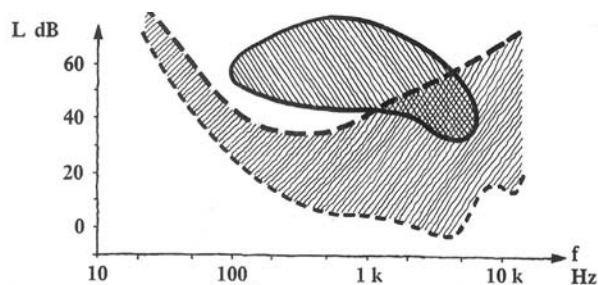


Figure 4.4.8. Shift of the threshold of hearing.

Figure 4.4.9 illustrates the way in which an audiogram is used to show hearing ability. A reduction in hearing is shown here as a downwards shift in the hearing level, where 0 dB hearing level, HL, corresponds to the hearing of young people with normal hearing. The normal range of speech is also included in the coordinate system used for recording the audiogram. The diagram clearly shows that a part of this range is cut off by a large shift in the threshold level.

A hearing test can be carried out with an audiometer which plots the audiogram directly. The person being tested is given a pair of earphones and a hand-operated switch. When the operator initiates the test, an increasing sound level at the first test frequency is first heard in the left ear and, as soon as the person hears the signal, they press the hand switch and the intensity of the sound will decrease while the switch is being pressed. By alternatively pressing and releasing the switch, the person being tested is able to maintain a sound level very close to their threshold of hearing.

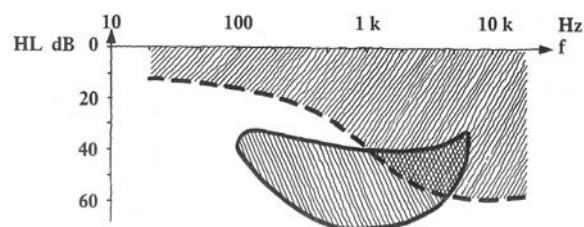


Figure 4.4.9. Principle of an audiogram.

The audiometer automatically records the levels during the test and the resulting audiogram shows the hearing ability of both ears, for different frequencies.

Periodic audiometric review will give early warning of hearing damage and indicate that measures to reduce noise should be implemented.

## Noise measurements

### Noise mapping

The preparation of a “noise map” is often one of the first steps taken for a noise abatement programme. A reasonably accurate sketch should show the relative positions of all machines and other items of interest. This map will immediately show which areas have excessive noise levels and provide a starting point for planning what steps need to be taken.

Noise measurements are the most important starting point when either planning noise control measures for existing plants or for estimating the noise levels of new plants being planned. Without existing measurements or predictions from existing measurements, objective decisions about the need or effectiveness of installed noise control measures cannot be made.

Because of the variety and number of characteristics related to noise and the corresponding large number of measurement and assessment techniques, great care is required when deciding which measurements to take and how to interpret them. The sound pressure level read on a

sound level meter doesn't always give sufficient information for judgements about whether there is a danger to hearing or for use as a basis for a noise control program.

Both experience and special training are required to be able to carry out measurements in complicated situations but in many cases a standardized sound level meter and relatively simple measurement methods are adequate.

There are many different reasons for carrying out noise measurements in industry. The most usual are:

- to determine whether noise levels are high enough to cause permanent hearing damage
- to establish a basis for noise control measures to be applied to machines and equipment
- to determine sound radiation from individual machines
- to ensure that noise levels do not disturb surrounding areas, e.g. in residential areas.

Measurement instruments and methods should comply with the appropriate standards applicable to the specific noise measurements to be carried out. These standards include requirements for instruments and methods used to measure noise from different types of machines and for assessment of the annoying and harmful effects of noise.

The most important international standards are those published by the International Standard Organisation (ISO). ISO is primarily concerned with measurement techniques, experimental conditions and measurement parameters. Many of these standards have been adopted as national standards by countries, (either directly or with minor changes).

#### Sound level meters

The sound level meter is an instrument designed to respond to sound in approximately the same way as the human ear in order to give objective, reproducible measurements of sound pressure levels. Many different sound measuring systems are available and although they differ in detail, all have a microphone, a processing system and a read-out unit. The signal from the microphone may pass through a weighting network, sensitive to various frequencies. There are three different internationally standardized characteristics identified as "A", "B", and "C" weightings.

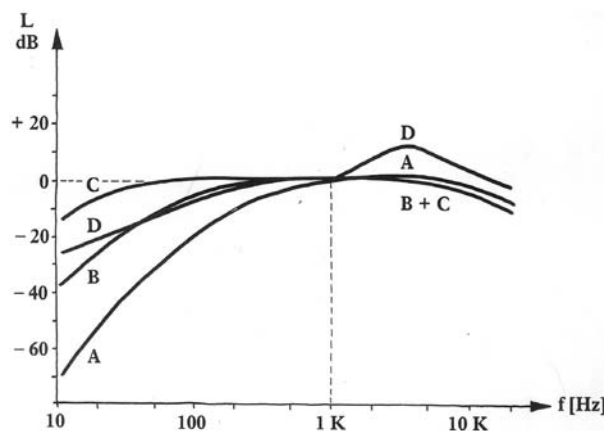


Figure 4.4.10. Frequency weighting filter.

There is also a specialized characteristic, the "D" weighting, standardised for measuring aircraft noise, see Figure 4.4.10.

The A-weighting curve is the most commonly used because it gives the best correlation between the measured values and the annoyance and harmfulness of the sound signal.

In addition to these weighting filters the sound level meter also has a "Lin", (linear), network that doesn't weight the signal but enables it to pass through unmodified.



*Time weighting*

Noise level fluctuates so it is necessary to reduce the fluctuations to give readings that can be followed. This is the reason why the sound level meter contains one or more internationally standardized time weightings or time constants. The most common time weightings are F (fast) and S (slow).

If the sound to be measured consists of isolated impulses or contains a high proportion of impact noise, the rise time of normal F and S time weightings of the sound level meter are not sufficiently short to give a meter indication representative of the subjective human response. A sound level meter with a standardized "I" (Impulse) characteristic is needed for such measurements. The "I" characteristic has a time constant which is short enough to enable detection and display of transient noise.

Although the perceived loudness of a sound of short duration is lower than that of steady, continuous sound, the risk of damage to hearing is not necessarily reduced. For this reason, some sound level meters include a circuit for measuring the peak value of the sound, independent of its duration.

A hold circuit is also incorporated into sound level meters to store either the peak value or the maximum RMS value. Some standards require the peak value to be measured while others ask for a measurement using the "I" time constant but the hold circuit makes it easy to read the measurement in either case.

*Octave band and third octave band*

When more detailed information about a sound is required, the frequency range from 20 Hz to 20 kHz can be divided up into sections or bands through the use of electronic filters that reject all sound with frequencies outside the selected band. These bands usually have a bandwidth of

either one octave or one third of an octave. The audible region is divided into 10 octave bands whose centre frequencies and bandwidth are defined in accordance with international standards. The centre frequencies of each consecutive octave band are twice the centre frequency of the previous one, e.g. 125 Hz, 250 Hz, 500 Hz, etc. The upper frequency of each octave band is twice the lower frequency. The octave bands are usually referred to by their centre frequencies.

The illustration shows the spectrogram for a noise signal measured with very narrow filters, 1/3 octave filters and octave filters.

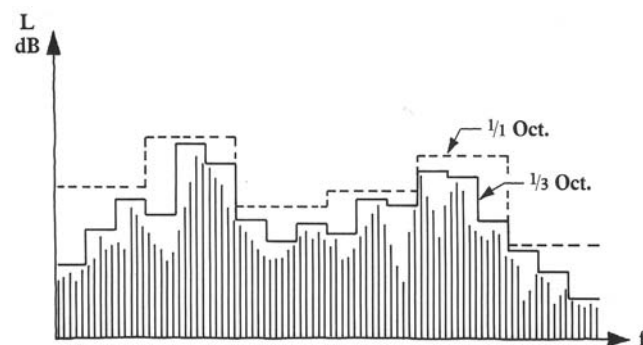


Figure 4.4.11. Noise spectrogram.

Figure 4.4.12 shows a noise measured in octave band. The left part shows an unweighted spectrogram of the noise and the right shows an A-weighted spectrogram of the same noise. The column to the right of each diagram represents the dB(A) value.

The spectrogram shows the level measured for each frequency band plotted as a horizontal line representing the level within the band. However, this does not mean that there will be frequency components at all frequencies within the band. The level measured with a filter will be equal to the sum of the levels of the individual frequency components within the bandwidth of the filter.

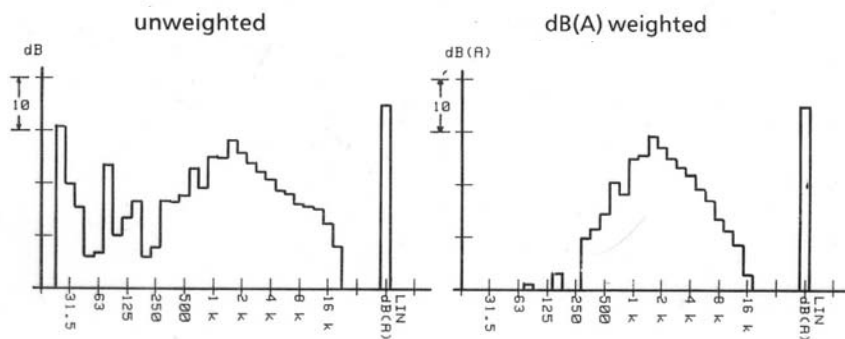


Figure 4.4.12.  
Unweighted and dB(A)  
weighted spectrogram.

### Noise Rating curves

It is necessary to evaluate the annoyance value of the noise in almost any noise abatement programme, particularly when the measured dB(A) values are above an allowable limit. Octave or third octave band frequency analyses must first be obtained for this purpose. Several methods for determining the level of annoyance are recommended in various standards. The simplest method is the use of noise rating (NR) curves given in an ISO standard. The NR curves are used by plotting the octave band noise spectrogram over them. It can then be seen which NR curve lies just above the spectrogram and the noise is then assigned that particular NR number. In the example in Figure 4.4.13 it is NR 78.

The shape of the curves shows that much more importance is given to the higher frequencies than the lower ones because high frequency sounds are more annoying than lower frequency sounds.

### Noise measurement procedure

The ideal way to fight noise problems is to locate the noise sources and reduce the noise emitted. While it can be easy to identify machinery that emits noise in an industrial environment, it can be much more difficult to pinpoint exactly where the noise is generated from, particularly when trying to measure the noise level in a factory building. The sound levels in a factory

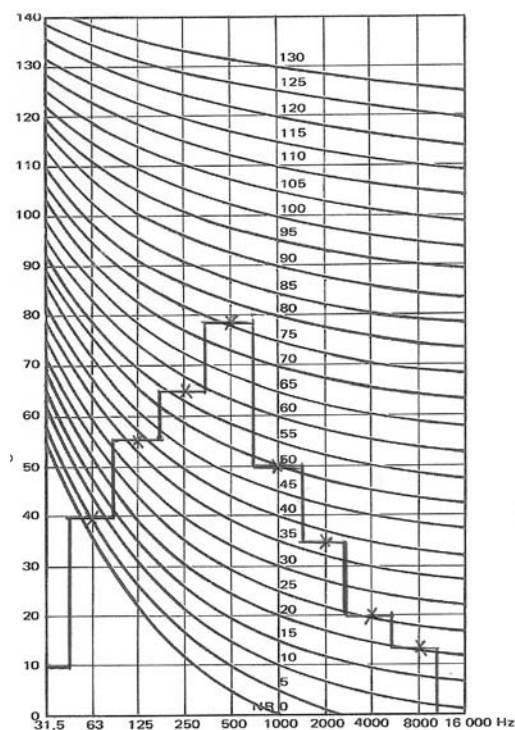


Figure 4.4.13. Noise rating curves  
with noise spectrogram.

space do not depend solely on the noise emitted from machinery and manufacturing processes but largely depend on the acoustic properties of the building. The essential parameter is the reverberation time. The problem in factory buildings is the very long reverberation time. Concrete floors and large surfaces, (walls and roof), cause sound to linger as they have very little damping ability. Noisy machinery placed close to reflecting walls, or in corners, can result in excessive sound levels throughout a plant. The same machinery may not cause the same problems in a factory with better acoustic properties because the noise levels will only be high close to the source.

Spatial decay describes the way in which a constant level from a sound source propagates. Noise decays very slowly with distance in a factory building with hard, sound reflecting floors, ceilings and walls. A noisy machine at one end of a factory can produce deafening noise levels at the other end of the building.

The purpose of noise measurement is the provision of reliable, accurate and thorough measurements which are dependable and accurately describe the noise situation. To ensure dependability and accuracy, the following procedure is recommended:

- Always calibrate all instrumentation before and (preferably) after measurements.
- Record the instrumentation used and note reference numbers.
- Make a sketch of the position of noise sources, measurement position and local reflecting surfaces which may affect measurements.
- When working outdoors, note the meteorological condition, especially wind direction and strength, temperature, and humidity.
- Check the background noise level to ensure that it is sufficiently below the measurements being taken or correct if necessary, see Figure 4.4.14.

- Carry out the measurements noting down relevant equipment settings such as A-weighting, etc.
- Keep a log, noting changes made to equipment settings, unusual occurrences, and make notes where relevant.

Valid measurements require the noise from unwanted sources, (i.e. background noise), to be at least 10 dB below the level of the noise emitted by the source being measured. If this is the case, the measurement is accurate to within 0.5 dB. The background noise must always be checked before measurements are made. If the difference between the measured noise source and the background noise (measured separately), lies between 3 and 10 dB, a correction may be made using the following diagram, see Figure 4.4.14. If this difference is less than 3 dB, the measured noise source level is less than the background noise level and a reliable and separate value for the noise source cannot be obtained.

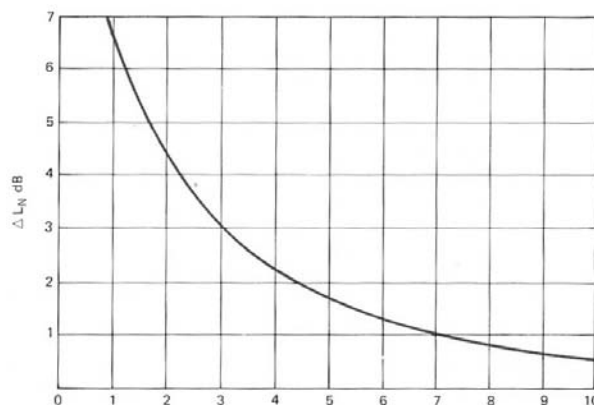


Figure 4.4.14. Background noise, correction curve.

The x-axis shows the difference in dB between a measured noise source, measured in presence of background noise, ( $L_{S+B}$ ) and the background noise, ( $L_B$ ). The y-axis shows  $\Delta L$  which must be

subtracted from the noise source measured in the presence of background noise.

### **PROGRAMMES TO ELIMINATE OR REDUCE NOISE**

It is important to state that noise exposure can be controlled, no matter what the noise problems may be. The best opportunity to achieve a working environment with low, non-hazardous noise levels is during the planning stage for a building or workshop and when purchasing new machinery. In the early stages of planning, important details about the acoustics of a building can be calculated. The possibilities to influence the design and layout of a workshop are also good at this time. The purchase of new machinery also offers the opportunity to achieve quieter production and material handling.

There are many ways to implement noise control projects in factories but there are (at least) three main ways to reduce noise.

1. Reduce the noise at the source, e.g. with enclosures.
2. Prevent or reduce sound propagation, e.g. through the use of sound absorbent materials.
3. Changing work or technology e.g. quieter methods of work or new production technology.

If attempts to reduce noise levels using the above methods are not sufficient, it will be necessary to protect workers in other ways, e.g. by building monitoring rooms or through the use of personal protective equipment such as ear muffs.

It is important to ask why any noise control project is being carried out. There are a number of relevant motivations including the protection of workers from excessive noise, the need to reduce noise being transmitted to a community surrounding an industrial site or because there

are potential economic advantages from reducing noise.

For work areas with a particularly severe noise problem, it may be advantageous to attack the problem in a number of stages. By systematically mapping the existing noise situation, a good picture can be obtained. Noise often comes from a number of sources and background noise is frequently found to significantly contribute to the total noise level. Noise levels for each machine and working process need to be measured separately in order that informed decisions about individual noise control measures are to be made. The work processes and machines that produce the highest noise levels should be noted.

When attempting to reduce noise, consideration must always be given to the fact that most noise sources simultaneously produce both airborne and structure borne noise. Most situations need a number of noise control techniques to be applied.

It is necessary to determine the individual sound level at each frequency in order to determine the degree of hazard from noise exposure and to decide on the correct remedial measure. To determine this level, the sound signal is sent through a filter that only allows passage of either a single frequency or a narrow band of frequencies. The amplitude of the filtered signal is a measure of the sound level at that particular frequency or frequency band.

While the technology to reduce noise exists, in some cases the necessary measures are expensive and complicated. A noise control project should result in the elimination or reduction of noise without increasing production costs. As noise problems are often closely related to other production deficiencies, the solution of noise problems may also result in increased production and economic benefits.

### Noise control in the planning stage

#### *Noise control in new projects*

There are valuable possibilities for the achievement of good acoustical conditions when planning new projects. It is usually possible to reduce the noise generation from machinery and processes in new plants through the use of known control techniques. Compared with older plants, it is easier to control noise in new plants but acoustic problems should be considered from the earliest planning stage of a new building.

When choosing new machinery, equipment, or material handling methods, consideration must be given to the potential noise disturbance. Persistent efforts should be made to change to quieter processes and working methods through the introduction of more remote control so workers can spend part of the working day in relatively quiet control and operation rooms.

#### *Planning a building*

Important details of the load-bearing structure and work areas of a building should be calculated and fixed early in the planning stage. These details are important for the acoustics of a building as the need for noise control depends first and foremost on the design and layout of a production plant. The structural design of a building frequently depends on the placement of machinery and the need for insulation against airborne and structure borne sound. There are some important guidelines:

1. Load-bearing structures, floors and machine foundations in a building should effectively isolate all noise and vibration sources.
2. Powerful noise sources should be enclosed by structures which adequately isolate airborne sound.
3. Rooms with sound sources or where personnel are present should be provided with cladding to absorb the incident sound.

4. Office areas should be separated by a joint of elastic material from building elements where vibrating equipment is installed.
5. Walls and ceiling construction, windows, and doors should be chosen so the required sound insulation is achieved.
6. Avoid mounting noisy equipment on light or movable partitions.

#### *Noise reduction measures in rooms*

The shape and size of an industrial workshop is largely determined by the production processes and flow of materials. The best possibilities to influence the design and layout of a workshop are in the early stages of planning but unfortunately, work environment questions are seldom discussed during this phase.

Some suggested guidelines on the layout of a new plant include:

1. Workstations and machines should be placed in a way that exploits the reduction of noise through distance.
2. Ensure that particularly noisy machines are installed in separate areas.
3. Quiet work or work requiring a quiet working environment, should be removed to a low noise area.
4. If noisy work is carried out close to a wall or another reflecting surface, the wall or surface should be covered with absorbent material.
5. Workshop offices, rest rooms, etc., should be provided with sufficient sound insulation.
6. Fixed installations such as ventilation equipment or cooling systems should be constructed with sound attenuation and mounted so that sound from fans, etc, is prevented from spreading via ducts, pipes and the building structure.



### *Purchase and installation of machinery*

Whenever new machinery is purchased, quieter production and material handling must be considered. Suppliers should state the sound levels produced by new equipment and indicate the feasibility of further noise reduction.

### **Reducing noise at source**

#### *Maintenance*

Before starting a noise reduction project it is necessary to investigate whether maintenance of machinery is properly carried out. Lack of maintenance can cause impact and rattle between machine parts. Periodic inspection and effective maintenance of machines will reduce the noise at source and prevent unnecessary noise radiation.

Information on the measures needed to maintain and install machines is useful when choosing the most cost-effective noise control measure. Individual noise control projects should be described as noise often comes from a large number of sources. It is important to define the noise level emitted by each part of any equipment or machinery. Any noise control project should start with work on the source of the highest noise level.

If the work process itself causes high noise levels and alteration or enclosure of machines is not successful in reducing noise to a safe level, changes to the work process might be preferable.

The following example illustrates the importance of finding the source of the highest noise levels. If two noise sources emit 90 dB and 100 dB respectively, the total noise level is approximately 100 dB. If the source of the 90 dB noise is reduced to 70 dB the total noise level is still approximately 100 dB, see Figure 4.4.15.

If the contribution from two sources differs, the total sound pressure level can be found by converting the individual dB values to linear values, adding them and converting back to dB.

An easier method is to use this simple curve for the addition of dB levels.

If there are two noise sources,  $L_1 = 55$  dB and  $L_2 = 51$  dB, find the total noise level from both sources. The difference between the sources is  $\Delta L = 4$  dB. Using the curve in Figure 4.4.15, the  $L_+$  axis shows approximately 1.5 dB, which is then added to the highest level of the two sources. The total noise level from the two sources is  $55 \text{ dB} + 1.5 \text{ dB} = 56.5$  dB.

Note that a difference of  $\Delta = 0$  corresponds to the situation of two equal sound sources and 3 dB is added to the level caused by one source alone. In other words, if the noise is doubled, the total noise level will rise by 3 dB. On the other hand, if noise control measures successfully reduce the noise by 50 per cent, the total noise level is only reduced by 3 dB.

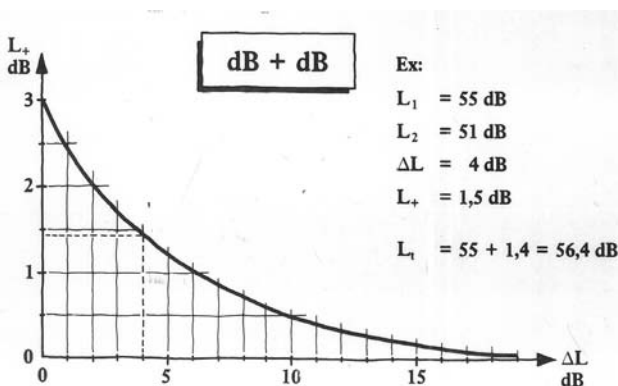


Figure 4.4.15. Addition of dB-levels.

#### *Machines*

Noise sources in machines or parts of machines need to be identified if they are to be controlled. It is important to avoid or reduce impact and rattles between machine components, e.g. by exchanging metal components with quieter plastic parts. Another measure is the enclosure or screening of particularly noisy components or processes. Reduction of noise radiation from



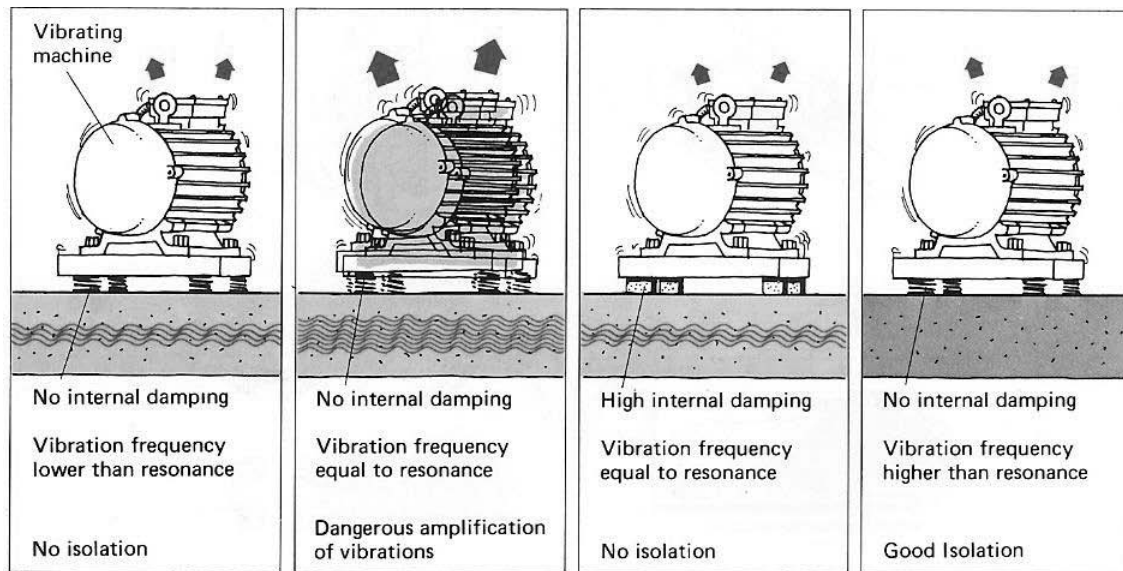


Fig 4.4.16. Vibration damping.

machines, equipment or materials handling is frequently achieved by the use of sound absorbing panels and silencers on air outlets.

Machines should be isolated so that vibrations that enter the structure and cause structure borne sound are reduced. These vibrations can be significantly reduced if a machine is mounted on flexible supports or placed on a concrete base separate from the rest of the building.

Any machine mounted on a flexible support always has a characteristic resonant frequency determined by the weight of the machine and the rigidity of the mountings. Vibrations produced by the machine at lower frequencies than its mounted resonant frequencies, are not isolated. However, vibrations at frequencies close to the resonant frequency are greatly amplified. Vibrations at higher frequencies than the resonant frequency are isolated.

It is clearly important to select the correct type of isolators.

The four examples in the figure have the same fundamental frequency. If the machine base is very heavy or very rigid, the fundamental frequency is determined entirely by the machine and base weights together with the rigidity of the spring. The lighter the machine and the more rigid the spring, the higher is the fundamental frequency.

#### *Enclosure of machines*

If it is not possible to prevent or reduce noise at source, it may be necessary to enclose all or part of the machine. For enclosure to be satisfactory it is necessary to:

- Use sealed material, e.g. metal panels for the outer surfaces
- Provide the inner surfaces with a sound absorbing material
- Mount noise attenuators on any openings for cooling air
- Fit easily opened doors for inspections or maintenance.

The following example, Figure 4.4.17, illustrates the effect of an enclosure, step by step.

A machine is mounted on a concrete floor. The diagram to the left shows the noise level measured in octave bands. The y-axis shows the noise level in dB within each octave band.

The first remedial measure (Figure 4.4.17b) is to mount the machine on vibration dampers to stop structure borne sound. The diagram shows a small reduction in the low frequency bands.

Figure 4.4.17c shows the noise reduction if an enclosure is built around the machine.

The last step shows the combined effect of vibration dampers and enclosure.

The installation and purchase of new equipment opens possibilities to install quieter components, machine parts, and electric motors. Another preventive measure to reduce noise is to ensure that cover panels on machines are rigid and well damped.

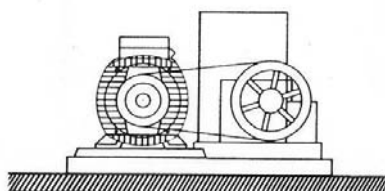
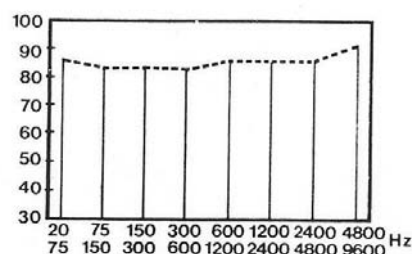


Figure 4.4.17a.  
Machine mounted on the floor.

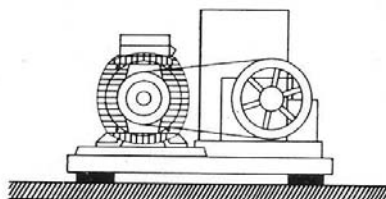
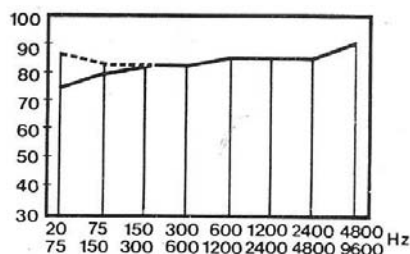


Figure 4.4.17b.  
Machine mounted on vibration dampers.

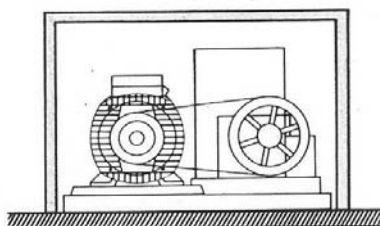
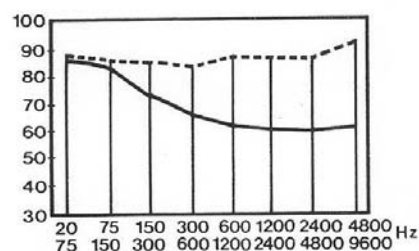


Figure 4.4.17c.  
Machine on the floor with an enclosure.

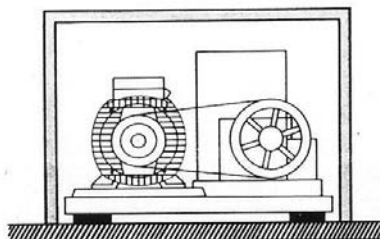
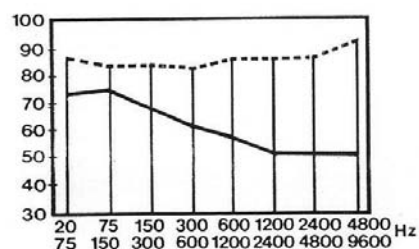


Figure 4.3.17d.  
Machine mounted on vibration dampers and with an enclosure.

### Materials handling

Materials handling is often a very noisy activity. Impacts between materials and parts cause very high noise peaks. Existing plants can be changed to avoid impacts between materials during manual or mechanical handling and transport by:

- Minimizing the drop height for items collected in bins or containers
- Increasing the rigidity of panels that materials strike.

When new transportation equipment is purchased, consideration should be given to equipment which:

- Transports material on conveyor belts rather than rollers
- Controls the speed of conveyor belts.

The influence of drop height on noise level is illustrated in Figure 4.4.19. The diagram shows both calculated and measured values when steel

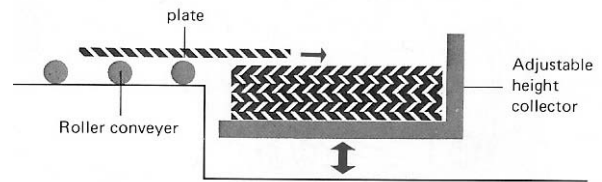


Figure 4.4.18. Materials handling.

tubes fall into a bin. When the drop height is 0.8 meters, the sound level is 130 dB. When the drop height is reduced to 0.2 meters, the sound level is 115 dB. To reduce the noise level below 110 dB, the drop height must be reduced to a value less than 0.05 meters.

### Preventing or reducing sound propagation

The total noise level in a workplace is mainly compromised of a small number of intense noise sources. Those people working with quieter equipment are unnecessarily disturbed by noise from other sources.

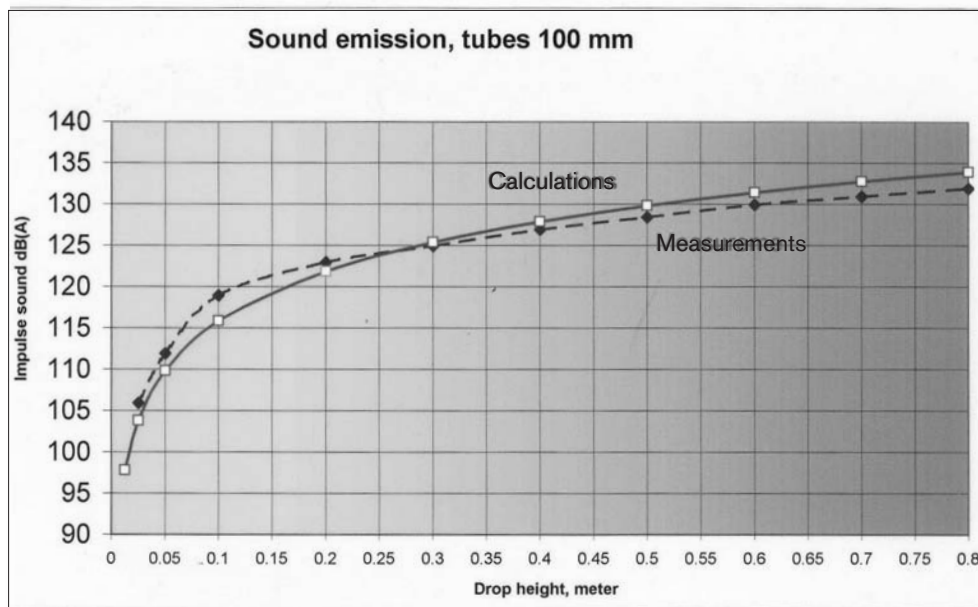


Figure 4.4.19. Drop height.

### Attenuation by distance

Sound that propagates from a point source in free air, attenuates by 6 dB for each doubling of the distance from the noise source, however, sound which is propagated inside a building is attenuated to a lesser value because of contributions to the total sound level from reverberant sound reflected from walls and ceilings.

A small sound source, i.e. a point source that radiates freely into free air, produces 90 dB at one metre. The sound level at 2 metres will be 84 dB, at 4 metres 78 dB, etc.

### Reverberation time $T$

An important characteristic affecting the acoustic environment of a room is the reverberation time, i.e. the time that a sound lingers within a room after the original sound source has ceased to generate. Sabine's original definition: the reverberation time is the time taken for a steady sound pressure level within a room to decay by 60 dB, measured from the instant the sound source is stopped. The relationship between the reverberation time and the absorption of a room is given by Sabine's equation. Varying either the volume,  $V$ , or the absorption,  $A$ , can alter  $T$ . ( $A = \alpha_1 S_1 + \alpha_2 S_2 + \dots + \alpha_6 S_6$ , and  $\alpha_i$  is the absorption factor for each area). Reverberation time is of special interest for noise control projects in workplaces.

$$T = 0,163 \frac{V}{A}$$

Figure 4.4.20. Sabine's formula.

### Sound absorption and absorbents

Sound energy is absorbed whenever sound meets a porous material. One part of the sound wave will be reflected back, another part will be absorbed in the material and another part will pass through the material. The ratio of the sound energy absorbed to the sound energy incident is

known as the absorption coefficient,  $\alpha$ . Porous materials intended to absorb sound are called absorbents, and usually absorb 50 to 90 per cent of the incident sound energy, depending on its frequency. In a room with large amounts of absorbent material the sound level reduces steadily with distance from a sound source. If a room is acoustically hard, i.e. with insufficient absorption, the overall sound level can be just as high anywhere in the room as in the vicinity of the sound source.

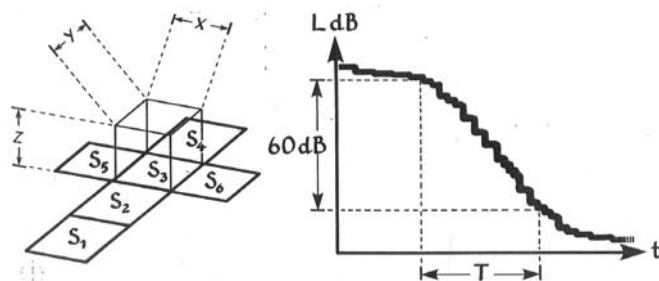


Figure 4.4.21. Reverberation time.

### Attenuation by using absorbents

In a workplace with hard materials on the ceiling, floor and walls, nearly all the sound which reaches these surfaces is reflected back. The diagram in Figure 4.4.22 shows how the sound level from a machine first falls relatively quickly and then remains more or less unchanged as you move away from the noise source. This occurs because the noise level close to the machine falls approximately as if it were in a free field, but at a certain distance the reverberant noise level in the room becomes more intense and dominant than the direct sound from the single noise source. In such circumstances the noise environment can be improved if the ceiling is covered with sound absorbing materials that will not reduce the noise level at the operator's workstation but will reduce the noise level in the rest of the workshop. The reduction depends on the

distance from the sound source. Figure 4.4.22 shows the sound pressure level at different distances from a source in a room without absorption and then in the same room after a large area of absorbent material has been mounted on the ceiling.

### Reverberation

Sound energy reflected back into a room creates a reverberant sound field. The sound pressure

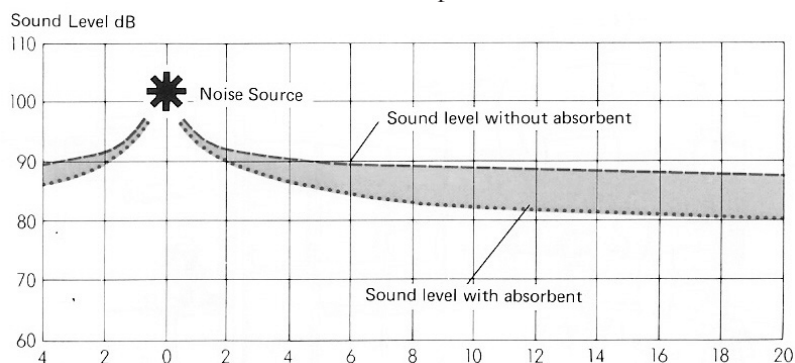


Figure 4.4.22. Attenuation by the use of absorbents. The x-axis shows the distance from the source.

level measured, (or heard), at a specific distance from the source, results partly from direct sound and partly from reverberant sound. The less reverberant a room is, the more one has to move away from the source before entering the region dominated by the reverberant field.

The distance from the noise source can be read in meters, (m), on the x-axis and the noise level in dB on the y-axis, see Figure 4.4.23. The diagram also shows that the noise level closest to the noise source will decrease by 6 dB when the distance to the source is doubled. Far away from the noise source the value will be the same even if the distance to the source is increased. The breakpoint is determined by the amount of absorbent material in the room.

The calculated sound level is shown in the formula in the box.

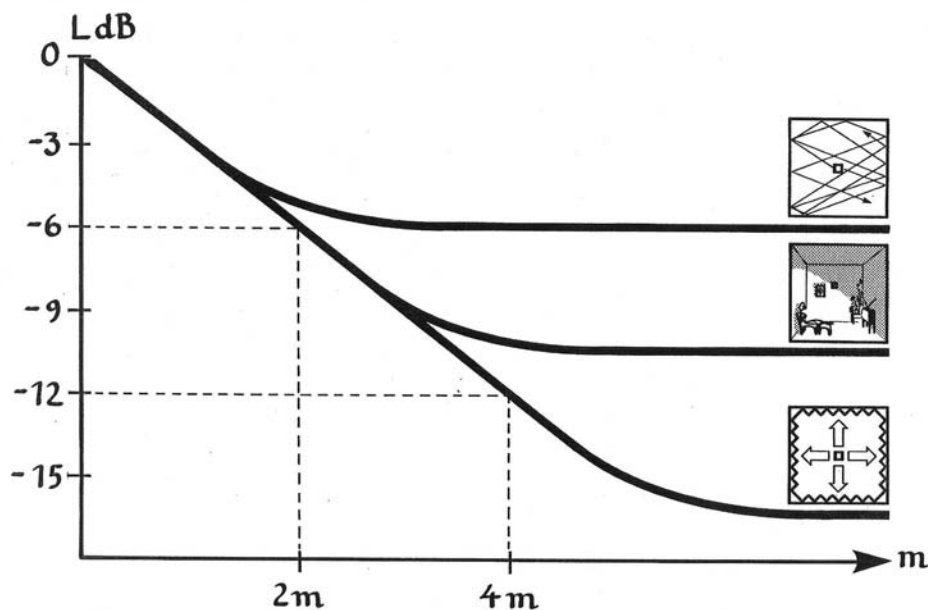


Figure 4.4.23. Reverberation.



An analysis of the diagram on "Reverberation" shows two extremes (the upper and lower figure in the diagram). The first is a room with very high absorption where the absorption will approach unity. The second is a very hard room where the absorption will approach zero.

Both these extremes are used in laboratories (anechoic and reverberation chambers) but in practice most rooms fall between these extremes (the middle figure in the diagram), which makes it difficult to find a correct measuring position. It is normal to divide the area around a noise source into four parts: A: near field, B: far field, C: free field, D: reverberant field. The dimension of each part depends on the absorption in the room. In area C the sound attenuates by 6 dB for each doubling of the distance from the noise source, see Figure 4.4.24.

If noise sources are screened or enclosed, the noise level is reduced in areas A and B (near field and far field).

#### *Sound insulation and sound reduction coefficient*

When a sound meets a wall or partition, a small proportion of the sound energy passes through, a proportion of the sound is reflected and a proportion is transformed into heat, i.e. absorbed.

$$L_p = L_w + 10 \log \left\{ \frac{\Gamma}{4\pi r^2} + \frac{4(1-\alpha_m)}{S \cdot \alpha_m} \right\}$$

$L_w$  = sound power, dB

$r$  = distance to the source, m

$S$  = total area of the walls,  $m^2$

$\alpha_m$  = mean value of absorption coefficient

$\Gamma$  = 1 if the sound source is a point source radiating energy in all directions

$\Gamma$  = 2 if the sound source is close to a single reflecting plane

$\Gamma$  = 4 if the sound source is close to two reflecting planes

$\Gamma$  = 8 if the sound source is close to three reflecting planes, (corner)

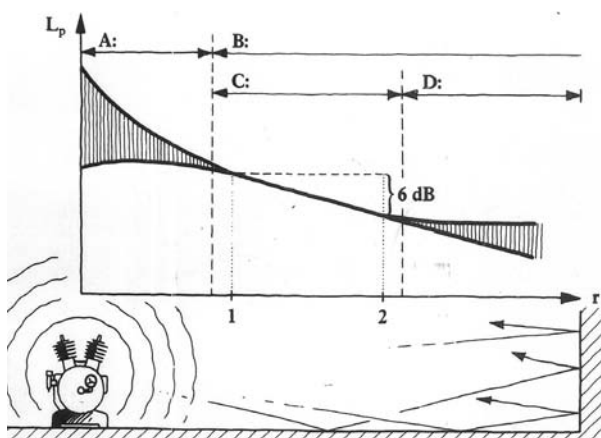


Figure 4.4.24. Workshop.

The sound reduction coefficient, (sound insulation), of the wall determines what proportion of the incident sound is transmitted.

A wall with 10 dB insulation allows 10 per cent of the sound energy to pass through, (20 dB corresponds to 1 per cent, 30 dB corresponds to 0.1 per cent, etc). The sound insulation ability of a partition separating two rooms is called the sound reduction coefficient and is expressed in dB.

(Material characteristics are described in a number of handbooks on sound insulation materials).

#### *Attenuation through the use of screens*

It is important to know the wavelength of a sound when investigating the effect of a screen placed in the sound field. The rule says "an object which is much bigger than the wavelength will have a screening effect on the propagated sound, whereas an object which is smaller than the wavelength will have little or no effect".



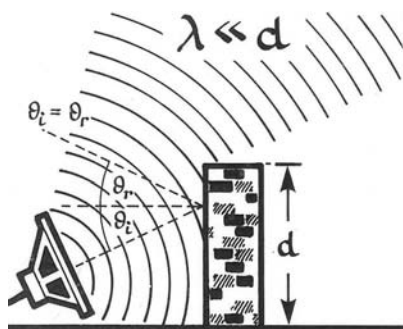
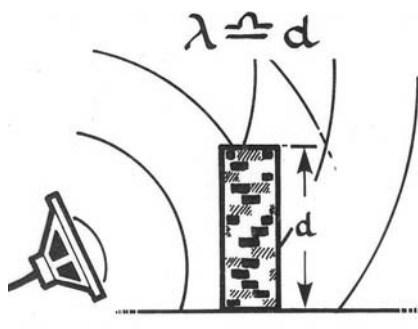
Figure 4.3.25a. Screen,  $\lambda \ll d$ .Figure 4.4.25b. Screen,  $\lambda \approx d$ .

Figure 4.4.25 shows the screening effect when the wavelength,  $\lambda$ , is much smaller than the screen,  $d$ , (see a), and when the wavelength is approximately of the same order as the screen, (see b).

Similarly, the sound field at the other side of a “leak” in a wall or a screen will be modified, see Figure 4.4.26. If the diameter of the hole is smaller than the wavelength, the sound field on the other side of the hole will be similar to the sound field from a point source with the hole as a source. On the other hand, if the diameter of the hole is bigger than the wavelength, a beam of the original sound field will pass through the hole. In both cases the field behind the screen will be heavily attenuated.

Figures 4.4.25 and 4.4.26 (screen and leak) are examples of diffraction, a characteristic of all wave motions. Diffraction is of special importance when attempting to prevent noise propagation or when building an enclosure.

#### *Structure borne sound*

A typical cause of vibration within a machine is clatter from loose bolts and screws. In this case it is relatively easy to reduce the structure borne noise by repairing the machine, however, it is more difficult to reduce vibration emanat-

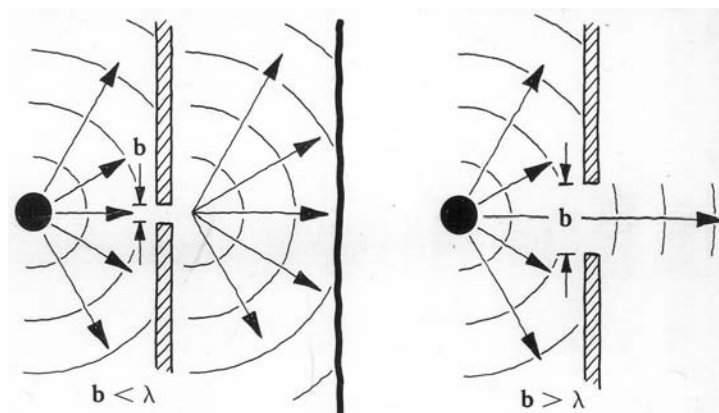


Figure 4.4.26. Leak.

ing from a working machine in good condition. Structure borne sound can often be reduced by preventing the transmission of vibration from a machine to the load bearing structure of a building. The following principles can be applied to prevent this transmission:

- Isolate the floor from the machine by placing the machine on a stable foundation with an elastic separating layer, e.g. on rubber or steel springs.
- Place large, heavy machines on special machine foundations completely separated from the building.
- Isolate vibrating machine panels wherever possible to minimise radiation of structure borne sound.

Heavy, vibrating machines require separate foundations and isolation joints between floor slabs to prevent the propagation of structure borne noise. In this case, two joints are used for more effective separation.

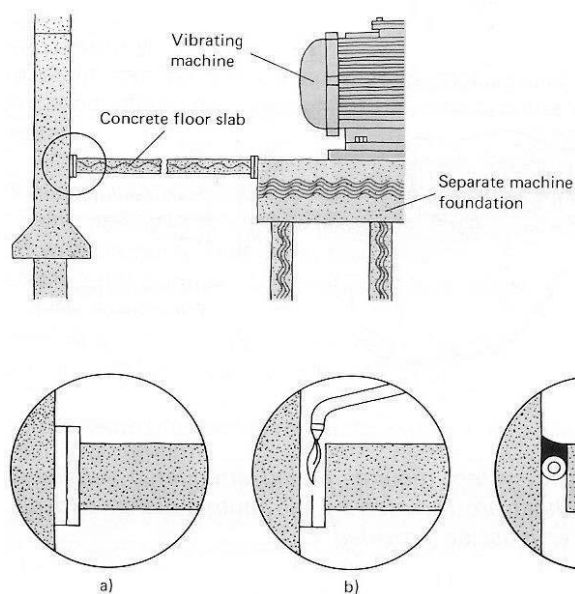


Figure 4.3.27 illustrates three steps to attenuate structure borne sound.

- a. before the floor is cast, a thick strip of foamed plastic is placed in all the joints between the floor and the rest of the building structure.
- b. after the floor has been cast, the foam is pulled or burnt out and the joint inspected and cleaned out (if necessary). There must be no connections between the two structures.
- c. the joint is then filled with a flexible material and sealed completely with a high density elastic material.

### Changing work or technology

In many cases, the only way to achieve an acceptable, low noise level is to change the method of work. This often requires a replacement of all or part of the production equipment. Examples of such measures are:

- changing the pump in hydraulic equipment
- replacement of noisy compressed air nozzles with quieter types

Figure 4.4.27.  
Attenuation of structure borne sound.

- mounting of attenuators in gas and air outlets
- alteration of equipment to avoid impact
- changes to machines to reduce noise generation
- provision of ventilation ducts with sound attenuators
- changes of mountings of fans in ducts to minimize turbulence

#### *Alteration of equipment to avoid impacts*

Two examples illustrate how equipment can be altered to reduce the noise level. Many manufacturing processes collect items in different bins.

The first example, Figure 4.4.28a, shows how equipment can be altered to avoid impact when manufactured items fall into a collection bin. When the bin is empty, the fall height is large and the noise level is high, (see the comparison of drop height in the section on materials handling). If the conveyor is constructed in a way that allows adjustment of the drop height and if it is fitted with rubber flaps on the inside of the collection bin, the drop height can be minimized and the noise level reduced. The conveyor rises automatically as the bin fills, Figure 4.4.28b. Figure 4.4.29a shows a material bin with welded panels which cause very high noise levels when items are collected in the bin. Figure 4.3.29b illustrates an example of another solution to a noise problem, a bin where the side panels can

be fixed to the edge of the frame with narrow brackets which reduces noise. The side panels can also be made of wire mesh to further reduce noise (if the size of the items allows).

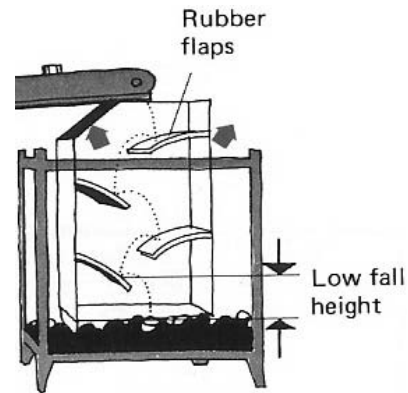


Figure 4.4.28b. Low fall height.

In addition to the above measures, another way to reduce noise levels is through the development and construction of new technical solutions. Such solutions boost competence and awareness of the interaction between the work environment and financial matters on the part of management, designers, planners and operators.

The development of new technical solutions is often a difficult and expensive option, however, this focus may reduce noise levels and also

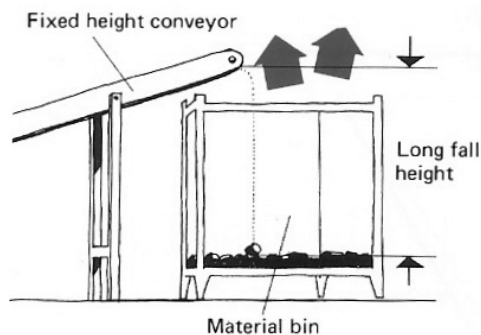


Figure 4.4.28a. Long fall height.

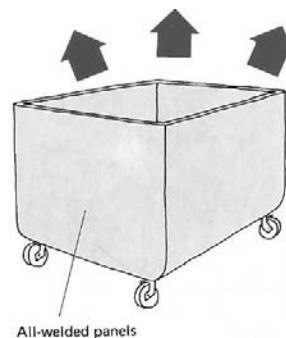


Figure 4.4.29a. Old material bin.

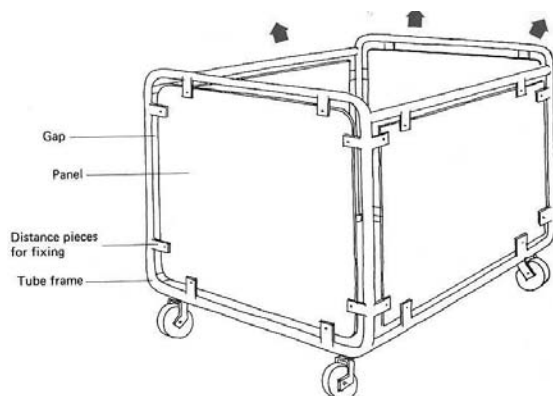


Figure 4.4.29b. New material bin.

improve company finances. The results of many case studies show that in addition to improved noise levels, other work environment hazards such as physical workloads and accident risks are reduced with new technical solutions. Case studies also show that financial improvements may result from a reduction in the number of rejects, higher productivity and improved product quality.

*Changes of mounting of fans in ducts to minimize turbulence*

The following example illustrates fan noise and how to control it. Fans generate turbulence that radiates noise. Existing turbulence in incoming air is made worse by the fan and the noise is amplified. If there is sufficient distance between the source of turbulence and the fan, the turbulence has a chance to die down and the noise level is reduced. Fans should be placed well downstream of obstacles, corners, and changes of cross section.

In Figure 4.4.30a the airstream is undisturbed with only minor turbulence formed after the fan. In Figure 4.4.30b the airstream is disturbed with major turbulence and a high noise level after the fan.

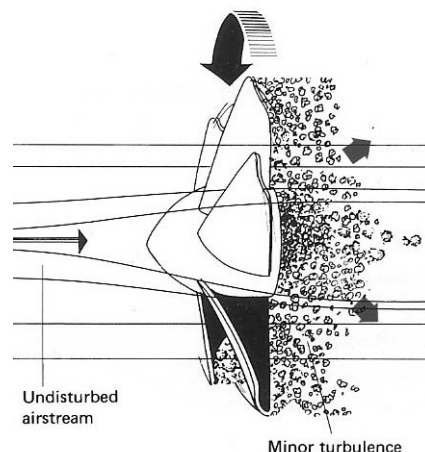


Figure 4.4.30a. Undisturbed airstream.

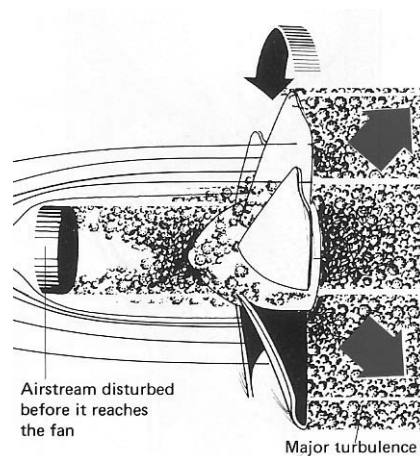


Figure 4.4.30b. Disturbed airstream.

Figure 4.4.31 gives some guidelines for mounting fans in ducts. In the top of 4.4.31a the fan is too close to an obstacle and in the bottom part, the fan is too close to a bend. Both situations form air disturbances which cause increased noise after passing through the fan.

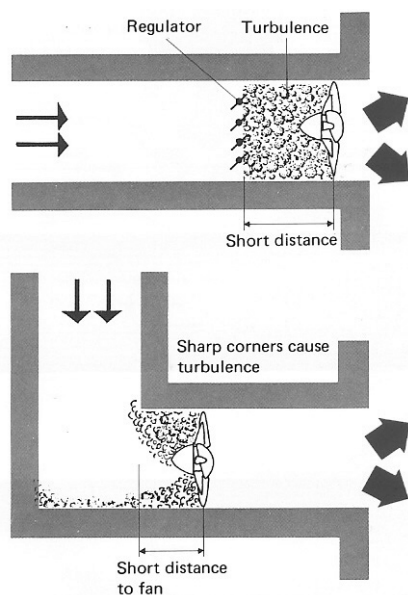


Figure 4.4.31a. Fans with high noise level.

Figure 4.4.31b shows a solution to the noise problems pictured in Figure 4.4.31a. In the first case, the regulator is moved further from the fan so that the turbulence has a greater distance in which to settle down. In the second case, the bend is made gentler to reduce the strength of the turbulence. The fan has also been moved further downstream to increase the settling distance.

### Protection of exposed workers

Persons exposed to continuous noise levels above the statutory limit, should undergo regular audiometric checkups. The simplest way to protect workers from noise induced hearing

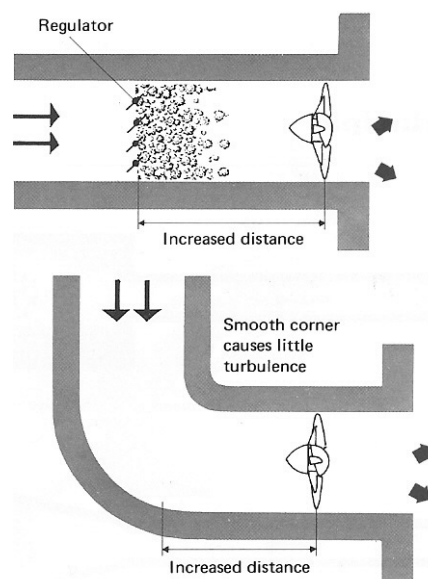


Figure 4.4.31b. Fans with low noise level.

damage is to provide them with hearing protectors. Two types of hearing protectors are available: ear plugs made of fine mineral fibres, silicone or plastic, or earmuffs, which completely enclose the ear and fit closely to the side of the head.

The effectiveness of ear protectors varies with type and manufacturer. Manufacturers have information on the typical values of the attenuation at different frequencies. It is important to check various manufacturers' specifications before choosing a particular type of ear protector.

Areas where the use of ear protectors is obligatory must be clearly marked and people working in these areas informed about the consequences of ignoring the directives.

Industry developments are increasingly directed towards automation of machines and processes. Automation allows remote control from a control room which makes it possible to limit the noise exposure of machine operators and process controllers, to shorter periods



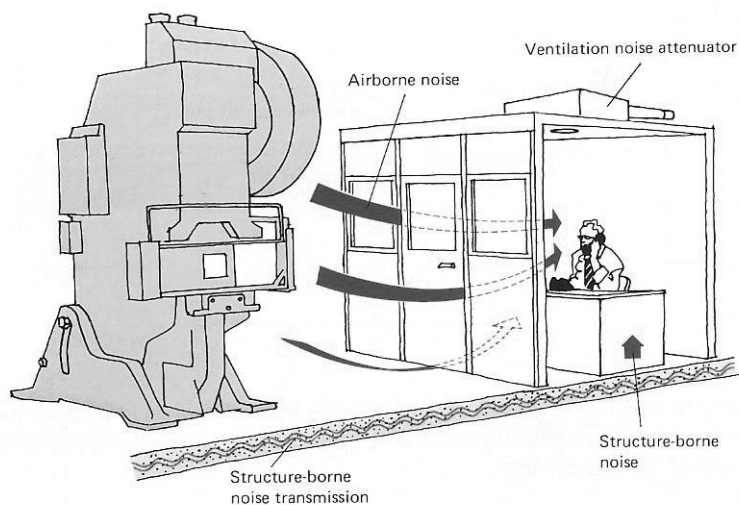


Figure 4.4.32. Control room.

required to service, repair and maintain machines. To reduce the noise exposure time a few important rules of thumb are:

- Build control rooms with good sound insulation properties.
- Choose door and window designs with effective seals.
- Provide ventilation openings with attenuators and ensure that cable cut-outs are properly filled with suitable acoustic sealants.

Noise problems in control rooms and workshop offices can be caused by direct airborne sound, (e.g. caused by gaps around doors), or from the transmission of structure borne sound.

#### PRACTICAL NOISE ABATEMENT MEASURES

To conclude, a number of practical examples of noise abatement measures are given for some specific situations. The examples are:

- air compressor, a low frequency noise source
- workplace, with a high frequency noise source
- machine tool, different types of airborne and structure borne sound sources

- hydraulic system, a noise source which needs an enclosure
- elevator, vibrations that enters a structure
- pipe mounting, vibrations from small objects
- vibrating panels, protective cover which give high noise levels
- machine mounting, low frequency vibrations
- industrial workshop, a variety of noise problems

#### Air compressor

Compressors with interior diesel engines produce strong low frequency noise. Low frequency noise radiates at the same level in all directions

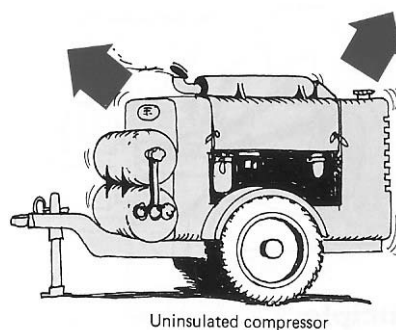


Figure 4.4.33. Air compressor without noise control.



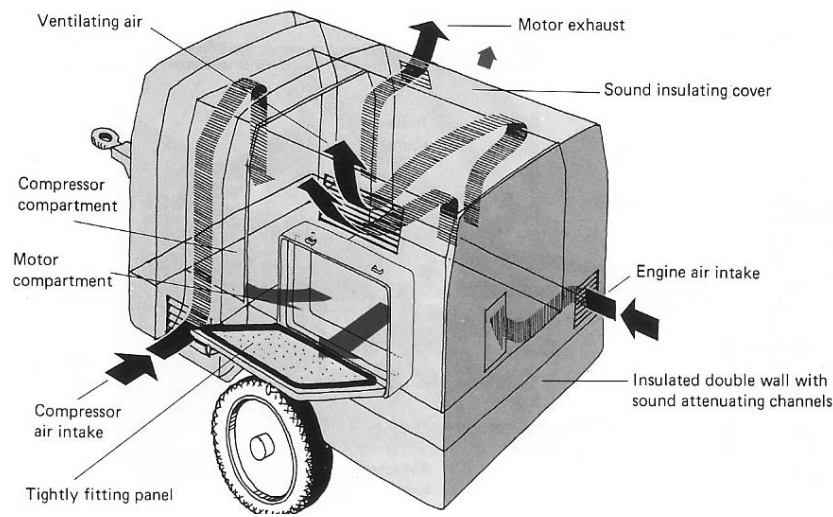


Figure 4.4.34. Air compressor with noise control.

because it travels around corners, through holes, and then continues to travel, see Figure 4.4.33. A normal sized shield has little effect so it is necessary to install effective mufflers at the intake and exhaust points to reduce noise from compressors.

A number of control measures have been installed to control noise, see Figure 4.4.34. The compressor is completely enclosed in dampening material, air and exhaust passes through mufflers and the inspection doors close tightly.

### Workplace

A riveting hammer produces very high frequency noise into a workplace, see Figure 4.4.35. When high frequency sound strikes a hard surface, it is reflected. High frequency sound does not easily travel around corners.

Figure 4.4.36 shows a sound isolating hood constructed with an inside lining of sound absorbent material. There is an opening near the base of the machine and the operator opening is covered with safety glass.

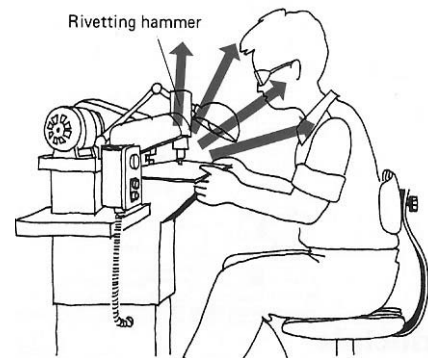


Figure 4.4.35. Workplace without noise control.

### Machine tool

Figure 4.4.37 shows different types of airborne and structure borne sound prevention methods. It is important to localize all noise sources and to find appropriate measures.

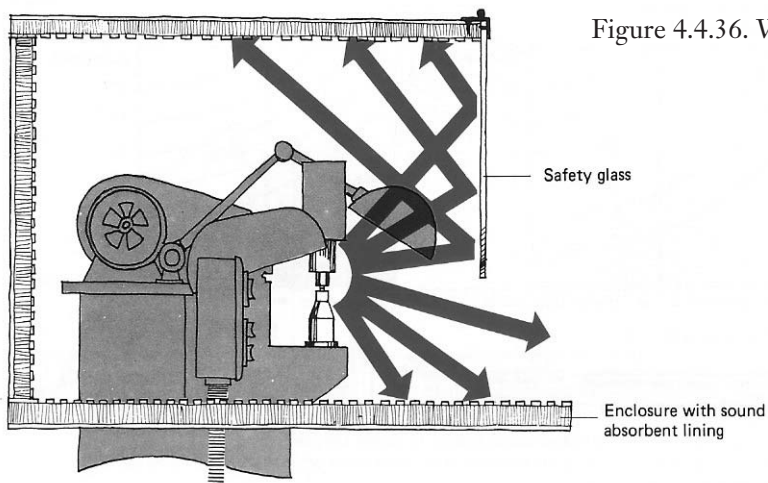


Figure 4.4.36. Workplace with noise control.

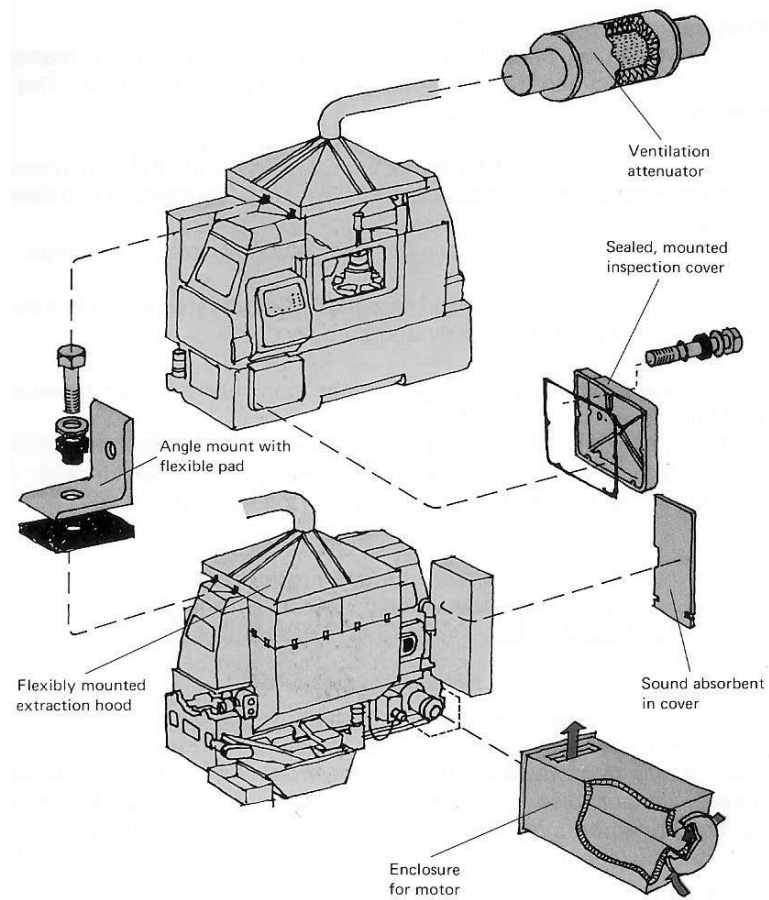


Figure 4.4.37. Machine tool.

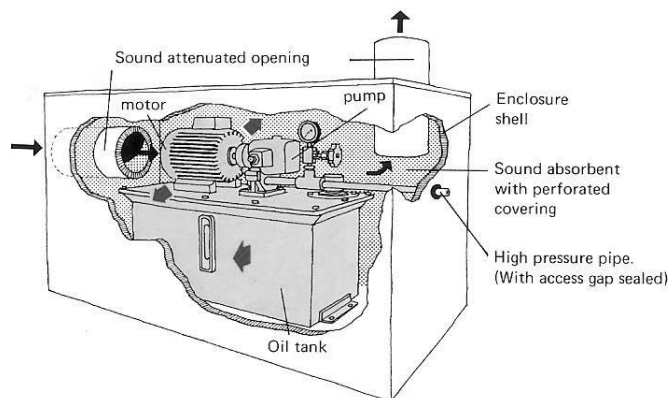


Figure 4.4.38. Hydraulic system.

### Hydraulic system

Some examples of enclosures of machines were presented earlier. Figure 4.4.38 shows the main problems that can arise with enclosures. An enclosure is built around a hydraulic system. The enclosure requires sound attenuated ventilation openings because both sound and heat are radiated by the motor, pump and oil tank. A sealed inspection cover must also be provided.

### Elevator noise

Vibration that enters a structure such as a concrete building travels a very long way because of the very low internal damping of the structure. Vibration and stop/start shocks can be heard throughout the building, see Figure 4.4.39.

The winding machinery must be completely isolated from the structure, e.g. by the use of spring supports, see Figure 4.4.40.

### Pipe mounting

The vibration from a small object will generally not produce a high noise level because the area of air set into motion by the object will also be small. However, connecting a large panel transfers the vibration energy into airborne sound much more efficiently by spreading the vibra-

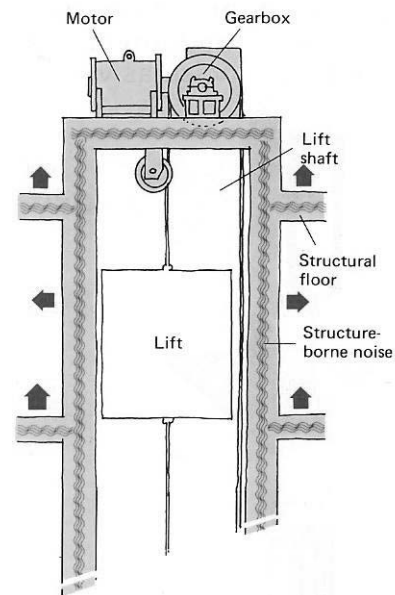


Figure 4.4.39. Elevator.

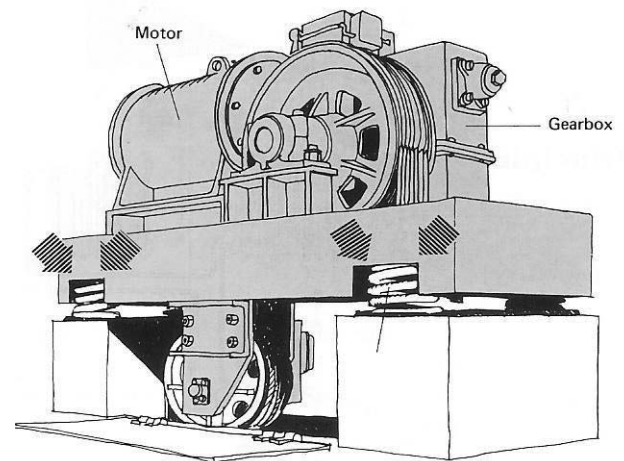
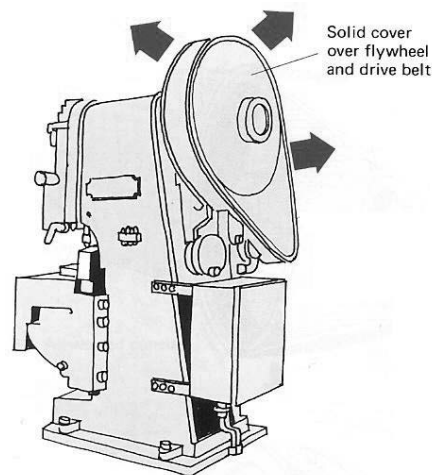
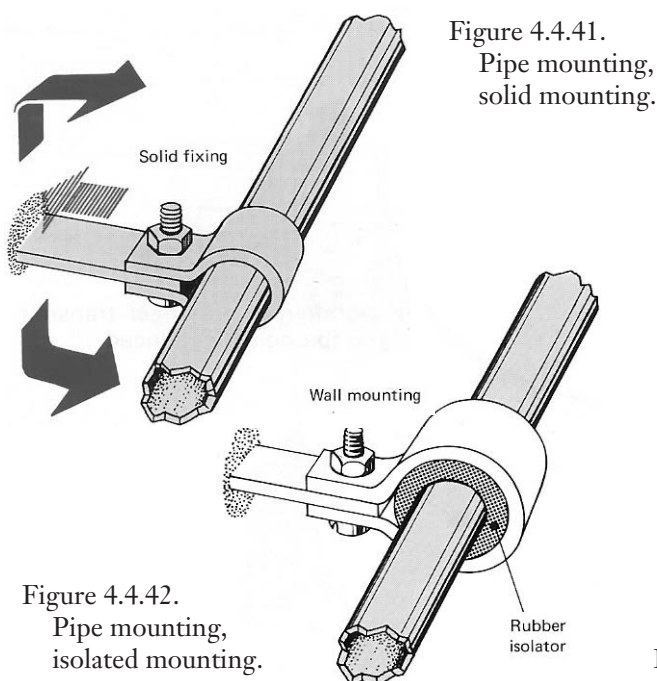


Figure 4.4.40. Elevator motor.

tion over a much greater area which gives a high noise level.

Structure borne sound in a pipe has little opportunity to develop airborne sound as the



area is small but when a pipe is fixed to a wall or panel, the vibration can activate a larger area of air or structure, generating a high level of airborne sound, see Figure 4.4.41.

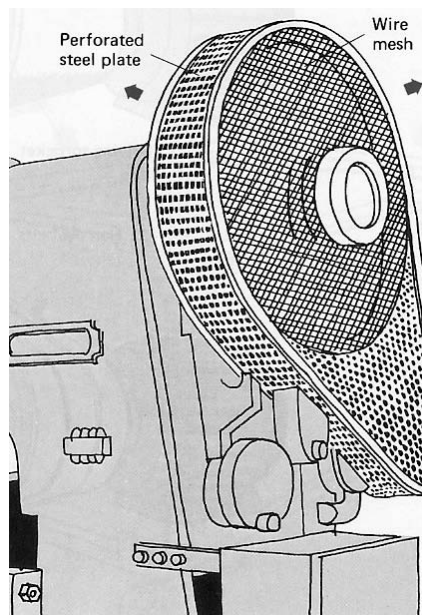
Pipe work must be properly mounted and isolated from the wall or panels so that they do not vibrate, see Figure 4.4.42.

### Vibrating panels

It is not always possible to avoid the use of large panels which vibrate and give rise to high noise levels, but, in many cases, they may be replaced by a panel with perforations or a broken surface.

The protective cover over the flywheel and belt drive of a punch press radiates noise efficiently, see Figure 4.4.43.

A replacement cover of wire mesh reduces the noise radiation, see Figure 4.4.44.





Heavy machine producing  
low frequency vibration

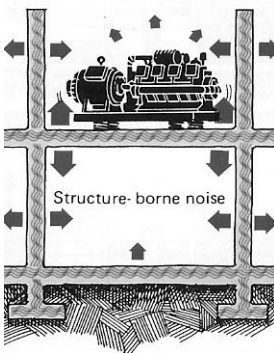


Figure 4.4.45.  
Machine mounting.

Highly stiffened floor

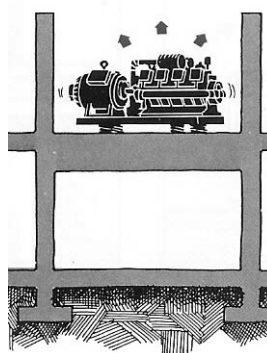


Figure 4.4.46a.  
Stiffened floor.

Supports under the mountings

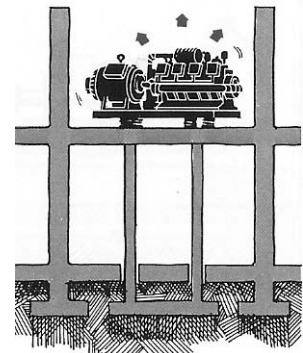


Figure 4.4.46b.  
Support from pillars.

### MACHINE MOUNTINGS

Figure 4.4.45 shows a heavy machine producing low frequency vibration. This vibration may cause the floor itself to resonate even though isolators of the correct rating are used.

Optimum isolation requires the natural frequency of the machine, (on its isolators) should not only be well below the exciting frequencies from the machine, but should also be lower than the resonances of the floor. In practice, this may be achieved by reinforcing the floor structure to provide a more rigid and solid base, see Figure 4.4.46a. Alternatively, the machine may be mounted on pillars mounted directly into the ground, see Figure 4.4.46b.

### INDUSTRIAL WORKSHOP

Figure 4.4.47 illustrates a workshop with a variety of noise problems. The noise sources simultaneously produce both airborne and structure borne noise.

The figure illustrates the fact that it often is necessary to apply several noise control techniques.

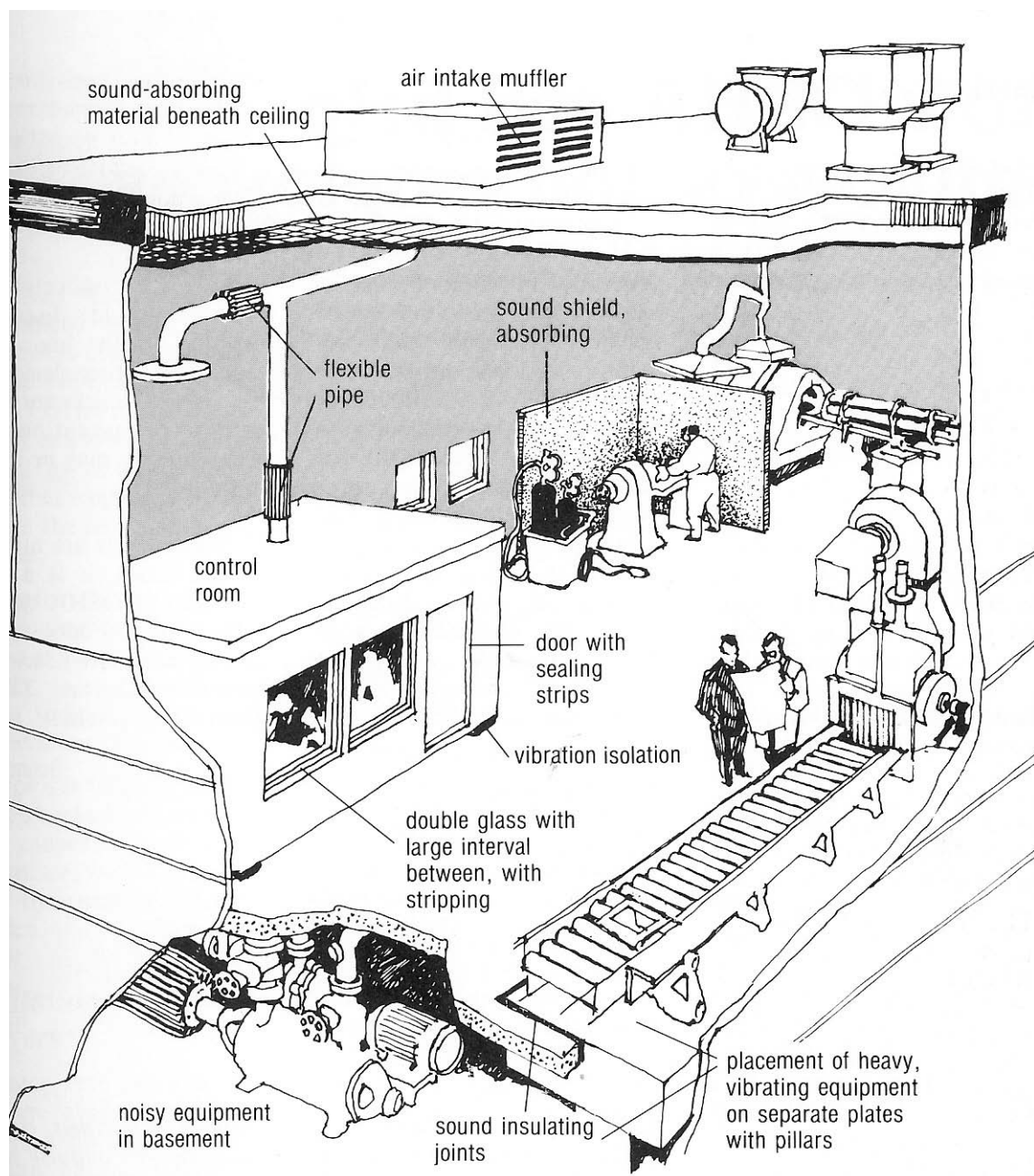


Figure 4.4.47. Workshop.



### SUGGESTIONS FOR FURTHER READING

Most of the illustrations and some other materials in this chapter are taken from the three following references:

- [www.bkhome.com](http://www.bkhome.com)
- Noise Control. Principles and Practice, Brüel & Kjær, 1982
- Bruel & Kjær Lectures:
  - BA 7040-11 Sound Level
  - BA 7214-11 Frequency of Sound
  - BA 7016-11 Psycho Acoustics and Audiometry
  - BA 7219-11  $L_{eq}$  – Noise Dose – SEL
  - BA 7220-11 Noise Evaluation and Documentation
  - BA 7102-12 Introduction to Building Acoustics

The references provide outstanding and comprehensive information on noise control. Brüel & Kjær is a world-wide Danish company, able to supply any equipment needed for noise and vibration projects. Brüel & Kjær's home page has links to electronic Primers which will provide the reader with introductions to subjects relevant to sound and vibration measurement as well as links to Brüel & Kjær's internet courses.

# Vibrations

*Rauno Pääkkönen*

## BASIC CONCEPTS

Exposure to vibrating bodies such as handheld tools and vehicles is a cause of occupational injuries and diseases. The ongoing transition from handheld manual tools to power tools and motorised vehicles in developing countries demands attention to be paid to this work as an environment problem.

Vibration is a series of mechanical waves generated from a vibrating body. In terms of exposure and its effects to humans, vibration can be divided into *whole body vibration* and *hand transmitted vibration*.

Whole body vibration can give symptoms in the back and stomach areas, generate resonance in different organs of the body and cause motion sickness. The main sources are vibrating bodies such as buildings, machines and vehicles.

Hand transmitted vibration gives rise to white finger syndrome (VWF), neurological and muscular disorders. VWF is a typical occupational disease among users of handheld tools such as drills and machine saws and the health effects vary from serious consequences leading to amputation of fingers to milder symptoms of annoyance.

Both types of vibration can impair human performance. Whole body vibration causes

lower back and stomach problems. It is estimated that worldwide 2–6 % of workers are exposed to harmful hand transmitted vibration and about 4–7 % of workers are exposed to harmful whole body vibration. In Europe questionnaires have shown a subjective individual estimations of exposure to both types of vibration varies between 15–35%.

The main control measure to prevent adverse effects from vibration is consideration of the problem during the design and construction of tools and equipment, vehicles, buildings etc. The reduction of vibration exposure by improving of equipment and vehicles is usually more complicated and costly, and normally less effective. Education and work organisation measures are complementary actions.

## SOURCES OF EXPOSURE

*Hand transmitted* vibration is a common problem in occupations that demand the handling of tools and the operation of equipment, e.g. in forestry and construction work, mining, and manufacturing industries. Tools that frequently expose users to vibration include chain saws, percussion tools that use pressurised air, nailing tools, grinders, vibrating machinery, rock drilling devices, or chip-hammers.

Machinery such as lawn movers, tractors, and vibrating machinery used in forestry and road work are typical sources of *whole body* vibration. Transportation vehicles such as aircraft, helicopters, trucks, all terrain vehicles and ships also expose people to vibration. Even a private car can cause problems if a road is bumpy and curvy. Some structures like floors and maintenance platforms can vibrate when vibration from processes or machinery is transmitted to those structures.

Vibration can appear as *impulses*. An impulse is defined as lasting less than a second but impulses usually occur at regular or irregular intervals of more than a second. Vibration impulses that flow from hand held tools to hands, feet or other parts of the body can cause adverse effects. In cases of whole body exposure, impulse vibration is caused by shocks and bumps. Limit values concerning human tolerance towards impulse vibration have been calculated based on collision research, however, these limits are normally not included in information on vibration induced occupational injuries.

An extreme form of vibration is the *G-force*, a phenomenon connected with acceleration e.g. in aviation. Effects from g-forces are similar to those from vibration, but g-forces are not usually related to occupational settings.

### Dimensions of vibration

Vibration is caused by continuous or fluctuating reciprocal movement in solid structures that move in their rotating or percussive paths. It is comprised of mechanical waves and is closely related to structural noise. The vibrating waves spread in materials in different directions and with different frequencies. Vibration can change direction and even frequency where there are joints. Newton's second law states that force, mass and acceleration are interrelated. Certain

frequency ranges are considered to be more dangerous than others.

Vibration is analysed with respect to *frequency, amplitude, direction and exposure* but as some of these dimensions interact, analysis might involve more than one dimension.

### Frequency

Frequency is expressed in Hertz (Hz). Occupational problems related to vibration are normally found in frequencies from 0.1 to 1000 Hz. There are extremes beyond this range, e.g. low frequency vibration (sway) that causes motions sickness, and high frequency vibration, e.g. from high speed tooth drills, causing white finger diseases (Figure 4.5.1).

Type of vibration	Frequency, Hz	Critical range, Hz
Whole body	1–8	1–10
Hand transmitted	5–1 250	80
Low frequency	0.1–1	0.2
High frequency (high speed drills)	1 000–10 000	5 000

Figure 4.5.1. Frequencies of vibration.

### Amplitude

Amplitude is expressed as acceleration values ( $\text{m/s}^2$ ) of certain frequency ranges or frequency bands. Figure 4.5.2 shows typical equivalent acceleration values of some vibration sources. The acceleration values for hand held tools have been measured from the handle of a tool. This acceleration is focused mainly on the upper extremities of the human body. The whole body vibration from vehicles has been measured from the seats.

Sources	Total equivalent acceleration, $\text{m/s}^2$
<b>Hand held tools</b>	
Impact drill	10–110
Rock drill	5–13
Rail saw	3–6
Steel plate cutter	4–20
Chain saw	2–5
Grinder	1–3
Bench grinder	15
Bolt and nut wrench	5–15
Concrete vibrators	5–20
<b>Vehicles</b>	
Excavator	1–5
Caterpillar with push plate	1–3
Motor sledge	2–5
Terrain vehicle	3–5

Figure 4.5 2. Some examples of equivalent acceleration ( $\text{m/s}^2$ ) values of vibrating tools and vehicles as measured by the Finnish Institute of Occupational Health.

The highest values of acceleration are found when hand tools like drills, cutters or vibrators are used. Most of the vehicles cause vibration values that exceed limit values as measured at the seat of the vehicle during normal use.

Certain frequency ranges are considered more dangerous than others. Therefore, frequency weighting networks have been constructed to facilitate the analysis of vibration measured by systems that give only one acceleration value for the specific vibration source under examination. This type of acceleration is called frequency-weighted acceleration. Fluctuating vibration can also be time-weighted and integrated, and in such cases the values are called “equivalent acceleration values” measured over a particular time period.

### Direction

Vibration normally occurs simultaneously in several directions so it is often measured and analysed in three dimensions (x, y and z). Sometimes rotating angles are considered. Different rules have been set up for analysing the axes of vibration and determining the correlation between harmful effects and the directions of vibration.

### Exposure

Exposure is assessed as an integration of duration and acceleration. Work with most vibrating tools will mean that guideline values are exceeded at some time, however, these tools are not used all the time so exposure should be calculated as a daily vibration exposure on the basis of the following equation

$$a_{bv(eq, 8h)} = a_{bv(eq, T)} \sqrt[3]{(T/8 \text{ h})},$$

where  $a_{bv(eq, 8h)}$  = daily vibration exposure (8 hours),

$a_{bv(eq, T)}$  = equivalent acceleration value over time  
 $T$  = time period

### How to measure

Figure 4.5.3 shows a three axial measurement and analysis system for vibration that weights frequency according to ISO standards and can be used in field conditions to analyse work exposures.



Figure 4.5.3. Vibration measurement from the handle of a drill. The figure illustrates the insertion of acceleration sensor to the handle of a drill. A three axial acceleration sensor can be fixed in a handle by tightly screwing or gluing so that the drill can be used for practical work.

Vibration is usually measured by accelerometers that change mechanical vibration into a charge or voltage form. The signals are then amplified and tape-recorded or analysed in many ways. For occupational health purposes vibration is usually measured and analysed according to ISO standards (ISO 2631 series, 1985-2003). Measurement of vibration is usually more complicated than measurement of noise. In many countries, specialists or engineering offices are experienced in undertaking these measurements. In addition, these specialists measure structural vibration, e.g. bearing vibration, building vibration, and ground vibration. It is important to analyse structural vibrations during the prototype phase for new vehicles or equipment, not only because of potential human exposure but also to avoid potential damage to structures and equipment.

### Mitigating and aggravating conditions

Adverse effects from vibration are not only related to the inherent characteristics of the vibration but to a combination of other risk factors such as the type and length of exposure, other physical work conditions including the nature of work tasks, and individual human characteristics. The following summary shows how these conditions can mitigate or aggravate the effects of vibration:

- the connection between the human body and vibrating device
- duration of exposure and rest breaks
- work posture and muscle tension
- weather conditions, smoking, drugs and noise
- individual susceptibility
- individual protective behaviour

### GUIDELINES

The European Union directive on human vibration (effective from 2005), sets the limits for hand transmitted vibration and whole body vibration at  $5 \text{ m/s}^2$  and  $1.15 \text{ m/s}^2$ , respectively. The action values for hand transmitted vibration are  $2.5 \text{ m/s}^2$  and  $0.5 \text{ m/s}^2$  for whole body vibration. These values are measured as frequency weighted total vibration for an 8 hour workday. The American Conference of Governmental Industrial Hygienists annually publishes recommendations for hand transmitted ( $4 \text{ m/s}^2$  for exposures 4-8 h) and whole body vibration. Vibration is also measured to provide helpful information for machinery maintenance, to analyse the condition of ball bearings, and to analyse structural vibration and the environmental spreading of vibration through the ground. The measurement of human vibration is only a small part of overall vibration measurements.

## ADVERSE EFFECTS

### Hand transmitted vibration

The most prevalent adverse effect related to hand transmitted vibration is white finger disease (VWF) (also known as traumatic vasospastic disease (TVD) or Raynard's phenomenon). VWF is usually caused by motor driven tools like chain saws that operate within the frequency range of 40-300 Hz. VWF is associated with blocked or reduced blood circulation in the small blood vessels of the fingers. If the blood does not circulate properly, the fingers become permanently white (Figure 4.5.4). Nerves are affected and cause pain, numbness, and tingling in the hand. These vascular attacks are provoked and aggravated by cold.

In the worst cases, the blood circulation of a finger can be totally destroyed necessitating amputation of the finger. This only happens very rarely, and only occurs after a very long period of severe vibration exposure.

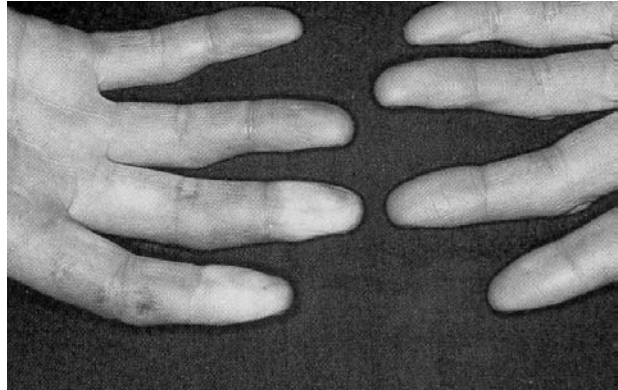


Figure 4.5.4. An example of vibration white finger in fingertips (left).

The Stockholm Workshop scale is an internationally accepted grading system for classifying Raynard's phenomenon and VWF induced by cold. The hand-arm vibration syndrome is divided into vascular and sensorineural components. Figure 4.5.5 shows the grading of symptoms related to vascular and sensorineural components, ranging from mild to very severe attacks.

Grade	Description of vascular component	Description of sensorineural component
–	no attacks	exposed to vibration but no symptoms
mild	occasional attacks affecting only the tips if one or more fingers	intermittent numbness with or without tingling
moderate	occasional attacks affecting distal and middle phalanges of one or more fingers	intermittent or persistent numbness, reduced sensory perception
severe	frequent attacks affecting all phalanges of most fingers	intermittent or persistent numbness, reduced tactile discrimination and/or manipulative dexterity
very severe	frequent attacks affecting all phalanges of most fingers and with trophic changes (tissue damages or necrosis) in the fingertips	

Figure 4.5.5. Stockholm workshop scale (ISO 5349-1, 2001).



### Whole body vibration

Whole body vibration is thought to cause symptoms and disorders of the joints and muscles, especially in the spine and stomach areas, but the scientific evidence is not strong. Some European countries have accepted the combination of low back pain, sciatic pain and degenerative changes in the spinal system as an occupational disease related to whole body vibration. Other reported effects are cardiovascular changes, such as elevation of blood pressure, and changes of respiratory, endocrine and metabolic systems, however, the scientific evidence for these effects is also weak.

Whole body vibration might impair human performance such as visual perception and balance. Resonance frequencies can reduce operational and visual capabilities (e.g. symptoms in the chest area at 25 Hz, and in the eye ball at 60 Hz) and may interfere with human activities that demand fine motor skills and reading. Writing becomes impossible if vibration is strong enough. Other reported effects are annoyance and discomfort. All these effects form a complex phenomenon that can only partly be explained by vibration.

Human tolerance of the impact from vibration has also been addressed through biodynamic models based on human responses. These models combine the duration of vibration impact and uniform acceleration and classify the exposures causing adverse effects into three classes: no injury, moderate injury and severe injury. According to Gierke and Coermann the limit for a 0.1 s impulse to cause a moderate injury is about 100 m/s<sup>2</sup>.

Motion sickness is caused by the low frequency vibration or sway of ships and vehicles such as aircraft, buses and cars. Symptoms appear more easily if a person has to read, write or focus the eyes on certain areas while exposed to

movement. Symptoms usually disappear within a few hours after the exposure has ceased. Motion sickness can deteriorate work ability substantially but there are significant differences between individuals. There is little information on individual susceptibility to this phenomenon.

### PREVENTION

The best way to control or avoid or minimize exposure to vibration, is to consider the problem from the very beginning, when planning and equipping new work processes and worksites. Long standing requirements to reduce vibration have been addressed by manufacturers of chain saws, pneumatic tools and transportation devices. It remains to be seen what effect the new European vibration exposure directive (2002/44/EC) will have on the development of vibrating machines and tools. This kind of development takes time, with the results of improvements being measured only after 10 - 20 years. Similarly, a directive giving standards for machine vibration (98/37/EC) has begun to influence manufacturers and sales figures. Legislation is often considered to be the most important way to influence the development of tools and machines, increasingly resulting in work becoming automated. To improve and reduce the vibration of existing objects such as tools, equipment, machinery, vehicles and buildings is usually more costly, complicated and less effective.

As already mentioned, there are other conditions that might influence exposure to vibration, including the duration of exposure, working posture, and weather conditions etc, so a combination of modifying factors might be needed to control vibration exposure. A management system should include a range of control measures such as:

- hazard identification and monitoring of exposure
- technical hazard elimination and engineering modifications
- routines for maintenance of vibrating equipment
- work organisation methods e.g. separating workers from the source of exposure and reducing the duration of exposure
- education and training of safe practices
- the use of personal protection equipment (PPE).

### **Hazard identification and monitoring**

The first step in assessing the problem is to identify where people might be exposed to vibration and to describe the sources. This can be done by a walk through the worksite to identify and record the type and number of vibrating machines, tools, vehicles and other vibrating structures. A combination of conditions determine the intensity of adverse effects so all those conditions have to be properly addressed. Such conditions are:

- acceleration, frequency and direction of the vibration
- activity being performed by the exposed person (work posture and muscle tension)
- duration of exposure and breaks
- the connection between the human body and vibrating device
- weather conditions, smoking, drugs and noise
- individual susceptibility
- individual protective behaviour

Attention should be paid to:

- workers with symptoms caused by vibration
- workers who complain about vibration.
- sources or activities associated with complaints or symptoms

Data could be collected by direct observation, checklists, by consultation with workers and/or supervisors, and by the review of injury and medical reports.

### **Technical hazard elimination and engineering modifications**

Having assessed the problem preventive actions must be taken. Prevention at source is the first option to consider. When a new tool or vehicle is being purchased, consideration of the vibration level can be one of the criteria for purchase. Once a vibrating machine or vehicle has been purchased, there are limited possibilities to reduce vibration by technical means. Appropriate design of tools and vehicles is therefore of the utmost importance.

The price of a product is a decisive parameter and unfortunately vibration dampened products are often more expensive. Currently there are cheap copies of tools and machines on the market and these cheap versions vibrate more than the original model because lighter materials are used and they are more poorly assembled. In addition these copies usually have a shorter life time and are less cost effective in the long run. It is important to highlight the benefits of using high quality tools.

Guidance about what to consider when purchasing equipment can be found in the Machine Directive of the European Union (98/37/EC). The directive states that if a machine causes hand transmitted vibration of more than  $2.5 \text{ m/s}^2$  or whole body vibration of more than  $0.5 \text{ m/s}^2$ , the

manufacturer must provide information on the vibration of the machine. The machine instructions must give the weighted acceleration value to which the arms are subjected if it exceeds  $2.5 \text{ m/s}^2$  as determined by the appropriate test code. If the acceleration does not exceed  $2.5 \text{ m/s}^2$ , no mention is required. The instructions must also give the root-mean-square acceleration value to which the body (feet or posterior) is subjected if it exceeds  $0.5 \text{ m/s}^2$ . Where the acceleration does not exceed  $0.5 \text{ m/s}^2$ , no mention is needed. Manufacturers may also give guidelines on the selection of vibration damping devices. For example, Figure 4.5.6 shows a forestry clearing saw that has been designed to reduce vibration.



Figure 4.5.6. Forestry clearing saw in action. The manufacturer notifies purchasers that the equivalent vibration acceleration is less than  $5 \text{ m/s}^2$ , a level that will not exceed limit values.

While it is difficult to reduce vibration by redesign, some possibilities exist, e.g. recoilless hammers, damped handles and insulation solutions for chain saws.

Principles for reducing vibrations are:

- increasing the mass of the vibrating body
- minimising tolerances of systems
- better balancing machines and reciprocating parts
- design of forms to reduce turbulence.

Figure 4.5.7 shows the development of vibration reduction in the handle of a chain saw over a period of 10 years. From the figure it can be seen that lower frequencies are harder to reduce than higher frequencies. At the lowest frequencies the vibration accelerations have even increased. This is how materials usually isolate different frequencies. The resonances are caused by spring-mass type vibration systems in machinery that can attenuate or amplify certain frequencies or frequency areas.

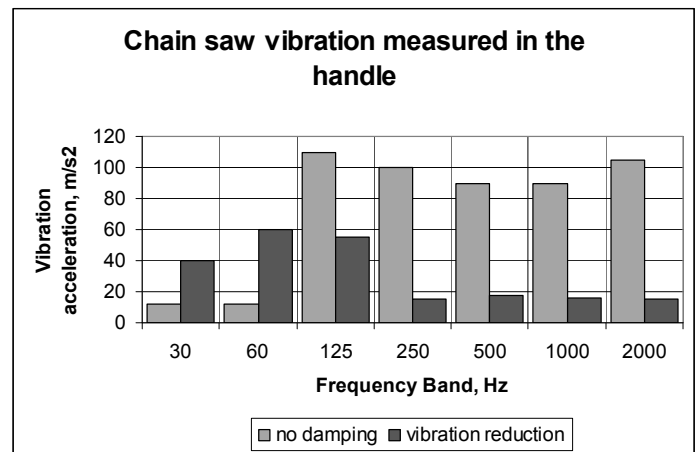


Figure 4.5.7. Vibration acceleration in the handle of a chain saw without vibration damping and after vibration reduction.

In *vehicles* whole body vibrations can be damped by:

- installing better isolated seats
- isolating the cabin from the structure of the machine
- improving suspension through active damping systems
- using pneumatic tyres
- ensuring that roads and work surfaces are smooth

Improvement by technical redesign requires technical understanding. Unsuitable materials, structures that are too light or some other choices can generate resonances that amplify vibration levels at certain frequencies and increase workers' exposure to vibration. In unfavourable conditions these resonance frequencies exist at the resonance frequencies of the human body, increasing discomfort.

Sometimes there is a danger that technical changes deteriorate ergonomic conditions by increasing the mass. Vibration of a structure can also be amplified through the use of vibration isolation. This can shorten the lifespan of a machine so this is not always a possible alternative solution. Improving the balance of machinery demands careful design, but it can reduce vibration levels significantly.

### **Routines for maintenance of vibrating equipment**

Most tools and vehicles deteriorate over time, particularly suspension systems in vehicles, regular planned maintenance routines must be established.

### **Organisational efforts**

The planning and organisation of work tasks and working conditions are a means to reduce expo-

sure to vibration. For example changes in working methods and organisation, such as separation of workers or job rotation can be effective. The possibility of more automated systems can be considered.

*Reducing the duration* of exposure (e.g. by the reduction of work periods or an increase in the number of breaks during work shifts), can eliminate or reduce adverse effects. It is also important to observe whether workers must adopt poor *ergonomic* postures while they are exposed to vibration.

### **Education and training**

Workers must be given information about how to detect, avoid and manage exposure to vibration. Concerning *whole body vibration*, training in how drivers can adjust their driving to the external circumstances will be helpful in reducing exposure. Such training should include information about what causes rough rides and what constitutes damaging vibration. Exposure to *hand transmitted vibration* can be avoided if workers learn how to operate and maintain tools. The following is a summary of practical hints that workers can use to reduce exposure to vibration:

- avoid unnecessary tight grip force from the handle of a vibrating tool
- use only good quality tools and cutting machines with properly sharpened teeth
- have regular breaks so that the hands have the possibility to recover
- keep your hands warm and do not smoke when working
- avoid all smoking, particularly when working
- take regular breaks
- keep gloves dry

### Personal protection equipment (PPE)

Gloves do not usually reduce vibration significantly but they do help to keep hands warm as well as protecting the hands, Figure 4.5.8. It is also important to take note of symptoms that may be caused by vibration, (e.g. tingling, loss of grip force, or white finger) and to take remedial action. While personal protective equipment is usually cheap and easy to provide it is of very limited value.



Figure 4.5.8. Gloves protect hands from sparks and help to keep hands warm but they do not protect hands from vibration.

#### ISO Standards

ISO 2631-1: vibration and shock - evaluation of human exposure to whole body vibration Part 1: general requirements. Geneva: International Organization for Standardization; 1997. 36 p.

ISO 2631-2: mechanical vibration and shock - evaluation of human exposure to whole body vibration. Part 2: Vibration in buildings (1 Hz to 80 Hz). Geneva: International Organization for Standardization; 2003. 11 p.

ISO 2631-3: evaluation of human exposure to whole-body vibration - Part 3: evaluation of exposure to whole-body z-axis vertical vibration in the frequency range 0.1 to 0.63 Hz. Geneva: International Organization for Standardization; 1985. 4 p.

ISO 5349-1: mechanical vibration - measurement and evaluation of human exposure to hand-transmitted vibration. Part 1: general requirements. Geneva: International Organization for Standardization; 2001. 24 p..

#### SUGGESTIONS FOR FURTHER READING

Griffin M. Handbook of human vibration. London, Academic Press; 1990.

Pelmeur PL, Wasserman DE. Hand-arm vibration. A comprehensive guide for occupational health professionals. 2nd ed. Beverly Farms, (MA): OEM Press; 1998.

#### General Web-sites on vibration

<http://www.hse.gov.uk/vibration/>

[http://www.ccohs.ca/oshanswers/phys\\_agents/vibration/vibration\\_intro.html](http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_intro.html)

[http://www.humanvibration.com/EU/VINET/pdf\\_files/Appendix\\_H1A.pdf](http://www.humanvibration.com/EU/VINET/pdf_files/Appendix_H1A.pdf)

<http://www.humanvibration.com/EU/VIB-GUIDE/HAV%20Good%20practice%20Guide%20V7.7%20English%20260506.pdf>

<http://www.humanvibration.com/EU/VIB-GUIDE/WBV%20Good%20practice%20Guide%20v6.7g%20English%20070606.pdf>

# Radiation

*Kjell Hansson Mild & Ulf Bäverstam*

There are two main types of radiation from electric and magnetic fields, non-ionizing and ionizing radiation. Ionizing radiation consists of subatomic particles or electromagnetic waves that are energetic enough to detach electrons from atoms or molecules, ionizing them.

The first part of the chapter, written by Kjell Hansson Mild, covers occupational exposure related to non-ionizing radiation from sources such as large electric motors, generators, power supplies and cellular phones. This part starts with definitions and a general description of the concepts and acronyms related to the electromagnetic spectrum.

The second part by Ulf Bäverstam addresses ionising radiation. The main occupational sources are X-rays used in hospitals and workplaces, and gamma radiation emitted from radioactive nuclides (e.g. used to irradiate patients undergoing cancer therapy or for sterilising foodstuffs).

The chapter does not discriminate between developing or industrial countries as the use of both non-ionizing and ionizing radiation are strictly coordinated globally. For example, the Atomic Energy Agency (IAEA) has made it a priority to support the development of non-military use of radiation in developing countries. Many IAEA publications are also directed to-

wards developing countries. International bodies including the International Commission on Non-Ionizing Radiation Protection, (ICNIRP), and the International Commission on Radiation Protection, (ICRP) produce guidelines that are applied all over the world. The USA is an exception having its own set of rules, although there are only minor differences from the rules applied in other countries.

## NON-IONISING RADIATION

### Electromagnetic fields

Electromagnetic fields, EMF, is the general term for electric and magnetic fields with frequencies from 0 to 300 GHz.

An electric field (E) is created as soon as there is a voltage difference between two points, e.g. around the cable of a lamp that is turned off but still plugged into an outlet. Electric fields are easily shielded. The E field is given with the unit volts per meter, V/m.

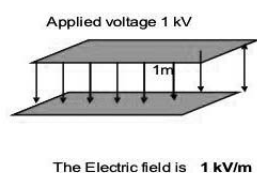
A magnetic field (B) is created when there is a current flowing. For example, magnetic fields (and electric fields), are found around the cable of a lit lamp. Magnetic fields are more difficult to shield.

The magnetic field is given by the flux density, B, with the unit Tesla (T).

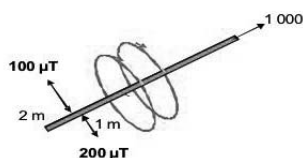


Both  $E$  and  $B$  are vectorial quantities, i.e. they have both magnitude and direction. The fields are usually displayed by means of field lines, and Figure 4.6.1 gives an example of this. The  $E$  field always starts with a positive charge and ends with a negative charge. The  $B$  field forms closed loops, i.e. the field lines have no beginning or end.

### Electric field ( $E$ ) V/m



### Magnetic field ( $B$ ) T, $\mu$ T



Defined from the force on charged particles.

Figure 4.6.1. Electric and magnetic fields. Two large plates are separated by 1 m and the potential difference between them is 1000 V (1kV). The  $E$  field between the plates is then  $E=1000 \text{ V/m} = 1 \text{ kV/m}$ . A current of 10 A is running in a straight conductor. The magnetic field at a distance of  $r$  m from the conductor is given by the formula  $B=0.2 \times I/r$  ( $\mu$ T), and this gives for 10 A and 1 m  $B=1 \mu\text{T}$ , and at 2 m  $B=0.5 \mu\text{T}$ .

## The electromagnetic spectrum

The behaviour of electromagnetic (EM) radiation depends on its wavelength. Higher frequencies have shorter wavelengths, and lower frequencies have longer wavelengths.

When EM radiation interacts with single atoms and molecules, its behaviour depends on the amount of energy per quantum it carries.

The most familiar form of electromagnetic energy is sunlight. The frequency of sunlight (visible light) constitutes the dividing line between the more potent ionizing radiation (x-ray, cosmic rays, etc.) at higher frequencies and the more benign non-ionizing radiation at lower frequencies. Generally, EM radiation is classified by wavelength into:

- electrical energy
- radiowave
- microwave
- infrared
- the visible region we perceive as light,
- ultraviolet
- X-rays
- gamma rays.

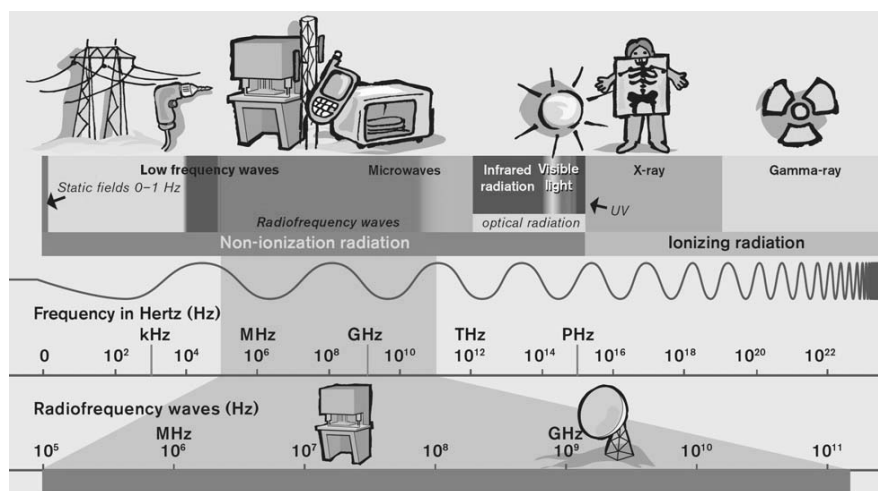


Figure 4.6.2. Radiation sources related to frequency and wavelength.

Low frequency fields include those that are induced around standard electric installations with a frequency around 50 Hz.

Intermediate fields are those in the range of 300 Hz through approximately 1-10 MHz.

Radio frequencies are between 1 MHz and 300 GHz. Microwaves are frequencies in the upper part of this range (300 MHz-300 GHz).

– Naturally occurring fields, like the earth's magnetic field, are static fields with extremely low frequency (ELF).

Electromagnetic fields are usually divided according to their frequency. Figure 4.6.2 illustrates how radiation sources are related to frequency and wavelength.

The wave propagates with the speed of light, in vacuum  $c=3 \times 10^8$  m/s, and the relation between wavelength,  $\lambda$ , and the frequency,  $f$ , is  $c = f\lambda$ . The electromagnetic spectrum is usually divided into different frequency bands.

#### International classification of electromagnetic field frequencies

Name	Acronym	Frequency range
Extremely low frequencies	ELF	0 - 300 Hz
Voice frequencies	VF	0.3 - 3 kHz
Very low frequencies	VLF	3 kHz - 30 kHz
Low frequencies	LF	30 kHz - 300 kHz
Medium frequencies	MF	300 kHz - 3 MHz
High frequencies	HF	3 MHz - 30 MHz
Very high frequencies	VHF	30 MHz - 300 MHz
Ultra high frequencies	UHF	300 MHz - 3 GHz
Super high frequencies	SHF	3 GHz - 30 GHz
Extremely high frequencies	EHF	30 GHz - 300 GHz

## HEALTH EFFECTS

Rather high exposure to electromagnetic fields may occur in many occupations, especially during work near electrical equipment that uses a large amount of electric power such as large electric motors, generators, power supply equipments or electric cables in buildings, radiofrequency heaters and sealers, glue dryers, and induction heaters. International guidelines from ICNIRP and national safety standards for EMF are set on the basis of current scientific knowledge in order to ensure that exposures to EMF are not harmful to health. Currently such guidelines are based on levels that will prevent acute effects such as nerve excitation from low frequency fields and thermal effects from radiofrequency fields.

Exposure to intense low frequency electric and magnetic fields may cause nerve excitation due to induced current in tissues. Uncontrolled excitation of the central nervous system is of special concern in occupations with potentially high exposure such as welding, high voltage switchyards, or work near induction heaters or MRI equipment in hospitals. Nerve excitation through the use of an intense magnetic field is being used for therapeutic purposes in electro-medicine (for instance Transcranial Magnetic Stimulation, TMS) but it is not something that should occur in an uncontrolled fashion in the working environment.

Exposure to intense microwaves may also lead to harmful heating of the whole or part of the body. The heating effect of microwaves is also being used in electromedicine in the form of shortwave and microwave diathermy, but there are guidelines that limit unwanted heating in the working environment.

Such limits incorporate a large safety margin so that exposures above the guideline limits may

not necessarily be harmful to health. In most cases normal exposure levels are much lower than the guideline limits, however, these limits have been disputed and there are health and safety concerns about occupational exposure to EMFs below present guidelines.

Epidemiological studies, particularly regarding EMF in the low frequency range, such as that experienced by people living near power lines, have been reviewed by a number of health agencies including the International Agency for Research on Cancer (IARC) in 2001. Many studies report small increases in leukaemia or brain cancer in groups of people living or working in magnetic fields of extremely low frequency (ELF) with intensity above about 0.4  $\mu\text{T}$ . A few studies have also associated workplace EMFs with breast cancer and some have suggested a possible link between occupational EMF exposure. Recently, there has also been a link to residential magnetic field exposure and mortality from Alzheimer's disease. Recent clinical studies have reported that EMF can effect heart rate variability and cause sleep disturbance.

The adverse health effects with respect to working with video display units (VDU) are mostly related to symptoms in joints, muscles and eyes. Based on today's knowledge there are no health hazards associated with EMFs emitted from VDUs.

A magnetic field inside a building in excess of 0.5  $\mu\text{T}$  may cause perceptible jitter in VDU displays and a prudent avoidance strategy may also serve to mitigate this effect.

The US National Institute for Environmental Health Sciences recently concluded the following about the risk of children developing leukaemia, "ELF EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukaemia hazard". The World Health Organization agency

IARC, evaluated magnetic fields and cancer in 2002 and classified the low frequency magnetic fields as a class 2B, i.e. a possible carcinogen. This is of specific concern in countries using child labour.

Epidemiological reports have also suggested associations with adverse health effects from exposure to radiofrequency fields at levels lower than the basic limits, however, causation has not been shown.

Research is continuing in many countries into possible health effects from EMF exposure, and new results will be reflected in standards, however, there will always be some degree of uncertainty because even scientific risk assessment cannot provide absolute certainty about what is a safe limit. While science provides the starting point for risk assessment, a decision on what is an acceptable risk is essentially a value judgement. A "better safe than sorry" approach that takes precautionary measures to cope with remaining uncertainties or weak evidence of risks to health, can be a useful substitute for absolute proof. What type of precautionary approach is chosen is critically dependant on the strength of the evidence for health risks and the scale and nature of potential consequences.

## PREVENTION

### The precautionary principle

What action should those take who are concerned about the potential health effects from long term exposure to EMF while scientists seek to improve information of adverse health effects? The precautionary principle is socially and politically attractive and continues to be applied in situations even where risks have been established. The principle is a relatively recent term used to characterize a "better safe than sorry" approach towards potentially hazardous technologies. The term has already appeared

in many international environmental treaties. For the countries of the European Union, the Precautionary Principle is explicitly enshrined in the Treaty of Maastricht. In Title XVI it states that “Community policy on the environment shall contribute to protecting human health and “shall be based on the precautionary principle”. As part of the declaration signed at the 1999 Third Ministerial Conference on Environment and Health, WHO was encouraged to take into account “the need to rigorously apply the precautionary principle in assessing risks and to adopt a more preventive, proactive approach to hazards”. The precautionary principle itself remains undefined. It has been interpreted to require prudent action to be taken when there is sufficient scientific evidence (but not necessarily absolute proof) that inaction could lead to harm and where action can be justified on reasonable judgements of cost effectiveness. In the case of EMFs, application of the precautionary principle is particularly problematic. It is not clear which aspect of exposure, i.e. duration or field intensity, should be avoided. Furthermore, whether there is “sufficient scientific evidence” that exposure to EMF could lead to harm remains subject to debate. Cost effectiveness is impossible to demonstrate in the absence of established risk factors, however, risk-benefit analysis can be made using assumptions about existing risks.

Specific interpretation of the Maastricht Treaty requirements evolve as they are applied, sometimes through courts of law. So far the precautionary principle has only been officially applied in Sweden for low frequency fields and in New Zealand for radiofrequency fields.

### **Prudent avoidance**

The concept of “prudent avoidance” was initially developed a decade ago in the United States specifically in the context of concerns about

EMF and as a distinction from the precautionary approach. Since then it has gained wider recognition first in Sweden and later elsewhere in the world. Although it is widely agreed that the potential health risk from low level EMF exposure is small, it is difficult to quantify. Many people feel that workers should be exposed to lower levels of EMF until additional research provides better information about possible health consequences. Prudent avoidance means taking simple, easily achievable, low cost measures to reduce EMF exposure, even in the absence of a demonstrable risk. The terms “simple”, “easily achievable”, and “low cost” are not defined.

Prudent avoidance was initially proposed to cover the actions of individuals, whereas the precautionary principle could be interpreted as a regulatory measure.

### **How have policies promoting caution been applied?**

One way is to try to put the recommended actions into perspective by enunciating priorities. For example, the Swedish National Institute for Radiation Protection stated in their policy about EMF that reduction of exposure to EMF should have a lower priority than protection from radon; natural UV radiation; leakage from nuclear power plants and radiation from the medical use of radioactive sources. Preventive measures for protection from magnetic fields should have the same priority as measures taken in areas like dental and veterinary radiography and industrial use of radioactive sources. Protective measures should be considered for those exposed to long term high magnetic fields provided costs are reasonable.

A high magnetic field is considered to exist if the values are ten or more times what is “normal” for that particular type of environment.

### Examples of precautionary approaches in occupational exposure

Just as individuals can exercise prudent avoidance, government regulators, electric power companies and other companies where EMF exposure may occur, can also exercise prudence. The following examples are divided into two different categories according to EMF frequencies.

#### ELF Extremely low frequencies 0 - 300 Hz

Certain occupations are associated with high field exposures. For example, the Swedish Trade Union Confederation (LO) demands that all workplaces should be surveyed for ELF magnetic fields and practical measures should be taken to reduce high exposures so that no one will be exposed to more than 0.2  $\mu\text{T}$  as an average over the workday. This can be achieved by measures including: marking of high radiation zones, reduction of magnetic fields, relocation of workplaces and changes of the organization of work. They also encourage manufacturers of electric appliances to consider alternatives that reduce magnetic fields at minimal cost. The National Institute of Environmental Health Sciences in the U.S.A. also encourages these alternatives. Recently a European standard on the emission of electromagnetic fields from machines was adopted. These should be labelled according the levels of emissions: Level 0 - No restrictions, Level 1- Only for use by professionals, and Level 2 - requiring special working instructions to avoid overexposure.

In 1995 the Swedish National Board of Occupational Health and Safety (the current Swedish Work Environment Authority), together with four other Swedish authorities, issued a guideline on how to apply the precautionary principle to ELF magnetic field exposure. They recommend the following:

“If measures generally reducing exposure can be taken at reasonable expense and with reasonable consequences in all other respects, an effort should be made to reduce fields radically deviating from what could be deemed normal in the environment concerned. Where new electrical installations and buildings are concerned, efforts should be made already at the planning stage to design and position them in such a way that limits exposure.”

A first step for an individual concerned about possible health effects is the provision of all available information about the workplace and the possible exposure to EMF. A very efficient way of reducing exposure is to increase the distance to the EMF sources. As a magnetic field often drops off dramatically about 1 m from the source, workers can work away from electrical equipment, and work stations can be moved out of the 1 m range of stronger EMF sources. Wherever possible machines designed to emit low EMF should be used and the length of exposure time to EMF reduced.

Anti-theft devices can emit localized fields in excess of the given reference values (guidelines) so a precautionary approach could be to keep a distance between these apparatus and the workers, a factor that should also be taken into account when planning new workplaces.

#### RF and microwaves

Most guidelines for occupational exposures state that exposure should be kept low and must not exceed the limit values. However, in many situations there may be a very negligible distinction between being within the limits or above them making it even more important to apply a precautionary principle in order to stay within the limits. This is especially true for work near RF dielectric heaters and sealers and glue dryers, which usually operate at 27 MHz so it is very important to strictly adhere to good work practices including maintenance and operating



procedures. Improper maintenance may lead to excess leakage from a machine, and small changes in the immediate environment may also lead to higher exposure levels. A 1998 International Labour Office (ILO) publication gives several practical examples for the application of shielding devices and their effects on ground planes and reflectors on operator exposure.

For most people the most common source of RF exposure is connected to mobile phone use. In the absence of conclusive information about any possible risk, concerned individuals can take a few simple steps to minimize potential risks. Time is a key factor in how much exposure a person receives. Those who spend long periods of time on hand-held mobile phones may consider holding lengthy conversations on conventional phones and only use a mobile for shorter conversations or when other types of phones are not available. Those who must conduct extended conversations on a mobile phone every day could switch to a type of mobile phone that places more distance between their bodies and the source of the RF, since the field strengths drop off dramatically with distance. For example, a headset and hands-free device can be used and a mobile phone carried at the waist or in the hand.

The Food and Drug Administration (FDA) in the U.S.A. has urged the mobile phone industry to design phones that minimize the user's exposure to any RF fields that are not essential for the function of the device. The UK Committee on Science and Technology has also given the same recommendation: We recommend that the industry and the National Radiological Protection Board explore ways in which the design of the mobile phones might limit personal exposure to radiation as a means of assisting consumer choice.

There have also been demands from members of the Swedish Parliament for the manufacturers of mobile phones to publish the values of the

specific absorption rate (SAR) for the various phone models, i.e. how much of the microwaves are absorbed by the user's head. It is known that the differences between various makes and models with respect to the SAR values can be twenty fold or more. A precautionary approach would be to buy a phone with a low value rather than one that only just meets the recommended standard. Choosing a mobile with a low SAR-value is also beneficial from the point of view of communication as a low SAR phone doesn't need to up-regulate the power as much as a high SAR device resulting in longer battery life and reach.

### Information needs

If they are to act prudently, individuals need a better understanding of the sources of EMF in order to identify options to limit their exposure. Education material on EMF provides this kind of information and gives people and organizations the opportunity to make informed choices. The WHO International EMF project provides a good starting point to obtain more information on the various aspects of EMF exposures and health. Their web page has several facts sheets (for instance on ELF and RF) as well as general information on EMF ([www.who.ch/emf](http://www.who.ch/emf)).

The exposure to RF and microwaves is increasingly dominated by mobile phone use. However, in occupational settings high exposures sometimes occur so information about the sources and various factors that may influence exposure levels is needed for an individual to act prudently. This information should be included in the instructions and the maintenance practice at each workplace.

During the last decades several new technologies (e.g. VDUs and mobile phones) have been introduced into everyday life, often without proper information about the technology and its potential hazards. This lack of information





Figure 4.6.3. Radiofrequency plastic sealer used in the tarpaulin industry. The operator gets high whole body exposure, and the hands are highly exposed. It would be desirable for the machine to be operated by remote control so that the worker could step back from the machine. A substantial RF current can also flow into the body of the operator depending on the material in the floor – i.e. how much RF ground the floor is.

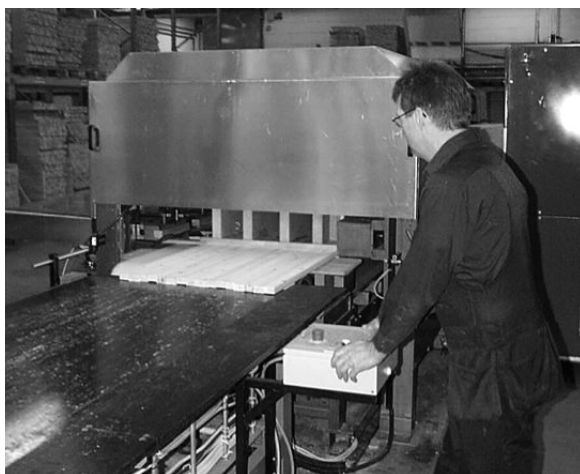


Figure 4.6.5. Radiofrequency plastic sealer in the clothing industry. The operator is working with her hands in very close proximity to the electrodes that results in a high exposure of the hands. Some machines also give rise to high whole body exposure, especially if the head and knees are close to the electrodes. This type of work place must measure electromagnetic fields, and most will require special working instructions on safety.

Figure 4.6.4. Radio frequency glue dryer. In most cases the electrodes are well shielded so exposure is low, but in some cases.

has raised concern among people who feel that the new technologies were imposed on them. Those who suffer from ill health the cause of which is unknown often blame EMF. In the future we will see many more new developments and applications that will lead to an increase in our everyday exposure to EMF making it very important to devote sufficient resources to informing the people about EMF and its possible effects on human health.

## IONISING RADIATION

Ionising radiation is the collective name for different kinds of radiation, but all have the common property of being energetic enough to be able to ionise biological tissue. The high risks associated with the use of ionising radiation necessitate special precautions. A basic prerequisite for protection of workers is a good formal organisation of the work.

The most common types of radiation in workplaces are X-rays and gamma radiation, and this discussion deals mainly with these two kinds of radiation. The X-rays used in hospitals and workplaces are generated in X-ray machines, whereas gamma radiation is emitted from commercially available radioactive nuclides. Uses of strong radioactive sources that emit gamma radiation include the irradiation of patients in cancer therapy, and for sterilising foodstuffs.

Beside medical and dental applications, exposure to radiation can also occur through the use of radioactive materials and radiation generators in the nuclear industry; in manufacturing; construction; engineering; paper; offshore drilling; education, research, and in non-destructive testing.

People can be exposed externally to radiation from a radioactive material or a generator such as an X-ray set, or internally, by inhaling or ingesting radioactive substances.

## HEALTH EFFECTS

Ionising radiation can be highly dangerous and can cause cancer and death. The concept of “dose” is central to any discussion about the probabilities of cancer from radiation.

### “The dose concept”

The basic dose unit for ionising radiation is the absorbed dose (D), defined as the energy absorbed per mass of irradiated tissue. The absorbed dose of ionising radiation is thus different from a dose of a medical substance (for example), which is not normalised to mass.

If energy is measured in joule (J) and mass in kilogram (kg), absorbed dose is given in gray (Gy). Thus,  $1 \text{ Gy} = 1 \text{ J/kg}$ . The absorbed dose is used in connection with acute, deterministic damages of radiation.

When calculating risks for late effects of radiation, the kind of radiation (X-ray, beta particles etc.) and the radiation sensitivity of the irradiated organs (lungs, stomach etc.) must be taken into account. When the absorbed dose is corrected for these factors, it is called the effective dose (E). The effective dose is measured in sievert (Sv).

Since dose is defined per unit of mass, one can define whole body doses and organ doses.

In sum, when defining doses differences are made between absorbed dose given in Gray (Gy) used when assessing acute damages and effective dose given in Sievert (Sv) related to late effects. Furthermore, doses can be defined as whole body doses or organ doses.

If a person is given a local absorbed dose of around 0.5 Gy or more, burn damage will be acute and severe but local.

If the whole body receives such high doses or more, different systems of the body such as the stomach and intestines or the central nervous system will be acutely affected since tissue will be destroyed. Above around 5 Gy, death is likely

to occur within weeks. The acute effects that appear after high doses of radiation are deterministic, i.e. they will occur, and the severity depends on the dose. Cancers may evolve years later, with a probability that is proportional to the irradiation received.

Much lower doses – also a few thousands of a sievert – may also cause cancer, often after several years. The probability of cancer is proportional to the dose, but the dose says nothing about the outcome of the disease. When discussing the probabilities of cancer and radiation dose, the concept of effective dose is used rather than absorbed dose. Calculation of the effective dose must not only take account of the energy but also the type of radiation and the radiation sensitivity of the irradiated organ.

However, the received dose, (measured in sievert), is not a measure of how severe the illness will be but an indicator of the probability of harmful effects, mainly cancer. For radiation protection purposes it is assumed that there is a linear relationship between the received effective dose and the probability of cancer developing later in life. The International Commission on Radiation Protection (ICRP) assumes that there on average is a five percent increase in the probability of getting cancer after a dose of one sievert.

### BASIC PROTECTION

Most countries have national laws and regulations governing the use of ionising radiation. International guidelines are published by the International Atomic Energy Agency (IAEA).

The three main protective actions are: shielding, reduced exposure time and distance. Three other actions are common to all protective work: good organisation (including maintenance), good education and good discipline.

Finally, it is necessary to have routines for monitoring exposure levels, and regular medical surveillance examinations.

### Shielding

X-rays and gamma radiation penetrate into and through matter – this is the basis for much of its use. A physical shield in the path of radiation blocks only part of the radiation while part of it passes through. The thicker and heavier the shielding material, the more radiation is stopped. Lead is commonly used as a shielding material because of its great specific weight. If the radiation source is stationary, it can be placed in a room with thick concrete walls to shield the surrounding area.

### Time and distance

In a constant radiation field the total dose received is the dose received per unit time (the dose rate) multiplied with the irradiation time. Reducing the time to half reduces the dose by the same factor. X-ray machines and other radioactive sources radiate more or less uniformly either in all directions (radioactive sources) or into a certain spherical angle (X-ray machines). This means that the amount of radiation hitting a certain area at a distance from the source is inversely proportional to the square of the distance. Thus, doubling the distance to the source will reduce the dose by four times.

### RADIATION PROTECTION WHEN WORKING WITH X-RAY EQUIPMENT

X-ray tubes are designed to emit radiation in a narrow beam through a narrow collimator, usually placed in a metallic shield. Various types of shields are used to protect workers and patients undergoing medical treatment from radiation. It is necessary to be concerned not only with the radiation in the primary beam, but also the ra-

diation scattered from the target and the shielding used. The higher the energy of the primary X-ray, the more scattered radiation is produced. The best shielding that allows only minimum scattered radiation, is achieved through the use of heavy material shields such as sheets of lead, iron or copper, or lead glass. Lead aprons can also be used.

While an X-ray machine is dangerous when it is turned on, it is completely safe when turned off. Therefore, one of the most important protective actions is to ensure sure that it is absolutely clear when the machine is on and when it is off, and to prevent people from entering the radiation field when the machine is on. The simplest and cheapest system is to use warning signs, however, such by themselves provide rather poor safety so they should be complemented by warning lights and automatic door locks coupled to the power line of the machine.

To achieve good radiation protection when X-ray are being used it is important that those using the machines have a good knowledge of how the machines work and how they should be maintained. Employees should be provided with sufficient information, instructions and training to enable them to understand the risks and the importance of working according to given rules and safe work practice.

### **RADIATION PROTECTION WHEN WORKING WITH RADIOACTIVE NUCLIDES**

Radioactive nuclides are used for various purposes, mainly for medical and technical applications. All radioactive nuclides have different half-lives (the time it takes for the radiation intensity to decrease to half its original value), and this property is used in the application of these nuclides. Nuclides with a long half-life are used in radiation equipment, while nuclides with

a short half-life are used for example, in medical diagnostics.

Examples of the use of strong radioactive sources that emit gamma radiation are the irradiation of patients in cancer therapy, and the sterilisation of foodstuffs. Since a radioactive source cannot be turned off, these strong sources must be completely shielded when not in use. A safe mechanical device must also be employed when opening and closing the collimator. It is also very important to keep radiation sources (including old sources) in safe custody so that they cannot be stolen or lost. All staff handling any type of radiation source must be informed, trained and equipped to work in a safe way.

Radioactive nuclides are often handled in laboratories prior to their use. Unsealed sources are handled, and to avoid both external and internal contamination through inhalation, or oral intake, special care must be taken. Protective clothing, gloves and goggles should be used and all work should be performed in fume cupboards or, if possible, in glove boxes. It must be absolutely forbidden to eat, drink or smoke in the laboratory.

### SUGGESTIONS FOR FURTHER READING

The health effect caused by different kinds of radiation is a controversial field of research, continuously providing new insights and doubts. The facts in this chapter are valid as of April 2009, when the text was finalized. The following suggestions for further reading cover both written texts and useful websites.

#### Non-ionising radiation

[www.who.ch/emf](http://www.who.ch/emf).

The WHO International EMF project provides a good starting point to obtain more information on the various aspects of EMF exposures and health. The site has several fact sheets (e.g. on ELF and RF) as well as general text on EMF. See also:

WHO Fact Sheet No 183,1998. Electromagnetic Field and Public Health. RF

WHO Regional Office for Europe. Electromagnetic fields. Local authorities, health and environment briefing pamphlet series, 32,1999.

WHO Fact Sheet No 205,1998. Electromagnetic Field and Public Health. ELF

website: [www.who.ch/emf](http://www.who.ch/emf)

For further information about electromagnetic fields see the standard physics text books by Barnes and Greenbaum (2008) or information texts by Hansson Mild:

Barnes FS and B Greenebaum (2008) Handbook of Biological effects of electromagnetic fields. Biological and medical aspects of electromagnetic fields. Third edition. CRC Press. ISBN 10-0-8493-9358-0.

Barnes FS and B Greenebaum (2008) Handbook of Biological effects of electromagnetic fields. Bioengineering and biophysical aspects of electromagnetic fields. Third edition. CRC Press ISBN 10-0-8493-9359-0.

Hansson Mild, K. The Electromagnetic Spectrum: Basic Physical Characteristics. Electromagnetic Spectrum. Encyclopaedia of Occupational Health and Safety 49.4, 1998.

Hansson Mild, K. Radiofrequency Fields and Microwaves. Radiofrequency Fields and Microwaves. Encyclopaedia of Occupational Health and Safety, 49.18, 1998.

[www.who.ch/emf](http://www.who.ch/emf) for more information and facts sheets about EMF.

Epidemiological studies, particularly on EMF in the low frequency range, (e.g. for those living near power lines), have been reviewed by several different health agencies. For a recent review see:

Schuz J and Ahlbom A. (2008). Exposure to electromagnetic fields and the risk of childhood leukemia: a review. Rad Protect Dosimetry doi:10.1093/rpd/ncn270.

#### Ionising radiation

[www.iaea.org/Publications](http://www.iaea.org/Publications)

This website contains scientific and technical reports, standards and guidelines.

[www.iaea.org/Publications/Training](http://www.iaea.org/Publications/Training)

This website contains training material, in many cases adapted to the need of developing countries.

[www.icrp.org](http://www.icrp.org)

Material for education and training and abstracts of International Commission on Radiation Protection (ICRP) publications can be downloaded.

[www.IAEA.org](http://www.IAEA.org)

The website of Atomic Energy Agency (IAEA) contains information about legislation on ionising radiation in various countries.



# Electrical safety

*João José Barrico de Souza*

Some of the risks associated with proximity or contact with electricity, or even the use of electrical equipment, are immediate. Others, however, are only seen later, even after the contact or proximity with the equipment or electrical wiring has ended. For example, contact with electrically charged items, which causes an electrical shock, leads to immediate reactions, but can also have long-term effects due to the circulation of electricity in the body's internal tissues. Electrical arcs have immediate effects and cause burns because of the heat involved. They can also lead to later damage through loss of liquid, exposure of internal tissues, contamination, kidney problems, etc. Remaining close to equipment parts or wiring that generate intense electrical or magnetic fields is also a condition that in the long-term can cause problems within the body. This matter is still being researched.

## ELECTRICAL SHOCK

### Definition

There are many definitions we could give to electrical shock in trying to explain that uncomfortable sensation that nearly all of us have already experienced. For our purposes, we can simplify, saying that an electrical shock is a rapid

and accidental stimulus on the nervous system due to the circulation of an electrical current above certain limits. We should remember that we have an “instrument system” on the surface of our body that is sensitive to temperature, moisture, pressure and other physical stimuli and that transforms them into electrical impulses. These electrical impulses are sent directly to a central organ that coordinates and supervises this entire “instrument system” through electric signals received from every part of the body's surface. This “instrument system's” electrical signals circulate through a marvellous and immense network of “conductors” that, loosely speaking, we could say make up our nervous system. The central organ of our nervous system reacts to these electrical stimuli, determining the necessary reactions: involuntary (those that happen without a conscious decision), or voluntary (which happen because we make a conscious decision). This system's reaction is seen in the production of pulses of electrical current applied in a gradual and coordinated manner in the muscle tissue. This tissue reacts by contracting to these very light “electrical shocks” (in microamperes, which are millionths of an ampere).



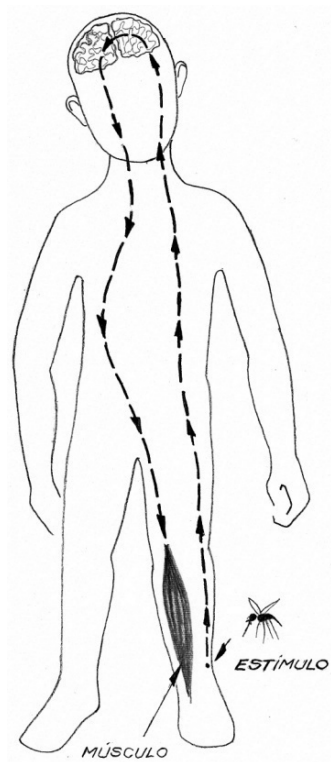


Figure 4.7.1. Muscle contraction due to external stimulus.

A system that operates both for sensitivity (instrumentation) and muscular activity (command) through extremely low-intensity electrical signals will suffer terribly if subject to electrical shocks hundreds or thousands of times more intense than those for which it is prepared. That is why we decided to include “above certain limits” in the definition of an electrical shock: our nervous system is based on the circulation of extremely low electrical currents and we do not consider these to be shocks. Live muscle tissue tends to contract when an electrical current travels through it. (This was Galvani’s great discovery.)

### Health effects

Shocks, which can be more or less serious, can have these *direct effects* on the body:

- Muscle contractions, the extent of which is related to the intensity of the shock, and is often responsible for the victim’s inability to release from the electrified item that is producing the shock, although others may be able to save the victims.
- Tetanisation, similar to a cramp, leaving the muscle tense and stiff, for some time, even after the shock has ended.
- Burns, which occur because of the heat generated by the flow of the electrical current. This can cause redness, blisters, deep burns and even char the tissue. These are more serious with high-voltage shocks, and deterioration of the epidermis is worse with higher electrical frequencies.
- Respiratory arrest, which can result from electrical current passing through the diaphragm, which is the muscle responsible for breathing. It can also occur indirectly when the electrical shock affects the respiratory control centre. In either case, the body loses its ability to oxygenate the blood, compromising the functioning of organs and, in a few minutes, of the brain, with irreversible damage.
- Cardiac arrest, which occurs when the flow of the electrical current causes the fibres of the heart muscle to flex excessively, “locking it”. Unable to beat, the heart stops circulating blood, depriving the organs of oxygen, including the brain, leading to the same irreversible damage as mentioned above.

- Electrolysis, which can occur in the blood and in other liquids in the human body. This is an important phenomenon where the shock comes from exposure to direct current. It causes the agglutination of mineral salts, coagulation and thrombosis that can lead to death. The change in the body's potassium balance is also important and can cause cardiac arrest.
- Fibrillation, which occurs when the heart muscle “loses its beat”. The heart stops beating in an orderly manner and starts to vibrate between 170 and 300 times a minute, but without pumping blood to be oxygenated by the lungs and without carrying the oxygenated blood to the organs. After a short time this causes respiratory arrest.
- The size of the contact area between the body and the conductor through which the current enters the body.
- The pressure established between the body and the conductor, which determines how good the contact is, thereby impeding or facilitating the passage of the electrical current.
- The nature of the electrical current, since the sensitivity is different for alternating current and direct current. Figure 4.7.3 shows that our bodies are most sensitive to frequencies between 15 and 100 Hz. This figure also shows the amount of current capable of stopping someone from being able to open their hand because of the electrical current flowing through the muscles that contract the fingers.
- With sufficiently high current there can be a muscular spasm which causes the affected person to grip and be unable to release from the current source. The maximum current that can cause the flexors of the arm to contract but that allows a person to release his hand from the current's source is termed the let-go current.

### Factors of seriousness

Factors that determine the seriousness of the shock include:

- The electric current's path through the body. What path the electricity takes, through where the electric current mainly passes and what organs it goes through.
- The intensity of the electric current. The more intense it is, the more serious the effects of its passage through the body will be and the more intense the muscular contractions will be.
- The time the shock lasts, even if measured in milliseconds and seconds, is of fundamental importance in determining its seriousness.
- The voltage, which is what causes the movement of the electrical charge (the current), and therefore the shock, through the body.
- The way in which the current is distributed through the body as it goes through it.
- The level of moisture on the skin, which increases or decreases the contact and flow of electrical current.
- Individual factors, such as health, physical constitution, body size, etc.

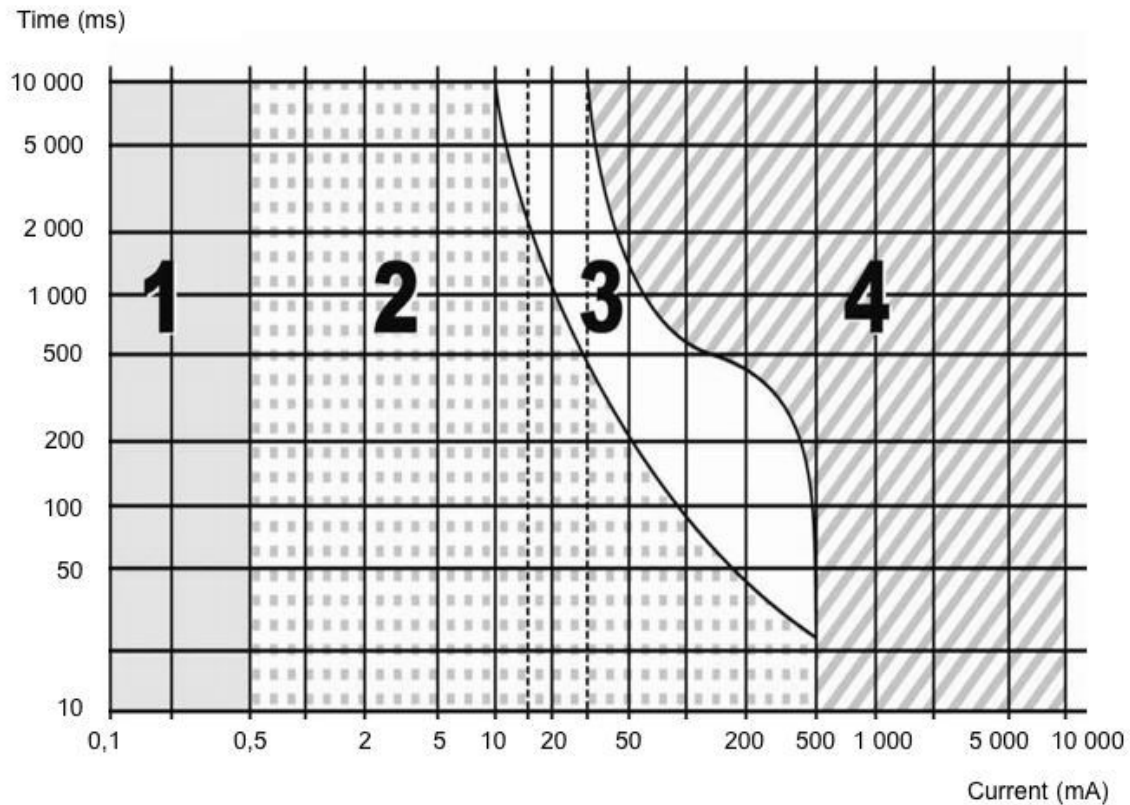


Figure 4.7.2. Zone 1: No perceptible effect. Zone 2: Generally non-harmful physiological effects. Zone 3: Generally reversible notable physiological effects (cardiac arrest, respiratory arrest, muscle contractions). Zone 4: High probability of serious and irreversible physiological effects (cardiac fibrillation, respiratory arrest). Source: IEC Publication 479-1

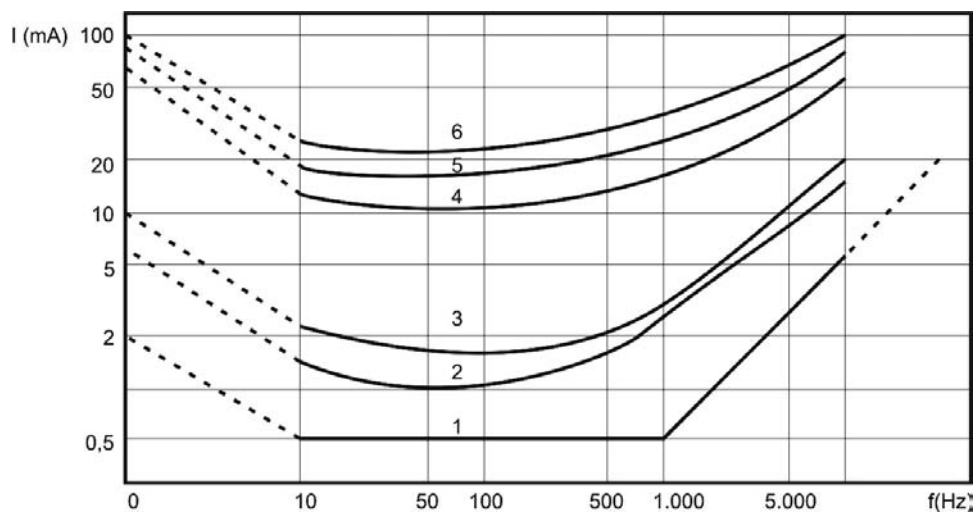


Figure 4.7.3. Influence of the frequency: 1. Conventional limit of the amount of current from which no reaction normally results. 2. Beginning of perception for 50% of people. 3. Beginning of perception for 99.5% of people. 4. Current at which 99.5% of people let go. 5. Current at which 50% of people let go. 6. Current at which 0.5% of people let go.

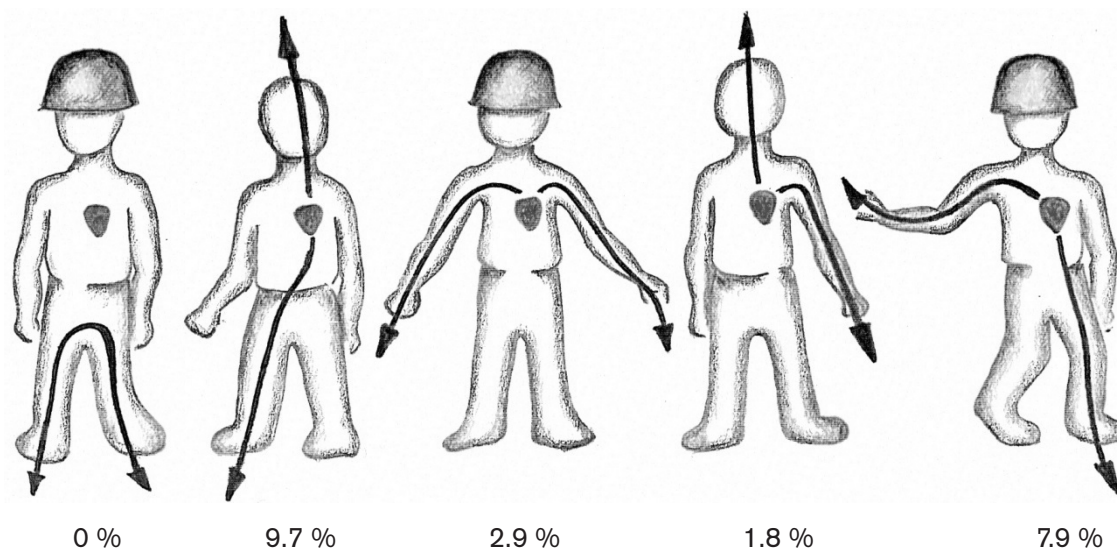


Figure 4.7.4. The percentage of the shock current that goes through the heart in some of the possibilities of contact between the body's extremities and conductors at different voltages.

### When and how does it occur?

Electrical shocks happen whenever a person simultaneously touches two points with different voltages. This may occur when one touches two conductors of an electrical circuit at the same time, or touches one conductor while another part of the body is in contact with a conductor having a different voltage. Since in the great majority of cases one of the conductors from the source, generally called the “neutral conductor”, is connected to the ground at the origin of the wiring, and since we walk with our feet on the ground, we are always connected to the ground and, through it, to the source’s grounded neutral conductor.

Electrical shocks can be divided into shocks caused by direct and indirect contact. Electrical shocks through direct contact are those caused by the body’s contact with an energized part that was designed to be energized when the wiring is in normal operating condition. Direct shocks occur when a person touches a wire, cable, bus-

bar or any other part of the wiring or equipment that is a conductor (outlet screws, receptacles, etc.) while simultaneously in contact with another object with a different voltage or with the ground itself (to which the neutral conductor is also connected), the voltage of which is considered equal to zero.

Electrical shocks caused by indirect contact, on the other hand, are those that occur when a person touches any conductive part that was not designed to be energized but that is so temporarily because of some failure or defect in the wiring or the equipment. Examples of this are shocks from motor casings, doors and casings for electrical equipment and casings for machinery or electrical tools.

### Who is exposed to shocks?

Everyone, by simply using electrical equipment, is prone to shocks through indirect contact because of defects in the equipment or wiring or from using electrical instruments, apparatuses

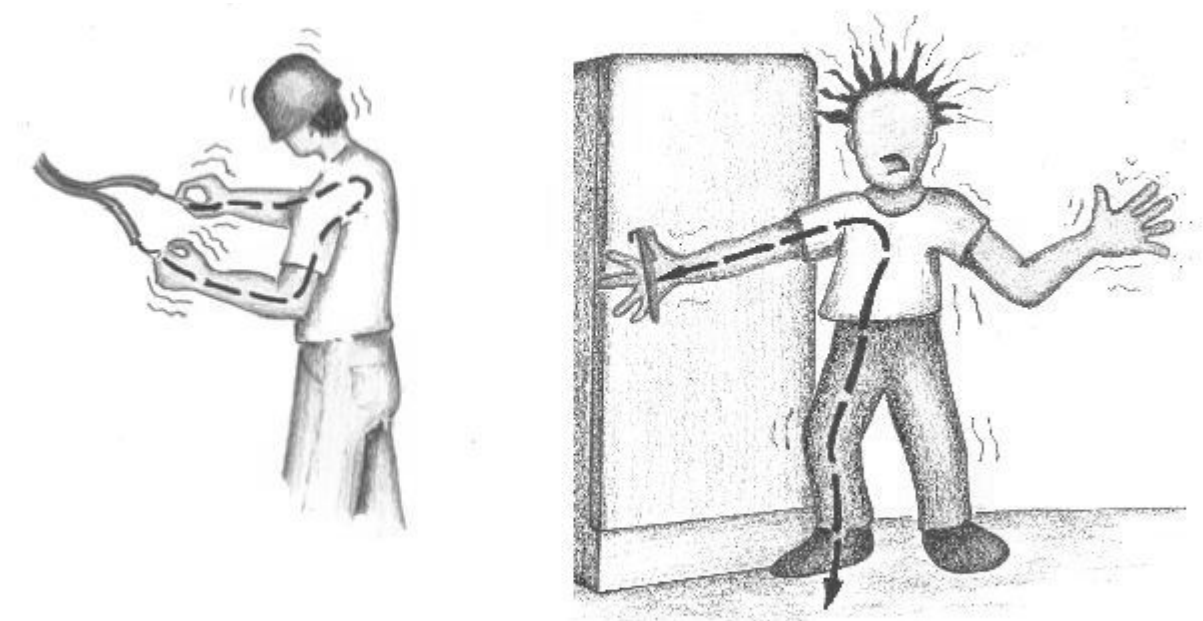


Figure 4.7.5. Direct shocks occur when a person touches an electrical wire and the ground, or another object with a different voltage; at left one hand on each wire, at right an indirect contact.



and tools improperly. Electricians and people involved with electrical wiring and services are naturally more prone to shock through direct contact for obvious reasons: they do their work near energised parts, from which the protective casing has been removed to allow the examination and handling of the equipment and tests on electric circuits.

## ELECTRICAL ARC

### Definition

An electrical arc consists of the passage of an electrical current from one conductive point to another through a gaseous medium. The intensity of the arc depends, among other things, on the voltage, the capacity of the source and of the resistance of the medium in which occurs.

### Danger of electrical arc

The temperature of electrical arcs is extremely high and the heat they generate is propagated by conduction, convection and radiation. An electrical arc has enough energy to burn clothes and cause fires. It emits vaporized materials, infrared, luminous and ultraviolet radiation, as well as causing a large pressure surge when it happens in an enclosed space, such as electrical panel compartments and the area around them. This great internal pressure increase results in the parts and material of the cabinet itself being blown out, in what we normally call an explosion.

### Where does it occur?

An electrical arc occurs whenever there is a break in an electric circuit, which can occur safely in perfectly controlled conditions or totally out of control, with very serious consequences. When an electrical arc is not controlled it does not extinguish itself quickly and safely,

but creates an area of air that has been ionized by the arc itself. This ionized air, being a better conductor, can establish a path for the electrical current between close parts with different voltages, creating the conditions for conduction from one metal conductor to another in a generalized manner. When this happens, the current in the arc can reach very high levels.

Characteristic situations for the occurrence of dangerous, but frequent, electrical arcs include accidental contact between conductors (short-circuits); opening switches on charge; errors in the insertion or removal of removable parts in energized circuits; or errors or the inappropriate use of testing equipment to measure voltage or look for defects. Arcs can also happen in certain climatic conditions because of sudden changes in environmental conditions, such as when opening the doors of electrical cabinet panel boards.

When there is a defect in which an arc occurs, the high temperature first melts the metal conductor, which is usually copper or an appropriate alloy, and then vaporizes the metal. When it melts, the metal's volume increases slightly. When it vaporizes, however, its volume increases several thousandfold (more than 50,000 times). Although only a small amount of copper is involved, the rapid expansion releases a great deal of energy in the form of a mechanical wave (the pressure surge). In addition to the strong pressure resulting from the change in the material's state (from solid to vapour), extremely high temperatures warm the air in the same way as lightning, and like lightning they are accompanied by a sound caused by the rapid expansion of air that is heated by the lightning current. Lightning is nothing more than an electrical arc in which the voltage and the current are extremely high and the duration extremely short.



### Exposed groups

Workers who operate, maintain or work near energized equipment without adequate protection or in any way that is not recommended are exposed to electrical arcs. It bears remembering that some operational processes, precisely because of the high temperatures they cause, involve electrical arcs, but in fully controlled situations. These include arc welding, special lighting and certain types of electrical furnaces.

### SECONDARY OR INDIRECT INJURY

#### Falls after shock

*Falls* should be considered an *indirect effect* aggravating the *direct effect* of the passage of the electrical current through the body. There are a considerable number of accidents in which electricity was merely the triggering event that momentarily caused a loss of muscle control and equilibrium, the serious consequences – which may result in irreparable harm – being due to falls from substantial heights. The impacts caused by the violent and uncontrolled muscular reaction during a shock causes sore muscles, and frequently fractures. In some cases it can extend the effects of the shock beyond the first victim, as for example when tools or materials being used for work are involuntarily thrown.

### ELECTRICAL RISKS TO PROPERTY

#### Fire

Fire is one of the most serious property risks and can cause very large losses. Electrical fires are almost always associated with conductor overheating caused by overloads; deficient contacts; or sparks, which are also small electrical arcs. These events, which are the initial cause, are multiplied and intensified as the fire develops.

The heating of the conductors by the passage of the electrical current is completely natural

and expected. What causes the damage however is overheating – heating beyond normal limits near combustible materials such as wood, paper or fabric, or flammable liquids, to electrical equipment or wiring. This is why ways are always created to dissipate the heat generated in the normal operation of electrical devices and equipment.

There are various ways to dissipate the heat. They include fans attached inside the motors, which dissipate the heat generated in the coils; ventilation slats in the casing for semiconductors in electronic equipment; placing lighting ballasts on supports made of resistant and non-flammable materials; or radiators of liquid-insulated transformers. These ensure operation at a temperature that is not harmful to the surrounding area.

#### Explosion

An explosion is simply an extremely violent oxidation reaction that happens when there is a particular mixture of oxygen (present in the atmosphere) and a flammable or explosive substance. For the reaction to take place there must be a source of ignition. This can be the abnormal heating of a surface or a spark that begins the combustion, which propagates through the entire mixture in the environment.

#### Electrical arc occurring in potentially explosive atmosphere

Certain measures should be taken to guarantee safety when equipment that causes arcs, such as isolating switches, contactors, general use switches and circuit breakers, need to be installed in environments containing potentially explosive mixtures, or when electrical equipment that generates heat needs to operate in these environments. There are various methods for installing electrical wiring and equipment in

hazardous locations. The methods are described in standards and the materials used follow strict manufacturing, assembly and use guidelines.

Not only gases and vapours from flammable liquids require special wiring. There are also certain types of dust and fibres that, when suspended in the air, create a potentially explosive mixture. Chemical plants, oil refineries and gas plants, grain processing plants and many others may contain areas considered hazardous locations. Strict procedures should be adopted for the materials, services and tools used in areas subject to the occurrence of explosive mixtures. This is the case even when electricity is not involved since tools can cause sparks on falling and hitting other hard materials.

### PREVENTIVE ACTIONS

Preventive action against electrical shocks can be divided into those that ensure the safety of people against shocks coming from direct (with live parts) or indirect contact.

One of the most effective measures to ensure people's safety against direct or indirect electrical shocks is to use extremely low voltage that cannot harm the body. This method requires taking a number of steps in regard to the source of the current, separation of the conductors and nature of the electrical current (direct or alternating). Called safety extra low voltage, this method is used in laptop power sources (15 to 19 VDC), fixed-line telephones (48 VDC), swimming pool lighting (12 VAC) and many other applications that make it safe to use the equipment in any situation regardless of the users' actions. These measures protect people in cases of both direct and indirect contact and therefore do not require additional protection measures. The use of these protection measures is intimately related with the environmental conditions (moisture, proximity with conducting parts

and others to be considered through analysis, in each particular case). When other methods are used to protect people, additional measures should also be taken: at least one kind to protect against direct contact and one other against indirect contact. There are also situations of greater susceptibility to shock that require additional protective measures to guarantee people's safety.

### Protection of people against direct contact

People can be protected against the effects of direct contact with measures such as:

- a) Live parts insulation, which consists of applying an insulating material to conductors that impedes all contact with the wiring's live parts. This insulation must be such that it can only be removed by destroying it. Paint, varnish, lacquers and similar products applied directly to conductors are not sufficient insulation to protect people against direct contact.
- b) Shields and enclosures are also meant to block all contact with the live parts of the wiring. The live parts (voltage different from the ground) must be inside enclosures or behind barriers that do not allow fingers (12 mm diameter) to be inserted to touch any energized

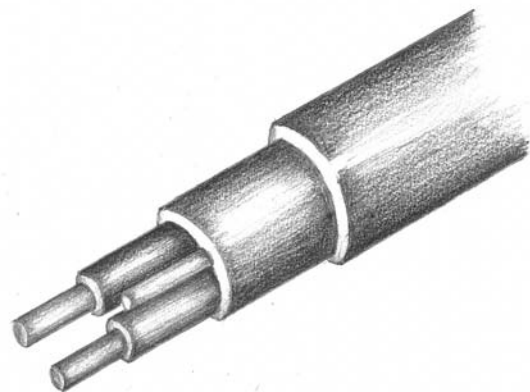


Figure 4.7.6. Example of insulation of electrical conductors.

part. The barriers and enclosures must be securely attached and sufficiently robust and durable to maintain the appropriate degree of protection and separation from the live parts in normal service conditions, taking into account the relevant external influence conditions. It should not be possible to suppress the shields or to open the enclosures or covers or to take off parts of the shields or covers except with a key or tool; or until after the live parts protected by these shields, enclosures or covers have been disconnected from power and cannot be reconnected until the shields, enclosures or covers are put back in place; or until a second shield or installation that cannot be removed without the help of a key or tool and that blocks any contact with the live parts has been put in place.

- c) The use of obstacles, which are items meant to block accidental contact with live parts, is another protective measure against indirect contact. The obstacles should block an unintentional physical approach to the live parts (for example, through screens or panels over the isolating switches), but not intentional contact by a deliberate attempt to get around the obstacle. Obstacles may be disassemblable, even without a tool, but must be fixed and cannot be accidentally removable. Note that this protective measure is considered partial and that its effectiveness depends on the knowledge and training of the people being protected. It does not protect just anyone, only those who have been told, which is to say those who have sufficient information and knowledge to avoid the harmful effects of electricity. These are normally operating and maintenance personnel and technicians in general who have been trained and instructed and are therefore authorized to remain and

work close to installations that have only this type of protection.

- d) Placing them out of reach (which can also be a partial protection measure) consists of keeping conductive parts with different voltages at a distance. In other words, the conductive part with a different voltage should not be placed within normal reach. Placing them out of reach is only intended to impede accidental contact with live parts.

Parts that can be accessed simultaneously must always (whether in a normal situation or defect situation) be at the same voltage.

horizontal above the floor .....	1.25 m
horizontal beneath the floor .....	0.75 m
vertical above the floor .....	2.50 m
vertical beneath the floor .....	1.25 m

These measurements can be changed according to the use of the locations and objects handled.

- e) The installation of ground fault current interrupter (GFCI) DR devices is an additional protection based on monitoring the currents that flow in a circuit's conductors. They work in such a way that when there is a difference between the current that "enters" and the one that "exits" through the conductors of the same circuit above a certain amount, the device immediately isolates the conductors. These devices are especially necessary to protect outlets installed in moist locations or feeding equipment meant to be used in moist locations or outdoors. This is not a complete protection measure and in no way makes it unnecessary to also employ other protection measures against direct contact. The use of these DR devices is more effective for protection against indirect contact. Using a DR with a minimum sensitivity of 30 mA

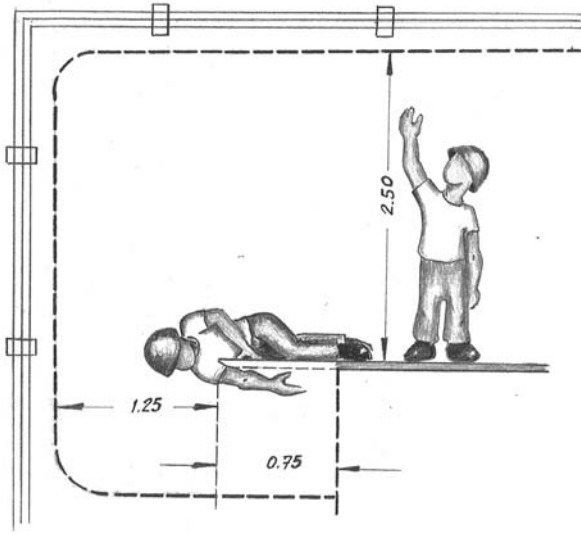


Figure 4.7.7. Conductive parts with different voltage should not be placed within normal reach.

protects against cardiac fibrillation and a DR with a minimum sensitivity of 10 mA protects against the victim being unable to let go.

### Protection of people against indirect contact

**Grounding**, as a precondition for protection, consists of actually and intentionally grounding all the casing and conductive parts that are not part of the wiring and that may, in a defect situation, become dangerous. Grounding is used in a number of techniques for protection against indirect contact. The basic principle of this protection method is to maintain the conductive parts that can be touched at the same time by any part of the body at the same voltage, which is to say equipotentialized, such that a simultaneous contact between any two points, whether between two objects or an object and the ground, does not lead to a current flowing between these points since they are already at the same voltage.

Together with keeping parts that can be touched at the same time at the same voltage, and depending on the grounding system of the wiring that supplies electricity, some variations of protection measures can be used that result in an automatic break of the power supply.

**Automatic break of the power supply**, which consists of establishing a good path (with low electrical resistance) between the external conductive parts that are not meant to conduct the electrical current and a point at the origin of the wiring, properly grounded (normally the earth). This causes the necessarily rapid operation of the fuses and circuit breakers, and thus the disappearance of the dangerous voltage between the accessible surfaces. This is certainly one of the most-used protection measures because it uses devices that are already necessary and that are in the wiring for protection against overcurrents, overloads and short-circuits. It should be observed that for this method to function satisfactorily, the protection elements and the conductors of the earth (protection) system must be adequate to each other and the protection earth conductor must actually be connected to the neutral point of the power source, making the operation of the protection elements operate in the shortest possible time and within the limits of the standards established as a function of the contact voltage and local conditions (dry or moist).

Fuses and circuit breakers operate more rapidly when the current flowing through them is higher. This is why we say the operating time is inversely proportional to the amount of the current. Therefore, if we establish a good path (low resistance) for the earth loop impedance electrical current between the energized casing and the grounded neutral point, we are able to make the current assume very high values, and thereby cause the rapid operation of the protection de-

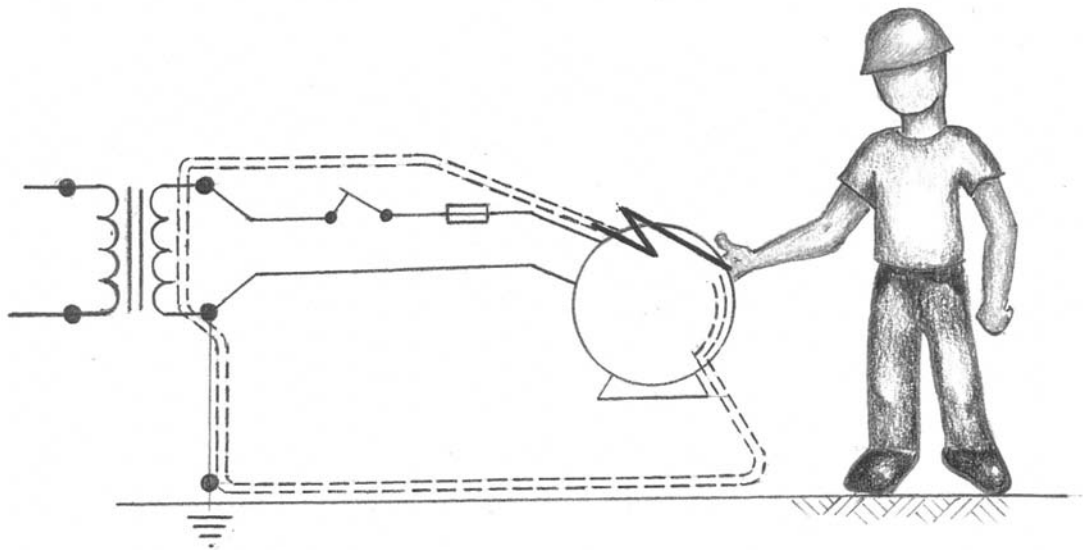
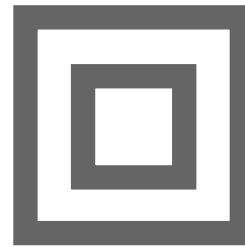


Figure 4.7.8. Automatic break of power supply.

vice. This eliminates the dangerous condition by automatically breaking the power supply. There are variables to be considered when the origin of the wiring is not directly grounded or when the casings are connected individually or in groups to independent grounds.

**Use of equipment class two or equivalent insulation.** This is equipment that has been tested and given double or reinforced insulation (Class II) or manufactured with complete installation. This equipment is marked with the symbol to the right (red pictogram on white bottom) on its identification label together with its nominal data.



To this class belongs also equipment that has received additional insulation over its basic insulation or that has received reinforced insulation and that guarantees safety conditions equivalent to those required for double insulation. The same principle applies to fixed wiring within buildings when associated with the choice of enclosures that, in addition to impeding access by fingers, are made of an insulating material. The case is an enclosure that protects against direct contact, and the plastic material of the case – because it is an insulator – impedes an internal



defect from causing a shock to someone who accesses the case from the outside.

Some situations and equipment require the use of **non-conducting locations**. This consists of guaranteeing some of the characteristics of the place and the wiring, so that these locations can be used for class zero (0) equipment, which requires only basic insulation. In these environments it should be impossible for people to simultaneously touch two exposed parts or conductors that may have different voltages should the basic insulation fail. It should not be possible to connect equipment with the protection earth. Obstacles – preferably insulating – should be interposed if necessary; walls and floors should have high resistance (50 k $\Omega$  for voltages of up to 500 V and 100 k $\Omega$  voltages higher than 500V.) Finally, if two or more pieces of equipment are used close to each other in these locations, they should be connected using an equipotential bonding conductor. This means of protection involves many variables and is difficult to put into practice. For this reason, it will be restricted to highly specific situations. However, some of its requirements are used as additional protection, such as placing mats around places for handling switches and circuit breakers, in front of electricity cabinets, work and test benches.

Another measure used to protect against indirect shocks is **protection through electrical separation**, at which the origin of the wiring – the source – is a Class II separation transformer. Here, there are limits to the operating voltage and circuit length. This means of protection is useful in critical processes such as those in operating theatres or critical industrial processes that electrical faults must not be allowed to interrupt. On first failure, the equipment can continue to operate safely until this first failure is repaired.

### Protection against thermal effects

Electric currents always involve the heating of conductors. Therefore, electrical equipment in which currents pass will heat up. These temperature rises are acceptable within specific limits, but are undesirable when they are able to harm people. They must therefore, just like the fixed components of an electrical installation and adjacent materials, be protected against the harmful effects of heat or thermal radiation, and especially the risk of burns, produced by the electrical equipment. Other risks involve compromising the safe functioning of wiring components, and the combustion or deterioration of materials.

Because fires can be caused by wiring malfunctions, the recommendations of the electrical equipment's manufacturer should be observed. Installations should be performed so that the part whose external surfaces could reach temperatures that are dangerous to the vicinity should be assembled using heat-resistant supports or separated by heat-resistant materials or so that the heat this equipment generates is dissipated.

When the equipment generates arcs in normal operation, it must be covered with resistant material, separated by resistant material or have a device to contain and/or extinguish the arcs, as shown in the previous item. Safe distances should be ensured when there are focalization effects, so that exposure to the thermal radiation does not cause a potentially dangerous temperature increase. This happens with heating resistors placed in reflectors that direct concentrated heat over surfaces. When using inflammable insulating liquids, as with transformers in oil baths, measures must be used to prevent inflammable liquid from spreading in the event of a leak. Protective measures should be taken at the installations to prevent flames, smoke and toxic gases and liquid spillages. People can also be



burned as a result of heat that occurs normally due to the flow of electric current. Therefore, the accessible parts of electrical equipment that are located within normal reach must not reach temperatures that could cause risks within the vicinity, but must remain within the temperature limit stated in the equipment's technical specifications.

### Protection in the installation

Protection against overcurrents (overloads and short circuits) is a basic requirement for installations. It is of fundamental importance that the installation's design conditions are preserved, maintaining the compatibility between conductors and protection devices (circuit breakers and fuses). By doing so, if overcurrents occur, the protection devices come into operation, averting damage to the conductors and avoiding heating or mechanical forces that could compromise the safety of the installations. The installations should also be protected against surges caused by atmospheric discharges and interference from manoeuvres or from other, higher voltage circuits, to protect the safety of people and preserve property. Tools or machines that have been switched off due to an accidental loss of power should contain devices that prevent them from automatically operating once power returns, avoiding potential electrical and mechanical risks to workers.

### PLANNING AND PROCEDURES

When planning, the wiring blueprint should take into account not only the aspects related to correct and safe operation, but also conditions for maintaining and conserving the installations, maintaining adequate lighting, work space, using devices that provide temporary earthing, lock out and tag out and access and locations that are compatible with the needs of electricians to

avoid undesired exposure to the effects of electricity. A plan report should describe the protection methods, the principles, the characteristics of the equipment that composed the installation, as well of the conditions of usage and materials that are expected to be manufactured, handled and stored in the respective buildings, since this will be the condition for usage, and safety begins with the plan when the installations are designed.

When working with electricity, procedures are fundamentally important. The procedures should be developed after a risk analysis that should involve the workers. The procedures should also contain all material and human resources for the safe performance of the tasks, with a step-by-step description and a list of safety steps and measures in a single document. The conditions preventing the performance of the tasks should also be mentioned in the procedures.

The main protection measure for services in the electrical installations is undoubtedly **de-energisation**, which ends up being part of other specific procedures. De-energisation is a group of coordinated, consecutive and controlled actions that guarantee the shutdown of power in the circuit, section or work station during the intervention and under the control of the workers in question. For an electrical installation to be de-energised and released for service, the pre-established sequence shown in the picture below must have been followed:

1. Actual shutdown (*disconnection*) of the electrical energy;
2. Preventing re-energisation (*Locking the electrical energy shutdown device*);
3. Proving the absence of energy (*using an appropriate tool*);
4. Earthing the circuit or electrical assembly with equipotentialization of the circuit conductors;
5. Warnings.

### Disconnection

Is the act of fully discontinuing the electricity by manually or automatically removing the electrical voltage through an appropriate device (disconnect switches; switch; circuit breakers). An alternative means is to use an appropriate tool following specific procedures.

### Preventing re-energisation

This involves guaranteeing that the disconnection is not reversed, to ensure the worker's safety in controlling the disconnection. In practice this means using mechanical locking using locks, padlocks and other locking devices or equivalent IT systems. The trained and authorised professional should use a disconnection device locking system to guard against the circuit being involuntarily or accidentally re-energised during the power stoppage. In large-scale buildings, in which there may be more than one electrician carrying out repairs in different places, the risk of inadvertently energising the circuits is extremely high. The risk in this situation can be eliminated by using the same number of padlocks as there are electricians working on-site.

By doing so, the circuit can only be switched on again when the last worker finishes their task and unlocks the switch(es), circuit breaker, cabinet, panel, etc., after finishing the services the clearance procedures should be used and the circuits switched on again after checking that all equipment is switched off through its command

devices. De-energisation one or all of the circuits in an installation should always be scheduled and widely publicised. This should prevent problems and accidents that might otherwise be caused by a sudden power stoppage. Re-energisation should also be authorised after notifying everybody involved.

### Proving the absence of energy

This is verifying the actual absence of any voltage in the circuit conductors. This check should be carried out using measuring devices that have been tested before and after the check. The check can be carried out through physical contact or approximation using specific procedures. The category of the instrument being used should be observed due to the possibility of electrical arcs being caused by measuring and checking live parts.

### Installing temporary earthing with equipotentialization of the circuit conductors

Having proved there is no power, a temporary earth conductor should be connected to earth and the system's neutral – if applicable – and to other accessible structural conductors. Following this, the earth groups should be connected to the phase conductors that have been previously switched off, therefore creating the same voltage between all of the conducting parts at the work location.

### Warning signs advising of cuts in the power supply

Appropriate safety warnings should be used to warn people and to state the reason for the de-energisation and the details of the person responsible. Cards, notices or stickers warning of the locking or lock-out must be clear and properly attached. If an alternative method is used, specific procedures must ensure communication of the condition that prevents energisation to all

potential system users. Only after the services have been concluded and no abnormalities have been found will the worker remove the tools, equipment and utensils and finally, the individual locking device and corresponding sticker. The person responsible for the services, after general inspection and certification of the removal of all locks, cards and lock-outs, will remove the earthing wiring and then follow the procedures for clearing the electrical system for operation.

### Summary comments

- 1) Disconnection should be carried out using the established procedure with communications and other protocol measures.
- 2) Whenever possible, the earth grips connected to the switched-off circuit phase conductors should be of a type that prevents the worker from getting close to them.
- 3) All energised elements existing in the vicinity of the work place (places that are simultaneously accessible) should be protected against accidental contact. They should be insulated using wraps, piping, or covers made of insulating material.
- 4) Other warning signs should be used to perform electrical services and the area should be cordoned off.
- 5) If there are irregularities or it is impossible to proceed in the manner expected, the person responsible should be informed immediately.
- 6) The wiring should be kept de-energised until the authorisation is received to re-energise. Re-energisation should only take place following these procedures:
  - a) Removal of all tools, equipment and utensils.
  - b) Removal of all workers not involved in the energisation process.
  - c) Removal of the energisation prevention warnings.
  - d) Removal of the temporary earthing of the equipotentialization and of the additional protections.
  - e) Unlocking, if any, and switching on of the disconnection devices.

## SAFETY INSPECTIONS

A safety inspection is an excellent tool for managing health and safety. It is made up of checks or inspections (observations, tests, measurements, evaluations) following systematic procedures. These procedures are aimed to ensure that procedures, systems, equipment and devices are always kept in perfect operating conditions, or other methods and actions taken personally meet the set standards or requirements. This equates to preventive measures to guarantee

the company's functional and organisational capacity. Safety inspections should be planned and carried out individually or in groups, using standardised documents such as checklists and forms, or simply by a visual inspection at the established or required frequency. They should always produce trustworthy and reliable records. Inspections are normally carried out on wiring, equipment, devices and procedures, to verify the set specifications, to discover abnormal operation, imperfections, improper behaviour, etc.

### Examples of inspections

- Work environments in classified areas (fires and explosions), aggressive areas (corrosion, humidity, toxic, asphyxiants, contaminating and radioactive)
- Electrical wiring where the services will be performed (rooms, cabins, cabinets, panels, posts, towers, systems, wiring, cases, platforms, etc.)
- Vehicles, machines and equipment (electrical and mechanical)
- Manual equipment and tools
- Personal protective equipment, PPE (gloves, shoes, etc.)
- Collective protection devices (earthing connections, cherry pickers, gas detectors, voltage detectors, rods, lighting equipment, insulating floors, work platforms, ladders, locking devices for dangerous energy sources)
- Material for signs (stickers, banners, trestles, identifying tape, cones, etc.)
- Inspection of fire extinguishers, hydrant systems and sprinklers
- Inspection of order, tidiness and cleanliness
- Final inspection of removal of materials, tools and equipment
- Elimination of the risk conditions
- Removal of warning signs.

## PERSONAL PROTECTIVE EQUIPMENT

Although personal protective equipment (PPE) is an extreme resource used when collective protection measures do not guarantee the necessary levels of safety, it is often used with electricity by workers who need to remove the screen and shield or also needs to be close to live parts to perform their tasks. PPE is used when the collective measure is not technically viable, when it is being implemented, when the existing measures are not entirely dependable or for emergency situations. Therefore, all workers (assistants, electricians, technicians, engineers, managers) involved in activities that are subject to electrical risks must use personal protective equipment that is appropriate for electrical risks, and other equipment when there are other risks at the workplace. Personal protection equipment, or PPE, means all devices all products for personal use used by the worker to protect him or herself against risks that could threaten his or her health or safety at work. Similarly, combined personal protective equipment means all equipment made up of several devices which the manufacturer has designed to protect against one or more risks that could occur simultaneously and that could threaten health and safety at work.

Appropriate PPE must be provided to workers for free and in a perfect state and operating condition. Use of the PPE should be implemented with worker orientation and training on appropriate use, safekeeping and conservation. Cleaning, maintenance and tests should be performed periodically following specific procedures. Workers should use the PPE only for its intended purpose, and be responsible for its upkeep and conservation, informing the employer of any changes that make it unsuitable for use. To perform their functions, workers should use their PPE in the situations and activities described below.

## Whole body protection

### *Work clothes*

This is safety clothing to protect the whole body. To protect the body against electric arcs, clothes should be chosen by taking into account the thermal energy that could potentially be generated in the many work places within the company's premises. The regulations provide that the clothes' characteristics must last their useful working life. These characteristics include resistance and flame resistance, as well as thermal insulation for its user. For protection against other agents, the PPE must also be appropriate. Remember that, for outdoor tasks, clothing must have reflectors and be of an appropriate colour. Where there are bees, wasps, etc. on posts or structures, clothing that is appropriate for insect removal should be used to free the area for the electrical services. Glasses and visors with safety lenses are also mandatory to protect against sparks from electric arcs.

### *Conducting clothing for power source services (live wire)*

Aimed at protecting workers against the effects of the electric field when performing service with live parts. A jumpsuit made of metallic material, gloves, hat and wellington boots made of the same material. It must also have a flexible mesh fixed to an insulating stick that will be connected to the wiring to keep the worker equipotentialized with the voltage of the wiring in all its points. It should be used with voltages of 66 kV or more.

### *Head protection*

Safety helmet to protect against impact and electric shocks aimed at protecting against head injuries from falling objects and to insulate it against electric shocks of up to 600 Volts. Should be used with the harness tightly securing the top

of the head and the strap passing under the chin to avoid the helmet falling off. They should be replaced when they are cracked, have holes, are out of shape or have excessive abrasions. The harness should be replaced when it is out of shape or in poor condition.

#### *Eye and face protection*

Safety glasses aimed at protecting workers against eye injuries from flying particles or exposure to harmful radiation. Every electrician should have safety glasses with lenses that protect against the specific risks of each activity. This could involve transparent lenses to protect against flying objects or coloured lenses to protect against bright light or other rays, be they sun's rays or potential arc flashes from working with devices or on live wires.

### **PPE for upper limb protection**

#### *Insulating safety gloves*

Insulating safety gloves for protection against electric shocks, aimed at protecting workers' hands from touching energised wiring or parts. Gloves not only come in a variety of sizes but offer different levels of insulation, which should be specified to ensure the glove is used correctly. They should be used with leather gloves to protect against puncturing and other injuries. Neutral talcum powder should be used inside the gloves to make them easier to put on and take off.

Insulating gloves should be inspected before use and periodically tested to ensure their insulation capacity. Gloves that have punctures, are torn, out of shape or in poor condition or have failed the electrical tests should be rejected and replaced. There are 6 classes of gloves: 00, 0, 1, 2, 3, and 4, and they come in 9 sizes (8; 8.5 to 12).

#### *Leather gloves*

Made using the appropriate leather and with fine stitching to ensure the maximum flexibility for the user's fingers. Leather gloves are used on top of the insulating gloves to protect against punctures and cuts from sharp and abrasive objects. These gloves have a fastening device with adjustment clips above the wrist.

#### *Safety gloves for protection of hands against abrasive agents*

Made from leather filings or thin, lining leather with reinforced stitching, these gloves protect the hands against cuts, punctures and abrasions. Workers should use these gloves when they handle abrasive or sharp materials but do not need great dexterity or precise finger movements.

#### *Safety sleeves for arm and forearm protection against electric shocks*

Made from insulating material, these are to protect workers against arm and forearm contact with energised wiring or parts. Sleeves normally offer insulation up to 20 kV and come in several sizes. They have straps and buttons that fasten to each other around the worker's back. They should be used with insulating gloves. The sleeves should be inspected before use and periodically tested to ensure their insulation capacity.

### **Protection of lower limbs**

#### *Safety shoes for protection against mechanical agents and electric shocks*

Aimed at protecting workers against accidents caused by ground irregularities and instability, avoiding slipping and providing insulation up to 1 000 Volts (touch voltage and step voltage). Safety shoes for electrical tasks should not be made of metallic components that could reduce their insulation.



### *Safety leggings for leg protection against electric shocks.*

Made from insulating material, leggings aim to protect workers against thigh and leg contact with energised wiring or parts. Leggings normally provide insulation up to 20 kV and come in a variety of sizes. They should be used with shoes appropriate for the electrical tasks. The leggings should be inspected before use and periodically tested to ensure their insulation capacity.

### **PPE for protection against falls from heights**

#### *Safety harness with lanyard*

The safety harness/lanyard system is aimed at protecting employees against vertical falls. Their use is obligatory when working at heights of more than 2 m from ground level. The safety belt should be placed around the pelvis (a little higher than the buttocks) so that if the worker does fall, the force of the impact will not injure his or her spine.

#### *“Parachute jumper” safety harness*

This harness is made of highly resistant nylon strips with high-resistance stitching and fastenings. The support is spread out using straps that are fixed around the thighs, thorax and back. The support is located in the strips over the back and front of the body. Together with a falls locking device, workers can safely and efficiently perform climbs, descents or rescues.

#### *Falls locking device*

The falls lock safety device is aimed at protecting users against falls from vertical or horizontal operations, and must be used with safety harnesses that protect against falls.

### **PPE for protection against other risks**

For electrical services at locations where there are other risk agents, other specific and appro-

priate PPE should be used to protect against those agents. These include:

- Purifying air respirator to protect respiratory system against dust, mist, gases, smoke etc;
- Ear protectors to protect the hearing system when the worker is exposed to sound pressure (noise) that exceeds regulatory recommendations;
- Clothing that is appropriate for the chemical risks, moisture, heat, cold, etc., that may be present in the environment;
- Safety shoes that protect against humidity;
- Safety gloves to protect against mechanical, chemical and biological risks;
- Others due to the specific nature of the additional risks.

### **WORK TOOLS**

All tools used on energised wiring or that could be accidentally energised must have handling areas (handles, gauntlet) covered with appropriate insulating materials. Electricians' normal work tools include pliers and screwdrivers. These, in fact, become extensions of their arms and must be appropriate for the task, be properly maintained and be in perfect condition for their functions, (sharp for cutting, adjusted for grasping, screwdrivers are sharp to prevent them slipping off screws). Pliers' handles and screwdriver handles and stems must be properly insulated.

To perform their tasks safely, electricians also need this equipment:

- Extendable ladders and step ladders (insulated);
- Cases and bags to transport tools;
- Rubber mats with special insulation or wooden platforms;
- Insulating rods and sticks;
- Temporary earthing groupings;
- Cherry pickers;

- Safety harnesses and tool belts or jackets, and
- Measuring equipment (ammeters, voltmeters, voltage detectors etc.)

The tool used in electrical tasks must be appropriate for the voltage, be periodically inspected and, in some cases, be tested and certified, in accordance with statutory provisions.

### FIRST AID AND TRAINING

Being prepared to provide first aid is very important. However, it is of fundamental importance that those who work with electricity understand how electric shocks can injure them, how shocks travel through the body, as well as their effects. They must also clearly understand how protective and safety measures work and operate and why they are necessary, at installations as well as in electrical activities and services.

Training includes educational and organised activities that aim to improve ability. Ability is nothing more than an amalgamation of teachable skills and actions. Training for electricity should include understanding responsibilities and should be systematic and continuous. It should include risk analysis techniques and develop the ability to predict occurrences, anticipating the risk. Training should focus on operational procedures and provide for conditions that make the training more efficient. It must be comprehensive and include the many types of worker involved in the tasks. Training for electricity is of paramount importance because identifying risks essentially depends on having a technical understanding of electricity. This is because our senses are unable to spot the risks of serious harm that electricity can cause. Therefore, training for electricity must be based on technical knowledge and safety, so that the worker can then be authorised to work with electrical installations or in their vicinity.

### SUGGESTIONS FOR FURTHER READING

IEEE (1998). Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems. The Yellow Book, IEEE, Std 902-1998

This guide provides plant engineers with a reference source for the fundamentals of safe and reliable maintenance and operation of industrial and commercial electric power distribution systems.

Fordham Cooper, W (1986). Electrical Safety Engineering. Butterworths.

Concerning electrical engineering and safety measures.



# Fire safety

*Håkan Frantzich*

## CAUSES AND CONSEQUENCES OF FIRES

### Causes

Fire not only causes fatalities amongst man and animals but also damages property and the environment. There are many examples of fires resulting in large numbers of victims, including fires in occupational settings that have resulted in a disproportionately large number of fatalities due to blocked or locked escape routes. Fires also cause injuries such as burns and complications due to smoke inhalation. Property loss is generally related to damage to buildings and contents.

In occupational settings, fire can disrupt or stop production, creating delivery problems that may have very serious economic consequences. Fire prevention and protection is very important. General goals are to ensure the safety of building occupants and to protect property and the environment. More detailed objectives include action to:

- prevent the outbreak of fire
- limit the spread of fire and smoke within a building and its immediate surroundings
- ensure that people can escape safely from a building in case of fire

- ensure the stability of a building in case of fire
- ensure the safety of rescue operation personnel.

Most countries have similar objectives, e.g. those adopted by the European Commission Construction Product Directive (CPD, Directive 89/106/EEC). However, the implementation of these objectives varies between countries as fire safety strategies have developed differently due to historical reasons. In some countries, fire safety demands the installation of sprinkler systems but in others fire separation barriers or management are more common. The fire safety systems installed in buildings depend on the tradition in a specific country and consideration of the occupants.

Protection against fires must be based on knowledge about how fires are caused. Fires occurring in buildings are generally accidentally triggered by humans, typically by smoking, open flames, kerosene heaters, sparks, welding and electrical faults. Arson is also a common cause of fire. The basic approach to fire safety takes fire hazards into account during the design

of buildings, workplaces and technical equipment. The most important factor in fire protection, however, is related to fire safety management procedures. It is necessary to maintain the fire safety equipment and in order to do that efficiently this should be performed in a systematic way, using a fire safety management system.

### Consequences

Fire is the type of accident that most people fear but in fact, the risk of being killed by fire is rather low compared to other risks, however, the frequency of fires is still very high in some countries.

It is difficult to compare fire risks between countries as statistics may not be reliable or exist in every country.

Figure 4.8.1 presents statistical data on fatality rates in different regions of the world.

The variation in fire frequency is rather large. Africa has the highest risk for fatalities followed by South East Asia and the Eastern Mediterranean. The figure includes fatalities in all sectors in society, not only in occupational settings.

Region	Deaths per 100 000 persons
Africa	11
North and South America	1
Eastern Mediterranean	3
Europe	1 - 2
South-East Asia	10
Western Pacific	1 - 2
World	5

Figure 4.8.1. Fire death rate per 100,000 persons based on WHO World Health Report 1999. An interval indicates a variation due to different income groups. A low death rate is associated with high income.

The frequency of fatality is also relevant when discussing the hazards to fire services personnel as it is not uncommon that they become victims of the fire they are fighting.

Fire also causes damage to property and to the environment. Information on the cost of fire losses is available from the World Fire Statistics presented by The Geneva Association Bulletin 22 (2006), indicates a general property damage cost between 0.07 and 0.28 percent (generally for 2001-2003 with some exceptions) of the gross domestic product (GDP) of a country, related to building damage and loss of contents.

The prevention or reduction of the consequences of fire can be considered either in the planning phase for a new building or when operations are carried out in an existing workplace. Fire safety design is traditionally based on guidelines issued by a fire safety authority and if these prescriptive regulations are followed, buildings will generally have an acceptable level of fire safety. Engineering solutions for fire safety are increasingly used for very tall, large or complex buildings. Traditional solutions are still the most commonly used and are applicable for most buildings. The following paragraphs present general guidelines that describe the way in which prescriptive design regulations can be formulated and how owners of workplaces can act in order to reduce the risk of fire. The design solutions presented generally follow the EU fire safety structure and are influenced by similar guidelines from Sweden.

### PREVENTION OF THE OUTBREAK OF FIRES

The protection strategies for a building and its users can be divided into two parts: general strategies and specific actions. General strategies are very much related to management activities

while specific actions mostly relate to practical issues; there is no clear border between them as they both serve the same objective.

### General strategies

In many ways, a fire safety system can be considered to be a technical system that needs to be correctly installed, operated and maintained in order for it to work as intended. General strategies are based on planning for an unwanted event, i.e. how can damage be reduced if a fire starts. General strategies may include the following:

- *A fire management plan* should be part of the design of the fire safety system and be included as part of the fire safety documentation for the building. The plan describes how fire protection is intended to work.
- *A well designed maintenance plan* will help to overcome a major problem related to maintenance, i.e. that tenants or building owners do not fully recognise the need for regular safety checks, e.g. of the fire detection system.
- *Safety checks*, as defined in the maintenance plan, should be performed to ensure escape doors are not blocked, emergency lighting is working in case of power failure, portable fire extinguishers are operative, etc. Figure 4.8.2 shows an example of a checklist of critical points that need to be attended to. It is important to clearly state who is going to do the checks and how faults will be handled.
- Regular *evacuation drills and education about how to act in case of fire* can reduce the risk of fatalities and injuries. People that have participated in such education or experienced a real fire, have a better chance of acting correctly if a fire occurs. In order to be effective, drills need to be realistic but not frightening. For example,

random evacuation drills may be performed in shopping malls with customers participating. People in occupational settings should also be given training about how to extinguish fires.

- Another important training activity is *how to call the fire department and how to warn others in a building* in case of fire. Many countries have a special telephone number to call in case of fire but it is important to provide the operators with accurate and useful information, e.g. knowledge on where the fire started, how many people have been injured and the name and phone number of the caller so they can call back for additional information if necessary.

Finally, employees can also be trained in *first aid* so they are able to help those injured by fire. If first aid is administered quickly, it often helps the recovery time of victims.

### Special actions

Separating the fire source from combustible materials is of primary importance to prevent fires as it is not always possible to eliminate fire hazards completely. For example, management actions would typically include: ensuring that there are lids on trash containers, forbidding the storage of combustible materials close to the outside walls of a building, or training staff members how to handle flammable liquids and gases. The same strategy can be used to prevent arson.



Part in the fire safety system	Description of what should be checked
Evacuation: <ul style="list-style-type: none"> <li>• doors</li> <li>• emergency exit signs</li> <li>• emergency lights</li> <li>• escape routes</li> </ul>	Routine monthly inspections. Weekly inspections in public buildings. No blocked escape routes. Doors able to be opened easily. Signs in proper places. Emergency and normal illumination working. Snow removed from outside escape doors.
Fire compartment barriers	Routine monthly inspections. Weekly inspections in public buildings. Fire doors not held open. Every six months, check that barriers have not been penetrated by cables, pipes or ducts, (especially after work has been performed in the building).
Access for rescue services	Regular checks to ensure that there is access around building perimeter. Hospitals should be checked every day.
Automatic fire alarm system <ul style="list-style-type: none"> <li>• detectors</li> <li>• alarm bells (and similar)</li> <li>• controls</li> <li>• power supply</li> <li>• alarm transmittance to fire department</li> <li>• orientation plans</li> </ul>	Regular inspections by authorised personnel from the installation company. Most equipment should be tested every month. Orientation plans should be checked on a yearly basis. Many fire alarm suppliers recommend that detectors are replaced every 6 years.
Evacuation alarm <ul style="list-style-type: none"> <li>• alarm bells, loudspeakers and flashing lights</li> <li>• alarm push buttons</li> <li>• power supply</li> </ul>	Evacuation alarm systems should be tested every month. Systems combined with automatic fire alarms should be tested at the same time.
Automatic sprinkler system	Regular inspections by authorised personnel from the installation company. Most equipment should be tested every month.
Smoke extraction system <ul style="list-style-type: none"> <li>• vents</li> <li>• fans</li> </ul>	Vents at ground level, (venting basements), should be checked every week for blockages. Vents at roof level should be checked every month. Snow should be removed from vents. Smoke extraction fans should be tested at least four times per year. System for supply air should be tested at the same time.
Fire protection in heating, ventilating, and air conditioning system	Dampers should be operated at least once every 48 hours.
Manual fire fighting equipment	Portable fire extinguishers and indoor fire hydrants should be inspected at least once a year. In public places they should be checked at least every six months. Water pipes specially provided for the fire services (usually vertical pipes) should be inspected every year.
Systems control	Systems that work together should be tested at the same time in order to ensure that they are able to function together. This could be performed as a total fire safety systems check, including operations by management and other members of the staff.

Figure 4.8.2. Example of a checklist for regular safety checks of technical installations.

### Heat producing equipment

A fireplace, hot machinery or other hot surfaces should be physically separated from any combustible lining both above, behind and below the installation. To prevent sparks from igniting items outside a fireplace, a non-combustible material should be placed in the vicinity of the opening to the fireplace.

Chimneys should be insulated from combustible construction materials, etc. Steel pipe chimneys can be insulated with mineral wool to limit the temperature on the surface of the surrounding material. A temperature of 80 °C on the exposed surface is a rational level to prevent ignition of most combustible materials. Ensuring that material is not stored close to hot surfaces should be a part of the maintenance plan.

### Electrical sources and sparks

Malfunction of electrical appliances is also a known source of fire. Correct electrical installation is required and electrical wires should be regularly inspected and maintained.

Sparks in industrial production plants or from welding can also be source of fire so it is necessary to physically separate combustible materials from sparks or welding. Special care must be taken when metal is welded or cut as heat can be transferred to other parts of a metal construction and ignite material at a distance from the place where the work is being done. Control of such hazards requires good management.

## LIMITATION OF THE CONSEQUENCES OF FIRE

### Limit fire spread within a fire compartment

If a fire starts in a room (and is not extinguished by the occupants), the type of contents and type of surface material used on the walls and ceilings, will significantly influence the development

of the fire. Usually, not much can be done to change the contents in a room but the surface material used to line the room can be regulated. Higher demands should be placed on the ceiling material as it is more important to the development of fire than the material used on the walls. A less combustible (more fire resistant) material should be chosen for use in places where the risk to occupants is higher, e.g. in places handling fire hazardous material or in rooms containing the building electrical centre.

### Classes of surface lining materials

In the European Union, a classification system (EUROCLASS) is used to regulate different surface lining materials. This system is based on the material's fire development magnitude (A – E), its smoke production property (s1 – s3) and its dripping or melting property (d0 – d2). Usually, polystyrene and other similar plastics have a tendency to both produce thick black smoke and to melt, forming a pool of melted material below the virgin plastic.

The lining material that is classified is the surface material, i.e. the paint, wallpaper or the virgin material e.g. wood. Wooden surface material typically has EUROCLASS D-s1, d0. Material with less fire protection properties (class E and those dripping and producing a lot of smoke), should definitely be avoided, e.g. low-density wooden boards and most expanded polyurethane boards. Lining a room with these materials will result in a very rapid fire development creating hazardous conditions within seconds.

Figure 4.8.3 shows the regulation of wall and ceiling linings in Sweden. It is also assumed that the lining material is attached to a wooden surface or even better a surface made of concrete, mortar, gypsum plaster board, etc. 'B' indicates a better performance than a 'C' and 's1' is better (producing less smoke) than 's2' and so on.

The following are typical material classifications:

- B-s1,d0: gypsum board
- C-s2,d0: gypsum board with wallpaper
- D-s2,d0: unprotected wood, MDF-board, plywood

Building class	Escape route		Other areas	
	Ceiling	Wall	Ceiling	Wall
<b>Class 1</b>	B-s1,d0	B-s1,d0	B-s1,d0	C-s2,d0
<b>Class 2</b>	B-s1,d0	B-s1,d0	C-s2,d0	D-s2,d0
<b>Class 3</b>	B-s1,d0	C-s2,d0	D-s2,d0	D-s2,d0

Figure 4.8.3. Requirements for lining materials in Sweden according to the EUROCLASS system.

**Class 1:** Buildings with more than 2 floors, buildings with 2 floors and hospitals, hotels or buildings with 2 floors and places of assembly on 2<sup>nd</sup> floor.

**Class 2:** Buildings with 2 floors and places of assembly on ground floor. Buildings with 2 floors and 2 dwellings. Buildings with 2 floors and a building area of more than 200 m<sup>2</sup> or fire compartments of more than 200 m<sup>2</sup>. Buildings with 1 floor, hospitals or places of assembly on ground floor or below.

**Class 3:** Other buildings.

### Limit fire spread between fire compartments

A large building, such as a multi-storey office building, should be provided with *fire compartment walls* and other constructions which form *fire separation barriers*. The idea behind the fire barriers is to limit the spread of fire within a building or at least to decrease the velocity of the spread of the fire which gives more time for the evacuation of the building, to fight the fire and to generally limit damage. The requirement is that all components in a fire separation barrier should have the same resistance, i.e. windows, doors and any penetrations, e.g. for cables or

pipes for the heating, ventilation and air conditioning (HVAC) system.

### Examples of fire compartments

Typical rooms that should be in a separate fire compartment are: staircases, hotel corridors, hotel rooms, assembly rooms or groups of assembly rooms, groups of school classrooms, hospital wards, elevator shafts, other shafts in multi-storey buildings, groups of office rooms, rooms for handling of hazardous material, garages, and some laboratories. Each floor in a multi-storey building is normally a separate fire compartment. In addition, building owners may also want rooms used for essential services, such as computer rooms or archive storage rooms, to be in separate fire compartments in order to limit the property damage in case of fire.

In the above list, some fire compartments consist of several rooms grouped together; they do not all have to be separate fire compartments with specially designed barriers. The maximum size of a fire compartment is usually determined by the longest distance from the most remote place in the fire compartment to an escape route. This means that larger fire compartments must have more than two escape routes in order to meet the requirements of maximum allowed distance to an escape route. Another reason to limit the fire compartment size is related to the possibilities for the fire brigade to extinguish a fire because a fire in a large fire compartment is normally very difficult to extinguish.

### Fire separation class

Figure 4.8.4 shows the various fire separation classes, described as EI xx, where xx stands for the length of time the barrier should be able to resist a fire load, according to EN 1363-1:1999 (similar to ISO 834) fire resistance test. The letters EI stands for integrity (E) and insulation

(I). This means that, for example, a door limits the smoke spread for the required time (E) and limits the heat transfer to the non-exposed side of the door (I). The temperature limit is usually set to 140 °C on average and 180 °C as the maximum temperature. These levels are then assumed to minimise fire spread to the next fire compartment.

In some cases, only the integrity is desired i.e. no requirement is defined for insulation. This partition receives a class E xx where xx indicates the time in minutes that the protection is sustained. Typically, protection levels for this type of construction are 15 or 30 minutes and are normally a requirement for some doors or windows where less fire protection is necessary. Fire spread is then assumed to be limited by the E-requirement and a separation distance, for example between two buildings. The duration of the fire separation is also determined by the use of the building. As for the lining material, the fire separation time is determined by the building class. The requirement for separation between fire compartments for Sweden is described in Figure 4.8.4. Similar requirements can be found in most other countries but perhaps with some differences in the length of the resistance time.

According to Swedish regulations, a fire compartment with more than two floors must be equipped with a sprinkler system. Staircases, shafts and similar rooms are not required to have this installation.

The biggest problem with fire barriers in a building occurs when the walls, floors, etc are penetrated for piping, electrical wires, etc. The fire separation may be damaged and special care must be taken in order to avoid a reduction in resistance; there are methods of passing wires, venting pipes, etc through a separation wall without any loss of integrity but they require

extra care. This is a safety control that should be installed during construction.

	Fire load <sup>b</sup> (MJ/m <sup>2</sup> surrounding area)		
Building class	< 200 <sup>a</sup>	< 400	> 400
<b>Class 1</b>	EI 60	EI 120	EI 240
<b>Class 2 or 3</b>			
– in general	EI 30	EI 30	EI 30
– between dwellings	EI 60	EI 60	EI 60

Figure 4.8.4. Fire compartment resistance (minutes) for walls, floors, doors etc.

<sup>a</sup> Can be used if the building is equipped with an automatic sprinkler system, even if the fire load is higher.

<sup>b</sup> Fire load is defined as the total heat of combustion of the contents in the room divided by the total surrounding area, i.e. the area of the floor, ceiling and walls.

Another weak point is the intersection between walls and the ceiling which needs special attention as smoke moves upwards.

The fire separation must be checked regularly in order to ensure that contractors have not damaged the barriers. Appropriate instructions for maintenance staff and contractors can be part of the maintenance plan. Doors and other mechanical parts in the fire separation barrier should also be checked regularly. Problems usually occur when self-closing devices are used and doors don't close accurately.

### Building structure fire safety

Buildings must be able to withstand a fire for some time without collapsing. Higher protection is normally required on the fundamental support structure to ensure that a total collapse can be avoided but the protection required differs depending on the type of construction material used. Steel is a good material in many ways but

has disadvantages in case of fire as the strength of the material decreases quickly when exposed to higher temperatures. Steel structures have to be protected with fibre insulation board, gypsum plaster board, or something similar, in order to withstand fire. Alternatively, while a concrete girder is better able to withstand fire, problems with spalling may arise, i.e. when material falls off a concrete beam due to tension caused by heat. Any protection added to a construction structure must be carefully mounted if it is to be effective but unfortunately poor workmanship is common.

As structural safety is a vital part of fire safety, construction should be designed according to a high quality design standard. The EUROCODE design guide provides rational and practical design advice.

Fire safety requirements on construction stability are normally defined by the time a construction needs to withstand a fire load. A normal resistance time for traditional buildings in Building class 1 (see Figure 4.8.3), and with a fire load less than  $200 \text{ MJ/m}^2$ , is 60 minutes (this requirement is expressed as R60). Longer times of 120, 180 or 240 minutes are required for higher fire load and for fundamental parts of the construction. For buildings in Class 2 or 3, a normal requirement would be R30 or even R15. Stairs inside an escape route should be at least R30 to ensure stability in case of fire. If a sprinkler system is considered, it is normal to reduce the requirement on the construction stability but not to remove all the protection as sprinkler systems are not 100% reliable and fire protection should never rely on a single system. Redundancy is vital for fire protection.

It is important that a building is constructed in a way that assists the ability of rescue services to make safe rescues. This can be done by ensuring building stability for a longer period of time

than it takes to evacuate the building. For example, if the response time for rescue services is around ten minutes, the building must be protected at least for 30 minutes for smaller buildings and longer if the building is more complex or has several floors.

### ESCAPE IN CASE OF FIRE

If fire breaks out in a building, occupants must have access to escape routes that permit them to leave the building safely. This means they must have access to a minimum number of escape routes with sufficient flow capacity. Many countries have developed standards. (e.g, British Standard 5588 series), that provide very detailed guidance on how an evacuation system should be designed. Below, such guidance is presented following parts of the prescriptive design method used in Sweden.

#### Escape route

The escape route is either an exit that leads directly outside or a path within the building that leads to an exit. The latter type of escape route must be protected by fire separation walls, i.e. the escape route must be in a separate fire compartment. The maximum distance for such an escape route is discussed below. The final destination of an escape route must be a street or similar safe place outside a building's perimeter. People tend to use familiar routes to get outside in case of fire, even if there are specially designed escape routes. It is important to plan escape routes that are used during normal, everyday life in a building, which also saves money.

#### Number of exits

In order to provide fire protection to occupants in all parts of a building, they should have access to at least two totally independent and separate escape routes so that if a fire blocks one of the

exits, occupants will still have a safe way out.

In buildings with many occupants, more than two mutually independent exits must be provided in order to keep the total evacuation time to a reasonable length.

In smaller premises, e.g. small shops with a direct visual access to the outside, one exit leading to the outside may be sufficient provided the distance to walk to the outside is less than 15–20 meters. In this case, it is important that people in a small premise can see what is going on in other parts of the room and are able to be notified if a fire occurs.

### Escape routes on all floors

If a fire compartment has more than one floor, any additional floors should have direct access to an escape route.

### Elevator evacuation

In high buildings it can be difficult to evacuate everyone through stairways so specially designed elevators, that can sustain fire, can provide an additional evacuation route. However, as the general rule is that elevators should never be used in case of fire, people in any building equipped with a special fire resistant elevator, must be aware that it is possible to use it during fire conditions. It should also be noted that a special fire elevator can be an alternative to evacuate elderly or physically handicapped people who have difficulties using stairs. The use of fire elevators as an evacuation strategy is not common but exists in some Western and South East Asian countries with many very tall buildings.

### Objects blocking escape routes

As an escape route is considered to be a relatively safe place, no goods or other items should be present in the area. Unfortunately, many escape

routes are also used to transport goods between different parts of the building, (e.g. in shopping centres), however, such transport should be minimized in order to keep the escape routes clear.

### Location of escape routes

To minimise the risk of a single fire blocking all the escape routes, they should be located remotely from each other. As mentioned above, the normal communication routes in a building should also be used as the escape routes as occupants are more familiar with them and consider them safer than exits that are seldom used.

### Separation between escape routes

While escape routes must be mutually independent, in many cases, the possibility must still remain for movement between them. The minimum requirement is a self closing door separating the two routes and if the escape routes serve more than 150 persons, there should be a separate room between the two escape routes. Both doors to the escape routes from this room must be fire rated and equipped with a self-closing device in order to avoid smoke spreading from one of the escape routes into the second escape route. Higher protection is required for buildings where a large number of people use the escape routes because the potential consequences are more serious.

Staircases used for evacuation must always be separated and fireproofed from the floors they are serving, particularly in very tall buildings where many people will need to use the stairs to escape from the building. Such staircases need to be specifically planned, e.g. for phased evacuation. In the case of very long horizontal escape routes it may be a good idea to separate a corridor with a simple smoke separating wall and door.



### Windows as an escape route

In some cases, windows may be considered as one of a number of mutually independent escape routes, but should only be permitted for use by a small number of people, e.g. in apartments, or small offices. It is essential that the people supposed to use this escape route are able to crawl through the window opening, so this is not a safe option for hospitals, hotels, or places of assembly. Any window used as an escape route must be simple to open and be large enough, i.e. with a minimum opening of 0.7 m width and 0.8 m height. The window must swing open around a vertical axis.

### Walking distance to an escape route

The primary objective of evacuation safety is to ensure that occupants are able to leave the fire compartment in which the fire has started. Calculation procedures can be used to compare the time available for evacuation with the time taken for untenable conditions to be reached in the room on fire. The building codes in most developed countries require such a performance objective but the way in which safety is achieved may differ from country to country. For example, in Sweden two methods are used: the prescriptive method and fire safety engineering. The fire safety engineering method demonstrates safety by calculation methods. The prescriptive solution is used most frequently because it is simple and quick to use. The prescriptive method limits the maximum walking distance to reach the closest exit from a place in the fire compartment, depending on the use of the building i.e. the fire risk associated with the building use, Figure 4.8.5.

Condition	Example	Distance, m
Good overview in the room and fire load less than 50 MJ/m <sup>2</sup> and low risk of fire start. No risk of a rapid fire development.	Some mechanical industries or concrete production factories	60
Low occupant density and it can be assumed that occupants are aware of the premises.	Dwellings, office buildings, and similar like garage, storage buildings, industrial buildings in general.	45
Not low occupant density or people are within a caring facility or have less knowledge of the premises or the risk of a rapid fire development cannot be neglected.	Assembly buildings in general (warehouse, shop, restaurant, education, theatre, cinema and similar). Industries for wood or plastic manufacturing. High rack storage buildings. Hospital.	30
Building with high risk of fire start or if high probability of evacuation problems.	Buildings with handling of flammable goods.	15

Figure 4.8.5. Allowed walking distance to the nearest emergency exit.

If the room is equipped with a high quality automatic suppression system (sprinkler) (e.g. satisfying ISO 6182-1 or NFPA 13), the allowed distance may be increased by 1/3rd. The sprinkler system is assumed to be a quick response type sprinkler i.e. having a Response Time Index (RTI-value) of less than  $50\sqrt{m \cdot s}$  and to have a full coverage of the building. The RTI-value is a measure of how fast the sprinkler bulb will activate exposed to a fire. If the escape route is a window, the allowed distance is only 1/3rd of the value in Figure 4.8.5.

If a stair is part of the walking path to the escape route, the stair is assumed to be equivalent to four times the vertical distance.

If the walking path within a fire compartment, to the mutually independent escape routes, is the same or can be the same, then this distance should be equivalent to double its length, see Figure 4.8.6. The reason for this is to have the different escape routes located as far away from each other as possible. Furniture, machines etc should be considered in calculating the walking distance.

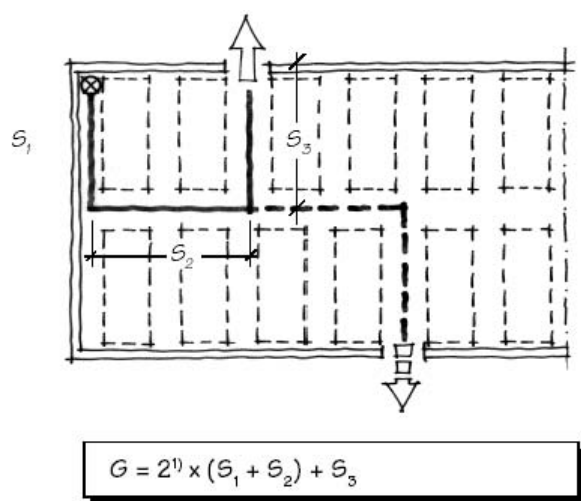


Figure 4.8.6. Measuring the walking distance. <sup>1)</sup>In a dwelling, office or garage 1.5 times the physical distance is sufficient.

### Walking distance within an escape route

The walking distance within an escape route should be limited (normally to 30 metres) so that rapid access to a safe location outside the building can be achieved.

### Width of escape routes

Safe evacuations require escape routes of sufficient size to avoid long queuing times in the room on fire. Normally, a door leading to an escape route must be at least 0.8 metres wide and in assembly rooms the unobstructed width

must be not less than 1.2 metres for each door. The total escape width can be calculated as 0.67 cm/person but this figure varies between countries. If the widest one escape route is blocked by the fire, the other exits must have a width equal to 0.33 cm/person and be designed to cope with the maximum number of people in the room.

### Doors

Escape route must always be able to be used and doors must never be locked when people are in the building. A locking system connected to any automatic system, such as a fire detection system, must not be used. Generally, doors in any escape route should swing in the direction of travel and be equipped with a self-closing device. However, in small rooms, e.g. hotel rooms, doors may open inwards and should be able to be easily and rapidly opened with a handle. In rooms serving a large number of people, e.g. assembly rooms, door handles can be designed to cope accordingly (see EN 179 or EN 1125).

If escape doors must be locked when no one is in the building, the locking system must be designed to prevent the operation of vital equipment (e.g. cash registers, lights), while the doors are locked. Care should be taken to ensure that doors leading to the outside are never blocked.

### Exit and evacuation signage

Exit signs can be used to mark escape routes and to guide occupants to exits. Exit signs should be similar throughout a entire building (this is normally regulated in countries). Figure 4.8.7 shows a typical exit sign, i.e. the European Community standard for such signs.

Signs need to be large enough to be clearly seen – a sign height of 1% of the assumed viewing distance is sufficient if the sign is lit by an external light source. If the sign is lit from behind, through a plastic or glass sign, a height



Figure 4.8.7. Standard EC exit sign (green with a white pictogram).

of 0.5% is sufficient as back lit signs give better visibility. Signs must be located above all exits leading to escape routes while additional signs can be provided to improve orientation within the building.

### Lighting

General lighting must be provided so that darkness does not limit safe evacuation. In some cases, emergency lighting will be provided in addition to normal lighting in both rooms and escape routes, as is the case in many hospitals, hotels and assembly rooms. All escape route signs should also be equipped with emergency lighting. Battery operated emergency lights are recommended even though they require higher maintenance. Maintenance can be limited by good design, e.g. by having a central battery pool for a group of rooms. Emergency power generators may be the electrical source for emergency lighting but generators normally have a long start-up phase and must be complemented by battery operated lights. Visibility is helped by the use of light colours for floors, walls and ceilings.

### Evacuation alarms

An evacuation alarm helps rapid and efficient evacuation by notifying people of a fire. Such alarms can be triggered manually or by an automatic detection system, i.e. a fire alarm. Hotels, hospitals and assembly rooms should normally be equipped with an evacuation alarm, however, other premises such as offices may also install an evacuation alarm. In premises where occupants

can be assumed to know the meaning of the evacuation alarm, e.g. in a small office or similar, a simple bell alarm can be used, complemented with flashing lights to increase the significance of the alarm and to help people with hearing disabilities. In other places where members of the public gather, a spoken message alarm may be a better solution because occupants need to be informed about what has happened and what they are supposed to do. Human behaviour plays a dominant role in this situation and occupants may feel very insecure about what to do if they are unfamiliar with the building.

A typical spoken message would contain the following information:

1. Tone signal for approximately 5 seconds
2. "Important message. There is a fire situation in the building. Please leave the building through the nearest exit. Follow the instructions given by management and proceed to the outside. Don't block the exits."
3. Repeat from step 1.

The alarm should continue until it is safe to shut it off. If necessary, the verbal message should be spoken in a number of languages, e.g. in an airport, and should be longer than 30 seconds. See EN 60849 for more detailed information on verbal evacuation alarm systems.

In some places such as hospitals and elder care homes, an audible evacuation alarm may not be the best option. Silent alarm signals to staff members may be a good solution that avoids upsetting patients /residents.

Smoke detectors are a simple form of automatic evacuation alarm that can be used to increase safety at low cost.

## TRAINING FOR RESCUE OPERATIONS

If a fire occurs, action must be taken to try to extinguish it. This can be done manually by occupants or professional fire fighters.

In many countries, part of building fire safety is provided by a professional rescue service paid for by citizens. The main objectives for rescue services are to assist with evacuation and limit fire from spreading. The earlier fire services arrive after detection of a fire, the higher the possibility for a successful operation. This is the reason for promoting the installation of automatic detection systems in buildings.

Unfortunately, in many cases fire develops rapidly before professional rescue services arrive. People already in the workplace have the best opportunity to limit a fire from growing by extinguishing it early but they need education on what to do in case of fire.

### Non-professional fire fighters

Well trained people are a good investment as they can take measures to limit a fire from growing and possibly extinguish it. A successful operation needs both good equipment and people who know how to handle the equipment. Typical equipment that workers can handle includes portable fire extinguishers, fixed hoses on indoor fire hydrants and fire resistant blankets that can be used to smother fire. Another major advantage of fire resistant blankets is that they are excellent for putting out fire in a person's clothes.

Depending on the type of occupancy, different types of extinguishers can be considered. Dry powder extinguishers are very efficient, especially for untrained people, but the powder is difficult to clean away afterwards, however, fire itself creates a mess. Water or foam extinguishers are other effective alternatives. It is not recommended that a portable extinguisher be used

to put out a clothing fire as that may harm the victim even more. The use of a CO<sub>2</sub> extinguisher on a person can cause severe cold damage.

In general there is little need for personal protection equipment for people fighting a small fire as the threat is minor and there is not much harmful smoke produced if fire fighting can be initiated early on. If a fire gets out of control, harmful smoke is produced and fire fighting should be handled by professional fire fighters.

Typical training exercises for non-professional fire fighters involve fighting fires with portable extinguishers, the use of hoses mounted on indoor fire hydrants and putting out a fire in a person's clothes. The training should involve all personnel and be repeated regularly, at least every second or third year. New employees should be given this training as soon as they are hired. It is also useful to combine this practical training with evacuation procedures and information about how to warn others, call the fire and emergency services, etc.

### Professional fire fighters

Fighting a serious fire is dangerous work that should be handled by professional fire fighters. Professional fire fighters have access to necessary protective clothing and breathing apparatus (BA) preventing the inhalation of toxic fire gases and burns that can result from being close to the source of a fire. If toxic fumes from a fire are inhaled they can have both acute and long term consequences. People who are not trained and/or equipped with BA should stay at a safe distance from a fire.

Professional fire fighters are trained to extinguish fires, particularly to control and extinguish small scale fires, e.g. in apartments and smaller premises. Fire fighters are also trained to use BA inside buildings as even small fires can produce a

lot of smoke. Smoke venting or sprinkler systems help to extinguish fires rapidly.

Fire fighters are trained to be aware of and able to detect the “flashover” point of a fire as it rapidly change from a small local fire to a fully developed one. When a flashover occurs all personnel must withdraw as no one can stay more than a few seconds in a fully developed fire, but trained fire fighters can also prevent a flashover by cooling the fire gases. (Such training is potentially dangerous and must be conducted in a controlled environment).

Fire fighters must also be trained to deal with “backdraft” that can occur if a fire develops in an under ventilated environment, e.g. a closed room. If smoke is hot and a vent such as a door is opened, oxygen enters the room. Because the smoke is hot and rich in fuel, it can rapidly catch fire and send a large plume of flame through the exit/vent, endangering nearby fire fighters.

A basic requirement for a successful fire fighting operation is good access routes to a building.

If fire develops in larger sites such as industrial complexes, it may be very difficult for fire fighters to handle this fire as the fire fighters are not always sufficiently trained to extinguish such large fires. The first priority is usually to prevent the fire from spreading to other buildings by cooling neighbouring buildings by wetting the walls from outside.

Toxic smoke is not only produced in a fully developed fire but also occurs after the fire has been extinguished but may still be smouldering. Extinguishing these small smouldering fires should also be done with some form of breathing protection equipment. At this time the fire poses no threat to the fire fighters and they mostly only need to use a filter mask to avoid the most harmful substances. The amount of toxic gases and small soot particles is lower compared to the fully developed fire. The best is of course to

use the BA also when finalizing the extinguishing phase but it may be sufficient to use lighter equipment instead of the heavier BA equipment.

### Equipment for professional fire fighters

Fire fighters are usually equipped with traditional extinguishing equipment like fire hoses, nozzles, BA, and protective clothing. Other equipment like chain saws and high water pressure nozzles may also be used. Foam concentrates can be mixed with water in order to increase its wetting effects, making it easier to extinguish a fire. Other extinguishing media that can be used are expanded foam, inert gases and dry powder. Dry powder can also be used in portable hand extinguishers. Water is the most commonly used extinguishing media. It is essential to have fire hydrants located outside buildings as the amount of water carried by rescue service vehicles is limited and transporting water takes time and energy resources.

But, in the end it is far much better to prevent the fire from even start. Prior prevention activities must, therefore, be the first objective in fire safety. The fire services is called when all other fire safety barriers fail.



**Fire safety standards**

ADB, Approved Document B, Fire Safety. Department of Environment, Transport and the Regions, London, 2006.

BS 5588 series – Fire precautions in the design, constructions and use of buildings. British Standards Institution, London, 1999.

EN 179 Building hardware – Emergency exit devices operated by a lever handle or push pad - Requirements and test methods, 2008.

EN 1125, Building hardware – Panic exit devices operated by a horizontal bar – Requirements and test methods, 2008.

EN 1363-1:1999 Fire resistance tests – Part 1: General requirements. 1999.

EN 60849, Sound systems for emergency purposes. 1998.

Eurocode 1: Basis of design and actions on structure. Actions on structures exposed to fire. ENV 1991-2-2:1995. European Committee for Standardization, Brussels, 1995

Eurocode 2, part 1-2: Design of concrete structures. General rules, Structural fire design ENV 1992-1-2:1995. European Committee for Standardization, Brussels, 1995

Eurocode 3, part 1-2: Design of steel structures. General rules, Structural fire design ENV 1993-1-2:1995. European Committee for Standardization, Brussels, 1995

European Commission Construction Product Directive (CPD, Directive 89/106/EEC)

ISO 6182-1, Fire protection - Automatic sprinkler systems - Part 1: Requirements and test methods for sprinklers. 2006

NFPA 13, Standard for the Installation of Sprinkler Systems. National Fire Protection Association, Quincy, 2007.

Regulations, Testing and Approval. Hanser Gardner Publ, Cincinnati, 2004.

World Fire Statistics. Geneva Association Information Newsletter 22, The Geneva Association, Geneva, Oct 2006.

Billington M.J. Means of Escape from Fire. Blackwell, Oxford, 2002.

The book provides further practical and detailed recommendations on evacuation design. It is highly influenced by British traditions.

**Useful Internet-links**

[www.nfpa.org](http://www.nfpa.org); National Fire Protection Association, USA.

Provides information about fire prevention.  
Produces standards for fire safety design.

[www.iafss.org](http://www.iafss.org); International Association for Fire Safety Science.

The non-profit organisation promotes fire safety research and cooperation. The organisation has a free e-mail list discussing various fire safety related subjects.

<http://iafss-es.brunamal.is>

Free lecture material on fire dynamics provided by IAFSS.

[www.ife.org.uk/](http://www.ife.org.uk/); Institution of fire engineers. International (originally from the UK) fire safety organisation.

Provides general fire safety information.

[www.sfppe.org](http://www.sfppe.org); The Society of Fire Protection Engineers. International (originally from the USA) fire safety organisation.

Provides general fire safety information.  
Good book shop.

[www.raddningsverket.se](http://www.raddningsverket.se); The Swedish Rescue Services Agency.

The web-pages contain information relevant for training professional fire-fighters.

**SUGGESTIONS FOR FURTHER READING**

Bengtsson L-G. Enclosure fires. Swedish Rescue Services Agency. Karlstad, 2005.

An excellent description of the way in which a fire in a compartment developed from a pre-flashover fire to a fully developed fire.

Sundström B. European Union, in Troitzsch J, Plastics Flammability Handbook, Principles,





# Prevention of chemical risks

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# Introduction

*Gun Nise & Catharina Wesseling*

The world production of chemicals is increasing. In 2001, 80% of all chemicals were produced in 16 countries, (in decreasing order): US, Japan, Germany, China, France, the UK, Italy, Korea, Brazil, Belgium/Luxembourg, Spain, the Netherlands, Taiwan, Switzerland and Russia. However, by 2020, developing nations are expected to lead the world in growth rates for high-volume industrial chemicals, i.e. those produced at more than 1000 tons per year, increasing their share of the world's chemical production to 31% (OECD Environmental Outlook for the Chemicals Industry, 2001). Since many developing countries have not yet put legislation on chemicals in place, no one knows exactly which or in what amounts chemicals are in use there. Along with other risk factors such as smoking and alcohol, exposure to toxic substances is an important contributor to chronic disease. Furthermore, ILO estimates that occupational exposure to hazardous substances causes some 340,000 deaths per year globally, not to mention the number of workers who become ill or injured by chemicals.

While there are tens of thousands of synthetic chemicals produced worldwide, the great majority of them lack adequate safety information. Hazardous chemicals are widely used at work-

places. A survey of workers in Europe in 2003 found that 16% handled hazardous products and 22% were exposed to toxic vapours. Exposure to dangerous substances can occur in a wide variety of workplaces, e.g. farms, car repair shops, printing plants, hairdressing saloons, etc.

Working with hazardous chemical substances always involves an element of risk of ill-health or accidents because of

- irritating, toxic, and sensitizing properties
- radioactivity,
- displacement of atmospheric oxygen and increased risk of fire, explosion or some other dangerous chemical reaction.

Chemicals can affect workers' health in many ways, e.g. may cause fatigue, headache, dizziness, irritation of eyes, airways and skin, asthma, neurological problems, cancer, endocrine and reproductive problems.

A polluted work environment is often harmful not only to workers but also to production. For example, high levels of dust, oil, and paints can interfere with efficient production, and require extra cleaning operations and inspection as well as spoiling materials or final products. The health effects from chemical exposure may reduce productivity and quality, and increase absenteeism and staff turnover. Improved con-

ditions increase labour output creating potential for higher productivity and quality.

The key issue for a better working environment is knowledge among both employers and employees. Knowledge about the possible risks from exposure is necessary when planning a safe working environment. Gaining acceptance of the need to work in a safe way may perhaps take more time because it requires understanding of the motives for such way of working.

Many of the problems caused by chemical hazards can be solved with little or no cost and there are often savings in materials and energy.

# Risk assessment and control

*Gun Nise & Linnéa Lillienberg*

To protect workers from exposure to dangerous substances requires risk assessment, action to remove or reduce the risks, and monitoring of the effectiveness of the measures taken. Risk assessment identifies potential health problems and is the basis for control measures.

## CHEMICAL EXPOSURE AND UPTAKE ROUTES

It is important to understand how a chemical gets into the body in order to understand potential risks of exposure. The most important uptake routes are inhalation or through skin absorption. All substances reaching the workers' breathing zone are inhaled as vapours, e.g. solvents, gases or dusts from work operations such as grinding, sawing, mixing, and packing or liquid aerosols from e.g. spray painting and by using compressed air for cleaning wet products. The amount taken up by skin absorption depends on the characteristics of the contamination. Skin (dermal) absorption can occur when the substances are in direct contact with the skin or contaminated clothes. Some chemicals penetrate the skin easily, e.g. many pesticides and several organic solvents. Ingestion can occur in dirty workplaces where people are allowed to eat, drink or smoke close to the work operation area. The occupational exposures and health

hazards are highly dependent on the amount of contaminant and the type of exposure. Irritating substances usually affect workers directly in association with the exposure, however, some exposures may not produce effects for many years, e.g. asbestos may cause lung cancer many years after exposure. Some chemicals (toluene, white spirit) produce both acute, sub-acute and long-term effects.

**Pesticides** can enter the body by dermal absorption, inhalation or ingestion. Dermal absorption is the most relevant uptake route for work with pesticides. Absorption through the skin is more likely when a pesticide is a liquid and comes into contact with sensitive skin areas like the scrotum and eyes. Fumigants and granulated nematocides with high vapour pressure and fine particles can readily be inhaled, especially when used in enclosed spaces. They are then easily absorbed into the bloodstream from the small airways. Particles that are too large to enter the small airways can be absorbed through the upper respiratory tract. Absorption from oral exposure occurs after eating or drinking with contaminated hands, splashes into the mouth, smoking during work, swallowing large inhaled pesticide particles or from run off on the face.



Occupational exposure to **organic solvents** may be through inhalation or through the skin. Uptake through ingestion is negligible under normal working conditions. Inhalation into the lungs is the most important uptake route. The solubility of a solvent into the bloodstream impacts on the amount taken up. While several solvents are easily absorbed through the skin, the amount taken up is usually much less than the amount inhaled.

Workers may also be exposed to **dust or aerosols** (inorganic and organic) through inhalation, skin contact or by ingestion. Inhalation is the most important route of entry. Skin absorption can occur when water-soluble materials dissolve in sweat and pass into the bloodstream. Depending on the size of the particles, dust will be deposited in different parts of the respiratory system. Small particles ( $< 5\mu\text{m}$ ) will primarily be deposited in the alveoli in the lung. Particles of  $5\text{--}10\mu\text{m}$  will predominantly deposit in the tracheobronchial tract, while large particles will be deposited in the nose and upper airways. Depending on the reactivity or solubility of a particle, small particles can also be deposited higher up in the respiratory system.

## RISK MANAGEMENT

Risk assessment is the identification of hazards that may cause adverse health effects. Proper risk assessment is a basis for appropriate preventive measures and risk management. Furthermore, training workers in safe work practices is an important part of risk management. Trained workers can apply safety rules as well as promote a healthy and safe work environment. Rotation of workers may reduce the average exposure of workers during the working day, but they will still be exposed to high concentrations during some part of the day and therefore at risk of adverse health effects.

## The risk assessment approach to chemicals

*Make an inventory:* Define the tasks to be assessed, learn which chemicals are used, find out whether new chemicals are generated during the work process.

*Collect information:* Find information about chemicals in e.g. Safety Data Sheet (SDS); identify their hazardous properties.

*Assess exposure:* Identify the duration, intensity, frequency, and uptake route (inhalation, skin uptake, and ingestion) of any exposures.

*Rank the problems:* Make a list of the identified risks in order of severity for use in an action plan on risk reduction.

Several models have been suggested to specify and classify the elements required for sound risk management. One simple model based on ISO 9000 series is a four step model representing a feedback loop: PLAN, DO, CHECK, ADJUST.

Resources and administrative support must be provided for risk management. Specific control measures should not be applied in an ad hoc manner but integrated into comprehensive and well managed hazard prevention and control programmes. At a specific workplace a decision making ladder can be used to analyse the process concerning hazard control, Figure 5.1.1.

Common sense must be used in all work with risk management or prevention. Can an industry afford to do all the necessary preventive measures at one time or is it better to implement them in prioritised steps? Is it worth installing equipment for prevention or is it better to build a new safer plant? It might be better to use personal protective equipment for a short period rather than starting preventive measures very quickly but inefficiently.

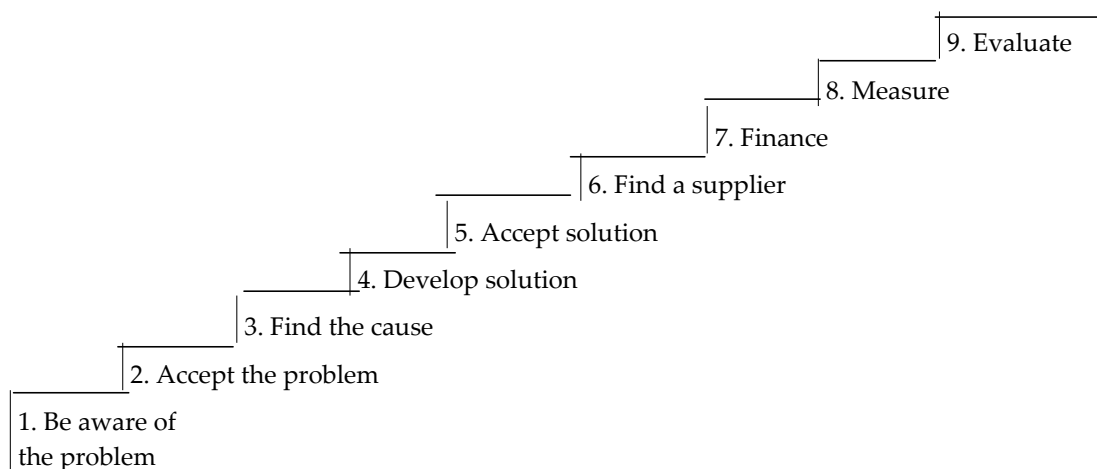


Figure 5.1.1. The decision making ladder shows the important steps for a successful risk management  
Source: A-B Antonsson, IVL, 1984.

### CONTROL OF HAZARDOUS SUBSTANCES

Hazardous chemicals or chemical products identified during risk assessment have to be controlled. There are often simple and inexpensive ways to control many problems and improvements often result in cost savings and production benefits.

A plan for intervention may include the following steps:

- Design the work process to avoid or minimise the emitting of dangerous substances to the workers' environment.
- When possible, eliminate or substitute hazardous substances with non- or less hazardous alternatives.
- Change the form of dusty substance to less dusty, e.g. pellets, flakes or liquid suspension. Use wet methods.
- Inspect and supervise the function of work process regarding e.g. ventilation and temperature.
- Organise work so that the number of workers and the time spent in a contaminated area are minimised.
- When exposure cannot be reduced properly, provide workers with appropriate personal protective equipment, and ensure that they are trained to use and maintain the equipment.
- Communicate the risks and the preventive measures planned and implemented to all personnel.
- Make up a maintenance scheme for machinery and exhaust systems.

### Eliminate or replace dangerous chemicals

The most efficient way to avoid hazardous exposure is by avoiding all use of dangerous chemicals. For example, it may be possible to rivet two pieces of work together instead of using glue. Organic solvents are often used for cleaning and degreasing in many work situations. Organic solvents can cause ill health and they are expensive. It is often possible to replace organic solvents with less dangerous substances. There are several water-based degreasing systems available that are as efficient as solvent-based ones and less expensive, safer and better for the environment. When using water-based systems it is important to dry the cleaned products properly to avoid rust. Less ventilation is needed except when warm alkalis are used. Respirators are not normally needed, though gloves and goggles should be used with alkalis.

### Use lids, covers, maintenance and enclosure of processes to control hazards and reduce losses

Substances evaporating from open containers or leaking from containers or pipes constitute a risk to workers health and increase costs. The

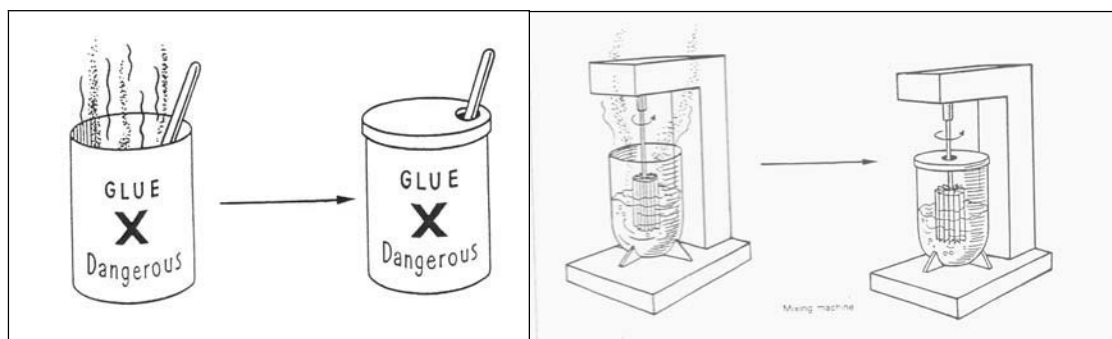


Figure 5.1.2. Use of lid and cover to reduce emission and exposure.

use of special lids can reduce vapours from organic solvents, glues and paints. The dispersion of aerosol from operations such as grinding and mixing, Figure 5.1.2, can be reduced by the use of covers. Poor machine maintenance can also create health risks and material losses. Dripping oil can affect workers skin, make floors slippery and constitute a loss of expensive oil. Some risks can be reduced by enclosure of a process e.g. in metal cutting operations using metalworking fluids. Exposure can then be limited to work tasks during short time periods, e.g. changing tools or process controls.

### Good housekeeping reduces exposure

Working procedures, such as grinding, sawing, mixing and packing, generate dust. The particle size varies and so does the hazard. A dusty environment badly affects materials and machines as well as the health of workers. Dust should be removed as soon as possible after it appears. Residual dust should be removed daily and more comprehensive cleaning should be carried out when needed.

### Dilution and general ventilation

General ventilation in industrial settings is normally provided by means of extract fans at roof level. Good general ventilation means rapid

fume clearance and a through draught, Figure 5.1.3. Such ventilation systems are not designed to dilute hazardous emissions, and are therefore only applicable to factories, stores and general workshops where no significant hazardous emissions occur. If the purpose is to dilute known workplace emissions to safe concentrations in situations where local exhaust ventilation cannot be applied, clean air can be introduced at ceiling level with diluted emissions extracted at floor level. Open windows and doors are often used to dilute emissions. When placed properly, a simple

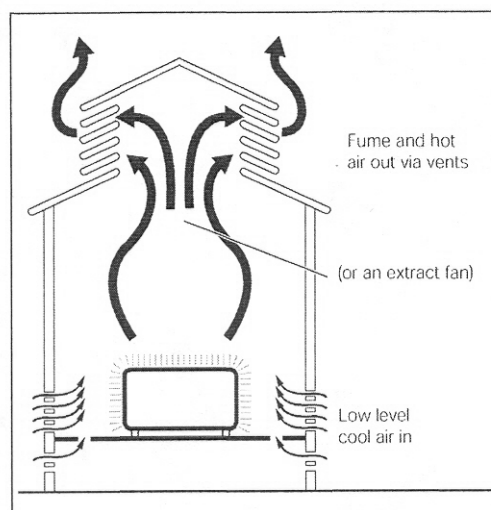


Figure 5.1.3. The principle of good general ventilation.

fan can be used to reduce hazardous emissions from a worker's breathing zone, Figure 5.1.4.

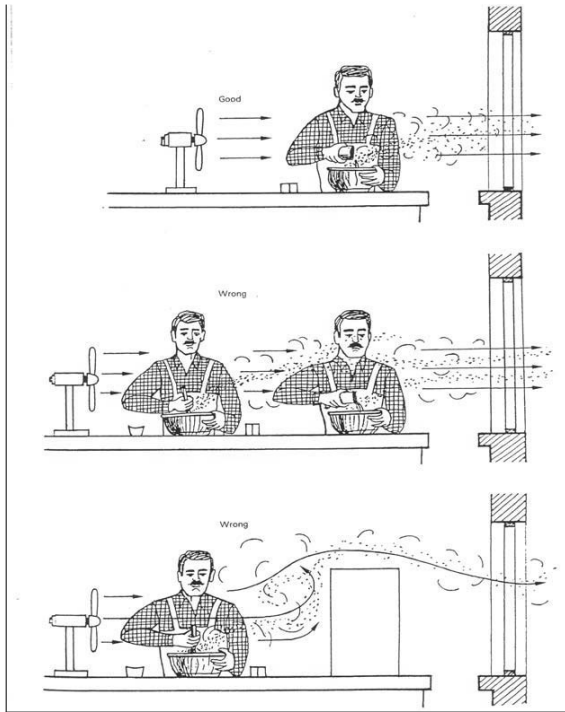


Figure 5.1.4. The use of a fan to reduce hazardous emissions.

### Local exhaust ventilation

Local exhaust or ventilation devices are often very efficient methods to eliminate chemical emissions at source. Hoods that are designed to draw the air upwards are best suited to capture pollutants that rise naturally, e.g. hot gases or vapours. Hoods can also be placed at the side or behind the source. It is important that the distance between the source and the hood is as small as possible, since the face velocity will quickly decay with distance. Furthermore, it is important that the air flow moves the pollutant away from the worker's breathing zone, Figure 5.1.5.

### Enclosures

Total enclosures under negative pressure, are systems designed to reduce the risk of exposure from the most toxic substances. Inside the enclosure, the pressure is maintained below atmospheric pressure in order to ensure that if the enclosing fabric is broken, air will flow inwards so that nothing will escape to the outside. Examples of such devices are hot cells, glove boxes, and blasting cabinets.

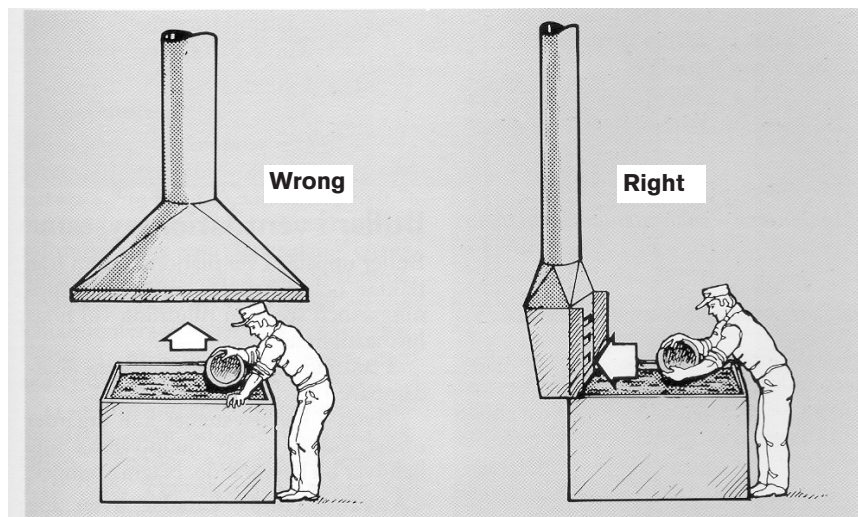


Figure 5.1.5. It is important that the worker don't have to stay between the hood and the source of the emission.

Partial enclosures with exhaust ventilation are devices where the source of emission is enclosed on all sides except the one where access is needed. An air velocity (face velocity) is maintained at the opening, which must be sufficiently high to prevent the substances from escaping through the opening. The direction of the air added to the opening area is important to avoid disturbances in the air flow around the worker, Figure 5.1.6.

### Push-pull ventilation

The capability of exhaust devices or fans to remove contaminated air is limited. Exhaust systems used in operations such as welding, degreasing or spray painting, are often not sufficient to remove emissions. The systems can be

improved by using a small fan to push clean air in the direction to the exhaust fan, Figure 5.1.7. In order to avoid turbulence, the capacity of the push fan shall be 10-20 per cent of the exhaust fan. Push-pull ventilation can work either horizontally or vertically.

### Displacement ventilation

With displacement systems, air is introduced at low velocity through floor terminals or other diffusers. Cool air floods the floor and the room heat sources lift the air up past the occupied zone and is then exhausted at high level. The principle is to flood the working area with clean air, which moves the emission towards extract grilles or fans placed at the opposite wall or at the ceiling level, Figure 5.1.8.

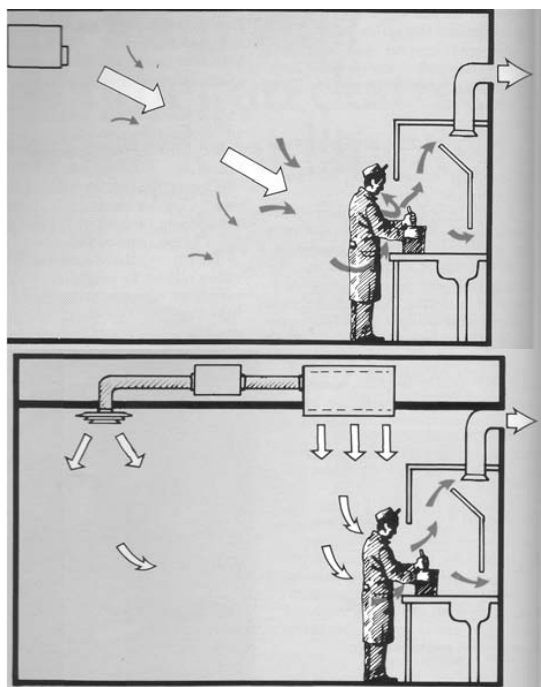


Figure 5.1.6. With the air supply at the opposite wall there is risk of whirls around the worker (above). Air supply above the worker minimises this risk (bottom).

#### To remember when looking for hazards:

Caused by the process: Open processes, e.g. mixing in open containers, painting big surfaces.

Processes generating dust or aerosols, fumes, vapours, e.g. welding, grinding, spray painting

Related to the chemicals that:

lead to high exposure of workers

result in many workers being exposed  
are highly volatile

are dispersed in the air

can cause health risks, either acute (e.g. poisons, irritants) or chronic (e.g. allergy, asthma, known occupational diseases)

are toxic for reproduction

### Personal protective equipment

If exposure cannot be adequately controlled in any other way, workers must wear personal protective equipment (PPE). PPE consists of devices provided to workers and required to be worn, while they perform job tasks that risk hazardous



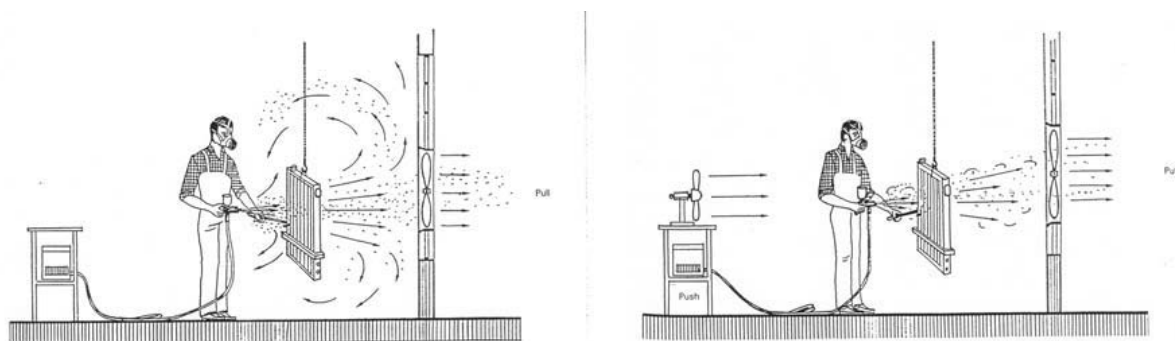


Figure 5.1.7. Push pull ventilation; improved ventilation with help of a small fan.

exposure. PPE should only be used for a short time until other control measures have been installed or when there are no other alternatives to prevent hazardous exposure.

**The workers may need to wear one or more of the following:**

- Protective overalls;
- Appropriate gloves which have been selected to protect from adverse contact with specific chemicals;
- Face shields;
- Respiratory protective equipment, where ventilation doesn't provide adequate control;
- Air-purifying respirators, half-mask respirators fitted with the appropriate filter will often be sufficient. If work includes spraying or work in a confined space, atmosphere-supplying respirator that provides breathable air from a clean air source may be necessary.

Workers who need to wear PPE should be trained in its proper use and on its limitations. It is also important to store PPE away from chemicals, to maintain it and to keep it clean.

### ILO CHEMICAL CONTROL TOOLKIT (ICCT)

IOHA (International Occupational Hygiene Association) has prepared an “International Toolkit” for ILO from COSHH Essentials, HSE

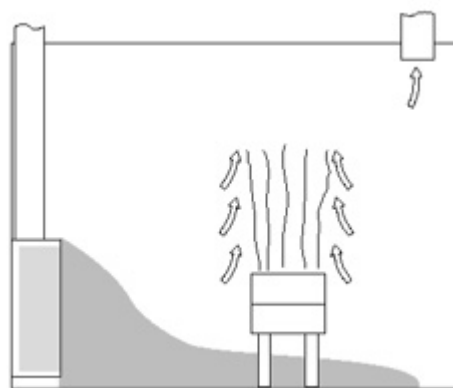


Fig 5.1.8. The principles of displacement ventilation; cool air is supplied at low velocity near the floor and spread over the floor. Convection from heat sources creates vertical air motion into the upper zone where contaminants are exhausted.

(Health & Safety Executive, UK). The IPCS established (2003) an international group that has further developed a “Workplace Chemicals Control Kit” designed for Small and Medium-sized Enterprises (SMEs) in developing countries. The aim was to provide simple and practical means to prevent/reduce risks of chemical exposures. The toolkit includes five stages:

#### *Hazard classification*

Includes determination of the hazards presented by the chemicals (based on Globally Harmonized System of Classification and Labelling of



## Chapter 5.1

Chemicals, GHS). There are six hazard groups, five for inhaled chemicals and one for skin contact. A three-step reference table is used to assign a hazard group to the chemical.

### *Scale of use*

A matrix helps to determine the amount of chemicals used or handled.

### *Ability to be airborne*

The physical form of the chemical has an impact on the likelihood of the chemical to get into the air. Three levels are chosen both for solids and liquids.

### *Finding control approach*

Using steps 1-3, it eral ventilation, engineering controls, containment and special controls.

### *Finding the task-specific control guidance sheet(s)*

A general guidance sheet for each approach is currently available and task specific control guidance sheets will be developed.

More information can be found on website of the SafeWork programme [www.ilo.org/safe-work](http://www.ilo.org/safe-work), under the topic Control Banding.

# Pesticides

*Catharina Wesseling*

Pesticides are one of the most important chemical hazards in developing countries. This intrinsically dangerous technology is promoted in settings that lack resources to control it. This chapter aims to: provide an overview of the occupational exposures and health risks associated to pesticide use, emphasising pesticide use in agriculture; critically examine current risk assessment and risk management processes, specifically the “safe use approach”; and to propose strategies to effectively reduce pesticide-related Occupational Safety and Health (OSH) risks.

## WHAT ARE PESTICIDES?

Pesticides, literally, are pest killers and they are designed to interfere with a variety of biological targets in living organisms. Inorganic substances, such as sulfur and arsenic, were already used as pesticides 2,000 years ago, but it was not until DDT was developed in 1939 that the economic potential of pesticides was fully discovered. The term “pesticide” usually refers to insecticides, nematocides, herbicides, fungicides and rodenticides, but also includes agents regulating plant growth and fruit thinning agents. Since living organisms share many biological systems, pesticidal action also commonly affects non-target species, including humans.

Today dependence on chemical pest control is ubiquitous and pesticide use continues to increase, mainly in developing countries. Pesticides production has been estimated at 2.6 million tons of active ingredients in 1998, of which 25% ends up in developing countries. There are some 750 distinct active ingredients in common use globally. Pesticides are usually grouped into categories with certain common chemical, and toxicological, characteristics. Examples are organochlorine, organophosphate, carbamate, and pyrethroid insecticides; chlorophenoxy, triazine, and bipyridyl herbicides; and inorganic and dithiocarbamate fungicides, Figure 5.2.1. However, as new pesticides continue to appear on the market, categorization by chemical groups is becoming very complex. Some important pesticides are difficult to classify or can be classified into several categories.

## WORKERS EXPOSED TO PESTICIDES

Pesticides are primarily used in agriculture, the most important economic sector in many developing countries. The proportion of farmers that uses pesticides, and the extent to which they use them, varies widely between and within countries, depending on the types of agricultural production and other socio-economic and

## Chapter 5.2

Chemical group	Biocidal action	Examples of specific pesticides
Organochlorines (OC)	Insecticides	DDT, methoxychlor, dicofol, BHC, lindane, aldrin, dieldrin, endrin, chlordane, heptachlor, endosulfan, toxaphene, chlordecone, mirex
Organophosphates (OP)	Insecticides, nematocides	Methyl parathion, chlorpyrifos, diazinon, methamidophos, terbufos, malathion, coumaphos, dichlorvos, ethoprophos, fenamiphos, monocrotophos, oxydemeton-methyl, phorate, temephos, azinphos-methyl
Carbamates	Insecticides, nematocides	Aldicarb, carbaryl, carbofuran, methomyl, oxamyl, propoxur, thiodicarb
Pyrethroids	Insecticides	Permethrin, tetramethrin, allethrin, fenvalerate, deltamethrin, cypermethrin
Biological pesticides	Insecticide Insecticide-fumigant	Bacillus thuringiensis Nicotine
Anilides	Herbicides	Alachlor, propachlor, propanil
Bipyridyl compounds	Herbicides (nonselective, desiccants)	Paraquat, diquat
Chlorophenoxy acids	Herbicides (broadleaf weeds)	2,4-D, MCPA, 2,4,5-T
Nitrophenols	Herbicides (some multiple biocidal action)	Dinoseb, dinitrophenol, dinitroresol
Phosphonates	Herbicides	Glyphosate
Picolinic acid	Herbicide	Picloram
Thiocarbamates	Herbicides	Vernolate, tiobencarb
Triazines	Herbicides	Ametryn, atrazine, cyanazine, metribuzin, propazine, simazine, terbuthylazine
Triazoles	Herbicides	Amitrole
Uracils	Herbicides	Bromacil
Urea derivatives	Herbicides	Diuron, flumeturon, linuron, methabenz-thiazuron, monuron, tebuthiuron
Anticoagulants	Rodenticides	Warfarin, superwarfarins
Inorganic compound	Rodenticides Fungicides Fumigants	Thalium sulfate Copper, arsenic, cadmium compounds Zinc phosphide, aluminum phosphide
Dithiocarbamates	Fungicides	Maneb, zineb, mancozeb, nabam, ferbam
Thiophtalimides	Fungicides	Captan, captafol, folpet
Organotin compounds	Fungicides	Fentin acetate, fentin hydroxide
Organomercury compounds	Fungicides	Methyl mercury, methoxyethyl mercury compounds
Miscellaneous fungicides	Fungicides	Benomyl, chlorothalonil, metalaxyl, thiabendazole, triadimefon, imazalil
Fumigants		Chloropicrin, dibromochloropropane, 1,2-dichloropropane, 1,2-dichloropropene, ethylene dibromide, methyl bromide, hydrogen cyanide, carbon disulfide, phosphine

Figure 5.2.1. Selected chemical groups of pesticides with examples of specific pesticides.

cultural factors. The production of ornamental plants, tropical fruits, vegetables, and other cash crops are particularly reliant on chemical inputs, but pesticide use is generally widespread. As an example, in Costa Rica, close to 100% of the farmers use pesticides and on average, each agricultural worker uses over 20 kg of active ingredient.

Women's participation in agricultural export production has increased worldwide. Women frequently perform unpaid agricultural tasks on family farms. Rural women also have an important role in the informal agricultural sector, for example as temporary workers in coffee and fruit harvests. Pesticide exposures among women may be much more frequent and higher than previously believed.

Many workers are also exposed to pesticides outside the agricultural sector. Examples include industrial workers in factories manufacturing or formulating pesticides, workers in commercial establishments that sell pesticides, applicators controlling industrial or domestic pests, vector control workers, gardeners, workers in food processing plants, and hotel and domestic service workers.

### PESTICIDE RELATED TASKS IN AGRICULTURE

Exposures occur primarily by handling pesticides during mixing, loading and spraying. Exposures also occur during transportation, maintenance of spray equipment, flagging, at fumigation airports, in pesticide storehouses, and during work close to fields being sprayed or after re-entry into recently sprayed fields (harvesters or trimmers), or during selection and packing of freshly sprayed fruits and vegetables. Within job categories, exposures vary widely. Applicators may distribute a granulated nematocide with bare hands, spray a liquid pesticide formula-

tion with a backpack, or distribute a powdered formulation by means of a closed-cabin tractor. Tasks involving direct handling of pesticides are most often carried out by men, whereas women workers usually perform tasks with indirect exposures. However, sometimes women work as pesticide applicators, for example spraying fungicides on banana crowns in the packing plants of banana plantations in Central America, or spraying the herbicide paraquat on coconut plantations in Malaysia.

### ROUTES OF EXPOSURES AND UPTAKE

Pesticides can enter the body by dermal, inhalation or oral exposure routes. Dermal exposure is the most relevant route of exposure and, in a majority of pesticide exposure situations, responsible for most of the body burden. Absorption through the skin is especially high, when the pesticide is in liquid form and when contamination occurs in skin areas that easily absorb pesticides, for example the scrotal skin or the eyes. Fumigants, granulated nematocides with a high vapour pressure, and powdered formulations with fine particles can be readily inhaled, especially when used within enclosed spaces, and are then easily absorbed into the blood from the small airways. Particles too large to enter the small airways can be absorbed through the mucous membranes of upper respiratory tract. Absorption from oral exposures occurs after eating or drinking with contaminated hands, by means of splashes into the mouth, smoking during work, and through swallowing big inhaled pesticide particles or run off from the face.

### HEALTH RISK PROFILES OF PESTICIDES

The risk profiles of pesticides are concerned with the relationships between exposures, toxicity, host factors and the consequent probability of health effects. Along with the chemical heter-

ogeneity, the toxicity of pesticides differs greatly and a diversity of health effects may occur, including systemic poisonings; topical lesions of skin and eyes; respiratory, immunological, neurological, and developmental effects; reproductive dysfunction; cancer; and disruption of different hormonal pathways. The risk that a health effect will occur is basically defined by the inherent toxicity of a compound and the characteristics of exposure. Adverse health effects may be reversible or irreversible, the onset may be immediate or delayed, the magnitude of an effect may be mild or severe, and the duration may be short or long-term. Differences in types of exposures (routes, intensity, duration, peak and cumulative exposures) to the same compound may relate to different health outcomes. Thus, the risk profiles of pesticides are often complicated by the diversity of possible toxicity-exposure combinations.

In addition, the health effects of exposures to mixtures of pesticides, (simultaneously or at different moments in time), and toxic effects from the “inert” ingredients in the pesticide formula-

tions, are largely unexplored but becoming an issue of increasing concern. Host susceptibility factors such as age, gender, and nutritional status also influence the occurrence of health effects. It has been demonstrated that genetic polymorphisms may influence individual susceptibility for poisoning, the development of chronic pesticide-related ill health, or cancer. Illiteracy, poor sanitation, high prevalence of infectious diseases, environmental pollution, and general conditions of poverty are external factors that also influence the health risks for workers, by increasing the probability of exposures, synergistic effects between toxic agents, or weakening of the immune system.

## CHEMICAL CLASSES OF PESTICIDES AND HEALTH EFFECTS

### Organochlorine pesticides (OCs)

OCs are composed of the following subgroups: DDT and its analogues (methoxychlor, dicofol), cyclohexanes (BHC, lindane) and cyclodienes (aldrin, dieldrin, endrin, chlordane, heptachlor,

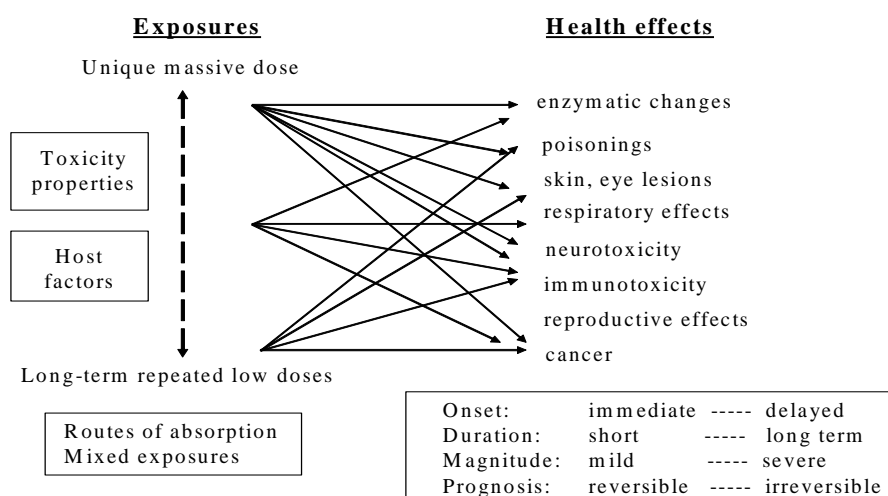


Fig 5.2.2. A schematic illustration of the complex relationship between different characteristics of exposure and a range of health outcomes.

endosulfan), toxaphene and related compounds, and others (chlordecone, mirex). Important characteristics of OCs are their lipid solubility and slow degradation resulting in persistency and bioaccumulation. OCs can be stored in body fat deposits for decades. Neuronal hyperactivity is the main and common acute poisoning symptom of most OC compounds.

OC pesticides were the first group of chemicals synthesized to kill pests and have been extensively used worldwide after World War II up to the 1970s. Many OCs are now recognized as Persistent Organic Pollutants (POPs) by the Stockholm Convention of 2001 and are being phased out globally. However, endosulfan is widely used in developing countries, although its listing in the Stockholm Convention has been proposed recently. In addition, intense discussions are ongoing on renewed use of DDT for malaria control.

#### *Acute poisonings*

Acute poisonings by DDT are infrequent but are characterized by neurological symptoms of gradually increasing severity (paresthesias, headache, dizziness, irritability, confusion, tremor, up to convulsions and coma) and non-specific general malaise (nausea, vomiting and fatigue). Cyclodienes, among them endosulfan, are easily absorbed through the skin and considerably more toxic. Convulsions are often the first poisoning symptom. Although banned OCs are no longer a problem with regard to acute toxicity, endosulfan is still the cause of numerous occupational poisonings including fatal poisonings.

#### *Chronic and delayed health effects*

Neurobehavioral impairment and increased reporting of neuropsychological symptoms have been observed among Costa Rican vector control sprayers with long-term DDT expo-

sure. OCs have estrogenic or anti-androgenic properties. Their endocrine disrupting effects have been associated to cancer occurrence in experimental animals and reproductive effects in wildlife, and these toxic pathways may play a role also in humans. OCs have been associated with leukemia, non-Hodgkin's lymphoma, soft tissue sarcoma, multiple myeloma, and cancer of the pancreas, lung, liver, skin, and breast. Endosulfan has been identified as the cause of reproductive and developmental effects in exposed human populations in India.

In addition, there are many organochlorine pesticides classified elsewhere, for example, chlorothalonil (an irritant, allergen, and possible carcinogen), captafol (a carcinogen), chlorpyrifos (a neurotoxic cholinesterase inhibitor), chlorophenoxy acids (carcinogens), and chloropicrin and 1,3-dichloropropeno (respiratory irritants).

#### **Organophosphate pesticides (OPs)**

OPs currently in common use include chlorpyrifos, coumaphos, diazinon, dichlorvos, ethoprophos, fenamiphos, malathion, methamidophos, monocrotophos, oxydemeton-methyl, phorate, temephos, terbufos, and in some countries methyl-parathion. OPs are cholinesterase inhibitors and the main toxic action is on the nervous system. Under physiological conditions the enzyme acetylcholinesterase controls the transmission of the nerve impulses at the cholinergic synapses throughout the nervous system by hydrolyzing the neurotransmitter acetylcholine. In exposed organisms, OPs serve as alternative substrate for acetylcholinesterase, causing accumulation of the acetylcholine and overstimulation at the receptors with the appearance of a cholinergic syndrome. OPs form stable complexes with acetylcholinesterase and recovery of the phosphorylated enzyme may depend on new protein synthesis. Many OPs are classified by the In-



ternational Program on Chemical Safety of the World Health Organization (WHO-IPCS) as highly (Ib) or extremely (Ia) toxic.

OPs, mostly insecticides and nematocides used as substitutes for OCs, are less persistent but more acutely toxic pesticides. They are among the most used pesticides in developing countries. Parathion (ethyl and methyl) is the only example of a pesticide that has been restricted in many developing countries after WHO-IPCS, based on its history of hundreds of fatal occupational poisonings, classified it in the Ia (extremely toxic) category instead of in the lower category corresponding to its acute toxicity in rats.

#### *Acute poisonings*

OPs are easily absorbed through the skin and some OP nematocides such as terbufos are also a considerable respiratory hazard with a very high vapour pressure. OPs present the most frequent cause of occupational poisonings in most developing countries. Acute poisoning symptoms include central nervous system symptoms (headache, dizziness, anxiety, confusion, convulsions, coma), autonomic nervous system (contracted pupils, blurred vision, sweating, salivation, lacrimation, bradycardia or tachycardia, bronchial secretions, bronchoconstriction, nausea, vomiting, abdominal cramps, diarrhea, increased urination, loss of control of sphincters), and of the skeletal muscle myoneural junctions (muscle fasciculations and cramps, muscle weakness, paralysis). These symptoms may evolve into respiratory failure and death. Although there is an antidote (atropine), occupational OP poisoning can be fatal, especially in regions with poor access to adequate health care.

#### *Chronic and delayed health effects*

It has been demonstrated that damage of the central nervous system remains after occupational OP poisonings with impairment of a broad spectrum of functions, including memory, concentration, and psychomotor and visuomotor functions. Neuropsychiatric symptoms, among them depression and suicidal ideation, are more frequent among workers with a previous OP poisoning. It is uncertain whether repeated low-dose OP exposures without poisonings cause similar deficits among workers.

Some OPs (for example, methamidophos, chlorpyrifos, fenthion, trichlorphon and parathion) can cause an organophosphate induced delayed neuropathy (OPIDP). OPIDP is a degeneration of the large diameter axons of the peripheral nervous system and spinal cord. OPIDP is associated with the inhibition and “aging” (irreversible inhibition) of another enzyme in the nervous system, the neurotoxic target esterase (NTE). OPIDP is characterized by weakness, ataxia and paralysis, and sensory disturbances of the extremities. OPIDP appears several weeks after the acute poisoning crisis has resolved and, in severe cases, leaves permanent damage. A so-called Intermediate Syndrome has also been described, characterized by muscle weakness of proximal limb and respiratory muscles, days after the acute poisoning episodes. Epidemiologic studies have found persistent weakness, increased vibration thresholds, or slowed nerve conduction among workers with previous OP poisonings.

In addition to the effects on the nervous system, OPs have been associated with occupational cancers, in particular non-Hodgkin's lymphoma (dichlorvos, diazinon, malathion), leukemia, and lung cancer; endocrine disruptive properties (malathion, methylparathion, dichlorvos, diazinon, chlorfenvinphos and others), and

to male reproductive effects (chlorpyrifos). Prenatal parental occupational exposures to OPs have been linked to childhood leukemia among their children. Many OPs are also skin sensitizers, for example chlorpyrifos and malathion.

### Carbamates

Carbamate insecticides and nematocides include aldicarb, carbaryl, carbofuran, methomyl, oxamyl, propoxur, and thiodicarb. Carbamates are also cholinesterase inhibitors, but differ from OPs in that the carbamylated acetylcholinesterase enzyme combination does not “age” and the enzyme is spontaneously reactivated. Carbamates are in common use in most developing countries, in agriculture, vector control and for domestic pest control.

#### *Acute poisonings*

Exposure routes are the same as for OPs. Many carbamates are also highly or extremely toxic (e.g. aldicarb, methomyl and carbofuran) and poisonings have the same clinical manifestations as OP poisonings but are usually of shorter duration and therefore less severe. Occupational fatalities are rare. In the late 1980s and early 1990s, aldicarb was used as a nematocide on banana plantations in Central America and caused several thousands of mild and moderate occupational poisonings. Carbofuran has caused poisoning epidemics in Nicaragua and Costa Rica.

#### *Chronic and delayed health effects*

It is generally assumed that carbamates do not produce chronic central or peripheral nervous system effects, because of lack of aging, but there are a number of case reports documenting such effects, for example in relation to carbaryl and carbofuran. So far, only one small epidemiological study has been carried out in Costa Rica. Although mild chronic neurobehavioral deficits

due to carbofuran could not be ruled out, overall such effects do not seem to be very common or severe. The nematocide aldicarb has been associated to immunotoxic responses.

### Pyrethroids

Pyrethroid insecticides cause a repetitive neuronal discharge by delaying the closure of the sodium channel in the nerve fibres after the action potential. Pyrethroids can be grouped in two classes in accordance with chemical structure and symptoms. Both Type I (permethrin, tetramethrin and allethrin) and Type II (fenvalerate, deltamethrin, cypermethrin) cause increased hyperexcitability of the peripheral nerves.

Since the 1980s, pyrethroid insecticides have been marketed as a less toxic and non-persistent chemical alternative to OCs, OPs and carbamates. Pyrethroids are more expensive than the highly toxic OPs and carbamates, so the cholinesterase inhibitors are often preferred by farmers with scarce resources. Yet, use of pyrethroids is widespread in many developing countries, in agriculture, vector control and control of domestic pests.

#### *Acute poisonings*

Dermal absorption and inhalation of pyrethroids is low. Acute poisonings are less frequent than poisonings with cholinesterase inhibiting pesticides but do occur regularly. Type I pyrethroids cause tremor and increased body temperature. Type II pyrethroids cause tingling, stinging and burning skin sensations (paresthesias), irritant respiratory symptoms, salivation, and writhing of the limbs and trunk (choreoathetosis). There are several reports, in China and the USA, of workers with abnormal skin sensations. In particular the face is affected by paresthesias. In China, several systemic occupational poisonings

with decreased consciousness and seizures have also been reported.

### *Chronic and delayed health effects*

Several pyrethroids are corrosive to the eyes. Long-term neurotoxic effects in humans have not been reported. Immunotoxic responses have been demonstrated for several pyrethroid insecticides in experimental studies, but no data exist in exposed workers.

### **Bipyridyl compounds**

This group consists mainly of the contact herbicides paraquat and diquat. Paraquat is classified by IPCS-WHO as toxicity category II (moderately toxic) based on acute oral toxicity data in rats, although the toxicity of paraquat in humans is known to be much higher. Independent on the route of entry, paraquat accumulates in the lung, where free radical-mediated membrane damage of the alveolar cells seems to be the determining toxic mechanism.

Paraquat, one of the most used herbicides worldwide, is a controversial compound. Paraquat is promoted by the manufacturers as a safe herbicide provided it is used in accordance with label instructions, but recent studies on exposure assessment and health effects demonstrate that determinants of exposure that were identified thirty years ago, still prevail in developing countries, for example defective and leaking spray equipment, absence of or deficient personal protective equipment, and inadequate spraying techniques such as spraying against the wind. Global campaigns to ban or severely restrict paraquat have been ongoing since the 1980s. In 2003, the European Commission's Standing Committee on the Food Chain & Animal Health voted to include paraquat in the list of pesticides permitted in EU countries, but in 2007 this decision was reversed after the

Swedish government sued the Commission for deficient assessment of the health risks.

### *Acute poisonings*

Little is known about systemic absorption of paraquat during occupational exposures. It is likely that exposures during work that result in systemic absorption often involve oral contamination. Paraquat can also enter the body through the skin, especially in the presence of skin lesions or after paraquat has damaged the skin barrier. Respiratory exposure has been considered negligible based on big particle size, low vapour pressure, and low measured inhalation levels. However, this has been questioned by several studies that observed systemic effects from respiratory exposures. In addition, frequent episodes of nosebleeds indicate that paraquat particles reach the upper airways. It remains uncertain at which inhalation levels nosebleed occurs and whether these levels may be relevant for systemic uptake.

Paraquat poisoning is characterized by multiple organ failure, most frequently kidney, liver and lung (adult respiratory deficiency syndrome), and occasionally also the central nervous system, heart, and suprarenal glands. Severe gastrointestinal burns occur in case of ingestion. Death is primarily a consequence of respiratory failure from either pulmonary edema in the first few days or extensive alveolar damage and fibrotic changes in later stages. No antidote or effective treatment has been identified. Fatalities after suicidal ingestions of very small amounts run in the thousands. Mild systemic occupational poisonings are common; severe and fatal occupational poisonings are not frequent but do occur. Fatal suicidal and accidental paraquat poisonings are more frequent among those working in agriculture than among the general population.

*Skin and eye injuries*

Paraquat is also a severe skin and eye irritant. The irritative and corrosive properties of paraquat cause skin injuries in a very high proportion of paraquat users (as high as 50% in exposed workers in both early and recent surveys) ranging from red, swollen and blistered skin up to third degree burns needing skin grafts. Injuries in the eye can equally range from mild conjunctivitis up to permanent loss of vision due to burning and scarring of the cornea. Nosebleeds occur from irritation of the upper respiratory mucous membranes. Nail damage is frequent and can be permanent with long term exposure.

*Chronic and delayed health effects*

In Nicaragua, a dose-response gradient between intensity of exposure and the prevalence of respiratory symptoms was reported. In South Africa, in one study clinical and histological lung lesions were observed among exposed workers who had skin injuries, and another study associated arterial oxygen desaturation during exercise with long-term paraquat exposure, which was also observed in a Costa Rican study. Skin cancer has been observed among industrial paraquat workers in Taiwan. Paraquat has been linked with Parkinson's disease in several epidemiological studies. The causality of paraquat in Parkinson's disease is supported by recent experimental studies that have shown that paraquat affects the dopaminergic system of the brain. In addition, synergism with maneb, a manganese containing dithiocarbamate fungicide, has been observed. From an occupational health point of view, this is of great concern considering that both types of pesticides are widely used, often by the same farmers.

**Chlorophenoxy herbicides**

The systemic herbicides 2,4,5-T, MCPA and 2,4-D belong to this group. Globally 2,4-D is one of the most used herbicides, used on many crops. In Central America it is aerially sprayed on rice and sorghum. Since the early and mid 1980s, 2,4,5-T is not marketed in most countries due to its dioxin contamination (see below). Agent Orange, a mixture of 2,4,5-T and 2,4-D, with high dioxin contamination, was used as a defoliant during the Vietnam War.

*Acute poisonings*

The main exposure route is oral, absorption by inhalation is moderate and skin absorption is poor. Acute toxicity is low to moderate. Cases of acute poisonings occur with some frequency, but occupational fatalities are unknown. Symptoms include nausea, vomiting, abdominal pain, diarrhea, headache, fatigue, weakness and, in severe cases, muscle pain and contractions, electrocardiographic changes, and kidney failure.

*Chronic and delayed effects*

Few cases of chronic toxicity of the peripheral nervous system and muscles have been reported. Chlorophenoxy herbicides have been associated with soft tissue sarcoma and lymphohematopoietic cancers among Swedish forest workers and US farmers.

In earlier times, these herbicides, in particular 2,4,5-T, contained 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) as a contaminant. TCDD is an established animal carcinogen, an endocrine disrupter, a teratogen, an immunotoxin, and causes chloracne, a severe skin disease. There is controversy whether TCDD may be responsible for the cancer excesses observed in worker's populations exposed to chlorophenoxy herbicides. The question of effects from TCDD on the offspring

of Vietnam veterans and the Vietnamese population remains unresolved.

### **Dithiocarbamates**

This category concerns a group of widely used fungicides mancozeb, maneb, zineb, ziram, and ferbam (all with a metal atom: manganese, zinc or iron). For over 30 years, mancozeb has been the pesticide with the highest import volume in Costa Rica, where it is aerially sprayed on banana plantations.

The acute toxicity of dithiocarbamates is low and systemic poisonings are rare. These fungicides irritate the skin, eyes and respiratory tract. The metabolite ethylene thiourea (ETU) of the ethylenedithiocarbamates (EBDC) fungicides mancozeb, maneb and zineb is a well-recognized animal carcinogen. Dithiocarbamates can cause irritant or allergic contact dermatitis and eye irritation, ETU being the possible sensitizer. ETU has also been associated with adverse effects on the thyroid. Manganese is a known dopamine neurotoxicant and maneb has been associated with a Parkinson like syndrome in exposed workers in Brazil. In animal experiments, interaction of maneb with paraquat has been observed in the destruction of dopaminergic neurons, suggesting a synergistic role in the etiology of Parkinson's disease.

### **Fumigants**

Fumigants are not a class of chemicals but a heterogeneous group of broad-spectrum biocides in gas form with different chemical structures and toxicities. Being gases, the main exposure route is respiratory, but they can also be easily absorbed by dermal and gastrointestinal routes. WHO-IPCS does not classify the toxicity of fumigants but many are highly toxic. Methyl bromide, a fumigant currently being phased out in industrialized countries, is increasingly used

in fruit and flower production in developing countries. Systemic poisonings are characterized by neurological symptoms and irritation of the respiratory tract. Methyl bromide can also cause severe skin burns. Other widely used fumigants include chloropicrin and 1,3-dichloropropene with irritative respiratory symptoms that can lead to vomiting and bronchospasm. Dibromochloropropane (DBCP), a nematocide used on banana and pineapples in the 1970s, is a spermatotoxin and left many thousands of male workers in Latin American, Africa and Asia, hypo- or azospermic and childless. Other health effects from DBCP, a multiple site animal carcinogen and an endocrine disruptor, have not been evaluated.

### **Other compounds**

There are many other chemical categories and specific pesticides of concern for developing countries, in particular herbicides and fungicides. In general, they have a low acute toxicity but may pose considerable allergenic, carcinogenic, and reproductive risks for long-term exposed workers. Persistent triazine herbicides have been linked to ovary cancer in exposed female workers. Benomyl and chlorothalonil are both skin irritants and sensitizers, and animal data on carcinogenicity are sufficient. Glyphosate is the main chemical substitute for paraquat. This herbicide, and in particular the most important commercial brand Roundup, is an irritant for skin, eyes and respiratory tract and may affect foetal development. Copper based fungicides are often contaminated with arsenic; inorganic and organic arsenic pesticides are recognized human carcinogens.

### **“Inert ingredients”**

The inert ingredients in a pesticide formulation are often not specified. They include solvents,



adsorbents, emulsifiers, stickers, penetrants, and synergists. Solvents and adjuvants may be more toxic than the pesticide itself or they may increase dermal absorption enhancing the toxicity of the pesticide. In addition, many of these compounds are skin irritants and sensitizers. Such products include alcohols, ethers, aliphatic and aromatic hydrocarbons, and chlorinated hydrocarbons. A widely used synergist is piperonyl butoxide, which has a low acute toxicity but could possibly inhibit pesticide-metabolizing enzymes.

### KNOWLEDGE, ATTITUDES AND PRACTICES IN DEVELOPING COUNTRIES

Despite listing a considerable number of pesticides and their health effects, the occurrence of many potential health effects from pesticide exposures in human populations still remains uncertain or unknown. Reasons for these uncertainties include lack of registration of diseases, incorrect diagnoses of the etiologies, difficulties of linking a health effect to a specific pesticide in the presence of multiple exposures, and gaps in scientific knowledge on specific pesticides, formulations of pesticides, multiple exposures, as well as host and external factors modifying toxicities and exposures.

During the 1980s, studies on knowledge, attitude and practice (KAP-studies) in relation to pesticides were carried out and show, without exception, the lack of knowledge and inadequate risk perceptions and practices of pesticide users. It has been widely presumed that pesticide problems are mainly due to the ignorance of pesticide users and lack of regulation. For over twenty years, training efforts, some of them huge and very expensive, have been undertaken to increase knowledge in developing countries. Indeed, recent studies in East Africa, Central America and South East Asia show that today, pesticide

users are in general aware that pesticides are dangerous and cause health and environmental effects. However, these same studies also show that hazardous work practices continue as shown in Figure 5.2.3. This table contains data from a recent Nicaraguan national survey, which found high prevalences of risk factors for pesticide illness and an incidence of 6.4 poisonings, mostly occupational, per 100 rural inhabitants in one year. A burning question is why are pesticides still a problem despite more awareness about the risks?

Practice	%
Purchase of pesticides	97
No use of personal protective equipment	90
Leaving containers in the field	41
Pesticide spills during the previous year	39
Entering recently sprayed areas	38
Decanting of pesticides	27
Blowing on blocked spray nozzles	25
Disposal of toxic waste in rivers	19
Washing equipment in rivers	18
Eating after application without washing hands	10
Letting their children work with pesticides	3

Figure 5.2.3 Pesticide practices by Nicaraguan farmers, 1999-2000. Source: Corriols M, Silva D, Marín J, et al. "Incidencia de intoxicaciones agudas por plaguicidas y estimación del subregistro en Nicaragua" (Incidence of acute pesticide intoxications and underregistration estimates in Nicaragua). Managua: OPS/OMS, 2002.

### RESEARCH ON EXPOSURE AND HEALTH EFFECTS FROM PESTICIDES USE IN DEVELOPING COUNTRIES

Pesticide research in developing countries is insufficient when the overall presence of this occupational and environmental hazard and sub-



sequent potential health risks are considered. In general, developing countries have few good exposure data. Some countries keep import statistics, but these are not systematically scrutinized for trends on the import of hazardous pesticides. Studies quantifying exposures are scarce and usually difficult to interpret. Exposure or hazard surveillance is generally absent.

Surveillance systems of pesticide illness are also uncommon. The WHO has estimated the annual number of acute poisonings at 3 million severe poisonings with only 700,000 of these being occupational poisonings. When milder cases are included, the estimate increases to 25 million agricultural workers or 3% of the active labour force. Surveys in different continents have reported between 1 - 7% of workers suffer a poisoning each year. In Central America, a recent estimate yielded 400,000 acute poisonings in one year with an overall incidence of almost 1.9 per 100 inhabitants. Most surveillance systems do not record dermal and eye lesions, but studies in Costa Rica show that they may be even more frequent than acute poisonings.

Studies evaluating chronic effects of massive overexposures or long-term exposures are even scarcer, but nonetheless there is increasing evidence on the deleterious effects of pesticides on populations in developing countries. In Latin America, genotoxicity studies among pesticide exposed populations have been carried out on workers of a number of countries. In Central America, a number of studies have been carried out on the neurological consequences of organophosphate and organochlorinated compounds. In Mexico, Ecuador and Costa Rica deficits in neurological developmental have been observed in children of agricultural communities. In Egypt, chronic effects among industrial pesticide workers have been studied. Early negative studies in South-East Asia on respiratory effects

among paraquat exposed workers have been followed by studies showing an excess of respiratory symptoms in Nicaragua and arterial oxygen desaturation during exercise in South Africa and Costa Rica. Many thousands of DBCP applicators working on banana and pineapple plantations suffered sterility in Africa, South-East Asia, and Central America and the Caribbean. Cancer studies have been carried out in various countries of Latin America and Asia, showing a variety of excesses among workers, children of pesticide exposed parents and the general population.

### RISK REDUCTION STRATEGIES

#### ‘Safe use’ approach

For decades, international bodies, in collaboration with local governments, have used ‘safe use’ approaches to reduce the risks associated with pesticide use in developing countries. The ‘safe use’ focus emphasises the prevention of acute health effects among agricultural workers and farmers.

The **WHO-IPCS “Classification of Pesticides by Acute Hazard”** contains important regulatory guidelines for those governments that don’t carry out independent risk assessments. IPCS limits its toxicity evaluation only to acute toxicity. Pesticides classified as “non hazardous under normal use conditions” are often widely used in developing countries without further evaluation of topical and chronic toxicity, as is the case with the fungicides mancozeb, maneb, and chlorothalonil, which are irritants or allergens and possible human carcinogens.

The most important ‘safe use’ initiative is the **International Code of Conduct of the United Nation’s Food and Agriculture Organization** (FAO) that aims to strengthen registration and regulation on pesticides by national govern-

ments. The code was first issued in 1985 and revised in 2002. The “Prior Informed Consent” (PIC) procedure of the Code, passed as an international agreement through the Rotterdam Convention of 1999, aims at controlling international commerce of particularly dangerous or obsolete pesticides. However, adherence to the code is voluntary and only 24 pesticides are included as a Persistent Organic Pollutants (POPs); criteria for inclusion of new products are difficult to meet but endosulfan is proposed to be listed. Debates on inclusion of WHO-IPCS Ia and Ib pesticides have been ongoing for about a decade but have not resulted in a formalised agreement. Industrialised countries continue to allow the manufacturing or formulation of prohibited pesticides for export, mostly to developing countries.

Another important initiative is the **‘Safe Use Initiative’ of the Global Crop Protection Federation** (GCPF) [formerly the International Group of National Associations of Agrochemical Manufacturers (GIFAP) and currently CropLife International). The global stewardship program of the GCPF was initiated in support of the FAO Code of Conduct. Three pilot Safe Use Projects of GCPF, conducted in Kenya, Thailand, and Guatemala, are now being extended to other countries in Africa, Asia, and Latin America. GCPF aims at enhancing collaboration between the private and governmental sectors in the training of pesticide users on “safe use”: distributors, agricultural technicians, regulators, inspectors, schoolchildren, teachers, and housewives. The training materials are reassuring about the need, benefits, and safety of pesticides, and may actually lead to increased use of pesticides.

### How realistic is the ‘safe use’ approach?

Pesticide use is increasing in developing countries. Governments preoccupied with food security are the target of industry lobbyists who claim that pesticides are indispensable and safe if used according to label instructions. Traditional alliances between pesticide manufacturers and ministries of agriculture are now extending to ministries of health. Factors that induce farmers to continue or increase their use of pesticides include: heavy marketing, fear of losing their harvests, the psychological assurance of literally observing a pest die, the relative simplicity of a pesticide application, and the loss of knowledge of sustainable non chemical pest control methods.

The assumption that pesticides are safe if used according to label instructions places the full responsibility and consequences of inadequate use with the pesticide user. The reasons why there are little or no changes towards safer behaviour even though there is a higher awareness of safety issues have not been well studied. However, it is easy to envisage that safe practices are difficult or impossible to implement in conditions of poverty and a tropical climate. For safe use of pesticides, pesticide users in developing countries need not only knowledge, but also resources or access to technical advice on proper selection of pesticide; adequate, dry and ventilated storage facilities away from the food and water supplies; adequate and well maintained spray equipment; full protective equipment with continuous replacement of contaminated parts; waste disposal facilities; continuous training programs; and medical care. In addition, farmers in developing countries have a high acceptance of risk because risk taking is part of daily life or because there are often other priorities for immediate survival.

### **Risk assessment and management in industrialised countries**

In industrialized countries, pesticide associated health and environmental risks are managed through registration of pesticides with regulations on their use based on extensive risk assessment procedures for individual pesticides. Health risk assessment is the determination of the probability of occurrence of potential health effects in association with different types of exposures. On the one hand, different exposure scenarios in occupational settings, residential exposures and consumer's exposures through food and water are evaluated and quantified. On the other hand, in vitro and in vivo experimental data are produced on acute and chronic systemic toxicity, dermal and eye irritant potency, sensitization, mutagenicity, genotoxicity, carcinogenicity, reproductive effects (teratogenicity, fetotoxicity, sterility, infertility) in multiple generation tests, and for some groups of pesticides neurotoxicity. After combining exposure and toxicity data, and assigning safety factors to allow for uncertainties, pesticides are then registered for use under specific conditions, which should guarantee that exposures don't exceed acceptable health risk standards. Results of monitoring of exposures and health may lead to later modifications of such regulations.

Despite the complexity and high costs of these risk assessment procedures, there are important flaws in the procedure. Testing is done in selected healthy, adult laboratory animals, not resembling vulnerable population groups. Tests for neurotoxicity, immunotoxicity, and developmental toxicity are not part of the typical testing battery. In the setting of standards, it is only recently that steps are being taken to look into multiple sources of simultaneous exposure. No regulatory body that has started to look into the effects of pesticide mixtures. In addition, testing

is done only on the active ingredient and never on pesticide formulations, despite potential hazards of the 'inert' ingredients. In fact, WHO-IPCS advises governments to lower the acute toxicity category of the active ingredient for the registration of pesticide formulations, in accordance to the degree of dilution. Finally, following up on exposures and health effects to evaluate the effectiveness of risk management strategies requires huge resources, even in rich countries.

### **Risk assessment and management in developing countries**

Human and technical resources are so restricted in developing countries that risk assessment is reduced to copying international guidelines of FAO (Codex Alimentarius or PIC) and WHO-IPCS (Classification of Pesticides by Acute Hazard) or of regulatory decisions by the European Commission or the U.S. Environmental Protection Agency (US EPA). There is no consideration of local or regional data on harmful human health and environmental effects or local circumstances of use, e.g. hot humid climate, impossibility of purchase and use of protective equipment; general poverty; illiteracy; undernourished populations; very young and very old workers; lack of recycling facilities for pesticide containers, and innumerable other aspects that differentiate developing countries from developed countries. The interpretation of the toxicological, epidemiological, and exposure assessment considerations of the risk assessments that underlie the risk management decisions in developed countries, are frequently, clearly erroneous. For example, pesticides not registered for use but with a food tolerance in the US, or pesticides that are regulated as RUPs (restricted use pesticides) by US-EPA, are routinely approved for a large variety of purposes and sold without any restrictions.

To continue the policy of safe pesticide use by national governments in developing countries, the key question to be answered is whether safe use of pesticides is at all possible. A true safe use approach for pesticides in developing countries should first consider whether there is a real need for a certain pesticide, by examining local pest patterns and the accessibility of less dangerous alternatives (non-chemical or chemical). If use of the pesticide is considered necessary, there must be an evaluation as to whether the conditions of use can guarantee that there will be no health and/or environmental damage. Regulatory authorities in developing countries need to be capable of making local risk assessments as a basis for decision-making, implying evaluation and integration of intrinsic toxicity data, exposure data, and considerations such as host susceptibility data, together with the socioeconomic, cultural and legal entourage. However, the resources needed for such an approach exceed the economic and technical capacity of virtually any developing country.

If less dangerous alternatives are not available, and safety conditions are adequate, the use of a hazardous substance may be temporarily justified, depending on the expected benefits. Once approved, the use and impact of hazardous substances must be closely followed up over time. However, little or no effort is made in developing countries to follow up the use and consequences of registered pesticides. Hazard or exposure monitoring, such as statistics on pesticide imports, exports and use or monitoring of residues in food, ground water or the environment, is usually absent, deficient or not accessible to the public. No human, technical or financial resources exist to carry out monitoring of adverse effects, including human, domestic animal and wildlife poisoning surveillance systems; human health and ecotoxicological studies; and

studies on economic consequences, such as costs of residue export retentions up to the complete bankruptcy of producers of certain crops due to pest resistance. Such studies are scarce and even when local research institutions produce relevant data, these are seldom considered in local policy making. In fact, we need to go beyond local risk assessment and apply the precautionary approach, i.e. include common sense and intelligence in regulatory decisions and use proactive policy making to solve pesticide problems.

### **Pesticide OSH at the company and farm level**

Management of pesticide risks at enterprise or plantation level presents many difficulties in developing countries. Regulations usually exist only in broad legal directives which, generally speaking, means any pesticide can be used on any crop or with any application method. The implementation of serious OSH pesticide programs is therefore limited from the very start and often there is no systematic follow-up on the effectiveness of preventive efforts or the adverse or beneficial effects of new products or technologies. Adverse effects that are observed may be downplayed because OSH managers feel powerless to comply with both the protection of workers' health and production requirements. Workers have little or no influence on pest management decisions even though they are the most severely affected. Integration of experts in Integrated Pest Management (IPM) and organic agriculture in pest management may be the best OSH solutions in the longer term.

### **Alternative pest control methods**

Pesticide technology is typically favoured over alternative pest control methods, however, alternative approaches are needed and successful examples exist. The FAO Code of Conduct,

despite its primary focus on safe use, has also promoted IPM programs, especially in South-east Asia, which achieved important reductions in pesticide use. IPM programs have also been carried out by public and private agronomic research institutes in Central America, on important crops like sugar cane, coffee, citrus and potatoes. These programs have included pest monitoring, biological control, and the use of pheromone traps and natural pesticides. IPM programs have proven to be more profitable than conventional pesticide-based pest control, although farmers sometimes have to bear the costs of a transition period. The disadvantage of IPM programs is that they still recommend the use of some chemical pesticides. Any use of pesticide is inherently not safe by itself, no matter if it is used under IPM or any other sustainable production system. Above all, there is a real risk that the strategy turns into an attenuated safe pesticide use approach. GCPF, on the one hand commits itself to IPM strategy and on the other hand, contradicts itself by advocating high-input and large-scale agriculture.

Organic agriculture does not use any synthetic pesticides and integrates other principles of sustainable land use. Industry has pointed out that organic agriculture is too much of a radical strategy and is unsustainable due to lower yields, which would force farmers to extend agricultural land use and cut forests to feed growing urban populations. However, studies show that organic agriculture can produce similar yields to traditional pesticide-dependent cropping and may be more profitable over the longer term because it uses more sustainable methods. Failures, such as the lack of technical assistance and research services on the implementation of this type of agriculture are avoidable.

## RECOMMENDED STRATEGIES FOR PESTICIDE ILLNESS PREVENTION

It is necessary to understand the full implications of pesticide use in order to reach acceptable and viable solutions. The safe use approach has proven to be an inefficient method to prevent pesticide-related illness in developing countries and in reality actually prevents countries from investing in sustainable methods of pest control. Other actions aimed at a progressive reduction and elimination of pesticide use and the prevention of occupational hazards from pesticides must be undertaken at international, national, local, and enterprise levels. The following suggestions would be some possible steps in the right direction:

- To measure the health, environmental and economic impact of pesticide use. If viable solutions are to be found and implemented, we need to create strong alliances between policy planners (agricultural, health, and economic development) and researchers of various disciplines. The full involvement and commitment of agricultural workers and producers is required to reduce pesticide use, starting with the most hazardous pesticides.
- Local data on the health and environmental impact of pesticides must be produced and taken into account in choosing strategies towards sound production systems and a decrease of pesticide dependence.
- Governmental agencies must be assisted by academics for systematic data collection and analysis, performance of ad hoc studies for the evaluation of emerging problems, and local risk assessments.
- Studies on health promoting and economically sustainable agricultural technologies that are not based on chemical pest control

are needed at enterprise, local, national, and international levels.

- Creative technical assistance projects are urgently needed to promote the use of alternative and safer technologies by producers. Such technologies should be assessed for effectiveness.
- The implementation of OSH programs, clean technologies, integrated pest management or organic agriculture needs to consider how cultural factors and risk perception affect their usefulness.
- Workers' rights to know and workers' empowerment need to be strengthened.
- The academic sector should assist workers, high-risk communities and the general public with sound information and provide them with tools for meaningful participation in decision-making.
- Industry should redefine its role toward development of less toxic and safer products, accompanied by responsible marketing and reliable information.
- The precautionary approach should become a commonly used and accepted regulatory tool, i.e. common sense and intelligence should be employed in regulatory decisions and proactive policy making used to solve pesticide problems.





# Solvents and gases

*Gun Nise*

## ORGANIC SOLVENTS

Organic solvents are widely used in industry and in many consumer products. They constitute a chemically diverse group of liquids characterised by their ability to dissolve, suspend or extract other material such as oils, fats, resins, rubber, and plastics, without chemical change to the material or solvent. Solvents are used within a broad range of sectors. Industry uses solvents for degreasing, paint and varnish removal and for cleaning. They are also used to thin paints, varnishes, adhesives, rubber and glues, in the manufacture of such products in addition to chemicals and pesticides. Organic solvents are also used for manufacturing of plastics and pharmaceuticals as used for dry-cleaning. Large quantities are used in printing and chemical industries, construction, engineering and wood processing.

Exposures to solvents occur throughout life, from conception to death. For example, organic solvent vapours inhaled by a mother can reach a foetus. Daily exposures can occur through all routes of exposure (inhalation, dermal, and ingestion) in both the home and/or at work, e.g. from the inhalation of vapours from a “fresh newspaper” to the uptake of a cleaning solvent. The effects from exposure to solvents can range

from an unpleasant odour to death from uptake of high concentrations.

Solvents can be divided into a number of categories based on their chemical structure however, they are all hydrocarbons. A common classification system is presented in Figure 5.3.1.

Chemical class of hydrocarbons	Solvent
Aliphatic	<i>n</i> -Hexane, heptane
Aromatic	Benzene, toluene, xylenes, styrene
Halogenated	Methylene chloride, chloroform, carbon tetrachloride, trichloroethylene,
Esters	Ethyl acetate, butyl acetate
Ketones	Acetone, methyl ethyl ketone, methyl-isobutyl ketone
Alcohols	Methanol, ethanol, isopropanol, <i>n</i> -butanol, ethylene glycol
Glycol ethers	2-Ethoxyethanol, 2-ethoxyethyl acetate
Miscellaneous	Carbon disulphide, dimethylformamide, tetrahydrofuran, limonene, ethylene oxide
Petroleum distillates	Naphtas, white spirit

Figure 5.3.1. A commonly used classification system of hydrocarbons according to their chemical structure.

The different chemical structures of solvents give them different properties that make them more or less usable for specific tasks. There are a number of technical properties that can be useful for consideration when evaluating exposure risks.

*Ability to dissolve fat.* Solvents can be used to dissolve dirt, fat etc. on the surface of a working material. If the solvent comes in contact with the skin, it will dissolve the fat on the skin and result in an irritation or possibly eczema from prolonged contact. Examples of solvents that easily dissolve fat are styrene, acetone, and white spirit.

*Flash point.* All solvents are more or less inflammable. The flash point is a measure of the risk of fire, i.e. the lower flash point, the higher risk of fire. The potential for fire is extremely high if the flash point is less than 21 °C, e.g. acetone and toluene. A solvent is considered flammable with a flash point up to 55 °C, e.g. styrene and white spirit. Organic solvents with a flash point above 55 °C are combustible, e.g. ethylene glycol. Chlorinated solvents like chloroform and tetrachloroethylene are not combustible.

*Limit of explosion.* This is the concentration of a solvent (in air) that may result in an explosion. There is a lower and upper limit of explosion (LLE and ULE, respectively). The concentration interval between LLE and ULE is the one to avoid. Below the LEL there is not enough solvent to continue an explosion; at concentrations above the UEL the fuel has displaced so much air that there is not enough oxygen to begin a reaction. In order to avoid explosion it is important to consider the presence of static electricity while handling organic solvents.

*Vapour pressure.* There are great differences in the rate of evaporation of different solvents. High volatility decreases the drying time but also increases the concentration of the solvent in the air and hence increases the risk of exposure.

Other properties that can be useful when evaluating the risk of adverse exposure from a solvent are the “partition coefficient between oil and water” (Pow) and odour threshold, see Figure 5.3.2. The octanol-water partition coefficient is the ratio of the concentration of a chemical in octanol and in water at equilibrium. The higher the Pow of an organic solvent, the greater affinity it has to fat, so the greater the ease that the body fat absorbs the solvent.

## UPTAKE, BIOTRANSFORMATION AND ELIMINATION

### Uptake through inhalation

During occupational exposure, solvents may be taken up via inhalation or the skin; uptake through the gastrointestinal tract is negligible under normal working conditions. The lungs generally provide the most important absorption route. The most important determinant of pulmonary uptake is the solubility of the solvent in the blood. Even for solvents that are readily absorbed through the lungs, the uptake cannot exceed about 80 %. The uptake at rest for methylene chloride, trichloroethylene, toluene, xylene, and styrene varies between 50 % and 70 % of the amount inhaled. Physical activity is the most important modifying factor on the toxicokinetics of organic solvents. The amount of solvents taken up per time unit increases during exercise. Figure 5.3.3 divides solvent into two groups. Those in the first group, (styrene, xylene, acetone, and butanol) are more soluble in blood and tissues than those listed in the second group, (methylene chloride, trichloroethylene, and toluene). The uptake of the solvents in the first group increases linearly with increasing work-load. In the second group, the uptake increases at 50 W, but remains fairly constant with further increasing workload. Studies on occupationally exposed workers have shown that body

Solvent (CAS No)	Boiling point °C	Melting point °C	Solubility in water g/100ml at 20 °C	Vapour pressure at 20°C (kPa)	Flash point °C	Explosive limits vol% in air	Octanol/water partition coefficient as log Pow	Odour threshold (ppm)
Acetone (67-64-1)	56	-95	Miscible	24	-18	2.2-13	-0.24	200-450
Benzene (71-43-2)	80	6	0.18	10	-11	1.2-8.0	2.13	
n-Butanol (71-36-3)	117	-90	7.7	0.6	29	1.4-11.3	0.9	15-25
Carbon disulphide (75-15-0)	46	-111	0.2	48	-30	1-50	1.84	
Chloroform (67-66-3)	62	-64	0.8	21.2	not combustible		1.97	200
Dichloromethane (75-09-2)	40	-95	1.3	47.4	combustible under special conditions		1.25	50-80
Dimethylformamide (68-12-2)	153	-61	Miscible	2.5	58	2.2-15.2	0.87	1
Ethanol (64-17-5)	79	-117	Miscible	5.8	13	3.3-19	0.32	350
2-ethoxyethanol (110-80-5)	135	-70	Miscible	0.5	44	1.7-15.6	-0.54	
2-ethoxyethyl acetate (111-15-9)	156	-62	23	0.27	51	1.7-14	0.24	
Ethyl acetate (141-78-6)	77	-84	Very good	10	-4	2.2-11.5	0.73	50-200
Ethylene glycol (107-21-1)	198	-13	Miscible	7	111	3.2-15.3	-1.93	
Ethylene oxide (75-21-8)	11	-111	Miscible	146	<-18	3-100	-0.3	
n-Hexane (110-54-3)	69	-95	0.0013	17	-22	1.1-7.5	3.9	
Isopropyl alcohol (67-63-0)	83	-90	Miscible	4.4	12	2-12	0.05	200
Limonene (5989-27-5)	178	-74	Very poor	0.2	48		4.2	30
Methanol (67-56-1)	65	-98	Miscible	12.3	12	5.5-44	-0.82/-0.66	400- 2000
Methyl ethyl ketone (78-93-3)	80	-86	29	10.5	-9	1.8-11.5	0.29	<25
Methyl isobutyl ketone (108-10-1)	117	-85	1.9	2.1	14	1.4-7.5	1.38	<100
Naphtas, alkylate (64741-65-7)	172- 215	<-30	None	0.1-0.2	≥ 44	0.6-8		260
Naphtas, hydrot- reated (64742-48-9)	155- 217	<0	None	0.1-0.3	40- 62	0.7-6		260

Solvent (CAS No)	Boiling point °C	Melting point °C	Solubility in water g/100ml at 20 °C	Vapour pressure at 20°C (kPa)	Flash point °C	Explosive limits vol% in air	Octanol/water partition coefficient as log Pow	Odour threshold (ppm)
Styrene (100-42-5)	145	-31	0.03	0.7	31	0.9-6.8	3.0	0.05-25
Tetrachloroethylene (127-18-14)	121	-22	0.015	1.9	not combustible		2.9	50-70
Tetrahydrofuran (109-99-9)	66	-108	Miscible	19.3	-14.5	2-11.8		
Toluene (108-88-3)	111	-95	none	3.8	4	1.1-7.1	2.69	0.03-3
Trichloroethylene (79-01-6)	87	-73	0.1	7.8	combustible under special conditions		2.42	20-100
White spirit (8052-41-3)	130- 230		None	0.1-1.4	21- 60	0.6-8	3.16-7.06	
Xylenes o- (95-47-6) m- (108-38-3) p- (106-42-3)	144 139 138	-25 -48 13	None	0.7 0.8 0.9	32 27 27	0.9-6.7 1.1-7.0 1.1-7.0	3.12 3.20 3.15	20-40

Figure 5.3.2 Useful properties for some commonly used organic solvents. Source: International chemical safety cards (ICSC) that summarize essential information on chemical substances; developed cooperatively by the IPCS and the Commission of the European Union (EC) and Health and Safety Guide (HSG) series published by the WHO. The HSG provide concise information on risks from exposure to chemicals, with practical advice on medical and administrative issues. Both are available from the IPCS INCHEM website ([www.inchem.org](http://www.inchem.org)).

fat accumulates a significant amount of some solvents, implying an endogenous low-dose solvent exposure even during work-free periods.

### **Uptake through the skin**

Considerable amounts of a number of solvents may be absorbed through the skin contributing to the total body burden of solvents. Skin absorption can occur during direct handling of the solvent as well as through products containing solvents, e.g. cleansing and defatting agents. Uptake varies widely between different solvents a number of factors, principally water solubility, lipid solubility and volatility of the solvent, influence uptake. Solvents that are soluble in both water and lipophilic compounds are easily absorbed.

Glycolethers and dimethylformamide are solvents that are both lipophilic and hydrophilic and they are easily absorbed through the skin. Skin absorption from vapours may also be significant. The high boiling point and relatively low volatility of glycolethers make them stay on the skin surface for long periods and enhance the possibility for skin absorption.

Most commonly used solvents require a very extreme exposure on the skin before the skin uptake reaches the level of lung uptake. For example, if both hands are kept in xylene for 15 minutes, the uptake will be equal to the respiratory uptake from air exposure to 100 ppm during the same period.

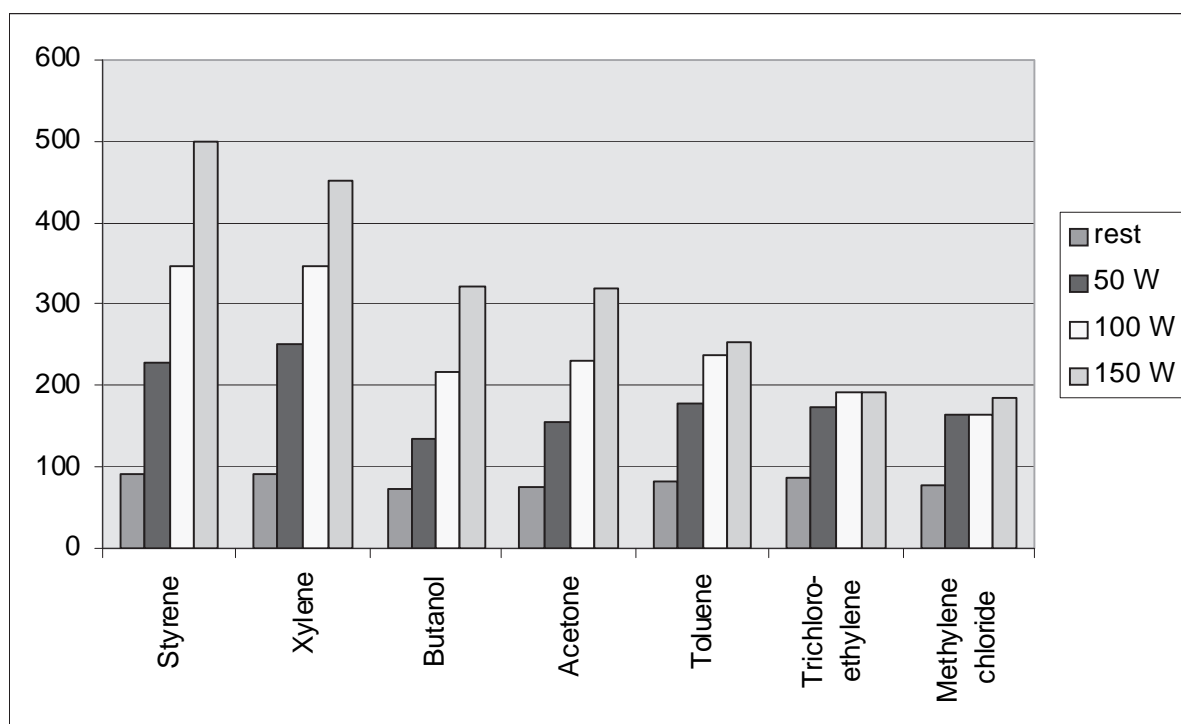


Figure 5.3.3 Effect of physical exercise on uptake (mg) of seven different organic solvents during four consecutive periods of exposure. (From Åstrand I. in: Modeling of inhalation exposure to vapours: uptake, distribution, and elimination. Vol II. Fiserova-Bergerova V. (ed). CRC Press INC. 1983, pp 107-130).

### Biotransformation and elimination

Absorbed solvents are usually biotransformed, principally by the liver, to more water-soluble metabolites that are excreted in the urine. Up to 95% of absorbed xylene and styrene, and up to 80% of the total amount of absorbed toluene and trichloroethylene, are biotransformed. However, some common solvents like methyl chloroform and tetrachloroethylene, are only metabolised to a small extent and are largely excreted unchanged by exhalation. Excretion of unchanged solvent by exhalation increases during physical activity. Biotransformation has important implications for the evaluation of solvent toxicity and in assessment of solvent exposure. Some solvents are biotransformed into reactive

metabolites that are more toxic than the mother compound. The hepatotoxicity of chloroform and dimethylformamide depends on reactive metabolites.

### HEALTH EFFECTS

The principal effects of solvents are irritation to the skin, eyes and lungs; headache, dizziness and light-headedness. Solvent exposure can impair a worker's co-ordination that can lead to poor performance and accidents; susceptibility varies from person to person. Very high solvent exposure can lead to unconsciousness and even death. If workers are exposed to more than one solvent at the same time it is very important to consider the overall effect. This may be additive or in



some cases, greater than the sum of the effects of the individual solvents.

### **Irritating effects**

Though the chemical properties of different solvents vary considerably there are some general health effects. Most solvents are irritating to the mucous membranes of the eyes, nose and throat with the eyes often being the most sensitive. Heavy exposures are often associated with cough, chest tightness, and breathlessness. At very high exposures, some common solvents such as toluene, xylene and methylene chloride can induce pulmonary oedema or chemical pneumonitis.

### **Effects on the central nervous system**

#### *Acute effects*

Short-term high exposure to organic solvents gives narcotic effects and several solvents have been used as general anaesthetics, e.g. trichloroethylene and chloroform. Acute symptoms are headache, dizziness, confusion, a feeling of drunkenness, and if the exposure continues, unconsciousness and death. While acute symptoms are reversible after an exposure ends it may increase the sensitivity to future exposures.

#### *Sub acute and chronic effects*

Most workers are exposed to mixtures of aliphatic and aromatic solvents. Such long term exposures are associated with symptoms such as impaired neuropsychological performance. Symptoms include memory problems, concentration difficulties, aggressiveness, depression, fatigue and sleeping problems. Several years of high solvent exposure are required for these symptoms to become chronic.

### **Effects on other organs**

#### *Liver*

Even though the liver is involved in the biotransformation of many organic solvents, occupational exposure seem to cause little hepatic damage. However, some halogenated solvents are classic hepatotoxins e.g. carbon tetrachloride and chloroform.

#### *Kidney*

Certain solvents like carbon tetrachloride and ethylene glycol may induce renal failure in humans after extensive acute exposure but most solvents have no adverse effects on the kidney.

#### *Carcinogenicity and mutagenicity*

Some solvents, (e.g. benzene, styrene, formaldehyde, methylenechloride, trichloroethylene, perchloroethylene, carbon tetrachloride and chloroform), are established or presumed carcinogens according to evaluation by the International Agency for Research on Cancer (IARC). Further information is available at the IARC website ([www.iarc.fr](http://www.iarc.fr)).

#### *Reproductive effects*

Several studies have suggested that occupational exposure to organic solvents during pregnancy may damage the foetus. Current hygienic standards are usually not based on the possibilities of reproductive effects and it is important to keep the solvent exposure of pregnant women well below these standards.

The observation that glycol ethers with short alkyl groups, (2-methoxy- and 2-ethoxyethanol), are teratogenic and testicular toxins at rather low doses, has seen most branches of industry shift to the use of glycol ethers with longer alkyl chains.

Name	Characteristics	Main uses	Health effects	Recommendations for safe use
Acetone	Colourless liquid with sweet or pungent smell. Very volatile. Absorbed through inhalation and through the skin.	Solvent for resins, fats, lacquers, oils, cotton, cellulose acetate, and acetylene. Employed in paint, varnish, lacquer, rubber plastics, and chemical manufacturing industries.	Inhalation may give headache, dizziness, and fatigue. Very high exposure may cause unconsciousness. Degreasing the skin. Prolonged skin exposure may cause dermatitis. Irritating for the eyes.	Adequate ventilation, local exhaust, or breathing protection, use protective gloves. If risk of splashes use safety goggles. No open flames, no sparks. Do not eat drink or smoke during work.
Benzene	Colourless liquid with characteristic odour. Can be absorbed through inhalation and through the skin and by ingestion.	In chemical syntheses of nitrobenzenes, halogenated derivatives, aromatic amines, styrene etc. for antiknock properties in unleaded gasoline. Solvents for paints, inks, rubber and plastics.	Irritates the eyes, skin, and respiratory tract. Prolonged exposure defats the skin, may have effects on the bone marrow and immune system. Is carcinogenic to humans.	Avoid contact. Important with adequate ventilation, local exhaust, or breathing protection, use protective gloves and clothing, face shield or eye protection in combination with breathing protection. No open flames, no sparks. Do not eat drink or smoke during work.
n-Butanol	Colourless liquid with pungent smell. Absorbed through inhalation and by ingestion. Can easily penetrate the skin.	Solvent in paints and lacquers and for synthetic and natural polymers. Used for extraction and dehydration in pharmaceutical industry.	The vapours irritate eyes and lungs. Inhalation and skin contact may cause headache, dizziness, and fatigues. Prolonged skin exposure may cause dermatitis.	Adequate ventilation, local exhaust, or breathing protection, use protective gloves. If risk of splashes use safety goggles. No open flames, no sparks. Do not eat drink or smoke during work.
Ethyl acetate	Colourless liquid with fruity smell. Very volatile. Can be absorbed through inhalation.	Solvent in paints, varnishes, lacquers, inks, and synthetic rubbers. Used in manufacturing photographic films, linoleum, plastic wood, artificial silk, and leather.	The vapours irritate eyes and lungs. Inhalation may cause headache, feeling of sickness, and dizziness. Very high exposure may cause unconsciousness. Prolonged exposure may cause kidney and liver damage.	Avoid generation of mists. Adequate ventilation, local exhaust, or breathing protection, use protective gloves and clothing. If risk of splashes use safety goggles. No open flames, no sparks. Do not eat drink or smoke during work.

Figure 5.3.4. Examples of some organic solvents frequently used at workplaces, their main uses, and health effects.

Name	Characteristics	Main uses	Health effects	Recommendations for safe use
Ethylene glycol	Odourless, colourless, viscous hygroscopic liquid. Uptake through inhalation and through the skin.	Used as antifreeze formulation in heating and cooling systems, a component in hydraulic liquid. As a solvent in lacquers, inks, adhesives, and resins.	The substance irritates the eyes and the respiratory tract. May cause effects on the kidney and the central nervous system. Long-term repeated exposure may result in abnormal eye movements (nystagmus)	Avoid generation of mists. Adequate general ventilation, use protective gloves. If risk of splashes use safety goggles. No open flames. Do not eat drink or smoke during work.
n-Hexane	Volatile colourless liquid with characteristic odour. Can be absorbed through inhalation and by ingestion.	Component in gasoline and solvent used in production of plastic and rubber, in printing of laminated products, in extraction of vegetable oil.	The substance irritates the skin. Repeated skin contact may cause dermatitis. The substance may affect the central nervous system and especially the peripheral nervous system. Animal tests show that the substance possibly affects the human reproduction.	Adequate ventilation, local exhaust, or breathing protection, use protective gloves. If risk of splashes use safety goggles. No open flames, no sparks. Do not eat drink or smoke during work. Avoid exposure during pregnancy.
Toluene	Colourless liquid with characteristic odour. Can be absorbed through inhalation and by ingestion. Can easily penetrate the skin.	Solvent in paints, coatings, inks, adhesives, in leather and pharmaceutical industries. For production of benzene and toluene diisocyanate. In gasoline to improve octane rating.	Irritates the eyes and the respiratory tract. Exposure to high levels may cause cardiac dysrhythmia. Long-term exposure may have effect on the central nervous system, enhance noise induced hearing loss. Animal tests show that the substance possibly affects the human reproduction or development.	Use strict hygiene, avoid exposure of (pregnant) women! Adequate ventilation, local exhaust, or breathing protection, use protective gloves. If risk of splashes use safety goggles. No open flames, no sparks. Do not eat drink or smoke during work.

Figure 5.3.4. Continued.

*Effects from specific solvents*

Exposure to some typical industrial solvents is associated with specific adverse effects, see Figure 5.3.4.

## **RISK ASSESSMENT AND RISK MANAGEMENT**

### **Solvents in the workplace**

Workers may be exposed to liquid solvent, solvent vapour or mist. Vapour is the gaseous state of a liquid that is formed when molecules evaporate from the surface of the liquid. The rate at which a solvent evaporates depends very much on the boiling point of the solvent, the lower the boiling point, the faster evaporation occurs. Increasing the temperature of a solvent, the surface area of the liquid and the airflow over its surface will increase its evaporation rate. Vapours follow the air movement in a working area and can spread throughout the workplace.

Solvent mists are small droplets of the liquid and can be formed during spraying and high speed mixing.

### **Work tasks related to high risk of solvent exposure**

#### *Cleaning and degreasing procedures*

Cleaning and degreasing of material and equipment occurs frequently in all forms of manufacturing. In many cases organic solvents are used, even if there are solvent-free alternatives, e.g. alkaline products, available. There are not only health risks posed by solvents in cleaning products but also the presence of other chemicals. Methods used during cleaning and degreasing affect exposure, e.g. the use of brushes, clothes or spraying changes the solvent vapour concentration in the air. When spraying there will be an aerosol of the solvent in the workers' environment that increases exposure. In some cases,

cleaning can be performed automatically which reduces workers contact with solvents and decreases the risk of high exposure. However, even if there is equipment for automatic cleaning, there are still many needs for manual cleaning.

Dry cleaning can result in high exposure to e.g. tetrachloroethylene, when washing machines are placed in badly ventilated premises.

When assessing the possibilities to reduce solvent exposure the first question to ask is "Is cleaning necessary?" It may be that small changes in the work process can reduce dirt on components making subsequent cleaning easier. In many cases, such changes reduce costs. For instance, by using the minimal amount of glue to assemble pieces of work, there is less need to remove excess glue from components. This reduces the amount of glue and cleaning solvent used. Enclosure of the cleaning process often reduces the amount solvent needed as well as reducing the amount of solvent emitted into the working environment. A well design ventilation system also reduces the emission of solvents into the workers' breathing zone.

#### *Working with paints*

Workers who manufacturing and use solvent-based paints are both at high risk of solvent exposure. In enterprises manufacturing paints, manual cleaning is associated with high exposure to organic solvents. Work tasks during batch preparation and container filling will give high exposure if there is inadequate or faulty ventilation.

Painters are exposed when they are using solvent based paints and may also be exposed when they are working in close proximity to newly painted areas or products. Painting large areas or working in badly ventilated spaces will easily give high solvent concentrations. Spray painting

also increases the risks of high concentrations of solvents in the air.

### *Printing operations*

Rotogravure and screen printing techniques frequently still use solvent-based printing ink. In order to increase printing velocity the solvents used have to evaporate rapidly so if there is insufficient ventilation around the printing press, workers will suffer considerable solvent exposure. Even when other printing techniques are used, organic solvents are still used for cleaning the printing plates and the press even though there are water-based alternatives available.

### *Other work tasks*

Production of glass fibre-reinforced polyester plastics, particularly lamination of large areas as in the production of boats and cisterns, are associated with high exposure to styrene. Furthermore, the use of solvent containing glues during e.g. floor laying, is associated with high solvent concentrations in the air. The production of sport shoes includes the heavy use of glues containing organic solvents. Glue is often stored in small open containers and brushed onto the sole and the shoe in work areas lacking adequate ventilation so the solvent evaporates easily to the worker's breathing zone.

## **SOLVENT HEALTH RISK MANAGEMENT**

It is important to have good work practices in order to minimise solvent exposure. Unnecessary evaporation of solvents can be prevented by using the minimum amount for the job, keeping lids on containers and by sealing containers for solvent contaminated waste. Where appropriate, natural ventilation can be optimised by opening doors and windows, and organising work so that the air flow moves vapours away from the breathing zone of workers.

Managing solvent risks can improve workers' health, reduce the amount of solvents used and decrease costs. Controlling exposure to solvents is often straightforward. The following steps may be useful.

### **Define the problem**

It is essential to find out what solvents are being used. In many cases, e.g. in paints, more than one solvent is present. Safety Data Sheets (SDS) should be received together with the product containing solvents. It is important not to buy any chemical product without getting a SDS with complete information about all the product contents. It is important to look for information about vapour pressure and boiling point that helps understand how easily the solvent evaporates into the working environment. The higher the vapour pressure, or the lower the boiling point, the more easily the solvent will evaporate. As a rule of thumb, highly volatile solvents have a vapour pressure greater than 25 kPa or a boiling point less than 50°C, and they easily evaporate to the working environment increasing the exposure level.

Observation of a process will help to find out how solvents are being used. It is important to include maintenance, working in confined spaces and cleaning tasks. The highest exposure often occurs out of regular routines or at the end of a shift. It is useful to find out how solvent vapour or mist is generated, how workers handle it and the frequency, duration and amount of solvent used. This information will help to assess the level of exposure and potential control methods. It may be necessary to measure the concentration of solvents in the air. If a solvent is absorbed through the skin biological monitoring can provide information about the total uptake.

It may be possible to modify the process e.g. by substituting a solvent with a less harmful one,

lowering the temperature or reducing the quantity that is used. Enclosure of the whole or part of a process usually makes a major impact on the exposure level. If it isn't possible to enclose a process, well designed local exhaust ventilation that removes vapour at source may be an alternative. When possible, vessels and baths should be closed in order to reduce solvent evaporation. Ventilation by opening doors and windows can reduce background levels of solvents, however, it is important to be aware that uncontrolled draughts can also increase exposure levels and disperse solvent vapours to normally non-exposure areas.

Good housekeeping is important to reduce unnecessary solvent vapour emission to the workers environment. Open container and solvent soaked rags on work surfaces or in open bins allow solvent evaporation into the workplace.

### Take action

Problems found during a risk assessment need to be prioritised. There may be some very bad situations that need immediate solutions but financial factors cannot be ignored so joint discussions between employers, supervisors and workers representatives may be helpful.

Workers should have enough training to be aware of the possible health effects of solvent exposure, and to recognise the symptoms of exposure and the measures that have been taken to reduce risks to their health. A well trained worker may be able to reduce the amount solvent used, decreasing exposure and saving on costs. There could be a need for respiratory protective equipment (RPE) until more efficient preventive measures are implemented. It is important to remember that RPEs only protect to a limited degree and their effectiveness depends on careful selection, use and maintenance.

### Control the result

It is important to regularly review the working environment to confirm that preventive measures remain effective. Control measures must be accepted by the workers and evaluated to ensure their effectiveness.

### IRRITATING AND ASPHYXIOUS GASES

Gases do not usually exist as liquids or solids at normal room temperature and pressure. Irritant gases are an important example of respiratory toxins. The site of injury is related to the solubility of the gas. For example, gases that are highly water soluble, such as hydrogen fluoride and ammonia, dissolve in the moist lining of the upper respiratory tract, and often produce immediate irritation. Less soluble irritant gases, such as nitrogen dioxide, ozone and phosgene, reach the bronchioles and alveoli, where they dissolve slowly and may cause pneumonitis and pulmonary oedema hours later. Gases may also act as asphyxiants by interrupting the supply of oxygen (simple asphyxiants) or by inhibiting tissue oxygenation (chemical asphyxiants). Examples of simple asphyxiants are carbon dioxide, methane and nitrogen, which may cause sudden death, and therefore may present a problem for those working in confined spaces. Chemical asphyxiants block the delivery or use of oxygen at the cellular level. They include carbon monoxide (a product of incomplete combustion), cyanide (in electroplating and fires), and hydrogen sulphide, which can be found in sewers, coal mines, petrochemical refineries and rubber manufacturing plants.

All gases can easily reach the breathing zone when they are used at the workplace. It is important to perform work in well ventilated area and to use exhaust ventilation properly.

Employees who are, or who may be, exposed to irritating and asphyxiating gases should have



sufficient information, instruction and training to understand the potential problems and precautions they need to take. It is especially important that they recognise symptoms that may occur several hours after end of exposure from irritating gases.

### Ammonia

Most of the ammonia produced is used for production of fertilisers, fibres, plastics, and explosives. It is also used in the production of animal feed, pulp and paper, rubber and in a variety of other chemical production processes. Ammonia and ammonium compounds are also used as cleaning fluids, and in food as leavening agents, stabilizers, and for flavouring purposes.

Ammonia is a colourless gas with pungent odour. The substance is a strong base and reacts violently with acid, strong oxidants and halogens. It is also corrosive and attacks copper, aluminium, zinc and their alloys. Heat evolves when ammonia is dissolved in water.

Ammonia can be absorbed into the body by inhalation and is corrosive to the eyes, skin, and respiratory tract. Inhalation of high concentrations may cause lung oedema. The symptoms of lung oedema often do not become manifest until a few hours after exposure and they are aggravated by physical effort. Rest and medical observation is therefore essential.

Exposure to ammonia or ammonium compounds can occur in occupations involving their production, transportation, and use in agricultural and farm settings, during fertilizer application, or as a result of animal waste decomposition. Ammonia is generated as a by-product in a wide variety of industrial activities.

As far as possible, ammonia, in the form of a liquid, gas, or concentrated solution, should be handled in closed systems. Impervious clothing and gloves, and eye and face protection, should

be used for sampling and other operations where there is open exposure. Particular care should be taken to the thorough washing out of pumps and other equipment that has contained or been used for transferring ammonia prior to disassembly or maintenance.

### Carbon monoxide

Many people using gasoline-powered tools such as high-pressure washers, concrete cutting saws (walk-behind/hand-held), power trowels, floor buffers, welders, pumps, compressors, and generators in buildings or semi enclosed spaces have been poisoned by carbon monoxide (CO). CO can rapidly accumulate, (even in areas that appear to be well ventilated), and build up to dangerous or fatal concentrations within minutes. Studies of human exposure have shown that motor vehicle exhaust and environmental tobacco smoke are the most important sources of CO exposure. The workplace is another important setting for carbon monoxide exposures. In general, apart from transportation to and from work, exposures at work exceed carbon monoxide exposures during non-work periods. Occupational groups exposed to carbon monoxide from vehicle exhaust include auto mechanics; parking garage and gas station attendants; bus, truck or taxi drivers; police; and warehouse workers. Certain industrial processes can expose workers to carbon monoxide produced directly or as a by-product including steel production, coke ovens, carbon black production and petroleum refining. Fire-fighters, cooks and construction workers may also be exposed to high carbon monoxide levels at work. Occupational and non-occupational exposures may overlay one another and result in a higher concentration of carbon monoxide in the blood.

Carbon monoxide (CO) is a colourless, odourless gas that can be poisonous to humans.

Carbon monoxide is absorbed through the lungs and is readily absorbed from the lungs into the bloodstream. The health effects of carbon monoxide are largely the result of the formation of carboxyhaemoglobin (COHb), which impairs the oxygen carrying capacity of the blood. CO is produced from incomplete combustion of carbon-containing fuels. With external exposure to carbon monoxide, subtle effects can occur, and exposure to higher levels can result in death.

To prevent from CO exposure it is important to reduce carbon monoxide emissions from combustion engines, improve ventilation at the source and if that impossible recommend use of personal protective equipment.

### Chlorine

Most chlorine is used in industry to produce chlorinated chemicals. The pulp and paper industry is a major user of chlorine for bleaching pulp to produce white paper. Chlorine is also used for disinfecting drinking-water supplies.

Chlorine is a greenish-yellow gas, with a pungent odour. Chlorine solution in water is a strong acid that reacts violently with bases and is corrosive. Furthermore, it reacts violently with many organic compounds, such as ammonia, hydrogen and metal powder, causing fire and explosion hazard. Chlorine attacks many metals in the presence of water, as well as plastic, rubber and coatings.

Chlorine can be absorbed into the body by inhalation and exposure to chlorine may result in watering eyes. It is corrosive to the eyes, the skin and the respiratory tract. Inhalation of gas may cause pneumonitis and lung oedema, resulting in reactive airways dysfunction syndrome (RADS). Rapid evaporation of the liquid may cause frostbite. Exposure far above the OEL may result in death. The effects from chlorine exposure may be delayed so medical observation is indicated.

Prolonged exposure may have effects on the lungs, resulting in chronic bronchitis, and it can also have effects on the teeth, resulting in erosion.

It is not sufficient to rely on the odour warning to indicate when the exposure limit value has been exceeded. Chlorine should not be used in the vicinity of a fire or a hot surface, or during welding.

### Hydrogen cyanide

Hydrogen cyanide is liberated during the use of cyanide salts or solutions in metal treatment operations, blast furnace and coke oven operations, metal ore processing, and photoengraving operations. It is also used in production of intermediates in synthesis of resin monomers, acrylic plastics, cyanide salts, nitrates, chelating agents, dyes, and pharmaceuticals. Hydrogen cyanide is released during petroleum refining and electroplating. Furthermore, it is used in the manufacture of silver and metal polishes, and electroplating solutions, and as a chemical reagent.

Hydrogen cyanide is a colourless gas or liquid with a characteristic odour. The gas mixes well with air easily forming explosive mixtures. The substance may polymerize due to heating under the influence of base(s), over 2% water, or if not chemically stabilized, with fire or explosion hazard. On combustion, it forms toxic and corrosive gases including nitrogen oxides. The solution in water is a weak acid. Hydrogen cyanide reacts violently with oxidants, hydrogen chloride in alcoholic mixtures, causing fire and explosion hazard.

The substance can be absorbed into the body by inhalation, through the skin and by ingestion and is irritating to the eyes and respiratory tract. The substance may cause effects on the cellular respiration, resulting in convulsions and unconsciousness. Exposure to high concentrations may

result in death so medical observation is indicated. Repeated exposure may affect the thyroid.

The occupational exposure limit value should not be exceeded during any part of a workplace exposure. Specific treatment is necessary in case of poisoning with this substance; the appropriate treatment means and instructions must be available. The odour warning is insufficient to indicate when the exposure limit value has been exceeded. Workers should never work alone in an area if there is a potential risk of hydrogen cyanide exposure. Depending on the degree of exposure, periodic medical examination is suggested.

### Hydrogen fluoride

Hydrogen fluoride (hydrofluoric acid) is an important industrial compound. It is manufactured from calcium fluoride and is used mainly in the production of synthetic cryolite, aluminium fluoride, motor gasoline alkylates and chlorofluorocarbons. However, the demand for chlorofluorocarbons is decreasing as a result of efforts to restrict their use. Hydrogen fluoride is also used in the synthesis of uranium tetrafluoride and uranium hexafluoride, both of which are used in the nuclear industry. It is also used in etching semiconductor devices, cleaning and etching glass, cleaning brick and aluminium and tanning leather, as well as in petrochemical manufacturing processes. Hydrogen fluoride may also be found in commercial rust removers.

Hydrogen fluoride is a colourless gas or fuming liquid with a pungent odour. The substance is a strong acid that reacts violently with bases and is corrosive. It reacts violently with many compounds causing fire and explosion hazard and attacks metals, glass, some forms of plastic, rubber, and coatings.

Hydrogen fluoride can be absorbed into the body by inhalation, through the skin and

by ingestion. The substance is corrosive to the eyes, skin and respiratory tract. Inhalation of this gas or vapour may cause lung oedema. The symptoms of lung oedema may be delayed and are aggravated by physical effort. Rest and medical observation are therefore essential. The substance may cause hypocalcaemia. Exposure above the OEL may result in death. Prolonged exposure may cause fluorosis.

### Hydrogen sulfide

Hydrogen sulphide is one of the principal compounds involved in the natural cycle of sulfur in the environment. It occurs in volcanic gases and is produced by bacterial action during the decay of both plant and animal protein. In industry, it is usually produced as an undesirable by-product, though it is an important reagent or intermediate in some processes. Hydrogen sulfide occurs as a by-product in: the production of coke from sulfur-containing coal, the refining of sulfur-containing crude oils, the production of carbon disulfide, the manufacture of viscose rayon, and for producing wood pulp.

Hydrogen sulfide is a colourless gas with a characteristic odour of rotten eggs. Heating may cause violent combustion or explosion. The substance decomposes on burning and produces toxic gas (sulfur oxides). Hydrogen sulfide reacts violently with strong oxidants, causing fire and explosion hazard, and also attacks many metals and some plastics.

Hydrogen sulfide is heavier than air and can accumulate in lethal concentrations in low-lying or enclosed areas.

The substance can be absorbed into the body by inhalation. The substance irritates the eyes and the respiratory tract. The substance may cause effects on the central nervous system. Exposure may result in unconsciousness and even in death. Inhalation of gas may cause lung

oedema. The symptoms of lung oedema often do not become manifest until a few hours after exposure so medical observation is indicated.

Specific treatment is necessary in case of poisoning with this substance; the appropriate treatment means with instructions must be available. The odour threshold is very low, below 1 parts per million (ppm). However, at concentrations above 100 ppm, a person's ability to detect the gas is affected by rapid temporary loss of the sense of smell. Prolonged exposure at lower concentration can result in similar effects. The odour warning is insufficient to indicate when the exposure limit value has been exceeded.

### Nitrogen dioxide

Nitrogen dioxide is formed in combustion processes e.g. from motor vehicles using petrol and diesel fuels. Nitrogen dioxide is used in the manufacture of nitric acid and ammonium nitrate fertilisers and as a chemical intermediate in nitration reactions and the oxidation of metallic compounds. It is produced in processes involving high temperatures e.g. welding, due to the oxidation of atmospheric nitrogen. It is produced in the combustion of fossil fuels so there could be exposure in coal-fired power stations. Exposure to nitrogen dioxide occurs during metal cleaning using nitric acid. Nitrogen dioxide is also produced on farms following the breakdown of silage, and following explosions in mines and quarries. Hospital personnel can also be exposed to nitrogen dioxide when nitrogen monoxide is used in intensive care treatment. The oxidation of any released nitrogen monoxide can lead to the formation of nitrogen dioxide.

Nitrogen dioxide is a reddish-brown gas or brown or yellow liquid with a pungent odour. The substance is a strong oxidant that reacts violently with combustible and reducing materials. It reacts with water to produce nitric acid

and nitric oxide. It also attacks many metals in the presence of water.

The substance can be absorbed into the body by inhalation and is corrosive to the skin, eyes, and respiratory tract. Inhalation of the gas or the vapour may cause lung oedema. Exposure far above the OEL may result in death. The effects may be delayed so medical observation is indicated. Prolonged and repeated exposure may have effects on the immune system and lungs, resulting in decreased resistance to infection. Animal tests show that this substance possibly causes toxic effects on human reproduction.

### Ozone

Ozone exposure can occur when ozone is produced and as an intermediate in chemical production. Ozone is used for bleaching of textiles, cellulose and sugar, sterilization of medical instruments and for water purification. It is also formed in gas arc welding and photocopying. Furthermore, there is potential exposure from the use of UV curing inks in the printing industry.

Ozone is a colourless or bluish gas with characteristic odour. It decomposes on warming producing oxygen which increases fire hazard. The substance is a strong oxidant and reacts violently with combustible and reducing materials. Ozone reacts with alkenes, aromatics e.g. aniline, and ethers, bromine, nitrogen compounds and rubber. Ozone attacks metals except gold and platinum.

Ozone can be absorbed into the body by inhalation and it irritates the eyes and respiratory tract. Inhalation of the gas may cause lung oedema and asthmatic reactions. The substance may cause effects on the central nervous system, resulting in headache and impaired vigilance and performance. Repeated or prolonged exposure may affect the lungs.

The symptoms of lung oedema and asthma often do not become manifest until a few hours have passed and are aggravated by physical effort so rest and medical observation are essential. Anyone who has shown symptoms of asthma due to ozone exposure should avoid all further contact with this substance.

### Phosgene

Phosgene is used as an intermediate in the manufacturing of many organic chemicals. The largest amount is used to produce toluene diisocyanate and other isocyanates used in polyurethane foam production, preparation of plastics, and pesticides.

Fire-fighters and workers engaged in welding and the building trade are at risk from exposure of phosgene formed by the thermal degradation of chlorinated solvents and polymers. Removers and non-flammable dry cleaning solvents (e.g. carbon tetrachloride, chloroform, tri- and tetrachloroethylene and methylene chloride) should never be used in closed areas where fire or heaters of any kind are since these chemicals can decompose to phosgene. Welding or heat-treating vessels or equipment that may have contained such materials should be avoided until they have been purged of all remaining chemical.

Phosgene is a colourless gas with characteristic odour. The substance decomposes on contact with water and moisture, producing toxic and corrosive gases (carbon monoxide and hydrogen chloride). Phosgene reacts with aluminium, and isopropyl alcohol.

Phosgene can be absorbed into the body by inhalation. The substance is irritating to the eyes, the skin and respiratory tract. Inhalation of this gas may cause lung oedema. The effects may be delayed. Exposure to high levels may result in death. Medical observation is indicated. The

odour warning is insufficient to indicate when the exposure limit value has been exceeded.

### *Sulfur dioxide*

Sulfur dioxide is produced from the combustion of fossil fuels and the incineration of refuse. It is also produced during ore and metal refining, and in the manufacture of sulfuric acid and elemental sulfur. Sulfur dioxide is produced in the conversion of wood pulp to paper, during casting and knock-out in some foundries, and is used as a preservative in beer, wines and foods.

Sulfur dioxide is a colourless gas with an irritating odour that dissolves in water to produce acidic conditions. The substance can be absorbed into the body by inhalation and it strongly irritates the eyes and respiratory tract. Inhalation of the gas may cause lung oedema. Rapid evaporation of the liquid (compressed gas) may cause frostbite. Sulfur dioxide may affect the respiratory tract, resulting in asthma-like reactions, reflex spasm of the larynx and respiratory arrest. High exposure may result in death. The effects may be delayed. Medical observation is indicated. Repeated or prolonged inhalation exposure may cause asthma.

Where preventing exposure to sulfur dioxide is not reasonably practicable (e.g. by using a different substance), then it is important to adequately control exposure by a combination of engineering and process control measures. If possible, attempts should be made to reduce the number of people exposed and the length of time of exposure in line with good hygiene practice.

### ISOCYANATES

Several isocyanates are used in industry to make urethane paints and resins. The compounds most commonly used are toluene di-isocyanate

(TDI), methylene bisphenyl di-isocyanate (MDI), and naphthalene di-isocyanate (NDI). The isocyanates can be absorbed into the body by inhalation and irritate the eyes, skin and respiratory tract. Isocyanates may cause effects on the lungs, resulting in impaired function. Asthma is the main adverse effect caused by the inhalation of isocyanates.

Completely cured polyurethanes are harmless but isocyanates can be liberated when products containing cured isocyanates are heated. Isocyanates are set free during welding, cutting, and grinding of products painted with urethane paints. Spraying of urethane foam is especially hazardous and workers must be supplied with fresh air in their breathing zone. The symptoms of asthma often do not become manifest until a few hours have passed and they are aggravated by physical effort so rest and medical observation are essential. Anyone who has shown symptoms of asthma due to this substance or from other causes should avoid all further contact with this substance.





# Dusts and metals

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## INTRODUCTION

Workers may be exposed to dust (inorganic and organic) and metals through inhalation, skin contact or ingestion. Inhalation is the most important route. Skin absorption can vary from negligible to very high depending on the chemical composition of the compound. Ingestion can occur in dirty workplaces where workers are allowed to eat, drink or smoke in the workplace. Health hazards associated with occupational exposures are very dependent on the dose and type of exposure. Long-term exposure to dusts or irritant gases may lead to the development of cough and sputum. This condition is termed chronic bronchitis when the productive cough occurs daily for at least three months a year over the last two years. A highly irritating or corrosive dust (e.g. from strong acidic or alkaline dust) may result in serious damage after only a single peak exposure if the concentration is high. Such an exposure may cause an irritant-induced asthma and be associated with non-specific bronchial hyperreactivity that lasts for many years. Flour dust may cause allergic asthma within a year of exposure. Some type of dusts will result in diseases after many years of exposure e.g. lung cancer from asbestos or silicosis from quartz.

Depending on the size of the particles, dust will be deposited in different parts of the respiratory system. Small particles ( $< 5 \mu\text{m}$ ) will primarily be deposited in the alveoli in the lung. Particles of  $5\text{--}10 \mu\text{m}$  will predominantly deposit in the tracheobronchial tract, while larger particles will deposit in the nose and upper airways. Depending on the reactivity or solubility of the particle, small particles might deposit higher up in the respiratory system.

## INORGANIC DUSTS

Most inorganic dusts will be generated in mechanical processes like grinding, sawing, cutting, crushing, screening or sieving. Handling dry materials or powder by weighing, filling, charging, transporting and packing will also generate dust, as will activities like insulation and cleaning work. Fumes are vaporised and condensed small particles generated during welding, plasma cutting or other cutting operations in metals at high temperatures. These particles contain oxides of iron, chromium, nickel, manganese and other metals.

## Asbestos

Asbestos is a general term to describe a group of minerals of crystalline hydrated silicates with a fibrous structure. Asbestos minerals are characterized by their strength, flexibility, durability and resistance to acid and heat. There are two main types of asbestos, amphiboles (straight fibres) and serpentines (curly fibres). Crocidolite (blue asbestos), amosite (brown asbestos), antophyllite, tremolite, and actinolite belong to the amphibole family. Chrysotile belongs to the serpentine family.

Asbestos is principally mined in Canada, Russia, Zimbabwe and South Africa. Asbestos has been used for many different purposes and in a wide range of products such as insulation of pipes, furnaces, and electrical wires. It has also been used in the construction industry in asbestos cement, shingles, tiles, and in textiles, brake and clutch linings and in plastics.

Inhalation of asbestos fibres causes several lung diseases.

### *Pleural plaques*

Pleural plaques contain connective tissue rich in collagen and are most often located under the parietal (the outer) pleura. Changes to pleural plaques are the most common abnormalities observed among asbestos-exposed workers and they appear decades after exposure. This disorder is usually not associated with any symptoms.

### *Asbestosis*

Asbestosis is a fibrotic disease of the pulmonary tissue. This is a much more severe disorder than pleural plaques as it impairs lung function. The most common initial symptom is dyspnea (laboured or difficult breathing). A non-productive cough becomes more common as the disease

advances. Pulmonary fibrosis may progress and death from this disease is not uncommon.

### *Cancer*

Asbestos exposure causes lung cancer. There is a synergistic effect between asbestos and smoking. This means that the incidence of lung cancer associated with smoking and the incidence of lung cancer associated with asbestos exposure does not increase in an additive way when both exposures coincide but multiplies, resulting in a much higher risk. Pleural and peritoneal mesothelioma are also associated with asbestos exposure, however the risk of mesothelioma is not related to tobacco use. Currently mesothelioma causes the death of more workers (around 100) per year, in Sweden, than the total number of work-related fatal accidents. Most of those now suffering from mesothelioma were exposed to asbestos 30 years ago. In the UK, the annual number of people diagnosed with mesothelioma in 2020 is calculated to be about 3,000. Some researchers have concluded that amphibole asbestos gives a higher risk of mesotheliomas than exposure to chrysotile, but both have been implicated in asbestos related diseases.

The European Union has banned the use of asbestos in new products. WHO recommends health screening, comprising chest radiography, spirometry, and symptom questionnaires, for workers exposed to asbestos.

### *Prevention*

If possible, asbestos, especially the amphiboles, should be substituted by other less dangerous materials. Various types of mineral wool are a better alternative for insulation and other types of fibres can be used in brake linings. If it is not possible to use a substitute, work must be made as safe as possible through the use of good ventilation, personal protection (respirators with

fresh air supply or half mask with P3 filter), wet cleaning methods and minimized manual handling of the dry material. In dusty environments using asbestos there may be a need to use disposable clothes (single use), fitted together with personal protective equipment like respirators or half masks. Such protective clothes must be used in a proper way and taken off before the respirators are removed to avoid inhalation asbestos-containing dust.

### Quartz or silica

Crystalline silica occurs in different forms of crystals. Quartz is one natural form found in rocks that can cause fibrosis in the lungs, *silicosis*, after inhalation. Workers are exposed in mines, quarries and during stone cutting, glass manufacturing and sandblasting. After heating quartz, crystals may reorganise into cristobalite and tridymite, crystals that are even more fibrogenic than quartz. Workers can be exposed in steel industries, foundries, and during manual and machine cleaning of roads and pavements made of stone and sand containing quartz.

Silicosis is a chronic disease and symptoms (shortness of breath) may not develop for many years. It frequently requires 15 to 20 years of exposure before chest X-ray shows abnormalities. Silicosis increases the risk of developing pulmonary tuberculosis. Inhalation of crystalline silica can cause lung cancer.

#### Prevention

Quartz should be substituted with other material wherever possible. For example olivine, staurolite, steel grit or aluminium oxide can be used instead of using silica sand as blasting abrasives. If silica sand is used in sand blasting, respiratory protection is necessary to avoid the risk of silicosis. Adding water to rock drilling is one way of reducing silica dust in the work environment.

Machines for cleaning roads and pavements should be closed with well fitted filters on fresh air intake vents. Quartz powder with a high moisture content, (produced by a wet method), is preferable for the manufacturing of quartz glass. The installation of spinning disc sprayers in storage houses increases the moisture content in the air. Effective exhaust hoods should be installed above crushers or mills and processes should be enclosed whenever possible.

**WHO recommends health screening for workers exposed to silica.**

### Coal

Coal mining is associated with several occupational risks. Many accidents occur due to unstable support structures in underground mining. Pockets of methane can cause fires and explosions. Coal mining is either on the earth's surface or underground. Coal dust may also contain a low percentage of quartz and thus increase the risk of silicosis. Other important exposures in underground coal mining are diesel particulates and nitrogen oxides.

Inhalation of coal dust may cause coal workers' pneumoconiosis (CWP), sometimes called "black lung". This disease exists in both a simple and complex form. The more complex form, progressive massive fibrosis, can lead to disability and death. The disease develops after 10-15 years of exposure to coal dust.

#### Prevention

Precautions against accidents due to construction collapses are strictly regulated and of utmost importance. Methane must be monitored in order to avoid dangerous levels of the gas. It is essential that there is a good housekeep-

ing policy and that workers are educated about health risks. There should be an efficient ventilation system and workers should not be exposed to contaminants during blasting operations. One potential source of coal dust exposure is at tips. The amount of dust can be reduced by making tip openings as small as possible, reducing the drop distance or most efficiently, by filtering air from the bottom and around the tip through a ventilation system. Diesel exhaust particulates can be decreased by using diesel fuel with low sulphur content, disposable exhaust filters, decoking engines (removing gum etc from cylinders giving better combustion) and by the use of adequate ventilation.

### METALS

#### Aluminium

Aluminium is a grey metal widely used due to its light weight. The highest exposed occupational groups are welders and powder production workers. Stamped aluminium powder is used in pyrotechnical products. Inhalation of this powder may cause a fibrotic lung disease, aluminosis.

An obstructive pulmonary disease, “pot room asthma”, is well known among workers in the primary electrolytic production of aluminium, however, fluorides might be more likely to cause this disease. Aluminium also affects the central nervous system and is the cause of dialysis dementia, which previously killed hundreds of patients around the world. Minor effects on the nervous system have been observed among welders.

#### Cadmium

Cadmium is a silver-white metal that is highly resistant to corrosion and therefore used for electroplating of other metals. Cadmium compounds are also used as pigments in paints,

glasses, and ceramics; in special alloys and in nickel-cadmium batteries.

Inhalation of high levels can result in a chemical pneumonitis and pulmonary oedema. Long-term exposure can cause tubular kidney damage as the metal is stored in the kidneys. Cadmium and its compounds are regarded as carcinogenic to humans. Some early studies pointed to a relation with prostatic cancer but more recent studies have failed to confirm these results. There is stronger evidence of a relationship between cadmium exposure and lung cancer.

#### Chromium

Chromium is a hard, corrosion-resistant, grey metal that exists in several oxidative states. The hexavalent compounds are much more chemically aggressive than the trivalent compounds. Hexavalent chromium (chromate) is used in pigments and for chromium plating. Stainless steel contains nickel and chromium and in manual metal arc welding chromium is oxidised to hexavalent chromium. Some types of cement and treated wood products contain hexavalent chromium.

As hexavalent chromium compounds are more chemically aggressive, they also cause more irritative symptoms when inhaled. Inhalation of hexavalent chromium particles may cause sneezing, rhinorrhoea, lesion of the nasal septum, which may result in perforation of the nasal septum, and asthma.

In general, hexavalent compounds pass biological membranes while trivalent chromium compounds do not. Exposures to hexavalent chromium compounds are associated with an increased risk of lung cancer.

#### Lead

Lead is a heavy, soft, bluish-grey metal. The largest amounts of lead are used in the manufac-

ture of electric storage batteries. The cable industry uses lead alloys for the covering of cables. Sheet lead is used in storage tanks. Lead is also used for soldering. Lead salts form the basis for many paints and pigments. Gas cutting of lead-painted outdoor iron constructions can generate very high exposure levels.

Lead causes several different effects on the human body. The most sensitive target of lead poisoning is the nervous system. Lead affects the central nervous system as well as the peripheral nervous system. Lead can cause anaemia as it inhibits the body's ability to make haemoglobin by interfering with several enzymatic steps in the production of the heme part of the protein.

Symptoms from the alimentary tract occur often in acute lead poisoning. The first symptoms are loss of appetite, digestive disturbances and gastric discomfort. Lead colic is characterized by sharp onset and recurrent spasms in the abdomen. This condition is associated with high blood concentrations of lead, above about 7  $\mu\text{mol/L}$ . Heavy and prolonged lead exposure may cause progressive and irreversible renal disease.

Lead can decrease the sperm quality in exposed male workers and cross the placenta in pregnant women, which can increase the risk of spontaneous abortions and retardation of neurobehavioural development and growth in the infants. The limits for exposure of men and women to lead are different in Sweden due to this fact. A woman, below 50 years of age, with a blood lead concentration above 1.2  $\mu\text{mol/L}$ , should be removed from exposure. The corresponding limit for men and women older than 50 years is 2.0  $\mu\text{mol/L}$ . Many countries have established biological exposure limits for lead.

## Manganese

Manganese is reddish-grey hard metal and is a very common alloy in different steels.

The primary target organs of manganese toxicity are the brain and the lungs. The toxicity of the nervous system is presented by various manifestations. The early stage is characterized by emotional instability and irritability. A severe form of aggressiveness and mental excitement is sometimes called "manganese psychosis". The advanced stage is characterized by neurological disturbances similar to Parkinson's disease.

In addition to the neurological effects, manganese is known to cause respiratory effects including chronic bronchitis and pneumonia.

## Mercury

Mercury is a liquid at normal temperature and pressure. Metallic mercury is used in many scientific instruments such as barometers. It is also used in the silent light switch, fluorescent lamps and in powerful street lamps. Some 500,000 gold miners are working in the Amazonas using liquid mercury to separate gold from sediments. They use the old method of heating the gold-mercury complex (amalgam), where mercury vaporizes and leaves the gold. Organic mercury compounds have been used as external antiseptics and pesticides.

Acute poisoning can occur after inhalation of high concentrations of mercury vapour or dust. Acute interstitial pneumonitis, bronchitis, and bronchiolitis will present symptoms of tightness and pain in the chest, coughing, and difficulty in breathing. In three or four days the salivary glands swell, gingivitis appears, symptoms of gastroenteritis and signs of nephritis develop. In more severe cases psychopathological symptoms will appear.

In chronic mercury poisoning digestive and nervous symptoms predominate.



Poisoning by alkyl mercury may occur after inhalation of vapours or dusts. Symptoms and signs of acute and chronic exposure result from the accumulation of mercury in the central nervous system. The signs are characterized by sensory disturbances with paresthaesia (numbness) in the distal extremities. A more severe intoxication may cause ataxia and concentric constriction of the visual field.

Pregnant workers exposed to mercury may have reproductive effects like stillbirth, low birth weight and birth defects of their offspring.



Figure 5.4.1. Gas-shielded welding with mobile local exhaust ventilation.

### Zinc

Zinc is highly resistant to corrosion and consequently is used for galvanising iron. Inhalation of zinc fume causes “zinc fume fever”. Malaise, chills, and fever may occur 4 to 6 hours after exposure. The condition is not fatal and affected subjects usually recover completely within 2 days. Inhalation of other metal fumes may also be associated with fever, “metal fume fever”.

### Exposures to metal fumes and dusts

Welding is an occupation associated with respiratory symptoms and bronchial obstruction. Metal fume fever (zinc oxides) and acute bron-



Figure 5.4.2. Solder fume extractor with HEPA filter.

chitis seem to be quite common. Occupational asthma may be caused by hexavalent chromium in stainless steel welding or by diisocyanates inhaled when welding polyurethane-coated steel. Irritative symptoms are common in soldering activities. Fumes from rosin (colophony) cored solder in the electronics industry are recognized as a cause of occupational asthma.

### Prevention

Fumes containing metal oxides and nitrogen oxides are generated in welding operations. Some of the most hazardous being chromium- and nickel oxides are generated when stainless steel is welded. Movable exhaust hoods, Figure 5.4.1, can be efficient in small shops when workers move the hood close to the emission source. These types of exhaust hoods can also be used for other non-repetitive tasks like casting, chipping, grinding or sanding with a motorised hand tool. If the exhaust system is not very efficient, personal protective equipment, like respirators with fresh air supply, should be used when welding painted steel and high-alloyed steel such as stainless steel.

Efficient local exhaust hoods should be used in soldering work. A push-pull ventilation system and simple blowers, with a filter or low-volume high velocity ventilation, Figure 5.4.2, can also be used.

Workers demolishing tanks and ships, or other large lead-painted steel constructions, with gas cutting equipment should use personal protective equipment like half masks with gas and dust filters. The manufacture of electric storage batteries involves potential lead exposure and should be performed in a well ventilated or enclosed system.

Whenever there is hazardous dust, an air cleaner should be used to remove airborne contaminants from the exhaust air stream before discharge to the atmosphere, see Figure 5.4.3. The air cleaner (filter or other cleaning device), should be located immediately upstream of the fan to protect the fan from corrosion and erosion.

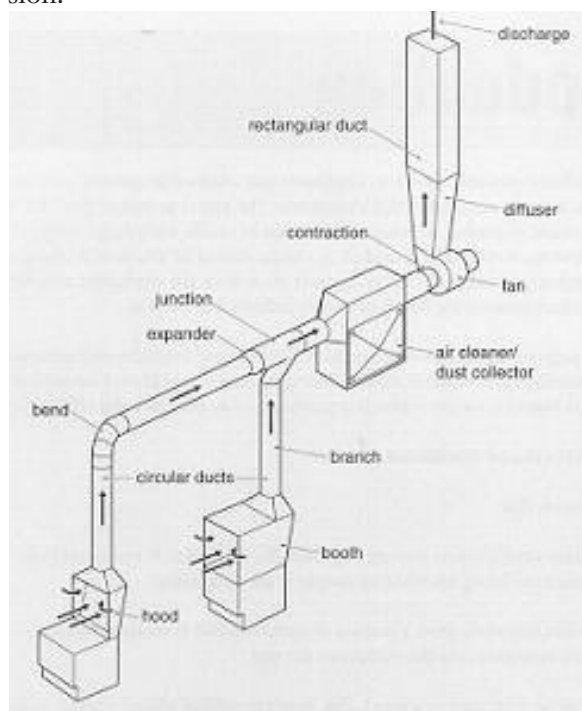


Figure 5.4.3. Air cleaner in the exhaust air stream.

## ORGANIC DUST

Organic dusts are airborne particles of vegetable, animal or microbial origin. These dusts are generated in farming, zoos, pet shops, vegetable fibre processing (cotton, flax, hemp, jute, sisal), textile industries, timber and wood processing, bakeries, flourmills, greenhouses, in fermentation and biotechnology processing.

### Farming

In farms producing plant crops there are exposures to organic dusts from handling grain, hay or other crops, processing sugarcane, working in greenhouses and with storage silos. Working with plant crops exposes workers to grain dust, pollen, mites and fungal spores in hay or other crops. Spraying pesticides and other chemicals in greenhouses will give exposures to organic aerosols.

In animal farms (cattle, pig, poultry) there are exposures to dust containing dander, dried fecal material, animal feed (e.g. grain, soy bean, fish), bedding, endotoxins and ammonia. Dusts inside animal confinement buildings are mainly respirable and ammonia may be absorbed on the particles.

The major health problems in farming are asthma, asthma-like syndrome (wheeze and breathlessness), chronic bronchitis, non-allergic rhinitis, organic dust toxic syndrome (OTDS) and hypersensitivity pneumonitis. Asthmatic symptoms are related to exposure to sensitising agents like storage mites, dander, pollen and soy beans. Grain workers and workers in swine and poultry houses have a risk of getting asthma-like symptoms. Exposure to endotoxins may lead to non-allergic rhinitis and induce chronic bronchitis or asthma. Causative agents leading to hypersensitivity pneumonitis are different microbial agents in mouldy hay, grain and other vegetable matter.

### *Prevention*

One way to prevent or decrease respiratory diseases among farmers is to improve the characteristics and the management of confinement buildings, e.g. with good cleaning routines. Adequate ventilation is the most effective measure to reduce dust and the health risks. The use of silage instead of hay will reduce microbial activity. During cleaning of a confinement building, e.g. after selling one stock of animals (pigs) and prior to the introduction of new ones, personal protective equipment should be used, e.g. half-face respirators with an ammonia cartridge and a dust filter (P2).

### **Bakery and flour mills**

Bakery flour mill workers are exposed to flour dust. Dough makers are the task group most exposed to flour dust and dust from dry ingredients in the dough. Most of the dust exposure occurs during relatively short work tasks like manual weighing, tipping and mixing, giving rise to peak exposures of short duration. Cleaning activities with compressed air will also give high peak exposures. The manual handling of dough, using flour to prevent the dough sticking to the work surface, is another activity that can give peak exposure to flour dust. Flour dust consists mostly of cereals from wheat, rye, barley, oats, rice or maize. It is well known that flour dust can cause allergies such as asthma, rhinitis and dermatitis. Specific sensitisation is more frequent than allergic diseases and the proteins in wheat flour are strong sensitisers. Other ingredients or flours that pose a health risk are soy bean flour, and enzymes like fungal  $\alpha$ -amylase, storage mites and moulds. The higher the exposure to flour dust, the higher the risk of rhinitis and respiratory disorders. Atopy is often defined by the presence of elevated levels of total and allergen-specific IgE-antibodies leading to posi-

tive skin-prick tests to common allergens. This condition in bakery workers increases the risk of sensitisation to flour allergens.

### *Prevention*

Prevention measures should be focused on activities that produce peak exposures. Automation is the most efficient prevention method. Another important measure is to install local exhaust ventilation above dough machines and at manual weighing stations. Flour dust consists of particle sizes ranging from respirable to 15-30  $\mu\text{m}$ , which complicates ventilation measures. It is difficult to install efficient ventilation exhausts at manual handling tables so it may be better to use maize flour instead of wheat flour to avoid dough sticking to work surfaces. Good working practices should be used, e.g. not using pressurised air in cleaning activities, not throwing flour onto dough and by emptying and handling empty bags carefully. Ingredients containing fungal-amylase or other enzymes should be handled in a safe way so that the workers are not exposed to any dust containing enzymes.

### **Forestry and woodworking**

Exposure to wood dust is common in those working in forests and sawmills and to carpenters, joiners and other wood workers. Sawmills often produce dust of relatively large and non-respirable particle size. Wood contaminated with moulds and spore forming bacteria produce small respirable particles. Wood dust contains terpenes, especially the dust from pine trees. There will also be respirable aerosols of saps, gums and wood tars.

Occupational asthma has been shown to be the most common respiratory disorder within forestry and wood working industries. In forestry where western red cedar is common, e.g. in British Columbia in Canada, wood dust is the

cause of asthma in many sawmill workers. Dusts from African maple, oak and mahogany are also known to cause occupational asthma. Wood dust is associated with several other respiratory disorders including mucosal irritation, rhinitis, chronic bronchitis, chronic obstructive pulmonary disease (COPD), inhalation fever, toxic pneumonitis and organic dust toxic syndrome (ODTS). Dusts from certain hard woods have been recognized to cause nasal cancer and wood dust has been classified as a human carcinogen. There are some wood dusts that can be toxic if inhaled or ingested, e.g. East Indian satinwood, ipe and South African boxwood. Wood toxins are usually alkaloids.

#### *Prevention*

Wood dust exposure can be reduced by using efficient exhaust ventilation, working at fully automated or semi-automatic machines, daily cleaning of rooms, cleaning of work pieces with a brush and vacuum cleaning of machines instead of using compressed air.

#### **Paper dust**

Workers in the pulp and paper industry are exposed to different substances such as sulphur compounds, paper dust, bleaching agents like chlorine, chlorine dioxide or ozone. High levels of paper dust seem to impair lung function. Workers exposed to high peak exposures of the bleaching agent ozone (gassings) have a risk of getting asthma and attacks of wheeze. Exposure to high peaks of chlorine-containing bleaching agents increases the risk of wheeze and chronic bronchitis but not asthma. Maintenance workers in the paper and pulp industry have an increased risk for lung cancer indicating that this group had been exposed to asbestos. Epidemiological studies in the paper and pulp industry have often found that workers exposed to chlorine com-

pounds have a higher risk of malignant lymphomas.

#### *Prevention*

The use of chlorine or chlorine compounds as bleaching agents should be avoided and exposure to paper dust should be reduced. Maintenance workers should use proper protective equipment during repair and maintenance work.

#### **Textiles**

There are many types of textiles, including cotton, wool, sisal, synthetic textiles, nylon, etc. Textile dust often consists of fibres of low weight so exposure measurements in apparently dusty environments may show surprisingly low dust levels in mg/m<sup>3</sup>. Many textiles are treated with chemicals. For example, formaldehyde resins may be used in crease-resistant finishes; polymers (like polyacrylates and polyurethanes) that may contain monomers, are used as resistant agents; pyrethrin and other pesticides and fire protecting agents are also used. New textile products include synthetic polyaramid products used in a range of products like plastic pipes, bullet resistant vests and for fire and heat protection. Sewing these products generates dust containing synthetic fibres.

Exposure to cotton dust involves a risk of chronic bronchitis and an occupational disease (specific to cotton dust), byssinosis. Byssinosis is caused by very high exposure to cotton dusts in operations such as ginning, carding and spinning. Dust exposure in both wool and synthetic textile production has been shown to cause chronic respiratory symptoms and impaired lung function. Reported symptoms include cough, throat dryness, and nose and eye irritation. Use of reactive dyes in textile plants may induce a production of IgE-antibodies which is assumed to be the mechanism behind the respiratory and

Type of dust or metal	Main health effect	Target organ
Asbestos	Pleural plaques, asbestosis, lung cancer, mesothelioma	Lungs
Crystalline silica	Silicosis, lung cancer	Lungs
Coal dust	Coal workers' pneumoconiosis, restrictive lung disease	Lungs
Lead	Effects on the central nervous system Anaemia Decreased sperm quality, spontaneous abortions, retardation of neurobehavioural development	Central nervous system Blood-forming organs Reproduction
Manganese	Chronic bronchitis, pneumonia, Tremor, psychosis, Parkinson-like disease	Lungs Central nervous system
Mercury	Pneumonitis, bronchitis Gingivitis, gastroenteritis Effects on central nervous system	Lungs Gastro-intestinal system Central nervous system
Flour dust	Rhinitis, allergic asthma	Respiratory system
Wood dust	Asthma and other respiratory disorders, nasal cancer	Lungs Nose
Cotton dust	Byssinosis, obstructive lung disease	Lungs

Figure 5.4.4. Examples of some dusts and metals at workplaces, main health effects and target organ.

nasal allergic symptoms in workers handling these dyes.

#### *Prevention*

Textile dust can be lowered by decreasing the number of machines in a workplace and by the installation of adequate ventilation. Good working practices, daily vacuum cleaning and the avoidance of compressed air for cleaning activities are also useful prevention measures. Exposure to synthetic fibers should be decreased by the use of exhaust ventilation.

#### **Other dusts**

Vegetable dusts such as tea and rice may cause chronic airway obstruction and bronchitis. Dust from dried sugar cane can cause bagassosis (extrinsic allergic alveolitis).

#### **URBAN AIR POLLUTANTS**

Recently it has been found that exposure to environmental particulate air pollutants is associated with coronary heart disease. The short-term effects of air pollutants have been studied among 38 million persons in eight European cities. An increase of  $10 \mu\text{g}/\text{m}^3$  in  $\text{PM}_{10}$  (particulate matter  $< 10 \mu\text{m}$ ) was associated with 0.5% (95% CI 0.2-0.8%) increase in hospital admissions for cardiovascular disease. A cohort of approximately 500,000 persons was formed in 1982 and followed for 16 years. Each  $10 \mu\text{g}/\text{m}^3$  elevation of fine particulate ( $\text{PM}_{2.5}$ ) was associated with a 6% increase of cardiopulmonary deaths. In an intervention study the cardiovascular death rate decreased by 10% in Dublin after the ban of coal sales in 1990, which decreased the average black smoke by  $36 \mu\text{g}/\text{m}^3$  in the city. One theory links inhalation of air pollutants to a low-grade

inflammatory process in the lungs, which causes an increase in blood coagulation and, as a consequence, coronary heart disease.

Inhalation of several occupational air pollutants causes chronic bronchitis and lung function impairment. Chronic bronchitis as well as decreased  $FEV_1$  are associated with coronary heart disease, and future studies will focus on various occupational air pollutants as causative agents for these conditions. Future knowledge may increase the scope of potential preventive activities regarding coronary heart disease through the reduction of air pollutants.





## Skin disorders

*Carola Lidén & Anders Boman*

### SKIN DISEASES CAUSED BY CHEMICAL EXPOSURE

Many chemical substances are hazardous when they come into contact with the skin. Some toxic chemicals such as pesticides are absorbed through the skin. Skin contact with many chemical and consumer products also cause irritation or allergies.

Contact dermatitis caused by occupational and non-occupational exposure to skin sensitizers and irritants is a common problem that affects a large number of the population in both developing and industrialized countries. Contact dermatitis is the most common effect caused by skin exposure to chemicals. The hands are the most common part of the body affected by con-

tact dermatitis (hand eczema), but the face, arms and whole body surface may be affected. The clinical picture includes redness, papules, blisters, dryness, scaling, fissures and itching, Figure 5.5.1. Hand eczema often becomes chronic, has a poor prognosis that results in sick leave, job loss or unemployment and negatively affects a victim's quality of life.

In Europe, 10% of adults are affected by hand eczema. More women than men suffer from it. The prevalence of hand eczema in developing countries is unknown but it is likely to be more prevalent due to higher exposure levels, limited access to preventive measures and lack of health care for diagnosis and treatment.



Figure 5.5.1. Allergic contact dermatitis.



Allergen	A substance which may cause an immunologically mediated hyper-sensitivity reaction. Low-molecular substances (contact allergens, skin sensitizers) (e.g. nickel ions, preservatives, epoxy monomer) may induce contact allergy and allergic contact dermatitis in exposed individuals. Proteins (e.g. pollens, or from fur animals) may cause respiratory allergy, asthma and rhinitis.
Atopy	Genetically determined ability to develop IgE anti-bodies to allergens such as pollens and fur animals, to develop allergic asthma, allergic rhinitis and atopic dermatitis. Atopic individuals often have sensitive skin and thus increased ability to develop irritant contact dermatitis.
Dermatitis	Inflammation of the skin (used here as synonym to eczema) characterized by redness, blisters, scaling, fissures and itching. Contact dermatitis and atopic dermatitis are the most frequent types.
Contact dermatitis	Dermatitis (eczema) due to skin exposure to irritants (irritant contact dermatitis) or contact allergens (allergic contact dermatitis).
Allergic contact dermatitis	Contact dermatitis due to skin exposure to an allergen to which the individual previously has been sensitized. Allergic contact dermatitis develops several hours or days after exposure to the allergen. The risk of skin sensitization and dermatitis is related to exposure and is not genetically determined.
Irritant contact dermatitis	Contact dermatitis due to skin exposure to skin irritants. Water, many chemical products such as detergents, organic solvents, alkaline substances, foods (e.g. fresh fish, meat, vegetables) and friction etc. are the most frequent causes.
Eczema	See dermatitis

Figure 5.5.2. Definitions on skin and allergy reactions.

While contact allergy occurs equally in atopic and non-atopic persons, irritant hand eczema is more common in persons with atopy, Figure 5.5.1. Colour of the skin does not appear to play a role in contact allergy, and heredity plays a minor role. The exposure pattern varies, however, between socio-economic groups, occupations, geographical, cultural and national regions. The overall risk factor for sensitization and dermatitis in already sensitized persons is skin exposure to skin sensitizers.

### CONTACT ALLERGENS AND DERMATITIS

More than 3,700 chemical substances are described as contact allergens but a limited number of substances are responsible for sensitization in

the majority of cases. The most important causes of contact allergy are metals, rubber and plastic chemicals, preservatives and fragrance chemicals (perfumes).

Contact allergens have a potential to induce cell-mediated allergy (delayed hypersensitivity) and allergic contact dermatitis after skin contact (another mechanism than in allergic asthma and rhinitis). Most contact allergens causing dermatitis are present in man-made products but some are found in plants and in other natural sources. It is estimated that 15-20% of the adult population in Europe is sensitized to one or more contact allergens. The level of sensitization in other parts of the world, particularly in developing countries, is little known due to limited access to

dermatologists, to diagnostic procedures such as patch testing and the lack of clinical and epidemiological data.

Once a person has developed an allergy to a contact allergen (sensitization), further exposure may cause allergic contact dermatitis (elicitation). Sensitization generally requires more intense exposure to the allergen, while lower doses are required for elicitation of dermatitis in those already sensitized. Contact allergy is regarded to be a lifelong allergy, while dermatitis may disappear if skin exposure to the allergen is avoided. The avoidance of skin exposure is essential for prevention of sensitization as well as elicitation of allergic contact dermatitis.

Some occupations represent increased risk for sensitization to specific occupational allergens and some common allergens.

### IRRITANTS AND DERMATITIS

Irritant reactions are frequently caused by different type of exposure, single or repeated. Some of the most prominent skin irritants are defatting agents such as detergents, solvents (including water), and corrosive substances that may cause irritant contact dermatitis. Some substances may act as both an irritant as well as a skin sensitizer.

In general the clinical appearance is the same for irritant and allergic contact dermatitis, and they are often combined. Correct diagnosis, and effective treatment requires knowledge about exposure to irritants and allergens, and patch testing for detection of contact allergy.

A limited number of substances affect both the skin and the respiratory tract, but by different mechanisms. Typical examples are fragrances and formaldehyde that are contact allergens that may cause allergic contact dermatitis after skin contact, as well as causing hyper-reactivity due to irritation of the respiratory tract.

### PREVENTION

Low exposure to chemicals has to be maintained if workers are to perform their jobs with minimal risk of acquiring a skin disease. A low exposure environment can be sustained by a number of administrative and practical processes, Figure 5.5.3.

Limitations on the use of dangerous chemicals and products can be enforced by national and international legislation and regulations. Such measures include occupational exposure limits (of concentration or time), regulations that limit the content of dangerous chemicals in products or conspicuous marking of containers. European and national authorities use regulations that limit use and labelling of chemicals. (Some specific examples concerning nickel, chromium in cement, preservatives, fragrances and latex are mentioned below).

1. Regulations on chemicals, products, work environment: limitations, labelling of chemical products, exposure limits, use limits
2. Substitution of dangerous substances and products
3. Technical solutions including automation, encapsulation of hazardous processes
4. Hygiene routines by workplace and workers to minimize hazardous skin exposure
5. Information about risks and preventive measures
6. Preventive skin care programmes including suitable soap and moisturiser without potent skin sensitizers
7. Personal protective equipment such as protective gloves, aprons, sleeves, boots, goggles, visors

Figure 5.5.3. Examples of measures at international, national, work place and individual levels for prevention of occupational skin disease.

Practical reduction of workplace exposure can include substitution of hazardous chemicals or products with less hazardous ones, techni-

cal devices or reorganization of work. Enclosing machinery, changing routines for handling chemicals or contaminated goods or using tools to handle containers and goods are also ways to minimize exposure.

As a last resort, personal protective equipment must be introduced as a barrier between a worker and a chemical. Impermeable gloves and sleeves may be used for hand and arm protection and boots and aprons can protect the feet and abdomen. Visors or ventilated hoods protect the face from splashes and fumes.

The cost of implementing a new routine or practical device to protect workers from exposure to chemicals is always balanced by lower costs for sick leave and ill-health.

### Protective gloves

When other methods of preventing skin contact with toxic, irritant, or sensitizing chemicals are exhausted, the use of protective gloves may be the only means left. Protective gloves are manufactured from various materials, Figure 5.5.4, but effective skin protection requires gloves to be made of impermeable polymeric materials. Gloves made of leather, cotton or other textiles do not usually give sufficient protection. (Permeability data on various protective gloves/chemical combinations is available).

Gloves should be personal, free of holes and clean on the inside otherwise a toxic, irritant or sensitizing substance can come into contact with the skin and is more easily absorbed due the

Material	Monomer	Trade-name, examples
<b>Natural materials</b>		
Natural rubber (NRL)	<i>cis</i> -Isoprene	Canners and Handlers, AirFlex, FL100/FL200, Natural Blue, Tan Rubber, Natural Rubber Latex HD, Best Master, Tuff Guard, Belmain Plus
<b>Synthetic materials</b>		
Butyl rubber	Isobutene/isopropene	ChemTek, Best Butyl, Butoject, NORTH Butyl
Chloroprene		Neoprene, Redmont, Chemi-Pro, Scorpio, Best Neoprene, Chloroflex II, Camapren
Fluoro rubber	Vinylidene fluoride/hexafluoropropene	Viton, Best® Viton®, NORTH Viton
Nitrile rubber	Acrylic nitrile/butadiene	Sol-Vex, Sol-Knit, Nitri-Solve, Blue Nitrile G25B, Camatril, Chemsoft
Polyvinyl-chloride (PVC)	Vinyl chloride	Snorkel, Ever-Flex Monkey Grip, Black Knight, Cannonball, Hustler, P56B & P57B, Supasoft
Polyethylene (PE)	Ethylene	P-glove
Polyvinyl-alcohol (PVA)	Vinylalcohol	PVA
PE/EVOH/PE	PE and EVOH laminate	4H/Silver Shield, Barrier
Polyurethane (PU)	Isocyanate	
Neoprene/Natural Rubber Latex Blend		Technicians, Omni, Comaprene, Lapren

Figure 5.5.4. Examples of commonly used materials in protective gloves made by major manufacturers.

occlusion caused by the glove. The use of gloves may also cause skin irritation particularly if they are worn for long periods. Gloves should be taken off frequently to let the hands and gloves dry. Cotton gloves can be worn underneath protective gloves in order to increase comfort.

The choice of glove should be based on considerations concerning the period of work, toxicity and adverse effects of a chemical, exposure possibilities, comfort and functionality. A well fitting, comfortable glove is essential when good manual manipulation is needed, but a cheaper less well fitting glove may be used for a short exposure.

The cheapest and generally least protective gloves are disposable gloves made of natural rubber latex. Thicker gloves and those made of synthetic materials are more expensive but give better protection. The purchase of larger quantities of gloves may be economically advantageous as lower prices can be negotiated. This is mandatory for public, government agencies within EU, communities, counties, regions and federal governments and their companies, however not for private companies.

### Preventive skin care programmes

Maintaining a healthy and functional skin barrier is important to prevent skin disease and the absorption of noxious chemicals. One important preventive measure is a good skin care programme for workers where at least a mild soap and a skin care cream (moisturiser) are provided. The use of pre-work “barrier creams” is generally not necessary. “Barrier creams” are not real barriers against absorption, but they may reduce soiling of the skin which can also be achieved by the use of an ordinary skin cream. Sometimes “barrier creams” can enhance skin absorption of hazardous substances.

The products used for skin care programmes

should not contain perfumes, odour masking agents or preservatives that are potent sensitizers. Many “barrier creams” contain such hazardous substances.

## HAZARDOUS SUBSTANCES

### Metals

Nickel is the most common cause of contact allergy. Nickel allergy is much more common amongst women than men due to differences in exposure. In Europe, 10-15% of women and 2-5% of men are allergic to nickel. Chromium and cobalt cause skin sensitization less frequently than nickel but they are still some of the most common causes of contact allergy, Figure 5.5.5.

Substance	Exposure and use
Nickel	Items in prolonged contact with the skin are the most frequent sensitizers. Occupational exposure of the hands to items with high nickel release (tools, coins, equipment etc.) may cause hand eczema. Exposure to nickel-containing solutions may also cause dermatitis.
Chromium	Chromium (VI) in cement is the most important cause of contact allergy to chromium. Chromium (III)-tanned leather may cause allergic contact dermatitis.
Cobalt	Which types of exposure that cause contact allergy to cobalt are not fully understood. Cobalt is a potent skin sensitizer.

Figure 5.5.5. Sensitizing metals, examples of exposure and use.

### Nickel

Currently nickel allergy predominantly affects girls and women who become sensitized by jewellery and other personal items, however, a century ago nickel dermatitis was an occupational disease that principally affected men. Occupational exposure to nickel is still a major factor in eliciting and maintaining hand eczema and may



also cause sensitization to nickel. Groups with high skin exposure to nickel at risk for occupational nickel dermatitis include electroplaters, electronics workers, metal workers, construction workers, car mechanics, hairdressers, cashiers, and employees doing wet work in hospitals and cleaning.

The essential factor in relation to nickel dermatitis is the release of nickel ions (rather than nickel content) from solid items. Various alloys and platings containing nickel have different properties when in contact with skin. Some alloys, such as nickel-silver and copper-nickel, release much nickel while others, such as many stainless steels, release little nickel, (so most stainless steels don't cause contact dermatitis). High exposure to soluble nickel compounds occurs in nickel refining, electroplating, nickel-cadmium battery production, chemical production, and nickel catalyst production.

### *Prevention*

The dimethylglyoxime (DMG) test is a simple screening test for nickel release, available commercially in many countries. It is very useful for identification of sources of skin exposure to nickel in order to prevent nickel dermatitis by reducing exposure. The test is based on DMG (0.8% in alcohol) and ammonia (10%). A cotton tipped stick with 1-2 drops of each solution is rubbed for up to 30 seconds on the surface to be tested. A pink-red colour indicates presence of nickel ions.

In Europe the "Nickel Directive" limits nickel release from certain items intended for direct and prolonged contact with the skin (jewellery, watches, buttons, spectacle frames etc.). Items such as tools, coins and handles are not covered by the "Nickel Directive", although they also contribute to nickel exposure and dermatitis. The "Nickel Directive" entered into full force

in 2001. Experience from Denmark and Sweden indicate that nickel dermatitis is becoming less frequent and severe and that exposure has decreased due to the limitation on nickel release. Similar regulation has recently been introduced in China.

## **Chromium**

Direct skin contact with uncured cement and cement-containing products is the main cause of sensitization to chromium in men. Soluble hexavalent chromium, Cr (VI), is present in cement in large parts of the world, and is an important cause of occupational dermatitis among constructions workers. It should be noted that uncured cement is very corrosive and may cause irritant dermatitis and chemical burns that facilitate sensitization to chromium.

Cr (III) is used to tan leather products. Dermatitis can occur in already sensitized persons through direct skin contact with leather. Such persons may be consumers, workers using protective equipment made of leather, and workers producing leather and leather products. Leather may also cause sensitization. During recent years, chromium in tanned leather has been discussed as an important source of sensitization in women.

Anti-corrosion and electroplating agents, catalysts, chromated products and magnetic tapes are examples of other causes of occupational contact dermatitis due to chromium.

A person who has become sensitized to either Cr (III) or Cr (VI) may react if exposed to the other form of chromium. Elemental chromium, Cr (0), is regarded as stable and is not allergenic at skin contact.

### *Prevention*

In some countries (Denmark, Finland, Sweden, Germany) exposure to soluble chromium has

since decades been reduced by regulation limiting the Cr (VI) level in cement and cement products to <2ppm. Reduction of the Cr (VI) content is achieved by adding iron sulfate to the cement. Contact allergy to chromium has decreased, largely due to the limitation. Similar regulation was implemented also by the EU in 2005.

### Cobalt

Contact allergy to cobalt is often seen in patients who are allergic to nickel or chromium. Uses of cobalt include binders for hard metals, organo-cobalt compounds, coloured glasses, enamels, ceramics, magnets, paint pigments, catalysts and metallic alloys such as Co-Cr used in spectacle frames and prostheses. Occupational skin exposure occurs by contact with hard metal products, alloys, paints, magnetic tapes, and in hard metal production. There is limited knowledge about the sources of skin exposure and sensitization to cobalt in the general population.

### Prevention

Dermatologists often recommend patients allergic to cobalt to avoid contact with nickel as cobalt and nickel allergy are often seen together. A screening test for cobalt, similar to the test already available for nickel, may be available in the future.

## RUBBER AND PLASTICS

Contact allergy to rubber chemicals is common, mainly caused by occupational and non-occupational exposure to finished rubber products. Contact allergy to plastic chemicals is also common, most often caused by occupational exposure to unfinished plastics, Figure 5.5.6.

### Rubber chemicals

Thiurams, carbamates and mercaptobenzothiazoles are used in the production of rubber products, and in many other products and processes. Many of the substances are skin sensitizers. Rubber gloves (household and surgical), boots,

Substance	Exposure and use
Rubber chemicals: Mercaptobenzothiazoles, dithiocarbamates and thiurams	Used as additives in rubber production, in articles such as gloves, watch straps, diving equipment, gas masks, elastic bands, elasticated garments and shoes. Used as pesticides.
Diisocyanates	Industrial uses of isocyanates include manufacture of rigid or flexible polyurethane foam, surface coatings, adhesives, elastomers and textiles. Occupational exposure in rubber workers, spray painters, plastic factory workers, foam manufacturers, printers, laminators etc. Polyurethane can break down into isocyanate monomers upon heating, exposure may occur in e.g. welders.
Epoxy resins	Used in a wide range products and materials - adhesives, paints, electric insulation, cement and glass fibres etc. Occupational and non-occupational exposure.
Methacrylates	Used as, or in production of binders for glues, paints, inks, coatings, in dentistry etc. Occupational exposure to uncured acrylic resins. Non-occupational exposure to anaerobic sealants, contact with cured products which still contain non-reacted monomer.
p-tert-Butylphenol-formaldehyde resin (PTBP-F-R)	Binder, used mainly in glues, paints, adhesive tapes and labels, inks and surface coatings. Used in glued leather products such as shoes and watchstraps. Occupational and non-occupational exposure.

Figure 5.5.6. Examples of skin sensitizing rubber and plastic chemicals, their exposure and use.

shoes, watchstraps, diving equipment, gas masks, tyres, tubes etc. are examples of rubber products in frequent contact with the skin. Ironically, protective gloves are the most important cause of contact allergy to rubber chemicals. Sensitizing rubber chemicals may be used also in paints, glue removers, anti-corrosives and pesticides.

Natural rubber latex proteins may cause IgE-mediated allergy which is another type of allergy with different symptoms (see below).

### *Prevention*

The use of protective gloves made of plastic rather than rubber materials should be considered (see below).

### **Plastics**

Many plastic chemicals are known skin sensitizers. The following are some of the most frequent sensitizers.

Epoxy resins are used in epoxy-resin systems that consist of resin, a hardener, and other components such as diluents, fillers and pigments. There are many different epoxy resins. Monomers and dimers of epoxy resins are extremely potent skin sensitizers and may cause sensitization after a single exposure to the uncured resin. Some of the hardeners and other components may also cause sensitization.

Epoxy resins are used in a wide range of products and applications such as two component paints, glues and adhesives, corrosion inhibitors, metal coatings and printing inks. They are used to insulate electric assembly and electronic devices, as an additive to cement for quick bonding and strengthening, in glass fibres and flooring materials etc.

Many acrylates, and particularly methacrylates, are potent skin sensitizers. Like epoxy resins, skin exposure to monomers, oligomers or uncured acrylic resins is the most important

route for sensitization. Acrylates are used in a wide range of applications and occupations. Dental acrylates cause hand eczema in dentists, dental technicians and dental nurses, but seldom affect dental patients.

Isocyanates, particularly some of the diisocyanates, are potent skin sensitizers. This has not received as much attention as the respiratory effects, which are more common and may be severe.

Phenol formaldehyde resins is a group of resins with varying properties, composition and applications. p-tert-Butylphenolformaldehyde resin (PTBP-F-R) is a frequent skin sensitizer, used mainly in adhesives, where flexibility and water resistance is needed. It is often used in shoes and watch straps and may cause severe dermatitis.

### *Prevention*

All skin exposure to uncured plastic resins should be avoided. It is essential for workers and consumers to know that the monomers pass through the common protective glove materials within minutes.

### **PRESERVATIVES**

Contact allergy to preservatives is a frequent problem. All preservatives are potential skin sensitizers, and some of them are extremely potent. Due to the continuous introduction of new preservatives, the situation is dynamic, Figure 5.5.7.

The presence of preservatives in products is often unknown since there is no requirement to declare ingredients on the labels of chemical or household products. There are inadequate safety data sheets. To add to the confusion, preservatives often have many different trade names and products frequently contain more than one preservative.

Formaldehyde is a common preservative in

Substance	Exposure and use
Benzisothiazolinone (BIT)	Preservative in chemical products, mainly for occupational use, such as in paints. Not allowed in cosmetic products in the EU.
Formaldehyde and formaldehyde releasers	Preservatives in a wide range of products including cosmetics, chemical products for consumers and occupational use.  Formaldehyde used also in textiles and leather in contact with skin.
Methylchlorisothiazolinone/methylisothiazolinone (MCI/MI)	Preservative in a wide range of products including cosmetics, chemical products for consumers and occupational use. Kathon CG is the most well-known of many trade names.  MCI/MI is an extremely potent skin sensitizer. Severe restrictions of use in cosmetics have been introduced in the EU and in North America. The use of MI only, often together with other preservatives, is increasing.
Methyldibromo glutaronitrile (MDBGN)	Preservative in a wide range of products including cosmetics, chemical products for consumers and occupational use.  Alarming increase in sensitivity to MDBGN recorded in Europe. From June 2008 not allowed in cosmetics in the EU.

Figure 5.5.7. Examples of skin sensitizing preservatives, their exposure and use.

paints/lacquers, binding agents, cleaning agents, printing inks, adhesives/glues, filling agents, hardeners, cutting fluids, cosmetics, toiletries etc. Formaldehyde resins are used in textiles to avoid shrinkage and in the production of leather. Formaldehyde is also used in many chemical processes.

Occupational exposure to formaldehyde occurs among health care workers, photographers, textile workers, metal workers, painters, carpenters, joiners etc. Non-occupational exposure occurs among the general population through contact with detergents, glues, cosmetics, toiletries etc.

Formaldehyde releasers act as preservatives by releasing formaldehyde into a variety of products including cosmetics and hygiene products. Some of the formaldehyde releasers are common skin sensitizers.

The preservative that causes the most problems is methyldibromo glutaronitrile (MDBGN). There has been an alarming increase in the

sensitization rate in dermatitis patients in Europe principally attributed to the use of MDBGN in cosmetic products. Strict limitations on the use of MDBGN were adopted in the EU as from June 2008 it cannot be used in cosmetics (including products for personal hygiene). However, the use of MDGDN is still allowed in chemical or other type of products.

Methylchlorisothiazolinone/methylisothiazolinone (MCI/MI) is an extremely potent skin sensitizer widely used in cosmetics and chemical products. However, its use has been limited in cosmetics because of the rapid increase in skin sensitization.

Benzisothiazolinone (BIT) is a chemically related substance but it is not allowed in cosmetic products in Europe.

## DYES

Many dyes are skin sensitizers and may cause allergic contact dermatitis. The chemistry is very complex due to the reactivity of the substances.

Hair dyes and dyes used in textiles are common causes of dermatitis. Some examples are given in Figure 5.5.8.

### Hair dyes

Contact allergy to hair dyes is a frequent problem among hairdressers and consumers in industrialized countries and developing countries. Hairdressers may develop severe hand eczema and consumers may develop dermatitis on the face, neck and scalp. There are several types of hair dyes including vegetable dyes based on henna, temporary dyes that are washed away quickly, semi-permanent, permanent or oxidation hair dyes. Permanent hair dyes generally consist of a cream base with a mixture of aromatic amines and couplers. The most important skin sensitizers are p-phenylenediamine and related substances that may be used in both permanent and temporary hair dyes.

Many other substances used in hairdressing, not only hair dyes, are skin sensitizers. Examples are bleaching agents, permanent wave agents, preservatives, fragrances, and nickel and cobalt in cutting equipment. Hairdressers are often affected by hand eczema due to the combination of intense wet work and exposure to potent skin sensitizers.

### Disperse dyes

Many disperse dyes are contact allergens. The magnitude of the problem is not known due to limited experience from patch testing with dyes. Disperse dyes are often used in textiles. Occupational dermatitis may be caused by exposure in production of textiles and fabrics. Dermatitis is also caused by wearing dyed clothes.

Group	Important skin sensitizers
Hair dyes	The most potent and frequent skin sensitizers are p-phenylenediamine and its derivatives 3-aminophenol and toluene-2,5-diaminesulfate. Hairdressers and consumers are exposed.
Disperse dyes	Dyes in a wide range of products and materials for consumers and occupational use. Used in textiles, leather, plastics, printing inks etc. Examples of some of the most frequent skin sensitizers: Disperse blue 106, Disperse blue 124, Disperse yellow 3, Disperse red 1, Disperse orange 3.

Figure 5.5.8. The most important skin sensitizing dyes in consumer products and occupational exposure, examples.

### FRAGRANCES AND COLOPHONY

Contact allergy to perfumes (fragrance substances) is an increasing problem. Fragrances are used in a wide range of products. Several hundreds of different fragrances are in use, and a small number are not allowed in cosmetics due to severe health effects. Fragrances are used in cosmetics, household products, chemical products etc. They are used to give an attractive and/or specific smell, and to mask bad odours, in products as cutting fluids, Figure 5.5.9.

Contact allergy to colophony (rosin) is common. Colophony is derived from pine trees by a variety of processes. It may be used unmodified or modified and has a wide range of applications. All modified colophony products contain components from unmodified colophony, and may cause contact dermatitis, Figure 5.5.9.

Substance	Exposure and use
Fragrances	Frequently used in cosmetics, hygiene products and chemical product etc. Respiratory symptoms caused by fragrances are due to irritation, not allergy.
Colophony (rosin)	Used in a wide range of products and materials for occupational and non-occupational use. Solder flux, emulsifiers, glues for different purpose, cosmetics, waxes are some examples. Asthma has been related to exposure to fumes from solder flux. The mechanism is not settled.

Figure 5.5.9. Fragrances and colophony, examples of exposure and use.

## PESTICIDES

The most important fatal effects of skin exposure to pesticides are acute toxic reactions due to skin absorption of organophosphorus compounds. Irritant contact dermatitis due to pesticide exposure is believed to be more frequent than allergic contact dermatitis. Allergic contact dermatitis caused by pesticides has often been related to fungicides and insecticides. It must be stressed, however, that there is limited experience and data from patch testing with pesticides for diagnosis of contact allergy. A broad range of skin effects of pesticides has been described. Some examples are given in Figure 5.5.10.

There is a broad variation in the degree of skin exposure to pesticides experienced by workers. Sprayers, mixers, loaders, packers, and mechanics perform work with high risk of direct skin contact with pesticides. Aerosols and residues on treated plants and surfaces may also contribute to exposure. Percutaneous absorption of pesticides varies considerably from compound to compound. Absorption is highest through scrotal skin, the head and neck. Occlusion, skin

Pesticide	Skin effect
Chlorothalonil	Extremely potent skin sensitizer. Allergic contact dermatitis has been described in workers exposed in floriculture, banana fields, wood preservation and to paint. Skin pigmentation (ashy dermatosis) has been described in banana field workers.
2,4-D and 2,4,5-T	May contain TCDD (dioxin) which is often formed during production. This is the explanation of several outbreaks of chloracne and porphyria cutanea tarda.
Paraquat	Irritant contact dermatitis, occupational keratoses, nail lesions, necrotic ulcers, deaths have been reported after skin exposure. Considerable amounts may be absorbed through damaged skin and under occlusion.
Carbamates, thiurams, benomyl, fluoxinam and other fungicides	Allergic contact dermatitis has frequently been reported. Carbamates and thiurams are used also in the production of rubber.

Figure 5.5.10. Examples of severe or frequently occurring skin effects caused by skin exposure to pesticides.

damage concentration, contact time, area, humidity and temperature are all important factors affecting skin absorption.

Prevention of skin exposure to pesticides is extremely important.

## ORGANIC SOLVENTS

Considerable amounts of several solvents may be absorbed through the skin from exposure to neat solvents, products containing solvents (e.g. cleansing and defatting agents), and in some cases, to vapours. The uptake varies widely between different solvents. Water solubility, lipid



solubility and volatility are of importance. Other factors influencing the rate of skin absorption are environmental factors such as humidity, temperature, air velocity, vehicle, occlusion, and exposure time.

Skin exposure to organic solvents has been estimated to be responsible for up to 20% of occupationally induced dermatitis. The main effects of organic solvents on the skin are irritation, irritant contact dermatitis and acute burns. Skin sensitization occurs rarely. Other effects are subjective irritation, whitening, contact urticaria, generalised dermatitis, and systemic toxicity due to percutaneous absorption. Skin may be exposed to organic solvents when hands are cleaned with solvents or cleaners containing solvents, through accidents, lack of proper protective equipment, or poor workplace routines and facilities.

Skin exposure to glycolethers and dimethylformamide is hazardous because they are easily absorbed. Aromatic solvents are more potent irritants than aliphatic solvents. Contact with perchloroethylene and several other halogenated solvents may cause severe burns. This can result from clothes that have not been properly dried after dry cleaning with perchloroethylene or trichloroethylene. Alcohols are less irritating than the aldehydes or ketones. Carbon disulfide is one of the most irritating solvents. While dimethyl sulfoxide (DMSO) is readily absorbed through the skin, its systemic toxicity is low. The use of turpentine has declined but previously it was a common cause of contact dermatitis among painters. D-Limonene, (a citrus solvent), is an organic solvent increasingly used in metal cleaning, and many other uses. Allergenic oxidation products are created when exposed to air. Several organic solvents are known to induce scleroderma-like eruptions with localized sclerosis of skin on hands and feet.

Protective gloves should be used to prevent skin exposure to organic solvents. There are different models of gloves made from different materials of differing strength, so their resistance to organic solvents is variable. When selecting protective gloves, it is essential to consider these aspects as well as the risk of side effects from the gloves themselves. Barrier creams are less efficient than protective gloves in reducing skin exposure and percutaneous absorption of organic solvents and their use may lull users into a false belief that their skin is protected.

### CORROSIVES

A wide variety of products and chemicals are corrosive to the skin causing chemical burns on contact. Usually, they have an extreme pH or are toxic to the keratinocytes of the skin. Examples of corrosive products are cement, hydrofluoric acid, concentrated acids and alkalis, phenol. Some concentrated chemicals such as the preservative MCI/MI may be both corrosive and sensitizing.

### SKIN IRRITANTS AND WET-WORK

Many chemicals and chemical products are skin irritants because they remove lipids from the skin. Commonly used products such as detergents, organic solvents, cleansers, soaps, mild alkali, defatting agents and even excess water may cause irritant contact dermatitis. Use of protective and medical gloves may also contribute to the development of dermatitis. Handling fresh foodstuffs is considered as wet-work and dermatitis among cooks and other kitchen staff is often attributed to contact with fresh vegetables, raw fish and meat and frequent hand washing.

Exposure to wet-work is very frequent in a wide range of jobs and in non-occupational settings. Clinically, irritant contact dermatitis caused by wet-work and exposure to chemicals is

a major problem. Physical factors such as friction from tools and handles, exposure to dust and man-made fibres may cause and aggravate dermatitis.

## NATURAL PRODUCTS

### Wood

A number of types of wood cause contact dermatitis due to skin irritation and contact allergy. Some tropical woods are extremely potent skin sensitizers, particularly palisander, rosewood, pao ferro, sandalwood, jacaranda, teak, African ebony and African mahogany. Important skin sensitizers in tropical woods are quinines. In Europe, pine trees are the most frequent sensitizers as they contain colophony (rosin), a common sensitizer.

Handling of fresh wood and exposure to saw dust may cause severe and widespread dermatitis on hands, forearms, face and neck mainly affecting wood workers such as carpenters, joiners, cabinet-makers and trades persons. Standard clothing is not good protection and airborne sawdust may drift inside clothing, and adhere to sweaty areas of skin like armpits, waist, groin and ankles. Finished wood products may also cause dermatitis. Dermatitis in forest workers is generally caused by liverwort and lichens growing on trees, not by the wood itself. Inhaling saw dust may also cause asthma, cancer and higher risk of Hodgkin's disease.

### Plants and lichens

Plants may cause allergic and irritant contact dermatitis, photosensitivity and contact urticaria. Some fruits and vegetables cause dermatitis. Dermatitis caused by plants often appears as streaks on the arms and face, or as dermatitis on the fingertips and palms. Agricultural workers, florists, gardeners, forestry workers, workers

in contact with food and the general population may be affected.

The *Anacardiaceae* family (cashew family) includes some 600 species of trees and shrubs, distributed throughout the tropics and temperate regions of Europe, eastern Asia, and the Americas. They are considered to cause more dermatitis than all other plant families combined. The most important genus is *Toxicodendron* which includes poison ivy, poison oak and poison sumac, frequent allergens except in Europe where these plants are not widespread.

Peels and juice from citrus fruits such as lime, lemon, orange and grape fruit may cause dermatitis by irritation, sensitization and photoallergy. Citrus peels contain essential oils and d-limonene (citrus solvent) used as fragrance substances and solvents.

### Natural rubber latex

The protein in natural rubber latex may cause contact urticaria, asthma, rhinitis and even life threatening anaphylaxis, due to IgE-mediated allergy. In Europe and Northern America, this type of allergy has become more frequent during the 1990s, largely attributed to the increasing use of natural rubber latex gloves in health care. In some European countries, 10% of health care workers who frequently use gloves are affected by latex allergy. Increased awareness of the problem in Europe and the USA has resulted in regulations and standardisation for prevention by improvement in the quality of the products. The situation on latex allergy in developing countries is unknown.



# Epidemiology

*Gun Nise & Bengt Sjögren*

The discipline of Epidemiology has developed tremendously over the last half century. The content of occupational epidemiology is studies of the occurrence of diseases and occupational exposures. This short presentation gives a touch of some features of occupational epidemiology. Comprehensive presentations of this topic are available in textbooks, some examples are given under “Suggestions for further reading” at the end of this Section. Most of the epidemiological studies can be divided into the following groups:

- Descriptive studies present the occurrence of a symptom or disease in a defined population, e.g. a particular effect/disease amongst a specific group of workers.
- Analytical studies compare the occurrence of a symptom or disease among workers exposed to a defined agent with the occurrence of symptom or disease among non-exposed workers.

Epidemiology has been a crucial tool in research to elucidate and establish the association between occupational exposures and adverse health effects, e.g. asbestos and lung cancer, benzene and leukaemia, heavy workload and musculoskeletal disorders.

Various approaches can be used to investigate the relationship between occupational or envi-

ronmental exposures and diseases. The design of a study is based on the character of the exposure of concern, the expected health outcome, and the feasibility of conducting the study. The probability of finding an increased risk very much depends on the intensity and duration of exposure, the number included in the study group and the occurrence of disease.

Epidemiology continues to play an important role in identification of major causes of occupational diseases which is the key element for prevention and controlling hazardous exposures.

Some basic definitions will be presented which are used in epidemiology describing associations between exposure and disease.

## BASIC CONCEPTS

### Risk

Risk refers to the probability that an event will occur, e.g. that an individual will become ill or die within a stated period of time or by a certain age. *The time at risk* refers to the period when it is possible for an individual to get a disease. For example, during pregnancy a woman is at risk of having miscarriage. The time at risk is usually given as *person-time*, a measurement combining persons and time at risk of developing symptom

or disease. The most commonly used person-time is person-years.

### Prevalence (P)

The prevalence of a disease is defined as the proportion of sick persons in a population at a specified time. P lies always between 0 and 1, since the lowest number of sick persons are zero and the maximum is 1 if the total population is sick. P is often expressed as per cent. Several factors can influence the prevalence, see Figure 5.6.1.

$P = \text{number of sick people at a specified time} / \text{total number of people in the population at the same time}$

Example: Today, in a group of 25 students, 8 have a sore throat i.e. the prevalence of sore throat among the students is 32 % (8/25).

P increases if:	P decreases if:
Long duration of disease	Short duration of disease
Patients with incurable disease live longer	Fatality rate is high
Number of new cases increase	Number of new cases decrease
Migration of cases into the group	Migration of cases from the group
Migration of healthy persons from the group	Migration of healthy persons into the group
Migration of susceptible persons into the group	Improved recovery rate
Improved diagnostic and/or reporting facilities	

Figure 5.6.1. Factors that can influence prevalence.

### Incidence (I)

Incidence describes the number of new cases of a disease in a defined population within a specific

period of time. In order to calculate the incidence, individuals have to be followed over time. The “I” can be 0 but has no upper limit.

$I = \text{Number of people who get a disease during a specified period} / \text{sum of the length of time each person in the study population is at risk}$

Example: Following the earlier mentioned 25 students over 3 years, we might find 26 events of sore throat. The time at risk is  $3 \times 25$  years. The incidence of sore throat will be  $26 / (3 \times 25) = 0.35$  cases/person-year.

### Cumulative incidence (CI)

The cumulative incidence (incidence proportion) is the proportion of persons in the study population getting ill during a specified time period. In general the CI increases with observation time, which is why the observed period must be given.

$CI = \text{Number of people getting a disease during a specified time period} / \text{number of people free from disease in the population at the beginning of the period}$

CI lies between 0 to 1.

### Risk measures

The commonly used *risk measures* are described below.

The *risk difference* is the difference between the risk of disease in two populations. Risk difference is the occurrence of disease in an exposed group minus the occurrence of disease in an unexposed group.

The *relative risk or risk ratio (RR)* is the occurrence of disease in an exposed group divided with the occurrence of disease in an unexposed group.

The *odds ratio (OR)* is a basic measure of risks used in case-control studies (see below). OR is

the ratio between two odds: the odds of exposure among the cases divided with the odds of exposure among the controls. The odds of exposure means the probability of being exposed divided with the probability of not being exposed.

When comparing groups it is necessary to consider possible age differences between the groups, since age affects the occurrence of most diseases. The number of observed cases in the population can be compared with the expected number of cases. This expected number can be calculated from the incidence in a standard population after adjustment of age differences. The ratio between observed and expected number of cases can be written as the *Standardized Mortality Ratio (SMR)* or *Standardized Incidence Ratio (SIR)*.

## TIME PERSPECTIVE

A *cross sectional study* investigates the occurrence of disease at a given point in time. The outcome of the study is the prevalence.

In a *longitudinal study* the conditions are followed over time. Such studies can be *prospective* (starting before any cases have occurred), *retrospective* (performed after the cases have happened) or *ambispective* (a combination of both).

## STUDY DESIGN

### Cohort studies, follow-up studies

A cohort is a population with some common characteristic, e.g. the same workplace or occupational exposure. A cohort study can be both prospective and retrospective. In a retrospective cohort study old personnel records from an industry can be used to give information about individual exposures and work tasks. It may be simple to collect data on diseases in this type of cohort, but it can be difficult to find reliable information about previous levels and duration of exposure. In prospective cohort studies it is pos-

sible to collect reliable exposure data, however, it will take several years or even decades before sufficient numbers on manifest or indicators of disease will develop. Sometimes the terms prospective and retrospective are employed to describe the timing of disease occurrence with respect to the assessment of exposure.

### Case-control studies, case-referent studies

A case-control study starts with a number of cases with symptoms or disease. Then a number of controls are selected from the same population from which the cases are recruited. Sometimes both the cases and the controls are matched on relevant confounders (see below). The exposures among cases and controls are compared. This is a suitable method to study rare diseases.

Cohort study	Case-control study
Start with exposure and look at disease	Start with disease and look at exposure
Several diseases but only one exposure at the same time	Several exposures, but only one disease
Both prospective and retrospective	Retrospective (and prospective)
Efficient for common disease and rare exposure	Efficient for common exposure and rare disease
Relative risk often expressed as SMR or SIR	Relative risk expressed as OR

## POTENTIAL ERRORS

Occupational epidemiological studies aim to accurately measure the exposure of workers, the occurrence and risk of disease. Errors can be either random or systematic.

### Precision and random errors

The *precision* of a test is expressed as the variation between repeated measurements. Perfect precision is defined as the absence of *random*



*errors*. Precision in epidemiological studies can be improved in two ways. The primary means is to increase the size of the study. Precision can also be improved by modifying the design of the study to increase the efficiency with which information is obtained from a given number of study subjects. Poor precision of individual exposure results in misclassification and leads to less reliable results.

### Validity and systematic errors

*Systematic error (bias)* occurs when the measurements have a systemic tendency to differ from the true value. A study has high *validity* when it measures what it purports to measure.

*Selection bias* occurs when there is a systematic deviation between the characteristics of those people selected for the study and those who are not. There is a risk of selection bias when:

- only voluntary subjects are included in a study
- comparisons are made between employed and unemployed persons
- a cross-sectional study of employed is undertaken in an unhealthy work environment where workers are transferred from the environment.

The main *information bias* is *misclassification* of either exposure or health status. Misclassification can be *differential* or *non-differential*. For example, exposure misclassification is regarded as non-differential if the exposure classification error is similar for persons with and without disease. Misclassification of disease or symptom is non-differential when the sensitivity and specificity of the diagnoses are the same over exposure categories. The effect of non-differential misclassification of either exposure or health status usually gives an underestimation of the associations between exposure and outcome. Differential misclassification can affect the results

in either direction (underestimating or overestimating effects). *Recall bias* is present if cases in a case-control study have better and more detailed memories of their exposures than controls do. The exposure classification will not be equivalent for the two groups. For example, in a study of solvent related symptoms, there is a more accurate exposure classification by workers' with symptoms than among those without symptoms. This can distort the result to an overestimation of the effect of exposure.

*Interview bias* can be a problem if different interview methods (e.g. personal interview versus questionnaire) are used for cases and controls.

### Confounding

The occurrence of disease among exposed and non-exposed can differ because of another factor causing the disease. If this factor is not accounted for in a study, the result will be a systematic error, a *confounding factor*. A confounder is:

- associated with the exposure
- an independent risk factor of a disease
- not part of the causality chain from exposure to effect.

For example, smoking causes lung cancer. If an investigation of the occurrence of lung cancer is carried out in a group of workers exposed to Chemical A, a comparison can be made with a group of workers not exposed to Chemical A. If smoking habits differ between the exposed and non-exposed workers, this factor will be a confounder that distorts the results. Confounding can be controlled either in study design (matching or restriction) or through stratification or adjustment in the analysis. If *matching* is used to control confounding, the cases and controls are selected in such a way that the potential confounding factor is evenly distributed among cases and controls. *Restriction* can be used to

limit the study to people with particular characteristics, e.g. smokers or non-smokers.

Control by stratification requires separate analysis for different strata (homogenous categories), e.g. calculation of separate risk estimates for smokers and non-smokers.

## Suggestions for further reading

### SECTION 5 AS A WHOLE

Encyclopaedia of Occupational Health and Safety, 4<sup>th</sup> edition ILO J. M: Stellman 1998. Free on [www.ilo.org/encyclopaedia/](http://www.ilo.org/encyclopaedia/).

Patty's Toxicology. Editors Eula Bingham, Barbara Cohrssen and Charles H Powell. 5<sup>th</sup> edition. Volumes 1-8. John Wiley & Sons, Inc. New York 2001.

#### *Webpages*

[www.pubmed.gov](http://www.pubmed.gov)

Pubmed is a service of the U.S. National Library of Medicine that includes over 18 million citations from MEDLINE and other life science journals for biomedical articles back to the 1950s. PubMed includes links to full text articles and other related resources.

[www.ilo.org/public/english/protection/safework/](http://www.ilo.org/public/english/protection/safework/)  
ILO:s Programme on Safety and Health at Work and the Environment (SafeWork).

[www.who.org](http://www.who.org)

[www.hse.gov.uk](http://www.hse.gov.uk)

Health and Safety Executive (HSE ) has free leaflets on many different topics related to safety at work. They also have guidelines on Methods for the Determination of Hazardous Substances (MDHS).

[www.ioha.com](http://www.ioha.com)

The webpage of the International Occupational Hygiene Association contains information on occupational hygiene topics.

[www.inchem.org](http://www.inchem.org)

The International Programme on Chemical Safety (IPCS) allows rapid access to internationally peer reviewed information on chemicals commonly used throughout the world that may also occur as contaminants in the environment and food. It consolidates information from a number of intergovernmental organizations whose goal is to assist in the sound management of chemicals.

[www.cdc.gov/niosh](http://www.cdc.gov/niosh)

The National Institute for Occupational Safety & Health (NIOSH) in the USA offers the NIOSH Pocket Guide to Chemical Hazards and Manual of Analytical Methods as well as other free information.

[www.osha.gov](http://www.osha.gov)

This website of the U.S. Department of Labor, Occupational Safety & Health Administration has information in both English and Spanish largely related to legal, compliance and cooperation issues.

[www.osha.europa.eu/en](http://www.osha.europa.eu/en)

European Agency for Safety and Health at Work. This is a tripartite organisation that produces some information in English.

[www.av.se](http://www.av.se)

Swedish Work Environment Authority.

[www.iarc.fr](http://www.iarc.fr)

International Agency for Research on Cancer. The World Health Organization's leading source for information about cancer.

## CHAPTER 5.1

Major hazard control: A practical manual. International Program on Chemical Safety. Geneva, 1994, 296 pp ISBN 92-2-106432-8.

An overview of major hazards, presented in a readable format. Appendices contain some practical tools and interesting examples of a variety of applications. Translated into French and Spanish. The manual is also published in local languages throughout the world.

A Strategy for Assessing and Managing Occupational Exposures, Third Edition, Edited by Joselito S. Ignacio and William H. Bullock. E-mail [infonet@aiha.org](mailto:infonet@aiha.org).

OSH professionals will find this resource beneficial when allocating resources for assessing and managing occupational exposures to chemical, physical, and biological agents. The topics addressed include basic characterization; qualitative and quantitative risk assessment and priority setting; monitoring, interpretation, and decision making; recommendations; reporting; and evaluations. A CD-ROM with supplementary materials is included.

Occupational Health. Risk Assessment and Management. Eds. Steven S Sadhra, Krishna G. Rampal, Blackwell Science Ltd, 1999, ISBN 9780 632 04199 2.

Integrates all aspects of workplace risk assessment and management, now the overriding emphasis in occupational health. Topics include: basic concepts and developments; toxic hazards; hazard characteristics and identification; standards setting; requirements for monitoring workplace exposure; contaminants; exposure modeling; risk perception and management; prevention and control; economics; emergency response; health sur-

veillance; auditing; compliance; pesticides, chemicals, carcinogens, biological agents, and radiation; equipment screening; manual handling; stress; and workplace violence.

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<http://www.pesticideinfo.org>

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important organic solvents used in the chemical and allied process industries. This handy reference features a glossary of solvent terminology and an easy-to-reference index of synonyms for chemicals and solvents. It features chapters on the major classes of organic solvents, descriptions for general use, and the chemical formulation, thermodynamic properties, health and toxicity, and combustible characteristics of solvents.

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[www.cdc.gov/niosh/ncpc/ncpc1.html](http://www.cdc.gov/niosh/ncpc/ncpc1.html)  
The National Institute for Occupational Safety & Health in the USA has a database on recommendations for Chemical Protective Clothing

#### *Websites on glove permeation data by glove manufacturers*

[www.bestglove.com/site/chemrest/](http://www.bestglove.com/site/chemrest/)  
[www.ansellpro.com/download/Ansell\\_7thEditionChemicalResistanceGuide.pdf](http://www.ansellpro.com/download/Ansell_7thEditionChemicalResistanceGuide.pdf)  
[www.northsafety.com/](http://www.northsafety.com/)  
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An introduction to the principles and methods of epidemiology. Basic epidemiology is a standard reference for education, training and research in the field of public health and has been translated into more than 25 languages. Available as textbook or PDF/Ebook version at: [www.who.int/bookorders](http://www.who.int/bookorders)

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# Prevention of biological risks



# Prevention of biological risks

*Mohamed Jeebhay & Eliana Alvarez*

## THE HBA PANORAMA

This chapter will present an approach to preventing exposure to hazardous biological agents (HBAs) in the workplace, taking into account international standards as well as specific, local considerations in eliminating, controlling or minimising exposure to a HBA.

The true disease burden associated with HBAs in the workplace is unknown due to the ubiquitous nature of these agents in the general environment. A number of diseases due to biological agents (e.g. asthma, tuberculosis, hepatitis, bilharzia, malaria and AIDS), also occur outside the workplace. These diseases have a major impact on work and working life potentially resulting in higher absenteeism, increased personnel turnover, poor worker health and lower productivity. When such diseases arise as a consequence of work-related exposures or activities, (e.g. needle-stick injuries causing HIV/AIDS; bakery work causing asthma, gold mining causing TB), the general public are likely to attribute such conditions to non-work-related exposures. It is therefore important to define the burden of disease from HBAs in the workplace and to identify high-risk work factors. This will enable workplaces to adjust working conditions

to suit the worker, to introduce intervention measures to minimise exposure to HBAs, to develop education and training programs to increase awareness and behaviour modification and to provide counseling and support programs for workers and families when appropriate. This will ultimately contribute to a reduction in the overall morbidity and mortality associated with biological agents, particularly in the workplace.

Infections, respiratory and skin diseases are the most common health outcomes due to hazardous biological agents. However, valid incidence and prevalence data for most occupational biological diseases is lacking because biological factors reveal a large diversity in distribution within working environments. The distribution is affected by geographic, microclimatic and nutritional conditions. Many developing countries have tropical and sub-tropical climatic conditions with high temperature and humidity which may activate or enhance the harmful effects of biological agents, e.g. malaria in oil palm plantations, fungal infections of the hands in wet food canning environments, bilharzia in fishing and rice plantations.

The epidemiology of occupational diseases associated with protein allergens of biological origin has begun to emerge in the last decade. Studies of workers in grain, bakery, laboratory animal and health care show the prevalence of allergic sensitisation to be between 5–50 per cent. The incidence (per person-year) of work-related sensitisation among apprentices in various trades including dental hygienists exposed to latex or pastry-makers exposed to flour, is almost 10 per cent. Similarly, various studies indicate a 12 per cent annual incidence rate for occupational allergic disease.

A *biological agent* may be defined as any agent which may cause an infection, allergy, inflammation, toxic reaction, malignancy or otherwise create a hazard to human health. Biological agents include micro-organisms, plant/vegetable cells; animal or human cell cultures; human endoparasites, including those that have been genetically modified. The three main sources of biological agents are microbes, animal and plant tissue, Figure 6.1.

The biologically active agents of *microbial* origin may include the organism itself (e.g. viruses, bacteria, fungi), toxins (e.g. endotoxins produced

by gram negative bacteria, mycotoxins produced by fungi), cell wall constituents such as (1→3)-B-D-glucans produced by moulds, or enzymes produced by genetic modification of micro-organisms.

Among *plant* tissue, processed plant proteins (e.g. grain, coffee, soya), vegetable gums or resins (e.g. latex, guar gum in plants), toxins, wood compounds (e.g. plicatic acid in western red cedar wood, tannins, colophony), proteolytic (protein breakdown) enzymes and organic dust from processing have been shown to be biologically active.

In the *animal* group, exposure to arthropods such as crustaceans, arachnids (e.g. storage mites) and insects (e.g. weevil) have been commonly associated with adverse health effects. Some species of arthropods (e.g. snakes, scorpions, bees) and vertebrates (e.g. rabid dogs), attack, bite or sting workers causing adverse effects such as skin inflammation, systemic toxic effects and transmission of infections. Furthermore, invertebrates other than arthropods, e.g. endoparasites (such as *Shistosoma*, *Anisakis*) and proteins present in urine, hair, dander, feathers, saliva and faeces of vertebrate animals, are also a

Category	Examples
<i>Micro-organisms</i>	
Viruses	Hepatitis, HIV, Influenza, Rubella, Herpes
Bacteria	Legionella, Mycobacterium TB, Leptospira, Thermophilic bacteria
Fungi	Aspergillus, Alternaria
<i>Plants</i>	
Lower plants	Lichens, liverworts, ferns
Higher plants	Wood, grain, cotton, coffee, tobacco, spices
<i>Animals</i>	
Invertebrates	Amoebae, Shistosoma, Plasmodium, Anisakis, Sponges, Sea-squirts
Arthropods	Crustaceans, Arachnids (spiders, storage mites, ticks), Insects (cockroaches, weevils, moths, bees)
Vertebrates	Fish, Amphibians, Reptiles, Birds, Mammals

Figure 6.1. Major categories of biological agents of natural origin.

common source of infectious agents or protein allergens.

The term “organic dust” usually refers to a dust of plant, animal or microbial origin, that may also contain a wide range of biological contaminants mentioned above (e.g. endotoxin, mycotoxin, allergens, volatile organic compounds).

Biological agents are ubiquitous in ambient air, contaminated water supplies and diseased animals. They enter the body by inhalation (air-borne, droplet spread), ingestion or through the faecal-oral route, skin inoculation and by direct contact with plants or animals (zoonosis). The extent to which they become hazardous to human health will depend on the occupational context, the circumstances surrounding exposure and the health status of the host (worker).

### HIGH RISK OCCUPATIONAL SETTINGS

Although biological agents are commonly found in most domestic and workplace environments, there are certain high risk occupational settings that constitute hazardous exposure because they result in adverse health outcomes, Figure 6.2.

These settings include health care and laboratory workers threatened by human pathogens causing infection. Agricultural workers are at risk from organic dust-borne biological allergens, toxins and parasitic worm infestations, especially in warm climates. Mining activities are a high risk setting associated with tuberculosis infection.

### HEALTH EFFECTS OF BIOLOGICAL AGENTS

HBAs mediate their adverse health effects through four main pathological mechanisms, infection, allergic, toxic/inflammatory and carcinogenic, Figure 6.3. The most common non-infectious diseases affect the lungs and skin, with a large proportion of these diseases or syndromes causing a general inflammation or affecting the immune system, Figure 6.4. One biological agent may be frequently associated with more than one adverse health outcome and it may be difficult to differentiate between the two disease entities, e.g. asthma and organic dust toxic syndrome or Hepatitis B infection and liver cancer in the same individual.

Sector	Examples
Agriculture	Cultivating, harvesting, forestry, flower production Breeding and tending animals, fishing
Agricultural products	Abattoirs Food processing plants (e.g. grain, sugar, coffee, tea, seafood) Storage facilities: grain silos, tobacco Processing animal hair, leather, silk Textile plants, sawmills, paper-mills
Animal care	Veterinary facilities, pet shops
Biotechnology/research labs	Production of enzymes; microbiology; animal units
Mining	Gold and coal mining
Health care	Patient care in hospitals, clinics, nursing homes
Pharmaceutical	Production of drugs, herbal products
Sewage and waste disposal	Waste removal, treatment plants

Figure 6.2. Common occupational settings with exposure to hazardous biological agents.



## RISK ASSESSMENT

An adequate risk assessment requires extensive knowledge of the work processes, health hazards and occupational hygiene practices. It is important to begin with:

- a detailed observation of the workplace
- the collection of information on hazards from surveys already conducted from similar workplaces or from the literature.

Pathological mechanisms	Examples of causative agents
<i>Microbial infection</i>	
Infectious material	Hepatitis (A/B/C), Leptospira, Mycobacterium TB
Opportunist pathogens	Legionella Pneumophila
Zoonoses	B. Anthracis, C.Psittaci
<i>Allergic response</i>	
Micro-organisms	Actinomycetes, Aspergillus
Proteinaceous material	Pollen, dust, animal secretions
Chemical compounds	Plicatic acid, gums, resins
<i>Toxic/inflammatory response</i>	
Endotoxins (gram neg. bacteria)	Stored grain, hay, cotton, swine and poultry confinement units
Mycotoxins (fungi) and (1->3)-B-D-glucans	Stored fodder, grain, nuts
<i>Carcinogenic</i>	
Wood dust	Hardwood (Beech, oak), Softwood
Mycotoxins (aflatoxin)	Stored nuts

Figure 6.3. Major pathological mechanisms for health effects associated with hazardous biological agents.

Pathological mechanisms	Examples of occupational syndromes or disease entities
General constitutional symptoms	Inhalation fever (fever, myalgia, fatigue)
Infection of any body organ/system	Infections (including zoonosis) e.g. TB, Brucellosis, Hepatitis B
Allergic/Toxic inflammatory lung reactions	Toxic pneumonitis
	Organic dust toxic syndrome (fever, myalgia, headache, respiratory symptoms)
	Rhinitis, conjunctivitis, urticaria
	Asthma
	Asthma-like syndrome (acute functional response)
	Hypersensitivity pneumonitis (extrinsic allergic alveolitis)
	Chronic bronchitis
	Chronic obstructive lung disease
Allergic/Toxic inflammatory skin reactions	Contact irritant dermatitis
	Contact allergic dermatitis
	Protein contact dermatitis
Cancer	Carcinoma (e.g. nasopharynx, liver, lung)

Figure 6.4. Occupational syndromes or disease entities associated with hazardous biological agents.

An analysis of observations made at the workplace may indicate the need for safer operations or control measures. Where obvious and serious hazards are observed, immediate implementation of adequate intervention measures should be undertaken. For example, if an inspection reveals very dusty areas in a grain/flour mill, local exhaust ventilation may be required.

There are many questions that need to be addressed before workplace measurements of micro-organisms and biological contaminants (e.g. endotoxin, mycotoxin, allergens, volatile organic compounds) are undertaken, e.g. clarifying reasons why measurements are being undertaken, how the results are to be used and what the readings are to be compared with.

Measurements of micro-organism concentrations in the workplace are often taken because a worker or workers have been affected by health problems suspected to be due to micro-organisms. One problem connected with measurements is that it may be hard to find “normal” or “background” reference values with which to compare the concentrations found. Presently there are no recommended occupational exposure limit values for airborne micro-organisms in the workplace and, accordingly, no recommended values. One reason for the absence of limit values is the lack of standardised methods of measurement. Comparison with concentrations in asymptomatic individuals or outdoor conditions is generally not possible. Instead the comparison has to be linked to an agent, a method and an environment. In order to compare the result with a general “normal concentration”, one needs to know how the investigations were conducted and conditions should be comparable, e.g. in terms of measuring method and analysis.

Another point to be considered is what gain is expected from the measurement and what the result is going to be used for. Very often it pays

to deal with the source of the hazard directly by taking immediate remedial measures without any prior measurement. But there are occasions when measurement can be justifiable, for example:

- when investigating an illness believed to have been caused by micro-organisms and/or biological contaminants
- to verify the effect of an intervention intended to reduce microbiological air contaminants
- e.g. after installing a new process and technique suspected to decrease micro-organism concentrations in the workplace.

## MANAGING RISKS

### Policies, procedures and exposure standards

Although the traditional emphasis of health and safety regulations and occupational health activities has been on microbes causing infection in occupational settings, the toxic/inflammatory, allergic and carcinogenic potential of HBAs have become increasingly important. Some of the well known regulatory initiatives include the comprehensive European Union directive No. 2000/54/EC on the protection of workers from risks related to exposure to biological agents at work. This directive covers high risk activities in food production, plants, agriculture, contact with animals and/or their products, health care, isolation and post mortem units, laboratories (clinical, diagnostic, veterinary), refuse disposal plants and sewerage purification installations. HBAs are grouped into four categories for the purposes of controlling exposure, Figure 6.5. Any material containing an HBA needs to be properly labelled, Figure 6.6.

Other well-cited standards include the ACGIH guidelines, US OSHA Regulations (Hepatitis B vaccination, blood-borne pathogens, TB) and the NIOSH criteria documents

for animal handlers and health care workers exposed to latex. The lack of emphasis on protein allergens causing allergic diseases in the absence of microbial infections, may point to the need for the development of specific guidelines in the future that deal adequately and effectively with allergens of biological (protein) origin.

In more recent years industrial hygiene and analytical capabilities have been refined for evaluation of bioaerosols and their protein allergens which has made surveillance technically feasible. Clear evidence is also emerging for exposure intensity response relationships for occupational allergens of plant, animal or microbial origin, illustrating the renewed emphasis on this group of agents. Allergen exposure levels below determined exposure limit values have been associated with a decreased risk of sensitisation and allergic health outcomes such as asthma. Some examples include wheat flour, fungal  $\alpha$ -amylase, natural rubber latex, western red cedar, rat al-



Figure 6.6. Biohazard sign (orange-red with blue pictogram).

lergens and wood dust. The stipulation of legally binding occupational exposure limits is therefore an essential strategy in preventing exposure to allergens, endotoxins and (1–3)Beta, D-glucans.

There may also be statutory duty for medical practitioners to notify cases of suspected occupational and/or communicable disease to the appropriate enforcement agencies, e.g. in the Ministry of Labour and/or Health.

Category	Definition	Examples
Group 1	unlikely to cause human disease	<i>E Coli K10, yeast</i>
Group 2	can cause severe human disease might be a hazard to workers unlikely to spread to community effective prophylaxis/treatment	<i>Legionella pneumoniae, Leptospira, Neisseria meningitidis (V), Rubella, Influenza A/B (V), Hepatitis A (V), Herpes simplex, Ascaris (A)</i>
Group 3	can cause severe human disease serious hazard to workers may spread to community effective prophylaxis/treatment	<i>Mycobacterium TB (V), Bacillus anthracis (V), Shigella dysenteriae Type I (T), Plasmodium falciparum, Rabies (V), Hepatitis B (V), Human immunodeficiency virus</i>
Group 4	causes severe human disease serious hazard to workers high risk of spread to community no effective prophylaxis/treatment	<i>Congo haemorrhagic Fever, Ebola pox</i>

Figure 6.5. Risk group categories according to the European directive No. 2000/54/EC on the protection of workers from risks related to exposure to biological agents at work. Symbols: A-allergenic, T-toxic effects, V-vaccine available.

### Workplace control measures

The diagnosis of an occupational disease in a worker implies that measures at the workplace are inadequate and pose a potential health risk to co-workers similarly exposed so prompt investigation and action is required. The exposure should be evaluated by an industrial hygienist. This evaluation will identify sources of high-risk exposure and provide recommendations for controlling the hazards either through substitution, body substance isolation, engineering controls (e.g. exhaust ventilation) and/or administrative controls (e.g. universal infection control precautions). Special care should be taken when instituting preventive measures that one hazard is not replaced by another hazard. For example, using natural rubber latex powdered gloves, instead of non-powdered or latex free gloves to prevent skin transmission of blood-borne pathogens in health care settings.

Below are some examples of preventive measures used to minimize exposure to biological agents in the work environment.

### Agricultural work

Aside from animal farming, there are a number of major occupational settings in developing countries such as sugarcane cultivation and sugar production, oil palm plantations, tea and coffee plantations, flower production, vineyards, fruit plantations, fishing and forestry.

Agriculture involves the handling of many different materials such as grain, hay and straw, livestock feed, excrement from livestock, skin particles, hair and feathers, all of which are potential habitats for the growth of micro-organisms and a source of potential allergens. For example, fungi occur in livestock feed, grass and cereals which have been damaged in storage. Airborne mould concentrations more than a million times higher than normal for outdoor

air have been found in some agricultural environments. In agricultural work where discomfort has occurred, total concentrations of up to  $10 \times 10^9$  mould spores/m<sup>3</sup> air have been recorded in the inhalation zone. On farms with asymptomatic agricultural workers, the concentrations are usually  $10^6$  mould spores/m<sup>3</sup> or less.

High concentrations of airborne bacteria occur in connection with animal husbandry, from dried dung. Prolonged storage of manure in livestock pens can cause high concentrations of bacteria in the indoor air. In hot and temperate climates natural hazards arising from snakebites and scorpion stings can be a common occurrence in wood cutters, fishermen, builders, oil plantation workers, sugar cane cultivators, mushroom gatherers and other agricultural workers.

#### *Pig-farming*

Changing pig litter, feeding and weighing pigs can generate large quantities of organic dust. The dust in pigpens usually contains bacteria and endotoxins as well as epithelium from pigs. Therefore, work that has to be done among livestock entails a serious exposure risk to organic dust. The concentration of organic dust in livestock pens increases with the level of activity and congestion of the animals. For example, heavy concentration of organic dust occurs in connection with the transfer of pigs between pens, culling, weighing, changing litter and manual feeding. Manual feeding generates heavy concentrations of organic dust, due to the activity of the pigs and the friability of the feed itself.

#### Preventive measures:

- Add water or vegetable oil (1 per cent) to the feed to bind the dust. Feed containing a large proportion of water should be consumed within a few days to prevent mould growth.

- Vacuum cleaning of feed troughs and fittings at least once every week reduces the amount of organic dust. Vacuum cleaning is more suited to smaller pens where the feed troughs and inspection paths are located at floor level.
- Daily oil showering of livestock at feeding time reduces the concentration of organic dust in the pens. This showering can be done using a mixture of rapeseed and linseed oil with water and an emulsifier. Oil showering is more effective than flushing with water. No work should be done in the pens while oil showering is in progress.

#### *Poultry farming*

Organic dust components in poultry houses include epithelium, feather fragments, manure particles and micro-organisms. Caging and culling of birds are tasks entailing very high concentrations of dust. In pens for laying birds, the deep litter on the floor helps to augment the concentration of organic dust on the premises. A large proportion of the manure enters the litter. Free-range systems add to the risk of dust exposure, e.g. because of the requirement for stray eggs to be collected manually several times daily. Personnel are also exposed to organic dust in the course of daily supervision, cleaning and production, between production rounds and when mucking out.

#### Preventive measures:

- Mechanised regulation of feed, water, lighting, temperature, etc. reduces the time personnel need to spend in poultry houses.
- Mechanical egg and feed handling.
- Manure should be stored for the shortest possible time inside a poultry house.
- Water mist treatment of the pens reduces dust content.

#### *Cattle-farming*

Personnel working with beef cattle are exposed to organic dust, e.g. when working with hay, straw, silage and concentrated feed. The risk of dust exposure is increased by manual feeding, manual mucking out and the movement of livestock.

#### Preventive measures:

- Handling of mouldy feed, straw and litter must be avoided.
- Manual mucking out must be done using a technique whereby litter is not blown out.

#### *Handling of hay and straw*

Dust is released into the air when hay and straw are worked in connection with gathering, storage, mucking out and feeding, etc. A great deal of dust is generated when straw is chopped for litter.

#### Preventive measures:

- Mouldy hay must not be used.
- Dust separators fitted to straw choppers effectively reduce the concentration of dust. When making silage from hay/straw it is important to remove the air as effectively as possible, because air seeping into the silage can give rise to microbial growth. The plastic covering should not be damaged when baling silage.
- Loft drying of hay must be conducted rapidly to avoid mould growth. Hay that is not dried in a loft must be dried when compacted to prevent mould growing.
- Hay and straw must have a low moisture content when stored.

#### *Grain handling*

Very heavy concentrations of dust are likely to occur during the threshing, harvesting and storage of grain. Damaged corn can easily be attacked by micro-organisms. Tasks that are associated

with a high-risk of exposure to grain dust include the cleaning of silos, driers and grain hoppers, as well as the threshing and milling of feed grains. Excessive dust is formed in chutes, elevators, open conveyors, hoppers, silos, dryers and scales.

Preventive measures:

- Chutes, elevators, conveyors and grain dryers should be fitted with local exhaust extraction devices.
- When crushing or grinding grain, moistening can be used to reduce exposure to dust. Moistening can take place in transit to the buffer hopper above the mill or crusher. Water can be applied in batches, using ordinary batch mixers, or continuously with helical screws.
- The grain kernel must be kept free of damage by setting the harvester correctly and providing gentle transport, to prevent the growth of micro-organisms.
- Dust exposure will be reduced if the harvester is fitted with a cab and ventilator. An airstream helmet should be used by the driver when threshing with a combine.
- For storage purposes, the temperature and water content of the grain should not be too high. The temperature should be continuously monitored at several points during the storage time. A rise in temperature indicates mould formation, which may then spread. In this eventuality, cold air-drying should be used.
- Chip stores, chip dryers and fuel plants should be positioned where dust cannot spread to other spaces.
- Chip stores should be completely emptied and cleaned (preferably vacuum-cleaned) before replenishment, because micro-organisms can grow in old residues.
- Respiratory protective equipment should be used for operations generating large quantities of dust and where it is suspected microbes may be growing in the chips.

*Sugar cane cultivation and sugar production*

Sugar cane is cultivated in tropical and sub-tropical regions for its sucrose content (for making sugar) and by-products such as molasses and bagasse (waste fibrous residue), used to make paper or as a fuel source. Aside from the common chemical pesticide hazards, the major biological hazards encountered in the cultivation process include inhalation of droppings (from insects, rodents and other pests contaminating the crops), snakebites or secondary infection of wounds due to machete tool-related injuries sustained during manual harvesting. Bagassosis (extrinsic allergic alveolitis/hypersensitivity pneumonitis), caused by breathing dusts containing spores of thermophilic actinomycetes which grow in stored and 'mouldy' bagasse in sugar cane mills/processing plants, is also unique to this workplace setting.

Preventive measures:

- Burn fields prior to harvest to destroy snakes, dangerous insects and other pests that live in cane fields.
- Identify sources of excessive dust, gas and vapours and introduce local exhaust ventilation where possible in mills. Dust control can be used effectively for controlling bagasse dust and appropriate respirators can be used for short-term tasks.

*Chip firing*

Organic dust containing micro-organisms can be released when wood chips are conveyed from storage facilities to a boiler, e.g. by shovelling.

Preventive measures:

- Wood for chipping should be as dry as possible, because fragmented fresh timber is very prone to mould.



- Wear gloves, long sleeved shirts and pants and boots to prevent insect/snakebites and trauma when working in foliage.
- Special antidotes should be available for poisonous snake bites and scorpion stings.
- Cuts should be washed and cleaned and anti-bacterial agent applied.
- All field workers should be provided with up-to-date tetanus immunisation.

#### *Oil palm and tropical plantations*

Oil palms are grown in tropical climates where natural biological hazards are an important consideration. These hazards include snakes encountered during forest clearance, insects like mosquitoes that spread malaria, parasites like hookworms that cause anaemia and gastro-intestinal disease. The retting operation in which the husk of the coconut is soaked in waist-deep water before it is sent for decortication, bleaching and processing, exposes workers to increased risk of parasitic and other infections. Workers employed in date palm plantations are at increased risk of developing occupational asthma from pollen exposure as well as chronic dry eczema and onychia (nail disease).

#### Preventive measures:

- Mosquito control and malaria prophylaxis is crucial (see Table VI malaria).
- Sanitation and safe drinking water are key in the prevention of waterborne parasitic diseases.
- Appropriate respirators should be used during the pollination process. Workers should wear gloves and wash their hands when working with trees and dates.

#### *Coffee and tea plantations*

Biological agents of importance for coffee plantation workers include bites or stings from

snakes, spiders, bees, mosquitoes and mites, some of which are important disease vectors. In addition to these natural biological hazards, allergic reactions from contact with certain species of caterpillars have been reported in tea plantation workers. Among workers involved in processing of coffee beans in processing plants, green bean handlers have been reported to develop occupational allergic rhino-conjunctivitis, urticaria and asthma. Similar reports of occupational allergies and asthma due to “tea fluff” have been reported in tea processing/blending workers. Tropical diseases such as malaria, yellow fever, filariasis, trypanosomiasis, leishmaniasis and onchocercosis are endemic in certain cultivating areas and tetanus is still a common occurrence in certain rural areas.

#### Preventive measures:

- Wear gloves, long sleeved shirts and pants to prevent insect bites/stings, trauma and allergic skin symptoms when working in foliage.
- Cuts should be washed and cleaned and anti-bacterial agent applied.
- All field workers should be provided with up-to-date tetanus immunisation.
- Local exhaust ventilation should be employed and appropriate respirators should be used during processing of coffee beans and tea (“tea fluff” extractors).
- Regular surveillance of workers for allergic symptoms and sensitisation using questionnaires and allergy tests (skin prick tests, allergen specific IgE levels).
- Sanitation and safe drinking water are key in the prevention of waterborne parasitic diseases.
- Mosquito control and malaria prophylaxis is crucial.

### *Flower production*

Flower production can be divided into three main processes, i.e. germination (planting parent plants), cultivation (done in greenhouses and nurseries) and post-harvest (selection and packaging). Increased health risks from biological exposures originate from exposure to outdoor mites (spider mites, predator mites), mould spores, pollen from plants (e.g. chrysanthemum, sunflower), dust from dried plants and from insects such as bees and locusts, all of which are known to cause allergic rhino-conjunctivitis, occupational asthma and urticaria. Contact dermatitis is commonly caused by irritants (60 per cent) or allergens (40 per cent), some of which may be biological in origin, for e.g. organic fertiliser, plant matter. Flower workers are also at increased risk of acquiring infections such as tetanus and rabies as well as stings by bees/wasps while working in the fields.

#### Preventive measures:

- Positive pressure ventilation of greenhouses; Improved work practices which will reduce the exposure time to potential allergens.
- Use of specific respirators and gloves to prevent contact with primary irritants or allergenic substances.
- Provide a source of potable water, good sanitary facilities, first aid and medical care for cuts and abrasions.
- Regular surveillance of workers for allergic symptoms and sensitisation using questionnaires and allergy tests (skin prick tests, allergen specific IgE levels).

### *Fruit plantations and vineyards*

Hazardous exposures among fruit farm workers are a result of concomitant exposures to agrochemicals (fertilisers, herbicides, fungicides, insecticides, sulphur) and biological agents

(vegetable or micro-organisms and their contaminants such as mycotoxins/endotoxins; fertilisers such as cottonseed meal, fishmeal, blood meal, sterilised sewage sludge; insects such as the honey bee). The handling of certain types of fruit, especially citrus fruit, are known to cause occupational allergies, asthma and contact dermatitis among fruit farm workers. Biological agents implicated are micro-organisms such *Botrytis cinerea*, a mould commonly found on grapes; plant allergens such as the Wall Rocket (*Diplotaxis erucoides*), Crucifera plant or vine pollen, *Vitis vinifera*; as well as arthropods such as insects (e.g. fruit moths) and mites (e.g. storage mites). Farm workers, particularly those on fruit farms, can become sensitised to spider mites (e.g. *Tetranychus* and *Panonychus* species), which live on the leaves of fruit trees. Excessive use of pesticides has been associated with increasing spider mite populations and increased risk of sensitisation. Studies in South Africa indicate that this mite may be more important than the common house dust mite in causing asthma symptoms among workers on grape farms. Although farmers, like other inhabitants of rural areas, are exposed to enhanced levels of pollens from grasses, weeds and trees, the prevalence of pollen-related allergy is certainly not higher, and possibly lower, than that in urban populations, as has been found in studies investigating atopy prevalence in these populations. Endotoxin exposures on contaminated seed and dry fertiliser can cause irritation affecting eyes, nose, chest (organic dust toxic syndrome) and skin. Prolonged and frequent contact with plant products can also result in sensitisation and contact dermatitis. Infections complicating cut or puncture wounds from tree thorns or tools are a common among fruit farm workers. Mycotoxins contaminating nuts are known to be associated with an increased risk of liver cancer.

Preventive measures:

- Avoid excessive pesticide use in spraying of crops.
- Introduce natural biological control mechanisms into crops.
- Wear appropriate respirators when picking fruit to prevent inhalation of mites when disturbing leaves on fruit trees and when handling fertiliser.
- Wear gloves, long sleeved shirts and pants to prevent insect bites/stings, trauma and allergic skin symptoms when working in foliage;
- Cuts should be washed and cleaned and antibacterial agent applied.
- All field workers should be provided with up-to-date tetanus immunisation.
- Regular surveillance of workers for allergic symptoms and sensitisation using questionnaires and allergy tests (skin prick tests, allergen specific IgE levels).

*Fishing*

While the main task of fishermen is fishing at sea, fish processing is also done aboard vessels at sea (see section on food processing plants). The biological agents commonly encountered during fishing include microorganisms (e.g. *Vibrio*, *Hepatitis A*, *Anisakis*, *Hoya* – sea squirt, fungal spores) and bioaerosols containing seafood allergens (e.g. muscle, blood, enzymes) and toxins (e.g. endotoxin, histamine). Exposure to these agents commonly results in skin infection and sepsis of puncture wounds, allergic respiratory diseases (rhino-conjunctivitis, asthma, extrinsic allergic alveolitis) and skin conditions (urticaria, contact dermatitis/eczema) from direct skin contact with seafood. Fatal poisoning and asphyxia can also result from exposure to toxic gases in confined spaces (e.g. hydrogen sulphide) due to anaerobic decay of organic material in unventilated holds. Toxic reactions have also been

associated with elevated endotoxin levels from contaminated fish.

Preventive measures:

- Wear cotton-lined gloves to prevent skin trauma and allergic skin symptoms when handling fish.
- Cuts should be washed and cleaned and antibacterial agent applied.
- Use local exhaust ventilation to remove seafood aerosols produced during seafood processing.
- Use respirators and/or air-supplied hoods when entering unventilated holds containing fish and fish products.

*Forestry*

While physical safety hazards are a major concern in the harvesting and transport of wood products, biological agents are a key concern in the harvesting of non-wood forest products such as food products (e.g. berries, mushrooms), chemical products (e.g. aromatics, gums and resins, latex, toxins), decorative materials (e.g. bark, flowers, grasses) and non-wood fibres (e.g. bamboo, palm leaves, reeds). Exposure to biological agents includes direct contact with plants, wood products like sawdust and pollen from trees. Direct skin contact could be a source of topical poisons causing contact urticaria and dermatitis. Inhalation of pollen causes allergic rhinitis and asthma, while inhalation of spores on mouldy damp bark causes a hypersensitivity pneumonitis. Working with large mammals such as oxen, buffalo and elephants may result in zoonosis (transmission of infections from animals to humans). Snake and insect bites/stings (e.g. bees, wasps, hornets, scorpions) can be poisonous and life threatening for workers allergic to insect poisons. In addition, infections and certain diseases (e.g. Lyme disease, malaria, yellow fever,

tick bite fever, onchocerciasis), are transmitted by mites, mosquitoes, ticks and flies. Other diseases (e.g. leptospirosis, rabies), are transmitted by wild or house animals and constitute a significant biological hazard, with the nature and incidence varying between different geographical regions. Micro-organisms can cause gangrene and tetanus by infecting bruises or cuts sustained from direct contact with thorns/spines and incorrect handling of tools during harvesting. Inhalation of hard wood and soft wood dust in sawmills is known to be associated with nasopharyngeal cancer.

#### Preventive measures:

- Provide direct training for work tasks and training in work organisation for those involved with cutting operations.
- Wear gloves, long sleeved shirts and pants, boots to prevent insect bites/stings, trauma and allergic skin symptoms.
- Use appropriate respirators and dust control procedures (e.g. local exhaust ventilation) for dusty operations.
- Provide a source of good sanitary facilities, first aid and medical care for cuts and abrasions.
- Special antidote should be available for poisonous snake bites and scorpion stings.
- All field workers should be provided with up-to-date tetanus immunisation.
- Mosquito control and malaria prophylaxis is crucial (see special section on malaria).

### **Work in the paper and pulp industry**

Bacteria and endotoxins are identified as important cause of safety and health problems in the pulp and paper industry. Endotoxins are bound to particles and cannot be released from a stagnant water surface. In cases where a liquid aero-

sol is formed, endotoxins can be diffused in air as a result of violent agitation or when water is sprayed. Recycled process water is often used in pulp and paper manufacturing to moisten wood, sludge, etc. While recycling allows economic gains, it also means water with high organic material content remains in the process for a greater length of time, which facilitates the growth of micro-organisms such as bacteria. Moistening is sometimes done with spray nozzles that can cause endotoxins to enter the workplace. In addition, a liquid aerosol can be spread from moist material in transit.

The concentration of airborne endotoxins varies from one stage of production to another. Elevated concentrations can be found in most processing parts of the cleaning department, especially at sludge watering presses and barking drums. Elevated concentrations also occur at water purification plants, especially aerated pools, and at papermaking machinery. It should be noted that personnel are not continuously stationed in the different production departments but spend a large part of their time in the control room, so that their exposure is probably lower than concentrations recorded. However, maintenance personnel can be exposed to relatively heavy concentrations and therefore likely to experience discomfort. Low concentrations can be expected in bleaching plants and in outdoor sedimentation tanks.

#### Preventive measures:

There are two alternative methods of reducing the spread of endotoxins from the different sources:

- a. To reduce the bacterial content of the process water. (It can be assumed that endotoxin diffusion is due to the use of recycled process water containing living and dead bacteria and

endotoxins). Bacterial growth can be partly controlled by adding biocides and by adjusting pH and temperature.

- b. To reduce the spread of endotoxins from the individual sources by means of encapsulation and local ventilation. During service and maintenance, personnel intervene in the process, working inside or very close to various processing parts, however, conventional remediation techniques like encapsulation and local extraction do not afford protection for maintenance personnel. The concentrations of endotoxins can be reduced by closure of the processing equipment, including the recycled water, for at least 30 minutes. The duration of the closure will depend on the nature of the premises housing the process emitting the endotoxins – the larger and better ventilated the premises, the shorter the period of closure needed.

### Refuse disposal

Manual and mechanical sorting of pre-separated refuse takes place at recycling plants and refuse disposal sites. The final, manual sorting of refuse most often takes place at a conveyor belt which also carries wrongly sorted refuse, such as dead birds, dog's mess, disposable nappies, etc., exposing workers to micro-organisms.

Organic material and contaminants in refuse are a breeding ground for the growth of micro-organisms which, when handled, can be diffused with dust into the atmosphere, especially if the refuse is wet or has become wet in the course of handling. Moisture, temperature and the presence of organic waste are important factors determining the growth of micro-organisms in refuse. Fungi live mainly on organic material such as bread, wood, paper and fruit, for example. Mould flourish in damp newspapers, but in

domestic refuse they develop less rapidly than the bacteria.

### Preventive measures, refuse separation:

- Where domestic refuse such as food scraps is sorted mechanically, it must not be left undisturbed for weeks during summertime, otherwise it may dry out and start to emit dust. The dust may contain a high proportion of micro-organisms and endotoxins and may constitute a health hazard when inhaled. The facility must be emptied daily and all spillage collected continuously. Refuse that cannot be processed within the next 24 hours must be removed so that none is left lying about.
- Maintain a high standard of cleanliness. Among other things, this means cleaning all processing parts daily, collecting all spillage continuously and cleaning the floor and walls of the refuse reception room every day. Conveyors, walls and floors of the sorting premises must be vacuum-cleaned daily and the floor flushed once every day. Compressed air must not be used for cleaning. All equipment must be cleaned before any repair work or servicing.
- Manual refuse handling should be mechanised as far as possible so that personnel will not come into direct contact with refuse.
- Pre-separated refuse that is to be sorted manually, should not be mixed with wet domestic refuse (food scraps or suchlike). Correctly pre-separated refuse is a *sine qua non* of a work environment free from micro-organisms.
- An effective local extraction device should be installed where sorting is done manually.
- Routine checks should be made of the purity of refuse arriving at the plant. Incorrect refuse must be turned away.
- Where possible, encapsulated conveyors



should be used for moving refuse inside the plant.

### Work in food processing plants

Common constituents of food products that cause occupational allergies, asthma and infection include proteinaceous material (e.g. pollen, spices, grain cereal flour and coffee dust, sugar cane, animal hair and secretions, storage mites, insect pests), micro-organisms (e.g. *Aspergillus*), parasites (e.g. *Anisakis* sp., *Hoya* sp.), toxins (e.g. histamine, endotoxin, mycotoxin) and synthetic enzymes such as papain and (1→3)-B-D-glucans (e.g. fungal  $\alpha$ -amylase).

The adverse health effects experienced in the poorly regulated seafood processing industry are the result of exposure to the seafood itself, including muscle and connective tissue, exoskeleton, blood, endolymph fish juice, skin, skin slime/mucin, gut, or to various non-seafood components present in the product. The production of seafood aerosols during processing has been identified as a potentially high-risk activity for allergic

sensitisation by high molecular weight proteins through inhalation. These processes include degutting, heading and cooking/boiling of fish, mincing of seafood, fish meal milling/bagging and cleaning of the processing line and storage tanks with high-pressured water, Figures 6.7 and 6.8. Occupational asthma is commonly related to crustaceans (e.g. crabs and prawns) and fishmeal production. Dermatologically-related allergic symptoms may be due to direct contact with the actual vegetable additives e.g. spices, in seafood. There may also be a systemic response to exposure through inhalation. Occupational skin exposure occurs mainly as a result of unprotected handling of various fish and their products at various stages in the production process. Fish juice contains high molecular weight proteins (meat, skin, skin slime/mucin, gut); biogenic amines; histamine and cadaverine; degradation compounds in old fish; digestive enzymes (pepsin and trypsin).

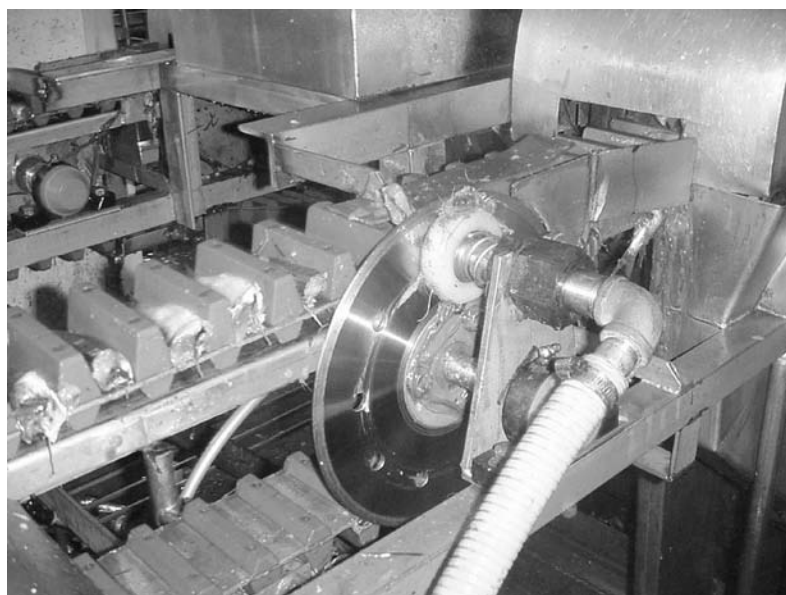


Figure 6.7. The fish degutting process produces bioaerosols containing allergenic proteins, bacteria and endotoxins causing allergies, asthma and irritant reactions.





Figure 6.8. The shovelling and loading operation in a fishmeal production plant is a source of bioaerosol production causing allergic sensitisation and asthma to fish (e.g. anchovy) allergens.

Exposure to flour dust in traditional bakeries and supermarket bakeries has been shown to increase the risk of allergic sensitization, asthma (also called baker's asthma) and dermatitis among exposed workers. Studies conducted among bakery workers have reported the prevalence of baker's asthma to be between 5–17%. Asthma is commonly due to sensitization to

wheat, rye and fungal alpha-amylase allergens present in flour. Studies in supermarket bakeries indicate that bakers have the highest wheat allergen exposures, followed by confectioners, whilst counterhands are the least exposed. High risk work processes identified in bakeries include shaking bags after loading flour and additives into mixers, high speed mixers using powdered



Figure 6.9. Bioaerosol emissions from the fish degutting machine can be reduced by enclosing the machine with a simple shroud of clear polythene.

Figure 6.10. The introduction of a bagging operation in a fishmeal production plant operating with a chute and local exhaust ventilation can reduce dry bioaerosol emissions.



ingredients, dusting of surfaces to prevent dough adherence to working surfaces and sweeping during daily cleaning of the bakery floors.

#### Preventive measures:

- Control measures to reduce the emission of bio aerosols in fish processing plants include process separation or enclosure as well as the use of local extraction ventilation systems to certain processes or equipment (gutting machine, fish meal bagging) , Figures 6.9 and 6.10.
- Where there is skin contact with the hazardous agent (fish sorting, spice mixing), appropriate cotton lined gloves and plastic sleeves can be worn.
- In small scale bakeries where mixers are used, enclosure of bakery mixers with lids; starting mixers at slow speeds until wet and dry ingredients form a mixture; using dredgers or sprinklers for “dusting” the work surface; substituting divider oils for “dusting” surfaces to prevent dough adhesion; and using vacuum cleaners instead of pressurised air hoses or brooms; and use appropriate respirators for short-term dusty tasks.

- An appropriate combination of emollients and moisturisers can be used as prophylactic measure to protect skin barrier function and prevent the development of irritant contact dermatitis.

#### **Work in sawmills/trimming plants**

Most often, the occurrence of wood mould in sawmills is first noticed when cleared off plants are trimmed or when packages are removed from the drying kiln. Wood mould attacks mostly occur in connection with disruptions in the drying process, especially when there is a long period of high humidity before the drying process. Mechanical and biological damage to the bark layer on timber can occur anywhere in the handling sequence from felling to saw milling and can result in heavier attacks from micro-organisms. While various kinds of bacteria and fungi in timber have different water, temperature, nutrition and acidity (pH) requirements for survival, favourable conditions allow mould fungi to grow superficially and rapidly.

At the sawmill, timber is usually moistened during the dry season of the year and the water

is often recycled so as to limit consumption. If so, the water derives a high content of organic material from the timber, which favours bacterial growth. Generally speaking, the concentration of airborne micro-organisms in sawmills depends on:

- the prevailing growth conditions, (temperature, humidity), while the timber was in storage
- the level of micro-organisms present in the timber and any liquid (e.g. recycled water) on the timber. Long delays between storage and drying posing a high risk of exposure to micro-organisms
- the growth conditions prevailing within the process, especially in the dryer
- aerosol (dust) diffusion into the premises, e.g. from sawing.

Endotoxins can spread in sawmills from the handling of timber that has been stored in water. Symptoms related to inhalation of endotoxins have been reported in sawmills processing watered timber. The commonest complaints are cough, phlegm and hoarseness of voice, mainly experienced by personnel working in places where the timber is first received and processed.

### Preventive measures:

- Storage times for roundwood and raw timber should be kept as short as possible, especially during the warmer seasons of the year.
- Timber should be dried in properly equipped drying plants which should not be charged beyond their intended capacity.
- Wherever possible, timber with visible mould should be segregated from other timber, strip-piled and yard-dried or dried separately in a timber kiln.
- Good strip-piling and stick management are important in preventing wood mould from

spreading. Sticks must not be made from blue timber. Badly discoloured sticks must always be removed from production because, when attacked, they are liable to contaminate undamaged timber in the course of re-moistening.

- In the event of a stoppage inside the saw, the facility should be emptied of sawn timber, otherwise there will be a risk of micro-organisms growing in the raw timber.
- Limit the use of recycled water.
- To limit the diffusion of dust, stick discharge should be separated from other activities.
- Sawmill machinery generating wood dust should, where feasible, be encapsulated or fitted with extraction devices.
- Dried and trimmed timber in storage must be protected from re-moistening by warehouse storage or by wrapping in impermeable material.

### **Work in health care institutions**

For health care workers, the main risk of acquiring workplace infections comes from inadvertent exposure to unsuspected infectious material, (e.g. blood, sputum, urine, faeces). Tuberculosis, hepatitis B and HIV pose the greatest risks to health care workers worldwide. Among the blood borne pathogens, Hepatitis B virus appears to pose a greater risk since exposure results in higher sero-conversion and resultant death than with HIV infection –30 per cent versus 0.5 per cent. The highest risk of exposure to blood borne pathogens occurs through needlestick skin injuries during blood collection, surgical operative procedures and insertion of intravenous catheters in patients with advanced HIV disease (AIDS). In communities with a high background HIV prevalence, the suppression of the immune system that results from HIV infection leads to a greatly increased risk of TB disease. Health

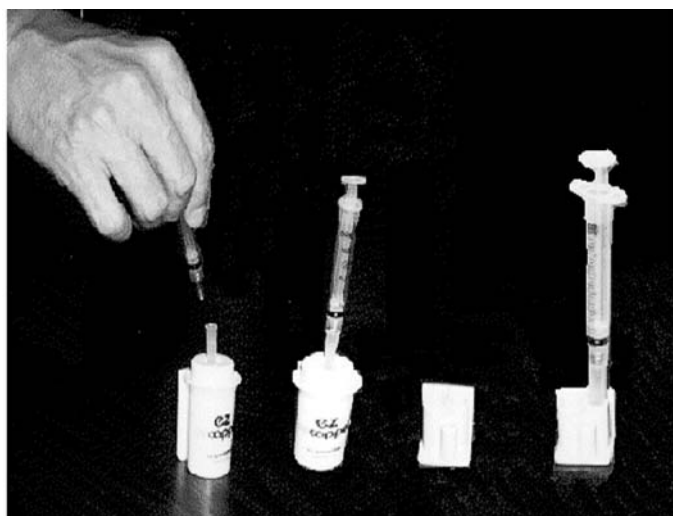


Figure 6.11. Avoid manual recapping of needles to prevent needlestick injuries by using specific needle holders for recapping of needles.

workers are at high risk of inhaling the TB mycobacteria when dealing with patients with open cavities in the lungs.

#### Preventive measures:

- Transmission of HIV and Hepatitis B virus is minimised by strict adherence to standard and universal precautions that require health care workers to treat the blood and body fluids of all patients as potential sources of infection, independent of perceived risk or diagnosis.
- Avoid manual recapping of needles to prevent needlestick injuries by using specific needle holders for recapping of needles and vacutainers (for blood samples) with sleeves with a needle release device, Figure 6.11.
- Adopt procedures to sterilise or disinfect equipment in contact with blood, blood products or other body fluids.
- Discard all medical waste and sharps in specially labelled containers marked for incineration, Figure 6.12.

Figure 6.12. All needle sharps and infectious material should be inserted into specifically labelled containers for disposal.



- Isolation and prompt treatment of highly infectious TB patients in wards that maximize natural ventilation and have positive pressure ventilation systems.
- Covering skin lesions, cuts or abrasions with occlusive dressings.
- Use of personal protective equipment such as respirators (e.g. when working with high risk TB patients), gloves, goggles and aprons.
- Immunisation of all health care workers against hepatitis B and passive immunisation (immunoglobulin) for non-immune exposed workers following occupational exposure to Hepatitis B virus.
- Post-exposure prophylaxis with anti-retroviral drugs (e.g. Zidovudine medication) following high-risk occupational exposures to HIV.
- Where a significant proportion of TB cases is likely to be HIV associated (communities with high background prevalence of HIV), voluntary counselling and HIV testing should be encouraged in anyone diagnosed with TB, in addition to conventional TB treatment.

### Work in mines and quarries

Tuberculosis is undoubtedly the most common occupational disease caused by a hazardous biological agent (*Mycobacterium tuberculosis*) in gold mines and quarries. Factors considered to contribute towards the increasing incidence of TB in developing countries include: poor dust (containing silica quartz) control; a high prevalence of silicosis; the general HIV epidemic; the migrant labour system, particularly the use of single sex hostels. Overall, TB rates are about three times greater in silica exposed miners and in workers with silicosis. The suppression of the immune system that results from HIV infection leads to a greatly increased risk of TB disease following TB infection, especially in communities where there is a high TB prevalence. Workplace factors

influencing transmission include overcrowding, poor ventilation and the poor quality of housing provided by employers. Other hazards of note in small scale mining, common in developing countries, include safety hazards as well as exposure to chemicals such as mercury and arsenic.

#### Preventive measures:

- Better dust control practices such as dust extraction and ventilation systems and wet processes such as using water in rock drills, will decrease the exposure to silica quartz and reduce the prevalence of silicosis.
- Reduce workplace TB transmission by improving living conditions for migrant workers, e.g. by improving hostels.
- Prompt diagnosis and treatment of workers with TB.
- Use of secondary prophylaxis (isoniazid medication) for workers who are HIV positive, have silicosis or who have been in contact with TB.
- Institute a broad range of HIV preventive activities including voluntary counselling and testing, health education including peer education, syndromic management of sexually transmitted illnesses (treatment covering for a number of causes at the same time), ensuring that the partner of the affected individual is also notified and treated when disease is diagnosed, and broader community interventions.

### SPECIAL DISEASES

Major epidemics such as HIV/AIDS, Malaria, Severe Acute Respiratory Syndrome (SARS) and Chicken-flu have been found to be major public health problems affecting working populations in one of two ways, either by affecting the worker's ability to work or posing a direct occupational health risk to high-risk working populations. Malaria may also be classified as an



Industrial sectors/ populations at risk	Nature of the disease	Prevention
Farmers, forestry workers, fishermen, oil workers, pesticide sprayers, migrant and/or contract workers in tropical countries	<ul style="list-style-type: none"> <li>• Transmitted by malaria-infected (<i>Plasmodium sp.</i>) mosquito</li> <li>• Infects the liver and red blood cells</li> <li>• Period between infection and the presentation of symptoms is 10 days to 4 weeks</li> <li>• Affected person presents with the following symptoms: fever and flu-like illness, shaking chills, headache, muscle aches, tiredness, nausea, vomiting, diarrhoea, anaemia and jaundice. May cause kidney failure, fits, mental confusion, coma and death</li> <li>• Diagnosis is made on blood smear</li> </ul>	<ul style="list-style-type: none"> <li>• Visit a doctor for vaccinations and anti-malarial drugs (e.g. Chloroquine, Proguanil, Mefloquin, Doxycycline) 4–6 weeks before travel</li> <li>• Take drugs on schedule without missing doses</li> <li>• Prevent mosquito and other insect bites by using insect repellent on exposed skin (e.g. DEET – diethyl-methyltoluamide, citronella based products)</li> <li>• Wear long pants and long-sleeved shirts, especially from dusk to dawn</li> <li>• Sleep under a Permethrin-treated mosquito bed net</li> <li>• Reduce mosquito breeding by regular insecticide spraying of swamps etc.</li> </ul>

Figure 6.13. Malaria – major features of the disease and its prevention.

occupational disease as is evident from the large number of farmers, forestry workers, fishermen and oil workers in tropical countries who acquire the disease, Figure 6.13. Similarly, the outbreaks of SARS and Chicken-flu affected not only the general public but also posed an occupational health risk to health care workers and chicken farmers respectively, Figure 6.14.

The HIV/AIDS epidemic is worldwide and it is estimated that over two-thirds of all the people living with the human immunodeficiency virus (HIV) live in sub-Saharan Africa, the region that also accounts for a large proportion of the world's AIDS deaths. The prevalence of HIV infection in these countries is over 20 per cent. The most affected groups are economically active women aged 15 to 49 years (more than 50

per cent are infected). In addition to the broader public health risk of developing the disease from community acquired infections as a result of unprotected sex, intravenous drug abuse or mother to child transmission, there are also certain jobs associated with a high risk for transmitting HIV. These include health care workers, sex workers, long distance truck drivers, migrant mine workers and farm workers.

The impact of the HIV/AIDS epidemic has been far reaching with labour intensive workplaces appearing to be at higher risk of lost production, depletion of skills and escalating worker benefit and medical scheme expenses. In order to stem the tide of this epidemic, HIV/AIDS should be treated as a management issue, more specifically as part of a company's strategic hu-



Industrial sectors/ populations at risk	Nature of the disease	Prevention
Travellers, health care workers, laboratory workers	<ul style="list-style-type: none"> <li>• Transmitted by Coronavirus (SARS-associated coronavirus)</li> <li>• Affects the respiratory system and eventually the entire body</li> <li>• Period between infection and the presentation of symptoms is 10 days</li> <li>• Affected person presents with the following symptoms: high fever, headache, feeling of discomfort, body aches, occasionally diarrhoea, mild respiratory symptoms, dry cough, pneumonia, respiratory failure</li> <li>• Diagnosis is made on isolating the virus from sputum or throat swabs or antibodies in blood</li> </ul>	<ul style="list-style-type: none"> <li>• Case detection to identify SARS</li> <li>• Isolation and management, infection control</li> <li>• Effective contact tracing and follow-up</li> <li>• Quarantine</li> </ul> <p><i>Health care setting:</i></p> <ul style="list-style-type: none"> <li>• Healthcare workers should wear N95 masks, together with head cover, goggles, gowns, and gloves when caring for these patients</li> <li>• Daily and terminal disinfection should be thorough, with careful washing and disinfection of the bed, handrails, bedside tables, floor, and equipment with hypochlorite solution</li> <li>• For intubated patients, use of closed system is essential to avoid air leakage and enhanced disease transmission</li> </ul>

Figure 6.14. Severe Acute Respiratory Syndrome (SARS) – major features of the disease and its prevention.

man resources management. The International Labour Organisation (ILO) lists four key areas of action to address HIV/AIDS in the workplace. (ILO Code of Practice on HIV/AIDS and the World of Work, Geneva, 2002):

- prevention of HIV/AIDS
- management and mitigation of the impact of HIV/AIDS on the world of work
- care and support of workers infected and affected by HIV/AIDS
- elimination of stigma and discrimination on the basis of real or perceived HIV status.

In order to achieve a reduction in HIV, a holistic approach should be in place. It is essential that this approach is integrated within a comprehensive occupational health program.

The key components of an intervention strategy to prevent HIV/AIDS in the workplace should include:

- A company HIV/AIDS policy, which is non-discriminatory and preventive in its orientation (see checklist in ILO Code of Practice on HIV/AIDS and the World of Work, Geneva, 2002).
- Promotion of awareness on HIV and other sexually transmitted infections (STIs) and their prevention through in-house education and training activities.
- Training of peer educators (e.g. trade union shop stewards).
- Early diagnosis and treatment of STIs using the syndromic approach.

- Access to voluntary pre- and post-test counselling and testing for HIV status on a confidential basis.
- Employee assistance programs that include ongoing counselling of HIV positive individuals focussing on psycho-social issues such as crisis intervention, medical aid, social security benefits and terminal care. Medical support such as TB prophylaxis using isoniazid medication, vitamin supplementation and treatment of opportunistic infections, is also required.
- Optimal condom accessibility and distribution.
- Provision of safe first aid support.
- Control of work organisation or environmental factors that increase risk of HIV transmission.
- Health information and management system focussing on ongoing surveillance and the development of intervention strategies.

A report recently published by the ILO (2008), *HIV/AIDS and the World of Work*, reported that more than 70 ILO Member States have, or are in the process of adopting, a general law on HIV/AIDS, while 30 countries have adopted, or are in the process of adopting, specific workplace rules. Other countries deal with HIV/AIDS under either equal opportunities or public health legislation, and some have integrated HIV/AIDS into labour legislation. The report notes that the majority of the 33.2 million people worldwide now living with HIV are still working and in their most productive years, with skills and experience their families, workplace and country can ill afford to lose. However, despite major advances in attitudes and knowledge about AIDS, many workers still face discrimination, stigma and fear of losing their job. The ILO is working towards a new labour standard in the form

of a Recommendation that would reinforce and extend the impact of the ILO Code of Practice on HIV/AIDS and the world of work adopted in 2001, with its focus on the protection and promotion of rights. It is envisaged that this would further support joint action on HIV/AIDS by the ILO's tripartite constituents and other partners, and strengthen the workplace contribution to achieving universal access to HIV prevention, treatment, care and support.

### INDUSTRIAL HYGIENE AND MEDICAL SURVEILLANCE

Exposure monitoring, using industrial hygiene surveillance programs, can evaluate the effectiveness of control measures in decreasing the risk of infection and/or allergic sensitisation of other workers not yet affected. Employers should also use the expertise of an occupational medical practitioner to design appropriate medical surveillance programs for the workforce as an adjunct to industrial hygiene evaluation and control measures. Various early sub-clinical biomarkers (e.g. skin prick testing, serum antibodies, target organ tests), can be used to identify signs of early infection, inflammation or allergic sensitisation before overt symptoms and clinical disease manifest. These tests can also be used to assess the effectiveness of control measures.

The medical management of an occupationally acquired infection/allergy is no different to that acquired outside the workplace, however, there are additional measures that need to be taken. After discussion with the worker, the medical practitioner should write a letter to their employer requesting that the person be moved to a job that has zero or minimal exposure to HBAs. Alternatively the worker may be declared as temporarily unfit to work in the presence of acute infection. It is also necessary to institute both appropriate treatment of an infection/al-

lergy and preventive measures such as post-exposure prophylactic treatment, counselling or vaccination for unaffected workers. Treatment should be the same for anyone who suffers a disease caused by exposure to an HBA regardless of whether the exposure was occupational or non-occupational.

### EDUCATION AND TRAINING

There should be education and training for all workers, managers, health and safety representatives and occupational health service providers. Specific training on HBAs should be part of comprehensive workplace education and training programs. Employers and managers need to be aware of biological risks inherent in the work processes so that they may institute primary preventive measures such as engineering controls, preferably in the design phase of the production process. Each workplace needs to have an integrated occupational health and safety management system which include procedures to eliminate or reduce worker exposure to hazardous biological substances and addresses the correct disposal of hazardous biological substances and other materials used on site.

Education and training programs are also essential in informing and educating workers about the production process; policy and procedures to be observed; their legal rights regarding health and safety; specific information on the properties and health effects of the hazardous biological agents they are exposed to; the preventive measures to be employed when working with these agents; first aid measures in case of an emergency and general health promotion. Some of this information is available in material safety data sheets (MSDS). Workers need to be aware of where these MSDS registers are located and trained in the use of MSDS.

Training is required whenever workers are required to use personal protective equipment (PPE) such as respirators, gloves and goggles. Such training should be interactive and demonstrate the use of PPE. The following elements must be covered in PPE training: identification of the hazard requiring respirator use; selection, use and proper fitting of respirators; duration of usage, limitations, maintenance and storage of respirators. In some circumstances more advanced training may be required e.g. where self contained-breathing apparatus and/or a full body suit is required to be worn.

Training and risk communication materials such as pamphlets, posters or booklets, are important tools in empowering workers and employers to take appropriate preventive measures. Some examples of preventive measures to be followed for latex and animal allergens, blood borne pathogens and tuberculosis are available on the internet (NIOSH, OSHA). A useful pamphlet, available in a number of languages, on educating workers and employers on biological hazards and their prevention, is on the European Union OSHA website. The ILO has produced a very useful education and training manual available in English and French "Implementing the ILO Code of Practice on HIV/AIDS and the World of Work" (2002). This Code of Practice outlines the approach to HIV/AIDS in the workplace, the rights and responsibilities of various stakeholders, achieving prevention through providing information and training, testing for HIV and care and support issues. Some of the best practices taken by companies in Southern Africa on HIV/AIDS have been published by the Organisation of African Trade Union Unity (OATUU) Health, Safety and Environment Program. This covers workplace case studies relating to HIV prevention, managing ill health,

human resource development, employee benefits and survivor support, as well as monitoring and planning issues. See reference list for above web site addresses.

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## SUGGESTIONS FOR FURTHER READING

### Basic texts

The following texts give a more detailed insight into aspects of risk assessment, exposure assessment and workplace control measures for hazardous biological agents:

- American Conference of Governmental Industrial Hygienists: Bioaerosols: Assessment and Control. ACGIH, Cincinnati, OH (1998)
- Fakhiri ZI. Workplace biohazards. In Encyclopedia of Occupational Health and Safety Eds Stellman et al. ILO (4th ed) 1998;38:2-12
- Myers ML. Industries based on biological resources. In Encyclopedia of Occupational Health and Safety Eds Stellman et al. ILO (4th ed) 1998;64:2-59

The following texts give more detailed insight into the various adverse health effects and diseases associated with occupational exposure to hazardous biological agents, their identification, diagnosis, management and prognosis:

- Rylander R, Schilling RSF. Diseases caused by organic dusts. In Encyclopedia of Occupational Health and Safety. Eds Stellman et al. ILO (4th ed) 1998;10:24-27
- Takahasi K. Occupational Infections. In Ladou J ed. Current Occupational and Environmental Medicine. 4th edition. Mc Graw Hill. USA, 2007; 262-279

- Aresery M, Lehrer SB. Occupational reactions to foods. Curr Allergy Asthma Rep 2002;2(1):78-86
- Bernstein IL, Chan-Yeung M, Malo JL and Bernstein DI, ed. Asthma in the Workplace, 3rd edition. New York, U.S.A.: Marcel Decker Inc., 2006

The following texts give more detailed insight into the policy and legal framework for the prevention and control of risks associated with hazardous biological agents:

- European directive No. 2000/54/EC on the protection of workers from risks related to exposure to biological agents at work (<http://www.allrisk-mgmt.co.uk/directives/00-054.htm>)
- Biologically derived airborne contaminants. In American Conference of Governmental Industrial Hygienists: TLVs and BEIs, 2008; 230-235
- ILO: HIV/AIDS and the world of work, Geneva, 2002 (<http://www.ilo.org/public/english/support/publ/pdf/hiv.pdf>)
- ILO: Report IV(1) - HIV/AIDS and the world of work, Geneva, 2008 ([www.ilo.org/wcmsp5/groups/public/---ed\\_norm/---relconf/documents/meetingdocument/wcms\\_090177.pdf](http://www.ilo.org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_090177.pdf))

### Best practice materials

The following texts give more detailed insight into practical examples and case studies of successful policies and programmes in dealing with HIV and AIDS in Southern Africa:

- Jeebhay M F, London L. Food and Allied Workers Union (FAWU) AIDS policy. SA Labour Bulletin 1993;17:13-14
- Loewenson R et al. Best Practices – Company action on HIV/AIDS in Southern Africa. OAT-UU, Benaby Printing and Publishing, 1999
- The Global Business Coalition (GBC) awards for Business in Action – Workplace programmes, Case studies, 2008 (<http://www.gbciimpact.org/live/events/awards/2008.php>)

### Training materials, examples of some websites

The following websites provide very well illustrated training material and pamphlets for prevention of exposure to hazardous biological agents in general and specific occupational diseases in particular:

- European Agency for Safety and Health at Work. Biological Agents fact sheet. Issue 41. OSHA, Belgium, 2003 ([www.osha.eu.int/ew2003/publications/factsheets/index\\_en.htm](http://www.osha.eu.int/ew2003/publications/factsheets/index_en.htm))
- ILO: Implementing the ILO Code of Practice on HIV/AIDS and the World of Work. An education and training manual, Geneva, 2002 ([www.ilo.org/public/english/protection/trav/aids/code/manualen/index.htm](http://www.ilo.org/public/english/protection/trav/aids/code/manualen/index.htm))
- NIOSH: [www.cdc.gov/niosh/alerts2.html](http://www.cdc.gov/niosh/alerts2.html) (needlestick injuries, animal handlers, latex allergy, organic dust toxic syndrome)
- NIOSH: [www.cdc.gov/niosh/hazcomm-hazid.html](http://www.cdc.gov/niosh/hazcomm-hazid.html) (wood dust, organic dust in dairy barns)
- OSHA: [www.osha.gov/SLTC/bloodbornepathogens/index.html](http://www.osha.gov/SLTC/bloodbornepathogens/index.html)
- OSHA: [www.osha.gov/SLTC/tuberculosis/index.html](http://www.osha.gov/SLTC/tuberculosis/index.html)

- OSHA: [www.osha.gov/SLTC/biologicalagents/index.html](http://www.osha.gov/SLTC/biologicalagents/index.html)
- Baatjies R, Jeebhay MF. Dust control in the Bakery - Manual. Occupational and Environmental Health Research Unit, University of Cape Town, South Africa, May 2007

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# Psychosocial risks and work

*Staffan Marklund*

## INTRODUCTION

In industrial countries, great interest has been shown to the psychosocial aspects of work for a long time, but physical and ergonomic risks have been the priority for preventive actions.

There are three common reasons given for this lack of emphasis on prevention of psychosocial risks. One claim is that such risks are 'soft', lacking scientifically established measurements, and evidence on exposure and consequences. Another is the claim that prevention of these risks cannot usually be achieved through legislation or the establishment of exposure limits. A third claim is that prevention of psychosocial risks is closely related to production, management, productivity and the economic performance of companies. The consequence is that psychosocial conditions are seen to be part of how management is dealing with its tasks and that suggestions for prevention may often be seen as negative for the managers.

The first claim is not valid, given that there is very strong research evidence on several aspects of the relationship between psychosocial conditions and health. Some of these research findings are presented later. The second claim is partially valid as effective prevention of psychosocial risks is only possible if activities are conducted at

the specific workplace and at the organisational level. However, similar preventive measures often have positive effects in a variety of different settings. There is good reason to believe that organisational learning is an important method to prevent psychosocial problems. The assertion that prevention of psychosocial risks at the workplace is a luxury that imposes higher production costs is rarely based on experience or evidence. Several research studies from industrial countries have shown that an improved psychosocial working environment directly increases productivity and limits costs for absenteeism and sickness.

While the prevention of occupational health problems usually covers four areas of risk, (accidents; chemical, biological and physical; ergonomic; psychosocial), it should be noted that all aspects of the work environment are closely interrelated. Prevention in one area frequently affects other areas. In the early stages of industrialisation, the priority is accident prevention in places with frequent injuries or fatalities. As fatalities and accidents incur high political costs, they are often the initial focus for legislation and social security. While there are large differences between countries, in general

these measures have resulted in considerable reductions in accidents. Accidents have also been reduced as workers shift from farming, mining and heavy industry towards high technology industries such as communications and pharmaceuticals.

Historically the prevention of specific chemical and physical risks has been closely related to accident prevention; however, new risks and scientific knowledge about the damaging effects of specific substances or conditions are always being discovered. The prevention of chemical and physical risks requires detailed knowledge of exposure and effects. Prevention can also be influenced by trade unions and national political developments.

The prevention of ergonomic risks includes a wide variety of factors but focuses on different physical loads and musculoskeletal disorders. “Physical loads” not only refer to heavy work but to other demands on the body related to awkward postures, movements that may cause disorders or pain, monotonous work and lack of movement during work. Prevention of ergonomic risks has developed through a combination of improved technical arrangements to lower demands on the body, organisational measures that increase work rotation, and promotion of increased muscle strength and physical fitness. In modern organisations, efficient prevention of ergonomic risks is often closely related to an improved psychosocial work environment, based on the experience that mental stress and psychosocial demands affect the way in which an individual copes with high physical strain and monotonous work.

Awareness and prevention of psychosocial work risks may be seen as the most recent development in the work environment history. Demanding psychosocial conditions have existed throughout history, but have become increas-

ingly important as the intensity of work has increased along with demands for higher quality and increased specialisation at work. The fact that work has in some respects become more individualised also means that psychosocial risks have become increasingly individualised and that the reaction to individual risks may vary between individual workers. However, there are similarities in the models used to prevent psychosocial risks and ergonomic risks as they both include workplace and organisational factors as well as factors related to individual workers and their capacities.

Psychosocial risks at work are clearly related to the degree of autonomy experienced by workers. In the early phases of industrialisation, workers were craftsmen with a high degree of control over all aspects of their work. Developments then led to a division of labour and a high degree of specialisation that has resulted in reduced worker control and lower qualification requirements. This process can be seen most clearly in industrialised countries but is also increasing in developing nations.

A specific characteristic relating to psychosocial factors at the workplace is the role of interpersonal relationships between workers. Social support and possibilities for cooperation are essential not only for the psychological well being of individual workers, but also for improved quality of products and services, and increased organisational creativity and learning in organisations. Awareness of the contribution made by individual workers to productivity and creativity may primarily emerge in wealthy countries first but is then exported to poorer countries via multinational companies, students educated abroad and international networks and organisation. Structures that support individuals to use their productive and creative resources may provide scientific and technical prestige to those who

deal with ‘modern’ questions in wealthy nations as well as in wealthy sectors in poor nations.

### STRESS AND PSYCHOSOCIAL RISKS

There is a close relationship between psychosocial conditions at the workplace and stress. Traditionally the concept of stress was closely linked to biological reactions to all kinds of strains both at work and outside work, e.g. as defined in the following example from Selye in 1974:

“Stress is the general reaction of the body to external or internal strain factors”

However, modern stress research not only deals with measurements of biomedical stress markers such as adrenalin or cortisol, but generally regards stress as the psychological balance between demands and individual abilities. A common definition originates from the work of Lazarus:

“Stress occurs when the relationship between the individual and her environment is seen as exhausting the resources of the individual and is threatening to her well being”

This kind of definition results in confusion between the concept of stress and stressors. Stressors are defined as the external factors in the work environment or other areas of an individual’s life that affect health or well-being. The term stress is generally concerned with individuals and individual reactions rather than with collective conditions at the workplace.

Psychosocial risks in the workplace include all non-physical hazards that negatively affect any individual. It is important to consider how work is organised and managed and to identify the mental demands required for specific tasks. Psychosocial conditions also include relationships between individual workers, workers with their supervisors and workers and customers or clients. It should be noted that these conditions are, at least formally, defined as external factors

to a job and how a job is organised. Psychosocial risks at work may be defined as follows:

Psychosocial work risks are any organisational conditions at work that disrupt the balance between demands from work and control over work, for an individual worker, that limit her/his ability to perform a good job.

The concept of psychosocial conditions is often confused with the psychological, psychosomatic or psychiatric reactions of individuals. While psychosocial conditions are often measured through individual cases, they do not only reflect the psychological status of the individual but also how the job is organised in general. Although psychological reactions to negative psychosocial conditions are common, it is well known that a range of ‘physical’ reactions also occur. Musculoskeletal and cardio-vascular disorders have been shown to have a high correlation with negative psychosocial work conditions.

One reason why psychosocial conditions are so important in modern working life is that they encompass various aspects of consciousness, motivation and identity for both individual and groups of workers. Work plays an important role in the formation of personal identity, the fulfilment of personal goals and personal satisfaction. Aside from work providing economic support, it also affects workers’ self esteem and sense of achievement. Work plays an important role in terms of social relations and workers’ pride in the group or company that they belong to. The social value of work is not only relevant for people with intellectual jobs but has been shown to be essential for all types of manual workers.

While there are differences between occupations and work situations, most people take some pride in their jobs. Work is a highly social activity in that people work together and have relationships with supervisors, customers and work mates. The development of theories and

measurement of psychosocial risks at the workplace involve important social factors such as collective behaviour, individual motivation and creativity.

### AN INFLUENTIAL EXPERIMENT

One of the first studies which used the concept of 'psychosocial' working conditions was the "Western Electric" experiments conducted in the Hawthorne Plant of the Western Electric Company in the USA during the Great Depression between 1924-1932. The study was headed by Professor Elton Mayo under the auspices of the American Academy of Science.

The company had identified high levels of fatigue among workers, inefficient movements between and during each moment of work, bad physical conditions due to poor lighting, cold rooms and noise, all conditions suspected of negatively affecting productivity and product quality. A pseudo-experimental design was adopted in order to study and solve these problems. Different interventions were studied and, where possible, control groups were used, (at least partially), to guarantee reliable testing of the effects of the interventions.

Two groups were primarily used in the so called lighting study:

1. A study group of about 120 women workers was set up. They were assigned a new supervisor and asked to try to work together. They were given special, friendly attention by the supervisor, served better food, and offered special clothing. The lighting was improved and the heating was raised. The workers were also encouraged to solve problems themselves whenever possible. In other words, these workers were asked to use their informal knowledge and ability to cooperate. The results showed a significant

increase in productivity and a decline in rejected products.

The next step involved changes to some of the physical conditions, made without the knowledge of the workers. The lighting and temperature were decreased, and the noise level was increased. The result was no decline at all in productivity related to these negative changes to the physical work environment.

2. The only change made for the control group was improvements to lighting; that single change resulted in improved productivity. When the lighting was decreased, productivity declined in contrast to the experiment group.
3. The same experiments were later replicated using a group of male workers. The results were less positive in terms of increased productivity, but still significant. The male workers were generally suspicious of both the supervisors and the company and continued to engage in individual competition for wages, and were less willing to share knowledge with workmates and supervisors.

The interpretation of these experiments has greatly influenced the understanding of psychological and social conditions at work and their effect on productivity – the notion of *psychosocial working conditions* was invented. Relationships between co-workers and supervisors are extremely important for productivity, however, as in the case with the suspicious male workers, it may take time to convince workers that a new supervisor is not trying to manipulate them. In some industrial settings there is a strongly negative culture among workers and supervisors that affects productivity and well-being, e.g. one worker shouldn't work harder than another or

workers shouldn't befriend a supervisor. Informal rules between workers and supervisors are extremely important for productivity as they affect behaviour and attitudes and are often very hard to change. If a group of workers has never been allowed to influence their own work, they will need considerable time before being convinced of the benefits of change. The development of good psychosocial conditions requires a supervision and control system that is friendly and takes workers' views into account.

The Western Electric experiments also showed that physical work conditions are related to workers' perception of the psychosocial situation. Productivity is improved if workers are able and allowed to talk to each other while working and during breaks. Even small issues such as the quality of food, may be an important sign of that management takes the well-being of workers seriously. The provision of special clothing for the female workers in the experiment group was intended to create a sense of group identity.

Each worker is a complex human being. Even though she or he may be doing a manual job there is a need to be seen, to be supported by others, to be accepted, to belong to a group, to feel secure and reassured. The Western Electric experiments showed that improved psychosocial conditions will increase productivity and quality of production in a more permanent way than some alterations to the physical work environment.

Theories on motivation and human needs are another research field that has contributed to the way in which psychosocial factors are defined and dealt with. In the 1950s, the personality theorist Abraham Maslow classified needs into a hierarchy: physiological needs, safety needs, social needs (belonging and love), esteem needs and self-actualisation. According to this theory, if all these needs are met in a satisfactory way,

an individual can use his/her breadth of skills, interact with others and be a productive, healthy person in working life. Maslow's ordering of the needs into a hierarchy means that the first step, physiological needs, must be met before an individual moves up to the new level. Maslow's view has been criticised and the common view today is that needs are not hierarchically ordered.

However, Maslow's theory on human needs is similar to how OSH has developed over time with the physical work environment and safety issues emphasised for a long time before the more recent focus on the psychosocial aspects of work.

Fredrik Herzberg's theory of motivation divides workplace environmental factors into motivational factors and hygiene factors. Motivational factors are based on work content and are the most important for a positive development of skills and job satisfaction. Hygiene factors refer to conditions such as salary, psychosocial climate, safety at work and the physical environment. While they are important to counteract the negative effects of work, according to Herzberg, they have very little effect on job satisfaction. Hygiene factors are based on the need for a business to avoid unpleasantness at work. If these factors are considered inadequate by employees, then they can cause dissatisfaction with work. According to Herzberg, management should focus on rearranging work so that motivating factors can take effect.

The social needs of the individual have implications for supervision and leadership in organizations. The emphasis on management of "human relations" can be regarded as an attempt to promote self regulation in addition to the execution of power based on rewards and punishment.



### THE DEMAND AND CONTROL MODEL OF PSYCHOSOCIAL CONDITIONS

An influential approach to psychosocial work conditions can be found in the *demand-control model* developed by Robert Karasek and Töres Theorell in the early 1980s. The model originates from and combines two different theoretical and empirical traditions – stress theory and classical alienation theory.

In general stress theorists studies the way in which people are affected by demands at work, particularly how excessive work affects health through the release of stress hormones in the body. However, research also shows that there are negative health effects from excessively low work demands, particularly for individuals who have to be alert while performing monotonous tasks. For example, workers in control positions, such as those in the control rooms of power stations, often have very little to do but, if anything goes wrong, large economic or other costs are involved. Other demand factors are related to the intensity, speed and complexity of work tasks and workers' specific or general experience. Some jobs present conflicting demands so worker may have to decide on priorities, quality and/or quantity.

The second element in the demand/control model originates from classical alienation theory. Robert Blauner's 1964 book, 'Alienation and Freedom', showed that most workers, even those involved in seemingly meaningless routine work, were striving to do their jobs as well as they could. Most workers wanted to develop their skills and to make an individual impression on their work but if they were denied this possibility, they performed less well and were more likely to develop negative attitudes towards work. An ability to affect work and control tasks was important.

Karasek and Theorell combined the two concepts of demands and control:

	Low demands	High demands
High control	Low strain jobs	Active jobs
Low control	Passive jobs	High strain jobs

Figure 7.1.1. The Demand/Control model developed by Karasek & Theorell.

The model defines *passive jobs* as those with low demands in terms of pace and complexity and where workers have very little possibility to decide when and how their job should be done. Stress theory is likely to define such jobs as "under-stimulating". Passive jobs often include a high degree of monotony and repetition.

*Low strain jobs* are those where workers have a higher degree of freedom, even though their jobs have low demands and low levels of intensity and complexity. Jobs combining high demands and freedom for workers are called *active jobs*. A number of professional occupations belong to this category. Jobs where the demands for speed or complexity are high but where workers have little influence over how and when the job should be performed are called *high strain jobs*.

The two most problematic conditions in the model were *passive jobs* and *high strain jobs*. These were jobs where there was either too little to do and no control over the work process/product or, too much to do and no control. However, the aim of the model is not only to define these categories. Combining the two dimensions of high demands, (active and high strains jobs), may not be problematic if it results in increased freedom for workers. The demand/control model implies that the increased intensity of work that occurs in many countries and industries should be balanced with increased control for workers. This process is happening partly because of increased

complexity of work tasks, increased professionalisation and educational levels, which generally results in a growth of occupations and professions with a high degree of autonomy. On the other hand, increasing demands in traditional production or services may not automatically increase control by workers.

Karasek & Theorell used this model to study the risks for cardio-vascular diseases. The model has also been used to explain other medical conditions such as musculoskeletal disorders, psychiatric disorders and more general outcomes like sickness absenteeism and work related disabilities. An epidemiological study of long term sickness absenteeism showed a very good fit with the theoretical and explanatory expectations. Figure 7.1.2 shows that the relative risk for long term sickness was more than three times higher among workers in high strain jobs compared to those in passive jobs.

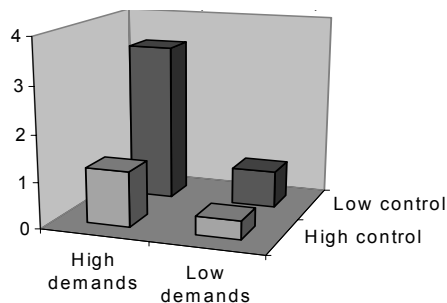


Figure 7.1.2. Demand/control for relative risk of long term sickness absenteeism, (60 days or more) among women. In the regression model the category 'passive job' (low control/low demands) is used as the reference category. The model controls for age and social support.

In addition, the demand/control model has been developed in various ways including the important step of including 'social support' as a dimension of the psychosocial work environment. The degree to which an individual worker can

get support from work mates and/or supervisors, affects the way in which demands are handled and the possibility of an individual worker to control their job.

### MEASUREMENTS OF PSYCHOSOCIAL WORKING CONDITIONS

Psychosocial working conditions are measured in a number of ways. Ideally any measurement of psychosocial conditions should focus on job characteristics rather than on individuals and it should encompass factors that are not heavily affected by attitudes and personality differences among workers. On the other hand, measurements may be more useful if they can be used generally for different occupations and/or work tasks rather than being very specific. The following options may be used. The first option is to ask employees to assess their own psychosocial conditions through the use of questionnaires. A second strategy is to use experts or other informants to assess a particular job or occupation through a developed task analysis. A third alternative is a combination of both the above options. All three have been used, but the most popular strategy today is to use employees as the main informants as validation studies show a high correlation between questionnaire results and expert assessments. Based on repeated questions and tests of different wording, questionnaires have proved to be a reasonably reliable methodology.

One of the most influential scales is based on a set of questions developed by Karasek and Theorell, for the measurement of demands and control at work. The questions are directed towards individual employees and can be used for most types of work tasks and occupations.

<b>Control over work/control at work</b>	<b>Never</b>	<b>Rarely</b>	<b>Some times</b>	<b>Mostly</b>	<b>Always</b>
My work demands that I work very hard					
My work contains too high a work-load					
I have enough time to perform my work tasks					
In my work I need to consider large amounts of information					
My work involves conflicting demands					
<b>Demands at work</b>					
I have the freedom to decide how my work should be done					
I have the freedom to decide what should be done					
I can decide when different tasks should be done					
I can decide my own pace at work					

Figure 7.1.3. The Demand – Control Questionnaire from Karasek & Theorell ‘Healthy Work’ 1990.

This scale has been used in a number of studies in several countries. Individual items, as well as the total measurement, have been validated through external measures, mainly using experts to define demands and control. Differences in psychosocial conditions between sectors and occupations have also been tested in several studies. The degree of sensitivity in relationship to various health outcomes has also been tested.

### Psychosocial job exposure matrix

A specific use for measurements of psychosocial conditions is the comparison of different occupations and differences between men and women within these occupations with respect to demands and control. This is done in a psychosocial job exposure matrix. Such a matrix can be constructed if there is reliable information about large groups of individuals in a range of occupations. This type of matrix was developed in Sweden in 2000, based on a series of surveys with data on psychosocial conditions for the 1990’s for men and women in different occupational

areas. Data on self reported health in different occupations was used to test the prognostic value of the matrix.

It is obvious that there are distinct and expected differences in psychosocial risks between occupations and between women and men. However, it may seem surprising to learn that female medical doctors report lower demands than female cleaners do or, that male electricians report the same degree of control as medical staff and farmers. There seems to be no reason to assume that demands at work are generally higher for intellectual work than for manual work. On the other hand, most traditional professions (such as lawyers, accountants and physicians) report a distinctly higher degree of control compared to blue-collar workers.

Occupation	Demands	Demands	Control	Control
	<i>Women</i>	<i>Men</i>	<i>Women</i>	<i>Men</i>
Engineer	6.1	6.4	7.9	8.3
University teacher	5.5	5.7	8.3	8.7
Pre-school teacher	6.4	6.6	7.6	8.0
Medical doctors	4.8	5.3	6.9	7.5
Registered nurse	5.8	6.1	7.1	7.5
Shop assistant	7.0	7.2	7.0	6.7
Farmer	6.8	6.8	7.4	7.5
Mineworker	-	6.8	-	6.0
Bus and lorry driver	6.3	6.5	3.8	4.3
Mail delivery staff	7.1	7.0	4.9	4.5
Mechanic	7.4	7.1	4.4	6.8
Electrician	7.3	6.9	5.5	7.6
Carpenter	7.5	7.1	5.6	6.9
Baker	7.3	7.0	5.1	6.2
Process operator	6.9	6.9	4.8	5.0
Ware house worker	7.2	7.1	5.6	6.5
Cook	6.9	6.1	6.8	6.5
Cleaner	8.3	7.6	5.6	6.3

Figure 7.1.4. Average values on demands and control for selected occupations in Sweden in 2000. Demands and control are both measured on a ten digit scale. High demands can be said to occur for values over 6 and low demands for values below 6. High levels of control can be defined as representing values over 6 and low control can be said to occur for values below 6.

There are also some interesting differences between men and women within the same occupation. Male professionals such as engineers, university teachers and medical doctors, report a higher level of control than women in the same profession. The same is true for some of the blue collar workers such as mechanics, electricians and carpenters. This may reflect the fact that more men are in supervisory positions,

but it may also be related to the specific tasks assigned to men and women within the professions. The fact that female blue-collar workers report higher levels of demands than males in the same occupation, may indicate that females and males are unequally distributed within that occupation or it may be that women working in typical male jobs have more problems in meeting job demands.

To conclude, consideration of psychosocial working conditions is important for all kinds of jobs and for all kinds of economies. The demand/control model for assessment of psychosocial working conditions shows that increased demands on workers should be balanced by increased control. Enhanced productivity through increasing quantitative or qualitative demands on employees is only possible if they are given more freedom to decide how and when tasks should be done. This is equally true for manual and intellectual jobs and for both wealthy and poor countries.

## Improvement of psychosocial conditions

*Annika Härenstam*

This chapter presents a number of organisational conditions, vital for a healthy workplace, focused on the premise that psychosocial conditions are an integral part of workplace organisation. However, there are numerous differences between various occupations, enterprises and industries within the labor market. Successful interventions to improve psychosocial conditions require comprehensive measures specifically adapted to each workplace. Psychosocial working conditions are also dependent on both national and international conditions and changes. While the conditions described in this chapter refer mainly to the labour markets in industrialized countries and Swedish studies are used, increased globalization means that even if the labor market conditions in developing countries are very different, there are very similar conditions within the industries described.

### CHANGES IN PSYCHOSOCIAL RISKS

Work organisation continually changes due to economic, political, ideological and technological circumstances. It has been suggested that since the early 1990's, there have been more frequent and extensive changes than ever before. Several studies have drawn attention to the recent, significant transfer of occupational risks

and problems in the work environment, Figure 7.2.1. The transfer of low paid, hazardous jobs from industrial countries to developing countries is a problem. Differences between metropolitan and rural regions in both industrialised and developing countries are also increasing. There is a transfer of OSH risks and problems from corporations to subcontractors as core industries increasingly outsource work and downsize. Responsibility has been shifted downwards from stock-holders to strategic senior management and on to operational managers and individual employees. Differences in working conditions and OSH risks are also found between those with regular employment and those with precarious employment.

Changes in workplace organisation have also been described as a process of “individualisation of responsibility” while Human Resource Management (HRM) often uses enthusiastic rhetoric to stress the positive aspects of individualisation, it can have different consequences depending whether increased responsibility is accompanied by increased control and improved learning possibilities. The ideologically driven, “hard” version of HRM, (such as quantitative result monitoring and measurement), is said to be directed towards relatively poorly educated, replaceable



groups of workers. The soft” version of HRM, (such as dialogue with management on the companies’ values and goals), is directed toward a core group of employees whose competence is desirable for a company’s principal activities. An important question is whether the process of individualisation has been internalised by employees to the extent that they drive themselves to work too intensely. Workers themselves, rather than managers or supervisors, increasingly leave their jobs feeling dissatisfied or uncertain about their work performance.

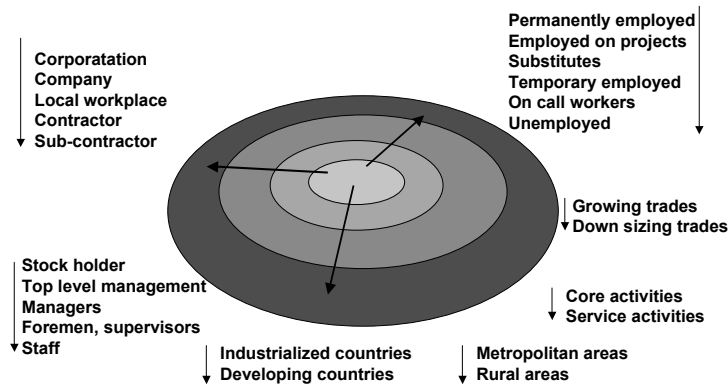


Figure 7.2.1 Changes in working life since 1990. Transfer of OSH risks and problems from centre to periphery. The text and the arrows indicate the direction of transfer of risks from actors and arenas with a strong position to those with a weaker position.

In many developed countries, changes in working life have resulted in many groups being given greater responsibility for their own work. For some groups e.g. in knowledge intensive services and high-technological industries, this change has meant a decrease in monotonous, low skill jobs as well as increased demands. Thus, increased authority and learning possibilities must also be implemented in order to maintain positive effects when work demands are raised. While strategic management and

authority over resources has been centralised, responsibility for jobs and production has been decentralised and survey results point to a negative development since the 1990s with respect to psychosocial working conditions when work demands were increased and decision-making latitude was reduced.

Centralisation of power can be described as “remote control”, where strategic operational decisions are more and more made at a greater distance from the place where work is done.

Increasing globalisation and the growth of multinational corporations and networks, combined with deregulation of financial markets, have contributed to this development. In the 1990’s, new information technology systems made it possible to monitor and manage workplace activities from a distance, even from other parts of the world.

Increased work intensity, combined with result orientated management systems, has also resulted in less reflection and exchange of experiences between colleagues and supervisors, and production workers and strategic decision makers. This is often exacerbated by large disparities in the professional backgrounds, knowledge, experience and status of high level strategic decision makers and those who work for them.

At the same time, various types of collective support structures such as trade unions have been weakened. Safety officers find it more difficult to carry out their work as workplaces become less socially integrated when operations are fragmented through outsourcing and sub-contracting. As the link between management and operational level is weakened, the employer’s responsibility also becomes attenuated. Any remedial process, e.g. on OSH, becomes com-

plicated if individuals who work together have different employers and supervisors, belong to different trade unions, have different safety officers and unequal access to occupational health services. Collective action is less influential when those affected need to use different means and resources for problem solving. In general, there are reduced opportunities for many actors including OSH experts, labour inspectors, managers, and workers, to address the problems of working life.

It is reasonable to assume that private companies and public organisations, whose operations are based on outside contracts and competitive tendering, are in a weaker position with respect to the promotion of a good work environment. An overview of 29 international research studies on occupational health risks in businesses using contracting out, found an association between this form of operation and occupational illness in almost all the studies. The authors' review of these studies identified three groups of problems which could explain this association: economic, organisational, and those related to legislation and supervision.

#### *1) Economic factors*

Competition and undercutting  
Performance-based wage systems  
Long, inconvenient and irregular working hours  
Understaffing and excessive work intensity  
Lack of resources  
High-risk activities which a company does not wish to carry out itself

#### *2) Organisational factors*

Unclear and complex responsibilities and job descriptions

Inadequate knowledge of work environment and health among those with supervisory and coordinating responsibilities

Weakened responsibility for employers because of a multi-tiered decision making and management structure which makes it difficult to monitor and report on work environment problems

Lack of qualifications, inadequate job training and lack of experience among employees

Difficulties for employees to organise and protect themselves.

#### *3) Legislation and supervision*

Work environment legislation and supervision is directed and adapted to cover permanent employees of large corporations so it functions poorly in many small companies

Problems to identify the responsible employer in establishments where many subcontractors work

Weakened supervision systems that are poorly adapted to contracting businesses

Lack of knowledge and monitoring of minimum requirements with respect to employment conditions and work environment.

Structural changes in working life have also had a personal impact on workers. Entry requirements for jobs have increased but "on the job" training has actually decreased for large numbers of workers e.g. in manufacturing and service industries. The emphasis on individual responsibility has blurred the line between work and leisure, and flexible working hours have made it harder for people to combine work and family life. For many employees, flexibility from the personal perspective has diminished as corporations implement strategies that are flexible from their point of view. Rapid change also makes it more difficult for people to plan their leisure time and more vulnerable groups in the labour

market find it increasingly difficult to use their occupational life to achieve their personal ambitions. Workers in relational occupations such as healthcare, education and social care, face particular challenges when trying to balance their work and private life because their clients needs cannot be predicted even if the organisational prerequisites are adequate.

Structural changes in the labor market also affect the extent and type of health problems experienced by women and men respectively. As the labor market is segregated by gender, women and men are exposed to different risks. Along with a general increase in the intensity of work, it has also been demonstrated that there are increased differences in working conditions based on gender, age, ethnicity and social class. In Sweden there has been an upsurge in the rates of work-related stress and sick leave in female dominated areas, particularly in the public sector. A number of studies have linked this increase to negative stress and high workload.

### Changes in different sectors of the labour market

In addition to general development trends in working life, there are major differences between industries and sectors. Possibilities to balance business requirements and employees' need for security and good working conditions vary because of factors such as business organisation and management, position in the labour market, and requirements for employee competence. Companies have traditionally been classified by what they produce, e.g. construction, or cars. The industrial economist Eric Giertz has proposed a classification system, based on market conditions, production process characteristics and management requirements, which has been useful for studies of the distribution of "good" and "bad" jobs, with regard to psychosocial and

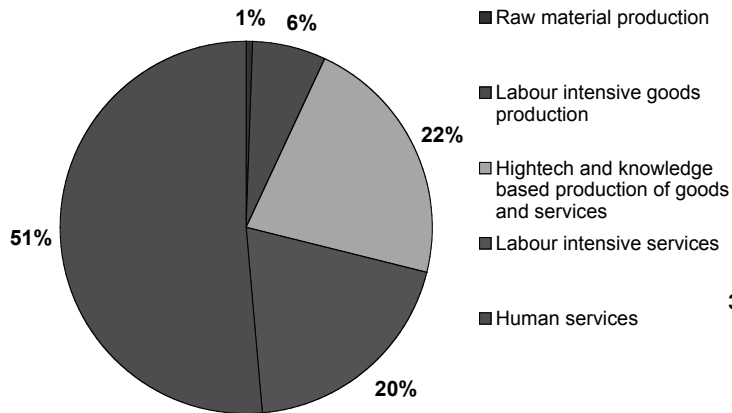
ergonomic aspects. The freedom to create a system of work organisation that will provide healthy working conditions varies greatly depending on the type of operation.

Different types of operations (using the above classifications), are found all over the world but their distribution in the total labour market differs between countries and regions. The gender composition within various occupations also differs from country to country but gender segregation in both occupations and industrial sectors is a feature of any labour market. Another characteristic observed in most countries is that workers in female dominated sectors generally have lower salaries and less influence over their work than sectors dominated by men or with a mixed workforce.

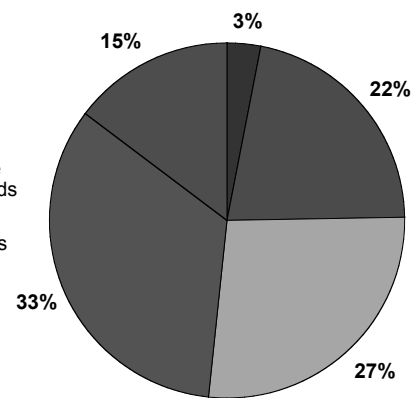
According to Giertz, there are similar characteristics within each of the operations across all countries, although the problems may be accentuated in countries with generally poor working conditions. Figure 7.2.2 shows the female and male labour force in Sweden in 2003, by type of operation.

High-tech and knowledge based industries include production of both goods and services. While 25% of the Swedish labour force works in this sector, the sector employs more men than women. In Sweden, human services such as education, health care, social care, policing, social services, and judicial services employ one third of the total labour force but more than half of the female labour force is employed in this sector. In contrast, labour intensive services such as cleaning, maintenance, trades, transportation, retail and customer support, also accounts for one third of the workforce but employs a larger proportion of men. In the past, most of these operations were an integral part of corporations or government agencies, but increasingly they are outsourced and organised by specialist

Distribution of the female work force



Distribution of the male work force



Data source: Work environment survey, Statistics Sweden, 2003

Figure 7.2.2. The Swedish labour force divided by gender and type of operation.

companies, often linked to multinationals. In Sweden, the production/manufacture of “labour intensive” goods and raw material harvesting (agriculture, mining, and fishing), now employs a small and diminishing part of the labour force but these are still the largest industrial sectors in many developing countries.

While management strategies have become increasingly homogeneous among companies with similar types of operations (i.e. clusters of companies in specific industries), they are increasingly dissimilar between different types of businesses, resulting in striking differences in work and business organisation. This trend appears to result from the growing use of standardised management principles, (e.g. benchmarking, key numbers, TQM (Total Quality Management), which may accentuate the differences in working and employment conditions.

At the workplace a number of dimensions link psychosocial conditions and organisational characteristics. Traditional research has identified

hierarchical structures, span of control, and the integration/fragmentation of work processes as the most important links. Recent research suggests that issues such as staffing policies, management technologies, organisational change, production resources, downsizing and “lean management” have the greatest impact on working conditions.

#### A COMPARATIVE STUDY ON THE RELATIONSHIP BETWEEN WORK ORGANISATION AND PSYCHOSOCIAL CONDITIONS

In the late 1990's, an investigation of organisational and working conditions was carried out in a broad selection of strategically chosen private and public sector establishments in Sweden. Data concerning both organisational and individual working conditions were collected by means of interviews, questionnaires, observations and measurements. The 72 establishments in the study were classified by: 1) the type of

operation and, 2) position in relation to other companies in a production chain. Their position was ascertained by comparing establishments where production is purchased or ordered by another company/authority with those that have control of the production themselves. Both these classifications were used for comparative analyses with respect to the use of various management strategies. Data on working conditions were also compared at an individual level. Multi-level analyses showed that a large proportion of the variance (16-65%) in psychosocial and ergonomic working conditions at the individual level could be explained by conditions at the organisational level, e.g. organisational structures and changes, employer and gender segregation. The results also showed that low status employees, (e.g. women, those from ethnic minority groups, or the poorly educated), were more vulnerable to organisational changes than other workers, which indicates that organisational changes contribute to increased polarisation of the work force with regard to psychosocial and ergonomic/physical working conditions.

### **Management strategies in different types of operations**

Six different management strategies were compared, based on the researchers' assessment of information from managers, documents and workplace visits. Variables from organisational descriptions have been summarised as indices that have been converted to a 0-100 scale. Figure 7.2.3 illustrates the differences between labour intensive services, human services and high-tech/IT companies in their use of particular management strategies.

The figure shows that labour intensive service companies were the most problematic and had implemented the smallest number of positive changes. The top bar represents "innovative-

ness", a management strategy associated with a healthy work environment, stimulating job tasks, and good control and learning possibilities. In addition, these establishments had invested resources in information technology, increased employee competence and extended external contacts for product development. In contrast, the bottom bar, "increased centralised control", representing increased remote control and measurements of results, was associated with poorer working conditions, repetitive/monotonous tasks, and reduced control and learning possibilities for employees. The same applied to numeral flexibility, i.e. more casual informal forms of employment and frequent changes in the number of employees. In between the two management strategies outlined above is "individualisation", associated with relatively good learning possibilities, control and motivation, low physical loads but higher mental demands. The same associations applied to "dialogue with management" or "soft management systems", which were also associated with better career opportunities.

In this study, functional flexibility showed no association with psychosocial working conditions. However, negative effects were observed when functional flexibility and greater individual responsibility was accompanied by downsizing and increased measurement of results ("lean management"), particularly in the public sector.

### **Organisational change and working conditions in high-tech and knowledge based operations**

High-tech and knowledge based companies, (including process industries, consulting and data companies), concentrated on core activities while transferring more simple tasks such as data entry, customer support and cleaning to contracting businesses and sub-contractors. Chang-

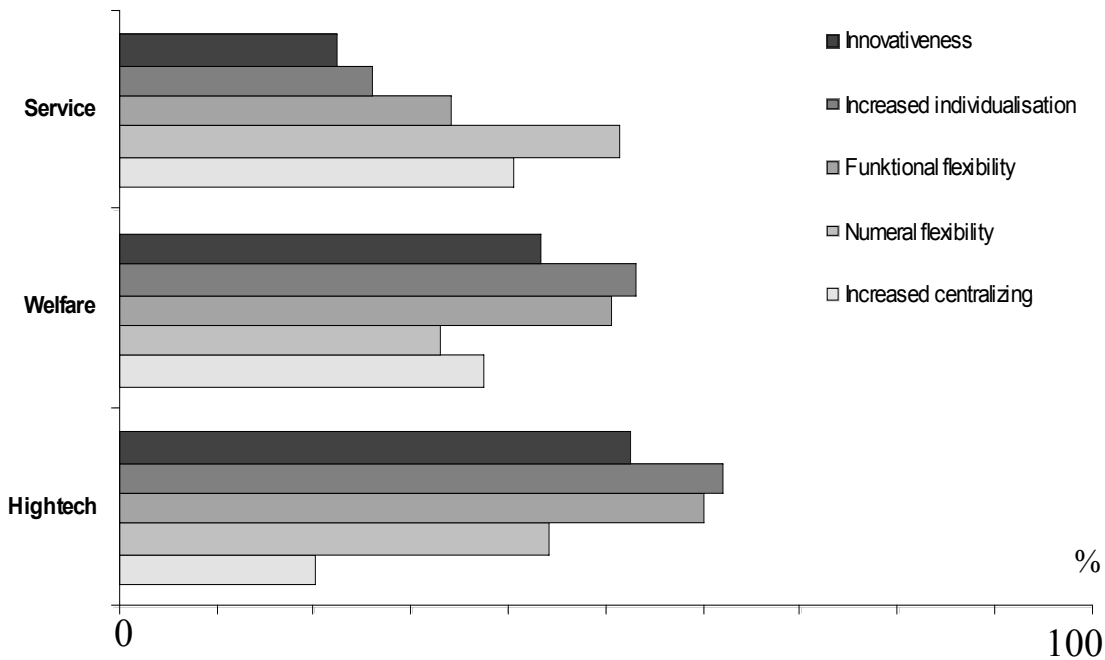


Figure 7.2.3. Management strategies at establishments in three types of operations. Average values in five indices (0-100).

es were often motivated by new technology and changing market demands and were accompanied by streamlining of production processes and a flattening of hierarchical management structures. Employees had increased customer contacts, buffers in the production process were minimised and work was organised according to “just-in-time” principles which increased employee competence. Employees viewed this as a positive change as they were given more training and responsibility and their jobs became more stimulating.

Difficulties were often related to increased demands for collaboration and changed relationships with managers and co-workers. Conflicts within working groups were more easily triggered as employees were expected to show initiative, face challenges and to appear to be

competent and capable. It was very important that employees were self-confident and had access to support in order to successfully meet new demands. Workers with lower status were not always allowed to assume a prominent role, a situation that was particularly applicable to women working in male dominated environments. In traditional industries, new management ideals, such as the importance of showing personal initiative, were sometimes perceived as disloyalty to the group or as wanting to promote one’s own career at the expense of others. Women also faced problems when asserting their development and career opportunities on equal terms with men but the positive consequences of the changes predominated in most of these operations.



### **Organisational change and working conditions in labour intensive service production.**

The production of services has been greatly affected by restructuring and downsizing in recent years. Included in the research were companies within retail trade, transportation, postal and banking services, hotels, restaurants, janitorial services, temporary staff agencies, call centres, operating, maintenance and construction companies. While much of this kind of work, (e.g. driving a bus, cleaning floors, making hotel beds), cannot be rationalised by new technology in the same way as high-tech and knowledge based operations, there is still strong competition and demands for efficiency. In labour intensive service production, companies are increasingly linked together into supply chains and standardise their production in order to address this challenge. The use of various forms of staff monitoring systems, (such as video-monitoring, drug-tests, recording of telephone calls with customers), are increasing used as means to control employees.

There is a growing tendency to measure work performance because contractors are increasingly carrying out this type of work. Companies compete fiercely for contracts and frequently undercut to procure contracts. If price is the decisive factor, there is a risk that companies with poor work environments will win contracts. It is rational from an economic perspective because service operations can save on personnel costs, a major part of their total costs, so changes often focus on reducing the payroll and increasing flexibility through less formal forms of employment and shorter training periods.

Production services such as selling, cleaning, serving and bus driving, are characterised by the immediate consumption of their products so service providers are very keen to hire and train

new staff quickly so they become productive as soon as possible. Personnel costs are directly linked to customer requirements in order to increase profitability which results in standardised, low skilled jobs, often with inconvenient working hours and lack of job security. In many countries, service employees (e.g. bus drivers or shop assistants), are increasingly exposed to violence and threats from customers, particularly if they are working alone, or outside normal working hours.

Overall, changes in the organisation of work in labour intensive services seem to have increased work intensity and imposed less convenient working hours for workers. Job expansion rarely required more qualifications or made jobs more stimulating.

### **Working conditions in human services**

A different pattern of change was found in healthcare, teaching, social work, child and elder care, police and court services and similar operations. The picture in human services was dominated by job expansion and restructuring, motivated by the need to cut costs in line with a new management system, labelled New Public Management (NPM), that has already been implemented in many countries. Human services employ many highly trained professionals, mostly women. The numbers of less highly trained workers such as nurse aids, clerical staff and cleaners have been reduced and their tasks reassigned to more highly trained professionals. For example, physicians and nurses now do more paperwork, administration, service and social care tasks; nursery school teachers are required to do more cleaning, tasks that were previously outside core professional work.

In an effort to prevent third parties (e.g. patients, students, clients) from the affects of downsizing, employees often made unreasonable

efforts to perform their jobs better, but many still felt inadequate and guilty about their work performance. As opportunities to nurture their professional interests and competence diminished, employees found their jobs less meaningful. Experience, professional knowledge, and cultural and social competence were valued less than “theoretical” competence. Constant restructuring destroyed functioning teams and networks, which in turn led to more frequent misunderstandings and conflicts. Work objectives were unclear and ambiguous while management was seen as overloaded and lacking in authority and resources to address problems. Violence and threats from clients and patients constituted an additional risk for many employees in services.

### Gender segregation

Few gender differences were found in comparisons of work and employment conditions for women and men employed in the same types of occupations and operations. However, changes in work life increase the differences between women and men at the group level as a consequence of the gender segregated labour market. In conclusion, women are mainly found in the sectors and in the types of operations where work redesign deteriorated working conditions. The opposite situation characterised many male dominated parts of the labour market. The discrepancy between working women and men appears to be increasing in Sweden in spite of the wide range of policy and actions in place to foster gender equality.

### REMEDIAL STRATEGIES

This chapter has shown that many aspects of the psychosocial work environment vary between different operations and occupations so strategies to prevent psychosocial risks must be spe-

cifically designed for the situation. The following sections summarise a number of strategies adapted to specific operations and industries.

### Human Services

In this sector, it is important to protect professional competence for operational requirements and to revive the confidence and satisfaction of employees. The fragmentation of operations through outsourcing and restructuring should be avoided because complex social systems become disrupted. It is also important that there is a connection between political promises to the community and the management of resources to realise such promises, largely through empowering managers with the necessary authority to control and allocate resources. Local operational managers within the human service sector face an almost impossible challenge when they are asked to reduce costs while increasing services for clients or patients. Such leadership conditions lead to paralysis. Decisions must be made at the highest level in the organisational hierarchy if meaningful changes to the principles of resource allocation, the creation of employee confidence and the prevention of occupational illness are to be achieved. If the following problems are to be resolved at individual establishments, operational managers must have the power and resources to properly manage the operation.

*Target groups:* Politicians and decision-makers at the strategic administrative level in municipalities, county councils and government.

*Attention/measures/improvement:*

- Creation of peace of mind and confidence for managers and employees
- Careful and thorough consideration of all the outcomes of restructuring
- Analyses of planned and implemented changes on operations and working conditions
- Adaptation of targets and means of achieving them, identification of connections between political objectives and resources
- Establishment of priorities within operations and limit the workload on groups and individuals
- Set up functioning information flow logistics, reduce unnecessary paperwork
- Support for additional resources for basic operations
- Set up decision making structures and administrative support that will allow operational managers to take responsibility, i.e. to control resources and to exert authority
- Ensure that employees are appropriately qualified and competent for the required work tasks
- Development of competence and professional autonomy
- Quality assurance in moderation limited to relevant aspects of the basic operation
- Evaluate by linking "customer evaluation" to evaluation of the work environment
- Train procurement officers/purchasers in work environment issues
- Financial incentives for good work and to reduce long-term sick leave.

### **Labour-intensive production of goods and services**

In view of the extensive outsourcing of labour-intensive production of goods and services, it is essential to have functioning rules for procurement and contracting. Work environment conditions are conditioned at the procurement stage when costs are specified so working conditions have to be taken into consideration when contracts are drawn up. Because of the vast scale of public procurement of services and political measures made to support the labour market, there is a risk that tax revenue may favour companies with the poorest work environment because these companies offer the lowest prices in order to secure contracts. Even responsible and serious employers are forced to compromise work environment conditions in order to obtain contracts. Politicians, trade organisations and supervisory agencies are important players in the implementation of measures on procurement

and contracting as they decide on laws and regulations. Consumers are another important group that could be engaged in improvements of conditions for workers. However, consumers need to know more about the conditions under which services are carried out. Customers/consumers are often unaware of the way in which services are delivered (e.g. how workplaces are cleaned, or telephone services are provided). There is a significant moral aspect to problems within these operations as consumers interests can be in opposition to workers interests.

### **High-tech and knowledge-based production of goods and services**

The reduction of problems and risks for conflict and gender and ethnic inequality in high-tech and knowledge-based operations encompasses a range of issues, not only for individual workers but, for the working environment in companies, the "culture" within the industry, and for gender

*Strategies at the structural level in labour intensive production*

*Target groups:* The political level, players at the structural administrative level including global, contracting parties, the EU and trade organisations, as well as customer and consumer groups.

*Areas requiring attention/measures/improvement:*

- Financial incentives for good working conditions
- Strengthen social responsibility also in companies that procure from suppliers and contractors in other countries
- Clear rules of employer responsibility, especially within chains of contractors and subcontractors, to prevent promotion of a poor work environment
- The issue of responsibility for work environment and occupational safety when many players are involved (purchasers, executors, contractors, subcontractors)
- The procurement process and wording of contracts so that minimum work environment requirements are taken into account
- Train procurement officers/purchasers in issues of work environment and occupational health
- The role of legislation and supervisory authorities
- Labour law and labour legislation
- New approaches to management of the work environment, distribution of knowledge and rehabilitation, e.g. employer circles, trade organisations, regional networks of authorities, companies and experts.
- Customer and consumer groups stipulating requirements also for social and work environment-related aspects of goods and services.
- Ethical standards for production comparable to those for environmental aspects.

*Strategies at the establishment level in labour intensive production*

*Target groups:* Business leaders, supervisors, safety officers, occupational health services and supervisory authorities

*Areas requiring attention, measurements or improvement in labour intensive production:*

- Work distribution principles that achieve alternative jobs, variety and learning possibilities
- Job security
- Freedom to discuss viewpoints, including negative, concerning working conditions
- Assignment of working hours in time and space, including predictability
- Breaks and opportunities for recuperation
- Social contact with co-workers and managers, not only customers
- The physical environment, noise, passive smoking, wet work, chemicals, accident risks
- Violence and threats
- Ergonomics and physical load
- Physical training in jobs with excessive, inadequate or one-sided physical load

and ethnic equality in society. The problems are unlikely to be solved by increased regulation or structural administrative measures as the problems are mainly cultural and social in character. While this industry offers many incentives in order to hire and retain competent staff and to develop their long term business operations, there are not similar strategies to achieve a good work environment, gender equality or to create possibilities to balance work and family life.

### **DIFFERENTIATION AND POLARISATION OF PSYCHOSOCIAL RISKS**

Although increased intensity, complexity and insecurity of work seems to be a problem in all sectors, there are large differences in the consequences for individuals and in the possibilities to prevent negative effects. This variation in effect is partly dependant on the composition of the workforce, e.g. whether they are professionals or come from less well educated groups, but is even more closely linked to the way in which production is organised in terms of time and the ability of the organisation to maximise control, autonomy and social support for individuals and the work group. From a cross-cultural perspective, there are still large differences in political and financial power between developing and industrialised countries. It is not unreasonable to believe that these differences will increase as low skill jobs with high health and safety risks are transferred to countries with weak legislation, high unemployment, low levels of union membership, and low pay rates. There is, however, a possibility that the opposite trend might occur as multinational companies organise work in a similar, standardised way throughout the world. The increased trend towards “employment flexibility” may be introduced in order to meet market demands but it may also be a method of avoiding legislation that protects employee

rights. The worst aspects of employment flexibility, e.g. temporary job contracts, atypical working hours, affect the most vulnerable workers, namely women and minority workers.

While there are general changes in working life, other changes are specific to parts of the labour market. A general trend of deterioration in psychosocial working conditions over the last decade has been identified by occupational health researchers. Several studies indicate a differentiation and polarisation of working conditions and occupational health between countries, sectors, companies and employees with a strong position and those with a vulnerable position. This type of research relies mainly on categorisation by occupation or class to identify differences between groups.

On the other hand, work organisation and management research has primarily described general management trends. There are many examples of studies about learning organisations, non-hierarchical (flat) organisations, “lean” production, Time Quality Management (TQM) and other management models but this field of research rarely links management actions and policies with the conditions actually experienced by employees.

There is a general outcome that emerges from the research described above. The choice of management level and the explanatory models selected for this research, tends to describe working life in general terms and suggests that solutions to problems can be found “downstream”. In other words, responsibility for action is assigned “downstream” to local managers or employees on the premise that the workplace is both the source of problems and the optimal setting for intervention. For example, there is a large volume of literature on stress management aiming at teaching the worker to adapt to working conditions instead of improving them.

Understanding the source of problems and identifying adequate solutions, requires knowledge about research on occupational health, organisations and management, labour markets and health promotion. If knowledge from these four research areas is integrated, it is easier to discriminate between general trends and trends that are specific to only certain sectors of the labour market.

This chapter argues that changes in work organisation and psychosocial conditions differ depending on the type of operation, partly depending on the company's position as a core or peripheral organisation. There are significant distinctions in how work is managed and organised, as well as in working and employment conditions. Employees in high-tech and knowledge-based businesses have experienced the most favourable developments in terms of the above conditions. In Sweden the worst psychosocial working conditions exist in the production of labour-intensive services. Human service employees have experienced the most the most serious negative developments with respect to psychosocial working conditions.

Polarisation within the workforce must also be considered. In Sweden, high-tech and knowledge-based operations mostly employ men, very few of whom are immigrants. In human services, about 80% of the workforce is women. Labour-intensive service production employs the highest proportion of workers with an immigrant background while the gender distribution is fairly equal. However, women and men work in different operations and workplaces within this sector - men mostly work in construction and transport companies while women work predominantly in service functions such as cleaning, retail, and restaurants.

Consequently, changes within various operations have distinctly different implications for

the working conditions experienced by women and men. Women are mainly found in female dominated sectors and the types of operations where work redesign resulted in deteriorated working conditions whereas, many male dominated sectors of the labour market experienced improvements from work redesign. Similarly, differences between ethnic groups continue to increase because immigrants are over represented in labour-intensive services that are characterised by a number of psychosocial problems such as low control and learning possibilities. Similar differences might be observed between the rich and poor world as companies move hazardous production to poor countries. It is important to discuss the ethical and moral issues in order to counteract dumping of hazardous jobs to countries and workers with very little power to demand a decent quality of working life.

It is not surprising that the best working and employment conditions are found in establishments performing their own "core activities" as primarily it is low skilled work that is outsourced and procured from contracting businesses. Increasingly, low skilled manufacturing jobs are outsourced to low wage countries. Contracting companies range from large companies and multinationals to small contractors, some of which only survive for a short time. The workforce in contracting companies largely consists of those with a weak position in the labour market, i.e. those who are young, poorly educated, with a foreign background and not organised in trade unions. Short contract periods also make it difficult for workers to organise and join forces in order to improve their employment conditions and work environment. Particularly difficult problems arise when unemployment is high, when workers are competing for the same jobs and are low skilled.



## TARGETS FOR PREVENTION OF PSYCHOSOCIAL RISKS

Work-related psychosocial risks can be approached on several levels: individual, establishment, industrial sector, regional, national and global levels. In order to identify psychosocial risks, systems for monitoring job content, working conditions, terms of employment, social relations at work, health, well-being and productivity are needed as a basis for action at the “appropriate” level.

All three parties in the labour market (workers, employers and government), are responsible for organisational improvements at the work place level. Professor Lennart Levi suggests the following matters are of particular importance in the promotion of healthy psychosocial conditions:

*Work schedules* should be designed to avoid conflict with non-job related demands and responsibilities such as family duties. Shift schedules should be constant and predictable.

*Participation and control mechanisms* should allow workers to take part in decisions or actions affecting their jobs.

*Workload* should be compatible with the capabilities and resources of workers and allow time for recovery from especially demanding physical or mental tasks.

*Job content* should contain tasks that provide meaning, stimulation, a sense of completeness, and opportunities to use skills.

*Work Roles and responsibilities* should be clearly defined.

*Social Environment* should provide opportunities for social interaction, emotional and social support and cooperation between fellow workers.

*Future* plans for job security and career development should avoid ambiguity. Life-long learning and employment skills should be promoted.

*According to the European Commission's Guidance (2000) on work-related stress, improvement of stress-inducing conditions in workplaces can be accomplished by:*

- Allowing adequate time for the worker to perform the job satisfactorily.
- Providing the worker with a clear job description.
- Rewarding the worker for good job performance.
- Providing ways for the worker to voice complaints and have them considered seriously and swiftly.
- Harmonising the worker's responsibility and authority.
- Clarifying the work organisation's goals and values and adapting them to worker's own goals and values, whenever possible.
- Promoting the worker's control, and pride, over the end product of his or her work.
- Promoting tolerance, security and justice at the workplace.
- Eliminating harmful physical exposures.
- Identifying failures, successes, and their causes and consequences in previous and future health action at the workplace; learning how to avoid the failures and how to promote the successes, for a step-by-step improvement of occupational environment and health (Systematic work environment management).

As a consequence of globalisation, there is also a need for international action. Unions, politicians and managers in multinational corporations have a particular role to play in order to strengthen the social responsibility of employers, to establish agreements on minimum standards for the work environment and to monitor the implementation of ILO conventions.

Actions to reduce work-related stress don't need to be complicated or prohibitively expensive. One of the most common sense and low-cost approaches is "Systematic Work Environment Management", a self-regulatory process, carried out in close co-operation with stakeholders. The above approach is an example of a general system of strategic work environment measures that have been recommended by political, scientific and union-employer assemblies. However, there is a need to develop a variety of strategies on the work environment in order to achieve a balance between production conditions, economic factors and working conditions within different operations.

Strategies must include the identification and linkage of problems and causes, possible actions and obstacles, and objectives and specific results. Someone must have the responsibility, authority and resources for any measures taken. It is especially important that affected employees are involved in any change process. Three key concepts for health promotion at the workplace have been suggested: leadership, resources and empowerment.

There is a need for innovative multilateral cooperation on legislation, expert systems, enforcement and ethical standards. In addition, development of worker participation in a wider political and economical context is an important challenge for the future. Worker participation is a fundamental requirement for the prevention of all occupational risks, but particularly

important for organisational and psychosocial factors. There is also a need for new forms of cooperation between regions where companies, authorities and people work and interact. Even competing companies can collaborate on minimum requirements for the work environment so that a poor work environment does not become a competitive advantage. A good example of this kind of collaboration was implemented by local authorities and distribution companies in Stockholm. Agreement was reached on requirements for approved docks used to receive goods which reduced work environment hazards for distribution drivers. Operations purchasing goods, e.g. restaurants and bars, had to construct facilities which met the new standards as they had nothing to gain by choosing another distributor if questions were raised about their docking facilities.

A renewal of trade union activities and strengthening of collective influence would help to prevent social dumping of inferior working and employment conditions to those in the weakest position in the labour market. New forms of cooperation could be established, e.g. collaboration between unions and regional networks of companies and authorities. Furthermore, as globalisation and new production trends emerge, there is an increased need for co-operation between unions in different countries.

More efficient "early warning" systems should be developed about changes in working life which can have hazardous effects for workers health. Adequate information about the effects of strategic decisions on operations and working conditions is not available for large groups of the workforce. Such information appears to have been pushed aside by the growing volume of standardised information about performance, results, costs and quality. Professional groups and core operational managers have a major respon-

sibility to report needs and to help to produce information that reflects operational problems and opportunities.

A balance between production conditions, economic factors and physical and psychosocial working conditions is the key to improving occupational health and ensuring a sustainable and health-promoting working life. To achieve this goal, action needs to be taken at many levels and by many parties. The global environment movement has increased knowledge about environmental risks, and motivated changes in legislation and behaviour of customers and companies. Work environment issues can be reinforced in a similar way. At the workplace level much can be done inexpensively. Increased control by workers, fair treatment from management and

a supportive psychosocial climate can not only improve productivity but increase well-being and decrease job-related accidents and diseases. At the industrial sector level, nationally and internationally, much more can be done in order to counteract undercutting for contracts and on work to encourage more healthy workplaces in specific branches of industry. Unions should continue to press for better working conditions and fair treatment of the workers. Politicians should contribute by formulating legislation for minimum standards for working conditions. Finally, purchasers, customers and clients have a moral responsibility to choose goods and services that are produced under reasonable conditions.

## Suggestions for further reading

In the text we have referred to some classic books on work organization and working conditions. These are:

Blauner R (1964). *Alienation and Freedom. The Factory Worker and His Industry*. Chicago: University of Chicago Press.

Herzberg F, Mauser B and Snyderman B (eds) (1959). *The Motivation to Work*, New York: Wiley.

Mayo E (1933). *The Human Problem of an Industrial Civilization*, New York

Maslow, A H (1954). *Motivation and Human Personality*, New York: Harper and Row.

McGregor D (1960). *The Human Side of the Enterprise*, New York: Harper and Row.

Summaries of these classic work as well as new research results and trends in this area can be found in a textbook that can be recommended for those who want to read more on theories and empirical studies on work organisation:

Thompson P & McHugh D (2002). *Work Organisations*, 3<sup>rd</sup> edition, Basingstoke, Hampshire: Palgrave.

In chapter 7.1, we present the Job demand Control Model. The theory behind that model can be found in a book by the founders of the JD-C model:

Karasek R & Theorell T (1990) *Healthy Work*. New York: Basic Books.

In this book you can also find references to two classic stress theory works, such as by Lazarus and Selye:

Lazarus R S (1966) *Psychological stress and the coping process*, New York: McGraw-Hill

Selye H (1974). *Stress Without Distress*, Philadelphia: Lippincott

Other recommendations for further reading:

At the website of European Foundation for the Improvement of Living and Working Conditions you can find many reports, for example of survey data on working conditions for European countries.

<http://www.eurofound.europa.eu/publications/index.htm>

In the text on different problems in different industries, we refer to a new classification of industries that we have found useful. This book is intended for managers who want to develop their business, but it is relevant also for occupational health specialists in order to bridge the gap in concepts between managers and OSH specialists.

Giertz E (2000). *Measuring success – Identifying performance indicators*. Malmö, Celemlab International AB.

In chapter 7.2, we refer to a Swedish study on work organisation and working conditions. The so called MOA-study has developed a methodology on assessments and analyses adapted for modern working life as to facilitate for practitioners to use research results. This study is presented in a report in English that can be downloaded from the web: <http://arblinc.sub.su.se>

Härenstam A, Rydbeck A, Karlkvist M, Waldenström K, Wiklund P, and the MOA Research Group. *The significance of organisation for healthy work. Methods, study design, analyz-*

ing strategies, and empirical results from the MOA-study. *Arbete och Hälsa*, 2004;13;1-89.

The specific empirical study that we summarise in the text is published in a scientific journal:

Härenstam A & the MOA Research Group (2005). Different development trends in working life and increasing occupational stress require new work environment strategies. *Work*, 24:261-277

Levi L (2002). The European Commission's Guidance on work-related stress: from words to action. In *Stress prevention in Europe: review of trade union activities – Obstacles*

and future strategies. TUTB Newsletter No 19-20, September 2002. <http://tutb.etuc.org/uk/newsletter/files/Newsletter-20.pdf>

Finally, we refer to an overview report on new trends in working life and the consequences for workers, particularly for those in exposed positions at the labour market:

Quinlan M, Mayhew C & Bohle P (2001). The Global Expansion of Precarious Employment, Work Disorganisation, and Consequences for Occupational Health: A Review of Recent Research. *International Journal of Health Services* 31:335-414.

# Development of work and enterprise survival

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# Introduction

*Gunnar Broms & Marianne Döös*

Enterprise survival is about competition in growing and shrinking markets. But this truism may conceal what is normally thought of as to the opposite of competition, namely collaboration. Below a competitive surface lie demands for a variety of forms of co-operation, since ability to compete today requires collaborative abilities. Abilities to be dealt with and realised within the enterprise as well as in networking between companies.

This section focuses on development within the enterprise. Our intention is to provide understanding and encourage action for change. The aim is to argue for a changed view of employees and introduce the potential of employees as decisive contributors to enterprise development and survival. The idea is to move away from the belief that workers have to be controlled and instructed in detail to be able to carry out even a limited work task. The possibilities are explored of a point of departure where workers are regarded as part of the thinking and development of the company, part of production in the sense that workers and teams take responsibility for work tasks and quality. Our hope is that the section as a whole will inspire various organisational actors to take action, and

encourage leaders to identify new opportunities for development.

This section is an argument for the standpoint that this view goes hand in hand with and enhances enterprise development. It highlights how work environment and work content is developed in relation to enterprise development.. One point of view often expressed by employers is that measures to improve the work environment, safety and job content are something that managers to a certain extent have to accept, an inevitable cost or even a luxury that only rich companies can afford. The argument here is that work environment is no longer reduced to a cost or a legal requirement, but rather is seen as a means of providing the best possible conditions for the employees to work and taking responsibility in a new manner.

## THE STRUCTURE AND CONTENT OF THE SECTION

In the following seven chapters the authors expound arguments of importance for developing the human aspects of production. The general standpoint is that the improvement of working conditions and work organisation is considered an important means of strengthening the enter-

prise in its efforts to stay competitive. A discussion is outlined where both employees, their unions and employers look on the development of work as a way to create safe and developing jobs as well as a way to improve the company's efficiency and its ability to meet new challenges. The framework provided and the questions raised are based on theories as well as long experience as practitioners and researchers.

*Gunnar Broms* and *Marianne Döös* provide a framework for the section by discussing the demands and threats that enterprises are facing and their impact on the development of work organisation and working conditions.

*Tommy Nilsson* gives a background to the development of a fruitful way of organising work and production. This is based on the idea of taking advantage of and involving both the intellectual and the manual capabilities of the employees. The social interaction within the enterprise and the participation of those concerned in decisions and improvement work are pointed out as important. Also, this chapter briefly introduces some work organisation concepts.

*Marianne Döös* provides an understanding of the mechanisms supporting experiential learning at the workplace, on the individual level as well as on the levels of work teams and organisations. Based on this she discusses how to create an

environment and an organisation conducive to learning.

*Jörgen Sandberg* and *Axel Targama* share their research findings on leadership. The forming of new, team based work organisations and the need for an acceleration of change within an enterprise lead to a shift in the demands on leadership. A shift from managing by using detailed rules and instructions to managing understanding.

*Martha Blomqvist* sheds light on organisational development and the advantages of gender integration at the workplace. She describes how the integration of work tasks may be used to open up some inequalities, discusses the obstacles and gives examples on how to overcome them.

*Gunnar Broms* discusses strategies for change and teamwork, the advantages of a learning strategy based on the participation by those affected by the change. The team organisation, its applications and advantages are concretised.

*Vimal Mabendru* provides an example of a process of change within his own company in India. The change covers both physical and technical changes as well as a radical change of the work organisation and leadership. The gender issue also plays an important role in this encouraging example.

# Enterprise survival – challenges and options

*Gunnar Broms & Marianne Döös*

In order to understand the challenges and options available for developing enterprises and work it is necessary to get a hold of the governing structures, i.e. the conditions under which companies live and compete. The increasing globalisation of markets is making new demands on companies. Companies all over the world are now exposed to competition, domestic as well as international. In developing and more industrialised countries alike, these changes call for development where competence is in focus and where co-operation and participation is encouraged.

Strictly hierarchical organisations are no longer thought of as efficient enough, and offer an adaptation to changing production conditions which is too slow for many companies. From the manager's point of view, breaking hierarchical structures means rupturing the control perspective. For the workers and their organisations it transcends mere fighting for better remuneration. Rather it affords a possibility of actively participating in the development of their own working conditions in favour of themselves as individuals, and in favour of the performance of the production system. So the roles of both management and workers change when former borders are crossed. From a strict company perspective, management has a lot

to gain by inviting workers as well as staff to find informal, practical ways of co-operating. This way of approaching change and development is not in opposition to co-operation already existing between management and the unions, and their representatives. The approach suggested is more of an adjunct.

## SCOPE AVAILABLE

What scope is available for the development of work and working conditions? The division of tasks, the distribution of decision-making powers, physical conditions and individual scope for development, and not least the remuneration paid for work input, vary from company to company and region to region. Most countries have passed legislation on the work environment, working hours and child labour (see other relevant sections of this book), but the strength and efficiency of enforcement vary a great deal. In their efforts to remain competitive, many enterprises transgress the limits of what is allowed or agreed upon nationally or internationally. We draw the conclusion that such owners and managers are convinced that this unsound exploitation is necessary in order to stay competitive.

On the other hand there are companies which believe their employees to be such valuable assets that they provide them with training, delegate decision-making powers and organise production in such a way that both manual and intellectual skills are utilised. In order to nourish this important asset they see to it that the environment is safe and supportive of high quality and efficient work in the long run. We assume that they do this not only to avoid trouble from trade unions, labour inspectors or safety engineers but also – or mainly – because they perceive a competitive advantage in so doing.

Although every enterprise is unique, and not ignoring the fact that conditions vary from country to country and region to region, we believe it is possible to observe some general trends which have an impact on enterprises and on the conditions of the employees within them. One such trend affecting most enterprises is globalisation. Globalisation opens up for competition across borders on a scale never before seen. The rapid development of information technology is a part of globalisation and facilitates it by making information cheaply and quick accessible to larger groups than ever before. Capital is moving more freely than ever across borders within transnational companies with production spread around the world.

Globalisation calls for strategies among small and medium-size enterprises (SME) to meet the challenge of the transnationals. Forming clusters or networking is one way of strengthening the SMEs' possibilities of competing both on the domestic and on the international market. SMEs are also playing an important role in the supply chain of the transnationals.

“In fact, the arguments for preserving and even encouraging diversity may sometimes outweigh the shorter-term advantages of the scale econo-

mies derived from standardisation and their propagation through transnational companies, free trade and free flows of investment. In fact, two processes (global standardisation in some areas but increasing diversity in others) co-exist.”

The above quotation from Freeman is aimed at highlighting the fact that companies are facing a world which is ambiguous, where tendencies of development are not clear-cut but a question of both-and, rather than either-or. Thus we have at the same time a tendency towards centralisation and standardisation in the name of cost-efficiency, and a trend of flexibility, customer-service and meeting local variations of demand.

In the following we will look further into the globalisation, the competition enterprises are facing and what this implies for the development of work.

### GLOBALISATION AND COMPETITION

The globalisation of the economy has expanded the limits of the market within which a company competes. This cuts both ways. Companies in the industrialised part of the world are constantly trying to expand their markets, and thus making more and more efforts to enter markets within the developing countries that until now have been unexposed to outside competition. The enterprises of the developing countries are facing a threat within their domestic markets from competitors from abroad, and are at the same time forced to look for markets also outside their own country or region.

Another trend is for enterprises to become internationalised. Head office, research and development (R&D), marketing and production are often separated in large companies. Production is not seldom located to countries where the economical conditions are considered favoura-

ble, salaries are low or the regulatory framework is weak.

This is so much the case that countries are competing with offers of e.g. limited or no taxation in order to attract start-ups by foreign enterprises. This is a dangerous trend whereby low salaries and room for unhealthy exploitation also may be seen as ways of attracting enterprises.

The development of the Internet and efficient and cheap international transport are also playing an important role in the growth of competition. Technological solutions and inventions quickly become available world-wide. This has accelerated the pace of change. The lifetime of product generations is getting shorter and shorter. In the mobile phone sector this is easy to observe, with new products and product generations appearing all the time. This in turn leads to a demand for constant change and adaptation of production. Not only do managers and technicians have to search for and introduce new ways of production, the workers also have to be involved and trained to cope with the new demands.

Yet another trend is the growing importance of specialised, contract manufacturers. These companies are transnationals with production sites spread around the world. Production can quickly be moved from one site to another. When one market is weak production can be closed down and moved to other, growing markets. These contract manufacturers try to facilitate the mobility of their production by using the same production technology and work organisation no matter where in the world they are operating. Work is strictly controlled by instructions and there is little room for forming local ways of working or involving the workers in the development of their own work organisation. The mobility of production also implies that

production must not be dependent on a skilled and experienced work force. Easily replaceable workers are the ideal.

There is today no homogeneity among companies concerning how to value and treat competence issues. Apart from the production concept of the replaceable worker we see a widespread trend whereby competence is regarded as the competitive factor of real importance. The aspect that we emphasise in this section is the contemporary situation, where knowledge management and competence development are seen as crucial to competitiveness and company success on the market. The significance of an organisation's ability to learn and renew competence is here recognised as a crucial issue for competition, and in such companies management is constantly struggling to organise for competence development. Cost has long been regarded as the main aspect of importance for competition on the market. To reduce the cost of the end product, manufacturing companies have focused their efforts on improving productivity. Productivity is traditionally defined as output in relation to input in terms of manpower and other resources. This has in many cases led to automation, long production runs and manpower reductions. But cost is no longer the only factor taken into consideration by customers when choosing between different offers. Time of delivery, quality, design, after-sales services and many other factors are equally important.

Customers today are also susceptible to consumers' apprehension of company behaviour in terms of polluting the environment, using child labour or overexploiting their employees etc. So competition is forcing enterprises to look for sounder and more ethical ways of developing their activities.



### DEVELOPMENT OF WORK AS A WAY TO COMPETE AND SURVIVE

Companies together with their suppliers are continuously improving production and supply systems and their performance. The technology is accessible to all, depending only on financial resources. What, then, makes the difference between one company and the other? Distance to market, unique products, access to raw materials and low energy costs, are of course some essential factors. But beyond that what finally counts is cost efficiency, quality, delivery accuracy, flexibility and a high level of service and adaptability to changed conditions and customer demands. This calls for the development of innovative capabilities within the enterprise.

“The diffusion of a new techno-economic paradigm is a trial-and-error process involving great institutional variety. There are evolutionary advantages in this variety and considerable dangers in being locked in too early to a standardised technology. A technological monoculture may be more dangerous than an ecological monoculture. Even when a technology matures and shows clear-cut advantages and scale economies it is important to retain flexibility and to nourish alternative sources of radically new technology and work organisation.” (Freeman)

Jeffrey Pfeffer – Professor of Organisational Behaviour – stresses that successful firms are achieving competitive success because of their way of thinking and treating workers in a non-traditional way:

“It means achieving success by working *with* people, not by replacing them or limiting the scope of their activities. It entails seeing the work force as a source of strategic advantage, not just as a cost to be minimized or avoided. Firms that take this different perspective are often able to successfully outmaneuver and outperform their rivals.”

The above leads to the conclusion that investments in sophisticated technical systems are no longer enough. For a company to stay competitive we would like to stress the importance of a developed work organisation with a high level of competence and motivation of all employees. Advanced technology depends on skilled people in order to be competently used. By contrast, the understanding possessed by people working in a company cannot be bought off the shelf – it takes years to develop and will have to be constructed and reconstructed on an ongoing, everyday basis.

With this as a vision there is hope for a positive development of work, with safe and healthy workplaces where the employees are seen as valuable and competent contributors to the continuous development of the enterprise.

During the process of change every workplace and enterprise should be seen as unique and will thrive through taking advantage of its unique qualities. Many of those qualities are formed by the composition and social interaction of the workforce. The competence, experience, creativity, co-operation and decision structure of the enterprise are then all to be seen as important competitive aspects.

# Learning at work

*Marianne Döös*

One struggle that many managers and occupational safety and health (OSH) experts engage in, all over the world, concerns ways of getting employees to behave according to instructions, rules and in line with what they are told by superiors and experts. This chapter aims at shifting the focus of attention, from a teacher instructing or a boss commanding to the individuals, groups and organisations that are learning.

The fact is that all knowledge construction is an active process on the part of the learner, and thus needs to be understood according to this logic. Learning does not take place at somebody's command, rather it needs to be enhanced and facilitated. Ongoing competence development and learning within the enterprise has turned out to be of competitive advantage. This adds another decisive reason for managers and leaders, for OSH-experts as well as for workers, to develop an understanding of the processes and conditions of experiential learning.

This chapter is about learning in working. It is meant to be of practical use and to contribute to company development, and to healthy workplaces as the result of competent work environ-

ment prevention. The following points will be treated:

- We are all learners all the time.
- The quality and usefulness of what is learnt.
- Some basic learning principles.
- Collective and organisational learning.

The text is written in a reasoning style and offers understanding rather than hard facts. It is not a manual or concrete advice. Some examples are aimed at enhancing the readers' possibility to draw conclusions and connect to their own experiences and to local practices and conditions.

In brief, to learn means to change and develop one's conception and understanding of something, and is in this chapter thought of as a process. Competence is related to the performance of specific tasks and is regarded as a capability to make use of knowledge in acting.

## **WE ARE ALL LEARNERS ALL THE TIME**

No matter what we do, we always learn into the bargain. Learning is intrinsic to activity. Ac-

tions have learning as their (unintended) consequence, while the intention of the action comes out as the result, i.e. the intended outcome. This can be simply summarised: we are all learners all the time, learning is for everyone an activity that is always going on. It makes no sense to label a person a learner or non-learner, since everyone in an organisation is learning. There is no such person as a non-learner. This means that everyone in a workplace engages in learning activities as he or she carries out normal work tasks. Learning, then, goes with the job. It takes place when we normally do not even think about it, while the learner's attention is focused on the task and not on learning.

On the other hand, there is a definite risk of negative learning when workers are assigned to jobs of a constrictive nature, i.e. when their experiences lower their interest and self-reliance and cramp their personalities, which in turn reduces the potential for constructive participation in corporate development. Another risk concerns illusory learning, where employees refrain criticising, even when invited to do so. If employees are afraid of raising critical questions and issues, this can result in illusory learning on the part of the manager. S/he may falsely overestimate the advantages and legitimacy of his/her own proposals and skill.

Learning is clearly an integral aspect of everyday work tasks. The importance of experiential learning is from now on used as a presumption. Managers ought to make use of this knowledge and organise the business for learning. It is also up to OSH-experts to understand and act according to learning principles if they want to rely on participative methods in order, for example, to e.g. reduce accident risks or improve the work environment.

### THE QUALITY AND USEFULNESS OF WHAT IS LEARNT

The important remaining questions at each workplace concern what is learnt, with what quality and especially to what benefit and advantage for the activity of the enterprise. On the whole, qualifying experiences and skill enhancement among shop floor employees will add value to the company, whereas refraining from competence development will reduce a company's prospects of coping with future challenges and demands.

In industrialised countries, competence development is today considered highly important in most organisations, but – at the same time – learning conditions frequently deteriorate due to staff reductions, the ideal of having slim organisations and the resultant work intensity and overload (see “Psychosocial risks and their prevention”, this book; on the pursuit of sustainable development, see Docherty, Forslin, & Shani 2002). In developing countries the crucial importance of skilled workers is not yet common knowledge.

Transformational capacity is needed in order to attain sustainable development in a changing environment. The American psychologist and organisational consultant Nancy Dixon has found that organisations capable of handling change have undergone three major shifts in relation to knowledge:

“The first is a shift in thinking about who in the organisation has credible and valuable knowledge that the organisation can use to solve its difficult problems.

The second is a shift from thinking of knowledge as an individual phenomenon to thinking of knowledge as embedded within a group or community.

The third is a shift from thinking of knowledge as a stable commodity to thinking of knowledge as dynamic and ever changing.”

Workplace learning, or more specifically, work *task* learning, has implications for individual development over the life span and in every walk of life. Both lifelong and life-wide learning are dependent on the learning that takes place when work tasks are performed and talked about with others. Work tasks and work situations represent ongoing opportunities for knowledge construction and re-construction. In fact, tasks and their surrounding conditions provide the main opportunities for learning and competence development in adult life. If learning conditions in a workplace are not favourable – either because of work tasks which are too limited and confined or else because of staff reduction and high work intensity – the potential for individual development is not used, and the organisation as a whole will suffer from having less capability to deal with change. Engaging the workers in carrying out an organisational change and revised layout may be a starting point for development.

Thus, work task quality makes a difference. Limited work tasks and unfavourable conditions for qualifying experiences at the workplace help to create stagnation and non-development among the employees. When tasks, quality issues, meeting attendance, customer demands, problem solving and so on are integrated in the work tasks of the workers, this is in line with contemporary ideas in companies where individual and enterprise development support and strengthen one another. The relation of learning quality to participation in everyday work as well as in change processes is also strong.

## SOME BASIC LEARNING PRINCIPLES

David Kolb stated that “learning is the process whereby knowledge is created through the transformation of experience” and to change one’s way of doing, thinking or understanding means learning. To learn implies changing one’s ways of thinking and/or acting in relation to the task one intends to perform. Learning can be briefly described as a situated process of knowledge-construction based on action, with the learner as an active constructor of knowledge and know-how. Piaget described learning in terms of processes of adaptation. Qualitative shifts in an individual’s understanding are seen as accommodations that alter cognitive structures, whereas experiences in tune with already existing structures are thought of as assimilations. The need for accommodation stems from an unpleasant feeling of imbalance that calls for a change in one’s thinking.

### Learning requires a learner

One basic principle of organising for workplace-based learning concerns moving away from the thinking where courses and transmitting information are in focus. It means acknowledging the learner and his/her everyday work tasks, environment and meaning context as crucial for learning. Thoughts on this point are elaborated in the “from arrow to flower” metaphor, Figure 8.3.1. Departing from traditional ideas of transmission, illustrated by the arrow from a teacher or instructor to a learning object, the learner is instead placed as the actor in the centre of a flower in an environment of “affordances” (Gibson). As a consequence of task-related intentions, the individual learns as s/he makes use of the specific environment and meaning context through action. Action that implies the capturing of possible opportunities which enable the individual to carry out and understand work tasks, e.g. seeing how others do things, identify-

ing a problem, observing a deviation, talking to workmates.

The figure exemplifies what is afforded in the environment of a machine operator dealing with a production disturbance. In solving the situation he will, for example, look to see how others have solved similar problems, observe a helpful deviation from what is normal running production, ask questions and have a look in the manual.

Figure 8.3.1 illustrates the move away from the transmission idea represented by the one-way arrow, i.e. away from the idea of knowledge being transferred from an active person to a presumed passive receiver. The learner is instead thought of as active and in the middle of carrying out a work task. This work task demands actions, and it is during these actions that learn-

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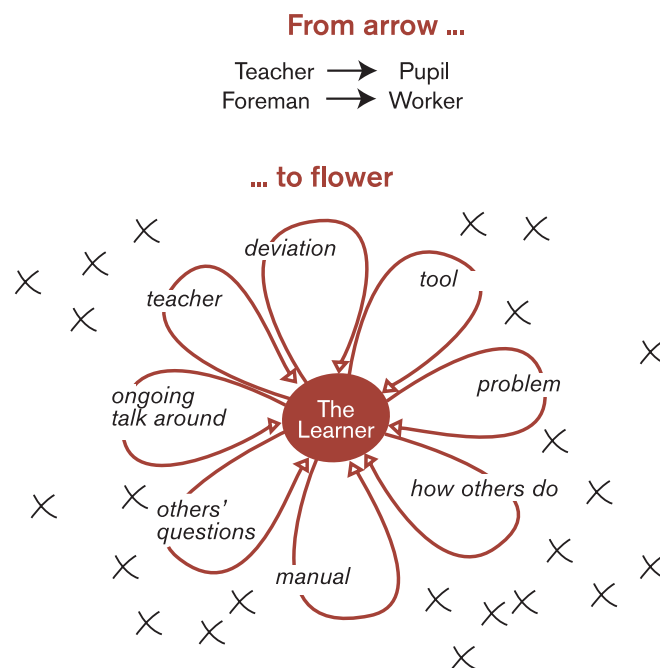


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action people take part in and change circumstances, conditions and situations.

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operator hears a bad sound from his machine) *or* through abstract comprehending and thinking (realising that the parts the machine just produced fall short of the quality required). Once prehended the individual can either transform the experience through acting, testing, trying out ideas in action (the operator enacts a possible solution to the quality problem, e.g. adjusts a machine setting) *or* with the help of his/her understanding observe, reflect and create an understanding (the operator creating the basis for a richer understanding of the production problem). These are both transformation processes whereby one turns an experience into one's own know-how. The transformation means that the experience is grounded in and to some extent

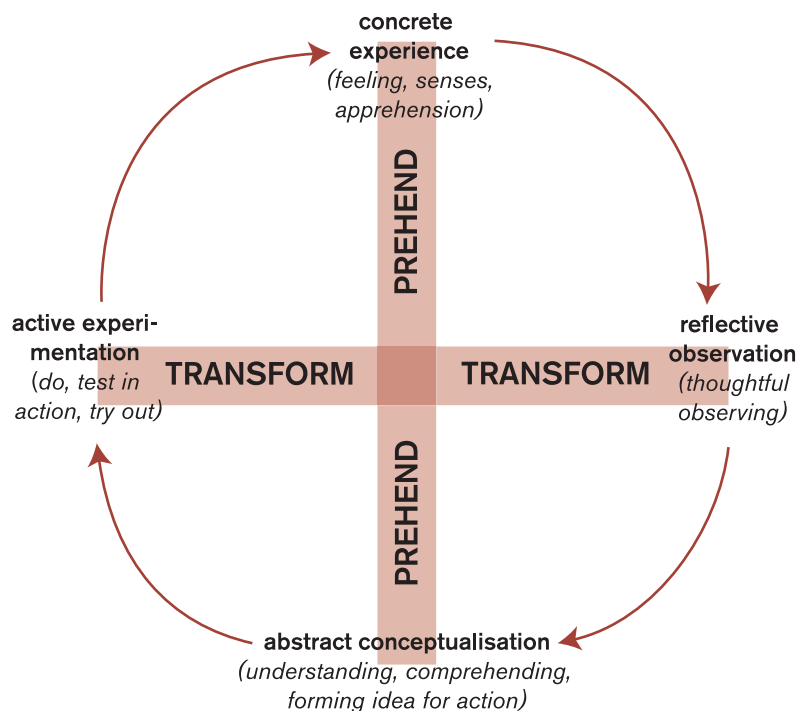


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also changes the individuals' thought networks. Kolb describes this as a process moving between the steps of concrete experience – reflective observation – abstract conceptualisation – active experimentation. It is useful to look upon them as four ingredients that *all* have to be put to use in order for learning to be qualifying in the long run. To concretise the theoretical concepts, here is a work-related example from the shop floor.

### Small, almost insignificant steps

Learning is commonly thought of as something quick and revolutionary, but studies have shown it to be a small-scale process in which the small incremental steps, for all their apparent insignificance, are of major importance. This goes for concrete experiences, e.g. in production tasks, as well as for comprehending, e.g. in the proceedings of workplace meetings. One experience is added to another and the normality of one's everyday work tasks is constructed, reconstructed and consolidated. When a person knows what is normal and usual, it becomes possible to be surprised and ask efficient questions concerning identified differences and deviations, questions that are relevant to learning and work task performance combined.

The outcome of learning can be envisaged as having two aspects. In terms of outwardly visible signs of learning, outcomes are expressed in the form of changed ways of acting, performing tasks, and talking. Within the individual, learning is expressed as constructing and reconstructing one's cognitive structures. These structures are the understanding and know-how an individual has concerning something specific and can be described as thought networks. The thought network concept is explicitly chosen to communicate possibilities for connections and development – in contrast to similar concepts named as cognitive structures, schemata and patterns.

### Example

A glimpse of the operator's learning process can thus be found in a situation of disturbance handling. He stands besides his milling machine. The machine runs automatically and the metal parts produced are lifted away by a robot. Suddenly he sees that the robot arm has stopped in an odd position. He ponders this occurrence, realising that the same thing has happened several times lately, which makes him identify this as something that might require action on his part. He has an inkling of the reason: he thinks that it has to do with metal shavings from the milling disturbing the sensor which signals to the robot. Thinking about this he develops a comprehension of the problem and forms an idea for action. He cleans the sensor, re-starts the machine and finds that the robot moves normally. With this new concrete experience he continues to work. In describing this work we have also described a piece of learning where the operator has now added an experience that gives him a better basis for action next time a similar problem occurs.

Through thought networks, perceived characteristics of a situation (e.g. a situation of problem solving, production disturbance handling) are linked to action, and to the judgements and decisions needed for an individual to find an action path. The thought networks can be described as situation-connected reasonings that are more or less alike in similar situations. Such likenesses give thought networks stability and durability,

although – at the same time – they are continuously modified and developed through the person's thoughts and actions. To summarise, thought networks manifest themselves as action alternatives, and are tied to the situations in which they are constructed and re-constructed. Experiential learning takes place as the constructing of these networks.

Several authors have related learning to life span development. Mezirow, for example, speaks of transformations that follow a disorienting dilemma and result in “a reintegration into one's life on the basis of conditions dictated by one's new perspective”. Our particular perspective tends to inform our actions in ways we are not fully aware of. Transformation of these habits of mind and points of view is a painful process:

“Our values and sense of self are anchored in our frames of reference. They provide us with a sense of stability, coherence, community, and identity. Consequently they are often emotionally charged and strongly defended.”

In giving an overview of the theory of transformative learning and how it has been used in practice Wilhelmsen states that the explicit purpose of transformation theory is

“to be useful for adult educators whose goal is not only to teach a subject but also to assist the development of their adult students' capacity for living in a complex and dynamic society.”

Over time, individual development is affected by task execution and individual task definition. One can say that behind the situation-related thought networks, there are long-term individual ways of understanding (habits of mind), that are more consistent over time and do not vary according to situation. In, for example, a

machine operator's handling of disturbances to production, his habit of mind affects his way of defining and dealing with his work task. Such habits of mind are not one-dimensional. They can be thought of as built along a number of dimensions, each of which can be seen as a continuum for possible development. In a study of operators' disturbance handling in automated production, a number of dimensions of importance for the mode of performing the work task were identified, Figure 8.3.3. For example, operators' ways of thinking (their habits of mind) about production disturbance handling varied with the extent to which their thinking was dichotomised or process-like; on a scale from frozen statements and truncated explanations, to the operator having related explanations and insight into active use.

### COLLECTIVE AND ORGANISATIONAL LEARNING

Nancy Dixon states that “collective meaning is meaning that organizational members hold in common. These are the norms, strategies and assumptions that specify how work gets done and what work is important to do”. Learning as a collective process means that individuals learn together through some kind of interactive and communicative action. This is a learning process that creates added value through synergy, whereby what is learnt becomes qualitatively different from what any individual could have arrived at unaided. Further, collective learning results in shared knowledge, in a similar understanding of something specific, and – grounded in this – a capacity for joint action. Knowledge that is jointly produced has a more stable character than knowledge produced individually.

Within all teams and organisations, individuals are the ones who learn and carry their knowledge forward to the next situation and

next task, to other specific environments and meaning contexts, and to meetings with other individuals. We learn together, but learning is always grounded in the understanding carried by each one of us. However, this is just one side of the coin. It is equally important to stress that knowledge resides in the relations between experienced people. The latter implies that competence is not entirely individual. A person's know-how is often richer, easier to use and expand, and better maintained and developed when s/he has access to other equally competent persons. Thus

in order to enhance learning in an organisation it is necessary to deal with these two aspects of knowledge – individual luggage, with its pros and cons, and the relational aspect.

Sharing and expanding knowledge

The sociology of knowledge concerns common-sense knowledge, i.e. “what people ‘know’ as ‘reality’ in their everyday lives”. When Berger and Luckmann describe the reality of common sense they refer to the actor's, the individual's, interpretations of a reality that s/he takes for

Non-reflective, routine way of thinking	Reflective, problem-solving way of thinking
<ul style="list-style-type: none"><li>• Dichotomised thinking, either/or, see no alternative</li><li>• Pose oneself no questions, no pondering; thought processes rapidly come to an end</li><li>• Frozen/petrified statements, truncated explanations</li><li>• Do not think ahead</li><li>• Controlled by external demands; wait for external changes</li><li>• Take things as they come, no anticipation</li><li>• Wish to achieve approved production standards</li><li>• Perceive faults as interruptions to routines, as a change/as breaks</li><li>• Few stories related to disturbances</li></ul>	<ul style="list-style-type: none"><li>• Think in terms of variables, processes and alternatives</li><li>• Ponder, reflect, ask oneself “How?” and “Why?”</li><li>• Have related explanations and insights into active use</li><li>• Future is present in ideas and thoughts, plans of one's own</li><li>• Controlled by internal demands of one's own and by goals; not dependent on external changes</li><li>• Quality assurance, influencing stages of operations both before and after one's own</li><li>• Aim to produce quality in excess of formal requirements</li><li>• Perceive faults as interesting problems to solve</li><li>• Masses of stories related to disturbances</li></ul>

Figure 8.3.3. Development makes a difference – machine operators' ways of thinking (habits of mind) concerning disturbance handling. Selection of a number of dimensions characterised through their end positions.

granted. No two people have the same personal histories or experiences of life. The idea that knowledge comes with experience will thus by definition imply that one person's knowledge differs from everyone else's, to a lesser or greater extent. These are valuable differences. Multiple perspectives and shifting nuances are often fruitful.

However, the differences also quite often result in that what one person holds to be true and valid seeming questionable to another. There is a problem related to individual knowledge in the sense that people easily believe and act as if one's own knowledge and know-how were the truth – instead of realising that it is rather one's own perspective. Thus the development of shared and joint knowledge requires an openness and an ability to reflect and when necessary accommodate, change one's own world views and habits of mind. In an organisation, then, individual experience is very useful and all the same has to be overcome to a certain extent in order for knowledge to become shared and collective.

The term “collective” does not imply that everyone in an organisation entertains exactly the same meaning; rather, it refers to an understanding that is close enough in order for members of the organisation to function as if they were in complete agreement. However, as Dixon points out, significant differences between persons are commonly found when collective meaning structures are examined closely. “Meaning structure”, the term Dixon uses, comes close to what in this chapter have been called cognitive structures and thought networks. She also stresses that many collective meaning structures are tacit, and that they are changing slowly as a consequence of day-to-day activities. By contrast, accessible meaning refers to the structures that an individual is willing to make available to others in the organisation. Accordingly, here lies the

open, and thus more useful connection between the individual and the organisation when new ideas are to be introduced and changed ways of working are needed.

In a changing world, collective meaning can have a negative impact on an organisation in that the organisation may not realize that the collective meaning it holds is dysfunctional. For example, collective meaning that was advantageous for a company during a certain period can become obsolete in a rapidly changing world. In such situations there is a need for making the collective accessible. It is also not uncommon for people who want to implement change on others to try to communicate with those other people's non-existent meaning structures, i.e. with thought networks that, for one reason or another, people have not (yet) developed. Such communication is doomed to failure.

Transformative collective learning is a process where participating individuals get access to others' ways of understanding. According to Wilhelmson, collective learning is seen when group participants broaden, shift and exceed their individual perspectives. Transformative collective learning entails the transcending of the individual perspective in that the group forms a new and, at least for the moment, common understanding. In Piaget's terms, this could be understood as a kind of collective accommodation.

There is reason to stress the importance of conversations and group dialogues for the accessibility and development of knowledge and understanding in an organisation. When work demands that people take part in and make sense of changes, the development of dialogue competence is of special value. In learning dialogues it is possible to access understandings through people making their different perspectives visible. Dialogue competence is thus not a personal trait, but a capability that comes with practice.

Dialogue is different from discussion and also something more than and distinct from ordinary talking. Dialogue meetings are not the same thing as ordinary workplace meetings. Dialogue can be characterised as a conversational ideal to strive towards, an ideal implying that the people taking part consider each other of equal value and each aim at developing their own and a common understanding. The point of departure for learning group dialogues is the fact that every participant has experiences that to some extent differ from those of the other participants. These differences are the ground for and idea behind organising group dialogues (e.g. at a workplace), but also its difficulty. Our varying experiences mean that everyone contributes a different truth to the conversation.

### **Cultivating competence-bearing relations**

Every workplace has processes that carry workplace know-how and competence. These processes can be seen as ongoing relations between persons. Apart from individuals carrying their knowledge between different contexts, the know-how of the workplace is accessible, arises and remains in the interstices, i.e. in relations between people. In a competence-bearing relation an individual is more able than he would be on his own. The presence of and actual access to one another increase and preserve the know-how. Thus there is a lingering knowledge which resides in having recurrent access to other sense-making and competent actors, i.e. to the work-mates one has thought, worked and experienced with and who thereby know what words, allusions and solutions stand for. Having workplace history in common means that people possess shared and lived answers to the reasons for the way in which things are carried out at the workplace.

If management one-sidedly views knowledge and competence as individual attributes, this

### **How to arrange dialogue meetings**

When people meet, dialogue develops spontaneously. Listening and talking about our own experience is how we learn from each other and develop shared conceptions. Why are so few encounters of this kind to be seen in the workplace?

Dialogue requires time and trust. The arrangement of dialogue meetings where people can train their dialogue competence requires planning concerning choice of topic and rules on how to talk. Briefly, a room is needed where people can sit in small groups of five. A leader presents the rules and content to the whole gathering. The rules in brief are: Pass the word around in the group. It is everybody's responsibility so see to it that everyone speaks. The topic chosen must concern a question that is relevant to all participants and to which there are no right or wrong answers. A question concerning an issue that the group can investigate a bit deeper and develop some common understanding around.

A constructive structure is to start by letting each and everyone of the five participants to one another express their own point of view of the way something ought to be (e.g. among hospital staff it could be "what is good treatment of patients in our hospital?"). The second step is to investigate impediments to achieving this, and the third to look for things that enhance and facilitate progress in the desired direction. Finally the group can write down a few points that the members agree upon, and present them in plenary session.

might threaten an organisational change process, because with such a view the ability to ask the useful and effective questions concerning how to organise for the knowledge that resides in the relations may be lost. Continuous use of this relational knowledge calls for the cultivation of competent relations – in contrast to what is very often the case when managers and change agents re-sort people as if they were inanimate objects. Skilled individuals are then deprived of part of their competence, since interactive processes and knowledge transactions are the backbone of the organisational competence.

### CONCLUDING REMARKS

One important conclusion to be drawn is that a vital connection exists between life span/width development and the learning that occurs within work-task-related everyday experiences. Further, learning and development – in their accommodative and transformative natures – are not to be reduced to easiness and simplicity when in process. Although the outcome is often positive, the processes of changing ways of thinking and transforming habits of mind are at times demanding, and may be associated with shakiness, crisis, pain, and even chaos, if the learning challenges basic values and ways of understanding. For example, leaving existing work tasks and related competence in order to take on new tasks might feel like sitting in a rowing boat when a storm is brewing, before regaining and walking on *terra firma*.

To act competently and to assign meaning to the world we live in, i.e. our contemporary societies, requires people not only to understand and learn in the actual physical and social setting, the specific community of practice. Siebert stresses the need for “a meta-cognitive capacity to observe how we observe, how and on the basis of which leading differences we construct real-

ity”. The work of managers and OSH-experts is definitely facilitated by an understanding of individual and collective learning processes, by knowing how changed points of view, revised stances and expanded know-how come about. Such knowledge provides a ground for believing in and daring to practice participation, introducing production teams, leading understanding and sustainable organisation development. This knowledge of learning processes is clearly relevant to have in mind when dealing with occupational prevention and making decisions concerning e.g. safety issues.

In order to connect learning to occupational safety and health issues, it can be stated that to a large extent risk, and safety, is constructed when people are not at all consciously dealing with it. It is in reality constructed in working, when focusing and carrying out one’s ordinary work tasks. When individuals and work teams are increasingly supposed to function with responsibility and autonomy, this calls for knowledge of learning processes and an ability to manage conflict between learning and control logics – issues discussed in “Constructing workplace safety through control and learning – conflict or compatibility?”

If learning in working at the collective and organisational levels is of importance for enterprise development, e.g. when adjusting business to changed external demands, then how can conditions supporting such learning be enhanced?

One answer to this lies in job enlargement and enrichment, which creates opportunities for more problems and question marks to solve and learn from. Variation in work tasks and communication around them makes it possible to identify differences and deviations. Another type of answer is that such favourable conditions have to be created locally through involvement and participation. To start with some small and con-



crete changes to the work environment might for example invite workers to engage in fruitful collaboration. The other chapters in this section provide aspects on work organisation, leadership, gender and team work strategies that are all in tune with the views on learning here presented, and can thus be used as inspiration for organising for a more learning organisation.

Peoples' habits of mind are not changed over night – these kind of changes, e.g. where workers are asked to broaden their work tasks and responsibilities, to be involved mentally take time. Thought networks and habits of mind are stable, even conservative structures. Albeit amenable to change.

# Learning at work

*Marianne Döös*

One struggle that many managers and occupational safety and health (OSH) experts engage in, all over the world, concerns ways of getting employees to behave according to instructions, rules and in line with what they are told by superiors and experts. This chapter aims at shifting the focus of attention, from a teacher instructing or a boss commanding to the individuals, groups and organisations that are learning.

The fact is that all knowledge construction is an active process on the part of the learner, and thus needs to be understood according to this logic. Learning does not take place at somebody's command, rather it needs to be enhanced and facilitated. Ongoing competence development and learning within the enterprise has turned out to be of competitive advantage. This adds another decisive reason for managers and leaders, for OSH-experts as well as for workers, to develop an understanding of the processes and conditions of experiential learning.

This chapter is about learning in working. It is meant to be of practical use and to contribute to company development, and to healthy workplaces as the result of competent work environ-

ment prevention. The following points will be treated:

- We are all learners all the time.
- The quality and usefulness of what is learnt.
- Some basic learning principles.
- Collective and organisational learning.

The text is written in a reasoning style and offers understanding rather than hard facts. It is not a manual or concrete advice. Some examples are aimed at enhancing the readers' possibility to draw conclusions and connect to their own experiences and to local practices and conditions.

In brief, to learn means to change and develop one's conception and understanding of something, and is in this chapter thought of as a process. Competence is related to the performance of specific tasks and is regarded as a capability to make use of knowledge in acting.

## **WE ARE ALL LEARNERS ALL THE TIME**

No matter what we do, we always learn into the bargain. Learning is intrinsic to activity. Ac-

tions have learning as their (unintended) consequence, while the intention of the action comes out as the result, i.e. the intended outcome. This can be simply summarised: we are all learners all the time, learning is for everyone an activity that is always going on. It makes no sense to label a person a learner or non-learner, since everyone in an organisation is learning. There is no such person as a non-learner. This means that everyone in a workplace engages in learning activities as he or she carries out normal work tasks. Learning, then, goes with the job. It takes place when we normally do not even think about it, while the learner's attention is focused on the task and not on learning.

On the other hand, there is a definite risk of negative learning when workers are assigned to jobs of a constrictive nature, i.e. when their experiences lower their interest and self-reliance and cramp their personalities, which in turn reduces the potential for constructive participation in corporate development. Another risk concerns illusory learning, where employees refrain criticising, even when invited to do so. If employees are afraid of raising critical questions and issues, this can result in illusory learning on the part of the manager. S/he may falsely overestimate the advantages and legitimacy of his/her own proposals and skill.

Learning is clearly an integral aspect of everyday work tasks. The importance of experiential learning is from now on used as a presumption. Managers ought to make use of this knowledge and organise the business for learning. It is also up to OSH-experts to understand and act according to learning principles if they want to rely on participative methods in order, for example, to e.g. reduce accident risks or improve the work environment.

### THE QUALITY AND USEFULNESS OF WHAT IS LEARNT

The important remaining questions at each workplace concern what is learnt, with what quality and especially to what benefit and advantage for the activity of the enterprise. On the whole, qualifying experiences and skill enhancement among shop floor employees will add value to the company, whereas refraining from competence development will reduce a company's prospects of coping with future challenges and demands.

In industrialised countries, competence development is today considered highly important in most organisations, but – at the same time – learning conditions frequently deteriorate due to staff reductions, the ideal of having slim organisations and the resultant work intensity and overload (see “Psychosocial risks and their prevention”, this book; on the pursuit of sustainable development, see Docherty, Forslin, & Shani 2002). In developing countries the crucial importance of skilled workers is not yet common knowledge.

Transformational capacity is needed in order to attain sustainable development in a changing environment. The American psychologist and organisational consultant Nancy Dixon has found that organisations capable of handling change have undergone three major shifts in relation to knowledge:

“The first is a shift in thinking about who in the organisation has credible and valuable knowledge that the organisation can use to solve its difficult problems.

The second is a shift from thinking of knowledge as an individual phenomenon to thinking of knowledge as embedded within a group or community.

The third is a shift from thinking of knowledge as a stable commodity to thinking of knowledge as dynamic and ever changing.”

Workplace learning, or more specifically, work *task* learning, has implications for individual development over the life span and in every walk of life. Both lifelong and life-wide learning are dependent on the learning that takes place when work tasks are performed and talked about with others. Work tasks and work situations represent ongoing opportunities for knowledge construction and re-construction. In fact, tasks and their surrounding conditions provide the main opportunities for learning and competence development in adult life. If learning conditions in a workplace are not favourable – either because of work tasks which are too limited and confined or else because of staff reduction and high work intensity – the potential for individual development is not used, and the organisation as a whole will suffer from having less capability to deal with change. Engaging the workers in carrying out an organisational change and revised layout may be a starting point for development.

Thus, work task quality makes a difference. Limited work tasks and unfavourable conditions for qualifying experiences at the workplace help to create stagnation and non-development among the employees. When tasks, quality issues, meeting attendance, customer demands, problem solving and so on are integrated in the work tasks of the workers, this is in line with contemporary ideas in companies where individual and enterprise development support and strengthen one another. The relation of learning quality to participation in everyday work as well as in change processes is also strong.

## SOME BASIC LEARNING PRINCIPLES

David Kolb stated that “learning is the process whereby knowledge is created through the transformation of experience” and to change one’s way of doing, thinking or understanding means learning. To learn implies changing one’s ways of thinking and/or acting in relation to the task one intends to perform. Learning can be briefly described as a situated process of knowledge-construction based on action, with the learner as an active constructor of knowledge and know-how. Piaget described learning in terms of processes of adaptation. Qualitative shifts in an individual’s understanding are seen as accommodations that alter cognitive structures, whereas experiences in tune with already existing structures are thought of as assimilations. The need for accommodation stems from an unpleasant feeling of imbalance that calls for a change in one’s thinking.

### Learning requires a learner

One basic principle of organising for workplace-based learning concerns moving away from the thinking where courses and transmitting information are in focus. It means acknowledging the learner and his/her everyday work tasks, environment and meaning context as crucial for learning. Thoughts on this point are elaborated in the “from arrow to flower” metaphor, Figure 8.3.1. Departing from traditional ideas of transmission, illustrated by the arrow from a teacher or instructor to a learning object, the learner is instead placed as the actor in the centre of a flower in an environment of “affordances” (Gibson). As a consequence of task-related intentions, the individual learns as s/he makes use of the specific environment and meaning context through action. Action that implies the capturing of possible opportunities which enable the individual to carry out and understand work tasks, e.g. seeing how others do things, identify-

ing a problem, observing a deviation, talking to workmates.

The figure exemplifies what is afforded in the environment of a machine operator dealing with a production disturbance. In solving the situation he will, for example, look to see how others have solved similar problems, observe a helpful deviation from what is normal running production, ask questions and have a look in the manual.

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Individual experiential learning can be understood as an ongoing interchange between *action* and *reflection*, where past experiences provide the basis for future ones. Action forges the link between the human being and the environment, where active participation and personal action are prerequisites for the learning process to take place. Through action people enter into both concrete experiences and the reflection that build up their know-how over time; through

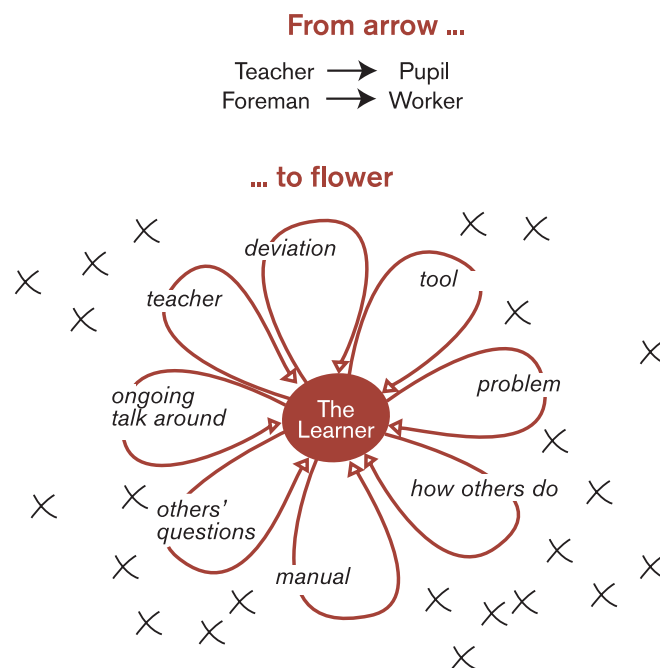


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action people take part in and change circumstances, conditions and situations.

The quality of the experiential learning process can vary in terms of what is learnt. High-quality learning requires all four learning ingredients to be active, Figure 8.3.2. Kolb describes the learning process as made up of two dimensions, where the ingredients or steps constitute the end poles, with a *prehending* (i.e. seizing, grabbing, catching) dimension and a *transforming* one.

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operator hears a bad sound from his machine) *or* through abstract comprehending and thinking (realising that the parts the machine just produced fall short of the quality required). Once prehended the individual can either transform the experience through acting, testing, trying out ideas in action (the operator enacts a possible solution to the quality problem, e.g. adjusts a machine setting) *or* with the help of his/her understanding observe, reflect and create an understanding (the operator creating the basis for a richer understanding of the production problem). These are both transformation processes whereby one turns an experience into one's own know-how. The transformation means that the experience is grounded in and to some extent

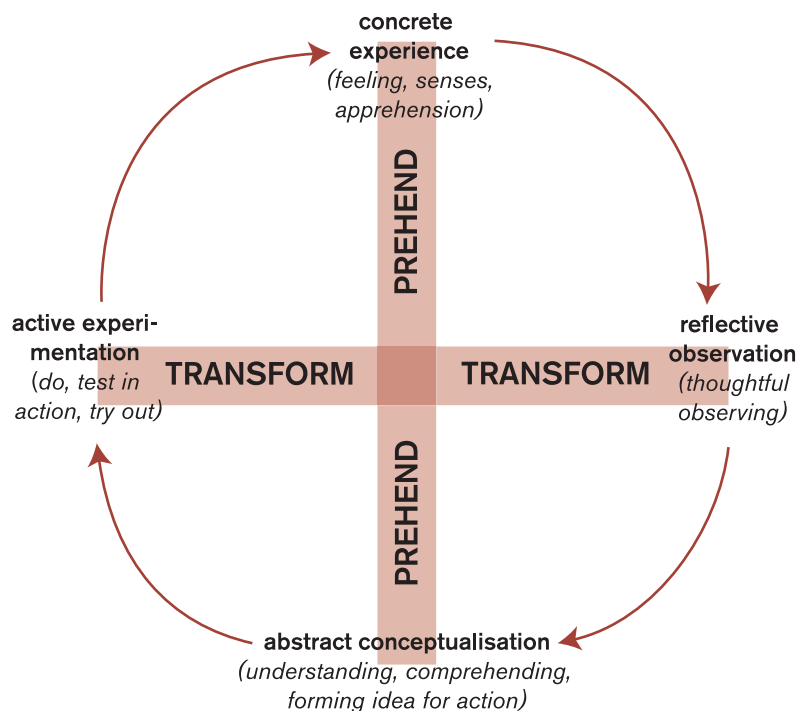


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A glimpse of the operator's learning process can thus be found in a situation of disturbance handling. He stands besides his milling machine. The machine runs automatically and the metal parts produced are lifted away by a robot. Suddenly he sees that the robot arm has stopped in an odd position. He ponders this occurrence, realising that the same thing has happened several times lately, which makes him identify this as something that might require action on his part. He has an inkling of the reason: he thinks that it has to do with metal shavings from the milling disturbing the sensor which signals to the robot. Thinking about this he develops a comprehension of the problem and forms an idea for action. He cleans the sensor, re-starts the machine and finds that the robot moves normally. With this new concrete experience he continues to work. In describing this work we have also described a piece of learning where the operator has now added an experience that gives him a better basis for action next time a similar problem occurs.

Through thought networks, perceived characteristics of a situation (e.g. a situation of problem solving, production disturbance handling) are linked to action, and to the judgements and decisions needed for an individual to find an action path. The thought networks can be described as situation-connected reasonings that are more or less alike in similar situations. Such likenesses give thought networks stability and durability,

although – at the same time – they are continuously modified and developed through the person's thoughts and actions. To summarise, thought networks manifest themselves as action alternatives, and are tied to the situations in which they are constructed and re-constructed. Experiential learning takes place as the constructing of these networks.

Several authors have related learning to life span development. Mezirow, for example, speaks of transformations that follow a disorienting dilemma and result in “a reintegration into one's life on the basis of conditions dictated by one's new perspective”. Our particular perspective tends to inform our actions in ways we are not fully aware of. Transformation of these habits of mind and points of view is a painful process:

“Our values and sense of self are anchored in our frames of reference. They provide us with a sense of stability, coherence, community, and identity. Consequently they are often emotionally charged and strongly defended.”

In giving an overview of the theory of transformative learning and how it has been used in practice Wilhelmsen states that the explicit purpose of transformation theory is

“to be useful for adult educators whose goal is not only to teach a subject but also to assist the development of their adult students' capacity for living in a complex and dynamic society.”

Over time, individual development is affected by task execution and individual task definition. One can say that behind the situation-related thought networks, there are long-term individual ways of understanding (habits of mind), that are more consistent over time and do not vary according to situation. In, for example, a

machine operator's handling of disturbances to production, his habit of mind affects his way of defining and dealing with his work task. Such habits of mind are not one-dimensional. They can be thought of as built along a number of dimensions, each of which can be seen as a continuum for possible development. In a study of operators' disturbance handling in automated production, a number of dimensions of importance for the mode of performing the work task were identified, Figure 8.3.3. For example, operators' ways of thinking (their habits of mind) about production disturbance handling varied with the extent to which their thinking was dichotomised or process-like; on a scale from frozen statements and truncated explanations, to the operator having related explanations and insight into active use.

### COLLECTIVE AND ORGANISATIONAL LEARNING

Nancy Dixon states that “collective meaning is meaning that organizational members hold in common. These are the norms, strategies and assumptions that specify how work gets done and what work is important to do”. Learning as a collective process means that individuals learn together through some kind of interactive and communicative action. This is a learning process that creates added value through synergy, whereby what is learnt becomes qualitatively different from what any individual could have arrived at unaided. Further, collective learning results in shared knowledge, in a similar understanding of something specific, and – grounded in this – a capacity for joint action. Knowledge that is jointly produced has a more stable character than knowledge produced individually.

Within all teams and organisations, individuals are the ones who learn and carry their knowledge forward to the next situation and

next task, to other specific environments and meaning contexts, and to meetings with other individuals. We learn together, but learning is always grounded in the understanding carried by each one of us. However, this is just one side of the coin. It is equally important to stress that knowledge resides in the relations between experienced people. The latter implies that competence is not entirely individual. A person's know-how is often richer, easier to use and expand, and better maintained and developed when s/he has access to other equally competent persons. Thus

in order to enhance learning in an organisation it is necessary to deal with these two aspects of knowledge – individual luggage, with its pros and cons, and the relational aspect.

Sharing and expanding knowledge

The sociology of knowledge concerns common-sense knowledge, i.e. “what people ‘know’ as ‘reality’ in their everyday lives”. When Berger and Luckmann describe the reality of common sense they refer to the actor's, the individual's, interpretations of a reality that s/he takes for

Non-reflective, routine way of thinking	Reflective, problem-solving way of thinking
<ul style="list-style-type: none"><li>• Dichotomised thinking, either/or, see no alternative</li><li>• Pose oneself no questions, no pondering; thought processes rapidly come to an end</li><li>• Frozen/petrified statements, truncated explanations</li><li>• Do not think ahead</li><li>• Controlled by external demands; wait for external changes</li><li>• Take things as they come, no anticipation</li><li>• Wish to achieve approved production standards</li><li>• Perceive faults as interruptions to routines, as a change/as breaks</li><li>• Few stories related to disturbances</li></ul>	<ul style="list-style-type: none"><li>• Think in terms of variables, processes and alternatives</li><li>• Ponder, reflect, ask oneself “How?” and “Why?”</li><li>• Have related explanations and insights into active use</li><li>• Future is present in ideas and thoughts, plans of one's own</li><li>• Controlled by internal demands of one's own and by goals; not dependent on external changes</li><li>• Quality assurance, influencing stages of operations both before and after one's own</li><li>• Aim to produce quality in excess of formal requirements</li><li>• Perceive faults as interesting problems to solve</li><li>• Masses of stories related to disturbances</li></ul>

Figure 8.3.3. Development makes a difference – machine operators' ways of thinking (habits of mind) concerning disturbance handling. Selection of a number of dimensions characterised through their end positions.

granted. No two people have the same personal histories or experiences of life. The idea that knowledge comes with experience will thus by definition imply that one person's knowledge differs from everyone else's, to a lesser or greater extent. These are valuable differences. Multiple perspectives and shifting nuances are often fruitful.

However, the differences also quite often result in that what one person holds to be true and valid seeming questionable to another. There is a problem related to individual knowledge in the sense that people easily believe and act as if one's own knowledge and know-how were the truth – instead of realising that it is rather one's own perspective. Thus the development of shared and joint knowledge requires an openness and an ability to reflect and when necessary accommodate, change one's own world views and habits of mind. In an organisation, then, individual experience is very useful and all the same has to be overcome to a certain extent in order for knowledge to become shared and collective.

The term “collective” does not imply that everyone in an organisation entertains exactly the same meaning; rather, it refers to an understanding that is close enough in order for members of the organisation to function as if they were in complete agreement. However, as Dixon points out, significant differences between persons are commonly found when collective meaning structures are examined closely. “Meaning structure”, the term Dixon uses, comes close to what in this chapter have been called cognitive structures and thought networks. She also stresses that many collective meaning structures are tacit, and that they are changing slowly as a consequence of day-to-day activities. By contrast, accessible meaning refers to the structures that an individual is willing to make available to others in the organisation. Accordingly, here lies the

open, and thus more useful connection between the individual and the organisation when new ideas are to be introduced and changed ways of working are needed.

In a changing world, collective meaning can have a negative impact on an organisation in that the organisation may not realize that the collective meaning it holds is dysfunctional. For example, collective meaning that was advantageous for a company during a certain period can become obsolete in a rapidly changing world. In such situations there is a need for making the collective accessible. It is also not uncommon for people who want to implement change on others to try to communicate with those other people's non-existent meaning structures, i.e. with thought networks that, for one reason or another, people have not (yet) developed. Such communication is doomed to failure.

Transformative collective learning is a process where participating individuals get access to others' ways of understanding. According to Wilhelmson, collective learning is seen when group participants broaden, shift and exceed their individual perspectives. Transformative collective learning entails the transcending of the individual perspective in that the group forms a new and, at least for the moment, common understanding. In Piaget's terms, this could be understood as a kind of collective accommodation.

There is reason to stress the importance of conversations and group dialogues for the accessibility and development of knowledge and understanding in an organisation. When work demands that people take part in and make sense of changes, the development of dialogue competence is of special value. In learning dialogues it is possible to access understandings through people making their different perspectives visible. Dialogue competence is thus not a personal trait, but a capability that comes with practice.

Dialogue is different from discussion and also something more than and distinct from ordinary talking. Dialogue meetings are not the same thing as ordinary workplace meetings. Dialogue can be characterised as a conversational ideal to strive towards, an ideal implying that the people taking part consider each other of equal value and each aim at developing their own and a common understanding. The point of departure for learning group dialogues is the fact that every participant has experiences that to some extent differ from those of the other participants. These differences are the ground for and idea behind organising group dialogues (e.g. at a workplace), but also its difficulty. Our varying experiences mean that everyone contributes a different truth to the conversation.

### **Cultivating competence-bearing relations**

Every workplace has processes that carry workplace know-how and competence. These processes can be seen as ongoing relations between persons. Apart from individuals carrying their knowledge between different contexts, the know-how of the workplace is accessible, arises and remains in the interstices, i.e. in relations between people. In a competence-bearing relation an individual is more able than he would be on his own. The presence of and actual access to one another increase and preserve the know-how. Thus there is a lingering knowledge which resides in having recurrent access to other sense-making and competent actors, i.e. to the work-mates one has thought, worked and experienced with and who thereby know what words, allusions and solutions stand for. Having workplace history in common means that people possess shared and lived answers to the reasons for the way in which things are carried out at the workplace.

If management one-sidedly views knowledge and competence as individual attributes, this

### **How to arrange dialogue meetings**

When people meet, dialogue develops spontaneously. Listening and talking about our own experience is how we learn from each other and develop shared conceptions. Why are so few encounters of this kind to be seen in the workplace?

Dialogue requires time and trust. The arrangement of dialogue meetings where people can train their dialogue competence requires planning concerning choice of topic and rules on how to talk. Briefly, a room is needed where people can sit in small groups of five. A leader presents the rules and content to the whole gathering. The rules in brief are: Pass the word around in the group. It is everybody's responsibility so see to it that everyone speaks. The topic chosen must concern a question that is relevant to all participants and to which there are no right or wrong answers. A question concerning an issue that the group can investigate a bit deeper and develop some common understanding around.

A constructive structure is to start by letting each and everyone of the five participants to one another express their own point of view of the way something ought to be (e.g. among hospital staff it could be "what is good treatment of patients in our hospital?"). The second step is to investigate impediments to achieving this, and the third to look for things that enhance and facilitate progress in the desired direction. Finally the group can write down a few points that the members agree upon, and present them in plenary session.

might threaten an organisational change process, because with such a view the ability to ask the useful and effective questions concerning how to organise for the knowledge that resides in the relations may be lost. Continuous use of this relational knowledge calls for the cultivation of competent relations – in contrast to what is very often the case when managers and change agents re-sort people as if they were inanimate objects. Skilled individuals are then deprived of part of their competence, since interactive processes and knowledge transactions are the backbone of the organisational competence.

### CONCLUDING REMARKS

One important conclusion to be drawn is that a vital connection exists between life span/width development and the learning that occurs within work-task-related everyday experiences. Further, learning and development – in their accommodative and transformative natures – are not to be reduced to easiness and simplicity when in process. Although the outcome is often positive, the processes of changing ways of thinking and transforming habits of mind are at times demanding, and may be associated with shakiness, crisis, pain, and even chaos, if the learning challenges basic values and ways of understanding. For example, leaving existing work tasks and related competence in order to take on new tasks might feel like sitting in a rowing boat when a storm is brewing, before regaining and walking on *terra firma*.

To act competently and to assign meaning to the world we live in, i.e. our contemporary societies, requires people not only to understand and learn in the actual physical and social setting, the specific community of practice. Siebert stresses the need for “a meta-cognitive capacity to observe how we observe, how and on the basis of which leading differences we construct real-

ity”. The work of managers and OSH-experts is definitely facilitated by an understanding of individual and collective learning processes, by knowing how changed points of view, revised stances and expanded know-how come about. Such knowledge provides a ground for believing in and daring to practice participation, introducing production teams, leading understanding and sustainable organisation development. This knowledge of learning processes is clearly relevant to have in mind when dealing with occupational prevention and making decisions concerning e.g. safety issues.

In order to connect learning to occupational safety and health issues, it can be stated that to a large extent risk, and safety, is constructed when people are not at all consciously dealing with it. It is in reality constructed in working, when focusing and carrying out one’s ordinary work tasks. When individuals and work teams are increasingly supposed to function with responsibility and autonomy, this calls for knowledge of learning processes and an ability to manage conflict between learning and control logics – issues discussed in “Constructing workplace safety through control and learning – conflict or compatibility?”

If learning in working at the collective and organisational levels is of importance for enterprise development, e.g. when adjusting business to changed external demands, then how can conditions supporting such learning be enhanced?

One answer to this lies in job enlargement and enrichment, which creates opportunities for more problems and question marks to solve and learn from. Variation in work tasks and communication around them makes it possible to identify differences and deviations. Another type of answer is that such favourable conditions have to be created locally through involvement and participation. To start with some small and con-



crete changes to the work environment might for example invite workers to engage in fruitful collaboration. The other chapters in this section provide aspects on work organisation, leadership, gender and team work strategies that are all in tune with the views on learning here presented, and can thus be used as inspiration for organising for a more learning organisation.

Peoples' habits of mind are not changed over night – these kind of changes, e.g. where workers are asked to broaden their work tasks and responsibilities, to be involved mentally take time. Thought networks and habits of mind are stable, even conservative structures. Albeit amenable to change.

# Managing understanding – a new leadership challenge

*Jörgen Sandberg & Axel Targama*

Managing change and development in organisations is an important part of managers' work. Typically, managers adopt a top-down approach in the sense that it is they who plan what change and development should take place and how it should be implemented. More specifically, with support from administrative specialists and consultants, managers formulate specific rules and instructions about work, which they impose on their staff, through a hierarchy of authority and responsibility. A major problem associated with the top-down approach is the resistance frequently offered to change. Despite the use of expensive and sophisticated techniques to inform the employees about a change, many employees seem to resist the proposed change and go on working in much the same way as before.

This chapter is about the new leadership challenge of managing understanding. To manage understanding, leaders must cease managing through rules and formal instructions. Instead leadership means leading via people's understanding of work and work tasks. The text aims at providing insights and ways of reasoning, rather than giving hard facts and concrete advice. The following will be treated:

- Participative development
- Understanding: The basis for action
- The case of competence in engine optimising
- Managing understanding

## PARTICIPATIVE DEVELOPMENT

Formal authority and positional power can be used to implement new systems and structural changes. Employees may resist the changes and be unwilling to learn the new procedures. But if a new accounting system has been implemented, you cannot go on working with the old one. If the office has moved to a new place you cannot go to the old one. But when we talk about behavioural changes – concerning customer focus, service, quality, employee relations etc. – the manager is completely dependent on the deliberate actions taken by the employees. If they do not change their everyday actions there will be no change at all.

During the last two decades, the top-down approach has also been heavily criticised by both practitioners and researchers as being inadequate for managing people effectively. The main reason derives from the comprehensive socio-

economic changes taking place in society today, such as rapid technological change, more knowledge- and service-based industry and intensified global competition. These changes require modes of organisational management that promote a high degree of flexibility, customer orientation, quality, efficiency, worker empowerment and ongoing competence development. With these new requirements, the top-down process has been shown to be too rigid and inflexible, and managers are searching for methods of managing people that will facilitate competitive renewal and growth.

This has caused organisations to try more participative management approaches strongly focusing on competence development, and the permission of more individual freedom and local independence at work. Participative approaches to management emphasise that the initiative to develop and improve the business is considered to be a question not only for managers and experts but also for operative personnel. A participative approach requires managers at all levels to be able to cope with problems emanating from leading development processes where many people are actively involved and where the manager will be teaching and coaching rather than dictating.

#### UNDERSTANDING: THE BASIS FOR ACTION

A more participative approach to management means that subordinates will solve problems and take actions on the basis of their own analysis and judgement. Their judgement will not only be based upon existing facts and given circumstances, at least not the ones the manager would consider as given. Instead, the employees will be judging and acting on the basis of their *understanding* of the situation and the tasks. Research such has also shown that people's work perform-

ance is not based upon some form of external stimuli such as instructions on how work should be done. Instead, people's work performance is based on how they understand those instructions and their work in general. Hence, in order to have an impact on employees' work performance, managers need to find ways of influencing employees' understanding of their work.

What, then, is "understanding"? The term does not signify a particular kind of knowledge or skill but, rather, what something means to a particular person. For example, the expression "a person's understanding of work" does not primarily mean that person's particular knowledge of work. Instead, it signifies what the work means to the person, what the work is about. Often our understanding of reality is so much a part of ourselves that we have problems describing it. It is just how things are. An outsider can of course analyse our understanding of work and identify a range of different ways of understanding one and the same work. But the individual is embedded in his understanding of his everyday work, and does not look upon it as just one way of understanding. Understanding of reality can be described as *the basis* for our actions and judgements. It provides us with intuitive answers to questions such as: What is it? What's going on here? What is it all about? How understanding operates in daily life can be illustrated with a few simple examples.

A professor was invited to give a series of guest lectures at a university in the former Soviet Union during the early transition phase away from communism. He knew that the students were eager to find out how business was done in the Western world. But he was disappointed by their general attitude. To him they seemed uninterested and totally passive. But to his surprise he received a comment from a student saying: "This is very interesting. You really seem

to mean what you say”. When analysing the above case we can see that the visiting professor’s and the students’ different expectations and behaviour are related to their specific understanding of what academic teaching means. The professor had experience from Swedish universities and saw lectures as an effort by a teacher to explain ideas and concepts, thus helping the students in their learning process. The students’ understanding of what a lecture is about had been shaped by experience of professors who were obliged to discuss all matters within the framework of Marxist-Leninist ideology. Students knew that this was something that *had to be said*, and they knew that the teacher had the same view. They understood a lecture as a kind of ritual, where the teacher preached the dogmas. They had to participate, but nobody took it really seriously.

In the middle of the 1980s a large IT company was developing software and providing IT service. The personal computer (PC) was already around at that time, but its capacity was still fairly restricted. The PC was a recurring topic during coffee-breaks, and it became clear that the software specialists had a *common understanding of what a PC was*. They made sense of it as “a smart typewriter, a game toy, a simple tool for customer listing etc.” These experienced software engineers never thought of producing administrative software for PCs. “Everybody who knows something about computers must realise that the PC will never play any role in administrative data processing at company level”. Who then started to develop administrative software for PC? It turned out to be a generation that had been playing with the PC as teenagers. They tested the capacity of the PC to the ultimate limits and learned everything about its technology. They *understood* the PC in a different way – as a promising and rapidly developing

technology of the future. While the above IT company no longer exists, the teenagers have become managers in the PC and server-based IT business of today.

The example teaches us that *understanding is an experience-based interpretation of reality*. It shows that understanding guides our observations, judgements and actions and controls what we notice, how we interpret our actual experiences, how we explain things and make sense of them. How our understanding of work forms the basis for the way we perform work can be illustrated by an empirical study of what constitutes competence at work from the car industry.

### THE CASE OF COMPETENCE IN ENGINE OPTIMISING

Traditionally, competence is regarded as a set of knowledge and skills possessed by a person in relation to particular work. However, a study of technicians at the Volvo Car Corporation in Sweden showed that competence is not primarily made up of specific knowledge and skills. Instead, knowledge and skills used at work are based upon *understanding* of that work.

More specifically, the task for the group of approximately 50 technicians (called engine optimisers) was to develop engines for new models of cars. Engine qualities (e.g. emissions, fuel consumption and performance) were optimised by adjusting various interrelated parameters within the engine’s electronic control system, such as its fuel and ignition systems. Engine optimising is thus a fairly complex task.

Despite the fact that all optimisers carried out the same kind of task, it turned out that they showed decisive individual variations in the way they *understood* what they were doing. This in turn was influencing the result of the optimising. Three different ways of understanding engine optimisation emerged from the study:

1. optimising separate engine qualities,
2. optimising interacting engine qualities or,
3. optimising the engine from the customers' perspective.

Within each way of understanding, it was possible to distinguish a number of fundamental aspects constituting the competence in question. Optimisers with type 1 understanding organise optimising into a stepwise activity, and within each step optimise one specific engine quality at a time. Type 2 understanding instead means focusing the relationships and interdependencies between engine qualities, and thus implies taking all engine qualities into consideration within each step. Finally, type 3 understanding includes the consideration of interdependencies, but focuses the relation between an optimised engine and how customers experience driving. Thus, the results demonstrated that particular ways of understanding optimisation work meant qualitatively distinct ways of delimiting certain attributes as essential and organising them into a distinctive structure of competence in engine optimisation. Hence, the workers' *understanding* of optimisation work could be said to determine what knowledge and skills were used by the workers in engine optimisation.

As Sandberg pointed out, these results provide an alternative answer to the central question of why some perform better than others. The variation in work performance is not first and foremost related to a specific set of attributes possessed by those optimisers who are regarded as most competent. Instead, *why some perform better than others is related to the variation in their ways of understanding the work.*

Moreover, if understanding of work defines what competence is developed and used in work performance, competence development then

involves first and foremost changing one's understanding of work. In other words, the most fundamental form of competence development would require one to be able to understand 'the same work' in a qualitatively different way. For instance, if workers with understanding 2 were to develop understanding 3, they would have to change their understanding of the work from "optimising interacting qualities" to "optimising from the customers' perspective".

### MANAGING UNDERSTANDING

The insight that understanding of work defines the specific knowledge and skills that are developed and used in work performance does not only have far-reaching implications for developing competence. It has also fundamental implications for how we design and conduct managerial activities with the purpose of improving work performance more generally. Instead of managing people by imposing detailed instructions and rules about how to accomplish tasks or by specifying details about the outcome of the work assigned to employees, managers need to *influence people's understanding* of the business and their work. When managers, for example, introduce the balanced score card as a tool for developing operations, the outcome of that effort will depend upon what development initiatives the employees will take in working with the score-card. And *people act according to their understanding of the reality* – in this case the essence of the system and what it means to use it. This implies that when managing by understanding, managers cannot only rely on their traditional positional power. Their role begins to resemble that of the teacher, i.e., to influence other people's understanding of something. Just as in education, people cannot be made to rethink and replace their understanding as a result of receiving orders. Learning is an active process on behalf of

the learner, and thus needs to be comprehended according to this logic.

Probably the most common mistake in development work is the one where a manager has been working on an issue such as a new strategy or an introduction of a new information system for some time, discussing with consultants, reading articles and reflecting on it now and then. Finally, the manager has developed a set of ideas that, according to him/her, represents a consistent and meaningful package of new thoughts on an important problem. This package is then presented to the employees, and the manager expects them to make sense of it in the same way as the manager him or herself. This is probably always a far too optimistic view. Every person must reflect upon the issue, discuss it with others and finally develop views that are integrated into his or her understanding of the situation. There is no easy shortcut to this. On the other hand it is not impossible. But managers must learn that managing by understanding can be achieved, not by telling people how to think and act, but by *creating conditions and practices that stimulate people to investigate, reflect upon and perhaps change their understanding of reality*.

Managers have traditionally been used to exert influence by the use of words. They try to produce elegant rhetoric in order to persuade people to think in new directions. But from the above analysis we can see that just presenting information – however well-prepared and elegant – will not lead to a change of understanding among employees. The manager is only presenting the raw material that employees could use in their reflective thinking and their discussions with each other. At best the manager will create curiosity and trigger a more active search and processing of information.

Dialogues represent a verbal process with much more strength in developing and changing understanding. In a dialogue people must show their cards and this means that you reveal essential parts of your present understanding to others, and this makes you vulnerable to influence. But this is the case also for a manager. Using dialogues means that managers must be open to revise their own understanding in the process of trying to influence others.

Since understanding is primarily experience-based, it follows that the natural way of impacting on people's understanding should be to provide opportunities to make experiences that trigger reconsideration of present understanding. One approach could then be to make employees participate in activities where they are encouraged to discover their own understanding, and this will normally require some help from outside. Staff development using group dynamics can be seen as a method representing this approach. For instance, team leaders are invited to participate in group exercises which are designed to provoke critical actions from the participants in their different roles. The participants then join in analysing their experiences from the exercises, and such experiences can have a heavy impact on people's understanding of themselves as leaders and of leadership as such. When understandings have been made explicit and people are aware of them, it is possible to work in a more rational manner to scrutinise the existing views and engage employees in the development of new forms of understanding work. It takes time and effort, but it works. It requires, however a climate of openness, honesty and confidence as a necessary background for the participation efforts. In positive cases these qualities also improve as a side effect of participative change efforts.





# Organisational development and gender integration

*Martha Blomqvist*

Women's work is of critical importance not only for their social, economic and political empowerment, and for family livelihoods, but also for economic efficiency and the sustainable development of society. All over the world, jobs are segregated by sex. The segregation may seem innocent enough and actions taken to weaken it are sometimes ridiculed. Nevertheless, it is a cornerstone in the uneven distribution of power and economic resources (The United Nations' Beijing Declaration and Platform for Action, 1995). Women's work conditions are typically more unfavourable than men's. To the extent that the inequalities are internal to the work organisation they can also be taken measure against at the organisational level.

Current changes in work organisation and technology present both threats and opportunities for an improvement of the situation. This chapter deals with a key aspect of change – integration of work tasks – which may be used to open up some inequalities. Below the concept of sex refers to the biology of a person. The concept of gender is wider and covers also the socially constructed roles, status, expectations, and relationships of women and men. Gender as

a social construct thus refers to what culture and society make of the biology.

## INTEGRATION OF WOMEN AND MEN AT THE WORKPLACE

Integration of work tasks is an often-described element in organisational change, presumed to have an impact on workplaces in most industries. The changes are part of a rationalisation strategy and thus motivated by corporate interests.

Nevertheless, this kind of change is also for the better for many employees. Horizontal job enlargement means more varied work tasks, making work more interesting and many-sided. Vertical job enlargement means that traditional white collar tasks, mostly from supervisory level, are led downward. Most forms of job enlargement – vertical or horizontal – also mean a reduction in one-sided musculo-skeletal strain. Integration of work tasks may therefore mean improved working conditions, for women as well as for men.

With the integration of work tasks the division of work is changed. Where both women and men are involved, the sexual division of work may also be affected. However, in highly gender-segregated

industries integration of work tasks cannot influence the division of labour based on gender. Men represent only a very small number of those working in people-related services; women are underrepresented in many areas of goods production. In these areas gender-segregation itself makes integration impossible. Sometimes, however, integration includes women's as well as men's tasks and thus both women and men. When job rotation or job enlargement involves both women's and men's work the reorganisation thus has the potential also to decrease the gender segregation.

### RESISTANCE

The presentation of the Indo Asian case does not comprise information about any difficulties related to the integration of men and women. Bringing together men and women to collaborate, co-operate and interact seems not to have caused significant problems. Research on similar re-organisations in a Swedish context does however show that changes including integration of women and men are very likely to meet with resistance. Studies report on employees opposing the change, on men as well as women reluctant to take on the non-traditional work tasks or to accept men doing what used to be women's work and vice versa. Men's manual work is traditionally on average heavier than women's and is understood to demand more technological knowledge, whereas women's work more often is repetitive and/or involves care-work or tasks connected with housework. The resistance arises when women and men are expected to cross these traditional gender lines of work tasks. Many women hesitate to take on heavy work, even when labour-saving devices are available, and they say they feel insecure with the technology. Men often maintain this understanding by claiming that only men are fit to do the heavy work, that the labour-sav-

ing devices are problematic to handle or do not function anyway and that learning to manage the technology is difficult for women. They claim that they themselves cannot do the women's work because their hands and fingers are too big, because they do not have the patience of women or because they find it impossible to do monotonous work or to work in a stationary position. Women, however, do not typically object to men entering their work.

Though there definitely are differences between the sexes as regards physical strength and deft with one's fingers, these are average differences, explaining only to some extent the gendered division of work. They are certainly not related to patience or to tolerance of repetitive work tasks. Neither can the differences in physical constitution explain men's many times rigid refusal to turn their hands to women's work tasks. The resistance encountered by efforts to integrate men and women becomes more understandable if we analyse it in terms of the status of work tasks and gender identity.

The definitions of women's work and men's work mostly involve differences in status, in pay and in career opportunities, all to men's advantage. Taking over women's tasks therefore often means that men suffer losses in status. Women engaging in men's work are likewise assumed to lower the status of men's work. Considering the status of the work makes men's resistance more understandable and even rational. Women's doubts about doing men's work can accordingly be understood as an unwillingness to challenge men's status. Gendered aspects of work further constitute an important part of male and female identity. Men's and women's behaviour and activity at work reflect and affirm their gender identities. Situations challenging traditional work tasks may therefore be very threatening to women as well as men.

## AVOIDING RESISTANCE

Due to the resistance the integration process is sometimes interrupted altogether, more often it is narrowed, i.e. including fewer employees and not as many work tasks as first planned. When carried through as initially planned a new reorganisation sometimes follows, in fact just establishing the previous order. However, not all attempts to integrate women and men end in failure. When men and women workers are socially integrated from the start, a further integration is fairly easily accepted. Stereotypical understandings about women's and men's capabilities and traits do not then have much strength. A male building caretaker gives an account of his thoughts about having to do staircase cleaning, formerly done by women only.

"It is not much fun. If I did not have to do it, I would rather not, I think ... But then one has to think about them too. I mean the womenfolk. It is good for them to be let off some of the staircase cleaning. It is fun for them to be outdoors and do all the things we do. It is good for them. Yes, it will do, it will do."

Though men and women at this workplace used to work separated from each other, they have for years on a daily basis had coffee and lunch together and therefore know each other fairly well. Feelings of solidarity and respect are developed, leaving little space for stereotypical understandings of gender.

Now and then the integration of men and women is accomplished in spite of vigorous protests. This presupposes that management acts very decisively, making it clear that no concessions are to be made, leaving employees with no choice but to accept the change or to quit the workplace.

In most cases though, neither is the climate at the work place characterised by men's solidarity

with women, nor is the management prepared to totally neglect the employees' views in the matter. The gurus of management philosophy are of little help. Some of them acknowledge the employees and their behaviour as significant for a successful change and underline the importance of paying attention to it. Some bring up the question of employees' resistance to change. None of the renowned authors of this genre, however, mention resistance caused by challenges to the gendered division of work. Its consequences are thus altogether overlooked in these fashionable recipes for organisational change.

## WAYS OF ACTING

One way to foresee and prepare for the resistance, and to make it possible to avoid some of it, is to map the gender structure at the workplace prior to the launching of the change. Such mapping should include a detailed survey of the gender division of work, of the jobs' informal status, of pay, of working hours, of technological knowledge and physical strength needed for different tasks and also of inclusion of care work, of tasks connected to housework and of monotonous work tasks. This map can then be used to identify possible points of conflicts and thus of resistance likely to arise.

As in all change processes, an open dialogue and detailed information about what is planned to happen is essential. Individual talks with employees believed to be particularly vulnerable and threatened by the integration of gender specific work tasks may be motivated. An obvious step is to attend to the ergonomic conditions and see to it that the design of work equipment, table heights etc do not form obstacles. Extra training for some employees may be called for in order to increase their self-confidence and skills. The wage system, mostly disadvantageous to women, often needs adjustments to make men's and women's work of equal worth. Women's

generally heavier family responsibilities must be considered when new working hours are introduced. In some cases it may be a good idea to set an example by first launching the change on a small scale, selecting for the work employees held in good repute, known to be open-minded, and likely to accept the change and to understand its long-term benefits. In other cases it may be better to introduce the change little by little over a longer period, making it possible for men and women to get to know each other, thereby weakening possible sexual prejudices and stereotypical understandings.

### WHY BOTHER?

What is the point in avoiding resistance? Is it worth the effort? Why not simply accept and respect the employees' wishes, adapt the change to their points of view, and see to it that gender-segregation is not challenged? First, adjusting to the obstacles means delimiting the work tasks included in the job enlargement and thus restricting the flexibility of the production process as well as improvements to working conditions. Second, integrating women and men means increases in equal opportunity.

Third, even modest changes are important if they challenge the gender order, i.e. the systematic division of the sexes and the subsequent subordination of women. Such changes make it obvious that gender is a social construct, thereby making other arrangements visible. A women worker recalls a gender challenging event that took place decades ago, and which since has affected her thinking:

"I remember once, it must have been twenty years ago, when there was one person missing and we made a joke with a guy, saying: 'Listen Peter, why don't you sit down and assemble components.'" "All right", he answered, and sat down and did it. "Ooo, Peter is assembling components!", everybody said. It was so incredible that a guy could do it. Yes, (since then) I have always believed that a guy can do it, as I knew Peter could. I believe that everybody can."

What by the time seemed like a funny episode has had significant implications for this woman's understanding of women's and men's capacities.

Finally, it is often assumed that integration of women and men in work increases productivity, that teams made up of both sexes are more efficient than other teams. This idea, following the managerial diversity argument, is, however, a matter of dispute. Available quantitative empirical evidence has been shown not to be very valid. On the other hand, no claims are made that gender-integrated teams would be less efficient than gender-segregated teams. Further, the idea tends to come close to arguments about fundamental differences between women and men, giving rise to doubts among equal opportunity staff, feminists and gender politicians in general.

Nevertheless, even without this argument, it is obvious that integration of women and men at work can be economically as well as democratically motivated.

## Strategies for change and team work

*Gunnar Broms*

This chapter discusses the process of change and the development of teamwork at the workplace, including strategies which encourage workers' participation, the creation of supportive environments for teamwork and methods of organisation for teamwork that can increase production and learning. The chapter also emphasises the ways in which OSH can be developed during a process of organisational change.

Before undertaking a process of change, it is crucial to examine the culture, history and current situation and challenges of an organisation as the basis for all decisions. While all organisations are unique, much can be learned from the experiences of others and we can be inspired to adapt these to our specific conditions.

### **PARTICIPATORY STRATEGIES OF CHANGE**

Most industrial companies have realised that in order to compete both nationally and internationally they have to develop their production to meet the challenges of competition. Change is nothing new. Production is constantly changing. But what is sometimes needed in order to meet new challenges is a break with the everyday evolution of the production system. Change might have to take another direction and will

thus be felt to be more radical than the so called normal changes of production. In order to give the process of change a new direction and to be successful you need to create conditions whereby the employees of the organisation can be convinced to become engaged and take an active part in the process.

An empirical study was made during the mid-1990s of the effectiveness of their change strategies in 69 Swedish organisations. The study concludes that so-called Learning Change Strategies are more successful in achieving effectiveness than Programmatic Strategies.

The learning change strategy was defined as one driven by vision, based on communication between top management and employees. This strategy involves different ways of sharing experiences and problem solving both within a function, between functions and between employees and management. Characteristic for this approach is the active involvement of the whole organisation. A programmatic strategy was defined as one driven by external examples, based on standardised concepts and methods and carried out in formal projects involving experts and having a demarcated focus.



Many changes are started without putting them into the context of the company development as a whole. This often leads to sub-optimisation, for example focusing on reducing the cost of maintenance, without looking into the consequences for the availability of the production machinery. Another example is reducing cost by reducing the number of product variations, which might lead to the loss of customers.

A learning change strategy aiming at involving the personnel at all levels starts with the development of a shared view of the needs of the company. A shared view is achieved by involving the personnel at all levels in the analysis of the current situation within the company regarding organisation, technology, efficiency, work environment etc. The current situation then has to be related to the external demands on the company and to a vision of the role of the company in the market. The company vision – often expressed in documents such as the mission of the company – has to be transformed and completed into development targets accepted and understood by the majority of the organisation.

The targets should ideally incorporate the perspectives of customers, owner/s and employees. Involving persons representing different interests, knowledge and experiences in the process of analysis and development is a good way of ensuring that important perspectives are not overlooked. Furthermore, it is important to involve as many as possible in the organisation during the process of change to give room for understanding and a more or less shared comprehension of the current situation and the challenges. All this adds up to an excellent framework for change. With this platform, change projects can be started focusing on relevant areas or aspects of corporate activities. Each project or work of change should always be relatable to the

overall vision, and information about the activity should also be spread to those that are not directly involved. Such openness gives less room for speculation and misunderstanding, which otherwise could easily impede the change process or create resistance based on false premisses.

### HOW TO GO ABOUT IMPLEMENTING CHANGE

Introducing new production concepts or other major changes is not easy. Changes are delicate processes. They require mental readjustment on the part of those involved. Many may feel uneasy and fearful. Experience has shown that change in industry needs to address two major aspects: the technical or organisational aspect of the change and the acquisition of support and motivation for the change within the organisation..

First, what needs changing in production? As technology changes, there is scope for significant gains through rationalisation. And not just by making changes of a technical nature. An open-minded analysis highlights causes, effects and possibilities. How can technology, layout, working methods and organisation support each other in the best possible way? What does the production process and the market demand from the work force? Under what conditions can this work be done as efficiently as possible?

Secondly, how are management or project leaders to win the support of the workforce for the work involved in making changes? Active participation in the change process by those concerned is important from a quality aspect. The quality of problem solving and development of ideas and solutions will increase when managers, technicians and workers use their know-how together. Furthermore, involvement is a way to prepare the organisation for the change, which result in turn shortens the time needed for the process of change. Finally, it is

easy to understand that those who have been given the possibility to take an active role in the change process are more disposed to accept and support the change. Such participation also leads to enhanced competence for coping with change which in turn is a good foundation for increasing the pace of future development within the company.

So the two levels of change have to be combined. No matter how technically sophisticated or clever changes in production or organisation might be, if those affected by the change do not understand or believe in the advantages of the proposals, the results will fall short of expectation.

The traditional one-way communication from management to employees is not enough to win the constructive involvement and commitment of the employees. A deeper involvement of workers and middle management in the process calls for new, more pedagogic and creative ways of communication and dialogue. It is therefore of crucial importance to look for a methodology that facilitates active participation by those involved. Physical models, simulations, training programmes and brainstorming are some examples of tools that are efficient in visualising, clarifying and concretising matters that might otherwise be difficult to grasp. Such tools are also useful in order to facilitate the expression and explanation by managers, technicians and workers of their ideas and misgivings. However, these methods must be combined with genuine commitment and a preparedness on the part of project leaders and managers to listen, be supportive and take action in order to see to it that ideas and solutions put forward are realised. The opposite is a situation where the participants feel like hostages in a process they cannot influence.

These methods have been used successfully in Sweden and other countries. Projects carried out by participants in international training programmes provide evidence for this. For example, a pharmaceutical company in Egypt reduced their production lead time by 10 percent; reduced the number of production steps by 17 percent while at the same time achieving radical improvements in the work environment such as reduction of noise and dust and improvement of lighting conditions. In a steel plant in Ecuador, the manufacture of construction elements was increased by 78 percent; the set-up time was reduced by 51 percent and material consumption was reduced by 57 percent.

### Methods for change projects

An illustrative model of the work shop is a practical tool to use when gathering a group of workers in order to discuss matters such as materials handling, production flow, work environment or work organisation. This type of scale model can easily be made from wood, plastic or cardboard, or a computerised three-dimensional illustration can be used. A model helps people to visualise problems and possibilities and changes can easily be illustrated or tested. The model is a democratic tool which gives all participants an equal opportunity to express their views without being trained to understanding flow charts or complicated tables of information etc.

Simulation is another efficient tool which can be combined with a physical model, to illustrate the actual production situation or ideas for improvements, e.g. a group of workers can simulate an event such as a production disturbance in order to get input for discussing boundaries of responsibility or information flow.

Both the above tools aim to access know-how and actively involve personnel in the process of change. A discussion based on a model or a

simulation often reveals obstacles or “hidden” ideas held by participants and presents an excellent opportunity for the project leader or management to take action and support such ideas. Such action and support shows participants that their involvement in the process of change is worthwhile because management is listening and prepared to take action.

A change project constitutes an excellent opportunity for learning. Working together to study problems or to create visions is a form of training for teamwork. If the formal and informal borders of responsibility and control can be crossed during the execution of a project, they can potentially be abolished during normal production as well. During the project members co-operate, express their opinions and ideas, present their findings to colleagues etc, all necessary and important skills for teamwork. Project members become empowered as they are stimulated to take responsibility and initiatives in order to solve problems or improve work operations. A project focusing on a technical change or improving the work environment or designing a new work station, can thus, besides solving the problem, also be used as a good starting point for changing the work organisation.

It must also be stressed that there are situations where there is no room available for the involvement of personnel and where this learning change strategy is not applicable. For example, a new production department might have to be planned before staff are even recruited. It is not always possible or efficient to involve all personnel operationally in the process of change, then a model of representation could be applied. As always there is no single methodology or strategy to suit every problem or change process.

## TEAM WORK – ORGANISING FOR EFFICIENT PRODUCTION AND LEARNING

Teamwork has shown itself to be a successful form of organisation, used in a great number of applications aimed at improving production and working conditions. The idea of teamwork, as defined here, is to integrate tasks such as planning and control in multi-skilled work teams, responsible for a defined production process. This type of organisational model can achieve high flexibility and an efficient, time saving decision-making structure. Tasks such as maintenance, quality control, testing, packing, delivery, material transports, etc. could be assigned to the team.

This is obviously not achievable in one step. While the formal change of the organisation can take place from one day to another, the real change of behaviour in the organisation takes place gradually over time. It is important to begin with the formulation of a vision and a strategy as a basis for the teams to gradually take on new responsibilities or tasks as their competence and experience grows.

### Advantages of team work

*Flexibility* – the members of the team cover different skills that enable them to manage new demands. Production bottlenecks can be solved within the team. A team organisation is also less vulnerable to shortcomings of individuals.

*Improved quality control* – the team is responsible for the output in terms of volume, timing and quality. There is no need for time-consuming and costly external quality control between each production step. Instead, quality defects which cause problems for a subsequent production step lead to immediate feedback and corrective action.

*Continuous improvements* – the solving of obstacles and the actions taken to reduce quality

problems are all part of the process of continuous improvement that naturally emerges from the work of a effective team.

*Efficiency* – human resources and skills are used where they are most needed within the team. That means that slack in terms of waiting time for orders, material or maintenance at each individual step of production is used by the members of the team by taking care of any of the other tasks assigned to the team including administration, planning, maintenance or project work.

*Potential for improved working conditions* – teamwork offers members the opportunity to do a greater variety of tasks, ranging from different manual tasks, control and supervision to administration and planning. Teamwork also affords a lot of social contact. In a team which functions well there is a good balance between responsibility and power of control. All the above factors are important for good working conditions.

### **Difficulties and demands when introducing team work**

*The significance of the psychosocial work environment* – working in a team makes high demands on the social skills of the members. Organisations that move from a strictly hierarchical organisation to a team-based structure, may experience problems with individuals who hesitate to assume new responsibilities, take initiatives or involve themselves in areas that were previously beyond their responsibility or power. Individuals within a team may feel unfairly pressured to perform or assimilate (in the case of newcomers), leading to stress and heavy workloads for some individuals. These demands call for support and regular assessment of the social functioning of teams.

*Resistance from middle management* – middle management often feels threatened by the introduction of teams to which power of decision has been assigned. Often the importance of involving middle management in the change process or assigning them new tasks is neglected.

*Isolation* – teams may grow very strong and self-sufficient, but while this is a positive effect of team organisation, it may also cause problems. It is essential, both during and after the change process, to create contacts, facilitate interaction and stimulate flexibility between teams as well as between teams and support functions. If not, teams may tend to optimise their own performance, neglecting possible negative effects on the overall performance of the organisation. The performance of the individual team must be subordinate to the interests of the whole organisation. Leadership plays a key role in this area.

*The achievement of integration* – resistance to the formation of teams is common when employees from different hierarchical levels or groups that have not previously worked together, are required to co-operate. Resistance to gender integration is another common reaction that might be beneficial to deal with.

### **THE FORMATION OF TEAMS**

The term “team” is used to describe many different ways of organising work. At the shop floor level a team is often made up of a number of workers grouped together to perform a particular function, e.g. to assemble a product from various components. The team members rotate between different manual tasks and can replace or help each other when necessary. This is an improvement both from the work content aspect as well as from the aspect of flexibility and disturbance handling at the production area.

It is not, however, a significant change to the distribution of power of decision and thus does not fully exploit the potential that lies in an organisational change. A more comprehensive definition of a team includes vertical integration of work tasks, not only horizontal. For example, a team responsible for the sub-assembly of a product may also be delegated to do administrative tasks such as planning, follow up, reporting, ordering of supplies or maintenance.

Figure 8.6.1 summarises some important prerequisites if team work is to succeed. The creation of such prerequisites is in turn a process to reach and not a condition present at the start.

*Complete teams* are teams to which have been delegated a complete process, a production assignment. However, there are many names for such teams, including Process Teams, Complete Flow Teams, Cross-functional Teams or End-to-end teams. The production assignment given to the team is defined by describing the team's expected output related to its clients, e.g. producing product  $x$  according to the demands of the clients with a high service level and as cost-efficiently as possible.

#### Important prerequisites

- Balance between responsibilities and decision-making powers delegated to the team
- Well defined assignment involving a variety of inter-related tasks
- Structure and principles for co-operation with other teams and external functions
- A physical production and workplace layout that support team-work
- Complimentary skills within the team
- Support from support functions (e.g. planning, personnel, maintenance) and management
- Clear and well defined targets at team level

Figure 8.6.1.  
Checklist – covering some of the more important aspects to be taken into account when forming teams.

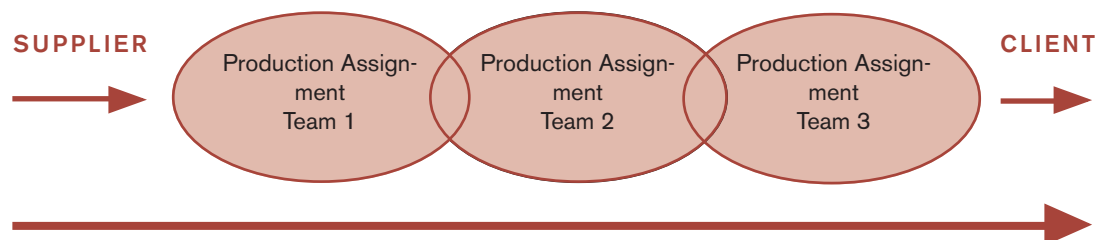


Figure 8.6.2. Serial production flow.

To fulfil such an assignment, a complete team needs appropriate production equipment, human resources and support functions. The team needs to be sufficiently empowered to take responsibility for the decisions and conditions that govern the process. Such responsibilities could include internal co-ordination of the resources, the maintenance of its machinery, quality control, contact with clients and suppliers, administration etc. For practical reasons, a team cannot control all the necessary resources they need as outside support and expertise may be needed, e.g. for training or technical support. However this support should be engaged only when the team demands it.

One Production Assignment may have another Assignment as its client or supplier. The targets of the team is regularly discussed and agreed

upon between the team and the production management.

There is no fixed model for how to compose the teams. Each organisation and situation calls for its unique solution, reached through a process of discussion among all those that will be affected by the change. Some recommendations, however, are to include responsibility for both manual and intellectual tasks within the assignment. The relation between what is performed and taken care of within the team and what is done by support functions should not be static. On the contrary, a driving force and constant challenge to the team members is to acquire knowledge and skills in order to take responsibility for an increasing number of tasks. This gives the team members room for development and learning on the job. An assembly worker may train to take care of quality assur-

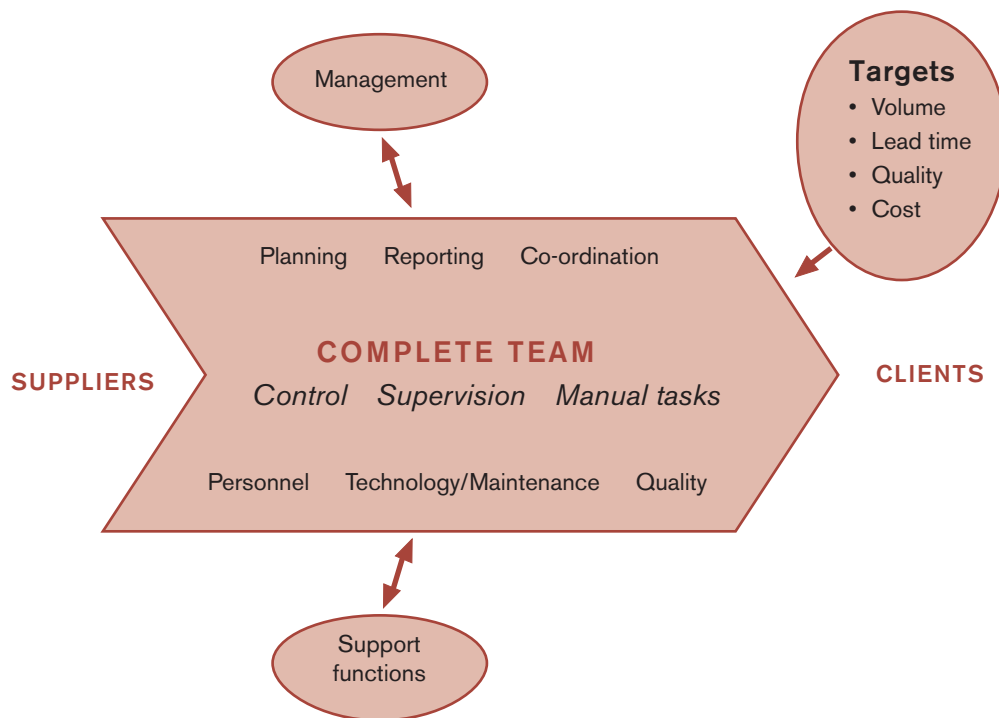


Figure 8.6.3. Complete flow team.



ance, a welder to plan the coming week in order to reach the targets set up, etc.

### **What effects can then be achieved with complete teams?**

The examples are multiple. In a Swedish truck assembly plant the teams have reduced the overall lead time considerably, the quality has improved and the man-hours put into the assembly of a truck has been drastically reduced in comparison to the traditional hierarchical and horizontally divided organisation. What do the workers say? Well, no one would like to go back to the old way. On the contrary, today they are proud to be “truck-builders” and responsible for their team’s production result.

In an electrical component manufacturing plant in India production teams have been formed. This meant a radical break with the existing “rules” of management, based on strict control through a strongly hierarchical organisation. Teams are now responsible for a complete assignment covering supply, welding, assembly and quality control. The team is taking care of its own planning and administration as well. The changes have been a success, resulting in significant improvements in productivity and quality. The changes implemented have instilled a team spirit, with highly motivated team members eager to take part in further improvements. Women and men now work side by side and have gained mutual respect for one another. This latter fact is, according to the manager, perhaps the most important social effect of the change.

A result no less important than the improved working conditions and production improvement, is that the organisations mentioned in the examples above are now more prepared for constantly changing demands. Changes are no longer seen as threats but as natural challenges

to be met in the best way possible. Personnel have through their participation during the process gained experiences that improve their competence of change – this may well be one of the most important skills in today’s ever-changing production environment.

### **CREATING A SUPPORTIVE ENVIRONMENT FOR TEAMWORK**

If the vision of teamwork is to be stimulated and supported to become a reality in an organisation, the technical systems, layout and workplace design, planning systems, training programmes etc. must all be arranged appropriately. When designing new plants or modernising existing plants it is vital to keep this view in mind from the very beginning of the process. The traditional procedure is the opposite; the production facilities are then designed solely from a technical point of view, with no thought for the organisational and work environment aspects.

Teamwork cannot normally be introduced without major changes to the production flow, the shop floor layout and the workplace design. Teamwork including intellectual tasks calls for a supporting environment. For example, machines might have to be grouped differently. The functional layout with machines in rows could be changed to complete production cells, U-shaped machine and assembly groups, or similar ways of creating a layout supporting communication and cooperation within the team. The team also needs an area for breaks, meetings and administration, quality control etc. It is not only the layout and production flow which have to be adapted: often the information system has to be redesigned as well. Team targets, set by the team and approved by management, have to be easy to follow, with key-figures that are easy to measure and evaluate. The team should themselves set the targets

and get them approved by management. The team should conduct its own follow up and the number of key factors should be limited. Computerised information systems at company level are often unable to break down key factors to a level that can be used by a team so only data that can be significantly controlled by the team should be measured and evaluated.

### **THE PROCESS OF CHANGE, ORGANISATIONAL DEVELOPMENT AND OSH**

A learning change strategy characterised by the active participation of broad groups of employees and the development of a team organisation has a great impact on the development of the occupational safety and health within the company. It is not easy to combine rude exploitation, dangerous working conditions and an unhealthy environment with participation.

Inviting personnel to participate in the identification of problems and the creation of visions, opens up the potential to discuss matters which concern individuals, such as health and safety. On the other hand participation is not guaranteed to secure a good working environment. Training, information and expert support is important to assist personnel to evaluate their work situation or to come up with solutions to occupational hazards, such as unhealthy exposure etc. A change process focused on improving the working environment is frequently an excellent starting point for stimulating employees' interest and participation in a process of change, as individual benefits are clear. Often too, the elimination of risks or the improvement of ergonomics is directly linked to production performance. A better place to work is a paying proposition!



## A rewarding change – an example from India

*Vimal Mahendru*

Indo Asian is a medium-size electrical manufacturing plant located in North India (a total of 125 workers and 55 support personnel). While the company had been fairly progressive in its philosophy and policies, it continued to rely on low-cost labour available in India to enable it being globally competitive.

With the opening up of the Indian economy in 1990, the company witnessed increased competition in the domestic market, and embarked on an ambitious export program to counter the threat to its existing marketing base within India. This increased the pressure on the company to improve its productivity, quality and competitiveness on a global scale.

The challenges of the new situation were met with decisive changes to the work organisation in a part of Indo Asian – basically a re-layout of the shop floor and flow management – and a journey of change was embarked upon within the Sub Assembly part of the company. Thanks to the change work carried out, break-through gains were made. Initially, the project scope covered 31 of the 125 workers. Later, the scope was increased to cover 47 workers and supervisors. Some of the break-through gains will here be accounted for.

### ORGANISATION OF WORK PRIOR TO THE CHANGE

The manufacturing process was organised per function, i.e. all power presses were located in one row, a separate spot welding section existed, the sub-assembly workers were sitting in one area, the manual assembly operators were in one separate block and so on. In this functional layout of the workshop each function was far apart from the next one. The criterion used for deciding shop floor layout purely concerned the ease of maintenance and common usage of utilities like process water, pneumatic lines, power points etc.

Within each functional area each individual was permanently assigned to a specific machine, doing a specific operation eight hours a day, repetitively. Job rotation was neither considered nor thought of. Emphasis on supervision was heavy and the supervisor was expected to get maximum out of each individual. The supervisor's role was to administer, manage and control. He was expected to plan for materials, manpower, job allocation, fixing of tool or machine breakdown, managing all contacts and relations with other departments, and even to authorise the workers' breaks for tea or hygienic needs.

The employees were not expected to arrange raw materials, check quality, have any real administrative responsibilities or even to be concerned for their colleagues who may be on leave or may be absent. Employees had a low team spirit and lacked feeling for their work and for their contribution. An employee was only expected to utilise his/her skills (read: hands) to convert input to output without applying thought.

#### **ABANDONING THE FUNCTIONAL LAYOUT – INTRODUCING TEAM WORK**

The functional layout was totally abandoned and work was instead organised into three teams producing three essential sub assemblies required in the manufacturing of miniature circuit

breakers (one of the company's main products). Within each team, the location of each workstation or machine was such that its output became the input for the adjacent workstation. The old practice of surveying and measuring each individual or workstation output was replaced by a total team target as the focus and measure of productivity. Direct supervision was totally removed by re-designating the supervisor as Quality Assurance Trainer and he moved to a separate Quality Assurance Team.

#### **SIGNIFICANT GAINS – TANGIBLE AND INTANGIBLE**

The results of the development work have turned out to concern tangible economic gains as well as intangibles. I will start with the latter.

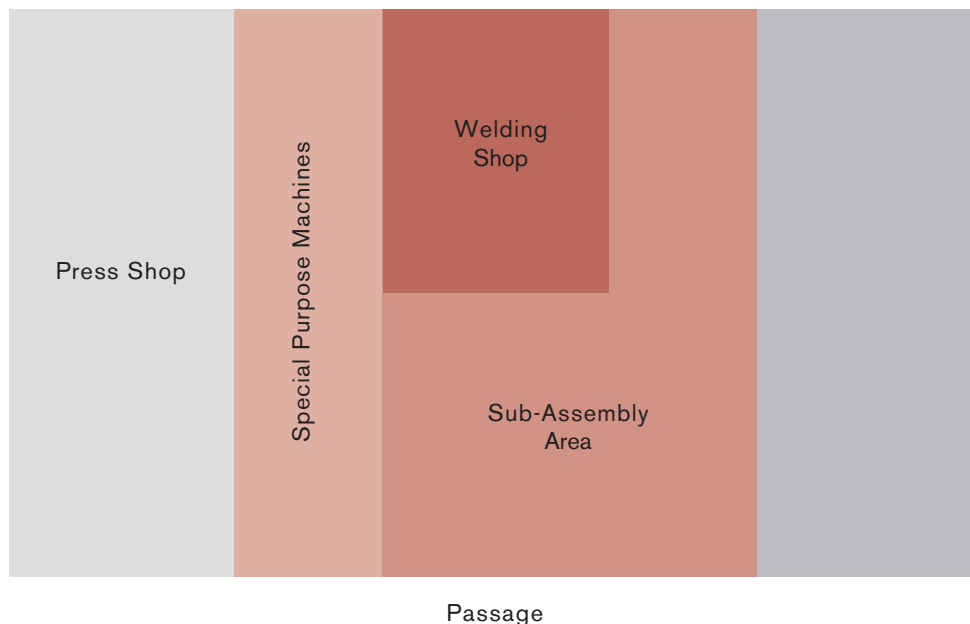


Figure 8.7.1. The initial situation.

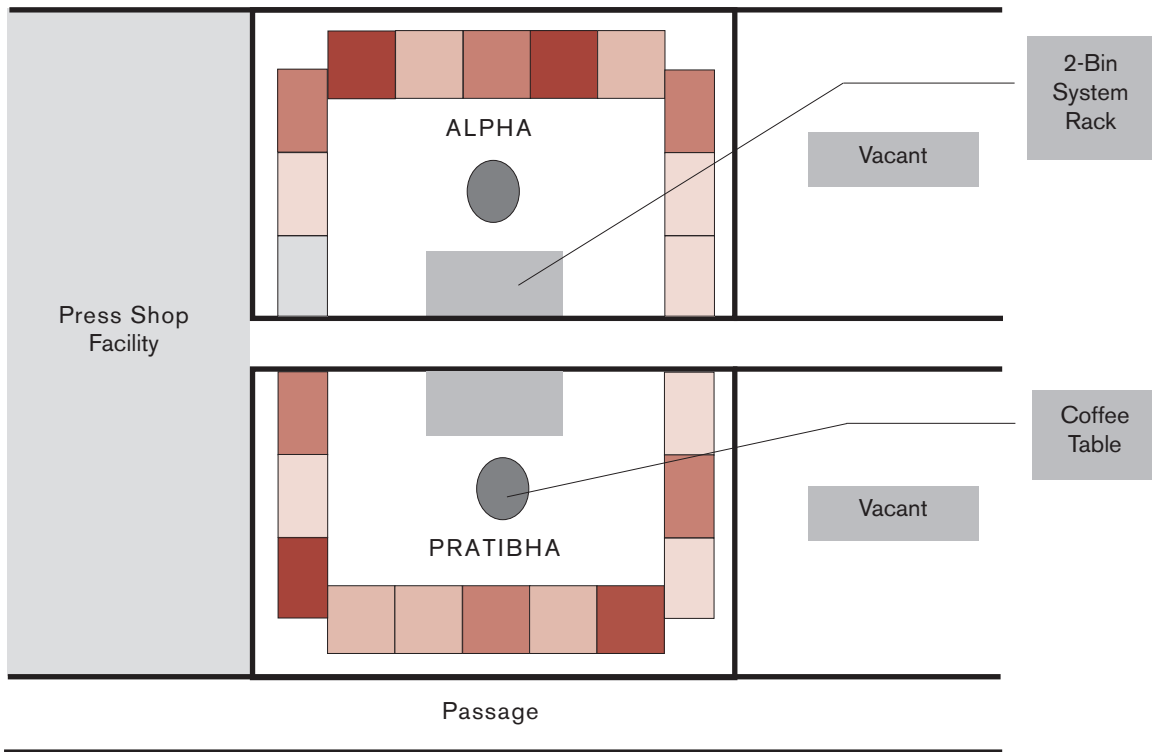


Figure 8.7.2. Proposed new layout.

### A mini cultural revolution

India is still a fairly conservative society. Women are increasingly becoming a part of the work force, but are sometimes only reluctantly accepted by their male colleagues. One of the most significant and fundamental gains of the change process was men and women employees working together. Traditionally, the social structure promotes separate working environments for men and women. Under the old system of work there were no obvious problems, since men and women worked independently of each other and never needed to collaborate. Every individual, man or woman, was concerned only with his/her own output with little or no need to interact with colleagues, especially of the opposite sex. The changed system brought men and women

together to collaborate, co-operate and interact. This led to a mini cultural revolution where women and men could sit together and discuss issues on an equal platform. Here they received recognition and respect from peers, something which the women in particular might not have experienced before, even at home.

Gender bias, not least in the work shop-floor masses is fairly high. The change implemented within Indo Asian is an exception, and not too many instances and places are visible where men and women are expected to work together as a team in the production shop-floor. In fact, the uniqueness of Indo Asian's achievement lies in the team work as well as the "gender-free" self-governed teams that have evolved.





Figure 8.7.3. Final layout.

### Commitment and self esteem

Another strong impact of the change concerned the self-esteem of the individuals making up the teams. Under the old practice, people were hired purely to carry out manual work tasks and were never recognised for their ability to think, plan or influence the outcome of their work.

In the new system the individuals started to be governed by the team's internal rules. In fact, even the revised layout was a direct outcome of their inputs and efforts, rather than an external "expert" or an "engineer's" master plan.

The team members decided who would do which operation, at what time and to what extent. This challenged their ability to think and come up with solutions. For the first time, we

witnessed individuals actually thinking about the work they were doing. This led to a far greater level of ownership, commitment and feeling of oneness with the organisation. Several of the team members mentioned that they were generally happier, because this reorganisation gave them an opportunity to express themselves and manage their work roles themselves, rather than being dictated to at all times.

### Quality, productivity and safety

In line with corporate objectives, we also witnessed *tangible gains in terms of quality, productivity and production output*. For example, in production rejections came down from 2.3 per cent to 0.7 per cent. Production output of the

sub-assembly team was raised from 7,000 sub-assemblies to 9,000 without any increase in manpower; and with no supervisory overheads. The monetary savings were substantial. There was also a significant improvement in other factors like absence and work-related injuries. Absence in the teams has fallen to negligible, while in other departments, where the teams have not been formed, it remains at 3.5 per cent. One minor injury was reported in 2000, and two minor injuries in 2001. Prior to the change process, there used to be about 6 minor injuries on average every year, with one major injury to an operator in 1995.

#### **ENTERING THE FUTURE WITH COMPETENCE FOR CHANGE**

Today, the company has further evolved the teams into a flow-managed layout. The team layout has in addition been made part of the final assembly area, and now we are seriously

contemplating evolving end-to-end teams which may take charge, not only of the sub-assemblies, but of entire product manufacturing. An apparent hindrance is the current use of two conveyor lines for the final assembly process. The conveyors very much support the functional layout and thus make team work difficult. The challenge for Indo Asian is to evolve teams around these conveyors, and ensure that the gains achieved by these developing self-governed teams are further multiplied. The challenge is also to take the experiences from one plant on to the other three plants of our company. In total the Indo Asian Group employs 1,200 employees in its four manufacturing plants and sales offices.

The change process has resulted in a company with committed teams and individuals who are carrying on with the good work, and are seeking out ways of further development on their own.

# Suggestions for further reading

## CHAPTER 8.1

Freeman, C (1997). The “national system of innovation” in historical perspective. In D. Archibugi & J. Michie (eds.): *Technology, globalisation and economic performance*. Cambridge: Cambridge University Press.

Pfeffer, J (1994). *Competitive advantage through people. Unleashing the power of the work force*. Boston: Harvard Business School Press.

## CHAPTER 8.2

Deming, WE (1986). *Out of the crisis*. Press Syndicate, University of Cambridge, Cambridge.

One of the standard books in work organization and management, focusing upon quality, describing methods and steps to create an efficient enterprise. Although more than 20 years old, many of the modern organization strategies have their take-offs in Deming’s ideas. A useful handbook if you are going to develop an organization.

Ishikawa, K (1985). *What is total quality control?* Prentice-Hall, Englewood Cliffs.

Ishikawa is not only the ‘father’ of the ‘fish-bone diagram’ to identify and analyse possible causes to problems in production and elsewhere. He was also a very important person in the quality movement, in general. The book explains his ideas, still used all over the world in designing quality systems in production.

Kondo, Y (1993). *Quality and Human Motivation*. In *European Quality (Special Showcase Edition, June)*.

Nilsson, T (1996). *Lean production and white-collar work: the case of Sweden*. *Economic and Industrial Democracy*, Vol. 17: 447–472.

Nilsson, T (2000). The history of teams – the case of Sweden and Volvo. In: *Work teams: past, present and future*, M. Beyerline (ed), Kluwer Academic Publishers, Dordrech/Boston/London.

Reid, P C (1990). *Well made in America – lessons from Harley-Davidson on being the best*. McGraw-Hill, New York.

More like a novel than a textbook it explains how managers of the once-ailing motorcycle company restored it to financial success through transforming work methods.

Taylor, F W (1911). *The principles of scientific management*. Engineering & Management Press.

Taylor is regarded as the ‘father’ of the scientific management, and has had an important influence on the design of production system, and the MTM system. By his ideas the productivity increased remarkably. On the other hand, he has been blamed for creating alienating jobs, and also work methods causing musculoskeletal disorders.

## CHAPTER 8.3

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Döös, M. (2007). Organizational learning. Competence-bearing relations and breakdowns of workplace relations. In L. Farrell & T. Fenwick (eds.), *World Year Book of Education 2007. Educating the global workforce. Knowledge, knowledge work and knowledge workers* (pp. 141–153). London: Routledge.

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Kolb, D. (1984). *Experiential learning. Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice-Hall.

Löfberg, A. (1989). Learning and educational intervention from a constructivist point of view: The case of workplace learning. In H. Leymann & H. Kornbluh (eds.), *Socialization and learning at work. A new approach to the learning process in the work-place and society* (pp. 137–158). Aldershot: Avebury.

Mezirow, J. (2000). Learning to think like an adult: Core concepts of transformation theory. In J. Mezirow (ed.), *Learning as transformation.* (pp. 3–33). San Francisco: Jossey-Bass.

Piaget, J. (1970). *Genetic epistemology.* New York: Columbia University Press.

Siebert, H. (2002). Constructivism. An epistemological change. In A. Bron & M. Schiemann (eds.), *Social science theories in adult education research* (pp. 109–129). Münster: LIT Verlag.

Wilhelmson, L. (2002). On the theory of transformative learning. In A. Bron & M. Scheemann

(eds.), *Social science theories in adult education research* (pp. 180–210). Münster: LIT Verlag.

Wilhelmson, L. & Döös, M. (2009). Sustainable heritage in a rapidly changing environment. In P. Docherty, M. Kira & A. B. Shani (eds.), *Creating sustainable work systems. Developing social sustainability* (2 ed., pp. 117–130). London: Routledge.

## CHAPTER 8.4

Barley, S. R. (1996). Technicians in the workplace. Ethnographic evidence for bringing work into organization studies. *Administrative Science Quarterly*, 41: 404–441.

Beer, M., Eisenstat, R. A. & Spector, B. (1990). Why change programmes don't produce change. *Harvard Business Review*, 158–166.

Brown, J. S. & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organizational Science*, 1: 40–57.

Beer, M. & Nohria, N. (2000). *Cracking the Code of Change.* Harvard Business Review. May–June 2000.

Dall'Alba, G. & Sandberg, J. (1996). Educating for competence in professional practice. *Instructional Science*, 24: 411–437.

Dixon, N. M. (1998). *Dialogue at work. Making talk developmental for people and organizations.* London: Lemos & Crane.

Fielding, N. G. (1988). Competence and culture in the police. *Sociology*, 22: 45–64.

Gadamer, H. (1994/1960). *Truth and method.* 2nd edn. New York: Continuum.

Sandberg, J. (2000). Understanding human competence at work. An interpretative approach, *Academy of Management Journal*, 43: 1, 9–26.

Sandberg, J. (2001). Understanding the basis for competence development. In C. Velde (ed) *International perspectives on competence in the workplace*. Dordrecht: Kluwer Academic Press.

Sandberg J. & Dall'Alba, G. (2006) Re-framing competence development at work. In R. Gerber, G. Castleton and H. Pillay (Eds). *Improving workplace learning: Emerging international perspectives*. New York: Nova Science Publisher.

Sandberg, J. & Targama, A. (2007). *Managing understanding in organizations*. London: Sage.

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## CHAPTER 8.5

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Ashkenas R. et.al. (1995) *The Boundaryless Organization. Breaking the Chains of Organizational Structure*. Jossey-Bass Publishers, San Francisco.

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Knights, D. & Willmott, H. (eds.) (2000) *The Reengineering Revolution. Critical Studies of Corporate Change*. London: Sage Publications.

Mitter, Swasti (1997) "Innovations in work organization and technology" in Date-Bah, E. (ed) *Promoting Gender Equality at Work. Turning Vision into Reality*. London: Zed Books and ILO.

The United Nations' Beijing Declaration and Platform for Action, 1995.

## CHAPTERS 8.6 AND 8.7

Rubrich, L and Watson, M (2004). *Implementing world class manufacturing. A bridge to your manufacturing survival. Shop floor manual*. W C M Associates.

The manual is basic, practical and provides an introduction and insight into concepts such as teamwork, Total Productive Maintenance, Kanban, Kaizen, 5S, Manufacturing Cells and others.

Pfeffer, J (1994). *Competitive advantage through people. Unleashing the power of the work force*. Boston, Harvard Business School Press.

Pfeffer gives a lot of evidence of the potential of improved competitiveness hidden in most organizations. Today's managers tend to express that their personnel is their most valuable resource. However, they give very little evidence of what this means to their way of organising work. Pfeffer's reasoning is based on experiences and studies from USA but is of interest and valid to most organizations. The book is recommended for those that would like to have some facts, evidence and insight in the theory and practice of empowerment and the importance of creating the relevant conditions for the work force to contribute to the overall performance of the organization.

# Age, gender and migration

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## Child labour

*Bahira Lotfy*

### WHAT IS CHILD LABOUR?

The term child and child labour has different legal and common usage meanings in different countries and even within a country. The ILO's minimum age convention sets a basic minimum age for employment of 15 years. Light work is allowed at 13 years and hazardous work is prohibited until 18 years. Child labour, as defined by IPEC (the International Programme on the Elimination of Child Labour) excludes the activities of children 12 years and older who are working only a few hours a week in permitted light work and those of children 15 years and older whose work is not classified as "hazardous" (IPEC, 2003).

Child labour as defined above is a narrower concept than "economically active children". It is estimated that in 2000 there were 186 million child labourers below the age of 15 years in the world, with 110 million below the age of 12 years. There were 246 million child labourers in the 5–17 year age group. On average, more boys are employed than girls, both in absolute and relative terms.

Child labour is generally speaking, work for children that harms them or exploits them in some way (physically, mentally and morally, or by blocking access to education), however, there is no universally accepted definition.

The worst forms of child labour include children of any age below 18 years who are involved in forms of slavery and forced labour. For example, forced recruitment for use in armed conflicts, commercial sexual exploitation (prostitution or pornography), illicit activities (particularly the production or trafficking of drugs), and hazardous work that jeopardises their lives, health or morals. With the exception of hazardous work, these "worst forms" are defined by other conventions and are consequently referred to as "unconditional worst forms".

The ILO set out the criteria for identifying hazardous work of child labour, as work that might expose children to:

- Physical, psychological or sexual abuse
- Work underground, under water, at dangerous heights or in confined spaces
- Work with dangerous machinery, equipment and tools, or which involves the manual handling or transport of heavy loads
- Work in an unhealthy environment which would expose children to hazardous substances, agents or processes, or to temperatures, noise levels, or vibrations which might damage.

Child trafficking is defined as children under the age of 18 years recruited in one place and then moved to another, (sometimes across borders), to be subjected to commercial sexual exploitation or forced labour or servitude.

## **WHERE DO CHILDREN WORK?**

### **Children in the rural economy**

More children work on farms than in any other form of work. The ILO's survey in 2000 indicated that 70 per cent of the world's working children were engaged in agriculture, fishing, hunting or forestry. This reflects the dominance of the rural economy in many developing countries. Some only help out on a family farm at peak times when there is a need for manual labour, such as weeding and the harvest.

### **Children in the informal economy**

Most of today's urban working children can be found working on the streets rather than in factories. Some children live on the streets, having left or lost their families. Others earn their living there, hawking food, drinks and a whole range of other products, carrying everything from someone's shopping to crippling loads, running to and fro at their employer's orders. By definition, the informal economy is unregulated: whatever labour laws and regulations apply in the formal economy, such as in factories and the civil service, are not observed and little attempt is made to enforce them. This applies both to laws governing a minimum age for employment and those covering health and safety at work. The millions of children living and working on the streets around the world come into this category, as do many apprentices sewing and hammering away in small workshops.

### **Children in the export economy**

Although it was concern about children in developing countries producing cheap exports for the industrialized world that fuelled publicity about child labour in the 1990s, the export economy involves a relatively small proportion of working children under 15 years. No accurate data is available, but about 5 per cent, some 10 million children, are thought to be involved in producing either agricultural commodities such as cocoa, coffee, rubber, sisal, tea and tobacco or manufactured products for export.

### **"Invisible" child workers**

Many working children are virtually invisible to outsiders, as they work in the privacy of people's homes. Most of these workers are girls. There is still no accurate estimate of the number of child domestic workers worldwide but a recent assessment suggests that 700,000 girls are involved in such work in Indonesia alone. The various terms used to refer to these employees reflect different attitudes towards them: "domestic servants", "maids" or "household helps". The organizations campaigning on their behalf generally refer to them as "child domestic workers" to avoid derogatory terms such as "skivvies", even if some of the children involved are treated as slaves – unpaid, working long hours and not allowed to leave their employer.

### **"Home workers"**

Some children who work in their own home are simply helping out with household chores while others are participating in a family business, such as helping to run a shop after school. While children working in their own homes are in an environment that ought to protect them against harm, some are nevertheless exposed to exploitation or hazards.

Routinely, laws concerning child employment do not apply to children working at home in a family business. Consequently there is a danger that families and employers avoid the terms of the law by claiming that children are working for their own family when this is not the case.

### Global dimensions of child labour

Currently more than 350 million children, aged from 5 to 17 years, are at work. They can be differentiated on the basis of their age, the effect that working has on their basic rights and, in particular, the extent to which their work causes them harm. More than 140 million of the total are old enough to be working under international standards. However, almost half of these children (60 million) – suffer harm because they are involved in the abuse of the “worst forms” of child labour, from which they should be protected. The remaining 80 million, in both industrialized and developing countries, have reasonable jobs. Out of the 211 million working children under 15 years of age, more than half (120 million), are involved in the “worst forms”. When older adolescents are also taken into account, this means that almost 180 million young people below 18 years, (1 in every 12 children in the world), are currently involved in the “worst forms”. The vast majority of these children, more than 170 million, are engaged in work that is hazardous, posing a health risk and, in some cases, even threatening their lives.

### Children at work in economic activity

It is estimated that in 2000 there were some 211 million children aged 5 to 14 years working in economic activity. This accounts for a little less than one fifth of all children in this age group. About 73 million working children are less than 10 years old. The total economically active child

population aged between 5–17 years is estimated at 352 million children. Estimates show that there are no significant gender differences in the global incidence of children at work. In both the 5–9 and 10–14 year age brackets, boys and girls are equally likely to be engaged in economic activity. Children at work in economic activity is a broad concept that encompasses most productive activities by children, including unpaid and illegal work as well as work in the informal economy.

Age group	Total population (in millions)	Children economically active	Work ratio (%)
5 – 9	600	73	12
10 – 14	599	138	23
15 – 17	332	150	42
Total	1531	361	23

Figure 9.1.1. Global estimates of economically active children ages 5 to 17 in 2000.

### Regional distribution

The Asian-Pacific region has the largest number of child workers in the 5–14 year age category, 127 million in total. It is followed by Sub-Saharan Africa with 48 million and Latin America & the Caribbean with 17 million. Developed and transition economies have the lowest absolute numbers of child workers. In relative terms, Sub-Saharan Africa has the highest proportion of working children estimates showing that almost one child in three below the age of 15 years is economically active. The ratio of working children in other regions of the world are all below 20 per cent. It is 19 per cent in Asia-Pacific, 16 per cent in Latin America & the Caribbean and in the Middle East and North Africa, it is 15 per cent.

Region	Number of children (approximated in millions)	Work ratio (%)
Developed economies	3	2
Transition economies	2	4
Asia and pacific	127	19
Latin America and Caribbean	17	16
Sub-Saharan Africa	48	29
Middle East & North Africa	13	15
Total	210	18

Figure 9.1.2. Regional estimates of economically active children ages 5–14 in 2000, based on ILO Bureau of Statistics, 2002.

### Children in hazardous work

In 2000 an estimated 171 million children aged 5–17 years were estimated to work in hazardous situations or conditions. In other words, children in hazardous work constituted about half the total number of economically active children with more than two thirds of those in child labour. A stunning 55 per cent of very young child labourers, (i.e. those below 12 years of age), were already working in a hazardous occupation or situation. Boys outnumber girls in hazardous work across all age groups. Seen in relative terms, among all children, about half of the working boys were in hazardous situations as compared with a little more than two in five working girls.

Children in unconditional worst forms of child labour: In addition to the number of children in hazardous work, it is estimated that there were about 8.4 million children involved in other worst forms of child labour as defined in ILO Convention No.182, Art. 3. This includes trafficking (1.2 million); forced and bonded labour (5.7 million); armed conflict (0.3 million); prostitution and pornography (1.8 million); and illicit activities (0.6 million).

Unconditional worst form of child labour	Global estimate in millions
Trafficked children	1
Children in forced and bonded labour	6
Children in armed conflict	< 0,5
Children in prostitution & pornography	2
Children in illicit activities	0,5
Total	9

Figure 9.1.3. Estimated number of children in unconditional worst forms of child labour. Source: ILO Bureau of Statistics, 2002.

Industry (major division)	Both Sexes	Boys	Girls
Agriculture, hunting, forestry and fishing	70.2	75.8	57.2
Mining and quarrying	0.5	0.5	0.4
Manufacturing	4.7	4.3	5.6
Electricity, gas and water	0.1	0.0	0.1
Construction	2.9	4.1	0.3
Wholesale and retail trade, restaurants and hotels	13.4	8.3	25.7
Transport, storage and communication	2.6	3.8	negligible
Financing, insurance real estate and business services	0.0	0.0	negligible
Community social and personal services	4.9	2.5	10.2
Unspecified industries	0.6	0.7	0.6

Figure 9.1.4. Distribution of Injuries/illnesses by industry and sex. Source: ILO Bureau of Statistics, 1997.

### MAIN CHARACTERISTICS OF CHILD LABOUR

There are wide variations in the types of child labour, some harmful and some not. Indicators that should be taken into account to determine whether work has a negative impact on children's development include working conditions (e.g. hours of work, exposure to physical hazards) and other risks and abuse to which working

children may be exposed (e.g. psychological and social adjustment risks, prostitution, and child slavery).

Long working hours are often responsible for fatigue that can cause accidents, and impair intellectual development. Some studies consider that 20 hours of work per week is a critical threshold beyond which education starts to be significantly affected. Many children work under exploitative conditions that apart from totally precluding schooling, have harmful effects on their physical condition and mental health. For example, the working conditions of child garbage pickers clearly increase the risk of diseases and disability through exposure to lead and mercury, heavy lifting, and the presence of parasites. Children in agriculture are more likely to be adversely affected than adults by climatic exposure, heavy work, toxic chemicals, and accidents from sharp tools and motorized equipment.

Domestic service is primarily undertaken by girls and is one of the occupations that can cause serious psychological and social adjustment problems. Such child workers typically live away from home and routinely work long hours, often in almost total isolation from family and friends. A 1987 WHO report found that psychological stress, premature aging, depression, and low self-esteem were common symptoms among young household helpers.

Children are particularly vulnerable to accidents since they are often unaware of danger or necessary precautions to be taken at work. Safety equipment designed for adults often does not fit children, and tools and equipment designed for adults are difficult for children to handle.

### WHY DO CHILDREN WORK?

There are many reasons why children are required to start work when they are too young or to do hazardous work. Children in developing

countries do so because they and their families need the extra income. Many end up doing unpaid work for their employers in exchange for board and lodging. In contrast, children in industrialized countries seek work for quite different reasons, usually to establish financial independence from their parents. The reasons children work can be divided broadly into “supply” and “demand” factors.

### What pushes children into work?

#### *Poverty*

The main reason why children start work instead of attending school, or leave school before completing their primary education, is that their families are poor and cannot pay the basic costs of food and housing without their children earning. But the reasons why families are poor vary enormously; some are global, some are national and some are historic. Some adult workers are not paid enough to support their families; the wages from both parents incomes are not sufficient to keep their family housed, clothed and fed. However, it is also common to find families in which one or both parents are not earning anything, maybe because a parent has died or left home, or because adults are unable to get work. Sometimes employers prefer to employ children, because they are more obedient and cheaper than adults. Alongside families where all the children are expected to work and earn their living from a young age, there are others where just one or two children work to earn money to enable another sibling to attend school. Around the world, the details vary but the story is the same. There is not enough money for families to survive without some or all of their children working. Children are viewed as a beneficial economic resource by both their parents and the developing country in which they reside. Struggling parents choose to rear children because



they believe that they will be able to substantially contribute to the household income. Some developing countries insist on child labor because of lower labor costs, and argue that developed nations' opposition to child labor is only an attempt to eliminate economic competition.

Poverty, birth control and child labour are interlinked. Large families have many mouths to feed and are often poorer. Younger children from large families are more likely to work and less likely to attend school. The poverty cycle is perpetuated by teenage pregnancy, and teenagers who send their own children out to work due to low household income.

Children may be forced to work to directly increase family income for subsistence, but they are also used as reserve income providers.

#### *Family breakdown*

Families break down for many reasons, leaving the household short of income. Sometimes divorce leaves one parent looking after more children than she or he can afford to feed. Divorce is sometimes brought about by domestic violence, which also directly drives children to leave home when they are still young. The death of either parent precipitates economic disaster for many households. Families also lose their livelihoods as a result of natural disasters and human crises that leave people destitute and force children to start earning.

#### *Attitudes to girls*

All around the world, children belonging to particular social groups leave school and start work earlier than other children in the same country. In industrialised countries the obvious differences are based on wealth and social class: children from poor families start work several years before their peers in rich households. In these countries, however, there are likely to be

laws, which are enforced, making it compulsory for all children to attend school until a minimum age. In most parts of the world, gender is also a crucial factor: girls are discouraged from staying at school beyond puberty (and are sometimes withdrawn much earlier) and are propelled into adulthood much younger than boys, through work or an early marriage. In some countries, school is a threatening place for teenage girls, where they are at risk of sexual harassment from male classmates and teachers, and sidelined by prejudice and poor curricula. Many are kept at home or drop out of school simply because they are girls.

#### *Discrimination against minority groups*

Some children also leave school and start work earlier than others because of their origin or identity. In Latin America, indigenous children start work earliest. In South Asia, the caste system determines that children from low status *dalit* families or *adivasi* (tribal or indigenous) communities start work first or do not attend school at all. In southeast Europe, it is children from the Roma minority. In each case, a combination of supply and demand factors are at work: the communities concerned feel that the school system was not designed for them and consider it normal for children to abandon school early to begin working.

#### *Inadequate laws*

More than 130 countries have signed an international convention saying that children may not work full-time before 15 (or, in some cases, 14) years of age. However, in some of the countries concerned, relevant laws are confusing, vague or not enforced. There are particular difficulties when laws are inconsistent, e.g. when one law dictates that children must remain in school until they are 12 years of age, while another

decrees that they may not start work until aged 14. Such inconsistencies are highly likely to put children into the labour market before they reach the legal minimum age.

### *Poor infrastructure*

Another factor is the practical difficulty of correctly establishing a child's age in countries lacking the infrastructure for systematic birth registration. This can disadvantage children in many ways. Law enforcers are hampered because they lack the means to establish the age of children. Young people without appropriate documentation may also be denied access to state services such as schooling.

### *The role of education*

Children who receive little or no school education miss out on knowledge that can create options for them later in life. Without education, people are less able to contribute as adults and are more vulnerable to exploitation and abuse. Non-attendance at school is consequently both a cause and effect of child labour. The importance of education for a society's economic and social development is widely acknowledged. However, even countries that have made an explicit undertaking to send every child to school still have to do a great deal to turn this commitment into reality. The shortcomings of existing school systems remain a major factor that pushes children on to the labour market when they are too young. Sending children to school does not come without a cost. In many countries, parents still pay a fee for their children to attend primary school, as well as buying books and providing school uniforms. For poor families these are significant costs in addition to lowering of household income when a child is at school.

Schooling problems also contribute to child labour. Some children seek employment simply

because there is no access to schools, e.g. because of distance or absence of a school. Schools in many developing countries suffer from problems such as overcrowding, inadequate sanitation and apathetic teachers. As a result, parents may find no use in sending their children to school when they could be home learning a skill (e.g. agriculture) and supplementing the family income. A number of factors help explain the failure of formal education systems to cater for the needs of children engaged in child labour or at risk.

Structural factors, under-development and extreme regional poverty make children's schooling an impossible option for destitute families. In some circumstances social norms or cultural attitudes towards education may favour work over schooling, turning the necessary into something virtuous and beneficial to the child.

Education in poor regions tends to be of low quality with inadequate support for teachers, lack of infrastructure, training and teaching aids, and conservative attitudes among teachers and decision makers in the education system. In most countries, industrialised and developing alike, there is often a complete divide between ministries responsible for education and those dealing with social protection, including child labour.

It is difficult to enrol child workers in the educational system without substituting the lost income from their work. This can be done by payment of the indirect costs of education (books, shoes, etc), providing free school meals linked to participation in classes, offering stipends, or by supporting income generation opportunities for adult members of the family.

In certain countries, there is a notion that educated women will not fit into their traditional roles by choosing not to be a wife or mother. Because of this notion, daughters are raised to

accept the traditional role of executing household duties. Such ethnic practices restrict the females' education and promote child labor.

Parents in developing countries often assign different roles to their children ("child specialization"), which may increase the number of working children. This phenomenon involves certain siblings going to school while others work. Rapid rural to urban migration is the cause for the increasing rate of child labour in urban areas of developing countries. Families leave severe poverty and terrible working conditions in agriculture in order to search for economic opportunities in cities, opportunities that often do not exist. Over the last 40 years, this movement has been huge. In 1950, 17 percent of the population of the developing world lived in urban areas, increasing to 32 percent by 1988. By the year 2000 it is estimated that this proportion had increased to 40 percent and will be at 57 percent by the year 2025. Such increases, coupled with worsening economic trends, force children and their families into urban poverty.

### **Why do employers want child labour?**

The relatively low wages paid to children are often a reason why employers prefer them to adult workers. Some children work unpaid, particularly as domestic workers, in conditions that would be denounced as "slavery" if they involved adults. Employers find children more obedient and easier to control. Unlike older workers, they are unlikely to initiate protests or form trade unions. It is also easy for adults to intimidate children. Employers can force child workers into submission when the children are dependent on them for food, lodging and even emotional support. In most parts of the world, it is still considered acceptable for parents to beat their children. Employers take advantage of the

public's acceptance of corporal punishment to beat their child workers as a means of control.

In the country with the largest number of child labourers in the world, India, adults justify the involvement of children in certain jobs on the grounds that only they have the "nimble fingers" which enable them to give special attention to detail. Some sorts of work, they argue, cannot be performed by adults.

### **WHY ARE CHILDREN ESPECIALLY SUSCEPTIBLE TO ENVIRONMENTAL HAZARDS?**

Children and adolescents may be exposed to many work-related hazards that can result in injury, illness, or death. About 100,000 young people seek treatment in hospital emergency departments for work-related injuries each year.

The rate of injury per hour worked appears to be almost twice as high for children and adolescents as for adults, about 4.9 injured per 100 full-time-equivalent workers among adolescents, compared with 2.8 per 100 full-time-equivalent workers for all workers. The industries with the highest injury rates for young workers are retail stores and restaurants, manufacturing, and construction.

Many of the industries that employ large numbers of children and adolescents who are young or inexperienced have higher than average injury rates for workers of all ages because young workers do not receive adequate health and safety training at work.

Health and safety hazards in the working environment can be related to the nature of the work, e.g. hazardous processes, to their exposure to hazardous substances and agents or to exposure to poor working conditions. Chemical, physical, biological and psychological hazards are often combined in the workplace and synergic interaction can magnify adverse effects that

may also be cumulative. It is not easy to isolate one single source or cause of an occupational hazard.

Children are susceptible to all of the dangers faced by adults in the same situation. Survival and physical integrity are as important to children as to older people, however, work hazards affect children even more than adults. Children are not just “little adults.” Their biological sensitivity, exploratory behaviour, and diet are very different from that of adults, making children particularly vulnerable to environmental exposures.

Children differ biologically from adults in their anatomical, physiological, and psychological characteristics. These differences make them more susceptible to occupational hazards. Their biological sensitivity varies by population, ethnic group, age, and genetic makeup but these variations are not usually taken into account during environmental exposure assessments. The child’s metabolic reactions, (the body’s way of processing and excreting toxic substances) are not as developed as those of an adult. Children are especially biologically sensitive due to differences in the pathways of absorption, tissue distribution, and the ability to bio-transform.

Health effects can be more devastating for children, causing irreversible damage to their physical and physiological development, resulting in permanent disabilities, with serious consequences for their adult lives. For example, carrying heavy loads or being forced to adopt unnatural positions at work can permanently distort or disable growing bodies. There is evidence that children suffer more readily from chemical hazards and radiation than do adults, and that they have less resistance to disease. They are much more vulnerable to psychological and physical abuse and suffer more devastating psychological damage from living and working in

an environment in which they are denigrated or oppressed. Physiological differences influence the amount of a chemical that is absorbed into the body. Children have a greater surface area to body weight ratio than adults, which may lead to increased dermal absorption.

Children’s tissues, organs, and biological systems are still developing, with several stages of rapid growth and development occurring from infancy to adolescence. This rapid development and immaturity of body organs and systems predisposes children to potentially more severe consequences within certain age ranges and windows of vulnerability.

Another factor that can influence a child’s vulnerability is that circulatory flow rates are generally higher in children, which may increase a child’s susceptibility to toxic effects.

In addition to the physical and physiological changes, children experience profound psychological changes as they mature. As a result, a young worker may be assigned to a task for which he or she is emotionally or cognitively unprepared, or unable to correctly judge their ability to complete an assignment safely. The adult pattern of afternoon sleepiness is first seen in children about halfway through puberty. Yet the adult pattern of a reduced need for sleep (8 hr per night) is not observed until sometime after the age of 18. Current laboratory research suggests that children younger than 18, and perhaps older, require approximately 9 hr of sleep per night. Heavy part-time work schedules may result in inadequate sleep, fatigue, and increased risk of injuries while working or commuting.

Most child workers don’t have the opportunity to go through the normal stages of childhood development or to develop meaningful relationships with family members, friends and other people in their community. They do not get the opportunity to play, to be spontaneous or to get

an education. Most children who work are not allowed to express their feelings or needs. Lack of training and supervision may increase the risk for work injuries and illnesses among children and adolescents. Children are especially vulnerable to accidents because they lack awareness of the dangers and knowledge of the precautions to be taken at work. Children and young workers tend to have more serious accidents than adults.

When speaking of children it is necessary to go beyond the relatively limited concept of “work hazard” as applied to adults, and expand it to include the developmental aspects of childhood. Because children are still growing, they have special characteristics and needs that must be taken into consideration when defining workplace risks. If child workers are generally more vulnerable to work-related hazards, very young children and girls are even more so. Children who start work at an early age have a longer period of exposure to cumulative hazards. In certain enterprises, children are hired because adult health has already been compromised.

### LEGAL FRAMEWORK

Child labour in the formal sector has been controlled to some degree by legislation so child labour is most prevalent in the informal and rural sectors. A lack of enforcement of labour restrictions perpetuates child labour in a variety of ways. For example, in developing countries the number of enforcement officials is low as survival is the most immediate priority.

There are also inconsistencies in legislation that may pose problems. In some countries, including Costa Rica, Thailand, and Sri Lanka, the minimum working age is lower than the required age of compulsory education, giving children access to employment before they have even completed the minimum years of schooling.

### INTERNATIONAL CONVENTION ON CHILD LABOUR

From the first international child labour convention in 1919, which saw working children in terms of wage employment in formal-sector manufacturing, the world’s position on child labour has evolved and expanded. Non-industrial work by children is now addressed. Most recently, any kind of work, paid or unpaid, that is injurious to children, is prohibited and safeguards and protections for children who work have been proposed.

### RECENT DEVELOPMENTS

In the last decade, several large international conferences focusing on child labour have brought together representatives of governments, workers, employers, and Non Governmental Organisations (NGOs) from industrialised and developing countries (Stockholm 1996, Amsterdam 1997, Oslo 1997). A number of regional meetings and conferences were also held during this period resulting in a variety of agendas of action to combat child labour.

In the spring of 1998, over 1 400 NGOs around the world showed their concern for the plight of child workers by supporting the historic “Global March Against Child Labour”. This march travelled for six months through more than 60 countries across Africa, Asia, Europe, and the Americas. The goals of the Global March were to raise awareness about child labour issues; to urge governments to ratify and enforce laws protecting children and providing them with education; to demand the immediate elimination of the most exploitative forms of child labour; to promote positive actions by employers and consumers; to ensure the proper rehabilitation of child labourers, and to mobilize greater national and international funding to support education for all children.

ILO's Conventions and Recommendations regarding child labour	
Serial No. of convention	Name of Convention
<i>Minimum Age</i>	
C. 5 (1919)	Minimum age (Industry)
C. 59 (1937), revised	Minimum age (Industry)
C. 7 (1920)	Minimum age (Sea)
C. 15 (1921)	Minimum age (Trimmers and Stokers)
C. 58 (1936), revised	Minimum age (Sea)
C. 10 (1921)	Minimum age (Agriculture)
C. 33 (1932)	Minimum age (Non-industrial employment)
C. 60 (1937), revised	Minimum age (Non-industrial employment)
C. 112 (1959)	Minimum age (Fisherman)
C. 123 (1965)	Minimum age (Underground Work)
C. 138 (1973)	Minimum age
R. 41 (1932)	Minimum age (Non-industrial employment)
R. 52 (1937)	Minimum age (Family undertaking)
R. 96 (1953)	Minimum age (Coal mines)
R. 124 (1965)	Minimum age (Underground work)
R. 146 (1973)	Minimum age
<i>Night Work</i>	
C. 6 (1919)	Night Work of young persons (Industry)
C. 90 (1948), revised	Night Work of young persons (Industry)
C. 79 (1946)	Night Work of young persons (Non-Industrial occupation)
R. 14 (1921)	Night Work of young persons (Agriculture)
R. 80 (1946)	Night Work of young persons (Non-Industrial occupation)
<i>Medical Examination</i>	
C. 16 (1921)	Medical Examination of Young Persons (Sea)
C. 77 (1946)	Medical Examination of Young Persons (Industry)
C. 78 (1946)	Medical Examination of Young Persons (Non-industrial occupations)
C. 124 (1965)	Medical Examination of Young Persons (Underground work)
R. 79 (1946)	Medical Examination of Young Persons
<i>Others</i>	
C. 182 (1999)	Worst Forms of Child Labour
C. 152 (1979)	Occupational safety and health
C. 138 (1973)	Minimum Age



## **ACTION TO BE TAKEN TO ELIMINATE CHILD LABOUR**

A worldwide movement has emerged to put an end to child labour in all its manifestations. Child labour is at the top of the agenda of a number of international organizations. National governments in a growing number of developing countries, supported by the ILO, are formulating action programmes to tackle child labour. NGOs in both the South and North are active on this front. There is a growing awareness among consumers and the public that child labour is unacceptable. Child labor is a pervasive problem in today's world, but it is not a hopeless one.

The evidence is clear that when individuals make a commitment, when communities mobilize, when societies come together and decide that child labor is no longer acceptable, great progress can be made toward the goal of ensuring that children are not denied a childhood and a better future. However, it's tough going.

Building consensus -and bringing real change- remains an immense challenge internationally, nationally and in the families and communities where child labor exists. The common sense objective is to provide kids the opportunity of a sound education and parents a fair chance at a decent job. This is an economic issue for countries and families, but it is also an ethical one. The fight against child labor is ultimately a battle to expand the frontiers of human dignity and freedom.

Since its foundation, the ILO has stood against the scourge of child labor. In recent years, through our work and collaboration with many committed individuals and institutions, we have seen a sea change in attitudes toward child labor. Denial and indifference have given way to acknowledgement, outrage, and a readiness

to act. A growing popular movement against abusive labor practices in general has been accompanied by a new understanding of ways in which the problem of child labor can be tackled effectively and sustainably.

The approach of the ILO's constituents -governments, employers, and workers- has been to work on the basis of partnership and trust at the community and production levels to build within countries the commitment to sustainable action for the elimination of child labor.

In 1999, a key instrument in this struggle was approved, Convention 182, which commits countries to take immediate action to prohibit and eliminate the worst forms of child labor. Over the past six years, 153 countries have ratified it, making it a national commitment and now the most rapidly and widely ratified convention in ILO history.

During the same period, there has been an impressive increase in ratifications of Convention 138, the minimum age convention that was adopted in 1973. This convention states that the minimum age for work should not be less than the age for completing compulsory schooling and sets a number of minimum ages depending on the type of employment or work.

A growing number of countries have sought the ILO's help to take effective action against child labor. The ILO's International Program on the Elimination of Child Labor (IPEC), which was founded in 1992 with six participating countries and major funding from Germany, has now expanded to include operations in 80 countries funded by 30 donors including employers' and workers' organizations.

Around the world, people are joining a growing community of conscience to act. A genuine worldwide movement against child labor has emerged. Child laborers themselves are making their voices heard, for example, through

grassroots movements such as the Global March against Child Labor. Young students are mobilizing in solidarity.

New alliances are emerging among employers' and workers' organisations, government agencies, and civil society organisations. These alliances have taken sector-specific action in several multinational industries -such as tobacco and cocoa growing, and the manufacture of sporting goods- in which the strengths and advantages of ILO's tripartite partners and civil society reinforce global efforts to combat child labor.

In addition, 19 countries are now involved in programs to end child labor within a specified period. These are foundations on which to build but much more needs to be done across the board.

We need to match national and international decisions with greater development cooperation targeting the reduction of child labor. We must sustain the international and national debates and awareness-raising efforts; identify and map hazardous child labor in different sectors and situations; build institutional capacity to deal with child labor at all levels; and put in place effective, independent and credible inspection and monitoring systems.

The problem of child labor cannot be solved in isolation. Projects alone are not enough. Where poverty breaks up families, economic and social policies must come together to help protect the dignity of family life.

For example, free, compulsory quality education up to the "minimum age" -which varies depending on the country and nature of the work- for entering into employment is a key element in the prevention of child labor. But, with budget restrictions everywhere, many countries can't afford to do so.

The international community must back the efforts of countries willing to take comprehensive steps through development cooperation programs, access to markets and policy advice that they receive from international organizations.

### **ELIMINATING CHILD LABOUR INTEGRAL TO ILO AGENDA**

Eradicating child labor is an integral part of the ILO's agenda for the world of work called the Decent Work Agenda, which seeks to promote opportunities for all women and men to obtain decent and productive work, in conditions of freedom, equity, security and human dignity. This development framework is centered on stimulating the investments that create the opportunities for productive work; with standards and rights at work, social security, health protection and safety nets and voice and representation for working people. The effective abolition of child labor is one of the principles at the heart of our agenda. We promote decent work because when you ignore the quality of work for parents, you open the door to child labor.

Every country in its own circumstances can define a reasonable threshold below which no family should fall. Decent work is not a universal standard, not a minimum wage. ILO conventions, which are ratified voluntarily by each country, constitute a sound social floor for working life.

We can take heart that already there has been a great deal of progress achieved in knowledge and experience, as well as an impressive worldwide movement to combat child labor. The global challenge remains daunting, but I believe that, working together, we can meet our common goals: decent work for parents, quality education for children, and real opportunity for young people.

Eradicating child labor truly is a moral cause and a societal challenge. If we summon the will to do it, we can bring hope to children all over the world and affirm the inalienable right of every child to have a childhood.

- Any attack on child labour must be comprehensive and advance on several fronts simultaneously. Prevention, removal and rehabilitation are the three cornerstones of a multi-pronged strategy.
- Affordable and accessible primary education of good quality is the centrepiece of any strategy to eliminate child labour.
- Legislation which clearly sets out the minimum age for entering employment must form the backbone of any strategy against child labour. Legislation alone will, however, achieve very little unless it is accompanied by adequate enforcement mechanisms and by effective action to improve the availability of relevant and affordable education and to provide poor families with alternative means of survival.
- Social mobilization is key to the success of any strategy. Concerted action by all actors is not only vital for finding lasting solutions, but it also fulfils the precondition for success, namely that the combat against child labour is first and foremost a matter of changing attitudes. Awareness raising can lead to remarkable changes in attitude on child labour.
- Integrated and multi-sectoral social policies and area-based approaches, which maximise the complementarity between health, education and population policies, and minimise the family's dependence on the child's income contribution, are critical to the elimination of child labour.
- Measures that support or compensate parents for the loss of income once the child is

removed from work are helpful, but can be costly and difficult to sustain. They need to form part of larger development programmes.

- Positive economic incentives are preferable to negative ones, because the latter can have unintended effects that are not always in the best interest of the child.
- Economic policies that generate equitable, labour-absorbing and poverty-reducing growth are as important as integrated social policies and practical programmes of action. Fiscal policies which provide adequate funding for basic social services while maintaining a stable macro-economic environment are essential to sustain such growth.

The main lesson that can be derived from experience so far is that child labour is not an insoluble problem. Given the political will on the part of governments and the mobilization of sufficient public support, much can be done to reduce the extent of child labour and the harm that it does to children. At the national level this political commitment should be reflected in national legislation and plans of action for the child, including strategies for the eradication of child labour and to ensure the necessary resource allocation for their implementation on a sustainable basis. International actions should be mainly in support of national actions.

Even though the complete elimination of child labour is a long-term goal, practical steps should be taken now.

First, the world community and individual countries need to show their commitment to giving top priority to the elimination in the shortest possible time of the most intolerable forms of child labour – slavery-like practices including sexual exploitation, forced and bonded labour; labour that is particularly hazardous or

detrimental to the education, health and development of children.

Second, wider legal protection can play an important role in protecting children, both to prevent unlawful work and to ensure that legal safeguards are provided for those who work in conformity with international standards. Three sectors – agriculture, the urban informal sector and domestic service – account for the vast majority of child labour in the world, and present serious enforcement difficulties. They are the sectors which national governments most often exempt from minimum age standards. National legislation needs to address the situation in these sectors. National governments should also harmonise existing legislation (state and local) on minimum age for access to employment with that relating to the completion of compulsory education. It is also essential that national legislation prohibits all child labour under 12 in all sectors of activity. The enforcement of national legislation could be made more effective through improved national systems for birth registration and collection of information regarding the scale, distribution and characteristics of child labour.

Third, the elaboration of a time-bound programme for the elimination of child labour and for achieving free, universal compulsory primary education should be given priority by governments. Once a developing country is committed and determined to eliminate child labour, donor countries can demonstrate that their concern with child labour is not only motivated by pressures from domestic consumers and economic interests, but that they are prepared to support the elimination of all forms of child labour – and not only those involved in export industries. International development assistance for basic education has been very limited in the past.

Fourth, it should not be forgotten that to attain the urgent goal of removing all children from particularly extreme forms of child labour within the shortest possible time will require a massive investment in protection and rehabilitation schemes, for which additional resources will need to be mobilised. As with any welfare-oriented approach based on transfers, the sustainability of positive economic incentives proves a problem. Incentives will therefore have to be combined with employment and income-generation activities for the parents of child labourers, with a goal of reducing the family's dependence on their children's contribution to household income. Given that the costs of proper rehabilitation measures can be quite high, there is scope for international agencies and donors to join hands in supporting governments in the removal and rehabilitation process.

Fifth, the design and implementation of programmes for the withdrawal of children from the most extreme forms of exploitation, and of plans for preventing children from entering the labour force will require the commitment and involvement of large sections of the population, including the children and their parents themselves. Social alliances against child labour need to be built, and a national authority designated with the necessary power and influence to act effectively.

Sixth, international cooperation will need to be strengthened in one other important respect as well – namely to combat the trafficking and commercial exploitation of children in prostitution and pornography. International agreements need to be developed to facilitate the detection, prosecution and punishment of those responsible for these particularly repulsive acts, and co-operation among national police forces and law enforcement agencies needs to be encouraged.

Much has been achieved in the past few years in raising the awareness of world public opinion, of governments and of powerful interest groups to the scandal of child labour, and in deepening understanding of its causes and consequences. It is now increasingly recognised that there is

nothing inevitable or irreversible about child labour. Great hopes and expectations have been aroused. The challenge is now to ensure that these hopes and expectations are not disappointed and that a brighter future awaits the world's children.

### **SUGGESTIONS FOR FURTHER READING**

UNICEF (1999) *The State of the World's Children*. New York: UNICEF

UCW Workshop Report: *Good Practices in Combating Child Labour*, Perrin, Burt (2003)

[www.childinfo.org](http://www.childinfo.org)

[www.worldbank.org/lsm](http://www.worldbank.org/lsm)

UNICEF, *Guidelines for Protection of the Rights of Children Victims of Trafficking in Southeastern Europe*, May 2003, available at [www.seerights.org](http://www.seerights.org)

Information on the International Programme on the Elimination of Child Labour:

[www.ilo.org/ipe](http://www.ilo.org/ipe)

[www.billingsgazette.com/index.php?tl=1&display=rednews/2005/02/21/build/world/33-childlabor.inc](http://www.billingsgazette.com/index.php?tl=1&display=rednews/2005/02/21/build/world/33-childlabor.inc)

[www.ipsnews.net/interna.asp?idnews=28491](http://www.ipsnews.net/interna.asp?idnews=28491)

# Gender and work

*Hanna Westberg*

## GENDER ISSUES IN A GLOBAL PERSPECTIVE

Rapid changes connected with globalisation, internationalisation, new technology, market orientation, political reorientation and accelerating transformation have ended in tremendous changes on the labour market with many different types of working conditions as a consequence.

The lack of power and material resources, traditional gender roles and norms, stand in the way of development, as is evident in most parts of the world. Unequal power structures for women and men constitute an obstacle to economic growth and democratic development. Equal opportunities for women and men to own land and assets, to earn money and to participate in working life, are essential for sustainable and democratic development. As a larger proportion of women than men live in poverty, efforts to reduce poverty are inseparable from aspirations to greater equality between men and women.

Gender is interwoven with everything. Femininity and masculinity are constructed through invisible influence to which the person is exposed in the family and in institutions, influence which permeates everything from school to organizations and the media and which is

incorporated into the structures of society. This invisible influence is manifested in fundamental values that for example result from unexpressed notions that exist in our surroundings and that we carry with us, often throughout our lives. Thus the sexual division of labour is maintained through socialisation but above all through invisible influence processes.

The point at which work-related problems will be legally accepted depends on the current social climate and is related to historical and cultural factors in society including attitudes toward men and women. Societal values and preconceptions are changed by new messages expressed through the transmission of “know-how”. These transmissions contain more or less hidden messages and processes that affect society. Knowing this is important for understanding working conditions for men and women and their relationship to health in different countries, different classes and social groups.

World Health Organisation (WHO) defines gender as follows:

“Gender refers to the socially constructed roles, behaviour, activities and attributes that a particular society considers appropriate for men and women. The distinct roles and behaviour may



give rise to gender inequalities, i.e. differences between men and women that systematically favour one group. In turn, such inequalities can lead to inequities between men and women in both health status and access to health care.”

Gender segregation in the labour market is highly complex and appears on all levels. In practice the labour market is divided – horizontally and vertically and even within an organisation. *Horizontal* segregation is when women work in certain occupations and industries and men in others. When women are employed at lower levels in organizations than men, this is known as *vertical* segregation. *Internal* gender segregation is when women and men are employed in the same occupation (and in some cases by the same employers) but carry out different work functions. This means that an apparently gender-integrated occupation may actually be highly gender-segregated in practice. Generally speaking, there is a man’s world and a woman’s world, worldwide. There are several occupations where women strongly predominate and others where men predominate. Vertically, there is a hierarchical division with men found to a greater extent in the higher managerial positions and women in lower positions. This is so regardless of whether men or women are in the majority in the occupational field.

A look at the official statistics for the distribution of the labour force by area of work in any country always shows a more or less skewed distribution. Women are more often overqualified for their job and have less influence over their work organisation and content than men. Women also generally have a greater degree of monotonous, repetitive motion in their work. Occupations where women are in the majority have lower status than where men predominate, even if the occupations require equivalent education

and training. In workplaces with as many women as men in the same occupations, the women often perform different tasks, which most of the time are classified differently in terms of status and pay. The work women perform is almost always valued lower.

In many situations, we stare blindly at the idea that if only the numbers of women within an occupation, organization, company, board of directors or in the government etc. become more equal, then gender segregation will decline and society will become more equal. But the values and processes that result in occupations becoming gender-marked and gender-segregated do not change especially when more women enter what was previously a clearly male-dominated area.

Gender segregation is not synonymous with *gender marking* – a process that renders an occupation typically female or male. If a society can deal with gender marking, gender segregation will fade away. Notions and ideas about what is feminine and masculine legitimize the placement of women and men in different occupational categories or the same occupational categories, but with the content differently defined. This leads to notions that “female” qualifications and qualities differ from “male”. The gender structure of the workplace is underpinned by the kind of generally shared perceptions of which requirements are posed by various jobs and by notions of which skills are possessed by women and men. Such qualities do not necessarily come from the individual; they may also be associated with what a particular job attributes to the individual, such as power, status and pay. *Gender segregation* is the process in which women and men end up in different types of occupation, so that two different types of labour market may be said to exist, female and male. Gender marking and gender

segregation interact, and are determined by the social structure of gender.

So *gender marking* takes place by a process in which the qualifications and characteristics of an occupation become associated with gender. This gives us an idea of which gender a person should have for a particular job. Gender marking becomes apparent when you associate a certain occupation with a man and another occupation with a woman. In theory, gender segregation may be seen as a result of gender marking of qualifications, characteristics, occupations and work functions. However, there is interplay between the gender-segregated society in which we live and the gender-marking process, one result of which is that the conditions that lead to gender marking change over time.

### Global gender gap

The World Economic Forum has constructed the Global Gender Gap. This is an index designed to measure “gender-based gaps in access to resources and opportunities in individual countries rather than the actual levels of the available resources and opportunities in those countries”. It is constructed to rank countries by their gender gaps, not by their development level. For example, the index reveals the size of the gap between male and female enrolment rates, but not for the overall levels of education in the country. There are four critical areas:

- economic participation and opportunity
- political empowerment
- educational attainment
- health and survival.

Awareness of the challenges and opportunities may serve as a catalyst for change, in both high- and low-ranking countries. All scores are

weighted by population when the global and regional averages are produced to analyse trends.

When the overall index scores have been calculated the index is bound between 1 (equality) and 0 (inequality). The equality and inequality norm remain fixed across time, allowing readers to track an individual country’s progress in relation to an ideal standard of equality. The index scores can be presented as a percentage value revealing how much of the gender gap a country has closed. Thus when the gender gap is closed (total equality is reached) the index reads 100% and when the gender gap is wide opened (total inequality exist) the index reads 0%. E.g. Oceania has closed over 70% of the gender gap, which leaves it about 30% short of total equality between women and men. Western Europe and North America. Latin America and Eastern Europe have closed 67% of their Gender Gap. Sub-Saharan Africa and Asia have closed approximately 63% of their gender gap and the Middle East and North Africa region comes last, having closed approximately 58% of its gender gap. All examples mentioned have to do with the overall index. The different subindexes are measured in the same way. Thus the gaps between women and men in average with regard to economic participation and opportunity and political empowerment are wide: only 58% of the economic outcomes gap and only 14% of the political outcomes gap have been closed.

According to the Global Gender Gap index the 128 countries covered, representing over 90% of the world’s population, are close to eliminating the gap between women and men’s educational attainment and health and survival outcomes: almost 92% of the educational attainment outcomes gap and 96% of the health and survival outcomes gap. The difference between women’s and men’s health has increased somewhat in the past few years.

So what kind of information do we get from the health gap measure? The differences between men's and women's health are measured through two variables. One has to do with the gap between women's and men's healthy life expectancy, calculated by the World Health Organization. This measure consists of "an estimate of the number of years that women and men can expect to live in good health, by taking into account the years lost to violence, disease, malnutrition or other relevant factors". The other variable has to do with the sex ratio at birth, which is presumed to capture the "missing women" a phenomenon existing in countries where sons are valued more highly than daughters.

The nature of health problems is changing. One problem has to do with ageing. Another problem stems from urbanisation and globalisation, which are resulting in worldwide transmission of diseases. The health system is not isolated from the rapid changes due to globalisation.

The health statistics used in the gender gap index are thus estimates made by the World Health Organisation (WHO). In an article about Health Statistics, the authors stress that there is a rapidly growing need for better health statistics. A new international partnership, the Health Metrics Network, was launched in May 2005, which hopefully will result in improved statistics and health information on all levels. The prime concern is to strengthen country HIS development in a way which may help to improve both the quality and quantity of health statistics.

Being the leading body in health statistics has its problems, due to the political pressure to which WHO's figures are subject. Another problem is that WHO often has to base its estimates on poor-quality country-level data provided by its Member States. To ensure accuracy and transparency of health statistics, WHO has improved its approach to producing estimates,

particularly at country level. Health statistics for recent decades present a profoundly unequal picture, with improved health in a large part of the world, but at the same time a considerable number of countries not improving at all and some even losing ground.

### Gender paradox

One part of the gender gap health and survival index is, as mentioned above, "an estimate of the number of years that women and men can expect to live in good health". A lot has been written about the so-called globally widespread gender paradox in health. The gender paradox means that women are considered to require more health care and report more sickness than men while generally living longer. One tentative explanation of women's lower mortality has been that they are biologically more robust, and men's higher mortality has been ascribed to lifestyle factors, psychosocial factors and health-reporting behaviour.

However, there are reasonable explanations for this paradox. Gender differences in life expectancy, for example, are largely influenced by environmental and behavioural factors. The health problems that women report often relate to non-fatal conditions, such as muscular pain, depression, sleeping problems, chronic fatigue etc. You may as well invert the interpretation. Instead of interpreting women's higher consumption of medicines, visits to doctors and sick leave as indicators of health problems they could instead be interpreted as factors that protect women from more serious disorders.

It is possible to link the gender paradox in health to sex marking and gender segregation. Men and women are raised to act and react differently, so it is reasonable that this also should apply to work-related health.

### Informal and formal work

The labour force participation rate is not easy to estimate. It is not only that the estimated statistics from different countries come from different, non-comparable sources, but in addition the informal sector/economy plays a major role in many of the developing countries. Nowadays the term used most of the time is informal economy, as the work done within the informal economy includes, not just one sector but several. The informal economy seems to be swallowing most of the increasing labour force in the urban areas of countries with high rates of population growth or urbanization. Entering employment in the informal economy is often a way to survive in countries with no unemployment insurance, no pensions or low wages.

Globalization is probably another reason for the growth of informal employment in many countries. Global competition opens up opportunities for formal firms to hire workers at low wages with few benefits or to subcontract the production of goods and services.

In a publication from ILO the definition of informal economy is:

“In the expanded conceptual framework the informal economy is seen as comprised of informal employment (without secure contracts, worker benefits, or social protection) both inside and outside informal enterprises.

Informal Employment in Informal Enterprises (small unregistered or un-incorporate enterprises), including: employers, employees, own account operators, and unpaid family workers in informal enterprises.

Informal Employment outside Informal Enterprises (for formal enterprises, for households, or with no fixed employer), including: domestic workers, casual or day labourers, temporary or part-time workers industrial outworkers (includ-

ing home-workers), and unregistered or undeclared workers.”

The formal and the informal parts of the economy are often dynamically linked. Many informal enterprises have production or distribution relations with formal enterprises and many formal enterprises hire wagedworkers under informal employment relations through contracting or sub-contracting arrangements. Some countries exclude informal employment in agriculture in their estimates of informal employment and some countries include agriculture.

When agriculture is included the proportion of informal employment increases significantly. Figure 9.2.1 shows total employment and from some of the developing parts of the world informal employment with agriculture excluded.

Women’s share of informal economy employment worldwide is between 60 and 80%. According to ILO “there is a link – although not a perfect correlation – between working in the informal economy and being poor”. This stems from the circumstances already mentioned (lack of labour legislation and social protection covering the informal economy workers), and from the fact that workers in the formal economy earn, on average, more.

	Men	Women	Total Informal employment as percentage of non-agricultural employment	Men's informal employment as percentage of men's non-agricultural employment	Women's informal employment as percentage of women's non-agricultural employment
WORLD	79	53			
Developed Economies & European Union	69	53			
Central & South-Eastern Europe (non-EU)	70	50			
East Asia	82	67			
South East Asia & the Pacific	83	59			
South Asia	82	36			
Asia			65	65	65
Latin America & the Caribbean	80	52			
Latin America			51	48	58
North Africa	76	26	48	49	43
Sub-Saharan Africa	86	63	72	63	84
South Africa			51	44	58
Middle East	78	33			

Figure 9.2.1. Labour force participation rate (%); source ILO.

### India as an example

In India the proportion of informal employment increased from 89% to 92% of total employment between 1989 and 2005. The first macro analysis investigation reveals that the female work force constitute 26% of the total labour force, almost all of them (92%) occupied in informal employment, including helpers or unpaid workers. 36% of the total female work force is casual agricultural workers and 36% is unpaid helpers. Among the male workers, 22% are casual agricultural workers and only 12% are

unpaid helpers. The highest representation for women within formal employment is in education, scientific and research service sector.

A large section of the Indian population is involved in informal employment and there are sectors which have more of informal employment than others. Apart from the usual agriculture and livestock-related work, the researchers find that work in textile production, wood and wood products, other manufacturing, manufacture of miscellaneous metal products, construction, and combined services also has a substantial

informal share in production. The proportion of informal worker in sectors like agriculture, construction, mining, manufactured food products, wood products and leather is higher than that of formal workers. There is also evidence of poorer households being more numerous within the informal than in the formal economy.

*National Commission for Enterprises in the Unorganized/Informal Sector (NCEUS)* stated in August 2007 that the majority of the informal workers were economically vulnerable. Therefore a suggestion of great importance is to formalize, for example, caring work, i.e. unpaid care of the elderly in the home, from non-market work to market work, which would lead to welfare benefits. Social policy intervention such as higher investment in rural infrastructure or education or health would really increase women's labour participation, which probably would lead to an expansion of their market participation, which in turn would cause value added tax to rise. A higher value added base would lead to a higher source of taxing and this would successively help raise funds for social sector, thus starting a possible good cycle for the less privileged women.

In India informal employment is a larger source of employment for women than for men. This is true of almost the whole developing world. Home-based workers and street vendors are two of the largest sub-groups of the informal workforce and in these two sections the majority are women. Taken together they represent an estimated 10-25% of the non-agricultural workforce in developing countries and over 5% of the total workforce in industrial countries.

## OCCUPATIONAL SAFETY AND HEALTH OF MEN AND WOMEN

### Gender and health

The female share of total world employment was 40% in 2006, which makes women indispensable contributors to national economies. However the women's proportion of the world's poor and working poor is increasing. It is estimated that women make up at least 60 per cent of the world's working poor and as long as there are inequalities in labour markets, women will find it harder than men to escape poverty.

Women's visible presence in paid employment, formal as well as informal economy employment, has motivated reflections on the one hand as to how their health should be protected, and on the other hand as to how gender affects their health related to work. Women and men commonly perform different tasks, work in different sectors and in different positions. A lot of women work in the informal economy in domestic work and street vending. Many work from their homes. Globally, women suffer more from job insecurity, limited possibilities for training and promotion, and low or no social benefits (e.g. insurance, sick leave).

Health and ill-health in a population develops through interaction between different social, economical and medical conditions. Thus the reasons for gender differences in health are complex and have to do with biological and cultural as well as social and structural factors. By structural factors is meant, on a global level, factors such as power, influence and access to resources. Sometimes the differences in ill-health are referred to two main categories: the biological, emphasizing the body, and the socio-cultural, emphasizing behaviour and living conditions. It is important to take into account both modes



of explanations simultaneously; neither mode of explanation will be sufficient in itself.

It is necessary to use a holistic perspective when looking at gender differences in health and ill-health and to consider the interplay between the biological sex and the socio-cultural gender. The concept of health should be understood in this wider perspective. Social structures including legislation, and power-conditions in work-life have a crucial bearing on where the line is drawn between health and ill-health. In an economic situation of shrinking resources, the economical and social factors will be of critical importance for both the definition of the term health and the use of it.

A gender perspective should be integrated with occupational health, so as to ensure that work is safe and healthy for both men and women, taking into account their social, psychological and physiological characteristics. When consideration of women's family roles is integrated, it may also be necessary to make a different definition of a risky work schedule, in order to include roles making it particularly difficult to combine work and family.

When considering women in health and safety work questions, relevant questions to men should be considered at the same time. For example, in the case of weight and size, differences between persons of one sex are much greater than those between men and women. Therefore if you make work and work-tools better adapted to women, in many cases you also make them better adapted to men. A discussion is ongoing about the way of collecting statistical data that will give us the best information about both women's and men's situations. When collecting data, adjusting statistically for gender instead of analysing data separately for women and men, limit information on the entire population. Less information loss will result if you analyse data

separately for men and women. This is to get knowledge about women and men separately, but when using the data, e.g. when designing workplaces, you have to regard the data jointly.

Health problems are related to workplace variables that are different for each sex. Women and men are often found in different occupations but also when they are supposed to have the same occupation their job-tasks often differ. One result of the separated labour-market is that in many occupations there are significant differences between the tasks women and men perform, and this naturally leads to their experiencing different problems related to the work environment.

### Are health issues gender neutral?

Biological differences between men and women are usually discussed from an average point of view. The biological differences between men and women are closely linked with perceptions of what is normal. When a woman doesn't correspond to the norm she is sometimes considered abnormal for her gender. Her other properties are also suspected of being more like those of the average man in terms of both personality and sexual characteristics. Depending on the division of power between men and women, the characteristics associated with men may be seen as more important, more valuable, or simply more normal.

Biological differences are sometimes seen as synonymous with genetic differences. In other words, if men and women produce different hormones in response to stress some people may conclude that this is necessarily an innate difference. Actually many biological differences are derived from the environment. Hormone secretion can, for example be affected by stress or illness.

According to socio-biological theories femaleness (femininity) is of biological origin and maleness is looked upon as being the norm. This type of theory makes woman a prisoner of her biology. On the other hand, socially constructed femininities and masculinities confirm the thoughts that govern our understanding of morbidity, treatment strategies and individual patients experiences. Biological preconditions and differences cannot be evened out, but there is no rational reason to label male or female biological characteristics as either better or worse. It is useful to describe the differences between men and women so as to take account of such differences, whatever their source may be, in the design of workplaces, the establishment of training programs and the setting of standards. Furthermore, the biological differences play a role in gender-specific patterns of ill health in the workplace.

Men are on average taller, larger and heavier than women, contributing to sex differences in a number of other important health-related variables such as average blood volume and oxygen consumption. The same physical load may exert greater strain on the average woman than on the average man, since lifting 20 kilos for an average man is equivalent to an average woman lifting about 12 kilos. This is calculated from women's average muscle strength being 60 to 70% that of men. Arm muscle strength for women is estimated at 50% of men's. However, the difference for horizontal pushing and pulling is smaller, and there is considerable overlap in size, shape and strength between the sexes. Both the differences and the degree of overlap are important, e.g. when designing tools so as to minimize repetitive strain injuries in both sexes.

The human skeleton is structured differently for men and women, e.g. the knee joints do not have the same structure. The epicondyles in

the knee joint, the two protruding section on the femur (thighbone), are closer to each other in women than in men. Women, therefore, are more liable to suffer injuries to the cruciate ligaments in their knees.

Sex hormones are different in men and women. Both men and women have testosterone, the male sex hormone. However, after puberty the level of testosterone remains the same in women but rises in men. In women oestrogen and progesterone vary cyclically in both quantity and relative proportion. This occurs throughout the day. Each sex hormone affects the way men and women feel psychologically.

Women and men's reproductive systems differ. Women menstruate, become pregnant and nurse children, and these processes may be affected by work-place exposures; for instance, prolonged standing can affect birth-weight and some chemicals may produce malformations. Women worldwide are very aware of their pattern of menstruation and how it affects their lives. For the great majority of women, menstruation is a "natural" process that presents few difficulties but perceptions of menstruation vary in different cultures. These perceptions may be positive or negative. Menstruation may be experienced as characterizing femininity, fertility, youth, or purification of the body, yet at the same time it is also linked with vulnerability and pollution, and with attitudes of disgust and shame. In some societies, menstruating is connected to religious and social traditions or taboos. This is the explanation why menstruation not only should be looked upon as a physiological process but also has social, cultural and psychological implications. The experience of bleeding is characterized from two different points of view; one from the woman's actual experience and the other from her position as a member of society which has attached certain

meanings to menstruation, The interaction of these two elements determines the woman's attitude to menstrual bleeding.

WHO report that physical symptoms during menstruation are reported from all parts of the world but changes in temper are not reported from all countries. Women in developing countries who reported temper changes did not report them as pre-menstrual but rather as something happening in the beginning of the menstruation. Thus the conclusion was that you have to pay attention to how you produce conscious or unconscious bias through how statements are valued and through assuming that a special condition exists. For example, in Zimbabwe when vocational and non-vocational educated women were asked about their menstrual experiences, they mentioned the hush-hush and the negative attitudes around menstruation as a problem whereas women in the industrialized countries often refer to premenstrual problems. The menstrual cycle or the notion of menstruation may cause discomfort or concern for the employee as well as skilled and unskilled female workers have to face discrimination from employers on the grounds of gender and physiological factors including menstruation and childbirth.

Men produce sperm, and this process is very sensitive to exposure to chemicals, vibration and radiation.

Absorption of solvents in blood may vary between men and women. Women's skin is thinner and more permeable to substances it comes in contact with. Blood levels for chemical substances vary between men and women since more of the chemicals can be stored in women's larger subcutaneous fat. Therefore it has been hypothesized that the average woman is at greater risk of harm from fat-soluble chemicals because of this higher proportion of fat tissue, thinner skin and slower metabolism. True or not, it would be

unwise to presume that an average sex difference applies to all or even most individuals in a population. The percent of fat varies in both sexes according to age, physical fitness and training.

Exposures at work often differ by gender. All over the world, men and women work at different tasks. An example from the developing countries is in agriculture where women may be exposed more often to pesticides indirectly during planting and harvesting and men directly during application.

Women and men are exposed to different physical and psychological stressors such as repetitive work, heavy lifting and monotony. Women are the majority of health care-workers, exposed to risks of infection (including needle-stick injuries), violence, musculoskeletal injuries and burnout. Women usually suffer discrimination, mobbing and harassment more often than men, especially if they enter male-dominated occupations.

Although not many psychological differences between women and men have been demonstrated scientifically, it has been suggested that men usually have higher self-esteem and confidence and that women are more emotionally expressive.

Men's and women's hormone responses to stress are similar, but the way stress is experienced may be different. The concentration of adrenalin, noradrenaline, cortisol and other stress hormones can be measured after different stress situations using urine and blood samples. In a study by Frankenhaeuser it was found that female white-collar workers had higher noradrenaline, levels while at work. The women's noradrenaline levels rose at the end of the workday when they had to rush home to another important responsibility. For male white-collar workers, the concentration of noradrenaline fell at the end of the workday. Other studies

have shown that when the external source of stress has the same value for men and women the differences in their reaction patterns disappear more or less. The conclusion made was that when women and men achieve more similar occupational roles and take equal responsibility for the home and childcare they will react similarly.

Knowledge of the health effects of working conditions in developing countries is sparse because of the lack of systematic research. However, it is well known that most women in developing countries still take on very heavy physical work in the household and outside it. Women are responsible for providing water and fuel for domestic consumption. These activities involve heavy loads and walking long distances. Given the current image of women's work is so simple, easy and harmless, it is important to educate the public about the fact that women's work often involves health risks. In addition, the large proportion of women in precarious jobs in the informal economy, and in the economic free trade zones, as well as the increasing gender gap in wages must be made visible.

In developing countries, effective workplace health and safety regulations often do not exist, or if they do they are not enforced, especially in the informal economy where many women work. New methods and strategies are needed to encourage stakeholders to implement these regulations on low-level jobs. Such a change in perspective needs alliance with international consumer groups, free trade associations and international social partners.

## Violence

It is very hard to estimate the work accident rate and even worse to estimate the extent of violence against women especially when it has to do with work related violence and violence at work. Men meet with violence too, but many

studies show that women are at particular risk. The nature of the work women perform, low paid, low status such as domestic work, service work, helpers, and high-risk occupations such as nurses, teachers and social-workers expose women to high risks of violent behaviour in the workplace. The informal economies hide a lot of work-related accidents and violence at work. A great deal of violence against women happens in the family and many women in the informal economy work in domestic work or as helpers in the family business.

In 1993 the United Nations General Assembly adopted the Declaration on the Elimination of Violence against Women, which is defined as "any act of gender-based violence that results in, or is likely to result in, physical, sexual or psychological harm or suffering to women, including threats of such acts, coercion or arbitrary deprivation of liberty, whether occurring in public or in private life." In a UN fact sheet from 2006 it was stated that:

"Violence against women takes many forms – physical, sexual, psychological and economic. They are interrelated and affect women from before birth to old age. As societies change, patterns of violence alter and new forms emerge. Some forms of violence, such as trafficking, cross national boundaries.

Women who experience violence suffer a range of health problems and their ability to participate in public life is diminished. Violence against women harms families across generations, as well as communities and reinforces other violence throughout societies.

Violence against women also impoverishes women, their families, communities and nations. It lowers economic productivity, drains resources from public services and employers, and reduces human capital formation.

Violence against women is complex and diverse in its manifestations, with far-reaching and long-lasting consequences and costs. Its elimination requires a comprehensive, systematic and determined response.”

The fact sheets also contain some data and evidence that the Secretary-General’s in-depth study on violence against women seeks to stress. Some of these are work-related or consequences inflicting on the working-life of women, for example:

- There is compelling evidence that violence against women is severe and pervasive throughout the world. Surveys on violence against women conducted in at least 71 countries show that a significant proportion of women suffer physical, sexual or psychological violence.
- The most common form of violence experienced by women globally is physical violence inflicted by an intimate partner. On average, at least one in three women is subjected to intimate partner violence in the course of their lifetimes.
- Women experience sexual harassment throughout their lives. Between 40 and 50 per cent of women in the European Union reported some form of sexual harassment in the workplace.
- Many women face multiple forms of discrimination and an increased risk of violence.
- Women subjected to violence are more likely to suffer physical, mental and reproductive health problems.
- Women who have experienced violence are at higher risk of contracting HIV. Fear of violence also prevents women from accessing

HIV/AIDS information and receiving treatment and counselling.

- Depression is one of the most common consequences of sexual and physical violence against women. Women subjected to violence are more likely to abuse alcohol and drugs and to report sexual dysfunction, suicide attempts, post-traumatic stress and central nervous system disorders.
- Violence against women may prevent women from fully participating economically and hinder opportunities for employment.
- The costs of violence against women – both direct and indirect – are extremely high. These costs include the direct costs of services to treat and support abused women and their children and to bring perpetrators to justice. The indirect costs include lost employment and productivity, and the costs in human pain and suffering.

### **Conferences on occupational safety and health for women**

A successful initiative to highlight and document women’s occupational safety and health took place in Spain 1993. This initiative has been of great importance for the interchange and stimulation of research, knowledge and actions in the field of women, work and health. The Centre for Analysis and Sanitary Programs in Barcelona organized an International Workshop Women, Health and Work. At this workshop the participants decided to launch the International congress on Women, Health and Work with the intention to gather research and knowledge about the differences between disease in women and men.

Up till now there have been five congresses (Barcelona Spain, Rio Brazil, Stockholm Sweden, Delhi India and Zacatecas Mexico). Each

Congress has started from the conditions that each organizing country found most important. The congress in Sweden was intended to bring together scholars, activists, representatives of civil society organizations and trade unions, of government agencies and persons involved in practical work from all parts of the world for critical discussions on questions related to women's working conditions, their living conditions and gender-specific issues related to health/ill health. The congress in India centred around the three main themes of gender, paid and unpaid work, The changing world of work and Scientific health practised in development. The choice of these themes by the organizers of the Congress was prompted by the outcomes of preparatory country-wide regional workshops in which researchers, non-governmental organisations, unions and persons involved in practical work gathered to discuss gender, work and health issues.

As a consequence of all five congresses, new networks were formed. The Spanish congress decided to continue working as a network so as to preserve the information gathered from the research done by the different groups. In Brazil a network was formed especially from interested parties within Brazil but also with some other Latin Americans participants. In Sweden one outcome was the creation of different working networks (the most important being an African network) on women's health and work. Both the Indian and the Mexican congresses formed networks. An initiative called "Woman, work and health initiative Asia" was created for the advancement of the research findings linked to the reality experienced by women, so as to have a positive impact on their lives and work conditions. The congress in Mexico generated an initiative for Latin America, similar to that of Asia, Initiative on Women, Work and Health

for Latin America. Other important outcomes were agreements on how to put further the occupational safety and health so women could take advantage of best practices reported at the congresses.

The most important role of the Women Work and Health Congresses has been to open the way to an interchange of knowledge between industrial and developing countries and between researchers, different organisations, unions, persons involved in practical work focusing on issues that are central above all for women and their conditions of work and health.

### HOW TO IMPROVE WOMEN'S WORKING CONDITIONS

In the late 1990s a Swedish research-group has developed a model for understanding factors interacting with gender-related ill-health, Figure 9.2.2. The three main factors believed to cause gender-related outcomes in health are living conditions, biological/physiological characteristics and psychological characteristics. These three factors are interlinked. For example, a woman's physical strength and body size probably affect her choice of occupation while physical training during her time off will have an effect on her physical capacity.

Psychological characteristics, e.g. motivation and cognitive capacity, are also crucial for her choice of career, and this in turn will influence coping strategies.



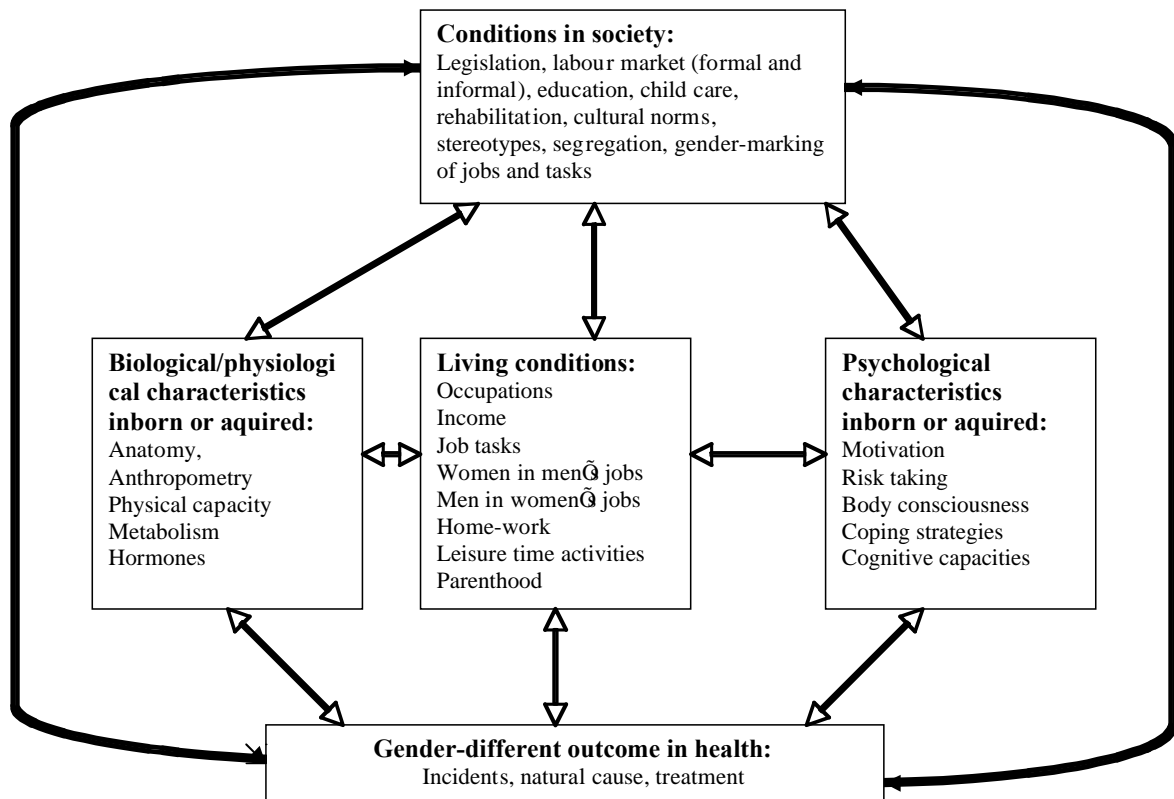


Figure 9.2.2. Factors interacting with gender-related ill-health.

The interaction of the three factors and the outcome is greatly dependent on conditions in society. Differences between countries and regions can partly be explained by the differences in social conditions. Possible explanations are differences in culture, history, religion, the share of the informal economy, etc.

Female-male differences in education, socialization and upbringing may lead to differences in the way workers manage their illnesses, their perception of risk, and the tendency to take sick leave or to seek treatment. Thus, differences in exposure to risk factors may combine with biological, psychological and social differences to produce sex-specific patterns of occupational

health problems. It is therefore important to examine occupational health research, implementation, policies, programs and projects with the above model in mind.

The model presented was partly inspired by another study aimed at developing methods for public health and epidemiological studies adjusted to work and living conditions for women and men. The focus was on psychological, ergonomic and chemical/physical exposure conditions. Interaction between exposures in paid work and between work, phase of life and family situation was examined. Statistical methods of analysis suited for identification of exposure pat-

terns were tried out and guidelines were defined for modelling work and health relations.

Recommendations proving important for the health and safety of both men and women at work included:

- examining the possibilities of combining paid work with the rest of life, i.e. family, unpaid work and leisure time,
- studying the mental and physical demands of work, the extent and location of work in time and space,
- examining the possibilities for relaxation and recovery, at and away from work,
- viewing the connection between chemical/physical occupational health problems, physical load and the individual's influence and attractiveness on the labour market,
- investigating organisational changes and changes of work conditions.

A checklist based on the model is presented on the following pages. It may be used for investigating and acting on issues related to gender at work.

Gender-sensitive perspective may reveal how social norms limit women's economic participation, and how this in turn increases poverty, decreases economic independence, compromises social networks and supports and puts women at risk of violence which they then find hard to name. All of which, of course, leads to poorer health outcomes. Without a gender-sensitive approach, this reality of women's lives remains invisible. It is important to remember that a gender-sensitive perspective means more than different sexual and reproductive bodies. A gender-sensitive perspective pays attention to the possibilities of the most commonly used deter-

minants of health producing, not just different but poorer outcomes for women.

If the aim is to improve the quality of health and safety and attain equitable health outcomes for all working members of society, it is essential to make sure that the multiple realities of people's lives are always included.

An often-heard argument is that poor countries and poor companies cannot afford health and safety measures. There is no evidence that any country or company in the long run would have benefited from a low level of health and safety. In fact, recent studies show that the most competitive countries are also the safest. Selecting a low-safety, low-health and low-income survival strategy may not lead to high competitiveness or sustainability. Thus all countries stand to gain economically by working towards gender-sensitive occupational health and safety programmes embodying a more humanistic and holistic approach.

## Gender-sensitive safety and health checklist

Conditions in society:	Yes	No	Comments; Type of action needed in relevant cases Responsible Date to follow up
Do the national laws and/or regulations address gender issues?			
If so, are they implemented in the work-place?			
Is the labour market gender-segregated?			
If so, is the segregation horizontal, vertical or internal?			
If so, is this due to cultural norms?			
Is there any noticeable informal economy?			
Are men and women equally distributed in the informal economy?			
<b>Conditions at the workplace:</b>			
Do men and women have the same opportunities of job advancement?			
Is any job and/or job task associated with a special gender?			
If so, is it due to physiological factors?			
Is there equal pay for equal work?			
Is there any policy and action plan against sexual harassment?			
If so, has there been any investigation regarding sexual harassment?			
Are there different working conditions for men and women?			
If so, is this due to segregation?			
If so, is this due to cultural norms?			
Are there different employment conditions for men and women?			

If so is this due to segregation?			
If so is this due to cultural norms?			
Are working hours evenly distributed in time and space for men and women?			
Do men and women have the same opportunities for development in their work?			
Is there any documented information about gender distribution in workplaces?			
Are workplaces designed/adapted so both men and women can carry out the work tasks?			
Are there separate restrooms for men and women?			
<b>Living conditions:</b>			
Are men and women equally responsible for and equally active concerning unpaid work at home?			
Do men and women have the same opportunities to take care of the children?			
Do men and women have the same opportunities of time to themselves?			
Do men and women have the same and safe opportunities of travelling to work?			
<b>Health risks:</b>			
Do measures for investigating and controlling the ergonomic situation and physical working conditions consider both men and women?			
Do measures for investigating and controlling chemical exposures consider both men and women?			
Do measures for investigating and controlling psychosocial exposures consider both men and women?			

### SUGGESTIONS FOR FURTHER READING

The Global Gender Gap Report 2007. World Economic Forum [www.weforum.org](http://www.weforum.org)

Global Gender Gap Index is a result of country rankings. Among other things the rankings together with detailed country profiles will serve as a catalyst for change by providing policy-makers a picture of their country's relative strengths and weaknesses compared to that of other nations.

Women's Health at Work. Kilbom Åsa, Messing Karen and Bildt Torbjörnsson Carina (eds.) 1998.

The main focus of this book is on ill health among women and a description of gender-related ill health in working life. The methodological problem is also discussed regarding the development of gender-sensitive measures of working conditions.

Gender and Informal Sector Analysis in India by Anushree Sinha and Haider Khan Research Paper No 2008/65, World Institute for Development Economics Research.

[www.wider.unu.edu/publications](http://www.wider.unu.edu/publications)

The paper clarifies questions about gender and the informal sector in the economy in a developing country. India is taken as an example but has similarities with many other countries in the developing world.

Gender Equality, work and health: A review of the evidence. Karen Messing, CINBIOSE, Université du Québec, Montréal, Canada and Piroška Östlin, Karolinska Institute, Stockholm, Sweden. World Health Organization (2006). [www.who.int/occupational\\_health/publications/genderwork/en/](http://www.who.int/occupational_health/publications/genderwork/en/)

The main purpose of this review is to describe the relationship between gender inequality and health and safety problems. It reviews gender and highlights specific issues for women and the necessity to strengthen and establish enhanced programmes and practices to ensure women's health and safety at work.

# Migrant workers

*Bo Johansson*

## MIGRATION AND MIGRANTS

### A historical review

Humans have always been on the move, colonising the earth since our earliest ancestors left their home ground on the African continent. The main driving forces for movement and settlement have probably been the same throughout history – to avoid scarcity and unsafe conditions in search of a safe haven with sufficient resources. Migration has occurred by choice or because unfavourable circumstances have forced people to move. The free movement of peoples has become increasingly restricted as societies have become more complex and tribal territories have developed into political nation states.

The demography of contemporary Europe is largely the result of settlements following the European era of the Great Migration, 400-900 AD as tribes of different origins challenged the prevailing order. During the first centuries of this period, it was mainly Germanic people who conquered and settled in the West Roman Empire in Southern and Central Europe. They were followed by Slavs, Hungarians and Turks who invaded what is now Turkey and Eastern Europe. From the 8<sup>th</sup> century, the Arabs conquered most parts of the Mediterranean coast-

line, including Spain and southern Italy, leaving a demographic and cultural imprint that still remains.

Apart from military invasion and forced rule, trade has been the foremost reason for migration. Established land routes, such as the Silk Road connecting China and Europe, improvements in the art of open sea sailing that gradually enabled trade, and military aggression, were all of paramount importance. The initial successes of pioneers were soon followed by migrants who settled permanently on the foreign shores. For example the Vikings' contacts with Britain and communities around the Black and Caspian Seas; the adventurous voyages by Columbus, Pizarro and Cortez to Latin America; Vasco da Gama's opening of the gates to India, and the Arabs' arrival in South-East Asia and Indonesia in the 15<sup>th</sup> and 16<sup>th</sup> centuries.

The colonization of the Americas was driven mainly by the desire of European rulers for gold and wealth, and by their subjects' need to escape poverty, famine and religious persecution. One result was the shift from continents inhabited by an indigenous population to territories dominated by colonizers. Another was the emergence of Catholic Europe as a contender for global power. The Australian aborigines gradually



faced the same fate as the American Indians as colonization started in 1788 with the deportation of British criminals. Migration to Australia escalated and was totally dominated by European migrants, whose descendants comprise 98% of the current population; Sydney is the third largest Greek city today. Although these massive migrations were voluntary, the destiny of the indigenous populations was hardly one of free choice. They were almost completely wiped out by new diseases, forced labour and armed brutality.

There is also a number of large scale forced migrations throughout history. One early example is found in the Bible, where the deportation of the Jews to Babylon in the 6<sup>th</sup> century B.C. is described. In more recent time one of the most appalling and important mass movements was the European slave trade, dominated by Great Britain, Portugal and France. Some 15 million Africans were captured and transported to forced labour in North America, once again changing the demography of the American continent. Slavery went hand in hand with the European colonization of Africa, needed not only for administration of the slave trade, but also inspired by the wealth of resources such as ivory, gold and diamonds. The search for these resources also turned many Africans into slaves in their own countries. European supremacy was justified by a predominant racist ideology that gave them the right to exploit and the duty to civilize “barbarians”. The imperial ideologist Rudyard Kipling summarized this position as “the white man’s burden”. If the mission failed the remedy was expressed by Mr Kurtz in Joseph Conrad’s novel *Heart of darkness*: “Exterminate the brutes!” The combination of the slave trade and colonization not only implied immense human suffering, but also the decline and fall of many prosperous African societies. Formal slav-

ery, often based on the import of slaves, has been the backbone for many imperialist economies, such as Egypt under the Pharaohs, and later under the Mamluks, ancient Greece, the Aztec empire, the USA until 1865 and Brazil until the 1870s. Although forced labour migration has been formally abolished, it is still a reality in many parts of the world. In spite of international conventions condemning trade in humans, the trafficking and smuggling of people into slavery is flourishing.

The next period of increased labour migration, which occurred from the middle of the 19<sup>th</sup> century up to the First World War 1914-1918, can be said to have initiated the migration flows of the contemporary world, depending on global events. Millions of Europeans escaped poverty and religious persecution by moving to new settlements in the Americas and Oceania. Large numbers of Asian workers, especially Chinese and Indians, sought a more prosperous future in plantations, trading and mines in Asia and Africa. That migration boom ended with the Great Depression following the crash of the Western stock markets 1929, which resulted in mass unemployment, restricted international trade and closed borders.

Since then the world has experienced two more peaks in international migration. The first was from the end of World War II in 1945 until the “oil crises” of 1973 affected the oil consuming countries of the world. (The oil-producing countries experienced their oil crises in the early 1980s, when the world market price was too low). That post-war period was characterized by increased labour migration, (both skilled and unskilled), mainly to and within Europe and the USA. The restrictions on immigration that were introduced in the seventies are still applied in most European countries as well as in North America and Australia. Since the legal labour

immigration have become more restrictive in the developed countries, more people enter as refugees applying for asylum or as close kin to a migrant already residing legally in the country. The final option is to enter a country as an undocumented migrant, residing and working without legal recognition and protection. Migration flows within and between countries are allowed or restricted because of political and/or economical considerations.

Large scale migration has been very important for the development of modern societies and advanced economies since the industrial revolution. In recent decades new or reformed transnational migratory systems have emerged in South East Asia, the Gulf, Africa, Central and Eastern Europe and elsewhere. Huge internal migrations from rural to urban areas and within regions have proliferated with the accelerated growth of advanced industrial and service economies, for example in China and India. These migrations have repercussions on social structures, culture and working life. These global developments have been defined as the ‘age of migration’.

The globalisation and transnational migratory systems are closely interrelated. The processes of globalisation have promoted the temporary character of work, increased offshore activities, outsourcing, sub-contracting, the formation of networks of private and public sector micro enterprises, sweatshop production, and home based work. These developments run parallel with the deregulation of established national frameworks of labour relations and working life norms, in both developing and developed economies. New forms of work organisation are structured along intersecting lines of social class, gender and ethnicity with the regulation of migration in accordance to labour market needs as an important vehicle for change.

## Concepts

Although it is individuals who move, migration is by its very nature a social process. The following definition from ILO’s “Glossary on Migration” on contemporary migration makes this clear:

This definition is the basis for this chapter. The concept covers all aspects of migration, including internal migration, e.g. domestic move-

*Migration – A process of moving, either across an international border, or within a State. It is a population movement, encompassing any kind of movement of people, whatever its length, composition and causes; it includes migration of refugees, displaced persons, uprooted people, and economic migrants.*

ment from rural areas to cities. The process of migration was defined by the sociologist Émile Durkheim as a “social fact”, meaning that behaviour and expectations don’t only emanate from individual responses and preferences but mainly from the community which socializes each of its members. These social facts exist outside of individuals. The totality is bigger and more complex than the sum of its parts because the totality is a function of those parts and their interactions.

The most important variables in the migration equation are the conditions in both the country of origin and the destination country and the historical relationship between these countries, the migrants’ group or family experience of migration, and the migrant’s own aspirations, knowledge and skills. The history of migration could expose countless fates of individual migrants but this is not the focus of this text that examines the overarching mechanisms that enable or force people to migrate. This perspective has been chosen because it is only in the light of such an understanding that wise policies and efficient strategic plans for the management of issues related to migration can be established.

Although this text deals mainly with unfavourable working conditions for migrants, it must not be forgotten that migration also offers opportunities for migrants to achieve their hopes and aspirations for a better life.

### Why do people move?

There are many different causes of migration and they vary over time, and can be interpreted from various perspectives.

#### *Micro perspective*

The application of neo-classic economic theory to migration has its roots in efforts made during the 19<sup>th</sup> century to establish statistical laws of migration. Such laws stated that people made rational choices, based on information about the conditions at hand, e.g., people moved from overcrowded areas to less densely populated places, or from areas with a low average income to regions with higher economic standards. The basic assumption is that migration is driven by causes that an individual regards as rational. Humans are seen to be ontologically a *Homo Economicus*, evaluating the options, and moving in order to maximise utility. When sociologists adopted this perspective *push-pull-theories* resulted. Migration is explained by a combination of push factors that incite people to leave their present residence, and *pull* factors that draw them to certain countries or internal destinations. Push factors may be war, political repression, famine, demographic growth, or unfavourable economic opportunities, while pull factors may include physical safety, civil rights, improved economic possibilities, and demand for labour. The potential and ideal long-term result was believed to be increasing economic equality between countries and regions of the world, finally resulting in global economic equilibrium.

The push-pull arguing provides us with neat explanatory theories based on human rationality. The problem is that they are not fully consistent with reality. Firstly these theories are individualistic and ignore history. The emphasis on individual choice disregards other important factors such as national restrictions and requirements concerning migration, or historical ties between countries such as political unions or colonial relationships. They also assume that *Homo Economicus* has access to all relevant information, which is very seldom the case. Nor is it the case, which would follow from the theory, that we find the poorest people in developing countries migrating to the rich and developed countries in Europe, America or Australasia. The theory also fails to answer why some of the poorest countries in the world host the majority of the world's refugees. It also doesn't explain why one of the most densely populated countries in the world, the Netherlands, attracts more immigrants than it produces emigrants. It also leaves us in complete ignorance of the causes, when faced with the complexity of global migration patterns, revealing the fact that different groups from varying origins systematically migrate to different regions and countries. Finally, it doesn't explain why the economic gap between the poorest and richest countries is constantly increasing.

If national policies are based on these theoretical assumptions they will either fail or create the very problems they intend to prevent. For instance, very strict immigration legislation implemented in order to combat irregular migration has proved to increase illegal immigration, which is the obvious case in e.g. Italy and Spain. The status of undocumented immigrants makes them more vulnerable, e.g. regarding housing, education, working conditions, wages, harassment and sexual abuse that in turn increases

public costs, human suffering and potentially social disharmony for the host country.

Given these criticisms, we could conclude that this way of reasoning should have been abandoned but unfortunately this is not the case. The logic of push-pull theory is definitely the soil for the European fear of so called “social tourism”, i.e. the expectation that people will immigrate, legally or illegally, solely to benefit from the host country’s social welfare. Far from being adjusted or completely abandoned, these ideas of rational choices are the backbone of migration policies and legislation in many countries. When transformed into political practice, they often increase the problems of the country in regard to illegal migration, human smuggling and trafficking, populist politics, failed integration policies and public xenophobia.

#### *Macro perspective*

An alternative historical-structural analysis, derived from Marxist political economy, attempts to explain international migration as an effect of the prevailing global economy. It starts by recognising the unequal distribution of political and economic power in the global economic system. Migration is seen mainly as a means to mobilise cheap labour for capitalism, as was clearly seen in many countries during the 20th century. The Scandinavian countries, especially Sweden, recruited skilled workers from southern and eastern Europe, in order to expand the capacity of export industries after World War II. Germany established a guest worker system with Turkey and South-European countries in the 1960s. In parts of the USA, agriculture largely depends on cheap migrant labour from Mexico and Central America. The exodus of vast numbers of skilled Indian IT technicians to Silicon Valley and other such centres is another recent example of the

strength of the capitalist economy’s impact on migration patterns.

Current global economic and political relations are increasingly dominated by both old and new actors including multinational companies, the International Monetary Fund (IMF), the World Bank, World Trade Organisation (WTO), OPEC, the G8 countries, and international NGOs. These organisations cross over regional and national borders, using technology that enables them to perform management and financial operations 24 hours a day all over the world, regardless of national and other geographical boundaries and interests. The presence and activities of the above global actors impacts greatly on international migration patterns, adding a new complexity that so far has not been met with refined analytical tools and methods that will be able to manage migration on a global level.

While the historical-structural perspective, in addition to the push-pull theory, sheds some light on international migration it is equally incapable of explaining the complexity of it. Whereas push-pull theories represent a micro level perspective focused on the individual, the macro perspective theory mainly illuminates macro-economic macro-level factors. Other factors are neglected, e.g. legislation and regulation that restricts migration, or individual choice. The historical-structural theory is therefore equally limited.

#### *Towards a holistic perspective*

A new approach to migration has been developed; “migration systems”. This concept includes both historical and current links between the countries of origin and destination. For instance, the German *gastarbeiter* system between Germany and Turkey had already established relations in the 18<sup>th</sup> century while the French

immigration pattern is mainly based on colonial and contemporary relationships between France and the Maghreb countries (Morocco, Algeria, and Tunisia). The Saudi Arabian migration system is very much linked to other Arab countries and has been that way since the dawn of Islam almost 1400 years ago, but also more recently includes migration from non-muslim countries such as Sri Lanka and the Philippines. Understanding of a migration system requires broad interdisciplinary study of the conditions at both the migrants country of origin and in the destination country. The migration systems theory also implies that migration patterns are based on previous historical relations between countries or regions, such as political unions (Egypt-Syria or Denmark-Greenland), colonisation (the Netherlands-Surinam-Indonesia or England and the Indian subcontinent), military occupation (USA-Cuba, Israel-Palestine or the Soviet Union-the Baltic states), trade (Sweden-Germany or Italy-Argentina), or a combination of several of these historical experiences. Contemporary realities such as bilateral or regional treaties, development programmes, and military collaboration are also crucial factors at the macro-level. It is of equal importance to find what forces are involved at the micro-level, e.g. social networks, which are created or inherited by migrants. These networks are immensely important for migrants to find work, housing, orientation in a new society. These networks also explain “chain migration” where a few migrants establish themselves as a bridge-head in a destination country and are then followed by others who are helped by the experiences and social knowledge of the initial migrants. When the migrant numbers reaches a critical mass they will form their own community.

There is still one concept missing, namely the intermediary that connects national, regional

and global conditions and the capacities, aspirations and difficulties of the individual migrant. Migrant communities, which often develop their own economic and social infrastructure aimed at sustaining their community and helping newcomers, partly fulfil this need. Chinese immigrants in the USA have established their own banking system. New religious congregations, such as the emergence of Muslim, Buddhist and Sikh religious organisations, mosques and temples in Northern and Western Europe, attempt to organise health care, education and social service for community members. The existence of such structures often results in temporary migrants becoming permanent settlers. There are two principal reasons for this. Either it becomes possible for migrants to integrate into their new society, to improve their conditions, and to establish a good life, or, migrants are able to stay but they remain on the margins of the host society. The result mainly depends on the migration and integration policies and practices of the host country. While migrants may prosper or suffer in both cases, the host society will only benefit from the first scenario. A prerequisite for that scenario is that pluralistic and inclusive views form the basis for policies at national, municipal and enterprise levels. This will enhance the migrant communities’ interest to act as mediators and social partners between the migrant minority and the majority of citizens rather than acting purely in their own interest.

When migration is treated in this way it will truly be a Dürkheimian “social fact”. There is no single answer to why people migrate, who will migrate, when or from where to where. Each migration movement must be seen in its own context, revealing its own dynamics, currently and historically.



## GENERAL TRENDS IN CONTEMPORARY MIGRATION

The overall global migration pattern shows a very complex picture. Today almost two million people migrate annually to settle permanently, and in some years as many leave their countries as refugees. One third of the annual number of international migrants moves from a developing to a developed country and another third moves between developing countries. 65-70% of global migration involves and affects developing countries. In addition there are tens of millions temporary migrant workers crossing borders annually. Most countries both send and receive migrants, and there are flows within and between continents. The European Commission summarises the present situation as follows:

“The present migration situation is marked by the rise in the absolute number of migrants, including in the number of women, the multiplication of the types of migration, the increase in trafficking in human beings, the growth of diasporas, the integration challenges for the migrants and the host countries, the strengthening of ties with people who have stayed in the country of origin, the diversification of destinations and origins, and the multiplication of migration routes. The migratory pressure is increasingly heavy on Europe and other industrialised countries, while south/south migration constitutes an important phenomenon (.....) In some cases, countries which until recently were only origin and/or transit countries have also become host countries,...”

*Communication from the Commission to the European Parliament and the Council 25.1.2006*

When domestic mobility is added, (as implied by the definition of migration), there is probably more than a billion persons on the move annually. These figures surpass all previous experiences

of migration in human history, and pose a serious challenge to the national and transnational management of migration. There are no doubts that Castles and Miller have good reasons to label our era “The Age of Migration”.

## Whence and where

The UN Population Division has published figures that indicate the expected annual net migration to and from various regions of the world. The table below shows that three regions are expected to be net receivers of migrants during coming years: North America (USA, Canada), Europe (the EU member states) and Oceania (mainly Australia). The remaining regions, Asia, Latin America and the Caribbean, and Africa, will be net senders of migrants. Most African emigrants are believed to leave North Africa, mainly for Europe, while the Asians will go to North America and Europe. Latin Americans will mostly leave for the USA.

Region	Annual net migration 2005-2010
Africa	-159,000
Asia	-1,242,000
Europe	579,000
Latin America	-573,000
North America	1,310,000
Oceania	84,000

In addition, substantial mobility within the continents is also foreseen. These movements are expected to be greatest in Asia, especially from the Philippines and the Indian subcontinent to the Gulf States, but also from South-East Asia to Japan. A considerable migration from sub-Saharan countries to South Africa is also foreseen. Latin American migration is dominated by movements from Central America, Puerto



Rico and Mexico to North America, but there is also expected to be considerable flows from Nicaragua and Panama to Costa Rica in Central America. It is also expected that there will be flows of people into Argentina and Venezuela from neighbouring countries in South America.

There is also a constant mobility within countries from rural to urban areas, especially in developing countries. Capitals cities and other big cities, such as Mexico City, Djakarta, New Delhi, Sao Paolo, Beijing, Cairo and Istanbul have rapidly grown into mega cities with 15-20 million inhabitants. Many of the rural newcomers end up in huge slum areas, shanty towns or favelas, trying to make a living from insecure and risky low paid jobs in the informal economy. Ciudad Nezahualcóyotl, a poor suburb of Mexico City, hosts three million residents, Libartador in Caracas, Venezuela has 2.2 million, and Aje-gunle in Lagos, Nigeria, has 1.5 million. There are more than 30 slum areas scattered round the globe that each house more than half a million people, most of them international or domestic migrants. In China alone 160 million people are reported to have moved permanently to the big cities in the last 10 years. The majority of these Chinese citizens live as undocumented city dwellers without social rights, such as education and health care, because the legal system doesn't allow them to register at any other place other than their birthplace.

Even if people are free to move and register domestically, urban infrastructures can't possibly keep up with the massive increase in population. Everything from primary health care to work place surveillance and housing lag behind, and the gap between those who have access to public facilities and those who don't is constantly widening. One common trait everywhere in the world, especially prevalent in developing countries, is the reliance of people on social networks

for security, assistance and jobs. However, in most cases this exacerbates their exclusion from public goods and denies them a foothold in the formal labour market. This development will be further accentuated by general population growth. The UN estimates that the world population will increase by 382 million people between 2005 and 2010, and that 90% of the increase will be in urban areas, resulting in more than 50 cities with more than 5 million inhabitants, most of them in developing countries.

### Features of contemporary migration

In 1999 there was a contest in Sweden to define which single word best described the evolution of the 20th century. The winning word was "faster", a word that characterises international migration. "More" and "everywhere" could also be added. Castles and Miller argue that the following five features, all relating to increased speed, numbers and complexity, depict contemporary migration trends: globalisation, acceleration, differentiation, feminisation and politicisation.

The globalisation of politics, economies, communication, transport and culture has also affected migration patterns. Although recognisable dominant routes of migration are discernable, it has truly become a global phenomenon. Even countries that historically have been almost totally closed, e.g. Japan, Tibet, Libya and Albania are now contributing to the global migration pattern. The receiving countries – traditionally USA, Canada, Australia, New Zealand, Argentina – has multiplied as migration patterns have become more complex. Today they have been accompanied by Russia as the world's second largest immigration country. In the past migration was often quite one-dimensional, e.g. settlers went to North America and Australia, refugees crossed into their neighbouring

country, or students from colonies went to the country of their colonial master. Today, almost every country face different types of migration, when people both immigrate and emigrate for diverse reasons. They can have a legal status as refugees, migrant workers, permanent settlers, temporary students, or just transiting on their way to another destination, but they may also leave or entry countries without any permits. This means that governmental instruments and policies have to be equally diverse, in order to cope efficiently with migration issues as well as with internal tensions in regard to the relations between minorities and the majority.

Migration is increasing in and between all major regions, and there are no signs that this will change. Since one of the main driving forces of migration is unequal economic conditions between regions, the widening economic and welfare gap between north and south and rural and urban areas leads us to expect this increase to continue. In the short and mid-term, occasional events, such as wars, famines, or catastrophes such as the tsunami in South-East Asia, hurricanes Katrina and Gustav in New Orleans and the earthquakes in Pakistan and China, may speed up the increase still more.

The general idea of a migrant is of a young male of working age, sometimes accompanied by women or with a woman who is planning to join him later. This perception is no longer true as since the 1960s, women have constituted a considerable part of international labour migration. Today half of the world's migrants are women many of them migrating for jobs as they are the primary bread-winners of a family left behind. A considerable number of female migrants have never worked for wages before so migration stimulates new groups to join the global labour force. The relative figures of male and female migrants can vary a lot in and between differ-

ent regions. For instance 70-80% of the unauthorised Mexican labour migrants in the USA are young men. The traditional movements of male migrants from southern African countries to mines and factories in South Africa exceed those figures. On the other hand, the migration of Philippines to other Asian countries, especially the Gulf States, consists of 90-95 percent women. Other examples of female dominated migrant flows are those from Sri Lanka to the Middle East, from Cap Verde to Italy, and from Thailand to Japan. Attention must be paid to the gender related vulnerability that migrant women face in host countries, especially in the housing and labour markets. Their position is often weaker than those of migrant men because they often hold jobs with very little or no protection under social legislation. These migrants include domestic workers, manual workers in agriculture or manufacturing, or even worse, those forced into the modern slave trade in the sex-industry. Their situation is made worse by the lack of autonomy and the strong subordination role that characterises such jobs. In addition these women are often young, poor and alone, lacking family support.

The gender aspects of migration are not given the active attention they deserve, although the concentration of women in vulnerable sectors has generated much debate and valid concern. While the fact that women are migrating on their own rather than as part of family migration seems to indicate greater freedom and choice, this is very often not the case. Women are often found in gender-segregated and unregulated sectors of the economy, where they are at much higher risk of gender discrimination, violence, human trafficking and sexual abuse.

Migration has always been a political issue, but the need to regulate migration through domestic politics and external agreements has in-

creased dramatically. Since the 1980s, migration has been on the agenda for most governments and important international organisations, such as ASEAN, EU, G8, ILO, AU, OECD, SISCA, SADC and others.

In the US and Europe migration issues are presently creating political tensions due to internal conditions. The US economy and their present level of agricultural self-sufficiency depend on labour migrants. European demographic developments mean that labour must be imported if social welfare is to be kept at present levels. These obvious reasons for encouraging labour immigration must be delicately balanced to avoid widespread public scepticism towards immigration and immigrants. To make this political task even more difficult, the devastating actions in New York and Washington D.C. on 11th September 2001, and other international terrorist activities have seen the economic and social incentives for labour immigration been surmounted by security concerns.

#### **MIGRATION'S IMPACT ON DEVELOPMENT**

What is the impact of migration on development? The definition of development as "...the desired changes from a life with many sufferings and few choices to a life with satisfied basic needs and many choices that are made available through sustainable use of natural resources" (Amartya Sen), offers no single answer. Migration can hamper or contribute to development. It can accelerate the development of one region or country at the expense of another, or it can fuel the development of both. Many international organisations now acknowledge the potential for development embedded in international migration. The UN *International migration and development. Report of the Secretary-General*, 2006,

states that "...international migration constitutes an ideal means of promoting co-development, that is, the coordinated or concerted improvement of economic conditions in both areas of origin and areas of destination based on the complementarities between them." It further points out that "...countries can cooperate to create triple wins, for migrants, their countries of origin and for the societies that receive them." In spite of this, UN efforts to promote development as expressed by the Millennium Development Goals, aiming at the eradication of absolute poverty and hunger, say very little about migration, labour or employment.

Migration is often regarded as a problematic issue, bringing burdens of economic constraint and social unrest to the receiving countries, and causing the loss of skills from the migrants' home countries. It is correct to point out that the ruthless exploitation of workers to the benefit of just a few curbs the economic and democratic development of a society. But, migration can also add positively to development by providing the labour demanded in expanding economies in both developed and developing countries. Migrants reduce unemployment and underemployment in their countries of origin, and contribute to the development of these countries through remittances and transfers of knowledge. If the management of migration rather than migration itself was seen as the problem, migration could turn into a powerful impetus for development. A statement from a World Bank report in 2003 points in this direction:

“Migration is increasingly seen as a force that can contribute to development. The importance of maximizing the development benefits of migration cannot be underscored: migration can assist countries in forwarding their development agenda. The achievement of the Millennium Development Goals (MDGs) both impacts and is impacted by the effective management of migration. While acknowledging the contribution of migrants in host countries, it is important to note that the flows of financial, technological, social and human capital back to countries of origin contribute to the development of migrants’ home countries. Indeed, empirical evidence suggests that remittances sent home by migrant workers have significant impacts on poverty and potentially on long-term economic development. Understanding the important relationship between migration and environment, poverty and development will enable countries to better address the challenges of international migration and maximize the benefits of migration for both sending and receiving countries.”

Striking examples of the relationship between development and migration are posed by the expanding economies of India and China. India introduced reforms for economic liberalisation in the 1970s, culminating with the complete abolition of import licenses in the 1990s. This opened the Indian market of one billion people for foreign investments and trade. The growth of the economy has risen from an average 3.5% in the 1970s to the present 6.5%, which among other things, has resulted in a rapidly increasing middle-class. The most obvious consequence of these economic reforms is the extraordinary progress of the Indian telecommunication sector. Technological innovations have given many Indian professionals the possibility to sell their skills on an international market and have attracted a lot of international investments to

India, resulting in an increasing number of new categories of immigrants from developed countries. The Chinese economic and competitive position in the global arena has become even stronger than that of India. An astonishing fact is that the main part of the US’s national debt is to China (2006). Economic growth has opened possibilities for rapidly increased Chinese investment abroad. Chinese foreign investment goes back to Deng Xiaoping’s Open Door policy. In November 1979 the Beijing Friendship Commercial Service Co. and a Japanese business established the first joint venture in Tokyo. Since China joined the World Trade Organisation (WTO) in 2001 the country’s direct investment abroad has reached 35 billion USD (2003) and more than 7 000 Chinese enterprises have invested in 160 countries and regions (2006). The affect on migration is that there are more Chinese residing outside China, and more foreigners residing in China. One example related to the economic upswing is that around 20 000 Chinese girls have been hired as au-pairs in US families. These au-pairs are teaching American children the basics of the Chinese language at an early age.

Migration thus affects the political, economical and social fabric of a society. It may create racial tension, e.g. the tension between black Americans and Koreans that resulted in the Los Angeles riots in 1992. Migration can create social conditions such as the slums in most mega cities, which often pave the way for increased criminality, drug abuse, homelessness, street-children, prostitution and the spread of infectious diseases. Solutions must be found in the management of the migration and the integration of migrants so management of the labour market and the working conditions plays a crucial role.

The International Organization for Migration has attempted to systematize the most important advantages and disadvantages regarding the impact of migration on development policy perspective.

The following text focuses on the main stakeholders involved in the process of migration: the country of origin, the country of destination, the enterprise hiring migrant workers and the migrants themselves.

Possible positive effects on development of migration	Possible negative effects on development of migration
<ul style="list-style-type: none"> <li>– Increased global economic efficiency.</li> <li>– Good for the individual, especially where there are new opportunities for workers not available in the home country.</li> <li>– Inflow of remittances and foreign exchange benefiting receiving individuals and countries.</li> <li>– Emigration may reduce unemployment in some sectors in sending countries.</li> <li>– Technology, investments and venture capital from diasporas.</li> <li>– Leads to increased trade flows between sending and receiving countries.</li> <li>– Possibility of emigration may stimulate investment in education an individual human capital investments.</li> <li>– Charitable activities of diasporas can assist in relief and local community development.</li> </ul>	<ul style="list-style-type: none"> <li>– Loss of highly skilled workers and reduced quality of essential services.</li> <li>– Reduced growth and productivity because of the reduced stock of highly skilled workers.</li> <li>– Lower return from public investments in public education.</li> <li>– Selective migration may cause increasing income disparities in sending country.</li> <li>– Sending country loses potential tax revenue.</li> <li>– Risk of creating a “remittance economy” and dependency among receivers, a problem exacerbated when remittances diminish over time.</li> <li>– Inflationary potential of remittances, especially on real estate.</li> <li>– Reduces the size of “political classes” (citizens endowed with the resources needed to act as agents of change).</li> </ul>

### Consequences for sending countries

There can be both negative and positive effects from emigration for the sending country depending on who is leaving and the state of the country. A positive effect can be that emigration may ease the pressure on the labour market, if there is a surplus of labour that produces high unemployment or underemployment. Migrant worker remittances represent the second largest legal international monetary flow, exceeded only by petroleum. Remittances have considerably

increased over time from 102 billion USD in 1995 to an estimated 232 billion USD in 2005. 167 billion USD went to developing countries, dwarfing the combined total of all kinds of international aid. A World Bank study from 2004 found that remittances were the second largest, in some the largest, source of external funding for developing countries, after direct foreign investments. For some countries remittances equal 20 percent of their total export value. For small countries with large diasporas, such as



Jordan, Lesotho and Tonga, it equals between 25 and 40% of their GDP. On the micro-level a number of studies also demonstrate that migrant households generally have more disposable income, and are able to pay off debts and save money. The bulk of remittances go to Latin America and South Asia. Mexico, India and the Philippines are the largest recipients in absolute figures. The Philippine government has become aware of this capital inflow and so deliberately educates nurses for an entry to the international labour market.

Apart from their financial return, emigrants also contribute with intellectual capital and often pave the way for foreign financial investments in their country of origin. Successful migrants can set an example that encourages others to invest in education that contributes to raising the level of human capital in their home country.

Although the majority of the world's migrants are poorly educated and unskilled, the migration of highly trained and skilled people is of great importance. The effects on development of "brain drain" of the brightest and most highly educated and skilled people is a much debated issue. Some of these migrants return to benefit their country but many remain abroad. The examples of this outflow can be multiplied. The following is just a small sample:

- Almost 10% of all people born in developing countries with tertiary education reside in developed countries.
- In many African countries one third or more of their college graduates live abroad.
- 40% of all African professionals have left the continent in post-colonial times.
- Up to 90% of Chinese and more than 80% of Indian PhD students who graduate in the USA remain there.

- If the physicians from Ghana working in North America would return, Ghana's number of doctors would increase by 33%.
- 20% of Jamaican specialist nurses emigrate annually.
- There are more trained Malawian doctors in Manchester than in Malawi.

Examples of migrating health workers indicate an especially alarming development, since the needs for their skills and services are rapidly increasing in developing countries in general, and in Africa in particular (not to mention that a doctor trained in Nigeria or Ghana has cost their country approximately 200,000 USD). In most African countries opportunities for education and training of medical staff is far too limited. The HIV/AIDS epidemic requires immense resources in terms of hospitals, medicines and staff. No country can manage that burden alone and the drain of medical staff makes the situation even worse. On top of that, many remaining medical staff suffer from HIV/AIDS themselves.

The ratio between highly educated emigrants and the total population of highly educated people very clearly reveals the proportionate loss of brain power. Figures from 2004 show that while only 3% of the total population of India is highly educated, 80% of them emigrate. For Bangladesh the relation (per cent of the population with higher education and the per cent of highly educated emigrants) was 1 to 62, for Brazil 10 to 55, and for Indonesia 2 to 75. This clearly shows that skilled workers and professionals are more eager and have greater possibilities to migrate than others. They are probably attracted by the prospect of higher salaries, better working conditions and improved living conditions that also offer the possibility to support their family staying behind. Developed countries are also keen to recruit skilled workers e.g. in the IT-sector.



There is also aggressive recruitment of health workers from developing countries. The combination of offensive recruitment and personal aspiration resulted in the exodus of 25,000 Philippine nurses to the USA, Canada, Saudi Arabia and Great Britain in 2003 alone. Philippine doctors even retrain as nurses in order to get a job in USA, where a nurse's salary is three times that of a doctor in the Philippines. Primarily this exodus is a complete waste to the country that has invested in the education and training of their youth when most of them leave for a developed country. When doctors or IT technicians are trained and needed in South Africa or India migrate to the USA, Europe or Gulf States, it naturally damages the development of their own countries. The obvious way to change this situation is to discourage migration through improvements of living and working conditions in developing countries, however, there is a hidden dilemma in this strategy. Improvements in the social, economic and educational situation give people greater possibilities to find the means to emigrate. Another paradox is that the human resources needed for the above improvements are found in the same people who migrate. This is not an exclusive problem for developing countries. The European Union, aims to be the world's leading knowledge based economy, invests a lot to encourage the return of European academics now residing in competing economies in North America and elsewhere.

### Consequences for receiving countries

"Migrant workers are an asset to every country where they bring their labour. Let us give them the dignity they deserve as human beings, and the respect they deserve as workers."

The quotation from the Director General of ILO, Juan Somavía, states the basic facts that migrant workers represent a valuable inflow of

human capital to the receiving countries, and that there are reasons to improve their treatment. Generally, poor advantage is taken of the migrants' potential so nations, employers and workers all lose out. High education and professional skills are naturally an advantage for an individual migrant, but do not guarantee prosperity or even a decent standard of living in the new country. Too many migrants face unemployment, under-employment or are employed in jobs below their capacity. Many end up outside the formal labour market and societal participation. Very few nations, developed or developing, can afford such mismanagement in the long run. Apart from the obvious human and economic waste resulting from this mismatch, it also creates an idea that immigration is a problem and that immigrants are intruders competing for and consuming scarce resources. The result can be social unrest, xenophobia, and populist or racist politics.

This is not to say that immigration doesn't cause problems for receiving countries. It can be a burden on the general welfare system, put pressure on the housing and labour markets, stir ethnic conflicts, increase criminality, and cause many other unwanted consequences. Immigration also implies responsibility costs for the state since immigrant families require education for their children, and access to health care and other social services. If these needs are neglected or badly managed, it will invite populist political movements to influence the national agenda, as has been the case in France, the Netherlands, Denmark and Austria, to mention a few recent European examples. Nevertheless, labour migration is almost always a gain for the host country because an adult worker crossing a border has cost nothing in terms of education and training and can start to contribute to the economy immediately if the migration process is properly

managed. Apart from contributing to the country as employees, migrants also may prosper as entrepreneurs. In 1992 Germany had 150,000 enterprises owned by migrants. Of these the 33,000 businesses ran by Turks generated 700,000 jobs, had recorded sales figures of 17 billion USD and invested another 4 billion USD in Germany. If the rights of the workers and their families were secured, immigration would probably be even more profitable, due to the attraction of a fair society and labour market, and the loyalty evoked by just treatment.

### Consequences at enterprise level

It is at the basic enterprise level, on the factory floor or in the field, that migrant labour issues become real and day to day problems are faced. However, it is also at this level that the way for mutually profitable conditions and relations can be paved. The first step towards reaching true long-term benefits for enterprises employing migrant workers is the eradication of short-term exploitation such as low wages, poor training, non-compliance with safety regulations, generally harmful working conditions. The illusion that it is profitable to employ people under such conditions lays in the hidden costs of low productivity that result from untrained employees with limited motivation to contribute to an enterprise. Unnecessary risky and unhealthy working conditions result in a high turnover of employees, creating a need to recruit more new untrained workers to work under the same unfavourable conditions, resulting in low productivity. This is a vicious circle for employers and employees and can go on until the enterprise fails. Another effect of this type of management is that an employer will create social conflict at the workplace and in wider society since the consequences of the exploitation of a migrant workforce are poor wages, intolerable working

conditions, and possible unemployment among the resident population.

If this vicious and unproductive circle is not broken, an enterprise will not truly benefit from hiring migrant labour, since these benefits are embedded in decent working conditions, trust and loyalty. Investments in decent working conditions will in most cases be costly in the short-term but will generate long-term profits from a better trained, healthier, and more motivated, loyal, stable, and productive workforce. Such a workforce will accumulate skills and contribute to the development of technology, production processes and administrative efficiency. The enterprise will also gain good-will among customers and subcontractors, which will also have a positive financial impact. Migrant workers may also contribute in other ways, for example through access to foreign languages and cultural skills needed to compete on domestic and international markets. Furthermore, migrant workers contribute to increased diversity among the workforce which offers a variety of perspectives and experiences for creativity and problem solving. This holds true for a small or medium sized local enterprise, as well as for multinationals. A number of global companies have adopted diversity as a management strategy to uphold quality and establish a recognisable worldwide profile. Toyota has production plants in 52 countries and sales organisations in 170 countries, states in one of their policy documents that each employee should come to work each day, determined to become a little better at whatever they are doing than they were the day before. One way to encourage continuous improvement is to delegate responsibility to diverse work groups. Toyota says "...if two people always agree, one of them is superfluous" but this statement also implies that diversity management and the employment of migrant workers may generate conflicts that

must be conscientiously dealt with. Conflicts may arise because of language barriers, so language training is useful. Conflicts can also arise because of different culturally based perceptions and values. The answer to this challenge should not be to streamline behaviour and opinions, but to encourage tolerance and open-mindedness to reach effective solutions.

### **Consequences for an individual**

International migrants generally come from middle income households as migration is a risky and costly enterprise that prevents poor families from emigrating. The outcome for an individual migrant largely depends on how well informed the migrant is about migration procedures in both the home country and destination country, and knowledge of the labour market in the receiving country. A successful outcome depends on the migrant's aspirations and qualifications and how well the receiving country can benefit from them. Migrant often follow family or friends who have told of their own fate in the new country. In the past many less than reliable stories of success have seduced kin and friends in Europe to embark for the US. The same is still true for Turks in Scandinavia, Egyptians in the Gulf States, Thais in Japan, amongst others. While some migrants find a good life or even make a fortune, most face hardships in the labour market, housing, health, and social life. This also applies to many skilled migrant workers and professionals who are often unable to make full use of their qualifications abroad irrespective of whether they have recently arrived or have a long period in the country. That statement is supported by the fact that most Latin Americans and Africans who obtain their qualified training abroad fail to get established on the labour market in occupations commensurate to their education. Many less skilled workers

migrate with the intention of earning enough to establish a better life when they return to their native ground but for many this is just a dream. Some achieve an acceptable standard of living and become rooted in their new country, so they bring their spouse and children and settle permanently. Others get stranded, hardly able to earn a living and unable to improve their conditions or to return to where they came from. Some of the difficulties endured by many migrant workers come from their inability or willingness to adapt to their new surroundings but more often these difficulties are rooted in unjust and unequal treatment in the host society. This treatment comes from public authorities, employers, landlords, and generally from ordinary people such as neighbours, and co-workers. In spite of that, many migrants do improve their lives, in most cases with the support of fellow countrymen and the migrant community. These immigrant communities are the main facilitators of successful integration for migrants, given that they are recognised as equal partners of the authorities of the receiving society.

### **LABOUR MIGRATION**

The patterns of international labour migration have changed considerably during the last century. During the first half of the 20<sup>th</sup> century migrants moved to North and South America, Northern and Western Europe, and Australia. In the middle of the century migration occurred for other reasons. One evident cause was World War II that resulted in millions of refugees and displaced persons, mainly throughout Europe, but also in the Middle East, North Africa and Southeast Asia. In addition the reconstruction of Europe, and the urge to increase the industrial capacity in countries which had remained undamaged by the war, generated an unprecedented migration of labour. In part this new kind of

migration generated “guest workers,” “seasonal workers,” or “contract workers” most of whom came from developing countries to work on very limited work and residence permits. From 1950-1975 northern Europe received 20-30 million labour migrants from the southern and eastern parts of the continent, from northern Africa, the Indian subcontinent and other former colonies. While many migrated on their own initiative, an equal number were directly recruited by governments and expanding European enterprises, such as Volvo, Philips, SKF, and the construction industry. Contrary to the intention of the host countries, many migrants brought their families and settled. This permanent settlement was described as an immigrant movement “from hostels to houses”. This unintended and unexpected development challenged the European welfare states in the 1970s. Their responses ranged from attempts to force assimilation (France), or restricted positive special treatment (Germany), to integration based on equal rights and freedom of cultural choice (Netherlands). The common ground for these different political strategies was the need to balance the rights and needs of the native population and migrants in demographically changed societies; the European countries “asked for migrant workers, but got people” according to Max Frisch.

The gates to these labour markets closed abruptly with the oil crisis in 1973, and constraints in the welfare systems and labour markets of Western developed countries followed. The lost work opportunities within these economies were counteracted by new labour markets in the oil producing Gulf States that attracted workers from throughout the Middle East and from the Indian subcontinent and eastern Asia. South America experienced a vast exodus of workers mostly to agricultural, informal or sweat-shop jobs in North America but also to

Europe. Until recently Mexico was the world’s largest exporter of labour migrants, but has been surpassed by the Philippines, which now has 8 million of its citizens working abroad (10% of the total population).

Movements within continents also increased. Many South Americans were attracted by increasing development in Argentina and Venezuela. The oil industries of Nigeria attracted labour migrants from neighbouring countries. Sub-Saharan emigration to South African mining industries and agriculture has also increased, mostly from Mozambique, Botswana, Lesotho and Swaziland, and lately from Zimbabwe, due to the political situation.

In the recent past, policy has primarily been directed towards the immigration of highly skilled workers who meet specific labour market needs, however, this must not obscure the fact that the vast majority of migrant workers are concentrated in the lowest socio-occupational categories of their host countries. They are found in low skill services, agriculture and labour intensive manufacturing, very often in the informal economy, where they occupy jobs rejected by locals, are paid very low wages and often are subjected to the harshest working conditions. The literature labels these jobs as 3D-jobs, meaning “Dirty, Dangerous and Difficult”. Migrants and indigenous and tribal peoples consistently fall within this unskilled category due to systematic exclusion and marginalisation that prevents them from integrating their traditional knowledge within the mainstream perception of a skilled workforce.

It is difficult to estimate the total number of migrant workers in the world. Statistics are incomplete or non-existent in many countries, and even where they do exist they cannot be used for international comparisons since there is no universally accepted definition of the term-

nology. Another difficulty is that large numbers of migrants are admitted on other grounds than labour migration and registered accordingly even though many of them join the labour force and become migrant workers. Furthermore, data on undocumented migration and employment are at best qualified guesses even from the most reliable sources. Given these difficulties, ILO estimates that there are roughly 100 million people, about 3% of the global workforce, currently residing and working, legally or illegally, in a country other than their own. There is approximately a 50-50 split between developed and developing host countries.

The table below shows the approximate global residence and distribution of internationally migrated workers.

Region	Millions
Africa	20
North America	18
Latin America	12
South-East Asia	7
Europe	31
Middle East	9
Australia	5
TOTAL	102

### Legal labour migration

Migrants with legal status (documented migrants) are those who have been granted a work and/or residence permit by the national authorities in the receiving country. The permit can be permanent or limited in time, (the most renowned being the US Green Card). A person carrying such a permit has all the rights and obligations prescribed by national legislation but these rights can vary from full equality with the native population to very restricted rights. Both employers and employees must comply

with prevailing national legislation. Many countries restrict migrant workers' staying by issuing temporary permissions, only allowing them to work in specified branches of industry. Low skilled temporary workers are usually not allowed to bring their families with them. Temporary worker programmes have increasingly been implemented in many developing countries over the last decades. In Africa the Republic of South Africa has a longstanding programme to provide labour for the mining sector. In 2000 more than 130,000 (almost 60%) of the work force in the mines were temporary migrant workers. Other African states heavily relying on admitted temporary migrant workers are Gabon, the Ivory Coast and Libya. In Asia we find the same pattern in the Gulf States, Brunei, Malaysia, Viet Nam, and recently also in China. Some developed countries have initiated legalisation programmes from time to time. In the early 1970s the French government offered undocumented migrants residing in the country the opportunity to apply for legal status. Of the resulting 150,000 applications, 130,000 were approved. A similar programme was introduced in the US in the late 1980s, requiring proven residence of 5 years or proof of 90 days work during the previous year. In 2004 Spain offered legalization with similar requirements. The main reasons for introducing these programmes were to combat illegal immigration, and to give migrants a helping hand to join the formal workforce. However, although many migrant workers became formalised, their financial position worsened as their net wage after taxation was less than before. The programmes also attracted more undocumented migrants arriving with hopes for legalisation.

Since legal labour migration procedures and migrant workers' status are regulated by law, it is tempting to suppose that there should be fewer problems with documented migrants' general



working conditions and OSH issues but this is not the case. One highly complicating factor is that although these persons enjoy a legal status, they very frequently end up in the informal labour market, which by definition is unregulated. Another reason is that laws and regulations are frequently violated by employers at the expense of locals as well as migrant workers, whether documented or not. Therefore it is an obvious risk that documented migrants workers will find themselves in the same unfavourable and hazardous working conditions as the other categories of migrants discussed below.

### *Discrimination*

Discrimination is directly related to legal labour migration because in order to be discriminated against in a legal sense, a person has to be legally in the country. The ILO Convention on Discrimination (No 111, ratified by 164 countries), sets a minimum standard but national laws on discrimination differ greatly between countries, and do not exist at all in some countries. Furthermore, compliance to the law is not upheld as proven by the existence of discrimination in almost all countries, developed and developing alike. A widely accepted definition of discrimination is “different treatment in similar cases”. Discrimination towards migrants on the labour market can occur in many ways, such as unjust denial of employment, unduly low wages, longer working hours, child labour, harassment, denial of rights such as union membership, and access to basic health services. In other words, migrants are forced to accept poor working conditions not offered to or accepted by others. Discrimination on the labour market is often combined with discrimination in the housing market and access to general public services. The interaction of these factors results in poor general living condi-

tions that are likely to affect physical, psychological and social wellbeing.

The ILO “Fundamental Principles & Rights at Work” (1998) specifically advises all states to actively strive for the elimination of discrimination in employment. Such endeavours shall not only combat discriminatory practices, but actively promote initiatives for equal treatment.

### **Irregular labour migration**

Migrants get different legal status depending on how they are recognised by the host country. Their legal status determines an individual migrant’s rights and duties on a scale from equality with native citizens to a total deprivation of all civil rights. Apart from immigrants with some kind of legal status, in many countries there is an increasing number who have no legal status at all. They have crossed a border without a permit or are bereft of legal rights while already in a country illegally, e.g. by overstaying their visa permission. Such persons are often referred to as “illegal immigrants”, which is misleading and unfortunate, since it might place them in a still worse position. Three main objections can be raised against the notion of illegal migrants and illegal migrant workers:

- People can never be illegal; illegality refers to actions, not to people. To state that someone is illegal denies the fundamental Principle of the UN Declaration of Human Rights - all human beings are equal. Such a denial supports the hypocritical Orwellian credo in his novel “Animal Farm”- “All animals are equal, but some are more equal than others.”
- The notion of “illegal migrant” implies that a person is acting against the law. That is not the case with the migrant worker, since there is no legal prohibition on work. The crucial point is that the undocumented worker is not against the law, but **outside** the law, and com-



pletely at the mercy of employers, bereft of all legal protection.

- If a national legislation doesn't accept or acknowledge undocumented migrants, it is the person who hires them, i.e. the employer, not the employee, who is acting illegally.

These migrants can reside in a country where they have no legal right to residence, which makes their *status* illegal, but *not their persons* *per se*. It is more appropriate to refer to this category of migrants as undocumented or irregular migrants.

Nevertheless, these migrants are of great concern for most countries. Their presence is often seen as a threat by the trade unions, since the exploitation of their labour can result in unemployment for the native population, lowering of wages, and as counteractive for improvements in occupational safety and health and the working environment. This is just one of a number of reasons why these workers are often completely without any rights. There are two different strategies used to tackle the issue. One is to restrict their admission to the labour market and the other is to protect undocumented migrants.

This question is especially difficult to tackle because undocumented labour is crucial to the economies of basic industrial and service sectors in many nations. The competitiveness of the agricultural industry in several states of the USA, construction industries in Spain and Portugal and the mining industry in South Africa are just a few cases where undocumented labour is of great economic significance. Although most governments officially combat the existence of a grey or black economy, they may turn a blind eye to the facts, resulting in silent consent on the issue of undocumented migrant workers. Of course, it is impossible to combine this situation with adherence to conventions and regulations

on social protection, access to health care, labour inspection or decent working conditions.

It is impossible to give a precise number of undocumented migrants in any country or globally. The ILO estimates that up to 15 percent of all migrant workers in the world are in this category. One reason for this situation may be the increasing commercialisation of the recruitment process. An ILO migration survey conducted in 2003 reports that 45 percent of the 90 responding countries allow private recruitment agencies to bring in migrant labourers. More than half of these also allow the agencies to charge fees from the migrants. Another reason must surely be the increasingly restrictive immigration regulations adopted by the USA, European Union member states, Australia, and most other developed countries. When the regular gates to entry are closed, many migrants will see no other option than an irregular one. In some cases this results in less governmental control of migration and increasing vulnerability for resident migrants. Examples of the worst effects of undocumented migration include those who lose their health or lives trying to reach a host country: those trying to reach the Spanish shore from northern Africa; people who become severely dehydrated from the desert sun while trying to reach Libya, or those who make the hazardous journey from Mexico to the American border. When nations try to plug these borders, smugglers and migrants find other ways. Increased patrolling of the Mediterranean has redirected the flows to the even more precarious voyage to the Canaries, multiplying the risks for the migrants. In the first half of 2006 more than 1,000 North African migrants drowned in their attempt to reach these islands that are part of Europe.

In addition to a general increase in irregular migration, this climate has contributed to the

opening up of a lucrative market for the smuggling and trafficking of migrant workers. There has also been an increase in altruistic and organisational efforts, particularly by NGOs, to meet the needs and aspirations of migrants by acting as bridges between the migrant communities, authorities, and employers. Other organisations provide much needed humanitarian aid and social protection. However, others find an opportunity to enrich themselves on the misfortune of others, acting as smugglers and job agents. For example, Mexican officials claimed in 2002 that 130 small and 15 major smuggling organisations were moving migrants to the US. This informal “industry” had an annual turnover of more than a billion USD. As a next step, other people may take advantage of irregular migrants by acting as employment agents who supply employers with cheap and undemanding labour. Others simply exploit the dependence immigrants are subjected to as employees. Women and children are vulnerable and far too many have become the victims of trafficking into slave labour or forced prostitution. A recent example of the efficiency of this “industry” is that during the soccer World Cup in Germany in the summer of 2006, 5000 East European, Russian and Ukrainian women were trafficked to work in temporarily established brothels in the cities hosting the sport events.

### Transnational migration

Another longstanding migration pattern that has increased during the last decades is “transnational migration”. This is a circular mobility pattern where people regularly move between two or more places where they have different kinds of relationships, be they through family, economic interests or cultural ties. People temporarily cross borders in order to find jobs or to trade. Some follow harvests or other regular

economic activities, while others go back and forth whenever opportunities arise. For example, in Sweden there is a growing number of Polish and Baltic citizens who come for temporary jobs in agriculture, construction and street trading. People from Thailand also come to Sweden for seasonal berry picking. Turkey has the same experience as citizens, particularly women, from former Soviet states find short-term jobs as maids or selling whatever they can carry in suitcase. These movements also include prostitution and other black economy activities. The increase in these movements is surely an effect of globalisation, related to profound improvements in transportation, information technologies, and increased movements of capital, since multinational companies transfer capital, goods and personnel across the globe. People moving in such networks are generally more protected and better off than people moving as free agents who are exposed to more difficulties, risks, discrimination a weaker legal position.

### Internal migration

Internal migration differs in many ways from international migration. The migrants are natives and therefore covered by the same laws and regulations as every other citizen and they normally speak the language of the country. Internal migration is more often seasonal, and vastly more extensive than international migration. Geographical conditions can mean that a seasonal worker can be constantly on the move within a country. For example, in Chile where the harvest season gradually moves along the vast south-north axis of the country, agricultural workers follow the shifting longitudinal climatic changes. Coffee-pickers in Costa Rica follow the altitudinal harvest seasons of the mountain slopes. Most internal migration consists of farmers and their families moving from remote rural

areas to cities to find jobs as construction or factory workers, domestic servants, drivers, tourism workers and in other low skilled jobs, often as day labourers. Many fall into the category of entrepreneurs who try to make a living as street hawkers or petty traders. Rural-urban migration is the fastest growing temporary migration in many developing countries marked by increasing urbanisation and manufacturing. The internal seasonal migration in India is as large as 50 million persons annually and in China the amazing number of 200 million internal labour migrants were registered in 2005, i.e. almost one fifth of the entire population. As earlier mentioned, Chinese citizens are only entitled to civil and social rights when they live at the place where they were originally registered. This reminiscence from the Maoist era, the hukou system, is severely detrimental to the masses of internal migrants who have left their original residence to find a job in the city or as seasonal workers in agriculture. A vast number of these migrants, around 80 million factory-workers in 2005, establish the back-bone of Chinas competitiveness in the globalized economic system.

In spite of some differences, internal migrants share many of the conditions of international migrants' because the vast majority of them end up in the informal economy with very limited or no rights. Although internal migrants are citizens of their country they may feel quite as lost as a foreigner since the life and the cultural practices and values of the city bears very little resemblance to the life they used to lead.

Conclusively, all categories of migrant workers face the risk of being subjected to abusive, exploitative and discriminatory treatment in host countries, and even in their own country. Adherence to human and labour rights norms for non-citizens is often inadequate in many countries, particularly for irregular migrants who have no

authorisation to enter or remain in a country so they lack legal protection.

### INTERNATIONAL REGULATIONS ON MIGRANT WORKERS

There is an international consensus that core labour standards provide a minimum set of rules for labour in the global economy, but these general standards do not explicitly address conditions for migrant workers. Every nation has sovereign rights to shape their policies towards migrants, but there is a lack of a multilateral and global framework for governing the cross-border movement of people. Rules for fair trade and capital have advanced, but they need to be complemented by fair rules for the movement of people. Nevertheless, there are a number of international regulations and conventions that a number of states have ratified, thereby taking on a moral responsibility to fulfil. The most important declarations on migrants' rights and health issues are to be found within the body of the United Nations.

UN statutes and declarations are all founded on the conditions expressed in the *Charter of the United Nations* (1945). Respect for general human rights is one of the most basic determinants of migrants' well-being and is essential to the achievement of greater social and economic development for individuals and societies. This implies that all migrants have access to affordable basic social and health services, including reproductive health services.

Furthermore, the *UN International Convention on the Protection of the Rights of All Migrant Workers and the Members of Their Families* (45/158), which came into force July 2003, is a detailed statement of views on the rights of migrant workers, both documented and undocumented migrants. Among the 34 states that have ratified the convention we find Algeria, Chile, Hondu-

ras, Lesotho, Libya, Nicaragua, Peru, Syria, East Timor and Turkey. Although all these states are classified as “developing”, there are immense differences between their practices with regard to workers’ and immigrants’ rights. The convention defines spouses and dependent children as family members, and aims to “contribute to the harmonization of the attitudes of States through the acceptance of basic principles concerning the treatment of migrant workers and members of their families.” In short it expresses equal rights with natives, unless otherwise stated by agreements or national law. The convention covers all kinds of migrants, documented as well as undocumented, and explicitly indicates migrant workers’ rights to equal treatment, to join unions and to benefit from the social security systems to which they contribute. The convention was approved by the General Assembly on 18th December 1990, and that date is now annually celebrated as International Migrants Day.

According to the UN, the human rights of migrant workers and their families include the following universal, indivisible, interconnected and independent human rights:

- The human right to
  - work and receive wages that contribute to an adequate standard of living
  - freedom from discrimination based on race, national or ethnic origin, sex, religion or any other status, in all aspects of work, including in hiring, conditions of work, and promotion, and in access to housing, health care and basic services
  - equality before the law and equal protection of the law, particularly in regard to human rights and labour legislation, regardless of a migrant’s legal status
  - equal pay for equal work
  - freedom from forced labour

- protection against arbitrary expulsion from the State of employment
- return home if the migrants wishes
- a standard of living adequate for the health and well-being of the migrant worker and his or her family
- safe working conditions and a clean and safe working environment
- reasonable limitation of working hours, rest and leisure
- freedom of association and to join a trade union
- freedom from sexual harassment in the workplace
- protection during pregnancy from work proven to be harmful
- protection for the child from economic exploitation and from any work that may be hazardous to his or her well-being and development.
- The human right of children of migrant workers to education.
- The human right of migrants and their families to reunification.

Since it is states, and not enterprises or employers that have signed this convention, there is a national responsibility to establish and empower the institutional infrastructure needed to follow up this serious undertaking. There has to be appropriate legislation, workplace surveillance capacity and means to enforce the law.

Additional international agreements are the 1994 *Cairo Program of Action of the International Conference on Population and Development*, and the *Beijing Platform of Action of the Fourth World Conference on Women* from 1995. Both affirmed the importance of promoting and protecting the human rights of migrant workers and their families, especially women. The UN World Conference in 2001 issued the *Durban Declara-*

*tion and Programme of Action* that urges states to allow migrants to unite with their families, and asks governments to make active efforts to reduce discrimination against migrants in the labour market.

ILO has issued 19 conventions directly aimed at OSH issues, covering general measures, particular branches or specified materials. These conventions address all employees, whether migrants or not. A number of other ILO conventions and regulations also refer explicitly or implicitly to migrants' rights. Two examples of such general conventions are the *Freedom of Association and Protection of the Right to Organize Convention* (No 87, ratified by 145 countries, 2006) and *The Right to Organize and Collective Bargaining* (No 98, ratified by 154 countries, 2006). Among the conventions explicitly addressing migrant workers the most extensive are Conventions 97, *Migration for Employment Migration*, and 143, *Migrant Workers (Supplementary Provisions) Convention*, that have been ratified by 45 and 19 countries respectively (2006). Convention 97 defines a migrant for employment purposes as "a person who migrates from one country to another with a view to being employed otherwise than on his own account". Such a person should be treated equally to other workers in terms of wages and other working conditions. Convention 97 also recommends bilateral agreements regarding recruitment, migration policies and information sharing. Convention 143 recommends policies to minimise illegal migration, to combat human trafficking and smuggling, and to promote the integration of settled migrants. These are important and progressive conventions, but it is still a vital task for the ILO and the social partners to convince governments world-wide to ratify and apply them.

### MIGRANTS' SAFETY AND HEALTH AT WORK

The health of migrants has long been acknowledged as a public health concern but although workers' rights to health are well established in international law, the health of migrant workers has not been given adequate attention. In general migrants have poorer health status than the native population. There are several plausible explanations (and counter arguments) for this situation. Many people who choose to move do so because of poor living conditions in their home country so their health is already damaged when they migrate. Some countries use this as a reason to deny migrants basic health services. A further explanation is that health is damaged by hardships experienced during migration or because of poor general living conditions in the country of destination. It is not possible to reach a general conclusion about the relationships between migration, work and health but requires specific examination of the facts in context. European studies indicate that health status varies between immigrants from different countries, and that women are generally at greater risk of health damage than men, however, results are very imprecise due to a lack of comparable data.

One of the most publicised migrant health issues in developing countries is the spread of infectious diseases, particularly HIV/AIDS. Since AIDS first appeared in 1981, more than 25 million have died from it. In 2005 more than 4 million were newly infected, almost 40 million were living with HIV, and AIDS claimed an estimated 2.8 million lives. Although the disease has an almost global presence, developing countries are the most affected. A South African researcher illustrates how migration has spread AIDS with this short description of migrant workers' conditions: "If you wanted to spread a sexually



transmitted disease, you'd take thousands of men away from their families, isolate them in single sex hostels and give them easy access to alcohol and commercial sex. Then to spread the disease, you'd send them home every once in a while to their wives and girlfriends." This quote summarizes several aspects of the general conditions experienced by migrant workers in e.g. plantation or mining camps: poor housing, little or no access to health care and information and social deprivation.

Migrant employees are likely to be generally more vulnerable to illnesses and to HIV/AIDS infection due to their general living and working conditions. Since most migrants live under scarce economic conditions, and many of them face language barriers, they are less able to get information on HIV/AIDS and prevention measures from media. When migrant workers succumb to AIDS or other diseases, or get severely injured, they potentially suffer because of their lack of access and restricted medical treatment, if medical treatment exists at all. Illness or injury often means that migrants lose their jobs and means for support for themselves and their families.

While HIV/AIDS is the disease in developing countries that attract most media attention, malaria is almost equally lethal. 300-500 million people are infected annually and up to 2 million die from it, most of them in sub-Saharan Africa. The Amazon basin in South America and the river deltas of South-East Asia are other highly affected regions. In 2003, 76 countries reported the presence of endemic malaria; almost all of them were developing countries in Africa, Asia and Latin America. Migrants and other travelers carrying the infection may transmit the disease to other regions.

ILO estimates that more than 2 million people die annually from work related accidents or

diseases, i.e. almost 4 people die at work every minute. Many studies show a higher prevalence of occupational diseases and injuries and fatal accidents among immigrants than among natives. In China, statistics from 2005 reveal that out of the 10,807 deaths in mining and construction, more than 75% were migrant workers. It is tempting to jump to the conclusion that immigrant workers are by nature more accident prone than others but studies reveal more disturbing reasons for these statistics, generally related to environmental conditions and work organisation. Migrant workers are often found in dangerous, dirty and difficult jobs, seldom get sufficient training in machine operation and safety routines, and are not equipped with appropriate safety equipment. In addition, migrants frequently work on short term contracts, which don't enable them to get enough practice to develop safety related skills. They also often work long hours that don't permit sufficient rest. Language and cultural difficulties are also safety risks, and safety regulations are often not translated into other languages. Their status as undocumented workers and their weak position in the labour market restrain them from demanding improvements, seeking health care or reporting accidents. They are seldom aware of their rights and fear retaliation so it is also reasonable to assume that there is a larger number of unreported accidents and diseases among migrant workers than among natives. In far too many cases migrant workers are trapped in a dangerous situation where they are regarded as an abundant and dispensable labour force.

The most hazardous work sectors are agriculture, mining and construction. In many parts of the world, especially in developing countries, these sectors employ the largest number of migrant workers, especially temporary and irregular migrants who are the least protected



by social, health and safety regulations. The informal parts of many economic sectors, where people work without contract or individual recognition, are not subject to protective regulations. Domestic services, the petroleum industry and shipping are other examples of jobs with high accident risks, documented poor working conditions and an overrepresentation of migrant and/or temporary workers

### *Agriculture*

Agricultural workers account for a particularly high proportion of unprotected workers, both in developed and developing countries. Their work is generally heavy, with long working hours, exposure to difficult climatic conditions, and exposure to hazardous chemicals, especially pesticides. These problems are compounded by poverty, extremely poor living conditions, and limited access to clean water, fuel and power, adequate shelter and nutrition. Literacy is often low, and so is the level of organization of workers in the sector.

1.3 billion of the world's total labour force, (more than 40 percent), are found in the agricultural sector. Of these, almost half a billion are hired workers, and the majority of them are women. According to the ILO, more than half of the recorded fatal workplace accidents in the world occur in the agricultural sector. In the late 1990s, 170,000 persons suffered work related deaths in the agriculture labour market. Millions are injured or poisoned annually by toxic pesticides. An illustrating example is derived from the US statistics, where 13% of all fatal accidents in the late 1990s occurred in the agricultural sector, while it constituted only 2% of overall employment. There are several reasons why agriculture stands out as a very migrant dense sector. One of the most important is the economic pressure on farming in many developing countries, due to

falling world market prices on important crops such as coffee, cocoa, bananas and sugar. This affects wages and general working conditions, mainly resulting in internal migration from rural to urban areas. Year round employment turns into downgraded seasonal jobs, and the gaps left by those who have internally migrated from farms or plantations, is filled with seasonal adult and child migrant workers, who earn lower wages, work longer hours, and enjoy less protection and worse housing. Such workers are often contracted by employment agents who compete by offering employers the cheapest workers.

ILO Convention No 184, "The Safety and Health in Agriculture", states the minimum age for farm work at 16 years but around 80 million children, aged 5-14 years, are employed in agricultural activities. Some countries, e.g. in the cocoa producing countries of Burkina Faso, Ivory Coast and Mali, systematically hire migrant children to work on the plantations. These workers are seldom organised, and therefore not represented by any trade union. In many cases this is a precondition for employment. Agricultural workers face occupational risks from exposure to pesticides that cause all kinds of damage from cancer to miscarriages and disturbed mental health; from dehydration due to working long hours in sunshine; snake bites and dangerous transportation to work sites in unsafe and overcrowded vehicles.

The main problems in agriculture are occupational injuries and fatalities related to machinery and transport equipment, and chemical poisoning from pesticides and other substances. These risks are also aggravated by inappropriate personal protective devices; inadequate methods for recording and reporting problems, and conducting relevant surveillance; an inability to respond with preventive, protective, curative, and rehabilitative measures. Combined with bad

living conditions and poor public health it makes agriculture one of the most dangerous work sectors.

### *Mining*

Mines are also one of the most dangerous places to work. The risks of explosion and collapse are obvious, and the risks posed by dust, heat, humidity, noise and vibration are well documented. Although mining only accounts for 0.4% of the global workforce, it is responsible for over 3% of fatal accidents at work (about 11,000 per year, about 30 every day). Data on injuries and fatalities exists in most countries, and reveals significant numbers of accidents. There are reasons to believe that the real numbers of occupational diseases (such as pneumoconiosis, silicosis, tuberculosis, hearing loss and the effects of vibration), are larger than official statistics. However, it is even more difficult to estimate the number of workers who suffer premature disability and death from their work. Mines are also the workplace for an unknown number of children some of whom are very young.

Worldwide, many miners are migrant workers. For example, workers from the whole sub-Saharan region are recruited in the gold and diamond mines in South Africa, Brazilian miners migrate to work in the bauxite and gold mines of Surinam, and masses of internal migrants work in Chinese mines. Migrant miners face the same conditions as other migrant workers in terms of weak or non-existing legal protection and rights, restricted access to health and other public services, and other kinds of discrimination.

For every mining job there is at least one job that directly depends on mining. In addition, 11.5-13 million people, (not included in the above figure), work in small-scale mines. The number of people relying on mining (large and

small), including dependants, for a living is likely to be over 200 million.

The mining sector also has another significant health related characteristic because workers, and sometimes their families, often live in camps in the vicinity of their work sites. These camps generally offer poor physical and social living conditions, where drug and alcohol abuse threatens public health and leads to greater risks at work. The commercial sex trade in such camps also increases the spread of sexually transmitted diseases.

### *Construction*

In 1999, global employment in the construction sector was estimated to 112 million, 75% of whom were in developing countries. (Actual numbers have probably increased). Construction has always exposed workers to physical risks and this has worsened due to the changing structure of the sector. Many construction sites are huge undertakings, and work is often carried out by a multitude of subcontractors, who hire temporary workers with different skill levels. This has severely undermined the historically high rate of unionisation in the sector, which in turn has led to worsening working conditions in regard to both OSH and pay rates in both developed and developing countries. An ILO report notes that “the increased employment of labour through subcontractors has also had a profound effect on safety and health at the workplace and has undermined collective bargaining and training provisions”.

Poor conditions have given the construction industry a bad reputation in many parts of the world so young people shun work in the sector. These places are often filled with migrant labour, working for low wages under bad working conditions and with insufficient or no training in risk protection and health promotion. This has

resulted in a race to the bottom in many countries, such as the Gulf States, Singapore, Israel, and Europe (e.g. Spain and Greece) where considerable parts of the construction sector are based on mostly irregular migrant low-paid labour. A horrifying example from Greece was the death of 40 construction workers, all undocumented migrants from Albania, Iraq and North Africa, killed during the frenzy to erect the arenas, hotels and other buildings for the 2004 Olympic Games.

### *The informal economy*

The informal economy constitutes the main part of the labour markets in developing regions throughout the world; it is fair to say that informal labour is the norm, while formal and regulated labour markets are the exceptions. The informal economy is characterised by the absence of contracts and a total lack or severe limitations on workers' rights.

The work performed in the informal sector is generally legal (rather than criminal), involving the legal production of goods and services by legal workers (albeit employed under illegal conditions or as unregistered self-employed entrepreneurs). These conditions make large numbers of workers extremely vulnerable. Women and children are worst off due to their generally weak position in society, and migrants who are often totally dependent on their employers for survival. Undocumented migrants, residing and working illegally in a country, are often totally at the mercy of employers since they have no way of complaining for fear of repression and/or expulsion by authorities.

Due to a lack of sufficient data and disagreements on definitions it is impossible to give accurate figures about the informal economy in any single country, still less on a regional or global level. Existing data often counts for infor-

mal urban self-employment and employment in small informal enterprises, thereby leaving out informal employment in agriculture and formally registered activities. Using a broad definition of informal labour, including both urban and rural workers, employed and self-employed, it is possible to state the following facts:

- Informal employment amounts to 50-85% of the total non-agricultural employment in developing countries.
- When informal employment in agriculture is included the total amount increases significantly, e.g. to more than 90% in India.
- Informal wage employment represents 30-40% of urban informal employment in developing countries, 60-70% of informal labour are self-employed (including unpaid family members).
- The contribution of the informal labour market to the total economy is considerably less than its proportion of labour, due to less efficiency, limited markets, unfavourable competition conditions, poor working conditions and other restricting factors.
- Women and migrants are more often in the informal economy than men and natives, and they are also over-represented in low-wage informal employment.

The table below shows the estimated percentage of workers in the informal economy in different developing regions. Although there is no known accurate number of immigrants among the total estimated number of workers in the informal economy, it is recognised that migrant workers constitute a considerable, (often dominant), share of the informal workforce, in absolute as well as relative terms. It is therefore reasonable to conclude that the percentages of migrants in the informal economy are even higher. The table also shows that the total informal economy is dominated by female labour.

Region/country	Excl. agriculture	Incl. agriculture	% of total women workers
North Africa	48%		43%
Latin America	51%		58%
Asia	65%		65%
Sub-Saharan Africa	72%		84%
South Africa	28%	34%	
Mexico	55%	62%	
India	83%	93%	

Unregistered migrant workers and informal labour markets are also crucial in many developed countries. A US nationwide survey of day labourers shows that almost all urban day labourers are immigrants, mostly from Latin America. In relation to health issues the survey reports the following data:

- 75% consider their jobs dangerous
- 67% have lost the opportunity to work due to a work injury
- 22% of those injured lost at least one month of work
- 19% had suffered a work injury requiring medical attention.

One way to improve the working conditions and secure the rights of workers in the informal economy is to organize them, either on their own initiative or through trade unions. There are different views among trade unions about how to relate to the informal economy, depending on the immigration policy of an individual state. In the Scandinavian countries unions only organize workers with a formal working permit, since the residence of undocumented

migrants is regarded as illegal. As a consequence, undocumented workers lack workers and other civil rights, in a country renowned and proud of its social welfare system. In southern Europe many unions organize undocumented migrant workers who become entitled to some protective measures and workers' rights, without getting full access to citizen rights. In many developed countries there are civic organizations supporting undocumented workers. In several developing countries, e.g. India and Brazil, and among migrant worker communities in developed countries, their strategy is the formation of separate unions.

A most interesting example occurred within the US trade unions in the 1990s. Trade unions faced difficult time due to the general economic situation when their traditional membership base vanished rapidly when factories and production moved to countries with lower costs. Domestic economic expansion was in the service sector, which offered low paid jobs that were rejected by most white Americans, but accepted by immigrants, both documented and undocumented. Organisation of these immigrants proved to be the way for the trade unions to survive. They started to penetrate the biggest service companies. For example, within a decade 70% of the migrant cleaners, (mostly Hispanics from Latin America), in Los Angeles were organised, thousands of immigrants had gained legal protection and the trade union had regained its strength.

The general reasons for unionising undocumented labourers are universal:

- Unions promote the rights of all workers
- All workers have the same needs, regardless of legal status
- Unionisation avoids splits and competition between workers
- An unprotected worker is a threat to all workers.

The ultimate empowerment device is of course the legalisation of undocumented workers that allows them to defend their rights on an equal basis with native workers. This would also help to combat the informal economy, and serve public interests through increased tax revenue. However, this is not a definitive solution as legalised workers will soon be replaced by new undocumented workers. A long-term solution must seriously and continuously address the underlying reasons for the reliance of low wage sectors on undocumented workers.

### WHAT SHOULD BE DONE?

The remedies needed to achieve decent working conditions are largely the same whether the employees are migrants or not, but migrants are generally more vulnerable.

Aside from purely humanitarian reasons, there are also very pragmatic reasons for authorities and enterprises to strive to offer everyone decent living conditions, proper housing, access to health service and education, and improvements in working conditions. The most obvious one is that healthy and educated people contribute to the development and prosperity of a society and an enterprise. Unhealthy and unproductive people are a burden and while they might be regarded as dispensable when there is a surplus of labour, that is a miscalculation as there is always a cost and production loss when new labour is recruited. Improvement in social conditions avoids social tensions. Social unrest results in increasing criminality rates and might also trigger violent outbreaks between social or ethnic groups. At company level, improvements will ensure loyalty from labourers, and avoid damaging actions such as strikes or deliberately slow production. To conclude, sound, responsible and efficient policies and management prioritises a healthy population and labour force.

#### Recommended measures – international level

- Establish transnational agreements on fair migration management.
- Establish means to implement existing international agreements and conventions in those countries which have ratified them.
- Propose and establish measures for fair treatment of undocumented migrants.
- Propose and establish measures to legalize undocumented migrants.

There is a variety of measures to be taken on different levels to improve general working conditions and the special needs of immigrants. On the international level, there are already accepted conventions, regulations and agreements on the movement of goods and capital, but globally accepted equivalents for the movement of people are still lacking. The international community should urgently establish such agreements. The promotion of regulations must be the responsibility of international organisations of states and social partners, such as ILO, WHO and international trade union federations.

The main tasks at national level are the implementation and enforcement of international and national labour conventions and regulations for fair migration management and treatment including measures that will avoid migrants ending up with illegal status. It is also a national responsibility to strengthen surveillance capability, especially in risky economic sectors with a high proportion of migrant workers, such as in construction, agriculture, mining, manufacturing and domestic services. The enhancement of occupational safety and health education is another important national obligation. Such improvements will not only directly improve working conditions but will counter desires for emigration and the loss of trained and skilled persons most needed for infrastructure development and the economy. Ultimately such improvements



will combat poverty and raise the level of democracy in a country. Another important measure is to find means to regulate the informal economy, since a large proportion of the native and immigrant population in developing countries are forced to find a living in this dangerous part of the economy. The informal economy not only damages individuals, but society as a whole, since it pays very little into general society and limits sustainable growth of an economy. The Peruvian economist, Hernando de Soto, points out that one crucial way to decrease the informal economy is to simplify and improve the possibilities for enterprises to be legally registered. This would enable people to get a foothold in the formal economy, and would also increase tax revenues. Another equally important reform would be to establish easy and cheap ways for people to register housing and private properties. Such legal contracts would increase the possibilities to expand business activities as entrepreneurs

can offer the banks financial security. The initial credit given for most newly established firms in developed countries, are loans on private housings (e.g. 70% in the US). In the same vein, initiatives such as reforms to ease access to loans and the provision of management training for migrant entrepreneurs would be useful.

Since national and municipal employers are the principal actors in the public sector, it goes without saying that they carry direct responsibility to offer decent working conditions for all jobs in that sector, whether the employees are native citizens or migrant workers. This also implies that migrant workers and their families should have access to at least basic education and health care services. Another important obligation for public authorities is the facilitation and reduction of remittance costs that can increase the inflow of capital sent by migrants working abroad.

Employers are fully responsible for improvements in working conditions, for reducing risks

### Recommended measures – national level

- Ratify ILO conventions on migrant workers.
- Incorporate those conventions into national law.
- Secure the right for all workers to organise.
- Sanction employers with the responsibility for maintenance of the legislated working conditions and make it their duty to report work related injuries, diseases and fatalities.
- Develop and implement national action plans on workers' health.
- Enforce and implement surveillance of work places and workers' health, including penalties for non-compliance.
- Inform employers of the potential gains of decent working conditions.
- Establish national systems for reliable statistics on OSH issues.
- Translate relevant national laws and regulations into appropriate languages.
- Prioritise capacity building for education and training in occupational safety and health.
- Promote access to free occupational health services for all workers.
- Reduce the administration and costs for transfers of remittances.
- Simplify and reduce the costs for registration of enterprises and private property.
- Introduce language training for foreigners
- Identify and disseminate information about best practices in occupational safety and health at work places.
- Public employers shall be the spearhead in offering decent working conditions for all employees.



at the work place and reporting work related injuries, diseases and fatalities. Employers also have a duty to inform employees about risks and dangers related to their work, and about their rights to protection, health care and decent working conditions. If this is successfully achieved, they will improve the quality of life for individuals, strengthen their enterprise and contribute to the development of the nation. If they are unsuccessful, economic and human prosperity will be hampered since development possibilities are undermined.

At all work places, public or private, the above measures towards all workers, particularly migrant workers, can be introduced in order to improve working conditions.

Although the formal responsibility for offering stipulated working conditions lies with the employer, employees have a responsibility to follow occupational safety and health regulations at the work place, and to minimize the risks for themselves and their workmates. Those duties include obligations to use available safety devices, follow safety routines and to actively search for information about risks and how to avoid them.

The speed of change in societies and the lives of individuals has increased tremendously as capital, services, ideas and cultural expressions travel between countries and continents in real-time. While people and goods require more time to move, modern transportation has reduced the time needed to travel around the globe. Work life and migration patterns are constantly changing and new work organisations, technology, and tasks will continue to emerge. What will probably not change is the existence of work and migrant workers. An increasing share of all human communication occurs in cyber space, but the value of face-to-face meeting in everyday life can never be replaced by global technologies. Migration has always been, and will remain a powerful force in the process of development. Multicultural mixing in schools, housing areas and workplaces will remain a challenge as well as a driver and inspiration for change and improvement. If societies remain closed or segregated they will most probably decline. The issue is not whether we want migration and multiculturalism or not. It is already here and it will stay. The key issue is whether we want to benefit from it or not.

### Recommended measures – enterprise level

- Appoint and train work safety supervisors, preferably among migrant workers.
- Establish cooperation between employer and employee representatives to identify and tackle unfavourable working conditions.
- Search, identify and eliminate risks regularly.
- Conduct awareness raising training for representatives of employers and employees about the situation and contribution of migrant workers.
- It should be compulsory to provide information about the rights and obligations of employers and employees. General information on health protection, e.g. on drug abuse and sexually transmitted diseases, should also be provided. This information should be in the languages understood by employees.
- Workers must be properly informed about work processes, including information about existing safety measures and how to use them. Newly recruited employees must be properly trained in the practice and use of safety routines and devices. (There are easily accessible training packages developed by the ILO and the International Organization for Migration).
- Training packages for cooperative and participative improvements of working conditions, such as ILO's WISE (for small size enterprises, e.g. in the informal sector) and WIND (for agricultural workers), should be explored.
- Written regulations and rules about safety at the work place should be translated into the languages represented at the work place.
- Introducing a mentor system for newly employed migrants.
- Organise the employers as well as the employees.
- Local trade unions find ways to uphold the rights of undocumented migrant workers.
- Language training for migrants.

### Recommended measures – individual level

- Learn how to use safety devices, and then use them.
- Learn about safety routines, and then follow them.
- Follow the rule: "safety first".
- Refrain from macho attitudes and behaviour.
- Report injuries and identified risks.
- Search actively for information about rights, duties and safety measures.
- Never work alone on dangerous work sites.
- Try to learn the basics of the spoken language used at the workplace.
- Organise, if possible.
- Support the workmates.
- Avoid drugs and alcohol.

### SUGGESTIONS FOR FURTHER READING

Castles, Stephen and Miller, Mark J., *The Age of Migration*, The Guilford Press, New York, 2003

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ILO conventions nr 97 and 143 on migrant workers and nr 111 on discrimination

*Fundamental Principles & Rights at Work*, Geneva, 1998

*Migrant workers*, Geneva, 2002

*Towards a Fair Deal for Migrant Workers in the Global Economy*, Geneva, 2004

*A Fair Globalization: Creating Opportunities for All*, Geneva, 2004

Kuption, Christiane (ed.), *Merchants of Labour*, Geneva, 2006

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Schierup, Hansen and Castles, *Migration, Citizenship and the European Welfare State*, Oxford, 2006

#### UN documents

*International Convention on the Protection of the Rights of All Migrant Workers and Members of their Families*, 1990

*International Migration and Development*, Report of the Secretary-General, 2006

*World Migration 2005. Costs and Benefits of International Migration*, Int. Organisation for Migration, Geneva, 2005

Özden, Caglar & Schiff, Maurice (eds.), *International Migration, Economics and Policy*, World Bank, Washington, 2007

#### Useful websites

WISE Work Improvements in Small Enterprises  
[www.ilo.org/public/english/protection/condtrav/workcond/workcond\\_pamphlets.htm](http://www.ilo.org/public/english/protection/condtrav/workcond/workcond_pamphlets.htm)

WIND Work Improvement in Neighbourhood Development  
[www.ilo.org/public/english/protection/condtrav/pdf/agri\\_wind.pdf](http://www.ilo.org/public/english/protection/condtrav/pdf/agri_wind.pdf)

# OSH at the enterprise

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# Informal sector and small enterprises

*Peter Hasle & Ann-Beth Antonsson*

## BASIC CONCEPTS AND PROBLEMS

Small businesses, whether formalized or informal, form the basis of the lives of millions of people all over the globe. Small businesses may face numerous problems and have to fight for survival every day. Both owners and employees have to live with a high level of uncertainty. Employment is insecure, with a risk of losing one's job from one day to another. Income may also be uncertain, and vary from one day, week or season to another. In addition, working conditions are often tough and risky in this kind of company, especially in developing countries. Working hours are long and sometimes close to unlimited for work carried out at home. Access to drinking water, food, basic hygienic facilities and medical care is limited. And occupational hazards are numerous, with a high risk of both accidents and long-term tear and wear. For the self-employed the situation may be even more difficult. Despite all potential problems, small enterprises provide income and meaningful daily relations for owners and employees.

And society is getting more and more dependent on this type of business. Employment in the informal sector and small enterprises is increasing, in both developing and industrialised countries. Although the business of multi-

nationals continues to grow both nationally and globally, they also pursue a strategy of outsourcing and lean production which is moving employment to small and medium-sized subcontractors. The strong trend towards deregulation and liberalisation of the economy is at the same time reducing the number of permanent public jobs and making it easier to set up new businesses. Low economic growth or even decline leaves no opportunities for formal employment. For millions of men and women, then, their only chance of survival is a small business. In many developing countries almost the entire business sector consists of small enterprises and the informal sector. Small enterprises are predominant both in agriculture and in the new urban sector.

The strong competition among subcontractors and the scarce resources of the informal sector put heavy pressure on workplace safety. The small enterprises have scarce financial and knowledge resources for proper control of occupational safety and health (OSH) hazards, even in the quite many cases when the enterprise would benefit economically by improving the situation.



The ability of enterprises to reduce the safety and health hazards relates to several factors such as

- Presence of urgent issues, other than health and safety, that have to be prioritised, sometimes leaving little or no time at all for improvement of working conditions.
- How obvious are the risks? How are the risks perceived by the companies, e.g. are they possible to control or part of the job? Are accidents expected to happen often or seldom? Are the causes of ill health or accidents identified?
- The costs of reducing the hazards in relation to available resources.
- Are the means of controlling the risks known to the companies?
- How the risks at work are judged compared to other kinds of risks e.g. in private life.
- What the cultural attitudes are to risks and accidents, e.g. if pro-activity is a common strategy in society.

At the same time it is difficult for labour inspectors, unions, business advisors and others to get in touch with the small enterprises. The available resources for outreach activities are small and the cost to reach a large number of small enterprises is high. It is this problem governments, organisations and OSH professionals have been trying to grapple with during the last two decades, and

it is this problem we will discuss in this chapter of the book.

### Definition of small enterprises

Definitions of small enterprises vary from one country to another and from one organisation to another. Much also depends on the purpose of the definition. If it is a question of financial considerations, definition may be according to turnover or equity capital. If it is a labour market issue, definitions are often based on the number of employees and may vary according to the characteristics of the national industry. A definition often used in the European Union is shown in Figure 10.1.1.

Many countries have requirements for the registration of a business. These are normally connected with size or turnover. Unregistered enterprises are often termed the informal sector. This can vary from sale of vegetables at the street of a large city to small factories with production of garment, food, furniture or metal utensils.

Part of the informal sector is the self-employed, a group which is more difficult to pin down than the SSEs. It can sometimes be difficult to distinguish between employment and the self-employed. Especially in developing countries, homework and contract labour fall

Size category	Abbreviation	No. of employees
Small and medium-sized enterprises	SME	< 250
Medium-sized enterprises		50 – 249
Small-scale enterprises	SSE	10 – 49
Micro-enterprises		0 – 9

Figure 10.1.1. Definition of enterprise size categories according to the European Commission.

between the two categories. A larger enterprise normally provides both raw material and production equipment, but the worker is only paid for products or services produced and is formally responsible for the production. Many countries are thus considering or have already implemented legislation on employment and OSH in order to remedy this situation. In many countries micro-enterprises and the informal sector can to a large extent be equated, the exception being strongly regulated countries such as Sweden and Denmark, where it is virtually impossible to set up a true informal enterprise due to strict tax control of almost all economic activities.

Another way of distinguishing between smaller and larger enterprises is by ownership. In this chapter we will focus on independent small enterprises that are not part of a combine. (In industrialised countries, the fraction of small enterprises that are part of a combine is growing.) These enterprises have a lot in common. We will therefore use the term small enterprises (SSE) as the general description covering enterprises with 0–49 employees. The informal sector is also

included in the small enterprises if not especially emphasised.

Within the category of small enterprises there are also sub-categories. This is especially the case with the smaller ones with only one manager, typically the entrepreneur himself, and the larger ones with more than one managerial layer. We will shortly be returning to consider the significance of the role of the sole manager.

### Occupational health and safety in small enterprises

It is generally difficult to study OSH in small enterprises. The reporting frequency of work-related accidents and diseases is lower than for larger enterprises. And making surveys is much more difficult and expensive in the small enterprises. In consequence, although most scientists and professionals agree that the risks in small enterprises are higher than in large enterprises, the evidence is quite scattered.

Risks are primarily related to the activities in the enterprises and thereby the characteristics of the particular industrial sector. Similar risks are

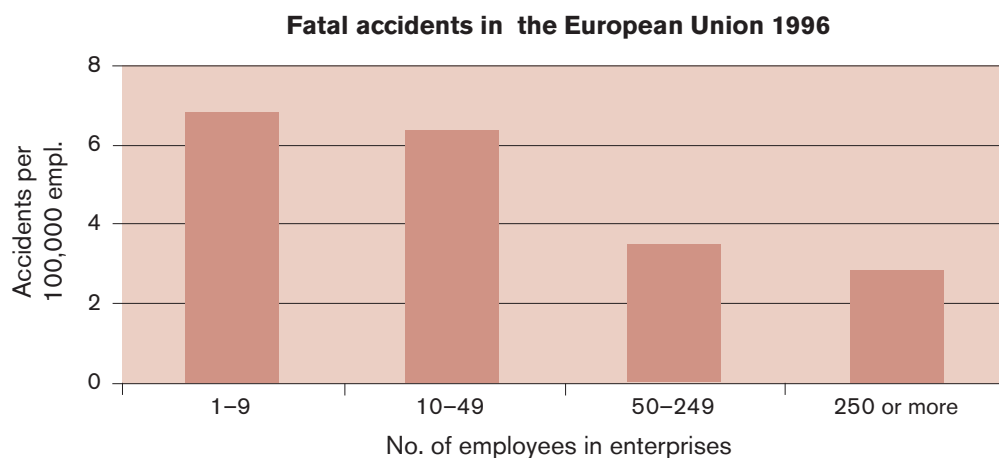


Figure 10.1.2. Fatal accidents in the European Union 1996, by size of enterprise.

prevalent in most enterprises in a sector, regardless of the size of the companies. When comparing enterprises within the same trade, OSH conditions are usually poorer and there are usually more accidents in the smallest enterprises.

Accidents are underreported in almost all countries, but fatalities are normally considered to have a high reporting rate, and this is one example where size-related distinctions are possible. Figure 10.1.2 clearly shows that in the European Union the risk of fatal accidents is doubled in small enterprises compared to larger ones. Partly this may be due to the fact that some sectors dominated by small enterprises have many fatal accidents. Sectors of this kind include agriculture, construction and transport.

But there may also be variations between small enterprises. These variations are larger than between large enterprises in the same sector. Consequently, there are also some small enterprises in hazardous sectors with a comparably good working environment. In some respects they may have advantages compared to larger enterprises, *viz*:

- Work in small enterprises is typically of a more varied character compared to the large enterprise. This means that there is less repetitive work, and there will be less full-time exposure to occupational hazards than in large enterprises. However, repetitive work is also found within small enterprises in certain industry sectors.
- In many cases close contact between owner and employees results in more meaningful work and a better psychosocial working environment. On the other hand, workers in small enterprises are more dependent on good relations with the manager.
- There is considerable diversity among small enterprises, with some having an extremely poor working environment where everything

is chaotic, and co-operation between owner and employees does not function, while others have a very good working environment. The variation range is larger in small enterprises than in large ones.

- Complicated technical measures to control the working environment will be relatively more expensive for small enterprises and there will often be problems in ensuring ongoing maintenance. Such technology is often based on production of large volumes and thus not suitable for most small enterprises that produce smaller volumes. In developing countries the investment cost will be prohibitive for almost all technology-based improvements in small enterprises.

### The culture of small enterprises

The culture of a small enterprise starts with its ownership. In the majority of small enterprises, the owner and daily manager are the same person, and he or she, as sole manager, occupies the central position in the enterprise. This is quite different from the large enterprise, where ownership and management often are separated and management consists of several hierarchical layers.

The basic point of departure is that the owner strongly identifies with the enterprise. The owner's personality is expressed via his/her ownership and operation of the enterprise. Criticism of the enterprise is therefore viewed as a personal slight against the owner. Work and family life flow together. Often, other family members have positions in the enterprise. In some cases the enterprise is even located in a direct extension of the family residence. This is especially the case for most informal and micro-enterprises in developing countries. The work also occupies more than average working hours for the owner, but at the same time there is room during work time to

attend to family matters should the need arise. In sum, being the owner of a small enterprise is a unique life-style.

Ownership and operations give the owner the possibility to achieve a high degree of fulfilment and meaning in his/her life and the enterprise provides an experience of existential values in the form of:

- personal growth
- self-determination and freedom
- fulfilment of own responsibility
- utility
- human dignity.

Identification with the enterprise means that the owner of a small enterprise often obtains a role where he/she behaves in a manner which is:

- action-oriented (it is important to get things done)
- patriarchal (it is I who decide and I am responsible for ensuring that things go well, both for my enterprise and my employees)
- egocentric (the world revolves around me and my enterprise).

Even though owners of small enterprises as a rule are perceived as very economically oriented, pure profitability is not always the decisive factor for the decisions taken. The survival of the enterprise's independence and the owner's full control over it, as well as the fulfilment of responsibility to the employees and society, often assume greater importance, as long as the costs are acceptable. However, in the informal sector in developing countries the daily bread will be the almost only priority.

Identification with the enterprise has several consequences for the owner's strategy. Most owners may not be interested in the enterprise growing so large that they lose perspective and control, and it is therefore only a few small

enterprises which are growth-oriented and have the desire to grow into a large enterprise.

The owners usually resist every form of state regulation, which can limit the possibilities of free action in the enterprise. At the same time, the authorities' demands are viewed as an administrative burden, e.g., sales and income taxes, environmental demands, building authorisations, and labour inspections are all seen as bureaucratic red tape and an unnecessary waste of time.

This is also true of most other external interference in the enterprise from, among others, consultants and advisors. There will typically be great reservation, and only when a personal relationship to an external individual has evolved will it be possible for the owner to take in advice and suggestions. Outside advisers who offer quick fix solutions to difficult problems will typically be considered untrustworthy and judged to cause unnecessary expenses of no utility for the enterprise.

Most small enterprises have a small network of persons whom they consult. These are primarily family members who work in the enterprise. For the formalised small enterprises the accountant is also a traditional key person. In addition, a bank counsellor, the enterprise's principal supplier and the owner of a co-operating enterprise and perhaps a permanent, trustworthy client, may also enter into the network. There may also be organisations to which the enterprise is affiliated that are considered trustworthy. This network also becomes a filter for the information received and accepted in the enterprise.

With the owner as sole manager the expectations from employees, customers and other become quite high. He/she almost has to act the Renaissance man: Leonardo da Vinci with knowledge and talents in a number of fields such as handling sales, suppliers, production planning, product development and human resource-

es. In many cases the manager also participates in the production process. This is reinforced by the owner's ambition to run everything in the enterprise him/herself, which makes it hard to delegate competence to others. Naturally, most owners cannot manage everything and concentrate on those production matters which lie most immediately in front of them. In many enterprises, especially the smallest, the owners are very much oriented towards production, as being the activity which obviously generates money. They concentrate on the organisation of production and find it difficult to allocate resources for other issues.

The owners are typically attentive to the possibility of ensuring their employees' stable employment. In some cases this means that they are hesitant to hire new workers for fear of having to discharge them again later. But the opposite may also occur, namely the owner feeling obliged to engage members of the extended family in a number disproportionate to the economic viability of the enterprise.

In the same fashion, they will frequently feel a sense of responsibility towards the employees who are taken ill, especially if it is a case of a workplace accident. They will attempt to assure them of continued employment in the enterprise and try to remove the problem which provoked the injury. In this way, the owner feels a clear responsibility for the working environment but often at an individual and very concrete level. At the same time, they find it difficult to deal with diffuse hazards whose long-term effect might entail a risk of an injury.

But it is also important to realise that the above observations may vary considerably according to the national culture, industrial relations, available manpower, industrial sector and others. In Malaysia for instance, there is a widespread use of migrant workers who can

only get a work permit for up to five years. In this case the workers have a different nationality and the owners know that employment is in any case temporary. The feeling of responsibility will therefore be much weaker.

The owner's strong identification with the enterprise also has its negative consequences. Most of them work much too hard under great pressure of time, with long working days. Stress factors are therefore also prevalent among them, such as:

- pressure of time
- mental alertness and tension
- insecurity regarding their own competence
- insecurity toward the relation to their employees
- negative spill-over from work to private life.

Some owners have difficulties mastering these strains, and they find managing in everyday life a heavy burden. This may lead to the emergence of psychosomatic symptoms such as fatigue and headache, and the extra energy needed to develop successful co-operation with the employees disappears, leading to organisational problems. Often such burdens are associated with a downturn for the enterprise, and a vicious circle may develop where good management and survival of the enterprise become increasingly unattainable.

However, far from every enterprise owner experiences such negative stress. Many owners understand how to master their daily tasks in such a way that they do not feel overburdened. Important parameters are the economy of the enterprise, the personal network and the attitude of the enterprise owner and his/hers experiences with the ability to deal with the demands imposed by their surroundings.

### CONSTRAINTS AND POSSIBILITIES FOR PREVENTIVE STRATEGIES

The one constraint always being pointed out is the cost of reaching the huge number of small enterprises. Visits to 100 firms of 10 employees will result in reaching the same number of employees as one visit in an enterprise of 1000 employees. It is also likely that the large enterprises are more receptive to the OSH professional. They may already have a safety officer and/or a safety committee and routines which OSH activities can fit into. But the need of the 100 small enterprises is likely to be much higher, as they have little OSH knowledge and often lack a systematic way of dealing with these issues. Therefore they rarely initiate any systematic or proactive activities in this field on their own.

For many developing countries the resources for outreach activities are very small. There are few labour inspectors, transport and occupational health services are limited, and publicly funded business advisory services are scarce. In addition, the availability of qualified professionals is very limited, and the OSH legislation is old and fragmented. Finding ways of overcoming the resource problem must be a major priority.

The field of OSH has its point of departure in large enterprises. OSH management, training programmes, measurement strategies, and control measures are developed in and for large enterprises. That also means that the OSH professionals, whether a government agency such as labour inspectors, researchers or consultants, have experience and understanding of OSH from large enterprises.

One major constraint therefore is that the thinking and systems do not fit the small enterprises. The usual approach is to try to bring up the small enterprises to work as systematically with OSH as the large enterprises. This simply

does not work. If a small enterprise does not have management systems for production planning and sales, it will not start to implement such a system on OSH, which is not a core issue for the enterprise. Trying to impose it on the small enterprises will have no effect and just be a waste of resources.

Many owners of small enterprises have strong reservations about government officials and OSH professionals. These will quite often meet with a negative attitude when they approach the small enterprise. Typical attitudes from small enterprises can illustrate the barriers which the OSH professional may encounter:

- The authorities harass the small enterprise with demands, entailing bureaucratic red tape and extra costs.
- The owner perceives identification of an OSH problem as personal criticism.
- OSH is purely an additional expense, which the small enterprise with its strained finances cannot afford.
- The employees are not interested in OSH, and they object to using the safety measures.
- The OSH professionals are arrogant and do not understand the special conditions of small enterprises.

Some small enterprises profess a more positive or neutral attitude, sometimes in order to end the conversation as fast as possible. The OSH professionals will thus have little chance of achieving anything unless they are aware of and have the proper qualifications to cope with such attitudes.

It may seem as the constraints pile up, with little room for effective actions. But it does not need to be so. Experiences from many countries around the world indicate that possibilities also exist. Owners of small enterprises are clever people (otherwise they would soon be out of



business) and they are action-oriented. They are used to getting things done, and when convinced they want to act immediately. At the same time they are rarely, especially in developing countries, offered any kind of support from anyone. The right offers of assistance to improve their business are thus likely to be met with interest and openness. The question therefore is what methodologies, services and institutional set-up should be organised so as to be able to reach the small enterprises with offers which would make a difference to them and the working environment.

### **THE APPROACH TO OCCUPATIONAL SAFETY AND HEALTH IN SMALL ENTERPRISES**

The first issue is whether the approach should be compulsory or voluntary. For many years, legal requirements have been the fundamental approach to OSH in both large and small enterprises. From the first OSH legislation in the middle of the 19th century until late in the 20th century, legislation has been the solution to OSH problems. In this long period of time small enterprises have been badly covered by the legislation, either because they were excluded by (legislation only applying beyond a certain size) or due to lack of inspection resources. However, during the last few decades voluntary approaches with various incentives have grown in influence. They include things such as information, training, occupational health services, campaigns, and certification. And just as for large enterprises, voluntary strategies have gained in importance for the small enterprises. It is much easier to get through to the owner of a small enterprise with voluntary offers than with strict enforcement. But this is not to say that legislation should be scrapped for small enterprises. It is important for the owners to learn that they have obliga-

tions towards their employees. The legislation should give the owner a clear responsibility for maintaining a safe and healthy workplace. The legislation can also serve as a point of departure for more voluntary approaches. “Why not get the best out of it when we are forced to do it anyway?” is the attitude of many owners. The legislation can thus open up better opportunities for the voluntary approaches. At the same time, when a labour inspector pays a visit to a small enterprise, this is an effective means to remedy concrete and clearly defined problems.

There are limitations to legislative approaches, just as there are situations where legislation is the best solution. In general, legislation is good when the demands are clearly defined and for example can be realised through a technical change of equipment, machinery etc. The demands can easily be presented to the small enterprises and it is easy to ascertain whether legislation is implemented. Enforcement is much more difficult when it comes to management systems which are much more complicated to implement and maintain in enterprises and also more difficult to inspect.

Given that enforcement by labour inspectors will always be limited, the voluntary approach is a necessary means to improve the working environment in small enterprises. But close co-operation is needed from legislation and inspection systems. Wholly voluntary approaches without legislative backing will mainly appeal to large corporations, which for image and efficiency reasons pursue management control of OSH as they do with other business issues.

### **The voluntary approach**

The question, then, is how to develop voluntary approaches which will appeal to small enterprises and especially micro and informal ones.

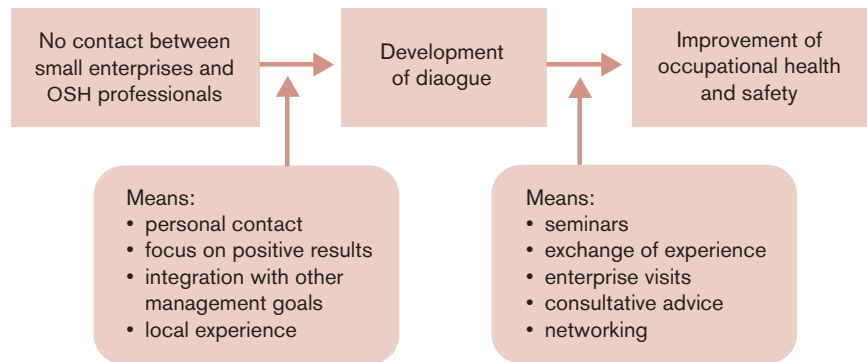


Figure 10.1.3. The approach to outreach OSH initiatives aimed at small enterprises.

The point of departure must be to establish a dialogue with the owner of the small enterprise. This foundation creates the best opportunities for initiating improvements. At the same time, different means are to be used for first establishing this dialogue and then initiating OSH improvements, see Figure 10.1.3.

A range of different possibilities can be utilised for establishing the dialogue. Establishment of personal contact, however, is an important precondition for success. Without personal contact, the relationship of trust and sense of equality which is a precondition of dialogue cannot be achieved.

The most important approaches to develop the personal contact are based on a visit paid by the OSH professional to the enterprise and include focusing on the following:

- a (genuine) interest in the joys and tribulations of the owner and his/her enterprise
- positive achievements in the enterprise especially regarding OSH
- integration of OSH with other present management objectives such as productivity, cost reduction, sales, quality, and external environment

- the enterprise's own experiences and realities
- relevant and credible offers of support.

With a dialogue based on trust and equality, a number of different possibilities for support can be offered. These offers should be tailored to the specific target group of small enterprises. There are many possibilities:

- offers of concrete consultative assistance such as solutions to concrete OSH problems or fulfilment of legal requirements
- seminars
- organisation of network groups
- training courses
- groups of owners for sharing experiences
- campaigns
- activities via local networks such as employers organisations, trade unions, technical schools, accountants, regional business support centres, etc.

Written information is a frequently applied method. Even though the written information may be designed for a special target group of small enterprises, it is the least effective means. Owners of small enterprises will normally not

read about what to do, and in many cases, especially in the informal sector in developing countries, they may have reading difficulties. The advantage of written information is the potential of reaching out to a very large group of enterprises, which in some cases may give enough results to justify the cost. Written material is also necessary in order to serve as practical guides and information to the owner. Such guides should not be used for mailing a lot of enterprises but rather be given to the owner during a visit to the enterprise, in order to give some guidance on how to continue working with specific issues without the personal support from the OSH professional.

Experience indicates that special professional and personal qualifications are needed to work successfully with small enterprises. It is therefore necessary that upgrading of their qualifications as OSH professionals be included in any planning of outreach initiatives. The upgrading of qualifications may consist of training activities, e.g. regarding how to work with small enterprises. Training can be done through seminars, training courses, and exchange of experiences among other involved professionals, possibly supplemented with supervision.

### **Personal contact**

The critical issue has proved to be development of a good personal relationship between the owner of the small enterprise and the OSH professional. For some professionals, establishing this contact may come naturally. They just walk into the plant and feel at ease about making contact. Many others, however, need to work more directly with preparing their method of contact and to improve their interpersonal skills. It is therefore important to look at some of the obstacles and potentials with regard to achieving the personal relationship.

Working with small enterprises has typically had low status. Prejudices about small enterprises have flourished among OSH professionals, labour inspectors and consultants.. The first task for many OSH professionals, therefore, has consisted in learning to be aware of their own prejudices. They may be critical barriers, although they are not all that visible at first glance, and one's own attitudes and prejudices, even if well suppressed, may impede the onset of a dialogue. Several possible attitudes may be prevalent among OSH professionals, such as:

- small enterprises are uninterested and unwilling to do anything about the working environment
- small enterprises are unsystematic because they do not have formal long-term planning and a clear organisational structure
- the working environment in small enterprises is characterised by many elementary working environment problems whose solution is a trivial task
- a small enterprise is a potential large enterprise unable to grow
- small enterprises are impossible to work with because there are so many of them, which means a limited amount of resources per enterprise.

In sum, the attitude can be described as a “we know best”, which is easily revealed by body language, tone of voice or style of questioning, and the owners of the small enterprise, viewing such an attitude as indicating lack of respect, will tend to reject further co-operation.

The OSH professionals' normal working methods consist of identifying OSH problems and proposing solutions. This method has proved to be less effective in the small enterprise. A typical sequence of events from using this method is illustrated below.

The owner feels personally responsible for the working environment and his or her employees. Hence, it is difficult for him or her to admit that there are OSH problems which might possibly damage the health of both the employees and the owner. In this case, possible OSH problems are attributed to conditions over which the owner has no control. The typical comment is “it can’t be done (technically or financially)”, or “the employees won’t use the protective equipment provided.” Faced with an OSH professional, whom the owner does not know, the OSH problems are therefore denied, and the professional never enters into a dialogue with the owner.

It is therefore necessary to use a positive approach, which gives the OSH professional the opportunity to express his/her respect for the enterprise and to obtain insight into the culture of the specific small enterprise.

For many OSH professionals it may seem provocative and improper not to point out OSH problems and shortcomings noticed at a visit. At the same time, the situation requires the professional to be positive and complimentary toward good examples, even if they are not always the best ones. There is no way around this problem.

The OSH professional needs to show genuine and positive interest in the enterprise and in the owner as a person. If one does not know very much about the enterprise’s special production (or about the sector), it is a good idea for a first-time visit to explain that one would like to learn more about the enterprise and its production. Subsequent visits may be commenced by explaining their purpose. From there one can go on to ask about the enterprise’s development situation since the last visit.

As this example makes clear, scarce resources limiting face-to-face contact with each enterprise to one single visit will be a serious con-

straint on this kind of voluntary approach. If the resources are that scarce, use of legislative approaches targeted at specific high risks should be considered.

This example shows that it is not realistic to expect big improvements after the first visit. Results are most likely to appear after continued contact and probably not in all enterprises. Realistic expectations are necessary in order to go on working with small enterprises for any considerable length of time.

Now encouraging results have been obtained by asking positive, interested questions concerning:

- products (special characteristics, special orders, customer base, market development)
- production processes
- the enterprise’s history
- the owner’s background.

A tour of the enterprise can be undertaken at an appropriate time. It is important to keep one’s eyes open for positive examples and to mention these to the owner, e.g. cases of OSH measures, products, technical arrangements, a good atmosphere or something else which may be relevant.

As the conversation unfolds, one can begin asking questions about the working environment, possibly with examples from the tour. The basis is still a positive interest and interest in the development of the enterprise. Examples could be:

- Are you satisfied with (a specific OSH measure)? Have you considered using it in other places?
- How did you solve the problems connected with...?
- Have the labour inspectors ever visited you? Did they take note of any irregularities? What did you do about it?
- Have you tried/heard about..., which I know other enterprises have experienced as a good solution?

- Do you have any plans for the working environment?
- What do the employees say about...?

Such questions may lead to concrete solutions in some cases, but they are also tools for developing a good dialogue, which is the point of departure for presenting an offer of *OSH advisory services* or participation in a *training programme*. The professional's ability to present a credible offer is crucial. The offer must be tailored to the enterprise's specific needs and certainly take into consideration its special conditions, e.g., workloads at certain times of the day or seasonal variations in the production process. Another important element is the demonstration of practical, down-to-earth solutions instead of more general or theoretical approaches. It is not enough to present a suggestion based on what the OSH professional believes are the enterprise's needs. The suggestion has to be presented and discussed in such a way that the enterprise can react and a joint dialogue about the best solution can develop.

It has often been seen that the owners, by way of introduction, emphasise that they have only very little time to spare. Often this already occurs during an initial approach, e.g. on the telephone. If the dialogue goes off well, however, it often happens that far more time is used than was originally agreed on, with the owner starting to volunteer information and clearly feeling happy and proud to talk about his or her enterprise. The photo album showing the history of the enterprise may also be got out, but that is up to the owner. The OSH professional must therefore certainly pose engaging questions, but never prolong the situation if the owner shows signs of being pressed for time or seeks a concrete way of ending the meeting.

### Exchange of experience between owners

Many attempts have been made to organise networking among or meetings for owners of small enterprises. The rationale behind this idea is twofold. Firstly, it has a potential for resource saving by bringing several owners together. Secondly it may have a greater impact, as owners are much more likely to listen to each other than to outside OSH experts. It has in some cases been difficult to drag the owners away from their business because they have so much work to do, and they are almost always behind schedule, but it has also proved to be successful in many other cases, not least in developing countries. In these countries the owners usually never received any offers of support of their business or of training activities.

When the owners show up, the sessions are almost always successful if the OSH experts can curb their inclination to give long technical lectures and can leave time and space for the owners themselves. With several subsequent sessions a certain dynamic in the group often evolves in which the owners vie with each other to prove themselves active in making improvements.

The pedagogic approach to the network or meeting session is crucial. On one hand the owners will expect to be lectured about interesting possibilities in OSH and related issues. On the other hand they will soon get tired of listening to lectures and they will be more interested in actively taking part and listening to fellow-entrepreneurs.

### Integration of occupational health and safety with other management goals

Arguing the potential economic benefits of OSH improvements is often considered an important catch point. This is also possible in many cases. It is especially the case with ergonomic matters such as materials handling and workstation

design, in which there are obvious rationalisation benefits to be gained from improvements. But in cost-saving terms as well, there may be mutual economic and OSH benefits. That is the case with waste minimisation and with certain aspects of energy and water saving. But the owners in spite of clear benefits may be reluctant to accept the possibility. They may lack confidence in the statements by the experts and, most importantly perhaps, they are afraid of all the trouble of organising implementation and fear it will cause unforeseen problems.

Personnel economy is often used as an economic argument for improvements of OSH, even in small enterprises. Such arguments are often perceived as irrelevant by small enterprises. Their experiences of personnel costs related to bad OSH conditions may be limited, mainly due to the fact that in a small enterprise, accidents and occupational diseases are rare events, though statistically the risk is higher than in large enterprises. Additionally, the owner's conclusion from the accidents or ill-health that occur is not always that proactive work is needed. It may equally well be that the employees have been careless.

It is important to realise that the owner has so many duties at once that his attention will be a limited resource, even though his business could benefit from certain actions.

### **Worker participation**

The importance of worker participation is gaining widespread recognition in most countries. In the field of OSH, a legal background for safety committees and safety representatives has been established in many countries. The significance of workers' participation in OSH as well as in other aspects of the enterprise is widely recognised. However, small enterprises are often exempted from legal requirements and unionisation is almost always non-existent

among their employees. It can therefore be difficult to find ways for workers' participation. The owner will often argue that he or she talks with the individual workers concerned, and that major decisions are the owner's sole responsibility anyway. But the owner may also complain that it is difficult to convince the workers in favour of using personal protective equipment or taking other preventive measures.

The same problem goes for commitment in the enterprise as such. However, experience from Sweden and Denmark indicates that many small enterprises benefit from getting worker participation better organised. Brief kick-off meetings every Monday morning or similar pooling of the week's experience every Friday afternoon, have proved beneficial to all parties, as well as opening up a possibility of discussing the working environment. Another approach is joint risk assessment, with the owner and the workers all participating in a discussion of OSH problems and of an action plan to solve them.

Promotion of workers' participation is therefore also part of the approach to improve the working environment in small enterprises. However, it is important to realise that promoting workers' participation only in matters of OSH may not be enough. If the workers are not informed and encouraged to take part in the development of their own jobs, they often show low activity also regarding the development of OSH conditions.

### **TOOLS TAILORED TO SMALL ENTERPRISES**

Supporting small enterprises is a complex task, where the time of the OSH professionals is limited, resulting in a limited support to small enterprises. At the same time there is a lack of knowledge in enterprises about OSH, resulting in a need for more detailed advice regarding



specific problems. If, however, the experts solve all the problems for the enterprise, very few enterprises can get such help. Additionally, the enterprises will not develop their own OSH competence, resulting in a never-ending dependence on OSH professionals.

The solution to this problem is to use different kinds of tools, supporting the OSH professionals' interventions in enterprises. Such tools are an adjunct to personal contact and will

- guide the enterprise in further activities, after the visit from the OSH professional
- support learning-by-doing in the enterprises, by giving ideas about what to do and how to do it
- result in improvements in OSH conditions when used by the enterprises.

Tools tailored to small enterprises are often developed to

- be short
- be simple
- be action-oriented
- build on the knowledge and experiences in the enterprise.

Typical examples of tools are checklists, which are often appreciated by small enterprises. Checklists correspond to the needs of many enterprises, such as the need for tools that give results and are easy and quick to use. However, checklists may be developed in many different ways, not all of which are suitable for small enterprises. Checklists asking questions about work environment factors such as chemicals, noise etc, assuming that the respondent has the necessary knowledge of these factors, are not usually fit for small enterprises. On the other hand, checklists posing questions about the different parts of production present in the enterprise, about safety devices, ventilation or noise reduction that ought to be present, are more

related to the world and reality of the small enterprise and therefore work better. Therefore tools for small enterprises have to be adapted to the specific target group, often in a specific industrial sector.

All tools do not have to include detailed information about problems and control measures. Sometimes one can make do with an open form, stimulating a dialogue within the enterprise in order to start a process aimed at assessing the occupational risks in the enterprise and drawing up an action plan to reduce them. Depending on the complexity of the occupational hazards and the present knowledge in the enterprise, this may be enough, but it may also result in risks going undetected or being underestimated. The dialogue itself, however, has a boosting effect on OSH improvements and is often more important than detecting all the risks.

## **INSTITUTIONALISATION AND INTERMEDIARIES**

The above discussion illustrates on the one hand that OSH improvements can be initiated in small enterprises and on the other hand that the difficult point is organisation and institutionalisation. Little happens by itself in small enterprises if legislation is the sole driving force. The daily fight for survival will fill the owner's working day and then some more. Intermediaries are therefore needed who can carry the OSH issue into small enterprises, and an institutional set-up is needed which can secure funding and the qualifications of the intermediaries.

The possibilities for such systems vary a lot from country to country. In most developing countries, resources for maintaining a basic OSH system are scarce, and even in the industrialised countries it is difficult to secure the necessary political priority for the problems of small enterprises. However, all countries have various in-

# CHECKLIST FOR SAFETY INSPECTIONS (General)

- Answer the questions with yes or no. Answer by putting a cross in the appropriate square, then fill in the three squares next to it. The completed form is an action plan that may be included in your health and safety work.
- Assess the hazards caused by the faults you have noted. Mark any hazards that are serious.
- Are there any questions or sections in the form that do not apply to your operation? Cross them out! Do you think some points are missing? Then add them!
- **Modify the checklist to meet your requirements!**
- We suggest you begin with the questions marked in colour. They are about the more important issues.
- We suggest that the manager/work supervisor and safety representative or one or more employees complete the checklist together. When necessary, the checklist can be broken down and different managers complete the sections that concern their particular area.
- Complete the checklist on a regular basis – twice a year, for example.
- **Follow up the inspection to verify that the measures you recommended have been implemented!**

Date: \_\_\_\_\_

Company: \_\_\_\_\_

Participants: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

	What action must be taken? Is any additional help needed?	Who is responsible for ensuring the work is done?	When shall it be finished?
<b>HOUSEKEEPING</b>			
<b>1.</b> Is housekeeping at the workplace satisfactory (waste, rubbish, stored materials and suchlike)? Are efficient cleaning procedures in effect?  Yes <input type="checkbox"/> No <input type="checkbox"/> ►►			
<b>2.</b> Is the workplace orderly enough to ensure that accidents are avoided, evacuation routes are not obstructed, that stacks of material do not collapse, etc?  Yes <input type="checkbox"/> No <input type="checkbox"/> ►►			
<b>3.</b> Are there stairs/ladders that need attention (to be fitted with handrails, safety railing etc)?  Yes <input type="checkbox"/> No <input type="checkbox"/> ►►			
<b>4.</b> Are the doors in good condition and made of good quality material?  Yes <input type="checkbox"/> No <input type="checkbox"/> ►►			

Figure 10.1.4. A simple checklist for safety inspections, available at [www.prevent.se](http://www.prevent.se)

stitutions which could be the point of departure for developing activities aimed at small enterprises.

Even with a weak labour inspectorate, the most effective way of using limited resources is an issue. In larger enterprises, does this mean inspecting boilers and pressure vessels, for instance, or are resources better employed in small enterprises? Control of boilers, for instance, could be outsourced to certified consultants, and large enterprises are likelier than small ones to be capable of maintaining a reasonable level of OSH. Even if more resources are allocated, the inspectors will obviously not be able to visit every small enterprise. So the labour inspectors will have to find other ways of getting in touch with small enterprises. One important opportunity is to work together with small business associations, large enterprises and their networks of small suppliers, craft guilds or similar organisations. Training of representatives of the organisations, seminars for the members, or possible organisation of direct services could be a cost-effective approach.

Integration with other services offered to small enterprises is another possibility. Many countries organise various forms of services for small business and entrepreneurs. These can take the form of small credit schemes, business advice, training or technological services. Integration of OSH with such services would be a good illustration of the working environment as a part of the everyday running of the enterprise. Even credit schemes would almost always include some kind of analysis of business opportunities and advice on business development. Including OSH in such analysis and advice would be a very efficient way of reaching many small enterprises at a time when the possibilities for prevention of OSH problems are quite good. In order, however, for such co-operation with

other services to succeed, the other services must have something to gain from the co-operation.

Occupational health services exist in one form or another in many countries. In some these services are backed by legislation and in other they are formed on a voluntary basis. However, nearly all of them cater almost entirely to large enterprises. Often they are even organised as in-house services in larger enterprises. A number of European countries do have occupational health service systems which reach many small enterprises, and in this situation occupational health services should also be developed to provide preventive services to small enterprises.

Health care might be another possibility. It has proved especially efficient as a possibility for the informal sector where living and working conditions are virtually the same. Prevention of health risks should therefore both be targeted at traditional hygiene, sanitation, and immunisation and at prevention of occupational health risks posed by chemicals, dust, bad working postures, and accident risks.

### **PROGRAMMES FOR SMALL ENTERPRISES**

The International Labour Organisation (ILO) has developed a number of programmes and methodologies aimed at small enterprises and the informal sector, especially in developing countries. We will briefly outline a few examples in the following sections. References are given at the end of the chapter and can be studied at the ILO homepage ([www.ilo.org](http://www.ilo.org)).

#### **Work improvements in small enterprises – the WISE concept**

The oldest and most comprehensive programme is named WISE. It was developed in Southeast Asia in the mid-eighties and has been successfully applied in a large number of countries. A training package has been elaborated, consisting

of a trainer's manual and an action manual for owners of small enterprises. The original action manual covers almost all manufacturing industries. During the last years a number of action manuals for specific industries have been prepared. They include among others wood industry and garment industry.

WISE is based on six principles, which are in accordance with the above discussion of approaches to small enterprises:

- build on local practice
- focus on achievements
- link working environment with other management goals
- use learning-by-doing
- encourage exchange of experience
- promote workers involvement.

Its organisation includes a number of subsequent workshops and intermediate enterprise activities. A standard WISE programme will include the following activities:

- recruitment of enterprises (visits to enterprises, assessment of baseline level, collection of examples with slides)
- initial workshops (one late afternoon/early evening and one morning or early afternoon for checklist exercise with meals), presentation of practical examples of improvements from participating enterprises, various small group works, introduction of a practical oriented enterprise checklist during a plant visit, formation of groups of entrepreneurs
- identification of possible improvements in enterprises (the groups of entrepreneurs visit each other together with facilitators and use the checklist as a tool for identifying improvements)
- midterm workshop (introduction of methods for planning implementation of a successful

improvement, presentation and group work) (one late afternoon/early evening with a meal)

- commencement of improvements in the enterprises (facilitators assist the entrepreneurs with advice during the implementation process)
- final workshop (the resource persons assist the entrepreneurs in preparing a presentation of their achievement, using slides and transparencies) (one late afternoon/early evening, with a meal)
- follow up workshop (after 3–6 months, in order to evaluate achievements and make slides for presentation at the workshop).

Experience indicates that the result will be 5–10 practical low-cost improvements in each participating enterprise, and that owners and managers from 15–25 enterprises will participate in a programme.

### Integration with business advice and training

Another approach is the integration of OSH in business advice and training targeting small enterprises. Based very much on experience from WISE, the ILO has worked intensively with this approach. It has been through the SEED (boosting employment through Small Enterprise Development) programme and the training package Improve Your Business (IYB). Both of these have job quality in small enterprises as a main objective. Job quality in this context means both OSH, social security and human resource development. This integration approach has also been tested in a large number of developing countries, both as offers to new entrepreneurs and for the improvement of existing small enterprises.

## PROGRAMMES FOR THE INFORMAL SECTOR

A number of different approaches have been developed for the informal sector. Some are especially aimed at home-workers, who may either be self-employed or in some cases employees and others in small informal businesses with employees. PATRIS (Participatory Action Training for the Informal Sector) is an example of a fully developed training package. One especially promising methodology has been

developed in Dar Es Salaam, Tanzania. The idea was to establish OSH committees between clusters of small informal enterprises in local areas of the city. These committees were trained by primary health care workers who themselves had received additional OSH training. The training provided by the health care workers was participatory and action-oriented and aimed at both general health and OSH.

## SUGGESTIONS FOR FURTHER READING

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# Management and participation

*Nils Petersson*

## BACKGROUND

Occupational safety and health (OSH) at the workplace is a management responsibility and this responsibility is formally stated in the legislation in many countries. Management must set objectives and allocate resources for OSH. If high standards of OSH are to be achieved, it is also essential to have continuous commitment from management and involvement of employees. It is not efficient to have a management system that regards OSH as a subject to be dealt with only by experts, separate from other management. Better results can be achieved when OSH becomes an integral part of the daily production system, and when all the personnel of an enterprise or organisation are involved.

The Occupational Safety and Health Management System (OSHMS) is described in the first part of this chapter. In the second part the participation in OSH of different groups of employees is outlined. In the third and last part two case studies explain how OSHMS can be implemented and the productivity increased by using a participatory approach.

## OCCUPATIONAL SAFETY AND HEALTH MANAGEMENT

OSH has not always been considered as a legitimate part of management systems. Instead of being a part of a holistic or systematic approach, OSH was considered to be a series of “one-off” problems to be solved outside of normal management systems. The holistic or systematic approach has become more common in many countries during the last twenty years.

There have been three major influences in the development of OSHMSs. One approach was developed by the Norwegians for their offshore petroleum industry. The second is associated with the moves during the last decades, e.g. in Great Britain, to deregulate and reduce bureaucracy in order to achieve more “flexibility” in working life. The third is the development and use of ISO quality standards and environmental management systems.

Because of the difficulties in accessing work sites, the supervision of OSH in the Norwegian offshore petroleum industry could not be carried out in the same way as in industries located on the mainland. National authorities were forced to put their trust in the offshore enterprises to create and maintain their own OSH systems that could be easily supervised without detailed



inspections. These offshore experiences were so positive that in 1992 Norway released a new regulation for “internal control” within mainland enterprises and undertakings. The regulation laid down all the measures that any enterprise was required to implement to ensure the level of OSH set by the legislation. In some countries, e.g. Sweden, it is not only legislation that sets OSH requirements but also regulations or ordinances from national authorities. All OSH activities should be planned, organised, carried out and maintained according to the legislation and other relevant national requirements. The concept of internal control also laid down the way in which OSH activities (e.g. inspections or risk measurements), must be documented so that the national authorities can easily supervise enterprises without time consuming and detailed inspections. Sweden followed Norway and introduced its internal control regulation one year later in January 1993. Norway and Sweden are examples of countries that have chosen to use legislation to establish OSHMS.

The introduction of internal control within enterprises has resulted in changes in the work of the supervision bodies, away from detailed inspections to supervision of the OSH management system, mainly in big enterprises. Thereby much of the bureaucracy has been possible to eliminate, making the supervision bodies more efficient in their control.

The quality system that later formed the ISO 9000 family of international standards, had its roots in the control system used in the military forces in the USA. In the ISO standards, a quality system covers organisational structure, routines, processes and resources for managing and controlling activities regarding quality. Standards for environmental systems, (ISO 14000 family of standards), were created later (with major input from the ISO 9000 concept),

and describe organisational structure, planning, responsibilities, practice, routines, processes and resources for developing, introducing, meeting, revising and sustaining external environmental policy.

In 1989 the European Union had already created a framework directive which obligated their member states to establish minimum and similar standards (to the ISO standards), for the work environment. This framework (89/391/EEC) requires all member states to have corresponding statutory rules which contain measures to encourage improvements in safety and health at work.

In 1996 a British standard and guidelines (BS8800), for OSHMSs was released. It was designed to facilitate the integration between the management of environmental issues and OSH. Other countries have also created their own national standards, similar to BS 8800. The introduction of the British standard was partly a way to make a rigid supervision system more flexible and adjusted to the labour market.

Several attempts have been made to issue an ISO standard for OSHMSs, which would correspond with the ideas of ISO 9000 and ISO 14000, but it has not been possible to get acceptance from the required majority of ISO members, as many countries preferred their own legislation. It seems unlikely that such a standard will be established in the near future, as ISO now has finished to try to overcome the disagreements and no group is working with the OSHMS standard any more.

In an attempt to overcome the lack of an internationally acceptable standard for OSHMSs, the International Labour Office (ILO) published a guideline on OSHMSs in 2001. The ILO guideline is aimed at both national and organisational levels. Using the guideline as a base, it is possible to create or amend national laws and

regulations to achieve effective OSHMS regulations. At an organisational level, the guideline can also be used to implement OSHMSs and to assist with integration into other management structures. The concept of OSHMSs that has evolved has become increasingly popular in industrialised countries and more recently in developing countries.

### Fundamental elements of OSHMS

Most standards and guidelines for OSHMS have many fundamental elements in common although there can be differences in implementation and maintenance of systems. The following discussion is largely based on the ILO approach and focuses upon OSHMS at an enterprise level rather than at national level.

The following elements are the foundation for most OSHMSs:

- Policy
- Organisation
- Planning and implementation
- Evaluation
- Action for continuous improvement

Taking the two first elements, policy and organisation, as examples, the organisation of an OSHMS must correspond to what is stated in the policy. Enterprises or organisations may have many or all of the elements needed for an OSHMS present. However, if the elements are not linked or integrated with each other, they do not constitute a system capable of handling OSH issues efficiently. Because of the nature of a system, it is also important to implement measures for continuous feedback, adjustment and improvement.

There are two key factors essential for the maintenance and creation of efficient OSHMS,

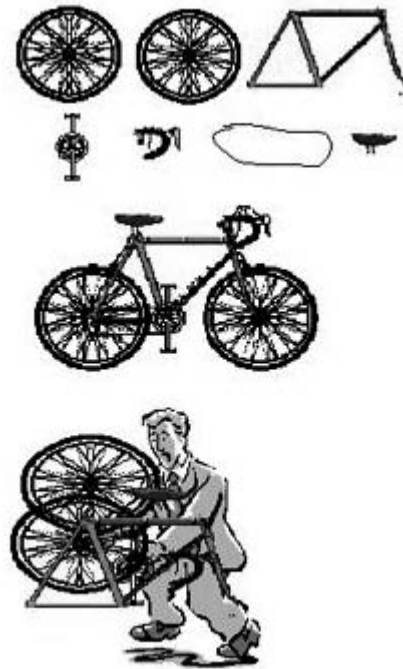


Figure 10.2.1. A “system” is characterised by a link between elements, where one element influences another. If the elements are not linked correctly the result is simply a collection of elements rather than a useful system. This is equally true for an OSHMS and a bicycle.

namely management commitment and workers’ participation. The workers participation in OSH issues will be further discussed later in this chapter. Workers’ participation in general is regarded not only as a democratic right but also as a tool to make enterprises or organisation more profitable and competitive.

Although many national laws and regulations state that the responsibility for OSH must be taken by employers, this does not mean that all employers are committed or active on the issue. Employers must not only be committed but also prepared to create a good climate and an efficient system which will encourage workers to actively participate in OSH issues. This requires,

amongst other things, that workers are provided with adequate training on OSH.

If an enterprise or organisation seeks certification of their OSHMS, a certification arrangement is needed where all the compulsory elements are defined as 'shall be included'. Systems which only suggest elements which may be included at the manager's discretion, cannot be certified.

### OSH policy

"Policy" has several meanings, of which two are the most predominant. The first is setting out the terms of a contract and the second being an agreement on how to act in specific circumstances. The second meaning is applicable to OSH issues and can be seen as a 'statement of ambitions'. For many years, enterprises have used business policies to tell their customers what they stand for, e.g. customer service, delivery or quality criteria. With the introduction of various standards on specific subjects, such

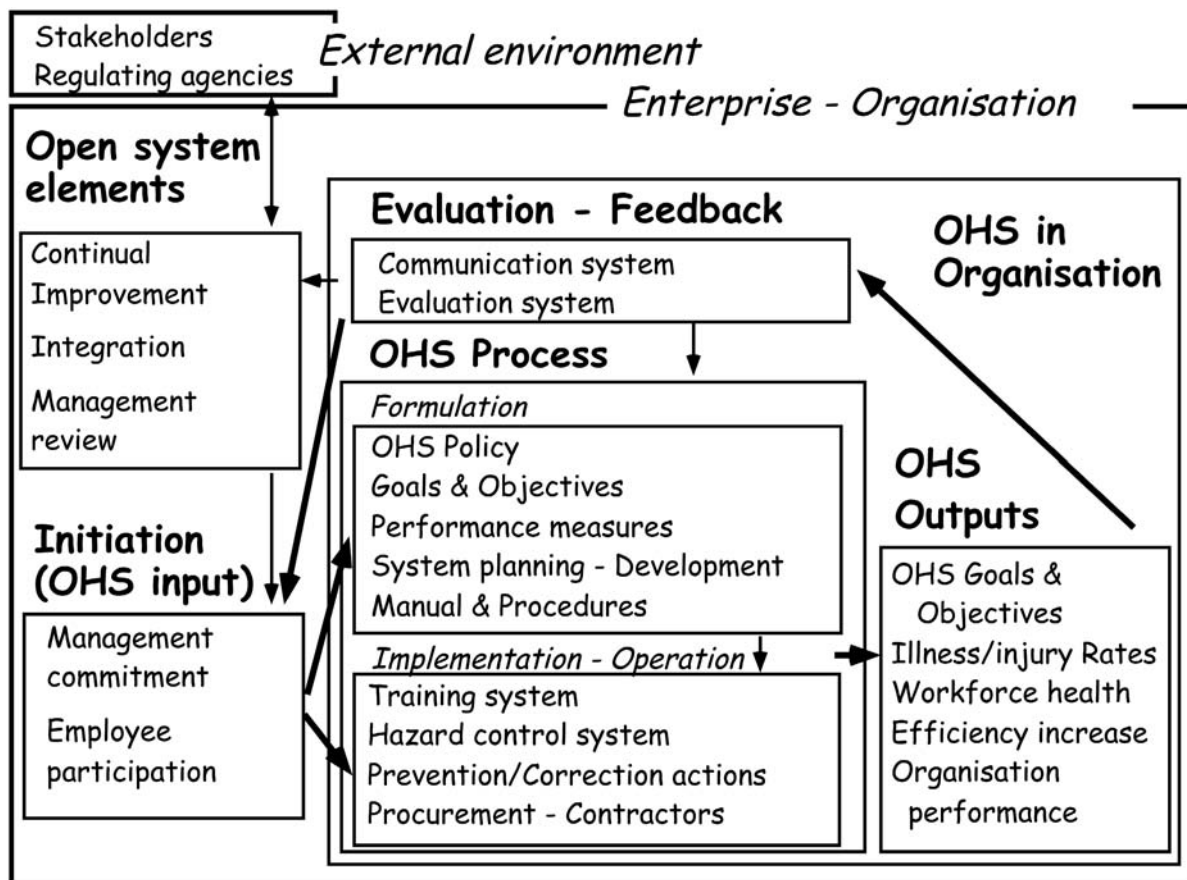


Figure 10.2.2. Important elements in OSH and the ways they can be linked to each other to constitute an efficient management system.

as the ISO 9000 quality standards, enterprises have also developed more specific policies in addition to their business policy. Such policies allow an enterprise to emphasise the importance they place on particular concerns and to make these concerns visible to their stakeholders such as customers and employees. It also states how management will act on certain concerns. A policy document is important when it comes to setting up enterprise activities.

An OSH policy states the overall objectives of OSH within an enterprise, principally the protection of the safety and health of all employees through the prevention of work-related injuries, diseases and near accidents. The policy should be prepared by the employer in consultation with employees. It is important that the policy states that the OSHMS must be continuously improved and that workers must be consulted and encouraged to participate. Each policy should be signed by the employer, comply with the country's laws and regulations, be specific for each organisation or enterprise and be written in clear language and communicated to all employees and other stakeholders.

### Organisation of OSH activities

Employers shall organise OSH and appoint personnel to identify, evaluate and eliminate hazards and to prevent or reduce risks. Those responsible need resources allocated to them, including time and training. Systems are needed for cooperation and communication at various levels within the enterprise and to promote the active participation of the employees.

Managers and all employees need basic training and refresher courses in OSH. Training has to be provided free of charge, if possible during working hours, and documented.

Many guidelines and national standards state that any OSHMS shall include relevant, clearly

written, easy accessible and updated documentation on OSH policy, including the objectives, responsibility, instructions, hazards/risks in the workplace, prevention activities and records of OSH statistics on accidents, etc.

A system for review, evaluation and follow-up of the OSHMS is essential.

### Planning and implementation

In order to implement or improve the OSH system in an enterprise/organisation, basic knowledge of the current situation is essential. It is appropriate for an initial review to be carried out by either an external expert or by a qualified staff member, in cooperation with the employees. External demands, such as national laws, standards and stakeholder requirements, have to be included along with identified hazards and the measures required to eliminate the hazards or reduce the associated risks. Such a document can form the basis for the implementation or improvement of an OSHMS.

Besides defining the objectives of any improvements it is also important to describe what activities have to be carried out to achieve the objectives. A responsible person must be appointed, deadlines set and adequate resources assigned.

Such objectives would normally include suggestions for continuous improvement of the workers' OSH situation. Objectives must be attainable, documented, communicated and their attainment evaluated.

Hazard control includes the ongoing identification and elimination of hazards. If a hazard cannot be eliminated, the risk should be reduced by control at source, e.g. by choosing a safe raw material, or reduction of exposure through engineering or organisational measures, e.g. by enclosing the source. The use of personal protective equipment is acceptable only as a tem-

porary measure or when all the above measures have failed.

An opportune time to identify hazards is when new equipment is purchased, when new raw materials are considered or when production processes are planned or reorganised. It is essential to consult with potentially affected workers in advance of such changes.

Although outside the core organisation, contractors are an essential group to include in OSH activities if the workplace is to be safe. It is important to have a system whereby contractors are informed, requested and committed to follow the existing OSH rules of the enterprise.

### Evaluation

The performance of the OSHMS has to be regularly evaluated so it can be judged against the stated OSH policy and national legislation, and be further elaborated. It is important to define indicators, closely linked to the enterprise OSH policy and objectives, to be used in the evaluation. An evaluation should not only be based upon reported work-related injuries, ill health or accidents, but should also include monitoring of actions.

Documented investigations of work related injuries, diseases, accidents and near-accidents provide important input for the creation of a safer workplace. Whenever possible, documentation should identify failures in the existing OSHMS. When corrections are implemented, it is useful to document and communicate the remedies used to other, relevant parts of the organisation so they can use the same remedies or avoid similar mistakes. This type of documentation may also be helpful for rehabilitation purposes.

Audits of the whole OSHMS should cover all the elements in the system, including the way in which the elements are linked and support each other; how well the OSH policy and objectives

are fulfilled; compliance with national laws and regulations; evaluation, follow up and reporting. It may be an advantage if one of the auditors is external.

### Action for continuous improvement

Production systems are always scrutinised to find the weakest link and to discover ways in which performance can be improved. The same approach must be taken with any OSH system, i.e. to find how the OSH can be improved to make workplaces safer and to reduce work related injuries and illnesses.

No OSH problems can ever be regarded as permanently solved; work has to be continuously reviewed. New hazards may be introduced, e.g. with new machines, processes or raw materials. Although enterprises should strive to eliminate hazards or reduce risks when introducing new processes or materials, this may not always occur.

Continuous improvements need to be a natural part of everyday working life and are essential for an efficient OSHMS. You will note the use of the term 'continuous', rather than 'continual'. It is accepted that OSH activities cannot be carried out continuously, without interruption, but OSH issues must always be on the agenda even though they cannot be worked on all the time.

The so called Plan-Do-Check-Act (PDCA) approach to improve product quality has been widely used. First made popular by E. Deming through his successful activities to implement continuous improvement, the method is sometimes called the Deming wheel, or the Shewart cycle, after the first person to present the concept in 1939. PDCA is based on the 'learning-by-doing' concept. It is also known as (PDSA), Plan-Do-Study-Act.

The PDCA method is usually carried out by small teams. In the planning phase data are



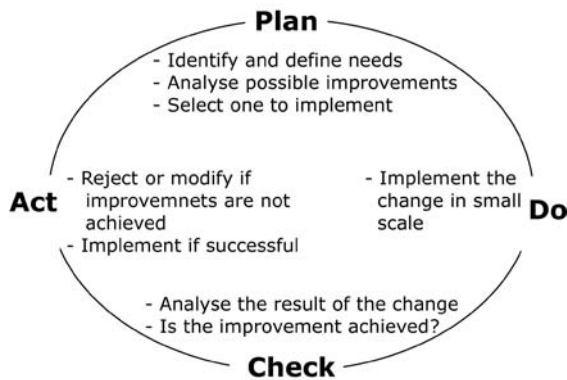


Figure 10.2.3. PDCA cycle.

collected and analysed to select an improvement that the team wants to test. In the do phase the selected change is implemented. An assessment of the change is carried out in the check phase. Based upon the result the next step is taken in the act phase, when the change is either accepted as positive or rejected and the PDCA process is started again.

### OSHMSs in small enterprises

Standards and guidelines on OSHM are often very general and intended to cover a broad variety of sectors. They are often written in a format that attempts to cover every aspect of OSHMS and are therefore more directed to large enterprises rather than small undertakings. Small undertakings may have an efficient information flow that may shorten the time between decision making and action and make results immediately apparent to everybody. An OSHMS for a small enterprise can be simple but still efficient. Most national laws, with some exceptions, do not make allowances for the size of the enterprise.

The OSHMS, and many of its elements, are still important for small enterprises. Hazard identification and risk assessment must be done

but possibly through the use of an easily accessible checklist and with the participation of all the employees. Workers need to be trained in OSH, whatever the size of the enterprise. Documentation on OSH measures, including actions taken, results achieved, records, etc, is also important in small enterprises. Routines for continuous improvement of OSH in enterprises are essential.

### OSHMS – bureaucratic systems or systems for action?

It is easy to get the impression from many standards or guidelines on OSHMS, that they are purely administrative systems that create cumbersome and expensive bureaucracy and a lot of wasteful work. In fact, an OSHMS is designed to have the opposite effect – to be an efficient system, optimal for the size and nature of the enterprise, to avoid unnecessary work, to prevent costly accidents and to use the valuable knowledge and experience of employees. In large enterprises, OSHMSs may need input from expert staff but line-managers are largely responsible for OSH on a day-to-day basis as it is an integral part of their work. Experts are only needed when the OSH problems to be investigated or solved are so complex that the trained line-managers or employees cannot handle them.

To conclude, the main idea of an OSHMS is to facilitate action and to implement preventive measures. Such actions should include investigations of hazards and not only be based upon results from past accidents or unhealthy exposures.

### The workplace as a “learning” or “controlling” environment

All OSHMS standards and guidelines emphasise the necessity of workers’ participation. The approach to participation in OSH at the workplace



can either take place in a so called “controlling” or “learning” environment.

Many national laws and OSHMSs tend to be detailed in an attempt to regulate or control the work environment and the behaviour of workers in a wide variety of specific situations. However, even a very detailed regulation cannot cover all the situations that may occur and an OSHMS which relies on detailed regulation may fail to deal with unpredicted hazards. A “learning” system which gives workers some freedom to handle OSH issues, based on general training in safety, may be more efficient than detailed regulations, not only for unpredicted situations but also for preventive actions.

An OSHMS can be designed to successfully combine to good advantage both a controlling and a learning system, but there is always a need to ensure that the controlling system doesn’t take over.

### **PARTICIPATION**

There are two different but complementary methods of participation, direct participation by individual employees and indirect employee participation through appointed OSH representatives.

The main problems encountered when introducing a participatory approach are connected to the “organisational culture” prevalent in many organisations. For example, a “top-down” management afraid of losing power, will hinder the introduction of participation. A further obstacle may be that workers have not received any training in OSH issues, be illiterate and lacking self-confidence.

### **The objectives of employee participation**

The wealth of a nation depends not only on its natural resources but to a great extent upon how efficiently it takes care of its human resources.

This is also true for enterprises in a world where competitiveness is accelerating. In the long run those enterprises which use only part of their employees’ abilities will have difficulties to survive on a global market. Employees working daily in their profession become experts on their jobs and often have ideas on how production efficiency and the work environment can be improved. These ideas should be taken into account and employees encouraged to come up with new ideas. It is therefore essential to create a system that encourage and consider employees’ ideas.

The promotion of employee participation may make the enterprises more efficient, coinciding with their business interests. Another objective may be to increase workplace democracy. The right of employees’ to exert influence over their own work environment is an important issue in many industrialised countries. For example, the European Union has a directive stating that enterprises should involve employees and create true employee participation in OSH activities. This type of involvement in OSH activities is less common in developing countries.

The total quality management (TQM) approach developed by Japanese enterprises focus both on the implementation of new ideas, enterprise culture and working methods as well as on the creation of efficient methods to involve workers in enterprise development and rationalisation. Important aspect of TQM is that it encourages and takes employees ideas seriously. The continuous improvement approach was derived from TQM.

Participatory is not only a good way to get new ideas and encourage creativity, but also to increase the acceptance of changes. Involvement in changes from the very first discussions is essential for understanding the need for a change and makes acceptance of change easier, even if it might be threatening or inconvenient. The

faster new ideas are accepted, the faster they are fully implemented, thus minimising drops in production efficiency and profits. So it is essential to have the participation of all those involved from the earliest possible stage.

While this chapter mainly focuses on participation in OSH issues there is no difference from more general participation. If the enterprise has not used a participative approach earlier, OSH issues might be a good entrance to a wider implementation of participation.

### The organisation of participation

The commitment of management to create true participation is reflected in the way participation is organised, e.g. by the structures set up, the time allotted, training given and physical facilities provided for employees to participate.

There are two distinct methods for organising participation - indirect participation through a system of representatives and direct participation by all employees. Neither system is ideal so the most efficient way is often to have both direct and indirect participation. The size of the enterprise and the questions being dealt with must be considered when deciding which system is the most appropriate.

However, any structure established for employee participation in OSH must ensure that all employees are given regular possibilities to express and discuss ideas with the responsible manager and their workmates. Although spontaneous meetings are valuable for contact between employees and management, they do not replace the need for regular and planned meetings. The time and place for such meetings have to be provided by management.

The following description is of the methods of participation through representatives, based upon the OSH structure found in the legislation in a number of European countries. The

establishment of safety committees at enterprise level is one way of organising regular meetings. In many countries safety committees are common in enterprises with more than 50 employees, although there are generally no obstacles to have safety committees in smaller enterprises. In order to make an impact and to have continuity, safety committee meetings should be held at least four times a year. National laws may prescribe more frequent meetings. Safety committees normally consist of an equal number of management and workers' representatives or with a majority of workers' representatives. If safety committees are to be effective on OSH issues, an agenda for meetings has to be given to the delegates in advance. Minutes from the meetings are valuable if they include the activities agreed upon and state who is responsible for actions and the timeframe. The minutes can be communicated to all employees, or for very big enterprises, to employees at the relevant departments, through notice boards, or emails. Safety committees can make a more significant impact on OSH issues if they are given a yearly budget and have the right to take investment decisions up to a certain amount. The enterprise OSH policy is the steering document for any safety committee and the focus should be on preventive actions. It is advisable to train safety committee members if they are not already familiar with basic OSH issues.

A complement to the safety committee is safety inspections or safety rounds. They can be organised by the safety committee and may include representatives of the committee and management as well as employee representatives from the department being inspected. Direct dialogue with the employees concerned is essential during safety inspections. Safety inspections are good opportunities to find not only OSH deficiencies but also good solutions. Just

as for safety committee meetings, safety inspection reports should state what has to be done, by whom and when.

The appointment of safety delegates is adequate for small enterprises where safety committees are difficult to organise and as a complement to safety committees in larger enterprises. If they are to be efficient, safety delegates must be given training in OSH so they are able to help employees to find hazards and to discuss necessary remedial actions with management. Safety delegates are the employee representatives and are normally appointed by the employees themselves. They should not be employer representatives who relieve employers of their responsibility for OSH. Safety delegates need not only special and adequate training but also time for activities and meetings. Management also has to provide safety delegates with the necessary documents in advance, e.g. tenders, documents relating to the purchase of new equipment or technical drawings for new building construction.

All the above methods are used when there is indirect employee participation based upon safety representatives and we will now discuss how to implement direct influence.

In large enterprises it is not possible or efficient to organise meetings with all employees at the same time and in the same place. Instead the direct employee influence must be directed towards smaller units as departments or teams.

At a departmental level safety inspections can be combined with more frequent and regular meetings between middle management and employees. OSH issues can be integrated into production planning meetings if these already exist within a department. It is necessary to hold such meetings at least once a month if they are to be effective. The aim of such meetings is not only for management to inform workers but

also to create opportunities for dialogue so that workers can express their opinions and communicate important findings and ideas. OSH issues are natural elements easily integrated into the agenda of such meetings.

If a department has many employees the direct approach to participation can be strengthened by meetings of smaller groups such as work teams of five to ten persons, including supervisors. Such meetings can be organised every week or when required but they should not be lengthy.

### Creating a climate for participation

Genuine and efficient participation is not easily achieved. It takes time to overcome the suspicion which may be present. It is important to allocate sufficient resources from the very beginning of the process and to make participation sustainable in the long-term. Management must be committed to employees' participation and be prepared to express their belief in such an approach.

The resources required are calculated by judging how much time employees need for participation. Although the Japanese quality circles mostly took place outside working time and with employees unpaid for the time they spent, such an approach would be less efficient and likely to fail in many other cultures. The European legislation on workers participation in OSH activities states that it should be on paid time and preferably during normal working hours. The continuous improvement approach, is an important part in many OSHMS standards and is an activity that should take part 'continuously', i.e. during normal working time.

A good climate for improvements by participation can be achieved by starting with small OSH activities or projects that are easily understood, recognised as important by both manage-

ment and workers, and have a chance of success. Ideas used in continuous improvement can be employed, such as getting employees to identify the hazards or OSH problems in their working area. These findings can be discussed and analysed in small team meetings. The analysis can include a simple risk assessment, suggestions for different solutions and analysis of obstacles to

implement the solutions. Although not all the problems will be solved in the short-term, these meetings will create awareness and empower the employees.

A keyword in creating efficient participation is continuous encouragement from every level of the organisation.

#### Checklist on OSHMS and participation

- Is there an enterprise specific OSH policy signed by top management, communicated and understood by all employees?
- Are all OSH objectives specified, attainable, measurable, and in agreement with the policy?
- Are OSH issues (e.g. hazards, decisions, training, responsibility) documented?
- Are the persons responsible for OSH given appropriate training and resources?
- Are all employees informed and given adequate training on OSH at their workplaces?
- Is there a joint (employee and employer) safety committee ?
- Are workers represented in decision making on OSH issues?
- Are hazards identified and action to eliminate hazards taken?
- Are risks assessed and preventive actions taken before PPE is introduced?
- Are there regular meetings between workers and management at departmental level?
- Is there a genuine dialogue where workers can freely express their opinions?
- Do workers have the right to hold meetings on paid time?
- Do workers have a place where they can hold their own meetings?
- Does management encourage workers to come up with their own ideas and to report OSH hazards?
- Is there any system of rewarding good ideas on OSH or other issues?
- Are workers or their representatives informed in advance when new equipment is to be purchased or new production lines or methods introduced?
- Do workers have any influence on the layout of the workplace?
- Do workers have the right to stop production if they perceive a situation to be dangerous?

## CASE STUDIES

### **Workers' participation in creating an Occupational Safety and Health Management System in a small Brazilian car repair shop.**

This is a summary of a report written by Mr Dorival Barreiros on a project carried out in Brazil.

Although the Brazilian Occupational Health and Safety Act requires all companies, regardless of their size, to have a risk management program, the majority of small enterprises fail to meet these requirements. The majority of SMEs regard this requirement as just more paperwork. Consultants are often contracted to prepare risk management programs which are designed to satisfy labour inspectors' demands rather than to contribute to improvements in working conditions. This process usually doesn't involve workers and the resulting program is more likely to reflect the point of view of the consultant rather than the workers' perception of the risks they face.

A project was established in a small car repair shop to establish and maintain a risk management program based on encouragement for the employer and the employees to work in a cooperative way.

Firstly, when identifying an enterprise willing to accept the project objectives, it was essential to not only consider the difficulties faced by small enterprises when dealing with OHS issues but to also consider both the common and conflicting interests of employers and employees on OSH issues. The enterprise involved in the project also had to be prepared to promote the free flow of information, to compromise,



Figure 10.2.4. Psychodrama was used.

to commit to work for true participation, allow transparency in decision-making processes, respect and involve everyone. After several visits to small enterprises, a auto body repair shop in Sao Paulo agreed to conduct the project in 1999, using action research and psychodrama.

The first step was to get the employer's commitment to the program. Then the enterprise had to create a positive environment for workers' participation.

After the first visit to the enterprise, there was agreement by both the employer and employees, on the need for the project. There was also

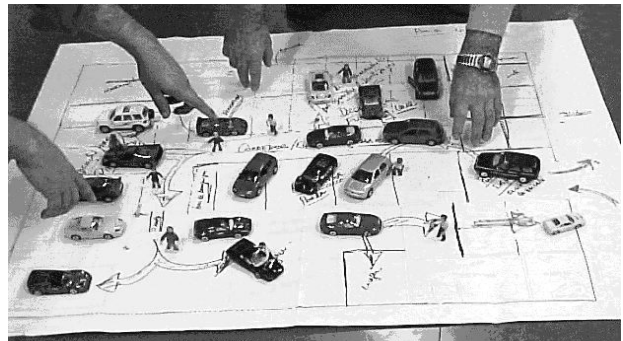


Figure 10.2.5. Models were used to visualise and discuss the layout.



agreement that the layout of the repair shop and the car body work and paint process were bottlenecks in the production process. Employees have been forced to increase their pace of work and to work overtime in order to maintain the required production level. Car body work and paint processes are not only complex tasks but also very physically and mentally demanding. Accidents related to car body work and paint process had been recorded.

Psychodrama and action research were applied depending on which method was judged to be the more appropriate to achieve the objectives. Psychodrama was used to:

- introduce the project to the workers and to make them aware of the importance of their involvement in the implementation of a risk management program;
- promote positive cooperation between workers, employers and the researchers;
- encourage each worker to reflect on the scope and importance of their job in a social, economic and technological context;
- stimulate participants to initiate an exchange of opinions, feelings and expectations with respect to the project objectives;
- create teams where each participant could get to know and understand each other better, e.g. to define their potential and limitations for developing their jobs and the importance of each job.

A psychologist was responsible for conducting the monthly psychodrama sessions (held between March and November, 1999) with both workers and researchers participating. When necessary the employer took part in these sessions. Each session lasted about 90 minutes, starting with a warm-up activity to stimulate

individual spontaneity and to obtain positive responses between the group members. Following the warm-up, group members were encouraged to display their experiences through a role-play. Finally, the group was invited to choose a way to share their feelings through writing, drawing or oral expression. A facilitator assisted the employer and the employees to identify the main hazards in their departments and supported them in their work towards effective solutions. Solutions were discussed collectively and the priorities were negotiated between employer and employees after consideration of their needs.

The following were considered to be essential elements in attaining the defined objectives of the project:

- The process must be participatory with both employees and the employer involved in most aspects of the activities. The issues addressed in the project should be generated by the employees and employer, not by the researchers;
- The process must be a cooperative one where employees, the employer and researchers must jointly contribute their expertise in a collaborative way;
- It must be a learning process for all the participants. While the researchers can assist with theory and knowledge they must also recognize the importance of the employees practical knowledge and ingenuity about identifying and devising solutions to workplace and OSH problems;
- The action research process must involve system development. The organisation must develop the competencies to analyse problems and to plan, implement and evaluate interventions;
- It must be a process which empowers the participants. Increased knowledge and partici-



pation in decision making related to OHS and the work process results in employees gaining increased influence and control over their own working situation.

A number of limitations in the work flow and the layout were identified and alternatives were proposed and discussed. The group was motivated to study alternatives to improve work flow and layout facilities in the repair shop. Other constraints were found such as poor housekeeping; congestion in areas where materials and components were stored; poor utilisation of space; excessive movement of cars waiting to be fixed; bottlenecks in work flow between car body work and paint process (more than one and half hours per day was wasted just to make enough space to keep work flowing between the two buildings). The group also identified hazards at the workplace through an inspection. It was important to have agreement on priorities because this process also contributed to the participants perception of risk. The seriousness of each situation was assessed during a brainstorming session.

The initial accomplishment of the project was the transformation of the existing layout which rationalised the use of space and made the work flow more efficient. Motivated by these results, housekeeping also became better managed. All sections were furnished with workbenches, specific places were provided to keep tools in order and a mezzanine was created to store disassembled parts.

The main hazardous situations related to the production process were identified and the associated risks were qualitatively assessed. Exposure to solvents was one of the main concerns which was partly solved by the introduction of a local exhaust system in the painting area. In addition, workers were trained to handle solvents with care and wear the appropriate PPE. Emergency

showers were introduced; chemical storage and trash disposal were improved. Health surveillance measures were planned. An ongoing maintenance program was seriously considered in the risk management program.

The manual handling of heavy and cumbersome parts were partially solved by lifting devices. The workers' awkward working positions, responsible for major ergonomic problems, remained a challenge as the solutions proposed required major financial investment.

Finally, as a result of the efforts made to establish the risk management program, it became increasingly clear that a well trained work group was very much needed. Further activities must rely upon everybody's commitment and participation in a collaborative environment.

## Sustainable OSH improvement at workplace through development of "Change Agents"

This is a summary of a report written by Dr Shyam Pingle on a project carried out in India.

The project "Sustainable OSH improvement at workplace through development of Change Agents" was carried out as an individual project in the Swedish international training programme "OSH & Development" 2002 – 2004. It was carried out in one unit of the Reliance Industries Ltd, in Jamnagar. The Reliance Group as such is the largest business house in India. It was founded by Shri Dhirubhai H Ambani and its activities span from petrochemicals, refining, textiles, oil production to marketing and retail services. The project was undertaken at the Fluidized Catalytic Cracker Plant in the Jamnagar Petrochemical Refinery, one of 16 operating plants at the site.

At the first planning stage of the project the objective was defined as, "To reduce occupational health risks in the work environment with focus on reducing risks due to exposure to heat, noise and dust".

The second step after having selected the unit of the enterprise was a presentation of the project to the senior management. During the following discussions with the management it was decided to name the project "CASH" as an acronym of Change Agents for Safety and Health. The management agreed upon setting aside a budget of USD 30 000 for equipment and training.

The third step was to identify and train Change Agents. The Change Agents were selected among supervisors. As training material the Swedish Joint Industrial Safety Council's manual "Workplace Safety and Working Conditions" was used, among other manuals. In total

the training consisted of 40 hours of lectures, discussions and workplace visits, attended by 28 participants. On the last day the of the training presentations were given by each group regarding plans of workplace improvements.

In a fourth step a baseline survey was carried out to identify and assess the OSH problems within the fields stated in the specific objectives: noise, dust and heat.

The fifth and most important part was the on the job implementation. Change agents formed project teams with participants from operations, maintenance, safety and occupational health, to identify problems and prioritize actions. Actions were taken on two fronts: imparting the knowledge to the field personnel and identify an implement engineering control measures. A road map was developed by the CASH team including action plans, training, awareness making, monthly progress review. The project leader spent at least 20 % of full time to manage the project and the CASH agents about 10 % of their working hours.

Several improvements were achieved; here just a few will be mentioned. Noise levels were reduced with up to 25 dB(A) in several areas, thus arriving to levels below the limit of 85dB(A). As an average the noise levels were reduced by 9 dB(A). The reduction was a result from several actions: insulation, relocation of machines, installation of silencer (also resulting in saving steam valued more than USD 60 000 a year!). Dust was reduced, e.g. in loading areas from 5.6 to 2 mg/m<sup>3</sup>. The profit of these actions which reduced the loss of catalyst is calculated to USD 300 000 a year. Heat exposure was reduced by 4 centigrade in certain areas by for example providing ceramic insulation heat shields. Finally the project resulted in a great increase of awareness among the working staff and increased compliance with safety rules, e.g.

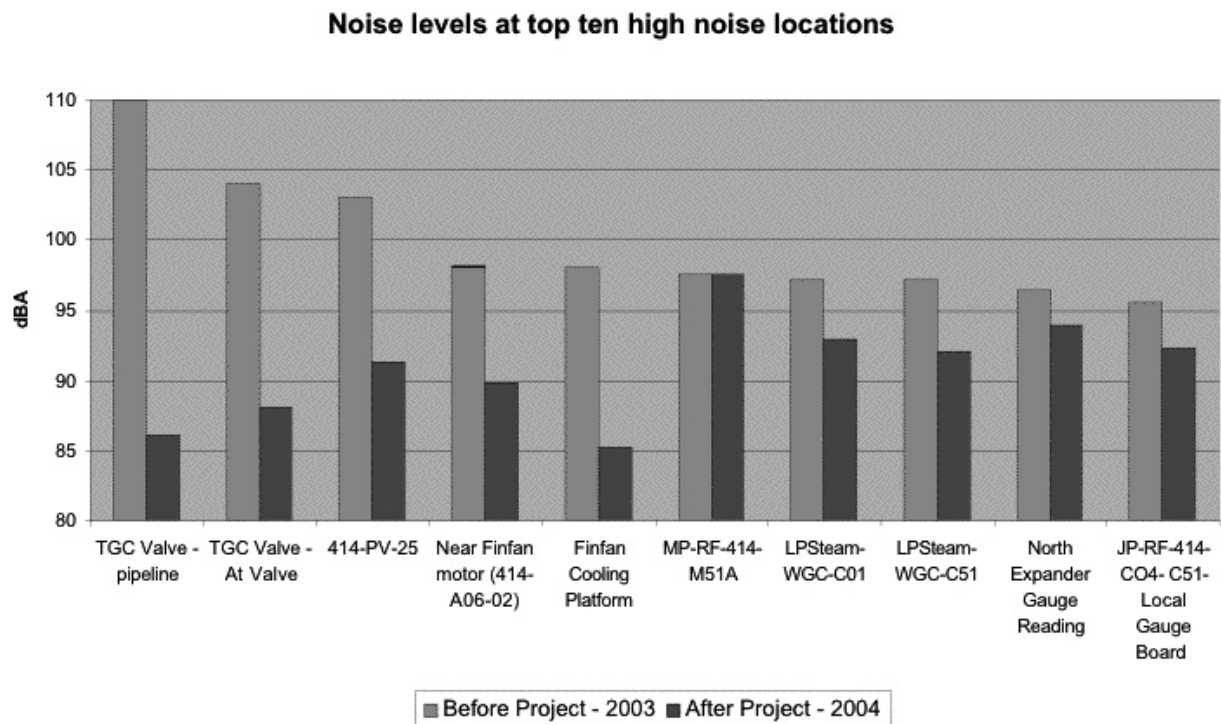


Figure 10.2.6. Noise levels before and after intervention.

use of hard hats and protective equipment when needed.

Some of the improvements were quite easy and not costly to implement. Thanks to the participation of the operators these solutions could be found. Other improvements were costly and requested support from engineers. However, as can be seen from the above also the costly improvements paid back in a very short time. The CASH project did not only result in several technical improvements but also in a “cultural change” which ensured employee and management involvement of unprecedented scale. The “doubting Thomases” who initially expected the project to be “the flavour of the month” which would fade away soon, ultimately became committed brand ambassadors for the project.

Actually the CASH project, that was initially a pilot project just in one unit of the enterprise has now spread to many other units in Reliance. Even before the pilot project was over it was extended to five other manufacturing sites in Reliance and ever since it is getting implemented at more and more new units. Success of this pilot project was followed up with more similar projects and their number has grown for the last four years indic. During 2008 there are totally about 1 200 projects for improvement of occupational safety and health within different parts of Reliance, emanating from the CASH project.

Although the support of the top management is essential, the projects as such must be decentralised and have to be run on a “local level” and by multidisciplinary teams. In doing so the processes also have a better chance to be incor-

porated in daily actions and become sustainable activities. Finally, the CASH project is a good example of how to spread information about projects and their results, and how to give the involved persons credit for their work. Actually the management has introduced a special trophy to acknowledge good OSH initiatives.

### **SUGGESTIONS FOR FURTHER READING**

<http://www.ilo.org/public/english/protection/safe-work/cops/english/download/e000013.pdf>

This link is to the complete ILO OSHMS text, which can be used for implementing OSHMS in an enterprise.

<http://www.av.se/dokument/inenglish/legislations/eng0101.pdf>

The full text of the provision of the Swedish Work Environment Authority on systematic work environment management also including recommendations on the implementation of the system.

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0655:EN:HTML>

The Council Directive 89/655/EEC of 30 November 1989 concerning the minimum safety and health requirements for the use of work equipment by workers at work.



# Occupational health services

*Kaj Elgstrand*

## THE ORIGIN OF OCCUPATIONAL HEALTH SERVICES

During the industrial revolution in Europe, many reports decried the health risks giving rise to diseases and accidents in the workplace. As a result, many large industries – such as those concerned with mining, iron and steel, chemicals, textiles, metal manufacturing, and paper and pulp – organised health services for their workers. The main aims of these industrial health services were the prevention and medical treatment of occupational injuries and diseases. In some places, full medical care was provided for workers and their families.

During the late nineteenth and early twentieth centuries, legislation to protect workers against occupational injury and disease began sporadically to be introduced. The first regulations reduced working hours for women and children. In the 1920s and 1930s, legislation was broadened to cover accidents and poisoning in the workplace. Safety devices began to be built into machines, wet drilling and local exhaust ventilation were introduced to control dust in mines, and the inhalation of gases, metal fumes and solvent vapours was reduced.

After the Second World War, occupational health factors other than accidents and acute

or chronic poisoning began to be studied, including heavy physical work, extreme thermal conditions, noise and psychosocial stress. The semi-automation of manufacturing in the 1960s and early 1970s focused concern on physically and psychologically monotonous work. Later, the emphasis shifted towards the adverse health effects of exposure to low levels of carcinogenic, mutagenic or teratogenic substances, biological and neuropsychological effects of chemicals and other problems caused by the rapid implementation of new technology, such as computers, process automatics and video display units.

In line with industrial developments, occupational health services, particularly those in the most industrialised countries, adjusted their goals to the changes in work. A concept of comprehensive occupational health emerged, dealing with all work-related factors and those related to lifestyle. The aims were now to promote the general health of workers (including their physical, mental and social well-being), to protect workers against health impairment from occupational exposure to hazards, to adjust the work to the workers and to optimise working conditions.



In the 1950s and 1970s, many European countries introduced legislation making occupational health services compulsory in workplaces. The coverage of the entire workforce in both industrial and non-industrial enterprises became a goal. In some countries, the services were based on collective agreements between employers and workers organisations. In a few countries, services remained voluntary and were left to local management and trade unions.

The concept of occupational health services was defined 1959 by ILO in a recommendation concerning *Occupational Health Services in Places of Employment*, stating among other things that the role of occupational health services should be essentially preventive (ILO recommendation no. 112). This recommendation was superseded by the *Occupational Health Service Convention* of 1985 (ILO Convention No. 161), supplemented by a recommendation in 1987 (ILO Recommendation No. 171). These documents are essential for development of occupational health services and the implementation of an occupational safety and health policy and functions at the enterprise level. They provide a comprehensive approach to the prevention of occupational accidents and diseases and also equity, accessibility and affordability. The documents include a description of occupational health service models and activities to be organised in the workplaces, as well as a multidisciplinary approach and co-operation between different occupations.

The following guidelines for occupational health services can be found in the ILO instruments:

- an advisory service
- an essentially proactive service,
- a service at enterprise level,
- a service for both employers and workers,

- a service for a safe and healthy working environment,
- consideration of both the physical-health and mental-health aspects of work. The activities of occupational health services can be grouped into five categories, depending on the objectives:
- preventive environment-oriented activities,
- preventive individual-oriented activities,
- first aid and treatment of accidental and other acute causes,
- general preventive and curative activities,
- information, education, training and advice.

The ILO instruments require the widest possible coverage of services in order to provide access to occupational safety services for all workers in all branches of economic activity and in all undertakings, including the public sector and co-operatives, and also for the self-employed, that is for all participants in working life. This principle requires flexibility of the models for provision of services in order to meet the varying needs of undertakings of different sizes, different types of industry and work, and to enable implementation in countries with widely varying societal and administrative systems.

WHO's occupational health strategy accords with the ILO's. Since *the Alma-Ata Declaration* of 1978, the WHO occupational health strategy has been closely bound up with its global strategy for health for all. Many of WHO's essential elements of primary health care have features in common with the ILO list of functions of occupational health services.

## ORGANISATION OF OCCUPATIONAL HEALTH SERVICES

Occupational health services (OHS) may be organised in many different forms. In the following a number of such forms are summarised. The examples given represent a potpourri intended to give an idea of the many different forms that are applied in different countries.

- In big enterprises with thousands of workers and production entailing many occupational safety and health risks, occupational health services may be organised as an “in-built” service. A unit of such services may include a number of full-time employees: one or two occupational health physicians, two or three occupational health nurses, one occupational physiotherapist, one safety and hygiene engineer or an occupational hygienist. In some enterprises the technical personnel are not part of the occupational health service unit but belong to another part of the enterprise.
- If the enterprise is smaller (e.g. 800-1500 employees) but its production entails many occupational safety and health risks, occupational health services may be organised as an in-built service but with less personnel: one half-time or full-time physician, one occupational health nurse, etc
- Small enterprises cannot employ their own occupational health service personnel. A number of such enterprises in one and the same area may jointly employ occupational health service personnel through a special OHS centre. The enterprises belonging to an OHS centre may be private, municipal and/or state owned. This model has been successfully applied, for example, in Sweden, but due to changing conditions for the small enterprises and economic constraints, the OHS centre model is less common today than twenty years ago.
- Specialised occupational health services may be organised for special sectors like construction, forestry or agriculture. Such services may be of the OHS centre model, serving enterprises in a local area, or bigger, nationwide organisations.
- The OHS centre model may be established, not based upon initiatives by the enterprises concerned, but as an independent enterprise seeking occupational health service customers among small, middle sized or big enterprises in a region.
- It is not uncommon for a small enterprise (e.g. in mining and manufacturing) to employ a full-time occupational health nurse and contract an occupational health physician part-time (for, say, two hours per week or one day per week) to guide the work of the nurse, and take care of more complicated medical issues.
- In total, more than 90% of employees in Finland have access to occupational health services. (For small enterprises with up to ten employees, in practice only 65% of the employees have access to occupational health services, although access is obligatory according to Finnish law). There are more than thousand occupational health service units in the country, of which one in three is an OHS centre, one in three an in-built unit and one in four a private OHS provider.
- Big multinational corporations with well-developed internal internet communication (intranet) have a forceful tool for programming and following up activities to ensure occupational safety and health for their employees. Such communication may also include detailed standards and training materials, accessible at the corporation’s worksites all over the world.

- Private insurance companies, *mutuales*, have long played an important role in Chile, guiding the occupational health services in the member enterprises. *Asociación Chilena de Seguridad (ACHS)*, the biggest of the Chilean *mutuales*, has its own hospitals for employees of member enterprises and their families, an occupational hygiene laboratory, a department for preventive medicine, and an extensive information and training programme in occupational safety and health. Other countries like Argentina and Colombia have established systems inspired by the Chilean *mutuales*.
- *The Tanzanian Occupational Health Services (TOHS)* is a non-governmental organisation jointly established in the late 1960s by the government and the ILO. TOHS is a non profit association. Although TOHS started voluntarily with six member companies in Dar es Salaam, it has swollen to tens of companies with upcountry branches serving the health needs of industrial workers, their dependants and the general public.
- The WHO Alma-Ata Declaration (1978) put high priority on the organisation of primary health care services for large populations. Many attempts have been made to establish occupational health services through primary health, some successful others not. Such an approach would seem logical, e.g. in Southern Africa, considering the scarcity of occupational health specialists in these countries. On the other hand, primary health in this region is heavily burdened with tasks related to HIV/AIDS, tuberculosis, malaria, dengue and other infectious diseases.

It is small enterprises that have most difficulty in providing occupational health services. In all countries of the world, access to occupational

health services is lower in small enterprises and higher in big ones. The sheer number of small enterprises is a problem in itself. Reaching all of them takes a lot of resources. Establishing contacts, paying visits and evaluating the need for occupational health services takes a lot of time. The economic outcome is uncertain. The situation becomes even more difficult when it comes to organising occupational health services for self-employed and for those active in the informal economy.

There are numerous reasons for the many different organisational forms of services. In some countries occupational health services are prescribed by legislation, in other countries occupational health services are based upon agreements between the social partners. In some countries, the ILO Convention on Occupational Health Services plays an important role for the organisation of occupational health services. In other countries there are no regulations or norms guiding the organisation of services. The size of enterprises and the character of production and risks for occupational accidents and diseases greatly influence the way in which occupational health services are organised. The sources of financing are decisive; in some countries, occupational health services in private enterprises are also subsidised out of public revenue, while in other countries the funding is strictly commercial.

The key issue is not the organisational form of occupational health services but the availability and functionality of the system, so that the safety and health needs of the employees at every workplace are adequately addressed. The form, however, is crucial for the availability of the services and the possibilities of addressing safety and health needs.

## PREVENTION VERSUS HEALTH CARE

Occupational health services include three kinds of medical activities: prevention of injuries and diseases, curative health care and rehabilitation. A fourth may be added: health promotion. In theory, if the prevention of injuries and diseases were fully successful, the other activities would not be needed.

The content of prevention versus curative health care in occupational health services is a longstanding topic of discussion. Should the services include also curative health care or should they be merely preventive? These discussions have produced different results in different countries (and also changed over time in some countries). There are countries where occupational health services are strictly preventive, while in others both the curative and preventive parts are included. Nor is it unusual for activities called occupational health services to contain only curative health care and no prevention.

International documents and statements, like the ILO conventions and recommendations and the WHO resolutions, are clear in this respect: occupational health services are essentially preventive but may also include curative health care. There are several reasons for including curative health care in occupational health services. Everyone will agree concerning the relevance of having facilities for first aid and treatment of accidental and other acute causes within or close to the workplace. Employers, managers and workers tend to value the possibility of injuries and uncomplicated diseases being treated directly in the workplace, instead of causing time-consuming travel to primary health care facilities far away from the workplace. OHS professionals may consider curative health care to be a necessary opening to the possibilities of preventing occupational accidents and diseases. When you

meet a worker as a patient, you have also reason to investigate his or her workplace and working conditions and reflect on what should be changed. On the other hand, curative health care may be too time-consuming, not allowing enough time for preventive work. It may not be easy for OHS personnel to refuse to carry out general health examinations if the workers, the trade union and the employer would like them to be carried out. Among OHS personnel, health examinations directed to specific health risks are considered much more meaningful than such general health examinations.

## TO WHAT EXTENT DO OCCUPATIONAL HEALTH SERVICES EXIST?

Other parts of this chapter deal with what occupational health services are supposed to be. This part is a critique of the existence of occupational health services.

In many developing countries, workers have never heard of, still less had any experience of occupational health services. In other developing countries, such services may exist within big companies, or in a few cases as nationwide service organisations financed by public and private means. In general, however, very few workers in developing countries have access to organised occupational health services. What is the situation in the industrialised countries; do occupational health services really exist there?

In addressing this question, let us focus on Europe. Two good reasons can be given for this. One is that Europe is supposed to be the most developed region in the world in terms of OHS, so we could expect a positive answer to the question. Another is that an extensive *Survey of the Quality and Effectiveness of Occupational Health Services in the European Union and Norway and Switzerland* was jointly published in 2001 by the Finnish Institute of Occupational Health and the

Swedish National Institute for Working Life. That survey included the 17 richest countries in Europe, so the report should help to answer our question related to the part of the world where occupational health services are most developed.

We need some criteria for “the existence” of OHS. The following three criteria will be used:

1. Workers should have access to the OHS; therefore the OSH coverage of a nation’s workforce will be our first criterion.
2. The focus on preventive action at workplaces to many is the most important qualitative criteria of OHS; therefore this will be our second criterion.
3. OHS personnel clearly need a certain professional competence for their tasks; this competence depends, among other things, on which professionals are employed within the OHS and on the special training they have received in OHS issues; this is our third criterion.

### OHS coverage

The normal way of describing OHS coverage is in terms of the percentage of a nation’s workforce having access to an organised OHS. Eight of the 17 countries were able to give a quantified answer. Five countries seem to have very good coverage: in France 100% of the employees are covered by organised OHS. Seven countries – among them the big countries of Germany, Italy, Spain and the United Kingdom – have poor OHS coverage or either stated that the coverage was not known or gave answers which are impossible to understand. In four of the five countries with big populations (40 million or more), OHS coverage is poor, non-existent or unknown.

The information about the OHS coverage in Germany, the European country having the largest population, is very vague. OHS “laws

and regulations are in place”, but coverage “varies from low to very good” and/or “should be higher”. According to the trade unions there are no data available on OHS coverage.

Based upon the above figures and the size of the working populations in the different countries, it can be estimated that one-third of employees in these countries have access to an organised OHS. As an overall measure this is a surprisingly and disappointingly low coverage. A great majority of the workers in Europe’s richest countries do not have access to organised OHS.

It should be noted that OHS coverage is not always the same as having access to occupational health services. In some countries, coverage is considered 100% if the legislation requires employers to provide occupational health services. So there may be countries where the coverage is 100%, at the same time as only 30 or 40% of the workers in those selfsame countries have access to occupational health services in practice.

### Focus on prevention

The focus on preventive action at workplaces cannot be quantified from the responses to the survey. A few countries report that all or most occupational health service activities are preventive. Most countries say that occupational health services “should focus more on primary prevention” or that prevention “should be strengthened”. A few countries report that there are no preventive activities.

In summary, the following is said based upon the survey:

“In general, OHS focus on prevention, mainly with respect to safety, personal protection and work environment issues at workplaces. Prevention largely means also prevention of diseases, injuries and the promotion of health. The methods and concepts of preventive activities vary according to the country, time of training of professionals, tradition and the re-



quirements of legislation and practices. Such new fields as work organisation, absenteeism and profit from prevention are also being used as arguments for or against preventive activities. Employers expect to get immediate benefits from prevention, whereas professionals see their work as long-term activity to improve the quality of life and work.”

### Professional competence

The competence requirements vary a great deal from one country to another. Professional competence is considered high in some countries (Belgium, Denmark, France, Norway, the UK). Needs for increased competence are expressed by many countries (Austria, Finland, Germany, Italy, the Netherlands, Spain, Sweden).

Surprisingly, only a few countries have mentioned competence related to manpower planning. How many OHS specialists are needed in the country? How many are employed? How many of those employed fulfil the competence requirements? Some countries (Germany, Greece, France and Ireland) mention a shortage of OHS personnel. A few countries give details.

### Back to the original question

Do occupational health services really exist in industrialised countries? Yes, they do, but only for a small portion of the working population in the 17 richest countries of Europe. The content of “preventive action at workplaces” is difficult to describe and define; it seems to differ greatly from country to country. Competence requirements for OHS specialists also differ greatly from country to country; there is a general shortage of OSH specialists meeting these requirements. Preventive actions at workplaces should be re-defined and re-established as the main content of occupational health services. Specialist training of OHS personnel should nationally and internationally be the main tool

for re-defining and further developing occupational health services. As for the quality of the training, the focus should be on preventive action in the workplace. As for the quantity of the training, national manpower planning should be employed.

The above figures concerning OHS coverage and access, and concerning specialists employed and fulfilling competence requirements, date from 2001, and the conclusions drawn here are based on those figures. There is reason to believe that the situation concerning occupational health services in these European countries has remained more or less the same during the last ten years.

### BASIC OCCUPATIONAL HEALTH SERVICES

Since 2003, the ILO, WHO and ICOH have engaged in the development of what are called *Basic occupational health services (BOHS)*, intended to create more realistic criteria and methods for developing occupational health services also in developing countries. The ultimate objective of the BOHS initiative is to provide occupational health services for all working people in the world, regardless of the sector of economy, mode of employment, size of workplace or geographical location, i.e. according the principle of universal service provision. According to BOHS, a stepwise strategy is recommended for the development of a sustainable infrastructure for occupational health services:

#### *Stage I: Starting level*

For workers and workplaces not having any occupational health services at all, “field OHS workers (if possible, a nurse and safety agent)” should be utilised. They may have had brief training in OHS and work for a primary health care unit. The content of services focuses on most important and severe health hazards and on their prevention and control.



*Stage II: Basic Occupational Health Services (BOHS)*

An infrastructure-based service working as close as possible to the workplaces and communities. The service provision model may vary, depending on local circumstances and needs. The personnel (usually a physician and a nurse) have undergone brief special training in occupational health.

*Stage III: International Standard Services*

The minimum objective for each country as stipulated by the ILO Convention No. 161. The service infrastructure has several optional forms and the content is primarily preventive, although also curative services may be provided. The service staff should be led by a specially trained expert (usually a specialist occupational health physician) and the team should preferably be multidisciplinary.

*Stage IV: Comprehensive Occupational Health Services*

This level is usually found in the big companies of industrialised countries or it may be provided by large OHS centres. The staff work as a multidisciplinary team including several specialists such as an occupational health physician, an occupational health nurse, an occupational hygienist, an ergono-

mist, a psychologist, a safety engineer, etc. The content of services is comprehensive covering all aspects of occupational health.

The two first stages (I and II) are designed for the smallest and micro-enterprises, the self-employed and the people employed within the informal economy.

Under the leadership of Jorma Rantanen, a pilot project was initiated in 2004 to establish Basic Occupational Health Services in China. The project is proceeding in collaboration with Chinese authorities, WHO, the ILO and ICOH.

It is not easy to estimate the quantitative need for OHS personnel in BOHS, as the structures of constituents and their needs may vary widely. According to the BOHS document, an experience-based estimate speaks for a minimum need of one physician and two nurses per 5 000 workers with a great deal of variation depending on the branch of industry and size of workplaces, as well as on their geographical distribution. If this criterion was to be applied to the world working population of 3 billion people, 600 000 occupational health physicians would be needed and 1 200 000 occupational health nurses. These figures are far, far beyond the current numbers of existing OHS personnel.

## SUGGESTIONS FOR FURTHER READING

ILO Convention No. 161 on Occupational Health Services, 1985.

ILO Recommendation No. 171 on Occupational Health Services, 1987.

These documents contain essential information for development of occupational health services and the implementation of an occupational safety and health policy and functions at the enterprise level. By April 2009, Convention No. 161 had been ratified by 28 countries.

Menckel, E & P Westerholm (eds.). *Evaluation in Occupational Health Practice*. Butterworth Heinemann, 1999.

A number of articles on evaluation of occupational health services; general principles and methods, quality aspects, ethics, economic appraisal, etc.

Lehtinen, S, K Räsänen, K Husman & J Rantanen (eds.). *Survey of the Quality and Effectiveness of Occupational Health Services in the European Union and Norway and Switzerland. People and Work Research reports 45*, Finnish Institute of Occupational Health, Helsinki 2001, in collaboration with the Swedish National Institute of Working Life.

An extensive report from an extensive survey concerning occupational health services in 17 European countries, summarizing overall impact of OHS, coverage and access, focus on preventive actions, effects on health and workability, cost effectiveness, professional competence, and more issues.

Lehtinen, S (ed.). *Challenges to occupational health services in the Regions. Proceedings of a WHO/ICOH/ILO Workshop in January 2005*, Helsinki 2005.

Reports on the current state of occupational health services in a number of developing and industrial countries.

*Basic Occupational Health Services*. 3rd revised edition, Helsinki September 2007.

This basic guideline has been written by Jorma Rantanen and published by the Finnish Institute of Occupational Health, as a response to the Joint ILO/WHO Committee on Occupational Health priority area for ILO/WHO/ICOH collaboration. It can be accessed through the Occupational Health part of the WHO website.



# National planning of OSH

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# Role of social partners

*Petra Herzfeld Olsson & Kerstin Ahlberg*

## INTRODUCTION

The importance of trade union and employer involvement in occupational safety and health (OSH) work is emphasised by international organisations such as the International Labour Organisation (ILO) and the World Health Organisation (WHO). The role of the social partners at *national* level is emphasised within the ILO's legal framework. It prescribes that the social partners should be consulted when national occupational safety and health policy is formulated and when implementation of any ILO conventions on occupational safety and health is being enacted.

The International Labour Organization has adopted several conventions and recommendations on occupational health and safety, considered to be international minimum standards. The role of the social partners is mentioned in many of these standards and is the major focus of this chapter.

While the chapter focuses on collaboration at national level, it should be noted that the social partners also play an important role in occupational health and safety at international and enterprise level.

Occupational health and safety at the *enterprise* level is covered in other chapters of this

book, however, the role of the trade unions is not discussed in detail. The ILO conventions do not give any explicit or prominent role to trade unions at enterprise level – it is the workers and their representatives who are guaranteed certain rights connected to work on occupational health and safety at the workplace. A workers' representative is a person, recognised according to national law, irrespective of whether they are a trade union representative or a representative elected by workers not affiliated to trade unions. In other words, representatives with or without trade union affiliation can be recognised.

This solution has mainly arisen because while many enterprises lack trade union representatives, it must still be possible to involve employees in work on occupational safety and health. However, in many countries trade unions are the representative bodies responsible for these issues, e.g. in Sweden, local trade unions elect the workers' safety delegate and workers' representatives in health and safety committees. In the UK trade unions appoint the workers' safety delegates.

The existence of trade unions is also implied – and sometimes mentioned explicitly – in some ILO regulations related to work on occupational



safety and health at work places. Trade union representatives often have better possibilities and resources to pursue workers' rights so the importance of involving trade unions in OSH work at workplace level is emphasised in the international arena.

The ILO involves the social partners (workers' and employers' associations) together with government representatives, in the development and adoption of labour standards on occupational health and safety at *international* level.

Trade unions and employers associations play an important role in the development and implementation of occupational safety and health issues at national level as they contribute valuable knowledge and experience of the working environment and working life. To fulfil this role, it is of crucial importance that associations are truly representative and independent. Consultations must take place under conditions which give representative associations an opportunity to express their opinions in total freedom and independence. That can only be guaranteed through full respect for freedom of association and consequently full respect for the principles embodied in ILO Convention No 87 Freedom of Association and Protection of the Rights to Organise (1948) and in ILO Convention No 98 Right to Organise and Collective Bargaining (1949). (These international minimum standards concerning freedom of association will be dealt with in depth in this chapter.)

In addition to the ILO legal framework, there are a number of other institutions and international bodies that aim to improve occupational safety and health. Within the UN system the World Health Organisation (WHO), the UN Environment Programme (UNEP) and the International Atomic Energy Agency (IAEA) can be mentioned. Beyond the UN system there are also a number of international bodies active in

occupational health including the International Organization for Standardization (ISO), the International Social Security Association (ISSA), international trade union secretariats (ITSS) and the OECD. This chapter analyses the "OECD Guidelines for Multinational Enterprises", an international tool intended to assist workers' and employers' involvement in OSH work at national level. The social partners are given a prominent role in the implementation of these guidelines.

The chapter is organised to firstly present relevant provisions on the right to freedom of association followed by explanation of the meaning of the ILO norms concerning the roles of the social partners in national work on occupational safety and health. The OECD guidelines are then described. The chapter ends with a section on ways in which the ILO standards on health and safety can be implemented at national level, using two examples from Latvia and Tanzania to give insight into how principles can be practically implemented.

### **THE RIGHT TO ORGANISE — A HUMAN RIGHT**

The right for workers and employers to associate, in order to protect and promote their occupational interests, is recognised as a human right in a number of regional and international human rights instruments. The basis of the human right protection is the UN Declaration on Human Rights and the UN Covenants on Human Rights. However, the UN has delegated labour related issues to the ILO and it is mainly within the ILO context that the meaning of the freedom of association as a human right has been developed. Two principal ILO conventions deal specifically with the freedom of association, Convention No 87 on Freedom of Association and Protection of the Rights to Organise (1948) and Convention No 98 on the Right to Organise

and Collective Bargaining (1949). The Committee of Experts and the Freedom of Association Committee investigate whether the ILO member states apply the ILO norms correctly and publish their conclusions in reports. These reports more fully develop the meaning and significance of freedom of association. Taking the ILO norms as a starting point for analysis of the meaning of workers' and employers' freedom of association, this chapter concentrates on issues of specific importance required for effective work on occupational safety and health.

### **The right of workers and employers to freely join and establish associations of their own choosing**

According to article 2 in ILO Convention No 87, every worker and employer has the right to join and establish trade unions and employers' associations without previous authorisation and without distinction in both the public and private sector. Without distinction means that this right should be guaranteed without discrimination of any kind based on occupation, sex, colour, race, beliefs, nationality, political opinion, etc. This provision deals with the relationship between an individual and the state so consequently the state is forbidden to interfere in this right.

The right of workers and employers to establish and join associations of their own choosing includes a freedom from legislative demands that influence which association the worker or employer should join. Trade union monopolies, imposed by law, are not compatible with freedom of association, however, there is nothing that prevents voluntary groupings of workers or unions into a monopoly to strengthen their bargaining position.

Workers should also be able to establish new trade unions at all levels including the enterprise

level. Indirect restrictions, such as requirements that more than 50 per cent of the workers in a unit become members, are unacceptable as the effect of such a provision is that only one trade union can be established in that unit.

Workers and employers must also be free to establish associations and set the associations' rules and constitutions without previous authorisation or approval from any public authority or third party. This freedom must be guaranteed both in law and in fact, however, simple formal requirements could be acceptable, e.g., to have a registered office, registration of the association, deposition of its by-laws to make them public, and details of its constituent meeting. An eventual registration process may not be so long and complicated that it constitutes an obstacle which in practice prohibits the establishment of a trade union.

If an administrative authority is required to approve any aspect of an association, the association must be able to appeal the decision to a court which is supposed to eliminate the discretionary element involved in the process, provided the legal ground for the judicial decision is acceptable.

Both public authorities and private third parties must be prohibited from interfering with the freedom of workers to join and establish associations; this is particularly relevant to the relationship between workers and employers. The protection offered to workers and trade union officials against acts of anti-union discrimination is an essential part of freedom of association, (outlined in article 1 of Convention No 98) and must be applied during recruitment and employment, including when work is terminated. All acts which prejudice a worker because of union membership or participation in union activities are forbidden. Examples of discriminatory acts are transfer, relocation, demotion, deprivation

or restrictions of all kinds (remuneration, social benefits, vocational training) and of course, as earlier mentioned, dismissal.

Workers' and employers' associations must also be protected against any acts of interference by each other or each other's agents or members according to article 2 ILO Convention No 98. General legal provisions that prohibit acts of anti union discrimination must be accompanied by effective and rapid procedures to ensure their application in practice. Such protection may be adapted to national legislation and practice, provided they prevent or effectively redress anti-union discrimination.

### **Freedom and autonomy for associations of workers and employers**

The consultative function of workers' and employers' associations on occupational safety and health issues, can only add quality to the decision making process if the associations are free to act and express their opinions according to their members wishes and objectives. The autonomy of associations must be guaranteed.

Freedom of expression is implicit in the individual right to freedom of association. Any individual WHO chooses to join a trade union is using their freedom to express an opinion. A trade union also bears that right which must be guaranteed if an association is to work meaningfully on occupational safety and health issues.

Another important aspect of autonomy is the right of the members of associations to elect their representatives in full freedom. Public authorities should refrain from interference which might restrict the exercise of this right, e.g., interference in trade union elections or interference on conditions of eligibility or the re-election or removal of representatives. However, interference to enhance the democratic element of the elections can be acceptable. A removal or

suspension of a trade union officer must be the result of an internal decision of the trade union, a vote by members or normal judicial proceedings.

Workers' and employers' associations must be guaranteed the right to organise their activities in full freedom and to formulate their programmes in order to defend the occupational interests of their members, including the right of trade unions to hold meetings and for their officers to have access to places of work and to communicate with management. Associations must also be free to organise their administration and activities to ensure financial independence and protection of their assets and property. Other rights include the right to certain political activities, the right to strike and the right to collective bargaining.

Legislative provisions which regulate the internal functioning of organisations are only acceptable if they simply establish an overall framework in which the greatest possible autonomy is left to the organisations. Restrictions should have the sole objective of protecting the interests of members and guaranteeing the democratic functioning of organisations. It must be possible to appeal decisions on such restrictions to impartial and independent judicial bodies.

A dissolution or a suspension of an organisation by an administrative authority is one of the most extreme forms of interference. Accordingly, article 4 of Convention No 87 states that trade unions and employers' organisations may not be dissolved or suspended by administrative authority. It may only be possible for an administrative authority to suspend or dissolve an association if it is seeking to undermine the internal or external security of the state, however, such measures must include guarantees against arbitrary decisions. Associations affected by such measures must have the right of appeal

to an independent and impartial judicial body competent to examine the substance of the case, to study the grounds for the administrative measure and, where appropriate, to rescind such a measure.

### **The right to establish federations and confederations**

Workers' and employers' associations often join or establish higher level organisations to coordinate and strengthen their efforts. Such associations often have a broad occupational, inter-occupational or geographical coverage. Article 5 of Convention No 87 gives workers' and employers' associations the right to establish and join federations and confederations and for these associations to affiliate with international associations without intervention from public authorities. All these rights also apply to federations and confederations.

### **STANDARDS IN OCCUPATIONAL SAFETY AND HEALTH**

A number of ILO Conventions (and their associated recommendations) deal specifically with occupational safety and health, e.g. Convention No 155, the Occupational Safety and Health Convention. These conventions identify two principal roles for the social partners at the national level. Firstly, there must be consultation with the most representative associations of employers and workers on any measures which implement the conventions. Secondly, each member state should formulate, implement and periodically review a coherent national policy on occupational safety, occupational health and the working environment, in cooperation with the most representative associations of workers and employers.

Representative worker and employer associations also perform other functions. For example,

Convention No 148 on Air Pollution, Noise and Vibration directs that these associations can designate technically competent persons to give their opinion on issues such as the hazards of exposure or exposure limits. The most recently adopted Convention, No 184 on Safety and Health in Agriculture, 2001, explicitly recognises collective agreements as a means for securing workers their rights in occupational safety and health matters.

Two key concepts in these ILO Conventions are "most representative organisation" and "consultation".

### **The most representative association**

The term "most representative organisation" indicates that only some associations of workers and employers have the right to be consulted, selected on objective, pre-established and precise criteria so as to avoid any possibility of bias or abuse. These criteria should be set by law, not left to the discretion of the government, but the criteria should not become so excessively difficult that an organisation is unable to meet them. The law must also offer associations the opportunity to demonstrate how representative they are and to challenge the position of "most representative". A commonly accepted criteria, advocated by the ILO Committee of Freedom of Association, is that the most representative associations are those that represent a majority of the workers or employers. Other less quantifiable criteria can be accepted if they are sufficiently detailed and objectively based, e.g. an organisation may be deemed to be represented if it is independent, experienced and well established.

There are no provisions on how many representatives must be consulted and it may be reasonable to involve more than one representative from each side on occasions. If there are two or more associations of employers or workers,

they may all be considered to be “most representative associations”, even if one organisation is larger than the others, based on the principle that they represent a significant body of opinion.

When the kind of tripartite consultation that the conventions prescribe takes place, it is of fundamental importance that the employers’ and workers’ representatives take part on equal terms. This doesn’t refer to a strictly numerical equality but to the substantially equal representation of the respective interests of employers, and of workers so that their views are given equal weight.

### **The meaning of consultation**

The meaning of the term “consultation” within the ILO context has mainly been developed as a general concept, not specific to the occupational safety and health area, however, these general standards are also applicable to consultation on occupational safety and health issues.

ILO Recommendation No 113 on Consultation (National and Industrial Level) prescribes that consultations at the national and industrial level should have the general objective of promoting mutual understanding and good relations between public authorities and employers’ and workers’ associations, as well as between these associations with a view to develop the economy, to improve conditions of work and to raise standards of living. Consultation at the national level should aim to ensure that the competent public authorities seek the views, advice and assistance of employers’ and workers’ associations in an appropriate manner on such matters as the preparation and implementation of laws and regulations affecting their interests; the establishment and functioning of national bodies responsible for the organisation of industrial health and safety and the elaboration and

implementation of plans for economic and social development.

The term consultation should be distinguished from other related activities such as “information sharing”, “co-determination” and “negotiation”. Negotiation implies initiatives taken by parties with differing or competing interests with a view to reaching an agreement. The consultations required under the terms of the ILO provisions are intended to assist the competent authority in taking a decision rather than leading to an agreement.

Meaningful consultations should be undertaken in good faith and given serious consideration by the competent authority even though they are not bound to accept opinions expressed during consultations. Public authorities remain entirely responsible for the final decision and are not required to justify a refusal but it is of course possible that the consultation procedure may set the objective of reaching a consensus between the various parties while respecting their autonomy.

Consultations must take place before final decisions are taken, irrespective of the nature or form of the procedures adopted. Consultation can mean either submitting the government’s proposed decision to employers’ and workers’ representatives or asking those representatives to help formulate the proposal by communication or discussions within tripartite bodies. The important factor is that the parties are consulted for their opinions before the competent authority takes its final decision.

The following example illustrates an acceptable method of consultation. When the government of the Czech Republic was drafting a new law on occupational safety and health, they reported to the ILO that the trade unions’ and employers’ associations had expressed views and that their proposals were being discussed in a

new round of negotiations concerning the drafting of the new law. The ILO was satisfied with this information.

If consultations are to be practical and effective, employers' and workers' representatives must have all the necessary information and sufficient time to formulate their opinions. Communication after the final decision has been made does not meet the obligation to ensure effective consultations. In many of the relevant provisions the term "in consultation" is used instead of the term "after consultation". This wording indicates that there may be several levels of consultation at various stages in the procedure established to give effect to the provisions of the Conventions and that the associations should be actively involved in the processes of decision making and implementation.

Governments should endeavour to secure an agreement of all the associations concerned in establishing the consultative procedures but if this is not possible a government may decide as a last resort.

### **The content of national policies**

As mentioned earlier, the ILO Conventions on occupational safety and health require consultations to take place when states formulate, implement and periodically review national policy on occupational safety, occupational health and the working environment which includes activities such as occupational health services or safety and health in mines or agriculture. The connected recommendation prescribes close co-operation between public authorities and representative employers' and workers' associations when national policy on occupational safety and health is formulated and applied.

National policies on occupational safety and health in the ILO context refer to both general and specific matters, e.g. air pollution. The aim

of a national policy is the prevention of accidents and injuries at work, by minimising, so far as reasonably practicable, the causes of hazards inherent in the working environment. Such policy should take account of some of the main factors which affect occupational safety and health and the working environment. These factors include:

- a. the design, testing, choice, substitution, installation, arrangement, use and maintenance of the material elements of work. The material elements include workplaces, working environment, tools, machinery and equipment, chemical, physical and biological substances and agents, work processes;
- b. the relationship between the material elements of work and the persons WHO carry out or supervise the work; the adaptation of machinery, equipment, working time, organisation of work and work processes to the physical and mental capacities of the workers;
- c. the training, including additional training when necessary, qualifications and motivation of the people involved in the achievement of adequate levels of safety and health;
- d. the communication and co-operation at all levels of an enterprise, including at the national level;
- e. the protection of workers and their representatives from disciplinary measures resulting from actions properly taken by them in conformity with the policy.

National OSH policy should also indicate the respective functions and responsibilities of public authorities, employers, workers and others, taking account of both the complementary character of such responsibilities and national conditions and practice.

The social partners should also be consulted on the implementation of national OSH policy, through laws, regulations or any other method



consistent with national conditions and practice necessary to progressively implement and monitor such policy. Recommendation No 164 stresses the importance of close co-operation between public authorities and representative employers' and workers' associations for both the formulation and application of the national policy, beyond what is required by the consultation provisions in Convention No 155.

### THE OECD GUIDELINES FOR MULTINATIONAL ENTERPRISES

The "Guidelines for Multinational Enterprises" (the Guidelines) adopted by the Organisation for Economic Co-operation and Development (OECD) also give trade unions and employers' organisations an important role in the endeavour to secure a safe and healthy work environment. The Guidelines, first issued in 1976 and regularly updated since then, are non-binding standards and principles of responsible business conduct addressed by the governments to multinational enterprises with a seat in any of the thirty OECD countries. In addition, by January 2006 the governments of nine non-member states – Argentina, Brazil, Chile, Estonia, Israel, Latvia, Lithuania, Romania and Slovenia – have voluntarily acceded to the guidelines. Since the year 2000, the Guidelines also apply when multinational companies of all these countries invest in states that are not members of the OECD, i.e. in most developing countries.

The Guidelines cover a broad range of issues, such as human rights, disclosure of information, employment and industrial relations, environment, anti-corruption measures, consumer protection, science and technology, competition and taxation. They are not a substitute for national law and regulation, but supplementary principles and standards of behaviour of a non-

legal character. The section on employment and industrial relations is based on the eight core ILO conventions and the ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy of 1977, which means that it includes all core labour standards, but also that its scope goes beyond that. Thus, multinationals must respect the freedom of association, recognise the right to bargain collectively, prohibit all kinds of forced labour (including child labour) and abolish all kinds of discrimination in employment. The Guidelines also cover information and consultation of employees, training and health and safety at the workplace. For example, enterprises are encouraged to raise the level of performance with respect to occupational health and safety in all parts of their operation, even where this may not be formally required by existing regulations in countries where they operate.

Observance of the Guidelines by enterprises is voluntary and not legally enforceable. However, there is a mechanism for exerting pressure on companies that do not respect them, as the governments of the adhering countries have a responsibility to promote the Guidelines and encourage their use. This is done through a system of National Contact Points that handle enquiries and resolve issues relating to the implementation of the Guidelines. In most countries the Contact Point is a government office, in others it is a tripartite body where the government, trade unions and employers' organisations are represented. There are even a couple of quadripartite national contact points, where other non-governmental organisations are represented in addition to the organisations for workers and employers.

Unlike the ILO system, the Guidelines allow trade unions and employers' organisations at national level in one country to help workers in

another country when their employer circumvents ILO core labour standards. For example, if a Swedish company operating an enterprise in a developing country does not respect the Guidelines, the trade union in that country can call the attention of a National Contact Point. If that country itself has not adhered to the Guidelines, the natural thing to do will be to turn to the Swedish Contact Point, which will investigate the matter. If it finds the complaint well founded, it will contact the Swedish company management and ask it to instruct the local management to respect the Guidelines. If this does not have the desired effect, the Swedish Government will intervene.

The effectiveness of the complaint procedure is highly dependent on the individual government's commitment, and there has been criticism that National Contact Points are too passive and that the procedures take too long. However, there are cases where it has been effective as multinationals fear the loss of goodwill caused by negative publicity more than the threat of legal action.

There are also cases where trade unions have contacted the company management directly and managed to influence it simply by referring to the Guidelines, without having to bring the matter before a National Contact Point. One example happened in the year 2000, when the Swedish Metal Workers' Union and the Swedish Union of White-collar Workers in Industry received a call for assistance from the Electrical Industry Workers' Union (EIWU) in Malaysia. EIWU organised workers in a factory, owned by a Swedish multinational company, where EIWU had collective agreements for its members. The local management wanted to have the company classified as belonging to the electronics industry, which would have the effect of depriving the workers the right to be represented by EIWU.

According to the Malaysian legislation regulating trade unions' activities, workers in the electronics industry could not decide by themselves to which union they might belong. The Swedish trade unions contacted the central management in Sweden and pointed to the first paragraph of section IV of the OECD Guidelines for Multinational Enterprises, which states:

"Enterprises should, within the framework of applicable law, regulations and prevailing labour relations and employer practices:

1. a) Respect the right of their employees to be represented by trade unions and other bona fide representatives of employees, and engage in constructive negotiations, either individually or through employers' associations, with such representatives with a view to reaching agreements on employment conditions;"

It had been perfectly in conformity with Malaysian law to do as the local management had planned. However, on several occasions since 1977, the Malaysian legislation had been subject to criticism by the ILO Committee on Freedom of Association. Consequently, the Swedish trade unions were able to convince the company to refrain from its plans.

### CASE STUDY – LATVIA

In Latvia the laws and systems for occupational safety and health have undergone major changes since the country seceded from the Soviet Union. While the former laws looked good on paper, in reality employees were poorly protected. A new system to protect workers safety and health has gradually evolved, largely motivated by ambitions to reach EU standards and membership. In 1995 Latvia signed the Association Agreement of Latvia and the European Union

on the approximation of legislation and in 16 April 2003 a Treaty of Accession was concluded. Latvia joined the European Union on 1 May 2004. During this process, the importance of involving the social partners in the new structure was emphasised. The Ministry of Welfare develops national policies on occupational safety and health and is responsible for the implementation and elaboration of national legislation on labour protection, including compliance with the relevant international instruments.

The ministry co-operates closely with both the Latvian Employers' Confederation (LEC) and the Latvian Free Trade Union Confederation (LFTUC). When new legislation on labour protection is being drafted, representatives of the social partners are involved from the initial stages providing them with an opportunity to voice their opinions from the very beginning of the process. There is also close co-operation on the exchange of information on occupational safety and health issues.

Two bodies have been established in order to promote cooperation between the government and the social partners in the field of occupational safety and health. The National Tripartite Co-operation Council (NTCC) was established to encourage co-operation between public institutions and associations of employers and employees, and a subordinate body, the Sub-Council for Labour Affairs (TCSLA) was later established to increase and make this cooperation more efficient. The Sub-Council is comprised of representatives of the Ministry of Welfare, Ministry of Justice, State Labour Inspectorate, Latvian Free Trade Union Confederation and Latvian Employers' Confederation. Both bodies have equal representation from the three groups of participants.

The main task of NTCC and TCSLA is to ensure and facilitate cooperation between the government, employers' associations and trade unions at national level with the aim of securing co-ordinated solutions to social and economic development problems through the elaboration and implementation of strategies, programmes and legislation. A further aim is to increase the joint responsibility of social partners for decisions and their implementation.

For example, NTCC comments on the implementation of the ILO Conventions ratified by Latvia and proposes legal improvements in accordance with the requirements of ILO Conventions and Recommendations.

According to a working group led by the Latvian Department of Labour and the Ministry of Welfare, the tripartite system still faces some general problems. For example, the social partners frequently attend TCSLA meetings without prior coordination of the various opinions of their respective associations making it necessary to postpone discussions, making TCSLA meetings fruitless. TCSLA is currently not competent to solve such problems of information exchange.

Improvements in the information exchange between the administrative staff of TCSLA and their members are needed and the social partners should establish internal procedures for coordination of issues prior to meetings, so that they can voice and defend an already agreed and representative opinion.

Although the tripartite dialogue between the representatives of government, employers (LEC) and employees (LFTUC) is quite successful, there are some problems according to the working group. One concern is the capacity of the LEC and the LFTUC to truly represent Latvian employers and employees. The LEC only represents one third of the enterprises in Latvia,

mainly large enterprises. Only 20 per cent of the workers are trade union members and LFTUC does not have trade unions organised in several important high-risk industries leaving many workers outside the tripartite social dialogue.

To make the tripartite dialogue more effective it is suggested that activities in order to attract new members should be promoted. The possibility of involving institutions representing the interests of small and medium sized enterprises in the social dialogue should be considered and the LFTUC needs to establish trade unions in several important high-risk industries.

### CASE STUDY – TANZANIA

This example from Tanzania illustrates that tripartite consultations on occupational safety and health do not necessarily have to be initiated by the public administration but can result from international collaboration. In the case of Tanzania, cooperation between trade unions in Sweden and Africa resulted in consultations at national level between trade unions, employers and government representatives.

The story began nearly twenty years ago when a delegation from the Swedish Agricultural Workers' Union (SLF), went on a study trip to Zimbabwe. The Swedish delegation became aware of the serious problems that their African colleagues faced from the use of hazardous chemicals, especially pesticides, at work. Work environment issues were not really on the agenda of the Zimbabwean trade union, (which was primarily dealing with wages and other terms and conditions), and workers had little knowledge of how to deal with the health and safety problems of chemicals. The Swedes went home and convinced their own trade union to start a campaign against hazardous pesticides both in Sweden and internationally. They also convinced the Swedish International Development

Cooperation Agency (Sida) to grant money for a project aimed at supporting the Zimbabwean agricultural workers in their efforts to control hazardous chemicals.

Over time, trade unions representing agricultural workers in other African countries wanted to take part in the project. The international trade union federation International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations (IUF) also became involved and in 1997 SLF and IUF started the Global Pesticides Project with Ghana, Tanzania, Uganda and Zimbabwe as pilot countries. The project had a number of objectives. The training of farm workers on the prevention of hazards from pesticides was a primary objective. Simultaneously, the agricultural workers' trade unions in each of the four countries would try to find channels of communication with their governments, as, according to the "Agenda 21" adopted at the United Nations Conference on Environment and Development in 1992, states are encouraged to adopt national "profiles", i.e. action programmes on chemical safety: states may be entitled to a subsidy from the UN, provided that all stakeholders participate in the formulation of programme plans. It was envisaged that when the farm workers had been trained they would be able to contribute to this process. A further aim of the project was to exert pressure at the African regional and international level, for example in the ILO, to enforce a ban on the most hazardous pesticides and measures for the safe use of others.

Ghana, Tanzania, Uganda and Zimbabwe were chosen as pilot countries for the project because the trade unions there already had a cadre of trade union representatives WHO were trained to lead study circles (small groups of workers WHO meet to discuss subjects such as

work environment issues). These study circle leaders travelled around and taught agricultural workers on farms all over the country about the general legislation on occupational safety and health in and more specifically about the hazards of pesticides and how to prevent them.

In the beginning, Sida paid the costs for farm workers in Tanzania to attend study circles. However, employers gradually realised that there could be benefits for them as well. The first sign was that some employers let their workers participate without deducting the time from their workers wages and this was followed by some employers sending their own representatives to the same training as their workers, paying for everyone. The successful culmination was a tripartite meeting in Arusha, (organised by the Global Pesticides Project) where employers, government representatives and trade union representatives were trained together for a week and agreed on a joint action plan defining the

responsibilities of each of the three groups. This in turn has led to the Tanzanian Agricultural Workers' Union reaching collective agreements with some of the largest employers, including some of the cut flower farms that have a bad reputation as regards pesticides, on the use of pesticides. According to these agreements, certain pesticides should not be used at all. Another result is the more widespread provision and use of protective equipment even though it is relatively expensive. Health and safety committees have been established in workplaces where such committees did not exist.

Importantly, the Tanzanian government now sees the Agricultural Workers' Union as a knowledgeable partner in the elaboration of the national profile on chemicals, illustrated by the fact that when a new Minister for Environment was appointed, he asked the Agricultural Workers' Union to brief him on the pesticides issue.

# ILO Conventions and recommendations

## Generally:

ILO Constitution, Declaration of Philadelphia.  
www.ILO.org

## Freedom of association:

c 87 Freedom of Association and Protection of the Rights to Organise Convention, 1948. www.ILO.org

c 98 Right to Organise and Collective Bargaining Convention, 1949. www.ILO.org

c 135 Workers' Representatives Convention, 1971. www.ILO.org

R 113 Consultation (Industrial and National Levels) Recommendation, 1960. www.ILO.org

## Occupational Health and Safety:

c 119 Guarding of Machinery Convention, 1963. www.ILO.org

c 148 Working Environment (Air pollution, Noise and Vibration) Convention, 1977. www.ILO.org

c 155 Occupational Safety and Health Convention, 1981. www.ILO.org

c 161 Occupational Health Services Convention, 1985. www.ILO.org

c 167 Safety and Health in Construction Convention, 1988. www.ILO.org

c 176 Safety and Health in Mines Convention, 1995. www.ILO.org

c 184 Safety and Health in Agriculture Convention, 2001. www.ILO.org

R 156 Working Environment (Air pollution, Noise and Vibration) Recommendation, 1977. www.ILO.org

R 164 Occupational Safety and Health Recommendation, 1981. www.ILO.org

R 175 Safety and Health in Construction Recommendation, 1988. www.ILO.org

R 183 Safety and Health in Mines Recommendation, 1995. www.ILO.org

R 192 Safety and Health in Agriculture Recommendation, 2001. www.ILO.org

## OECD guidelines for multinational enterprises:

<http://www.OECD.org/topic/o,2686,en>

## UN's Agenda 21:

<http://www.un.org/esa/sustdev/documents/agenda21/>

# SUGGESTIONS FOR FURTHER READING

Benjamin O. Alli, Fundamental Principles of Occupational Health and Safety, International Labour Office, Geneva, 2001.





# Education and training

*Kaj Elgstrand*

This chapter deals with education and training in occupational safety and health (OSH). The basic terms will be defined. The need for education and training in OSH will be discussed for different target groups. The conditions, problems and possibilities related to OSH training in the basic schooling system as well as for OSH experts and other professionals will be highlighted. Comments will be made on training as a part of international development cooperation. Methodological aspects will be discussed: selection of contents, defining of objectives, methods of instruction, presentation techniques, written training materials, attractive teaching. Comments will be made concerning evaluation of training.

## TERMS

*Education* is the term used for the act or process of imparting or acquiring general knowledge, developing powers of reasoning and judgment, and generally preparing oneself or others intellectually for mature life. In other words, education is concerned with the development of the abilities of the mind, learning to know. It is generally used to characterise what goes on in primary and secondary schools, and at universi-

ties, ending with the acquisition of particular knowledge and skills for a profession.

After education comes *training*. Training is practical education, learning to do, usually under supervision within a profession. Vocational training aims at learning a trade or an art. Post-graduate training, like specialist training courses or doctoral studies (= research training), may be carried out at universities or at other kinds of institutions. Further training is often organised within enterprises, by employers' and workers' organisations or at special training institutes.

The terms "education" and "training" are sometimes used as synonyms. They both aim at learning through the acquisition of knowledge, skills and/or attitudes. Applying the above definitions, the focus of education is on knowledge while training focuses on skills.

*Attitude* is a person's manner and tendency of thinking or feeling about a certain issue. Their way of thinking and/or feeling about things. Attitude is closely related to value.

*Learning* could be defined as the acquisition of knowledge, skills and/or attitudes by systematic study or by trial and error. This chapter is concerned with learning by individuals, individual learning. In an earlier chapter, 8.3, organisational learning has also been discussed.

*Information* applies to facts told, read, or otherwise communicated. Information may be more or less organised or unorganised, systematic or unsystematic, important or unimportant, useful or useless. An information process is generally one-sided: the information goes from the sender to the receiver. A training activity, on the other hand, is more complex and built on two-sided communication, often including evaluation, criticism and questioning of theories and empirical material.

Defining learning may be one thing, describing what learning really is may be quite another thing. How does this acquisition of knowledge, skills and attitudes happen? Why does learning occur in one case but not in another? Giving scientifically based answers to these questions is possible but tricky. For the purposes of this chapter it is suggested that learning requires exposure to information. This information can be intentional or unintentional. Learning not only requires exposure to information, learning also requires an activity by the individual exposed. For the acquisition of knowledge, learning requires reflection and questioning, for the acquisition of skills it also requires practice.

### **BASIC NEED FOR OSH TRAINING**

The analysis of needs for OSH training should be one of the initial parts of any preparation of OSH training activities. Such needs should be related to the target group in question, according to its basic knowledge and professional tasks. Needs analysis sounds almost like a clinical procedure; you apply your formula and you get the answers: current and future needs for knowledge and skills minus already existing knowledge and skills = training needs. In practice, however,

this analysis is not a simple, clinical procedure. It is a procedure requiring negotiations and many compromises. There is no country, industrial or developing, where you can afford to provide all important target groups with the OSH training needed to prevent risks for occupational accidents and diseases among major parts of the working population. This is true in the short terms, let us say 1-2 years, but also in the longer term. The resources available for this kind of training activities are always limited in relation to the needs. Competent teachers represent one such limited resource in all countries. So priorities have to be set, among many other reasons because the need for OSH training is only one of very many needs confronting industrial and developing countries and competing for resources.

Even so, let us try to reach some kind of agreement on the basic OSH training needs of some key target groups. For the present we will confine ourselves to a quantitative aspect of this basic need. (We will be returning to the qualitative aspects of this need later on). How many lesson hours in basic OSH do different target groups need? An answer to this question, based on experience collected from many different countries, is drafted in Figure 11.2.1.

The needs indicated in the above table, cannot be met once for all. The continuous development of new technology and new forms of production and work, related to computerisation for instance, puts new demands on different professional groups. These new demands include demands for new knowledge of OSH issues and ability to cooperate with new groups of employees.

	Number of lesson hours				
	-20	21-50	51-100	101-150	151-
<b>Pupils</b>					
Primary and secondary schools	x				
Vocational training		x ————— x			
Technical schools and institutes			x		
<b>Students</b>					
Students in engineering		x ————— x			
Medical students		x			
Teacher students		x ————— x			x
Students of economy		x ————— x			
Doctoral students	x ————— x				
<b>OSH specialists</b>					
Personnel in occupational health services					x
Labour inspectors					x
Specialists in occupational medicine					x
Safety experts					x
<b>Further training of professionals</b>					
Workers	x ————— x				
Work supervisors, foremen			x		
Safety delegates			x ————— x		
Production engineers			x ————— x		
Product designers		x ————— x			
Production managers		x ————— x			

Figure 11.2.1. The need for basic education on occupational safety and health, expressed as number of lesson hours. Source: Lundgren 1971, modified by Lundgren and Elgstrand 1979, and by Elgstrand 1987 and 2009.

### THE SCHOOLING SYSTEM

OSH issues are of importance to all kinds of employees. Appropriate attitudes and knowledge in these issues should therefore be developed by pupils already before entering working life. *Primary and secondary schools* have the task of laying the foundation of the attitudes and thinking

related to health and safety at work, the pupils being producers as well as consumers of our future work environment. Given the powerful influence of example, the work environment of the school itself has an important bearing on its prospects of promoting knowledge of and appropriate attitudes towards OSH issues among

the pupils. If the school and the teachers say one thing but act in another way, the pupils tend to let actions speak louder than words.

What knowledge and attitudes concerning OSH should the pupils have acquired before entering working life? The school environment not being the same thing as the environment in working life, we cannot expect that the newly hired, coming from school, to have any detailed technical knowledge about what the work environment and OSH are and should be. Knowledge of this kind requires familiarity with the nature of work and has to be attained in practice, in the process of learning one's duties and profession. What is essential is for the pupils to understand that work tasks can be performed in different ways, that some ways are "safer" than others, and why the safer ones should be used. To understand this, one needs to know how work satisfaction, safety and health at short and long term relate to production, work organisation, costs and work efficiency. A pupil who is well prepared for working life knows, intuitively and without any doubt, that he or she is responsible for himself or herself. They also know that their actions are of importance for their fellow workers' health, safety and work satisfaction.

The above argument and aims may seem reasonable. Are they feasible? No, not really, or at least not without great effort. Even in industrial countries, there are great difficulties to be overcome. One is that the schooling system in most countries is a very conservative structure, not open to changes. Another is that the schooling system has difficulty combining the general contents related to development of the abilities of the mind with contents adjusted to the changing needs of practical life. A third difficulty is found when scrutinising the competence of the teachers. The teachers are not prepared for promoting knowledge and attitudes about OSH

and working life. The same difficulties, and many more, have to be overcome in developing countries. In many poor countries, pupils stay only a few years at school, many children never get to school. Governments and municipalities have little resources and therefore can offer only very tiny salaries for the teachers. The teachers may have to go for a long time before getting paid at all. Such conditions do not support the training and recruitment of competent teachers, and teachers can hardly be expected to engage in anything but the most essential, like teaching the pupils to read and write.

Can nothing be done, then, to implement information about OSH in primary and secondary schools in developing countries? Of course things can be done. National initiatives may not be feasible in the first step, local initiatives may. School teachers with experience from work in industry, or otherwise having good contacts with industry, may include OSH information in the curricula. If, in a certain area, there are enterprises recruiting workers, they may also be interested and able to assist the schooling system in providing basic information about work and about OSH to the pupils. Factory inspectors with children in school may be willing to lecture about work in industry and how to prevent risks of occupational accidents and diseases. Parents' work may be interesting subjects for teaching and practical visits, and can also provide opportunities for highlighting OSH issues.

In developing countries where there are *secondary technical schools*, conditions favour the inclusion of information on OSH issues. The education in these schools is oriented towards technical professions, and therefore offers many opportunities to link up with OSH. Such links may for example describe the positive relations between on the one hand production and productivity, and on the other hand nutrition (es-

pecially in heavy manual work), work load and work postures, adequate design of tools, machines and workplaces, hygienic factors (such as noise, heat stress, chemical factors). The teaching should give information about the relation between occupational health risks and fatigue.

At *universities and colleges*, the conditions for including OSH are more favourable than in primary and secondary schools. The universities are often more willing and able to include new subjects than primary and secondary schools are. The education given at universities is also oriented towards professional careers, like engineering and medicine, where the links to OSH are readily apparent.

Education for technical professions is of special interest, as technicians and engineers often have a direct influence on their own and other employees' work and work environment. Production engineers, machine constructors, industrial designers and others cooperate not only in the creation of production systems, machines and products but also in the creation of other peoples' work and work environments, including risks of occupational accidents and diseases.

Also medical schools are of special interest in this context. Physicians, nurses and other medical professionals encounter the results of badly designed and organised industrial work, e.g. injuries and occupational diseases. Their basic education should allow them to look for the causal links between work, injuries and diseases. When making a diagnosis, they should always ask questions and include information about the patient's work and profession.

When organising OSH education, within a faculty of engineering or medicine, there are two alternatives. One is to integrate the OSH issues with the teaching of various subjects, the other is to establish OSH as a teaching subject in its own right. The integrated variety is attractive as

it resembles the application of knowledge which is sought for in practice. If, for example, you want to establish a safety adapted to production, the OSH issues clearly have to be integrated with production. In vocational training directly oriented to a profession, there may be practical parts of the education and thereby opportunities for integrating OSH issues in the teaching of different subjects. In theoretical education at high level, for instance at a technical faculty or college, such an integrated teaching of OSH issues is difficult to organise. In order to include OSH in the teaching at the traditional institutions, it may therefore be necessary to establish a special subject or course on OSH issues. This may also be needed to get the necessary teacher resources. The integration of the OSH teaching with other teaching then has to be organised in other ways, for instance as individual projects or through other types of practical assignments.

### TRAINING OF OSH SPECIALISTS

OSH specialists are those who work part time or fulltime with OSH issues in enterprises or organisations, and who have taken part in specialist training focussing on OSH issues. In developing countries they are generally far fewer OSH specialists than needed. The existing specialists therefore have a multitude of tasks. In addition to their ordinary work as researcher, factory inspector or specialist in occupational health services, they are consulted by organisations and government, act as teachers at universities and enterprises, and much more besides.

Training of specialists may be organised as part of the basic professional education, or as a postgraduate training after basic education and after some professional experience. The latter model has proved successful when it comes to OSH specialist training, as specialisation in OSH issues requires the trainee to have had pre-



vious, direct and thorough experience of what work and working life is and demands. If the trainees have little or no experience from working life, but there are possibilities of spreading out the theoretical training over a longer period and also including practical training in the course, such a course may be very successful. The confrontation between and integration of theories and practice may even be more fruitful if it can also be arranged so that the trainees are allowed to make a case study, special assignment, etc., which will be carried out during their practical training and presented and discussed during a final, theoretical training period.

A country may need many different specialists in OSH issues: specialists in occupational health services (occupational health physicians, occupational health nurses, occupational health physiotherapists, and others), occupational hygienists, ventilation experts, safety engineers, ergonomists, noise experts, and others. But to need is one thing, to be able to afford is often another. In Figure 11.2.1 it is suggested that to become an OSH specialist one should have a special training including more than 150 lesson hours. 150 lesson hours correspond to 3-5 weeks full-time study. This must be considered to be very little for a specialist training course, even if it comes on top of a good basic education in engineering, medicine or another relevant basic discipline, and thorough experience of working life. Even so, the organisation of such a specialist training course goes beyond the resources available in many poor developing countries.

Considering the lack of resources in developing countries, it may be tempting to advocate joint specialist training for different OSH specialists, like occupational health physicians, occupational health nurses, safety engineers, hygi-

enists etc. Joint training of this kind can also be considered to be good for collaboration between these specialists, after completing their specialist training.

The idea of joint specialist training courses requires two important conditions to be taken into consideration. One is that the trainees have different educational backgrounds. An engineer has a very different basic education compared to a physician. The physician's educational background in turn is quite different from that of the nurse. This means that their needs and capacities for learning new things differ considerably. Another condition that has to be considered when planning joint specialist training courses, is that these specialists, when trained, have different work tasks. This is another reason why their needs for specialist training differ. Instead of joint or separate specialist training courses, it might be worthwhile to explore the possibilities of organising specialist training courses which are partly the same for different trainees and partly separate.

Cooperation between different OSH specialists is certainly important. More important and more difficult to achieve, however, is cooperation between OSH experts and the personnel in enterprises who have the real power to change production, work and OSH risks: the managers, engineers, supervisors – “the production people”. This calls for the OSH specialist training courses to include different meetings and interchanges between the trainees and the production people. The applied exercise described in Figure 11.2.2 gives one example of such a meeting during a OSH specialist training course, between the trainees and production people.

Topic	OSH evaluation of work operations, workplaces or work processes.
Objectives	After active participation in the exercise, the trainee will be able to make a preliminary analysis of OSH problems at a workplace (or for a work process). He or she will be stimulated to further studies.
Participants	Students of technology, forestry, agriculture or other fields. Managers, production engineers, work supervisors, workers.
Duration of the exercise	At least one day, if possible one and a half day or two days.
Pre-requisites	<p>The exercise should occur in the middle or at the end of a course, after studying the basic issues of OSH and the principles of the methods and techniques to be applied.</p> <p>The exercise has to be carefully planned by the responsible teachers, by officials at the work place and also by the students. The responsible teacher has to make at least one visit on beforehand at the workplace to be studied.</p> <p>During the exercise, the students should have access to necessary checklists, handbooks, simple tools for measurements and material for presentation of the findings (big sheets of paper, overhead projection materials, et cetera).</p> <p>For more complicated measurements, the teachers should provide the expertise. If available, photographic or video-presentation of work operations may be a useful part of the preparation of the exercise and at the final discussion.</p>
Plan of the exercise	<p>a) 1-2 hours of information and discussion about factors as organisation, economy, production prospects, work force situation, etc., should be carried out in the actual area of work, industry, plant or production process.</p> <p>b) 3-5 hours of observation, measurements and interviews at the workplace. The students should be working in groups of 2-5 persons. The teacher assists.</p> <p>c) 2-4 hours of analysis of the observations and planning the coming presentation of the analysis (drawing sketches of the workplace, preparing overhead projection, et cetera). This should be done separately in each group of students, eventually assisted by the teacher.</p> <p>d) 2-4 hours of presentation of the analysis, including proposals for change and action, and concluding discussions. The presentations are made in front of all students, the teachers and representatives of the workers and plant in question (production manager, production engineer, head of maintenance department, or others). In the concluding discussion the students should get feedback from the representatives of the plant about the quality of their observations and whether their proposals are feasible or not.</p>

Figure 11.2.2. An example of an applied exercise.

In many African countries factory inspectors represent a well-qualified core of OSH specialists. To a great extent this can be ascribed to systematic efforts over a long period of time, including specialist training, by ILO and the corresponding governments. The Finnish Institute of Occupational Health and other Finnish institutions and sponsors have also played important roles. In some countries the factory inspectors represent the only corps of qualified OSH specialists. It is an important task for the governments, international organisations and development cooperation agencies to see to that these factory inspectorates do not gradually lose their resources. On the contrary, they should be enabled to employ new inspectors and also update their knowledge and skills through further training in OSH issues.

Specialist training in OSH requires national planning. The needs for such specialists have to be analysed, considering both qualitative and quantitative factors. Which specialists are needed? How much training do they need? How many specialists are needed? Do we have the resources needed to organise and carry out such specialist training? Which priorities have to be agreed upon?

Small and poor developing countries do not have the resources needed to organise OSH specialist training courses. They have to look for other solutions. Traditionally, those solutions have been to go abroad and get the necessary OSH specialisation, for instance in England, France or the USA. Apart from being possible only for very few, this solution entails the risk of some of the trained specialists staying on in the country where they gained their specialist qualification. (It is a risk seen from the point of view of the national needs. From the personal point of view, the trainee may rather consider it as a chance). There may even be the risk, of course,

of the specialist training abroad not meeting the real needs of the trainee's home country.

The training of specialists requires competent institutions and individuals for the establishment and running of the training programmes. Small and poor countries do not have the resources needed. An attempt might therefore be made to organise such training for a region, where the different countries and their institutions can contribute with their resources.

### TRAINING OF MANAGERS AND WORKERS

Knowledge about work hazards and ways and means to counteract them is essential for management, supervisors and workers. Poor conditions of work and the working environment may even, to a large extent, be ascribed to lack of such knowledge.

Managers have to attend to many different demands and their time is always scarce. Production issues have to be dealt with, primary materials have to be supplied, customers' complaints have to be confronted, the financing of the enterprise may cause trouble, personnel need to be recruited and trained, officials of the municipality have required the waste from the enterprise to be better taken care of, authorities have complaints about taxes being paid too late, competing enterprises have developed cheaper and better products, a marketing campaign tends to be too costly, etc. So it is quite natural that managers and employers cannot always pay due consideration to issues of occupational safety and health, especially if they do not see a positive link between production and occupational safety and health.

In 2001 the ILO published guidelines which may help to stimulate managers' interest in OSH issues, integrated with dynamic management strategies, "Guidelines on occupational safety and health management systems". The

guidelines have been shaped by internationally agreed occupational safety and health principles. They provide an instrument for the development of a sustainable safety culture and outline the OSH management system in the organisation: policy, worker participation, organisation, responsibility and accountability, competence and training, etc. The guidelines may serve as a checklist for managers' OSH information and training needs.

Every worker should be familiar with the main hazards of his job and how these are controlled. From the beginning - starting a new job or shifting to new work tasks - the worker should be taught that the right way to do a job is the safe way, and to practise occupational safety and health at all times. The creation of awareness of and commitment to safety and health among workers should therefore be an important goal in training activities of enterprises. It should, however, be preceded and supported by equal awareness and commitment among policy-makers, managers and specialists in order not to end in poorly met expectations. Expectations which are not met create disappointment and disillusion.

The training of employees is generally the concern of the enterprises where these employees work. The possibilities of carrying out such training are obviously far greater in a big enterprise having hundreds or thousands of employees than in small undertakings with just a few employees. The big enterprise may have a special training department, OSH specialists who can organise and carry out the training activities, and supervisors and managers may have knowledge about OSH issues. A small enterprise may have greater risks of occupational accidents and diseases than a big enterprise, but might be unaware of them, and have no resources for preventing them.

Trade union representatives in enterprises, like safety delegates and shop-stewards, need special training on OSH issues. According to Figure 11.2.1, their basic need for OSH training corresponds to 50-100 lesson hours. Besides their need for basic knowledge about work hazards and ways and means for counteracting them, they need to be able to communicate effectively with their fellow workers, supervisors and managers. Trade Union Confederations may have special employees working fulltime with OSH issues. They need broader OSH training and more of it than safety delegates, as they have to work with many different enterprises and work environments.

Even if the OSH training of workers and trade union representatives generally is the concern of the enterprise or the trade union, joint initiatives may be needed in order to support such training. Joint initiatives may be taken nationally or by business sector (the building industry in a country, for example). Common goals and procedures may need to be agreed upon. Development of written training materials may benefit from joint financing and/or actions.

### **TRAINING WITHIN INTERNATIONAL DEVELOPMENT COOPERATION**

Since the 1980s, training and information have been dominant activities in international development cooperation within the OSH field. The ILO and WHO have provided many fellowships and sponsored many courses in OSH issues for trainees from developing countries. ICOH, the International Commission of Occupational Health, has also been active in organising OSH training courses.

In the beginning of the 1990s there was a shift from national and bilateral training activities to regional projects. The ILO carried out two big OSH projects for 20 countries in the Asian-

Pacific Region and for 21 countries in Africa. These projects were mainly sponsored by the Finnish Ministry of Foreign Affairs. Within the African project more than 100 regional, national and local workshops, seminars, and courses were organised, besides many other activities. The Asian project was design to strengthen occupational safety and health infrastructure in participating countries, mainly through dissemination and sharing of information, and educational and training activities. Related to these two projects and an East African regional project, the Finnish Institute of Occupational Health together with the ILO published the *African Newsletter on Occupational Health and Safety* and the *Asian-Pacific Newsletter on Occupational Health and Safety*, four times per year. The publication of these two newsletters is still ongoing, providing valuable information useful also for training activities.

The regional component is being addressed in two long-term programmes on “Work and Health”, one involving Central American countries another southern African countries, members of SADC. These programmes are mainly funded by the Swedish International Development Cooperation Agency (Sida), and emanate from earlier bilateral cooperation between the Swedish National Institute for Working Life and other Swedish institutions with institutions in a few countries in the two regions. The two programmes have three main components: research, training and actions for change. The main emphasis lies on actions for prevention of OSH risks in building industry, agriculture, mining, hospitals, and in the informal sector. Professional capacity building as well as institutional capacity building (for monitoring occupational hazards and health risks) are supporting the preventive actions in both the short-term and long-term perspectives. Training and research activities are part of the programmes. They are

not ends in themselves but tools for the achievement of the programme objectives. The two programmes started in 2003 and 2004, and were originally planned to continue for twelve years each. Due to changes in Swedish development cooperation policy, the Swedish financing of the programmes will end in 2009. New sponsors are therefore being contacted in order for the programmes to continue.

Alternating theoretical and practical training periods are advocated in this chapter. Since the end of the 1980s this has been successfully applied in two different international training programs for OSH specialists in developing countries. The training programmes have been organised by the Swedish National Institute for Working Life (NIWL) in collaboration with other Swedish institutions, and financed by the Swedish International Development Cooperation Agency (Sida). *One* is a long-term partnership with universities in Costa Rica and Nicaragua concerning research and research training. The Central American research students have spent time in Sweden for collaborative analyses and write-ups of the publications, while spending 85% of their time in their home countries for data collection. *The other* is a one or two-year training programme, in which 275 OSH specialists from countries in Africa, Asia, Latin America and Eastern Europe have participated between 1993 and 2008. Each course has consisted of six, seven or eight weeks of scheduled activities in Sweden and one or two participating countries. Between the course periods, the participants have carried out an individual action project in their home countries, aimed at eliminating or reducing of OSH risks. These projects have been planned and reported during the scheduled parts of the course, and carried out in the participants’ home countries.

## METHODOLOGY

This part will focus on the methodology of traditional forms of education and training, where trainees regularly meet each other and teachers: courses, workshops, seminars, etc. Distance education will be briefly touched on later in this chapter.

### Selection of contents

Contents are the most important component of a training course, in the same way as they are the most important component of a single presentation. This simple fact is not infrequently forgotten, as planning a training activity stimulates the trainer to think about the forms, how to design the training or the presentation. How to do the training should be the second concern, the first should be defining the content of training.

Which problem areas and what kind of facts should be selected for the training activity? In theory the answer is easily found: contents should be selected to suit the trainees (= the target group), the needs of the enterprise or country, and what has to be learnt by the trainees. In practice, many confounding factors exist. One is that we always tend to be so complete, we try to cover all possible areas and aspects. As the time that can be dedicated for the training is limited, our ambition to be complete often results in contents which are too superficial and general.

Seen from a national point of view, OSH training should focus on how to prevent risks of occupational accidents and diseases that may lead to serious accidents and diseases and/or that may happen to many employees. In order to do so, the training has to be based on an analysis of the national needs, not on what the textbooks say are important in other countries. The facts presented should stimulate to action. A few positive examples of what can be done and what has

been done, is worth much more than detailed analyses of what is difficult or impossible to achieve.

### Defining objectives

Training activities are organised for different reasons. An institution may want to be responsible for organising training because it generates resources to the institution. Another institution may want to organise courses because they give an opportunity for the researchers of the institution to meet practitioners, a meeting that may give valuable information and impulses to the researchers. In another case, the governments and the employers cannot agree upon an action to be taken (banning the use of asbestos, for example), but they can agree on organising training activities as more knowledge is always needed. Training can sometimes be organised for what could be described as formal reasons; advancement in certain careers requires the completion of certain training activities.

Without disregarding any of the above mentioned reasons for organising training activities, we will now focus on training organised for another reason: for the trainees to learn something. The objectives of such a training activity should be *learning objectives*. They should state what the trainees will know and be able to do after participating in the training, which they did not know and were not able to do before participating.

There are many courses having this kind of objective:

“The objective of the course is to teach the basics about what causes silicosis, and to inform about methods for reducing exposure to silica dust.

This is not a learning objective. There is not a single word that can be linked with learning.



Instead, this objective contains instructions for the teacher. So, it is a teaching objective. Now, let us make it a learning objective:

“After active and successful participation in the course, the trainees will

- know what silicosis is and how it is caused
- be able to reduce exposure to silica dust in a workplace.”

As our course is action oriented, we are not quite satisfied with the first part of the objective. We prefer to express objectives in behavioural terms, that is being able to do things. Therefore, we change the objective to:

“After active and successful participation in the course, the trainees will

- be able to describe what silicosis is and how it is caused
- be able to reduce exposure to silica dust in a workplace.”

Fine, now we are satisfied. These are learning objectives, expressed in behavioural terms.

At this point it should be noted that learning objectives need to take account of the trainees’ background, needs and future activities. Our learning objectives are relevant for trainees who aspire to become safety managers or occupational hygienists. If the training were to be organised for future occupational health physicians, however, the first learning objective would be “be able to diagnose silicosis and describe how it is caused”. The second objective might not be relevant at all or would be changed to “be able to reduce or at least advice on measures for reduction of exposure to silica dust in a workplace”.

Next question: How do we know that a trainee has achieved the objective? Well, the first part is not difficult. We ask the trainee to describe, orally or in writing, what silicosis is and how it is caused. If the teacher (who may be a pulmonary physician or an experienced occupational hygienist) accepts the description, the

objective has been achieved. The second part of the objective requires more than a description. It requires that the trainee to carry out in practice activities which reduce exposure to silica dust at a workplace. It also requires the activities and their outcome to be documented and possible to evaluate. Dust exposure has to be measured, before and after the activities intended to reduce it. How is all that to be organised for 16 participants in a course? Well, let us assume that the course is organised for safety managers in the mining industry in our country. The 16 participants represent many workplaces in a total of five different mining enterprises. It is a course with four weeks of scheduled lecturing. Three weeks in December one year, and one week in November the following year. During the first three weeks the trainees study what causes silicosis. They learn in theory how exposure to silica dust can be reduced at workplaces by studying a number of practical cases where this has been done. They learn in theory and practice how to plan and carry out actions to reduce exposure to silica dust. They learn to measure exposure to silica dust. At the end of the three weeks each trainee has produced a short plan for reducing exposure to silica dust at a workplace in the enterprise where he is safety manager. The plan has been discussed repeatedly and been developed together with a tutor. During the period from January to October the second year, the trainees carry out the action plans at their enterprises. They write a short report, summarising the actions undertaken and describing the results achieved. During the fourth week of the course, all trainees’ actions are presented, discussed and evaluated. It is also discussed how the experiences gained during the actions undertaken can be developed into systematic long-term programmes for reducing silica dust exposure in the five mining enterprises. Back to the ques-

tion: How do we know that the trainees have achieved the second part of the objective? We will use the approved reports from the actions as *indicators for objective achievement*. This means that when the tutor, or the course coordinator or the course faculty, has approved the report, we consider the trainee to have achieved the second part of the objective. Most trainees will pass. A few will pass only after having completed their actions and measurements, or improved the written report. One or two trainees will not pass at all, because they were never able to carry out their planned actions. Should a trainee who has carried out all planned actions but not succeeded in significantly reducing exposure to silica dust be passed? Yes, if he really has tried he should be passed, even if the objective in the second part has not been achieved.

The above stated learning objective may be formulated in a more precise way. “to reduce exposure to silica dust” is not very precise. “To reduce exposure to silica dust below the occupational exposure limit (OEL)” would be more precise. On the other hand, such an objective would require prior knowledge of the exposures being over the OELs at the workplaces chosen, and their reduction below the OELs would have to be feasible during the time and with the resources available.

Earlier it was common to say that a course should “give knowledge” in certain areas, about certain facts. This expression assumes that

knowledge can be given by one person to another. It suggests that learning is a far more easygoing process than we nowadays believe. Today we believe that learning always requires work by the learner, often hard work. Therefore, we prefer not to say that a course will “give knowledge”. We prefer to say that the trainee, after active and successful participation in the course, “will know” certain things. The course and the teachers are facilitating the learning, not giving it to the trainee.

The learning objectives of a course have three main functions. First, they represent a summary of the course, its contents and ambitions. They are a declaration of the course, useful to people interested in participating and to the employer paying the trainee’s salary during the course. They form part of the basis for decisions to apply to the course and participate. Second, the objectives are important references to organisers and teachers during the planning and process of the course. The objectives indicate the direction, the orientation of the training activities. Third, the objectives constitute the point of departure for the evaluation of the course. The effectiveness of a course is evaluated in relation to its achievement of the objectives.

In order to fulfil these functions, the design of the learning objectives has to meet a number of requirements. These requirements are summarised in Figure 11.2.3.

1. The learning objective shall be oriented towards the trainee. It should express what the trainee will be able to do after active participation in the training activity, what he or she could not do before.
2. The learning objective has to be relevant. The achievement of the objective should fulfil a need for the trainee in his or her professional development, and be socially applicable.
3. The learning objective has to be realistic and feasible. The learning objectives for a short course have to be less ambitious than those for a course of longer duration. It may have to be accepted that all trainees in a training course will not be able to achieve the same learning objectives.
4. The learning objectives have to be established using clear and understandable language. It is important to avoid using words that are open to many interpretations. Therefore, verbs like this should be avoided: have knowledge, discuss, understand, appreciate believe, trust, develop. Instead, words like the following should be used: write, identify, differentiate, solve, make a list, compare, plan, construct, implement.
5. If, in spite of the systematic attempts to meet the above mentioned four requirements, the meaning of the learning objectives is not completely clear and understandable, indicators for the achievement of the learning objectives have to be defined. The indicator(s) for the achievement of learning objectives shall specify: what?, where?, for whom?, how?, how much?, when?

Figure 11.2.3. Basic requirements for learning objectives.

### Methods of instruction

How is OSH training to be designed and organised? The suggested recipe is: *Confront and integrate theory and practice!* It is an over-simplified recipe, but it may facilitate the identification of some essential ingredients in an efficient OSH training.

First of all, the training in itself might be regarded as a confrontation between theories and practice. The organisers, the teachers and the training material (textbooks, et cetera) representing the theories, the trainees and their experiences and their present or future jobs representing the practice. If the training process includes a continuous evaluation, criticism and

questioning of theories and empirical material, this process will result in learning not only by the trainees but also by the teachers and organisers.

If the organisation of the training allows trainee participation at different stages of planning, the process of training and learning is likely to develop not only more smoothly but also more efficiently. In addition, trainee participation might be considered as a means of democratising the educational process and therefore an end in itself. Different goals and procedures must be linked to trainees' participation in the planning of education, depending primarily on their previous experience of working life. In

vocational training of students with no experience of working life, the initial planning will get a stronger and more adequate injection if the students are replaced, for instance, by representatives of former students or representatives of the appropriate professional association.

The trainees' previous experience of working life is a factor of basic importance to the teaching and learning process. Ambitious courses on occupational safety and health, ergonomics, etc, have been included in many vocational school programmes, with highly unsatisfactory results. It is sometimes said that the students lacked motivation for the subject in question. This, however, often gives the teacher the idea that he has been a poor pedagogue, which is not necessarily a meaningful and fair explanation. The students' experiences of working life are such a basic requirement for OSH teaching, that if non-existent not even the best teacher and pedagogue can replace them.

Even on a course with no period of practical training involved, there are methods for confronting the theories with practice: case studies and the use of checklists, amongst other things. As an example of how to apply and combine these methods, Figure 11.2.2 describes an exercise that has been arranged successfully as a part of many OSH courses given in various countries, industrial as well as developing.

Whenever possible, an OSH training activity should include at least one visit by trainees to a workplace, together with teachers. Suitably organised, workplace visits provide valuable information and insights, enabling integration between theories and practice.

The composition of mixed, heterogeneous student groups may be a way of ensuring a valuable confrontation between theories and practice. For instance, the exercise described in Figure 11.2.2 might have been enriched if the

student groups consist of a mixture of production engineers, machine constructors and designers, trade union representatives, etc.

Teamwork in multidisciplinary fields such as occupational safety and health has distinct advantages, and is indeed necessary. Efficient teamwork calls for good communication between team members and an understanding and appreciation of each other's work and achievements. This calls for teamwork practice and, if possible, education and training in the principles of communication and of group dynamics.

The time factor is present during all training activities for adult participants as a constant challenge, to organisers and trainees alike. It may be seen as a privilege for a trainee to take part in a training course while the employer pays the salary, and your wife or husband alone has to take care of the family. Training based on manifold communication (between lecturers and trainees, between trainees, between trainees and tutors) takes more time than does more teacher-centred training. The time constraints and the many persons involved make it necessary to state precise rules as regards when to talk and when not to talk. In the beginning of a course, such rules may be followed as a courtesy to the eccentric organisers, but little by little this courtesy may be replaced by respect for all actors involved in the process and for the fulfilment of common goals.

### Presentation techniques

It is widely accepted that an oral presentation is more efficient if it is accompanied by a visual presentation. Which is the most important part, the oral or the visual? Maybe both, or none. Both oral and visual parts of a presentation have to support why the presentation is made: explaining, reasoning, finding things out, questioning, evidence, credible authority (as opposed to

patronizing authoritarianism), all in relation to the content and the objectives of the presentation. The content is the most important element of a presentation. Presentations largely stand or fall depending on the quality, relevance and integrity of the content, presented orally and/or visually. The way to make big improvements in a presentation is to get better content. Exquisite design formats will not salvage weak content. If our numbers are boring, then we have got the wrong numbers. If our words or images are not to the point, making them dance in colour will not make them relevant. Audience boredom is usually a sign of content failure, not decoration failure. Formats, sequencing, and cognitive approach should be decided by the character of the content and what is to be explained, not by the limitations or possibilities of the presentation technology.

Firstly, given the importance of the content of the presentation, as stated here, we are, secondly, allowed concern ourselves with the details of a visual presentation.

For the training of adults, *photo slideshows* came to be widely used in industrial countries 50 or 60 years ago. Nowadays they are seldom used, and in the near future they will probably not be used at all. Photos and other kinds of pictures, including videos, can without much problem be included in computer-guided presentations like power-point presentations. So, let us forget about slideshows and instead take a closer look at presentations aided by overhead or power-point.

*Overhead presentations* require an overhead projector, electricity, transparencies and (colour) pencils. They have been in use for the last 30 or 40 years, and have been widespread both in industrial and developing countries. In many countries today, overhead projectors are potential museum exhibits, due to the widespread use of the power-point technique.

During the 1980s a computer presentation package was developed which was eventually acquired by Microsoft and turned into the PowerPoint software programme. Since the end of the 1990s, *power-point presentations* have taken over as the predominant visual aid for presentations at all kinds of meetings: product presentation; sales promotion; planning events, education and training activities in enterprises, universities and even primary and secondary schools; scientific meetings, and many others. Every year, huge numbers of power-point presentations take place. A power-point presentation requires a computer, a power-point programme, a video-projector or LCD screen, electricity, and skills to develop the presentations with help of the program.

The main advantage of the overhead and power-point presentation techniques is that they allow the teacher to sequence and present the contents in a well-structured way. With both techniques, photos and other pictures can easily be included in the presentation. Furthermore, both techniques allow easy storage and further development of the presentation material. The fact that the power-point presentation offers so many technical possibilities related to the shapes and movements of the text, colours, illustrations and different kinds of decorations is a great advantage. Many presenters, however, use these possibilities in a way which turns the advantage into a disadvantage. Form comes before content, the presenter's trigger-happiness comes before the trainees' understanding, and the presentations tend to be overburdened with information.

When planning an oral and visual presentation, the statements and suggestions gathered in Figure 11.2.4 may come in useful.

1. Be prepared. If you have little time, much time or no time to prepare the presentation, the most important thing is always to decide what you want to communicate. What is your message? Is it relevant to the audience?
2. Formulate the objective of your presentation. Which are the key points that you want the audience to remember or be able to do?
3. Encourage spontaneous questions. Listen to them. If necessary, reword the question and direct your reply to the whole audience.
4. An oral presentation will be more efficient if you not only talk but also use the possibilities to show pictures. The most important characteristic of a picture is that it can be read and understood by the onlookers. Don't show tables which cannot be read. Never say that the picture is for you, and not for the audience. It will only irritate the audience and maybe make them negative to your message. How can you know that your pictures can be read by the audience? Test it in beforehand in the room where the presentation will be made.
5. Don't use too many pictures. Better to have a few relevant pictures than a lot of half-relevant ones.
6. When you show a picture which is not a text but a photo, drawing or figure, use simple and understandable pictures. They should be understood not only by yourself but also by the audience. Comment the pictures to ensure that they are understood in the way you intend.
7. If you use a video presentation by power point, it is especially important that you prepare the presentation in advance. Test your presentation in beforehand, so that you are sure that it functions in the room where you will make your presentation, with the equipment and the cables available. Don't arrive with your computer or floppy disc two minutes before your presentation. It may work, but sometimes it does not.
8. If your presentation does not function, it is due to your lack of preparation. It is not the organisers' or the course site's or the equipment's fault, it is your fault. As presenter you are responsible for your presentation functioning the way you want it to.
9. If the presentation has caused few spontaneous questions, finalise by asking the participants about how they understood the message. Was there anything that was not understandable or possible to agree with? Any other comments, questions or proposals?
10. Study also and reflect on Figure 11.2.5.

Figure 11.2.4. Guideline for oral presentations.



### Written training materials

The written training material often contains the main theoretical part of what a trainee is expected to learn during a course. Lessons serve as introduction to and/or summaries of the written material. Practical cases/visits/exercises are included to highlight problems to be understood and/or to train abilities to be mastered. In the ideal case, these different forms cooperate efficiently towards the same end: the trainee's attainment of the learning objectives.

Recent decades have witnessed the birth of a new kind of written OSH training material. *Better work environment* was developed in Sweden in the 1970s. It was translated into more than 40 languages, and promoted by the ILO. Inspired by the Swedish material and test courses in South-East Asia, the ILO itself developed *Higher productivity and a better place to work* in the 1980s. These two sets of written training material were profusely illustrated and had many examples of technical and other solutions to OSH problems, questions to be discussed, and checklists to be used during workplace visits and analyses. They were action-oriented and could be used during teacher-led lessons as well as during discussions without any OSH experts present. They can be used in enterprises of different sizes. The ILO material has been developed in such a way as to be specially useful in small enterprises. The quality of these two bodies of training material is proved by the fact that they have been continuously developed and are still in use. Kogi & Kawakami have developed another written training material, *Positive programme*, which has benefited from the experiences gained through the use of the older materials. *Positive programme* is more focused, more to the point and structured more straightforwardly. The key concepts are: learning from good examples in local work-

places, active participation, action-oriented support and group work aiming at consensus.

Some of the above mentioned training materials are based on the WISE methodology developed by Dr. Kawakami: *Work Improvement for Small Enterprises*. WISE is an action-oriented training method which focuses on participatory approaches and low-cost improvements. It is built on local practice, focuses on achievements, links working conditions with other management goals, learning by doing, exchange of expertise, and promotion of worker involvement.

The training materials which have now been mentioned are "international", including examples from different countries and cultures. And, in fact they have been used in many different countries for the basic training not only of workers, supervisors and safety delegates but also of engineers and managers. One wishes, however, that this kind of international materials were used nationally only after very considerable adjustments to the reality of the country in question. Most people tend to be stimulated by information and reference that is closely related to their own reality. Pictures, examples, cases and other kinds of information should therefore come from their own country, not from another country or as "general" information to fit any country. It is valuable, of course, to include some information from other countries or from international organisations or contexts, but the basic part of the information should be rooted in the trainees' own country.

### DISTANCE EDUCATION

Distance education has been practised for hundreds of years. Correspondence and the use of radio and television were the main technological instruments for distance education during the twentieth century. In recent decades, computers and internet have made the use of distance

education easier and faster. Nowadays there are numerous concepts and forms of distance education. A few of these are summarised in the following;

#### Computer-based training, CBT

...refers to the use of computers as a main component of the educational process. CBT is especially effective for training people to use computer applications and for simulations to learn how to drive airplanes, boats and other vehicles.

#### E-learning, electronic learning

...is a type of technology supported learning where the medium of instruction is computer technology. In an enterprise it may refer to strategies that use the company network to deliver training courses to employees. In most universities, e-learning is used to define a specific mode to attend a training programme where the students rarely attend on-campus classes or have face-to-face access to teachers or other educational facilities. Conventional e-learning systems were based on instructional packets that were delivered to students using internet technologies. The role of the student consisted in learning from the readings and preparing assignments. Assignments were evaluated by the teacher. More recently, increased emphasis is placed on social learning and the use of social software such as blogs, wikis and podcasts.

#### Mlearning, mobile learning

...is learning across contexts and with portable technologies like hand-held computers and mobile phones. Focus may be on the technology, the mobility of the learner, or on how society and its institutions can accommodate and support the learning of an increas-

ingly mobile population that is not satisfied with existing learning methodologies.

#### Virtual school, cyberschool

...describes an institution that teaches courses entirely or primarily through online methods. Courses and schools may be accredited or not, and courses may be full-time or part-time. Courses are given at primary and secondary levels, and some universities provide accredited online degrees.

#### Open university

...refers to a university with an open-door academic policy, i.e. no entry requirements. The term may also refer to universities employing specific teaching methods: open supported learning where the students receive constant academic attention from academic staff and tutors, and/or distance education. There are now many institutions in the world with the name Open University, some of them being 'mega-universities' with more than 100,000 students. The Open University in the UK was established in 1969 and has more than 180,000 students enrolled, including more than 25,000 studying from overseas.

Access to internet coverage is still very low in many countries. In 2007, the internet users of countries like Angola, Benin, Cameroon and Congo DR averaged 2% of the general population, while in countries like China, India, Indonesia and Vietnam the average use was 10%. At the same time, in Canada, USA, Germany, France and Japan the average use was 64%.

As for education and training in the field of occupational safety and health, distance educational methods have been employed for many years. Email-communication is used for tutoring, teleconferences may be used as a part of

courses, the web is scanned for articles to support practical assignments, and discussion groups may be established through the internet, etc. In a more ambitious sense, however, there are few examples of complete, sustained OSH training activities carried out online, via distance. On the other hand, during the last ten years successful attempts have been made in many countries to establish such online training in occupational safety and health. Some of the experiences related to these attempts have been documented by ICOH's Scientific Committee on "Education and Training in Occupational Health".

### ATTRACTIVE TEACHING

OSH training activities should be problem-based. Trainees should take an active part in the training. The training itself should be action-oriented. New tools, like power-point presentations and textbooks like the present one, will be available to more and more people. In spite of all new tendencies and ambitions, the teacher will continue to play a crucial role in education and training in OSH issues, in industrial as well as developing countries.

This part of the chapter is dedicated to the teacher's role in training. What is attractive teaching, and what is unattractive teaching? The author has discussed this question with many individuals and groups in many different countries during the last fifteen years. The answers to the question are summarised in Figure 11.2.5. The hypothesis is that attractive teaching facilitates efficient learning.

### EVALUATION OF TRAINING

There are two kinds of evaluations that are generally applied in relation to training: evaluation related to the results of the training, and evaluation related to the process of training.

The first kind, *evaluation of results*, is more difficult and also more important. The success of

this evaluation to a high degree is dependent on how well the training objectives have been formulated and communicated to and accepted by trainees and teachers.

So, the evaluation of results tells us to what degree the course objectives have been achieved: how well the trainees have learnt to know and do what they did not know or were not able to do before the course. These results can be evaluated during the course and immediately after completion of it.

*Process evaluation* of training activities emphasises how well the training is or has been running from practical and psychological points of view. Has adequate information been given in due time? Were the course contents relevant and important, considering the needs of the trainees? Did the design of the training allow necessary adjustments of contents and activities? Has study material been given and proved to be useful? Have the practical facilities been adequate? Have the teachers and organisers given the necessary support and guidance? And many other questions. Process evaluation of a training activity is often made asking trainees to respond to this kind of questions in questionnaires and/or discussions. Such questionnaires and discussions are likely to elicit much valuable information about the meaning and applicability of the training, as well about the practical problems that trainees and teachers have been faced with.

If applied in a systematic and consistent way, combinations of result and process evaluations will give important inputs to the further development of the training activities.

The *effects* of the course are the long-term effects on the individual trainee, his or her enterprise, and/or society as a whole. To evaluate these long-term effects is not easy, due to the existence of many confounding factors. Special research projects may need to be carried out.

Attractive teaching	Unattractive teaching
1. The teacher has a message and the message is relevant for the trainees	The teacher has a lot of facts and opinions, without direction and aim
2. The teacher stimulates activity and reflection on the part of the trainees	The teacher encourages passiveness in the trainees
3. The teacher uses different methods of instruction	The teacher uses only one method of instruction: talking and talking
4. The teacher practices what he or she teaches	The teacher is not acting in accordance with his or her own recommendations
5. The teacher is willing to learn, and shows it	The teacher knows everything; the trainees nothing
6. The teacher adjusts to the trainees; for instance, offering examples according to the backgrounds and needs of the trainees	The teacher is not concerned about the trainees' needs; the examples given – if any – are irrelevant or incomprehensible for the trainees
7. The teaching is stimulating; raises interest and curiosity, trainees understand that there is more to learn	The teaching is boring; the trainees feel that too much time has been spent on it
8. The teaching is linked in a meaningful way with other teaching and/or other activities of the same training programme	The teaching is without understandable links to other teaching and other activities within the same training programme
9. The trainees are concentrating on the message, sharing the information	The trainees are talking and/or thinking of things other than the message

Figure 11.2.5. Analysis of what constitutes attractive versus unattractive teaching.

Adults participating in vocational training, post-graduate courses, etc. not infrequently criticise a lecture, a book, the teaching of a certain subject or a whole course for being “too theoretical”. This may be an opening statement that leads to a valuable interchange of information between the trainee and the teacher, but it does not necessarily mean that the course really has been “too theoretical”. Of course, the training might have been unsuitable for the trainee, or vice versa. The information about the course, its contents and objectives, might have been poor, or a mistake might have been made when selecting the trainee in question. Furthermore, the problem areas selected for the course, or some of the lessons given, might have been irrelevant for the trainee because of lack of experience of working life. Other explanations might be poor information about the reasons for the teaching in question, mistakes when selecting the problem areas or lessons, or insufficient pedagogical

competence of the teachers. “Theoretical” is sometimes used as an ugly word when talking about education and training, thereby covering more useful statements. The idea behind the complaint “too theoretical” might have been, for instance, “too much sitting in the lecture room, which I have not been used to for a long time”. Finally, it should not be forgotten that a good education should allow the student to understand and use new, good theories in order to change bad practice.

In some cases the trainees consider that more time should have been spent on a single course element, or the course as a whole. This is healthy. If, on a certain topic or training activity, the trainees would like more time to be spent, that can be seen as a sign of wanting to learn more. If, on the other hand, the trainees have the opinion that too much time has been spent, it is worrisome and should be further analysed and maybe acted upon.

## SUGGESTIONS FOR FURTHER READING

### Basic texts

Benjamin Bloom et al: Taxonomy of Educational Objectives. Handbook I: Cognitive Domain. Handbook II: Affective Domain. David McKay Company Inc., New York 1956, sixteenth printing (1971). 205 + 200 pages.

The definition of objectives is an essential part of all planning for education and training. This classical work of Benjamin Bloom et al will allow the reader to enter a sophisticated sphere of learning and understanding.

Carl R. Rogers: Freedom to Learn. Charles E. Merrill Publishing Company, Columbus Ohio, 1969. 160 pages.

Rogers' book has greatly influenced the education and training of both adults and children. It introduced student-centred learning as an approach to education focusing on the needs of the students, rather than those of others involved in the educational process, such as teachers and administrators. This approach has many implications for the design of curriculum, course content, and interactivity of courses.

JJ Guilbert: Educational Handbook for Health Personnel. WHO Offset Publication No. 35, World Health Organization. Geneva 1987, sixth edition, revised and updated (1992). 390 pages.

A handbook for teachers and organisers of health personnel. It provides practical advice, in fairly simple language, on how to organise education and training in order to facilitate learning by trainees.

Edward R. Tufte: The Cognitive Style of Power Point. Graphics Press LLC, 2003. 25 pages.

A critical appraisal of possibilities and problems related to the use of Power Point presentations in communication and training.

ICOHs Scientific Committee on "Education and Training in Occupational Health" organised in 2005 a conference on "Occupational Education and Training for Everyone Everywhere", dealing with distance education. During this conference many successful attempts to establish online training were reported, some of them jointly developed by institutions in industrial and developing countries. The conference presentations are available through the ICOH website: [www.ichweb.org](http://www.ichweb.org)

### Training materials

Safety-Health and Working Conditions: Training Manual, Checklist and Discussion Leader's Guide. Joint Industrial Safety Council, Stockholm 1987. 130 pages.

A Swedish training material that has been translated to about 40 languages and promoted by the ILO. Generously illustrated, making use of checklists, questions for discussion, etcetera. Since its appearance in the mid 1970s, it has been used for the basic occupational safety and health training of more than one million workers, safety delegates, supervisors and other personnel in Sweden.

JE Thurman, AE Louzine & K Kogi: Higher Productivity and a Better Place to Work: Action Manual and Trainers' Manual. International Labour Office, Geneva 1988. 115 + 80 pages.

Practical ideas and advice for owners and managers of small and medium-sized industrial enterprises on how to take simple, effective, low-cost actions to raise productivity while improving workplace conditions. Checklists, rules and many illustrated examples. Published in English, French, Spanish and Portuguese.



K Kogi & T Kawakami: Positive Programme – Trainers' Manual for Occupational Safety and Health. Japan International Labour Foundation, 2002. 165 pages.

A trainer's manual with many photographic examples related to good solutions for materials handling, machine safety, workstation changes, physical environment, welfare facilities and environmental protection. The design and running of two kinds of training activities for workers and trade union members are described: a one-day seminar, and a four-day training course. Detailed suggestions are given related to objectives, key activities and methodology.

# Supervision and control

*Bernt Nilsson*

## THE HISTORY OF LABOUR INSPECTION SYSTEMS

Labour Inspection had its roots in the industrial revolution in Great Britain and then spread to Europe and beyond. In 1802, the British Parliament passed an act on the “preservation of health and morals of apprentices” but there was no real supervision until 1833 when the Government appointed four inspectors to supervise working hours. A Factory Inspectorate was set up in the middle of the 19 century. In Germany and France established an Inspectorate in 1870.

During the nineteenth century most European countries adopted legislation which reflected not only new developments in industry but democratic and social advancements. In 1890, representatives of 15 States, including Great Britain and Germany, attended a conference in Berlin which adopted the first international labour standards. It was affirmed that all states that adopted legislation on labour standards, should ensure supervision of such legislation by an adequate number of specifically qualified officers, appointed by government and independent of both employers and workers.

## THE PRINCIPLES

The International Labour Organisation (ILO) was created at the end of the First World War and its Constitution required all member States to set up a system of labour inspection. While two of its first international instruments dealt with labour inspection, i.e. Labour Inspection Recommendation 1919 (No 5) and Labour Inspection Recommendation 1923 (No 20) contained a number of basic principles of modern inspection, the instruments were non-binding.

At the end of the Second World War, work was completed on a new set of standards resulting in the Labour Inspection Convention 1947 (No 81) and associated recommendations (Nos 81, 82 and 85). The following principles formulated in these documents were very far-sighted and are still very relevant today:

- labour inspection is a public function
- there is a need for cooperation between labour inspection, workers and employers
- there is a need for cooperation between labour inspection and other institutions
- labour inspection is oriented to prevention
- universal coverage.

The first principle is that labour inspection is a public function and a government responsibility, which should be organised within the larger context of a state system in order to administer social and labour policy and to supervise compliance with legislation and standards. Labour inspectors should be accorded the status and independence of public officials, able to exercise their power impartially, free from undue pressures and constraints from outside the system.

The second principle concerns the necessity for close cooperation between the labour inspectorate, employers and workers. Such cooperation begins with collaboration between the labour inspectorate, government, employers and employees' organisations in the formulation of labour protection legislation and its application in the workplace. This type of collaboration presupposes the guaranteed participation of workers' representatives and a commitment by employers to their responsibilities.

The third principle concerns the need for effective cooperation with other institutions such as research organisations, universities, prevention and welfare services and experts such as doctors, engineers, chemists and psychologists. Labour inspectors need external cooperation and help to meet the complex technical and legal requirements of today's enterprises. While inspectorates are generally unable to have sufficient staff competent in all the relevant aspects of industrial technology, each inspector should have sufficient general knowledge in order to identify, understand and assess hazards and to call in specialists when needed, constituting a coherent supervision role.

The fourth principle relates to an increasing orientation and emphasis on prevention being adopted by labour inspectorates in an effort to avoid near misses, accidents and occupational diseases by assuring compliance with existing

legislation. This approach ultimately leads to the development of a culture of prevention which enables individuals to lead long and healthy lives to sustain productivity and quality. The vision is based on a holistic view aimed at avoiding technical, social, medical and psychological hazards.

The fifth principle pertains to the trend towards universal coverage as the work of labour inspectorates extend to the largest possible number of working people in all areas of economic activities and in workplaces. In principle, labour inspectorates should not accept that certain categories of employees are protected while others are excluded. In recent years a number of countries have extended their labour inspection services to sectors which have traditionally not been covered such as central government administration, the public sector, the armed forces and the self-employed.

The concept of labour inspection is further developed and described as part of a larger administrative system in the Labour Administration Convention 1978 (No 150) and Recommendation, 1978 (No 158). Ratifying states must organise an effective system of labour administration with coordinated functions and responsibilities and within this system consultation, cooperation and negotiations with employers' and workers' organisations must be secured.

ILO Convention 150 sets out the administrative functions of a labour inspection system including:

- preparation of legal instruments
- administration and coordination of existing labour inspection services
- monitoring and review of national labour policy
- preparation and implementation of laws and regulations
- handling various aspects of national employment policy and terms of employment

- regulating conditions of work and working life conditions
- service and advise to employers, workers and their organisations
- represent the state in international labour affairs.

ILO Convention No 81 (Labour Inspection Convention 1947) describes a system of labour inspection to ensure the enforcement of legal provisions relating to conditions of work and protection of workers in industrial and commercial workplaces. The provisions of the convention include:

- the organisation and functioning of inspection services
- the responsibilities of a central authority
- cooperation with other public and private services, and with employers and workers or their organisations
- the recruitment of sufficient numbers of qualified staff, both male and female
- material means and facilities (offices and transport)
- the thorough and regular inspection of workplaces
- the publication of reports and annual statistics on the work of the inspection services.

Inspectors are public officials who should be recruited with sole regard to their qualifications. They should be protected from improper external influences. Both men and women should be eligible for appointment.

Inspectors must also respect certain obligations. They are prohibited from having any direct or indirect interests in the undertakings under their supervision, they must not reveal manufacturing or commercial secrets of workplaces they inspect and must not reveal the source of any complaint.

Under Convention No 81 labour inspectors are entitled to certain powers including the power to:

- freely enter any workplace liable to inspection
- freely carry out inquiries, in particular to question people
- examine documents and take samples of materials and substances
- decide upon and order appropriate remedies for hazards at the workplace.

The numbers of inspectors should be sufficient to secure effective work in regard to the number of workplaces and employees. The inspectorate should also take measures to ensure that there are enough technical experts and other specialists to ensure a qualified enforcement of the legal provision.

By May 2004, 134 member states had ratified ILO Convention No 81 (Labour Inspection Convention 1947), which is a considerable coverage.

### THE ROLE AND SCOPE OF LABOUR INSPECTION

While fundamentally similar, the enforcement role of labour inspectors varies from country to country and may be broadly described as either generalist or specialist. The former describes a system where inspectors have a broad mandate to deal with a large diversity of matters related to work such as employment, wages, industrial relations issues, general conditions of work and safety and health. A specialist system is one that mainly deals with a specific labour inspection issue, usually occupational safety and health.

The general pattern of intervention also differs in the labour inspection services in various countries and may be broadly categorised as sanctioning systems or compliance models. Sanctioning systems, such as that used in United

States, are mainly concerned with punishable contraventions or violations of regulations whereas compliance models, such as that used in Germany, try to secure legal compliance using prosecution or the imposition of criminal or administrative penalties only as a last resort. In this case advice and consultation is used as the main method of intervention.

Furthermore there are some general groups of inspection services:

- The generalist model where inspectors have a wide range of responsibilities including occupational safety and health; hours of work; conditions for migrant workers; wages and illegal employment. They may also be responsible for industrial relations and conciliation services. Such generalist authorities are often centrally managed and directly under ministerial control. In addition to France, Portugal and Spain, most other French and Spanish speaking countries belong to this group.
- The Nordic Countries, United Kingdom, Netherlands, Ireland, New Zealand and some countries in Africa are examples of countries whose labour inspectorates operate principally for the enforcement of compliance of legislation on safety and occupational health but also on some regulations on general conditions of work. In several of these cases the government requires the inspectorate to be accountable to a bipartite or tripartite board.
- Inspection systems in countries with “federal states” are often characterised by a wide range of inspection responsibilities beyond occupational safety and health, e.g. hours of work and wages. Inspectorate functions are frequently delegated to regional government and authorities. Australia, Brazil, Canada, Germany, Austria, India, Switzerland and the United States are (to varying degrees), examples of this pattern.
- In addition to the principal labour inspectorate, there might also be a number of smaller and specialised inspectorates often providing services to specific industrial sectors such as mines, agriculture, nuclear stations, ports, harbours and railways. Other services may include specialist technical inspection for hazards such as radiation, explosives, pressure vessels or chemicals.

It is obvious that confusion can arise when different systems are discussed and compared because labour inspection covers a very wide range of duties which differ greatly from country to country. It is particularly important to keep this in mind when resources and competences are discussed and compared. To summarize, a labour inspection service is likely to be responsible for two or more of the following functions:

- occupational safety and health (including working hours)
- general conditions of work (including wages)
- industrial relations
- employment (including illegal employment and vocational training)
- social security matters (including compensation for accidents and diseases).

### **POLICIES AND METHODS**

As labour inspection systems are normally part of the general public administration of a country, the procedures and practices often reflect the predominant social, cultural and economic characteristics of that country.

However, despite administrative diversity, every labour inspection system must address a number of core issues: the setting of priorities through the assessment of risk; establishment of a balance between enforcement and advice; the effective application of sanctions; training of

inspectors and identification of effective inspection methods.

### Setting priorities

Inspectors must have defined principles to work by when they are setting priorities and deciding which sites will be inspected so that they can perform their duties in a consistent way that is not seen as arbitrary. A systematic knowledge of accident risks and ill health in different sectors is an important tool for deciding on priorities. High quality national statistics on occupational accidents and ill-health are indispensable. A register of enterprises and other inspection sites helps inspectors to target individual workplaces, especially if the register contains information about the safety and health situation, current supervisory activities and complaints.

There must also be a strategy to deal with demands for both proactive and reactive inspections. In many cases a lack of resources, (usually a shortage of inspectors), tends to generate a multitude of reactive inspections which greatly diminishes possibilities for successful priority setting. If the objectives of a labour inspection system are to be achieved it is vital to develop a defined programme with clear priorities, planned inspection campaigns and other activities aimed at problems, sectors of industry and specific sites.

### Enforcement

Every inspection service must decide on the balance between enforcement and advice when exercising their supervisory role. Convention No 81 gives equal weight to both approaches and there is no conclusive evaluation about the most effective method. Normally a mix of enforcement and advice is used, although it is important to bear in mind that an inspector has legal power and is not normally replaceable in this capacity.

In many countries there are other systems that can provide advice, e.g. safety and health services. No matter how the system is structured, it is important that there is a formulated principle on the subject so that a consistent approach is assured. It is also important that employers understand what is expected of them – compulsory requirements must be clearly distinguished from advice or guidance.

The scope of any inspection authority is to secure compliance with laws and regulations. The use of sanctions is central in such a system and generally follows the principles of the public administration in each country. While some systems invoke sanctions very readily when non-compliance is established, others give employers more time to take action following improvement notices. Most systems offer the possibility of prosecution when serious breaches of the law are established or when accidents have occurred. A general preventive effect may also be generated by reports from court cases regarding health and safety prosecutions published in mass media.

### Training

There is a wide range of training models for inspectors, as could be expected given the diversity of organisations and mandates for supervision. In the field of occupational safety and health, high quality training is essential if high quality enforcement is to be achieved. An important requirement is that a newly recruited inspector has experience from working life or gets such experiences as part of the induction training. The training of new inspectors can essentially be divided into three parts.

Firstly, inspectors must have knowledge of potential hazards in the work environment such as dangerous substances, noise, ergonomics, machinery, accident risks and psychological factors. An inspector should be able to identify and assess



risk factors at the workplace and to call for specialist assistance if necessary. Secondly, an inspector must have knowledge of relevant laws and regulations. The third crucial element needed for the formation of a professional and effective inspection service is training in the “art of inspection”. Such training would most likely include not only practical training in different inspection methods and formal procedures but also development of communication skills. Some larger, industrialised countries have special training institutes for inspectors while in other countries there may be special training departments within the inspection service. In many cases labour inspector training is organised as a combination of theoretical training and on the job training over one or two years.

### Inspection methods

All inspection services need a framework which establishes effective inspection methods. These methods, which should be evaluated and documented in manuals will form the common ground for training of new inspectors. In general the methods could be described as:

- Risk induced inspection, traditional “basic” preventive inspections based on a walk through of the establishment leading to a general assessment of the working conditions and resulting in detailed demands.
- Cause specific inspection targeted at defined problems like chemicals or noise, with the aim of identifying defects which are then corrected by senior management.
- Programme specific inspections which are part of a project or a campaign combined with information activities in massmedia.
- System specific inspections which target management arrangements for safety and health within companies.

- Incident induced inspections which could be initiated by an accident or a complaint.

### TRENDS IN LABOUR INSPECTION SYSTEMS

While labour inspection systems are generally well established in industrialised countries, many developing countries still face many difficulties such as a lack of resources, corruption, administrative shortcomings and war.

The International Labour Conference 90<sup>th</sup> Session 2002 Report of the Committee of Experts on the application of Conventions and Recommendations offers many examples of the situation faced by developing countries. In some cases inspectors have no free access to workplaces, while in others the legal system is ineffective or companies are not registered. Many countries have an insufficient number of inspectors and their training is poor or nonexistent.

Lack of economic resources is a common problem. Inspectors may have to resort to other paid activities to compensate for low salaries. Travel costs are not properly reimbursed and the available means of transport are minimal, in some cases just one car or motorcycle per country. Offices may also be unsuitable and poorly equipped.

In many countries self-employed workers in the informal economy comprise a large portion of the working population. Family businesses, other small enterprises and agriculture are dominant. The work environment is often bad, with hazardous machinery, heavy work, long working hours, hazardous chemicals and poor ventilation. Many children are exposed to severe hazards.

This situation is largely related to the economic and social situation of the country. There is no realistic possibility to solve these problems with inspection activities. However, with good political support Labour Inspection in combination with a clear legal framework can make a

big difference. Good training of inspectors and effective inspection procedures in combination with activities to increase the general awareness of work environment issues in society are of great importance.

To summarise, many inspection systems are facing important challenges:

- To change the fact that many inspection services have too few inspectors, insufficient training possibilities, low salaries and compensation and inadequate equipment.
- To develop integrated systems that would eliminate ineffective parallel activities. This may result in the elimination of separate inspection systems for safety and for health or it may be a dual system for both insurance inspection and labour inspection.
- To develop effective ways of working with small enterprises and the informal economy.
- To find ways to cooperate with important stakeholders such as union and employers' organisations in the area of work environment.
- To implement effective methods of inspecting the work environment management systems within companies.
- To train inspectors to handle "new" problems such as ergonomic risks, psychosocial risks and work related stress.
- To implement systems which generate relevant and trustworthy statistics on occupational accidents and diseases and effective ways of setting priorities and targets for inspection.
- To develop computerised registers of inspection sites.
- To find ways of using information to support inspection systems.
- To develop evaluation methods to monitor the effects and performance of inspection systems.

## SUGGESTIONS FOR FURTHER READING

The core ILO Conventions concerning Labour Inspection are:

- Convention No 81 (1947), concerning Labour Inspection,
- Convention No 129 (1969), concerning Labour Inspection in Agriculture
- Convention No 150 (1978), concerning Labour Administration

The following report offers many concrete examples of the current situation faced by Labour inspection in developing countries:

- International Labour Conference 90<sup>th</sup> Session, 2002, Report of the Committee of experts on the application of Conventions and Recommendations, Report III (Part A)

In the following ILO publication, written by Wolfgang von Richthofen you find a guide to Labour Inspection and its fundamental principles. It describes how major developments in the economy, the labour market and technology affect Labour inspection:

- Wolfgang von Richthofen, 2002. Labour Inspection – A guide to the profession. ILO.



# A global perspective on OSH

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# Introduction

*Christer Hogstedt & Tord Kjellström*

The first chapter of this section provides an overview of the major global economic and social driving forces behind the changing patterns of work and work hazards around the world. The term globalisation has been used in recent years to highlight the trend of accelerating trade, liberalised financial transactions, and market-based industrialisation in most countries in the world. The chapter describes the process from a number of points of view, analyses the mechanisms behind globalisation and highlights the risks and opportunities for OSH development at country and global level. It is hoped that readers will get a better understanding of the links between globalisation and OSH and the challenges that face OSH professionals and administrators when dealing with the impacts of globalisation.

Chapter 12.2 uses statistics and graphs to show how occupational injuries and diseases are associated with development. It reminds the reader that several major OSH hazards that are practically eliminated in developed countries, are still of importance in developing countries and can be exacerbated by globalisation. Globalisation has encouraged the rapid growth of new workplaces in developing countries. Case studies of OSH issues illustrate problems to look

out for and suggest sources of information on preventive methods with the aim of encouraging readers to seek out data and information and to develop an evidence-based approach to OSH practice.

Chapter 12.3 introduces various international institutional actors and stakeholders involved in the process of globalisation and have an impact on OSH developments. Many of the international agencies in this area have published strong statements on the need for protection of workers from OSH hazards and offer specific advice on how to achieve safer and healthier workplaces. The importance of collaboration between OSH professionals and the workers affected by OSH hazards is emphasized, and the benefits of collaboration among professionals in different countries are explored. Readers can find potential partners for OSH preventative actions at local level, or at least virtual partners via the Internet. The aim is to encourage policy development and local action that will counteract negative effects from globalisation on OSH, and take advantage of any positive opportunities for OSH enabled by globalisation and international cooperation.

# Globalisation and working life

*Christer Hogstedt & Tord Kjellström*

## THE CONCEPT OF GLOBALISATION

Previous chapters in this book have outlined various occupational health hazards and their potential effects. This chapter analyses the impact of work on health from a global perspective and within the context of globalisation using examples of typical hazard situations for different countries. Issues and problems concerning globalisation and OSH require high level policy solutions.

The Encyclopaedia Britannica describes globalisation as follows:

“A process of worldwide economic integration. Factors that have contributed to globalisation include increasingly sophisticated communications and transportation technologies and services, mass migration and the movement of peoples, a level of economic activity that has outgrown national markets through industrial combinations and commercial groupings that cross national frontiers, and international agreements that reduce the cost of doing business in foreign countries. Globalisation offers huge potential profits to companies and nations, but has been complicated by widely differing expectations, standards of living, cultures and values, and legal systems as well as unexpected global cause-and-effect linkages.”

It should be emphasised from the outset that globalisation and economic development can have both positive and negative impacts on the world of work, employment levels and conditions and the OSH situation. If the social dimension is properly taken into account, globalisation can be a positive force for social development and health. To achieve this would involve policies, regulatory and economic instruments for globalisation that ensure that:

- inequalities are lessened rather than amplified
- decent standards of living and working conditions are achieved
- population groups are not marginalized by the changing economy
- unemployment is reduced

The term “Progressive Globalisation” has been used by some to highlight the alternatives to a pure neo-liberal agenda for globalisation. The four cornerstones of the alternative progressive approach are: equitable global trade; regulation of global commerce; redistribution of global wealth; and democratic global governance.

The impacts of globalisation are often different in developing countries and industrialised countries and aspects that are positive in one country may be negative in another. Many com-



mentators consider that the main beneficiaries of globalisation are large multinational corporations while others say globalisation also leads to benefits for workers and the population at large. Globalisation is a process that creates many conceptual and practical challenges.

UNDP's Human Development Report of 1999, listed features of globalisation, emphasizing the systematic move towards deregulation, meaning less influence of government on enterprises and reduced specified protection of workers and the community from work hazards, environmental pollution and social impacts of enterprises. A stronger role for international agencies, particularly the World Trade Organization (WTO), is mentioned as a part of globalisation. This has led to greater influence over all countries by the dominant powers (governments and commercial enterprises), with important consequences for OSH, (explored later in this chapter). However, globalisation can lead to stronger international collaboration which can also lead to OSH improvements, when particularly hazardous processes or compounds are phased out or banned in more and more countries. Unfortunately, such bans are seldom implemented or enforced in developing countries, creating continued OSH problems, even when the hazardous workplaces are economically controlled from the industrial countries. The increasing role of unorganised flexible labour further undermines regulatory efforts in this area. Examples are plentiful; e.g. pesticides, solvents, and asbestos. Globalisation has been greatly facilitated by more rapid telecommunications and the Internet, which opens up new possibilities for sharing information and developing collaborative networks at grassroots level, but these benefits may take a long time to reach workers in poor urban and rural areas of developing countries.

Globalisation is also a process of expanding Western consumer culture into all parts of the world. This includes not only new work opportunities and work hazards, but also the car culture, food culture and leisure culture of the most affluent countries. Underpinning these developments is a growth culture, implying that economic growth above a certain percentage level is an absolute requirement for a good quality of life. Catching up on basic economic development is a must for the developing countries in order to achieve a decent standard of living, however, the economic growth need is different once a society has reached a relatively high level of economic development. The growth culture brings with it not only occupational health hazards, but also environmental health hazards and life-style hazards. Globalisation involves a number of public health challenges and occupational health professionals should play a strong advocacy role for policies that protect health.

A critical analysis of the phenomenon of globalisation, by the French sociologist Pierre Bourdieu, sees this term as "an idea, which has a social force and obtains belief", that like an axiom, nobody can deny or escape. It is the main weapon in the battles against the gains of the Welfare State that which he expects to be further eroded. Long working hours, weekend work, split shifts and other irregular working hours are being reintroduced as a part of flexible working conditions, a key aim of neo-liberalism.

Financial markets have become sensors for what is good and bad, and market forces primarily determine whether an enterprise, or a whole country, is able to maintain its activities. As has been shown at numerous times in recent years, these markets are often influenced more by emotion and gambling on future events than by the fundamentals of enterprise capital value and income generation. Bourdieu writes "the

### The challenges of the social dimension of globalisation

(source: World Commission on the Social Dimension of Globalisation, ILO 2003)

Globalisation is a term that is used in many ways, but the principal underlying idea is an increasing integration of economies and societies. It is driven by new technologies, new economic relationships and the national and international policies of a wide range of actors, including governments, international organizations, business, labour and civil society.

Broadly speaking, the process of globalisation has two aspects. The first refers to those factors - such as trade, investment, technology, cross-border production systems, flows of information and communication - which bring societies and citizens closer together.

The second refers to policies and institutions, such as trade and capital market liberalization, international standards for labour, the environment, corporate behaviour and other issues, agreements on intellectual property rights, and other policies pursued at both the national and international level which support the integration of economies and countries. In terms of the latter aspect, the existing pattern of globalisation is not an inevitable trend - it is at least in part the product of policy choices. While technological change is irreversible, policies can be changed. Technological advances have also widened the policy choices available.

The social dimension of globalisation refers to the impact of globalization on the life and work of people, on their families, and their societies. Concerns and issues are often raised about the impact of globalisation on employment, working conditions, income and social protection. Beyond the world of work, the social dimension encompasses security, culture and identity, inclusion or exclusion and the cohesiveness of families and communities.

Globalisation brings new potentials for development and wealth creation. But there are divergent views and perceptions among people as concerns its economic and social impact, and indeed widely varying impacts on the interests and opportunities of different sectors and economic and social actors. Some argue that the present model of globalisation has exacerbated problems of unemployment, inequality and poverty, while others contend that globalisation helps to reduce them. Of course, these problems predated globalisation, but it is clear that for globalisation to be politically and economically sustainable, it must contribute to their reduction. Hence the goal of a globalisation which meets the needs of all people.

neo-liberal ideologues want us to believe that the economic and social world is structured by equations”, which ignores the importance of a social and political will. A community may consider good health, social equity, democratic participation and environmental sustainability to be more important than mere economic growth and wealth creation. Such equations include a number of assumptions and limitations based on political and social ideas and guide priorities for

investments and decision-making about working conditions by banks, development agencies and commercial corporations. These priorities focus on short-term financial and employment gains, but the longer term consequences for health and the environment are generally overlooked. While globalisation is nurtured by these equations, OSH protection may suffer because of it. A powerful driving force for health protection would be created if global agreements on im-

proved OSH systems were incorporated into the equations.

These equations are an integral part of econometric models used to interpret, plan and fine-tune economic policies and actions at the macro level. They depict associations between national economic growth, interest rates, foreign exchange rates, government tax rates, unemployment rates, consumer price index and inflation, etc. In order to keep the inflation rate within predetermined ranges, actions are taken on other variables (e.g. the central bank interest rate). Important factors for OSH are the unemployment and tax rates. Low unemployment is seen as an indicator of a risk for inflation and when it goes “too low”, actions are taken to cool down the economy. Thus, a systemic unemployment of about 3–6% is maintained through these equations. Similarly, a high tax rate is deemed as a bad indicator for economic growth and the equations make governments mindful of the maximum level of tax that can be collected which in turn reduces the possibilities

for governments to meet the needs for old age care, health care, education and child care from taxation. Systemic unemployment and limited tax resources create health problems for the unemployed, makes workers and unions weary of demanding improved OSH conditions, and limits the ability of governments to improve their OSH services and health services in general.

Globalisation can also be defined as a set of processes leading to the creation of a world as a single entity, relatively undivided by national borders or other types of boundaries (cultural, economic etc.). This concept has important consequences for the role of national governments in globalisation, e.g. how to deal with a global health issue that transcends national boundaries and requires the involvement of a wide range of stakeholders to effectively address the issue. All around the world, communities, non-governmental organizations and other members of civil society need to formulate and implement preventive actions in conjunction with governments.

### Key elements of globalisation

#### *Economic driving forces:*

- liberalised *trade*, “free” trade
- liberalised *financial transactions* across borders
- reduced government sector, *reduced taxes*
- reduced government *regulations* (including OSH regulations)
- multinational enterprises *transferring jobs* to low-cost countries
- harmonisation of business systems to *Anglophone Western model*

#### *Cultural trends:*

- *car culture*: motor vehicles for transport, high energy consumption society
- *food culture*: “McDonaldisation”, more processed foods, more sugar, fat, energy-dense foods, centralised production and less local production, higher food transport costs (also called “coca-colonisation” with special reference to obesogenic environments and diabetes).
- *leisure culture*: tobacco smoking promotion by tobacco companies, alcohol, gambling, Western style TV and movies

To some degree, engagement in a truly global process has developed inside the anti-globalisation protest movement that had an important impact on the discourse at the Seattle World Trade Organization (WTO) meeting in 1999. Naomi Klein argues that the economic processes of globalisation, promoted by the WTO, excludes many people from the process and its proceeds create inequalities and “fences” that separate people from their legitimate participation in decision-making. True globalisation would bring people together, would create mechanisms to strengthen occupational health protection and improve the living standards for the poor. The protest movement has become the defenders of such values of global cooperation, and is therefore seen by Klein as the true expression of a globalised world.

The focus of the G8 meeting in Scotland in July 2005 was debt relief for the poorest countries, additional aid to Africa and global warming. Pressure from the protest movement on the world's richest countries to do something on these issues may have been one reason for the contents of the meeting agenda. A sign of a true global concern among the governments involved would have been another reason. The meeting was almost derailed by the terrorist attack on the London transport system, but the meeting went ahead as planned and the outcomes can be considered a reflection of positive globalisation.

The globalisation debate continues and the stakes are high. The literature about globalisation is divided along many lines:

- whether or not globalisation is occurring,
- the extent or speed to which it is happening,
- whether it is having positive or negative impacts on individuals and societies.

While this chapter primarily deals with issues specifically related to OSH, globalisation also

impacts on other aspects of economic and social development which may eventually impact on occupational safety and health.

### **ECONOMIC FORCES BEHIND GLOBALISATION**

Globalisation was initially seen as purely an economic force, the logical outcome of the elimination of barriers to capital movement and investment across borders, barriers to trade, and local barriers to enterprise. As indicated in the previous section, social and cultural forces are also important in globalisation, but the economic forces are those most amenable to international agreements and regulations. Economic forces can be seen both as a cause of and an outcome of globalisation. Economic growth in developed countries and expansion of the domain of multinational enterprises have created strong lobbying forces for making the globe into a single market (see Box). The International Monetary Fund (IMF) has underpinned this with demands on developing countries to “open up” their economies and provide opportunities for global businesses to enter into previously closed national markets.

Foreign direct investments, frequently cited as engines for growth, take place mostly between North America, Europe and Japan, which together, with China, receive more than 90% of foreign direct investments. The rest of the world, with 70% of the global population, receives less than 10% according to the International Union of Health Promotion and Education (IUHPE). Global income growth due to liberalized trade and investment was almost \$500 billion between 1995 and 2001 and was mainly accrued in wealthy countries.

Currently the globalisation process is not “global” in terms of trade and investments. Least developed countries, with 10% of the world's

people, account for 0.3% of the world trade, only half of their share two decades ago when the push to global trade first began in earnest. Trade issues that favour the wealthy countries, such as trade in services, intellectual property rights and global investment and competition policy, have resulted in action and agreements at the WTO but those favouring the less affluent countries, such as lower agricultural subsidies in industrialized countries, technology transfer, capacity building and debt relief, have not. Working conditions and OSH issues have also been sidelined in the WTO agreements.

The continued failure to reach an agreement on reducing the enormous agricultural subsidies in the USA, Europe and Japan has highlighted the reluctance of rich countries to “walk the walk” instead of just “talk the talk”.

A parallel development can be seen for macroeconomic objectives advocated by the IMF, including currency devaluation, public spending reduction, and tighter monetary policy. The World Bank’s policies, which followed the IMF measures, involve reducing the role of the state,

for example through privatisation and opening up of the economy. A major justification for these policies is the objective of creating stable economic conditions and making developing country economies more “competitive” and attractive for international investors. However, what is good for the investor is not always good for the population as a whole.

Economic development is an important driving force for improved quality of life, but it is increasingly understood that development needs to be built on sustainability and positive social development. The former was the focus of the Earth Summit in Rio in 1992 and the latter has been taken up strongly by ILO during recent years.

The term “wealth creation” is increasingly used in corporate reports and the media as a positive label for the accumulation of economic gains of the globalisation process. There is a problem when the wealth created is accumulated as share value in corporations or financial holdings of the industrialized countries with too little saved or made available for key infrastructure

### The “Washington consensus”

During the 1980s conservative economists in the US Treasury, the World Bank and the IMF developed an agreement on what constituted “good development policies”:

- liberalised financial transactions across borders
- less government interventions, reliance on market wisdom
- privatisation of government assets (e.g. telecommunications, water supply, electricity supply, public transport)
- free trade
- low inflation
- reduced government borrowing
- low proportion of GDP from aid or loans

These principles have become the foundation for globalisation to date, and are the focus of much of the criticism of globalisation.

such as housing and health services in developing countries. Wealth created by corporations and individuals in developing countries is too often transferred to banks in industrialized countries, a process made possible by liberalization of cross-border financial transactions. In addition, globalisation is linked to growth of intellectual property income from the use of technologies created in industrialized countries and new workplaces in developing countries will create wealth for multinational enterprises both through patents and through ownership of the new factories.

Multinational enterprises have grown in recent years to the extent that their overall market capital value is larger than the GDP of whole countries. The world's largest economies (countries and corporations with a value over \$ 100 billion) are listed in Figure 12.1.1. The Figure includes the total GDP of countries and the tax collected, and it is sorted by the tax collected nationally or the market capital value of the corporations. The largest corporations, such as General Electric, Cisco Systems and Exxon-Mobil, have a larger market capital value than the tax collected in industrialized countries like the Canada or Spain. Wealth is certainly created, but where does it end up, how is it applied to contribute to improved social and working conditions, and who is controlling the economic resources? The comparison of market capital value and GDP is not ideal as they represent different economic dimensions, but when the comparison is made with tax collected, the comparison reflects the power of economic decision-making of governments and corporate boards.

The corporations listed at the top positions in Figure 12.1.1 are mainly carrying out business in the areas of military arms systems (e.g. General Electric is a major producer of jet engines for military aircraft), electronics, oil, medical drugs,

computers, telecommunications and retailing. Major mergers and other changes in the corporate world change the position of different corporations in these lists over time.

Countries listed in this Figure with the largest economies are mainly from the OECD. Denmark has the lowest GDP of US\$ 162 billion, which would have been only barely larger than the largest corporation value in 1995. (N.B. the GDP numbers here are in actual US\$, which is different from the PPP\$ referred to in other parts of this chapter.) In the Figure we take into account the fact that the GDP figures include not only the turn-over of the various corporations, and also consider that government income and economic power in general is limited to the tax income. Total tax receipts are usually in the range of 30-40% of total GDP. Governments can assert control over the tax income based on democratic principles, where all citizens of voting age have an influence, however, corporate boards are controlled by their share-holders, and in reality often by a very small group of people. There is no direct democratic input from the population into what the corporations do.

The 20 countries included in the Figure 12.1.1 have a combined GDP of US\$ 27 trillion, which is about two thirds of the global GDP of US\$ 40 trillion. The total tax revenue in these countries is about US\$ 8 trillion, while the combined market capital value of the companies in the tables is about US\$ 6 trillion.

Another economic force of globalisation is the constant seeking of a "competitive edge" by countries and trans-national corporations. This may lead to an obsession for the creation of new products and services to sell, rather than a strengthening of social systems and an improved quality of life. The share of the national GDP or wealth that is devoted to social support, publicly provided health services, education, and other



Rank (according to column c)	Country company	a. GDP total	b. Tax collected (%)	c. Tax revenue or market capital value
1	United States	10,065	30	2,979
2	Japan	4,141	27	1,122
3	Germany	1,846	38	700
4	France	1,310	45	593
5	United Kingdom	1,424	37	533
6	General Electric			477
7	Italy	1,089	42	457
8	Cisco Systems			305
9	Exxon Mobil			286
10	Pfizer			264
11	Microsoft			258
12	Wal-Mart stores			251
13	Citigroup			250
14	Canada	695	36	249
15	Vodafone group			227
16	Intel			227
17	Royal Dutch/Shell			206
18	American Int. Group			206
19	Spain	582	35	205
20	Nokia			197
21	Merck			196
22	Oracle			182
23	BP			178
24	NTT DoCoMo			175
25	SBC Communications			175
26	China	1,159	15	174
27	IBM			164
28	GlaxoSmithKline			160
29	The Netherlands	380	41	157
30	EMC			156
31	Verizon Communications			148
32	Coca-Cola			143
33	HSBC Holdings			141
34	Johnson & Johnson			135
35	Toyota			124
36	Novartis			123
37	BristolMeyersSquibb			123
38	Home Depot			120
39	NTT			117
40	Australia	369	32	116
41	Mexico	618	19	115
42	Sweden	210	54	114
43	Nortel Networks			113
44	Rep. of Korea	422	26	110
45	Belgium	230	46	105

Figure 12.1.1. Countries/companies ranked by *tax revenue or market capital value* (US\$, 2001).

Source: OECD and UN statistics.

public services is reduced or restricted in order to make the economy more investment friendly or more competitive. This is an inherent character of globalisation, and is based on an economic model that favours pure markets over development with safeguards for community needs and basic infrastructure. The “structural adjustment” policies (SAPs) of the IMF have been used as tools to achieve the pure market model of globalisation, particularly when dealing with ailing economies of less affluent countries. SAPs have also been applied as entry requirements to the European Monetary Union (EMU). The SAPs have led to cuts in public services and their applications without appropriate safety nets undermine efforts to improve public health.

Globalisation can also be viewed as a process of dividing labour between affluent countries, which continue to maintain and develop their science and knowledge-based industries while the more menial production tasks are carried out in the less affluent countries. Increasingly, new jobs in developing countries are in service industries, such as data entry and processing centres, and phone call centres. These types of jobs are not associated with the risks of heavy industry, but they come with other hazards such as musculo-skeletal damage in the form of repetitive strain injury, or various forms of work stress.

The globalisation process is facilitated by lenient occupational and environmental quality standards and lax levels of enforcement in less developed countries. Capital for investment in production industries will move to the country with the lowest costs, usually the country with the least protection for health and the work environment. Media reports have identified this process of corporate flight as a new problem for Mexico. Because their membership in NAFTA has encouraged more health protection in the work environment in Mexico, manufacturing

has moved to other developing countries with less costly regulatory environments. Some corporations that moved their production facilities from the USA to Mexico for cost reasons, are now moving from Mexico to countries with even lower costs (e.g. China). When corporations move to other countries, the health and social costs for the workers, are seldom quantified or considered.

### TRADE, WTO AND OSH

Increased trade, based on the principle of each country using its competitive advantages, is a key element of globalisation. To achieve this, free trade or trade unimpeded by duties, quotas, subsidies or non-tariff trade barriers, is a requirement according to the organizations facilitating globalisation. A number of multi-lateral and bi-lateral trade agreements have been established for this purpose. Agreements between relatively equal partners can be of substantial economic benefit, but developing countries cannot be considered as equals in these negotiations.

Multilateral free trade agreements have been developed throughout the world during the second half of the 20th century. These agreements aim to facilitate international trade by lowering or removing trade barriers. If these agreements incorporate related social issues such as working conditions, they may help to advance occupational safety and health. On the other hand, trade agreements that ignore labour standards may have a negative impact.

The European Union (EU) has paid attention to occupational health and safety in its efforts to develop the social dimension of working life. A comprehensive Framework Directive, on the minimum requirements for health and safety at work has been approved and supplemented with some 16 special directives. General duties placed upon the employer include duties of awareness,

duties to take direct action to ensure safety and health, duties of strategic planning to avoid risks to safety and health, duties to train and direct the workforce, duties to inform, consult and involve the workforce, and duties of recording and notification.

The North American Free Trade Association (NAFTA) of the USA, Canada and Mexico has initiated a programme for occupational health and is planning to improve the collection of information, research, and the training and education of experts, workers and employers within the framework of the new Association. However, a web-search for “NAFTA and occupational

health” easily identifies some dubious occupational safety and health features of NAFTA.

The Subcommittee on Social Security and Occupational Safety and Health within the Employment and Labour Sector (ELS) of the Southern Africa Development Community (SADC), was established in 1996 to promote employment and productivity, and harmonize labor and social protection. The Subcommittee plans to implement the Codes on the Safe Use of Chemicals and HIV/AIDS in the Workplace, as well as monitoring OSH activities in the region, harmonization of social security schemes

#### **Case studies on WTO rules and linkage with international guidelines.**

Source: WTO/WHO, 2002

Two cases of trade versus health illustrate how the various rules and regulations can interact. In one case the US Environmental Protection Agency had regulated that, in the most polluted areas of the country, only gasoline of a specified purity could be sold in an effort to reduce urban air pollution from motor vehicles. Refineries had to comply if they started up new production, and imported gasoline had to comply with the regulation. Venezuela and Brazil complained to the WTO that this was interfering with their exports of gasoline to the USA. After much legal and technical wrangling and an appeal, the conclusion by the WTO was that the regulation amounted to unjustified discrimination and to a disguised restriction of trade. Thus, imported gasoline that pollutes air in vulnerable areas cannot be stopped at the border.

Another case was the decree banning asbestos use in France as well as imports, exports and production. Canada challenged the decision based on the argument that controlled use of asbestos would reduce the health risk to an acceptable level. The case at the WTO was argued by the EU on behalf of France. The WTO panel concluded that the French ban was allowed, because the health risk was substantial. Canada appealed, and the WTO Appellate Body confirmed the previous ruling and concluded:

- WTO Members have an undisputed right to determine the level of health protection they deem appropriate.
- There is no requirement to quantify the risk to human life or health.
- The ban was considered essential because the alternative of controlled asbestos use, proposed by Canada, was not demonstrated to be practical.

These are important concepts for OSH and could be used as arguments for stopping trade in other health-damaging products or practices. The key to success is that there is no discrimination of imported products versus domestically produced products.

and the development of training institutions in the relevant fields.

The World Trade Organization (WTO) has a very strong influence on OSH practice in developing countries as it can influence the acceptable level of preventive practice through trade rules and their enforcement. The priority for the WTO is to promote free trade and any national rules or regulations that appear to be non-tariff trade barriers can incur economic sanctions. For instance, if the government of Viet Nam decides to severely restrict the use and importation of benzene-containing glues, a country that would like to export such glues to Viet Nam, can protest if an international ban is not in place. If Viet Nam maintains its ban, it can be reported to WTO by the exporting country. If WTO concludes that the ban was not needed for human health protection reasons, Viet Nam can be penalised by special tariffs on its exports to the other country.

The WTO rules mean that a country can only ban or restrict the use of a hazardous chemical compound or process if an internationally agreed guideline from WHO, ILO or another international agency clearly advises of such bans or restrictions (see Box). This results in great difficulties for any individual country wishing to go beyond the internationally agreed guidelines for worker protection. As international agreements always involves compromise, it means that occupational health and safety standards will be eroded in countries with advanced policies in this area (e.g. Sweden), while developing countries that lack OSH policies will be limited to internationally agreed minimums.

### **SOCIAL AND HEALTH DEVELOPMENT**

The social impact of globalisation includes a risk of increased inequity of income distribution and lack of societal investment in health services (in-

cluding occupational health services), education, social services and community infrastructure (e.g. drinking water and sanitation). The annual Human Development Report of UNDP provides excellent descriptions of the impacts of globalisation on social development and highlights different aspects of these social issues each year.

The 2001 Human Development Report stated that as many as 1,200 million people live on less than 1\$ a day (1993 PPP US\$), 2,800 million on less than \$2 a day and the richest 1% of the world's people (60 million) received as much income as the poorest 57% (3,500 million). Furthermore, in 1998, the world's richest 200 individuals had a combined net wealth surpassing the world's poorest 2,500 million people.

The resources controlled by the richest people are enormous compared to the needs of the poor. A modest 1% tax on the assets of the world's wealthiest 200 persons would fund primary education programs for all of the world's children currently lacking such access. Another sign of this distortion of resource allocation is the lack of spending on health research that benefits the poor. Out of US\$56 billion spent by the public and private sectors on health research, only 10% is devoted to tackling the diseases and conditions of the poor that account for 90% of the global burden of disease. Most of the research funds are spent on fine-tuning treatment of the diseases of affluence in developed countries.

In order to address health and social deprivation issues, a meeting of the United Nations in Mexico in 2001 developed the "Millennium development goals" for poverty reduction, Figure 12.1.2. The question is whether globalisation will actually take countries towards the development goals or not.

There are also goals concerning the provision of water and sanitation, education and commu-

Goals	Achievements	Unfinished path
1. Halve the proportion of people living in extreme poverty.	– Between 1990 and 1998 the proportion of people living on less than \$1 a day in developing countries was reduced from 29% to 24%.	– Even if the proportion is halved by 2015, there will still be 900 million people living in extreme poverty in the developing world.
2. Halve the proportion of people suffering from hunger.	– The number of undernourished people in the developing world fell by 40 million between 1990-92 and 1996-98.	– The developing world still has 826 million undernourished people.

Figure 12.1.2. Two key millennium development goals for 2015.

nicable disease control. While these goals do not directly touch upon working conditions, if they were achieved by 2015, they will create better living conditions for many of the poorest people who are most affected by hazardous working and living conditions. The lack of specific goals for working conditions and OSH reflects a notion that OSH hazards contribute only a minor part of the global burden of disease and injury - this may well be an erroneous assumption. There is also an idea that adult health is less important than child health, probably based on the notion that adults can look after themselves. However, workers affected by working environment hazards are often powerless to change their conditions, and ultimately, the health of parents will influence the health of their children.

The UNDP Human Development Index, HDI, is measured by combining life expectancy, educational attainment (adult literacy and combined primary, secondary and tertiary enrolment) and adjusted income per capita in PPP US dollars. In most of countries the HDI is improving, but in a number of developing countries' HDI went backwards during the 1990s, Figure 12.1.3.

On average for the whole world population a child born today can expect to live eight years

longer than one born 30 years ago. Many more people can read and write, with the adult literacy rate having increased from an estimated 47% in 1970 to 73% in 1999 (UNDP data). This type of analysis based on global averages hides the underlying inequalities and the trends for the rich to get much richer and the poor to get a little bit less poor.

In the least developed countries, the situation is appalling. For instance, Sierra Leone has been ranked last in the HDI list for several years. A child born there, has a 50% probability of dying before reaching the age of 39, and only 32 percent of the adults can read. The bottom 28 countries on the HDI ranking list are all in Africa. The epidemic of HIV/AIDS has compounded the social problems caused by poverty, as millions of children become orphans and many in the working age groups succumb to the disease.

It is sometimes argued that improved health and life expectancy is primarily a question of encouraging economic growth in order to improve the GDP per capita. However, if the countries are split into regions according to development level, as has been done by the World Bank, the relationships between GDP and health development become even clearer. The industrial

countries have a very small increase of life expectancy in relation to GDP, while developing countries have a steep increase.

Economic development provides resources for better nutrition, housing, health care, family planning, etc., including preventive health activities and OSH programs. However, these activities to support health do not get initiated and maintained without sufficient financial resources under government control, enlightened decision-making by governments and resource allocations towards services for the poor.

There are social impacts imposed by limitations on how much of the national resources are applied to public services and how income is distributed within society. Impacts include lower quality working environments and the resulting health hazards and consequences. Limited

resources and wealth redistribution are exactly what current globalisation processes entail.

Globalisation may create new economic opportunities in less affluent countries, but the fruits of these opportunities are not always leading to an improved quality of life for those working in the new workplaces.

As Loewenson points out, while new formal employment opportunities have been developed in Africa, many others have been lost. New processes and forms of work organization have introduced chemical, physical and psychosocial work hazards unfamiliar to the workers and often to their supervisors as well. New jobs tend to offer few advancement opportunities, as the poorest countries have to accept the low-skill, low-technology production that is of least interest to the affluent countries. In addition, increas-

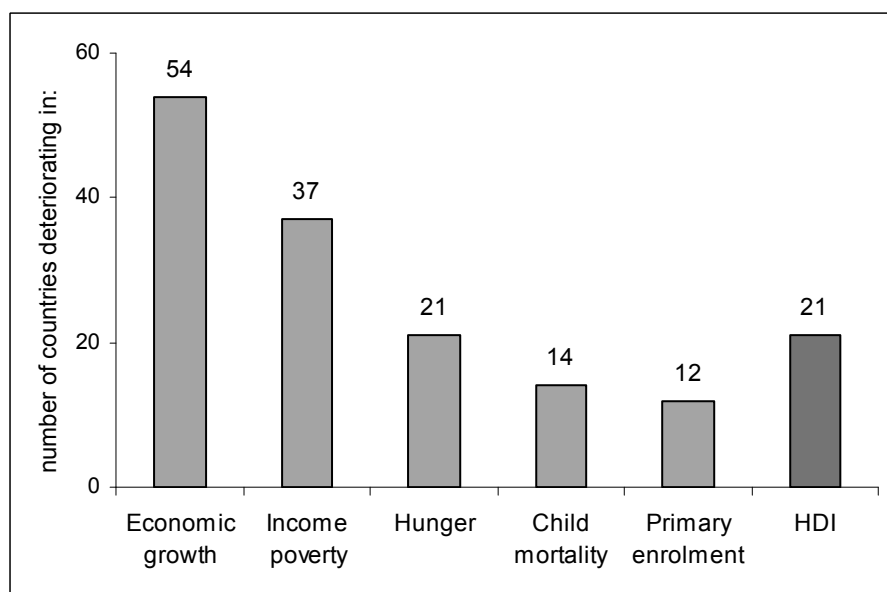


Figure 12.1.3. Lack of progress in achieving Millennium Development Goals. Number of countries going backwards instead of forwards during the 1990s. Source: UNDP.



es in productivity, often obtained by increasing the pace and intensity of work and the workload, have increased occupational health problems, such as musculo-skeletal problems and stress-related problems. The economic forces can create more inequity in the world, between countries and between the haves and have-nots within countries, and can undermine OSH. Globalisation needs to incorporate policies that shield the workers from these negative forces if it is to contribute to positive social development.

The above concerns about OSH and the social impacts of globalisation are of particular importance for women workers. Many of the new workplaces created as a part of globalisation, primarily employ young women. This may be because young women are least likely to join trade unions and present collective demands for improved working conditions. Women also have low social ranking and can easily be hired and fired without too much fuss. Discriminatory practices, such as pregnancy testing, and poor provision of infra-structure and services for the women workers have been common concerns. Another high-risk and vulnerable group is children. While gender discrimination cannot be said to be an inherent feature of globalisation, globalisation can definitely increase its impact if the social dimensions are not properly incorporated.

### **GLOBAL WORKFORCE AND WORK ORGANISATION TRENDS**

As the world population has increased, so has the workforce, and OSH is of importance to more people than ever. In 1960 the world population was 3.0 billion, which had increased to 6.1 billion by the year 2000. The median estimate for 2050 is a population of 8.9 billion, but the population may be in the range 7.4 to 10.6 billion depending on the developments of fertility

rates in developing countries according to UN statistics. If current fertility rates remained, the world population would have reached 12.8 billion by 2050, which is at least 2.2 billion more than the most pessimistic current estimate by the UN. The good news is that it seems that the global population explosion has been significantly defused by family planning programs, education of women, and socio-economic development leading to fewer children per woman.

The potential workforce is often estimated as the proportion of the total population that is in the age range 15-59 years. The changing demographics of the world means that this proportion is increasing in developing countries, while it is decreasing in industrialised countries; in the former the size of the child population has been large and is diminishing, while in the latter, the size of the elderly population is rapidly increasing. Many people outside this age range are in fact actively working, and the participation of women in the employed workforce has increased over the years in most countries, depending on social, cultural, religious and other reasons. In addition, the age group above 60 years of age includes a considerable proportion of working people in many countries, while the 15-19 year olds are increasingly continuing with education.

In traditional societies, all able-bodied people participate in family and community activities required to maintain and build their community. Work is not isolated from other aspects of daily living, such as child rearing, cooking, and other family activities. Work is limited to what is necessary for survival and consolidation of the community. Many people in developing countries are still living in conditions similar to these, and quality of life is measured differently to the quality of life in affluent countries.

OSH hazards can be of great importance to the health of these people, but they are often

ignored by health authorities because the concept of work is not applied to their activities, e.g. subsistence agriculture. Globalisation brings industrial development and new structures of employment to traditional agricultural societies, which may further exacerbate the division between work and other family and societal activities.

This economically active population (EAP), is described by age and sex group in the ILO Yearbook of Labour Statistics and in the online ILO LABORSTA database. Of the 3.0 billion people in the world in 1960 (0.9 + 2.1 billion, Figure 12.1.4, 1.4 billion were considered economically active (0.41 + 0.97), and in 2000 these numbers had increased to 6.1 billion and 2.9 billion, respectively.

Thus, approximately 45% of the world's population, and 58% of the population over 10 years of age, is considered as belonging to the global "economically active population", i.e.

approximately 60 % of the male and 40 % of the female population of the world, Figure 12.1.5. The "activity rate" measures the proportion of the total population that is involved in "economic activities". According to ILO statistics it has increased slightly (from 45 to 49%), but more important changes have taken place at the end of the age spectrum for men and in the middle age range for women. The activity rate among men has gone down considerably below 25 years of age and above 50 years of age during the last few decades, while among women there has been a significant increase of the activity rate from 60 to 70 %, in the age range 25 to 60 years.

One of the key differences of activity rates between industrial and developing countries is the very high activity rate among children and young people in developing countries. In industrial countries the activity rates for children under age 15 is now almost zero, and one can assume that almost all of them are attending

Year	1960	1970	1980	1990	2000
<b>Industrialized countries, total population</b>					
Both sexes	916	1008	1083	1148	1191
Men	440	486	524	558	579
Women	477	522	559	591	612
<b>Industrialized countries, economically active population</b>					
Both sexes	410	463	523	566	601
Men	258	280	305	320	332
Women	152	182	218	246	269
<b>Developing countries, total population</b>					
Both sexes	2104	2683	3347	4106	4865
Men	1070	1365	1705	2091	2472
Women	1033	1317	1642	2015	2394
<b>Developing countries, economically active population</b>					
Both sexes	966	1192	1528	1932	2347
Men	616	750	945	1181	1415
Women	350	442	583	751	931

Figure 12.1.4. Total population and economically active population (in millions) in more and less developed regions. Source: ILO statistics.

Year	1960	1970	1980	1990
<b>Industrialized countries, men</b>				
Agriculture	23	16	12	10
Industry (total)	42	45	44	41
Industry (manufacturing)			28	26
Services, etc.	35	39	44	49
<b>Industrialized countries, women</b>				
Agriculture	31	19	12	8
Industry (total)	26	28	27	24
Industry (manufacturing)			23	20
Services, etc.	43	53	60	68
<b>Developing countries, men</b>				
Agriculture	73	67	61	57
Industry (total)	11	14	17	18
Industry (manufacturing)			11	12
Services, etc.	17	19	22	25
<b>Developing countries, women</b>				
Agriculture	82	78	73	67
Industry (total)	7	8	11	13
Industry (manufacturing)			10	11
Services, etc.	11	13	16	20

Figure 12.1.5. Proportion of economically active population in industrialized and developing countries in different sectors, per cent. Source: ILO statistics.

school. The rate for 15-19 year olds has also decreased from about 50% to 30% since 1960. In less developed regions reductions of the rates are also taking place, but more slowly. Child labour is an important factor in these trends.

Major changes in composition of the workforce, analysed by the type of economic activity have taken place during recent decades accelerated by economic globalisation during the 1990s. Agriculture has been, and still is, the primary workplace for the majority of people in the less developed countries, Figure 12.1.5. Health hazards of traditional agriculture include vector-borne diseases, injuries, and increasingly, pesticides poisoning. Other primary industries, such as mining and forestry, have developed at the early stages of industrialization and these are

also industries with high risks for occupational injuries and diseases.

Figure 12.1.5 shows that by 1960, the more developed regions had a workforce structure that emphasised industry and services, while the less developed regions had not been able to come close to that type of workforce structure by 1990.

At an early stage of industrial development workforce change is characterized by rapid growth of manufacturing, construction and transport industries. Industrialisation comes with increasingly sophisticated technologies, which bring new OSH hazards. Globalisation has led to a shift of manufacturing from the affluent to the developing countries with concomitant shifts in workforce composition. OSH programs that

build on the knowledge accumulated from the use of the new technologies are needed to protect workers from a variety of hazards.

Injuries, exposure to physical and chemical agents, and an increasing pace of work are the main problems in manufacturing industries, while pesticides, organic dusts, heavy physical work, biological factors and injury hazards are the principal occupational health burdens for agricultural workers. As mentioned earlier, the negative aspects of globalisation can make these trends worse for workers in developing countries. A number of case studies show that in the worst conditions, 50-100% of the workers in some hazardous industries in developing countries may be exposed to levels of chemical, physical or biological factors that exceed the occupational exposure limits applied in industrial countries.

The latest wave of change also includes major growth of service industries, again accelerated by globalisation. This is very evident in the more developed regions and is now an emerging trend in the less developed regions. The consequence for the latter countries is that old occupational health problems persist, at the same time, new hazards have also emerged causing a double burden. During the last decade many administrative functions that used to be based in the home country of corporations, e.g. accounting, call-centres, and data management, have been outsourced to subcontractors in developing countries. This move provides local employment for people trained in IT and related fields and these workplaces may be seen as rather benign from an OSH point of view. However, new hazards such as certain musculo-skeletal disorders and stress-related diseases develop.

An important cause of stress among the working population is the trend, associated with globalisation, towards more flexible work

organization. What is most efficient from a micro-economic point of view, may lead to social and health impacts in the form of stress or reduced feelings of wellness, satisfaction and achievement. If workers have less job security, are forced to change work schedules at short notice, are paid according to output even if the working conditions limit their ability to produce, etc., stress may cause serious mental and physical health problems. The reduced influence of trade unions in recent decades has contributed significantly to these developments. Many corporations and governments have made efforts to limit trade union membership and involvement in work organization and OSH matters. The result is a workplace environment where individual rather than collective concerns and actions are emphasized. Competition rather than collaboration is the basis of daily life. The winners are given privileges and higher salaries, and are hailed as examples for the majority to emulate, the majority being defined as losers earning lower incomes and told to try harder. Job loss becomes a more frequent crisis as restructuring and downsizing is carried out to protect shareholder value. In fact, the share prices of corporations invariably rise after announcement of substantial reductions of the workforce. Unemployment has become a normal occurrence as macro-economic models build in a 3-6% unemployment rate as ideal. If this level drops, there are worries about inflation. The social and health impacts of any unemployment need to be built into economic models in order to take full account of the costs to society.

At country level, the proportion of the population that is economically active and the distribution according to sector can change dramatically over time due to the general economic situation influenced by globalisation forces. Unemployment varies in conjunction with these

**Workforce changes in Thailand in conjunction with the Bhat crisis in 1997.**

Source: Stiglitz 2002

In the early 1990s the government of Thailand was encouraged by the IMF (International Monetary Fund) to liberalize its financial sector and make the local currency, the Bhat, freely convertible on international financial markets.

In 1997 investors suddenly lost confidence in the Bhat and the currency value fell rapidly. Thai companies, dependent on foreign exchange, had to pay much more for it. Some companies could not pay back their loans, and general economic difficulties emerged that led to employers shedding staff (down-sizing) and increased unemployment. The number of employed was reduced for the first time in many years see Figure 12.1.6. For men in the construction industry, the loss of employment from 1997 to 1998 was particularly dramatic, with approximately one third of workers losing their jobs. Figure 12.1.6 indicates that many of men who had been working in construction or manufacturing, went back to agricultural work, where they had been working in earlier years. Women appear to have been less affected than men, but the growing trends of women's employment in the manufacturing and trade sectors were reversed in 1998.

changes. An example is the dramatic changes in Thailand, where in 1997 the liberalisation of capital markets made it easy to exchange Bhat with other currencies and led to an attack by financial market players. The value of the Bhat plummeted, banks and manufacturing firms rapidly experienced great difficulties so workers lost jobs which in turn impacted on their families.

A root cause of such dramatic changes often appears to be premature liberalization of the financial sector and foreign exchange regulations in a country, moves encouraged by the IMF to stimulate economic growth. Such liberalisation is one of the pillars of globalisation action by countries that aim to attract foreign funds for investment. The downside is that the foreign capital can be withdrawn at short notice if investors lose confidence, resulting in the currency rapidly losing value in relation to the major international currencies. Investors can engineer a crisis of confidence in order to make fast money on so-called short selling. For instance, in the case of Thailand, it means that someone borrows Bhat, sells them to get dollars, and then

pays back the Bhat after the currency has fallen in value so that much fewer dollars are needed to pay back the loan. A person in a position to spread negative rumours can make big profits in this way. Someone has to pay for these profits and in this case Thailand and its people suffered the economic consequences.

It should be remembered that in the least developed countries the major part of the workforce is still working in agriculture, other types of primary production or in small-scale industry and service enterprises. These workers face different occupational health problems from those experienced in the industrial countries. In the least developed countries, occupational health hazards are aggravated by numerous non-occupational factors such as parasitic and infectious diseases, poor housing conditions, sanitation, and nutrition, as well as general poverty and illiteracy.

**EXPORT PROCESSING ZONES**

Export processing zones (EPZs) are an important feature of globalisation, intended to attract

Variable	1990	1995	1997	1998	1999
<b>Men, total (%)</b>	<b>16.5 (100)</b>	<b>17.8 (100)</b>	<b>18.1 (100)</b>	<b>17.7 (100)</b>	<b>17.7 (100)</b>
Men, Agriculture (%)	10.4 (63)	9.0	8.9	9.2	8.8 (50)
Men, Manufacturing (%)	1.6 (10)	2.2	2.2	2.1	2.2 (13)
Men, Construction (%)	0.9 (5)	1.5	1.6	1.1	1.1 (6)
Men, trade and hotel services (%)	1.4 (8)	1.9	2.2	2.1	2.2 (13)
Men, Personal services (%)	1.5 (9)	2.1	2.1	2.2	2.3 (13)
<b>Women, total (%)</b>	<b>14.4 (100)</b>	<b>14.8 (100)</b>	<b>15.0 (100)</b>	<b>14.5 (100)</b>	<b>14.4 (100)</b>
Women, agriculture (%)	9.3 (65)	7.9	7.7	7.2	6.7 (47)
Women, manufacturing (%)	1.6 (11)	2.2	2.1	2.1	2.2 (15)
Women, Trade and hotel services (%)	1.6 (11)	2.2	2.4	2.4	2.5 (17)
Women, personal services (%)	1.6 (11)	2.1	2.2	2.4	2.6 (18)

Figure 12.1.6. Recent workforce changes in Thailand. Number of employed people (millions).

Source: ILO statistics.

foreign investment for production facilities that process imported materials into final exported products. Depending on their purpose they have been called various names, such as free trade zones, special economic zones, bonded warehouses, free ports, and maquiladoras (primarily along the US-Mexico border). In many cases key aspects of working conditions and OSH are specifically excluded from EPZs. An ILO list of priorities for improving social and labour conditions in the EPZs highlights the problems that may arise:

- *Labour standards*: internationally or nationally established standards for work hazard exposures should be applied to EPZs and strongly enforced

- *Labour-management relations*: the right to join a union and for the union to be actively involved with working conditions should be applied in EPZs. Collective bargaining and tri-partite negotiation mechanisms should be established.

- *Human resources development*: general education and job skills training should be a key aspect of EPZ operations, in order to broaden the future job opportunities for workers and to upgrade the level of production towards more advanced technologies. This includes retraining of workers as production methods change.

- *Wages and working conditions*: remuneration packages should be fair and contribute to an improved living standard for the workers. Working hours is a particular problem to monitor to



ensure that excessive demands are not created on the workers. This is of particular importance for women. Safety issues concerning night-work need to be resolved. Another issue in tropical countries is the impact of extreme heat on workers.

– *Social infrastructure*: this includes adequate and sanitary accommodation, safe and reliable transportation, educational and recreational facilities, health centres and childcare facilities. In addition pension and other social security measures should be provided in order to stabilize the EPZ work force.

These zones are an important aspect of Foreign Direct Investment and they have grown in number, Figure 12.1.7, and taken on more and more diverse economic activities in recent years. EPZs started as assembly factories and labour-intensive processing plants, benefiting from low salaries in developing countries, however, more recent zones include finance operations, technology and science centres, logistics and transport centres, and tourist resorts.

An analysis for China using ILO statistics shows the impact that the EPZs may have on the workforce distribution. Between 1990 and 2000 the economically active population in China increased by about 80 million people. The industrial manufacturing sector in China had 83 million economically active people employed in 1999. The 30 million people in EPZs, Figure 12.1.7, amounts to about one third of the ten

year growth in employment in China or a third of the whole industrial manufacturing workforce. The EPZs are clearly key components of the globalised labour market, and the OSH conditions in these zones is greatly important for workers health.

The effect on employment of the EPZs in China and other Asian countries, has created new job opportunities for millions of young women, who through these jobs get an entry to the formal job market with better wages than in agriculture or domestic service. However, poor work environment and work practices have been a common concern. This has included lack of proper accommodation for women workers, and the creation of social ghettos in barrack style living quarters. Pregnancy testing to avoid employing women who will need maternity leave, is another aspect of gender discrimination. Framework agreements between a few multinational corporations and international union federations have played an important role in dealing with these negative factors and in upgrading the working conditions. As the EPZs evolve from basic manufacturing and assembly work to more high-tech production and services, more men have been employed in the EPZs. Upgrading of the production in the EPZs is a key to improving the working conditions and occupational health services for workers.

Both the positive and negative aspects of EPZs have been widely discussed in recent years.

Item / Year	1975	1986	1995	1997	2002
Countries with EPZs	25	47	73	93	116
Number of EPZs	79	176	500	845	3000
Total employment in EPZs (millions)	n.a.	n.a.	n.a.	22.5	37
– of which, China	n.a.	n.a.	n.a.	18	30
– other countries	n.a.	n.a.	n.a.	4.5	7

Figure 12.1.7. ILO estimates of the development of export processing zones (= EPZ). Source: ILO statistics.

For instance, a report by a South African NGO, the International Labour resource and Information Group suggests that four countries surveyed (South Africa, Zimbabwe, Tanzania and Namibia) had enjoyed little benefit. A number of potential EPZ sites had been identified in the countries, but few were actually operational and the cost per job created was extremely high. In Zimbabwe less than half of 138 planned EPZs are operational. In Namibia, 25 000 new jobs were predicted, but in fact only 370 were in place. In Tanzania only 500 of 7 000 expected jobs had materialized. The report concludes that export oriented industrialisation strategies are wrong for the African region, and these have created a race to the bottom as some countries competed with each other by lowering taxes and relaxing labour laws. This orientation risked keeping the economies of African countries underdeveloped, by encouraging the export of dominant raw materials.

A similar critique of EPZs in Eastern Europe, points out that these zones are growing rapidly in the former Soviet Union states. These zones are free of taxes, pay low customs duties, and

have flexible labour rules. They provide a form of hidden export subsidies, and have become major centres of money laundering, parallel imports of counterfeit goods and forbidden re-importation of merchandise destined for other countries. Governments are getting worried about these practices, and restrictions are now being instituted.

### TRADITIONAL SUBSISTENCE WORK

Work in a traditional setting is a part of daily routine where the boundary between work and other household tasks is flexible. Many tasks involve health hazards, e.g. indoor cooking using wood, coal, agricultural waste or cow dung exposes the cook (usually a woman) and young children in her care to potentially very high levels of indoor air pollution. Levels of particulate matter and carbon monoxide are far above health guidelines and up to 100 times higher than those measured in polluted outdoor areas. As many as 500 million women and children may be exposed to these conditions according to WHO, 1997, and the health implications in terms of Acute Respiratory Infections for the

### Pesticides use in Viet Nam after market “reforms” of family farming

Kjellstrom, pers comm. Based on personal observations and information from staff in the Ministries of Health and Agriculture, Hanoi, 2001.

After “Doi Moi”, formerly communally owned farms were privatised during the 1990s. Since then, pesticides (mostly imported from China), have often been sold in the local shop with scant attention to safety information and precautions, leading to a rapid increase of severe pesticides poisonings. In the previous communal farming situation, specially trained staff would provide pesticides and carry out the spraying but after Doi Moi, individual farmers were made responsible for this work, with disastrous effects. Pesticide containers would be stored in the cooking areas, children could be exposed unintentionally and leaking containers could contaminate food preparation surfaces. Pesticide hazards are often poorly understood by farming family members and protective equipment is not used. Overuse of pesticides also occurs, because the merchants encourage the notion that “more is better”. After more than ten years, the Ministry of Health in Hanoi is considering how to return to specialised pesticides spraying staff.

children and Chronic Obstructive Lung Diseases and mortality for the women are very large (approximately 2.5 million deaths/year).

Indoor air pollution from cooking and heating with solid fuels in the developing countries now ranks among the most important risk factors for the global burden of disease according to the WHO World Health Report 2002.

Daily collection of water and firewood are also chores that create a high work load and many hours of walking, again particularly for women and young children. Increasing population density and meteorological conditions such as droughts, make these chores even more taxing for many people. Opportunities for exposure to insect and snake-bites are high in wood collection activities in many tropical areas, and fresh water collection creates risks of schistosomiasis.

The influence of globalisation on traditional farming includes an increasing use of pesticides in family farms with few, if any, safety precautions. In addition, the globalisation pressures to produce foodstuffs and other agricultural produce for export, extends plantation farming practices with associated high use of pesticides. This process may also result in a reduction of the production of local food for family consumption and associated malnutrition.

The changing situation for women in agricultural settings has been analysed in detail by Leslie London. Agriculture has a central economic role in most developing countries, not only because food production is a key element in survival at community level, but also because cash crops are seen as a way to economic development. These crops include edible plants and fruits, as well as coffee beans, palm oil, and inedible cotton and flowers. Developing country societies are encouraged, (or forced through “structural adjustment” policies), to establish new, intensive agricultural production, industri-

alized agriculture, which uses larger amounts of fertilizers and pesticides than traditional agriculture. The pesticides used may be those that have been banned or severely restricted in high-income countries and the risk of occupational poisoning as well as the use of these pesticides for suicides has increased. Women often work longer hours than men and their work tasks brings them into more contact with pesticides. Their risk of poisoning may therefore be higher than for men, and in addition they are more vulnerable to certain reproductive effects than men. In spite of this, studies of pesticide exposures and effects among women are rare, and the full health impact on women of this aspect of economic development is not known.

Small-scale industrial and service enterprises that emerge with economic development, have some similarities with traditional work - heavy workloads, poor safety precautions, and long working hours. Work usually takes place in an environment that seldom meets decent standards. Family members and workers including children, pregnant women and elderly people, share the work in these small-scale enterprises, such as home industries, small farms and cottage industries. In these situations, most workplace exposures also affect non-working family members because most of the time is spent in the combined home and work environment. It has been estimated by ILO, that two-thirds of the workers of the world still work in conditions that do not meet the minimum standards set by ILO.

### INFORMAL AND ILLEGAL WORK ARRANGEMENTS

The above description of traditional subsistence work refers to issues of informal work. Much of the work carried out in the world is unpaid, including the daily chores that support basic survival: water collection, firewood collection,

### ILO Child Labour Convention

(<http://www.ilo.org/public/english/standards/ipecc/simpoc/ra/index.htm>)

In the context of ILO Convention No. 182 concerning the Prohibition and Immediate Action for the Elimination of the Worst Forms of Child Labour, 1999, the International Labour Organization, through IPEC/SIMPOC (International Programme on the Elimination of Child Labour/Statistical Information and Monitoring Programme on Child Labour) has carried out 38 rapid assessments of the worst forms of child labour in 19 countries and one border area. The investigations have explored very sensitive areas including illegal, criminal or immoral activities. More specifically, they have focused on the topics of children in bondage; child domestic workers; children engaged in armed conflict; child trafficking; drug trafficking; hazardous work in commercial agriculture, fishing, garbage dumps, mining and the urban environment; sexual exploitation; and working street children. The studies have been made using the ILO/UNICEF rapid assessment methodology on child labour, which balances statistical precision with qualitative analysis, and aims to provide policy makers with insights into the magnitude, character, causes and consequences of the worst forms of child labour quickly and at low cost.

In addition to the 38 rapid assessment reports resulting from this project, two reports on child domestic workers based on national statistics from Brazil and South Africa have been produced. The purpose of the national reports is to provide an in-depth analysis of child domestic workers - a widespread yet hidden worst form of child labour - at the country level. The findings of all the studies will be used to determine strategic objectives for the elimination of the worst forms of child labour in each country or region, and guide policy makers, community leaders, and practitioners to tackle the persisting existence of these unacceptable forms of child exploitation on the ground. It is also hoped that these reports will raise awareness and promote the urgency of preventing more children from entering the worst forms of child labour.

residence building and repair, small-scale agriculture, fishing, cooking, etc. These activities sometimes are more hazardous than formal employment and these hazards need to be reduced if the benefits of modern occupational health ideas and preventive activities are to be achieved.

Problems in the informal economy are compounded by the fact that many of these tasks are carried out by women and children. The low status of women in many societies, mean that little attention is paid to the conditions under which their work is carried out. Similarly, when children are the workers, concerns about work hazards get a low priority. Children are powerless to influence their own working environ-

ment, and are totally dependent on adults for their protection.

As earlier mentioned, one of the key differences between activity rates in industrial and developing countries, is the very high activity rate among children and young people in developing countries, Figure 12.1.8. In industrial countries, the activity rates for children under age 15 have now been reduced almost to zero, while in developing countries the rates are also reducing, but more slowly; for the 15-19 year olds many of these countries are about 40 years behind the more developed regions. For those under 15 years of age, they are even further behind, Figure 12.1.8. The high rates of economic activity among these young people in less

Year	1960	1970	1980	1990	2000
<b>Industrialized countries, boys</b>					
Age <15 years	4	2	0.3	0	0
15 – 19 years	59	50	43	36	32
<b>Industrialized countries, girls</b>					
Age <15 years	2	1	0.2	0.1	0
15 – 19 years	47	40	37	32	28
<b>Developing countries, boys</b>					
Age <15 years	37	31	25	19	14
15 – 19 years	75	71	65	59	52
<b>Developing countries, girls</b>					
Age <15 years	28	25	22	16	12

Figure 12.1.8. Percentage economically active in the age groups up to 19 years in more and less developed regions. Source: ILO statistics.

developed regions, is one indicator of the higher proportion of child labour there. It also reflects the great inequality of education opportunities in the two types of regions.

There are other work arrangements and work situations associated with particular health risks. These include piece workers working at home, contract labour, and slavery that still exists in certain countries under different names. Each situation has its own hazards, and because of the illegal aspects of many of these work arrangements, it may be very difficult to carry out any OSH activities for these groups apart from eliminating the work arrangement itself.

A group of workers with particular health risks are “sex workers” involved in prostitution. It is mainly women who are involved, but male prostitution is an increasing concern and their health protection needs have become more widely discussed, as a result of the global AIDS epidemic. Sexually transmitted disease is not the only health problem they face. Violence from clients and pimps is a daily threat. Prostitution is also closely linked to drug abuse, due to the mentally and socially deprived situation of sex workers and the ease of access to drugs in the so-

cial strata they are put in. Some drug addicts also use prostitution as a source of income for their pre-existing drug habits.

Trafficking of young women, girls and boys, who become virtual slaves for sex services, has been given increasing attention in recent years, facilitated by low cost air travel and global outreach of sex tourism and organized crime. Differences in ethical and legal standards concerning prostitution in different countries, makes it difficult to develop a coherent international approach to deal with the problem. The globalisation of the sex industry is also facilitated by the Internet, which makes it easy for clandestine services to be established and advertised while its actual physical location is moved as required.

Informal and illegal work arrangements present major challenges for OSH, and economic globalisation will exacerbate the situation unless new global approaches to deal with the negative social and health consequences can be found.

## MIGRANT WORKERS

Migration of people between and within countries, is an age-old issue. Wars, environmental decay and other cataclysmic events have led to the movement of large numbers of people throughout history. The distribution of nationalities within Europe was shaped by such mass migrations and the slave trade was another phenomenon that moved large population groups from Africa to America and the Caribbean. In recent decades, this process has again been expanded due to active recruitment of workers from one country to another, e.g. the “guest worker” phenomenon in Germany, Switzerland, Sweden and other countries. Some West Asia countries also have systematically recruited workers from abroad, e.g. many domestic workers in Saudi Arabia and Kuwait are from the Philippines or South Asia.

Globalisation may reduce some of these flows of people while increasing others. As manufacturing facilities are established by multinational corporations in the EPZs of developing countries, the need for guest workers will be reduced. On the other hand, highly trained workers and service workers from developing countries are sought by industrial countries in order to fill gaps in their workforce, caused by ageing populations with a diminishing proportion of the population being economically active.

Health care personnel are an important group in this context, as the increasing proportion of elderly people leads to increased demands for health care and services. Some countries, e.g. New Zealand, have made conscious decisions to train less medical doctors than required, as it is cheaper for New Zealand to import trained doctors from selected developing countries. One negative effect of such policies is the exacerbation of the brain drain from developing

countries that can ill afford the losing of these highly trained people. In some developing countries, e.g. the Philippines, the training of nurses is at levels high above national demands, as these nurses can get jobs in industrial countries or the Middle East. They often transfer part of their earnings home, which contributes significantly to the export income of the Philippines.

However, many migrant workers end up having to take the jobs that local people don't want, which can involve jobs with higher hazards. Wages and other conditions, such as working hours, are also likely to be worse than those in the regular work force. Access to health services may also be more limited. All of these factors create more health risk related to work than in usual work situations.

Internal migration inside countries can be driven by systematic efforts to concentrate new industries in border zones or EPZs with less taxes, little or no occupational health regulation or protection for workers, and with other limitations on workers health conditions. In Latin America, these industries are often *maquiladoras* that carry out only the labour intensive parts of the production while the actual product is sold from an industrial country base.

Migrant workers often have to leave their families in their original place of abode, leading to social isolation, poor living conditions and other social health risks. These include alcohol abuse, sexually transmitted diseases and violence.

## WAR, TERRORISM AND VIOLENCE

This is an aspect of global occupational health that is sometimes overlooked. We are not thinking primarily of war injuries and health damage in combatants, even though this is a major public health issue in itself, but of injuries and health damage to civilian non-combatants, who often become the victims of armed conflict. The



World Health Organization stated, in an Executive Board paper in 1981, that “the role of health workers in promoting and preserving peace is a significant factor in achieving health for all”. Unfortunately, the last hundred years have been the most violent period in human history. More than 190 million people lost their lives directly or indirectly due to wars between or within nations, and more than half of them were civilians.

Wars or internal conflicts are often based on struggles over economic resources, such as the diamonds of Angola or the forestry products in West Africa. Globalisation can exacerbate the risks of such wars by providing open or clandestine markets for these goods. Global political processes are often needed to control such trade and to get the combatants to the negotiating table.

Increasingly, armed conflicts involve civilians - labelled collateral damage - and the conflicts are not confined to defined battle-fields, but extend to built-up areas. Conflicts in the Middle East, Africa, and in the Balkans have caused massive numbers of dead and injured in primarily civilian territory. Some civilians evacuate from a conflict area, causing large groups of internally displaced people and refugees. Another factor is systematic ethnic cleansing as occurred in Rwanda and Sudan. Many occupational groups are compelled to stay in very hazardous conflict areas including health and emergency service workers and workers in essential water and electricity services. The majority of civilians injured or killed in conflicts are women and children.

Conflicts disrupt legal trade and other normal community business activities, which will interfere with food production and distribution. Famine related to conflicts or genocide, is estimated to have killed 40 million people in the 20<sup>th</sup> century. In addition, sexual violence is a

common feature of wars and conflicts, which has devastating effects on women and children.

One of the destructive injury hazards that has attracted major attention in recent years, is land mine damage to non-combatants. The people affected are most often farmers, agricultural workers, or women and children collecting water and firewood. It is estimated that 60-70 million land mines are in the ground in at least 70 countries. These cause at least 60,000 injuries and 40,000 deaths each year, and broadly defined many of these injuries and deaths are occupational. The people who walk into fields with mines do so because they are attempting to restore agricultural production in otherwise devastated areas. Truck drivers and other transport workers are also likely victims of this type of violence, which has the added feature of creating life threatening health hazards that remain as long as the mine in the ground.

A new feature of violence and its effect on workers is terrorism. Since the attack on the World Trade Centre in New York in 2001, also labelled 9/11 or September 11, the US-lead war on terror has dominated the international discourse and media headlines in most countries. Many of the victims were emergency service workers, or office workers in the buildings. Subsequent attacks on a nightclub in Bali, a hotel in Mombasa, commuter trains in Madrid and the London transport system also injured or killed many people, none of them direct participants in an armed conflict. The risk of a terror attack may become another occupational hazard, with very severe consequences but, for most people, relatively low probability. One of the key political challenges at the beginning of the 21<sup>st</sup> century is to find ways of steering the world away from a path towards more and more violence and terrorism.

Many believe that widespread poverty and inequality sow the seeds of terrorism, and that the best way to reduce the risk of terrorist acts is to assure that inequalities are reduced. However, the extremist philosophy of the terrorists is also driven by fundamentalists religious or ethnic conflicts.

The latest major development in the area of war and conflict is the war in Iraq in 2003. The conditions in that country under Saddam Hussein were difficult for the average worker, but the war did not improve the situation even years after the regime change. Security problems have created severe difficulties for normal life and the breakdown of health services and basic infrastructure continues to be a threat to health. An important feature of this war and the continuing occupation, is the enormous cost not only to the Iraqi nation, but also to the occupying countries, primarily the USA, UK and Australia. The cost of the actual fighting has been estimated at US \$ 200 billion (by July 2005), and the continuing occupation costs about US \$ 5 billion per month. One estimate of the total cost including indirect costs over several years calculated that it could reach US\$ 2,000 billion.

These major outlays of financial resources are not supposed to be recovered through sales of Iraqi oil, as that income should go to the rebuilding of Iraq. The accumulated costs after only one year, amount to a figure more than three times larger than the entire global, international aid budget of approximately US\$ 50 billion. The consequences for health will be costly, and OSH will be another area that will have difficulties getting attention and resources.

### CHALLENGES FOR OSH DURING GLOBALISATION

This chapter has discussed the potential positive and negative facets of globalisation on OSH.

The economic forces linked to globalisation demand:

- more labour flexibility, which threatens OSH with strong variations in employment and unemployment,
- less regulation of working conditions, which means softening of OSH rules or enforcement of such rules, and
- less resources provided for OSH services and preventive activities in workplaces.

There are many examples of such negative effects on OSH and a concerted effort to improve labour standards in all societies through international action is an important way to promote OSH. The economic forces of globalisation can also be partly ameliorated through rules and advice from the major banks and other financial backers of workplace development in developing countries but overall, there are reasons to be worried about the effects on OSH from globalisation forces.

On the other hand, globalisation can be a major force for a positive development of OSH if appropriate concern is given to the social dimensions, for example, if international labour standards were accepted as minimum standards or if competitive advantage from poor labour standards were eliminated. Improved access to information through globalisation of communications can make it easier for local agencies to assert themselves when specific OSH issues are debated with investing enterprises. Global agreements on banned chemicals and technologies, can be more easily enforced in a globalised system of development.

The specific national or local priorities and applications for OSH have, of course, a very strong local flavour depending on the type of agriculture, industries and workplaces that exist. The degree to which globalisation influences a

country will also vary; what is important in one country is not necessarily important in another because of the predominance of different types of occupations or geographic conditions. These differences are also related to the development level of the country. At an early stage of development traditional work in primary industries dominates but as a country develops economically, industrial work and the service sector usually expand and the proportion of people working in agriculture, mining, etc diminishes. At the global level, approximately half of the population, (3 billion people), still live in traditional subsistence conditions and the occupational health impact of the changes related to development is very large. This impact can be positive as traditional hazards diminish, but poor implementation of development can lead to new health risks.

Globalisation carried out in a people-centred manner can create improvements in living and working conditions for areas and population groups that suffer from social and economic deprivation and from preventable health problems. Globalisation can make use of modern scientific knowledge and available technologies to improve the quality of life for the billions of people living in poverty. However, the process must take account of the cultural and social conditions of each community.

A challenge to this homogenisation of the world and hegemony of power has been launched through the so-called Glocalisation movement. It is a way to build a strong network of local communities, based on mutual respect for cultural and social differences, with an emphasis on local government and what it can do to protect its community from the negative effects of globalisation. The networking involved in the Glocalisation movement can benefit OSH through sharing of common principles of mini-

mum standards, and through exchange of positive solutions to OSH problems.

A people-centred globalisation will depend on resource transfer from the affluent societies to the less affluent ones. This was already accepted in 1970 as a principle for international cooperation within the United Nations, when the benchmark for foreign aid was 0.7% of the GDP of affluent countries. Only a few countries, e.g. Norway, Sweden, Denmark, Netherlands and Luxemburg, have ever achieved this and the average for all OECD countries has never risen above 0.33%. The G8 meeting in July 2005 that promised additional aid funding is a step in the right direction, but it remains to be seen how much additional aid will actually be provided.

Resources need to be invested in activities that build up long-term development infrastructure in the receiving countries; education, public health programs, water and sanitation, housing, environment protection, and improvement of local agriculture and other primary industries. They should not be squandered on military spending or luxury excesses of the country leadership, which has so often been the case. The development resources of a country need to be under democratic control. Globalisation that ignores these basic principles, can make things worse rather than better.

People-centred positive globalisation protects knowledge, shared resources and other features that can be labelled aspects of the “global good”. We only have one planet to live on and need to be mindful of its limitations and possibilities. Scientific knowledge that is of importance for the protection of life on the planet and the health of its inhabitants should be considered to be a global good, not appropriated through intellectual property rights for private profit purposes. If knowledge has been developed through privately funded research, it seems reasonable

### How intellectual property and patent rights may jeopardize OSH implementation in developing countries

New technologies of importance to health can become so expensive that their use is delayed or totally blocked and health is damaged. This can be of great importance for OSH implementation.

Examples include:

- the most dangerous industrial solvent, benzene, continues to be used in developing countries in simple glues, because modern, less dangerous glues need to be imported from industrial countries or manufactured on a licensing basis, become too expensive
- new industrial products or processes that reduce OSH risks are covered by patents that stops developing country companies using the same processes
- workplace monitoring and other safety equipment produced in industrial countries can be covered by intellectual property rights that make them prohibitively expensive in developing countries, where the market may still be too small for alternative local production
- the same applies to modern and safer technologies used in agriculture or industry, which are out of reach for many workers due to intellectual property rights.

that the costs of the research are recovered. However, any profit beyond this would be excessive if it creates high prices of a drug or technology that then becomes out of reach for those who need it. The recent controversy over AIDS drugs in Africa is a key example of this problem.

New drugs to treat HIV-positive people so that AIDS is delayed or prevented, are normally sold at a price that is too high for the developing country patients or their governments to pay for. The drug companies keep the prices high through patents and royalties, ostensibly in order to recover research costs. In addition, a large proportion of the turnover of pharmaceutical companies is spent on marketing, which for truly essential drugs should not be required. These costs have to be recovered, but prices often stay high even after these costs have been recovered, as long as the patents make such price policies possible. An agreement for special low price scales on HIV/AIDS medicines for developing countries was reached at a WTO meeting

in 2002 in Doha, but its implementation has not gone smoothly.

People-centred globalisation would promote the notion of essential knowledge for health becoming a global public good, and one step in this direction would be to change the WTO-rules to reduce the Patent validity time from 20 years to a shorter time; the time when the research costs have been recovered.

Another “global good” is the global environment, which is being threatened by over-exploitation, pollution and careless economic development. Globalisation of “thought and awareness” can create a general understanding that decision-makers at all levels need to consider the impacts of their decisions on the global environment. Development at local level in developing countries, can be influenced by such positive globalisation, so that, for instance, rainforest resources are used and maintained in a sustainable manner. Even more important is an understanding in affluent countries that a wasteful lifestyle and societal infrastructure has major

consequences for the livelihood of people in other countries and the whole globe.

Looking into the future, overcoming the remaining OSH hazards due to poverty and correcting the OSH deficiencies of globalisation, are not the only challenges that OSH professionals will face. According to a statement in 1995 by occupational health institutes collaborating with the WHO, growing issues of importance for OSH in the future will be:

- occupational health problems linked to new information technologies and automation including stressful aspects of work organization and ergonomic hazards leading to repetitive strain injury (RSI), etc.;
- new chemical substances and physical hazards;
- health hazards associated with new biotechnologies;
- transfer of hazardous technologies;
- aging working populations;
- special problems of vulnerable and underserved groups e.g. the chronically ill and disabled, including migrants and the unemployed; and,
- problems related to growing mobility of worker populations and occurrence of new occupational diseases of various origins.

Globalisation was not mentioned in this statement, probably because in 1995 it had not yet become such a hot international topic. ILO established a special World Commission on the Social Dimension of Globalisation that highlights the priority the issue has now been given. It is an overarching driving force for several of the other items mentioned above, and must be considered a key issue for OSH development.

Experience from many countries shows that a healthy economy, a high quality of products or services, and long-term productivity gains are difficult to achieve in poor working conditions with workers who are exposed to health and safety hazards.

Another major challenge, which all countries will have to deal with eventually, is the ageing of the population and the adaptation of work and how it is organized in a population with large numbers of elderly people. This is not an effect of globalisation as such, but this demographic development goes hand in hand with the trends of globalisation. It will create expanded needs for social security systems and changes in workplaces and workforce utilisation that will impact on OSH. In addition, an ageing workforce may be particularly affected by the stress involved in a more rapid work pace and more rapid change of work content and technologies. The ultimate effects could become “burn out” and many other stress-induced conditions, which has led to increasing numbers of workers being on sick leave or taking early retirement. The current debate about the issue of an aging workforce in the more affluent countries, including Sweden, is focusing on the economic value of increasing immigration of young educated people from developing countries, but this cannot be considered a sustainable solution to the challenges of an aging work force. The depletion of people with training from developing countries (the brain drain) is one negative impact and another is the further environmental pressure (pollution, greenhouse gases, etc.) from larger populations in high consumption societies of affluent countries.

# Global situation concerning work related injuries and diseases

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## THE OFFICIAL PICTURE

Work related injuries and diseases come in many different forms and are often difficult to record, because other causal or risk factors than work are also involved. A worker injured by machinery inside a factory will clearly be classified as an occupational injury, but what if the worker was injured in a car crash driving between two work-sites during working hours? It is likely that this will be classified as a traffic injury rather than as an occupational injury. Similarly, if an insulation worker who smokes develops lung cancer or other respiratory disease that could be caused by asbestos, it is unlikely to be classified as an occupational disease in many countries. The smoking will usually be considered as “the cause” of the lung cancer, even if the asbestos exposure was a major causal factor. Establishing a link between occupation and injuries and diseases is a question of awareness and attitude of the diagnosing medical practitioner, and also relates to the quality of recorded data on occupational exposure and health effects records.

These examples highlight some of the reasons why official statistics on mortality and morbidity from OSH hazards is incomplete in most countries. Many developing countries make poor or no effort to record work related health problems

which makes it difficult to assemble a true, global picture of the extent of work related injuries and diseases from official records. However, estimates of the scale of global occupational health problems have been made by WHO and ILO, using various assumptions based on the official statistics available.

There are approximately 3 billion economically active people, (mainly of working age, 15-64 years), in the world, 80% of whom live in developing countries. These people are exposed to a variety of hazards resulting in major health problems as summarized by WHO in 1999:

- Each year, work-related injuries and diseases kill more than 2 million people worldwide, Figure 12.2.1, which is greater than the global annual number of deaths from either malaria, AIDS or tuberculosis.
- 250 million occupational accidents result in more than 300 000 fatalities annually (current estimate 355 000). Many of these accidents lead to partial or complete incapacity to work and generate income, which has indirect health effects on the family of the injured worker.
- Annually, an estimated 160 million new cases of work-related diseases occur worldwide, including communicable diseases, cancers,



<b>Causes \ Regions</b>	<b>Estab- lished Market Econo- mies</b>	<b>Formerly Socialist Econo- mies of Europe</b>	<b>India</b>	<b>China</b>	<b>Other Asia and Islands</b>	<b>Sub- Saharan Africa</b>	<b>Latin America and the Caribbean</b>	<b>Middle Eastern Cres- cent</b>	<b>Work- related mortality, Global total</b>
	(EME)	(FSE)	(IND)	(CHN)	(OAI)	(SSA)	(LAC)	(MEC)	World
Communicable diseases	11	2.9	98	11	27	140	20	9.9	320
Cancers	165	61	51	173	70	28	38	24	610
Respiratory sys- tems diseases	17	10	13	77	7.6	6.8	6.6	8.0	146
Circulatory sys- tems diseases	77	66	93	116	50	26	39	52	519
Neuro-psychiat- ric conditions	7.6	2.2	2.6	2.8	2.1	0.7	1.3	1.2	20
Digestive sys- tems diseases	2.9	1.5	3.3	4.9	4.7	1.3	2.2	1.8	23
Diseases of the genitourinary system	1.8	0.6	1.0	1.5	1.3	0.6	0.7	1.1	8.5
Accidents and violence	16	21	48	74	83	55	30	28	355
<b>Total mortality</b>	<b>298</b>	<b>166</b>	<b>310</b>	<b>460</b>	<b>247</b>	<b>258</b>	<b>138</b>	<b>126</b>	<b>2,002</b>

Figure 12.2.1. Estimates of annual mortality (thousands) due to occupational injuries and diseases by world region and cause of death, circa 1995. Source: ILO.

respiratory and circulatory diseases, mental and neurological illnesses, as well as hearing loss, musculo-skeletal and reproductive disorders that rarely kill those affected. At least 1.6 million of these disease cases die each year, Figure 12.2.1.

The world regions reported in Figure 12.2.1 are those used by the World Bank (WB) for much of its statistics. It has become more widely used for health data since the World Development Report 1993, which was the first by the WB to focus on health issues. This regional division

was also used in the major reports by Murray & Lopez (1996) on “global burden of disease” (where the DALY method was presented).

The established market economies include all “Western” industrialised countries, Japan, Australia and New Zealand. Russia and all of Eastern Europe is within FSE. India and China are regions on their own. The most populous countries in Other Asia and Islands are Indonesia, Bangladesh, Vietnam and Malaysia. This region includes many smaller Asian countries and Pacific Islands. Sub-Saharan Africa includes all of Africa except the Northern Africa coastal

World region	Economically active population (millions)	Total employment (millions)	Fatalities (thousands)	Fatal accidents reported to the ILO (thousands)	3 days' absence accidents reported to the ILO (thousands)	All accidents reported to the ILO (thousands)
EME	409	381	16	15	7 632	7 647
FSE	185	162	21	8.7	582	591
IND	459	420	48	0.2	0	0.2
CHN	708	700	74	18	76	94
OAI	404	329	83	5.6	252	258
SSA	261	11	55	1.7	47	49
LAC	193	115	30	7.0	1,699	1,706
MEC	113	49	28	1.9	191	193
<b>WORLD</b>	<b>2 732</b>	<b>2 165</b>	<b>355</b>	<b>57</b>	<b>10 480</b>	<b>10 537</b>

Figure 12.2.2. Occupational injury deaths and non-fatal injuries causing absence from work by world region, circa 1995. (Injury = accidents and violence). Source: ILO.

States. Latin America and the Caribbean include all of the Americas south of the USA. The Middle East Crescent includes North Africa, the true Middle East, and Pakistan. The economically active population by region varies between 113 and 708 million, Figure 12.2.2.

While the figures in Figure 12.2.1 give an impression of great accuracy, they are only calculated numbers with sizeable confidence intervals. The published ILO estimates include lower and upper limits for the total occupational mortality, ranging from 1.9 to 2.3 million deaths. The figures for EMEs, the most affluent countries, are likely to be the most accurate, but even in these countries the data generally rely on workers compensation data, which excludes people working outside of such insurance systems.

The estimates are based on information about the workforce mix between different economic sectors, which as was shown in Figure 12.1.6, is very different at different development levels. Agriculture, with generally high injury rates,

dominates in the developing countries. The ILO estimates takes this into account, but due to variation in the recording of work related health problems in different countries and different occupations, even fatalities can be poorly quantified. The problem is highlighted in Figure 12.2.2.

In spite of the basic requirement that all Member States of the ILO should report fatal work accidents/injuries, the level of under-reporting is dramatic, Figure 12.2.2. For instance, of the estimated 48,000 deaths due to occupational injury in India, only 211 were reported to ILO! The number of reported non-fatal injuries causing at least 3 days absence from work amounts to more than 10 million, Figure 12.2.2. Using the ILO reported injuries and dividing it by the total estimated fatalities gives an indication of the problem of selective recording and reporting. For EMEs, the ratio of reported injuries per fatality is 472, while it is 29 for the whole world and 8 for the non-EME regions of

the world. If the EME ratio reflects a more valid picture of the number of injuries per fatality, the total number of occupational injuries causing at least 3 days absence from work would be 167 million (instead of 10 million), of which 160 million would occur in the non-EME countries. It is possible that the lower ratio of injuries per fatality in non-EME regions is partly due to a truly higher fatality rate per injury, but the data available cannot elucidate this issue.

These higher numbers of injuries can be used to estimate the likely injury rates per worker. It is 1.8 per 100 workers and year in EME countries (one in fifty workers having a 3-day absence injury each year), and in non-EME countries it would be 6.9 per 100 workers and year (one such injury per 14 workers each year). Compared with other health problems that people in the adult age groups experience, these are high rates, and with better reporting and recording systems, and compliance with reporting requirements from employers and workers, the true picture is likely to be that the rates are even higher.

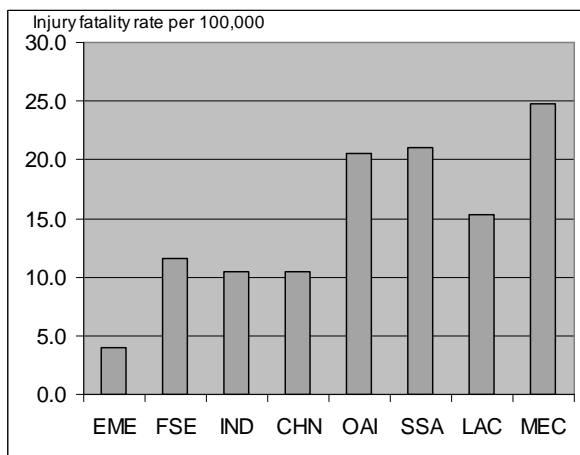


Figure 12.2.3. Occupational injury fatality rates by world region, 2002 (per 100,000 economically active persons; based on data from ILO).

Nevertheless, a comparison of the ILO estimate of occupational injury fatality rates by region shows some intuitively reasonable differences, Figure 12.2.3. In EME countries the rate is 4 rising to about 25 in the MEC countries. Eastern Europe, China and India have about twice the EME rate, and the other developing country regions have higher rates again. The rates are based on the economically active populations listed in Figure 12.2.2. This table also includes ILO data on the numbers of people in employment, which are lower than the economically active populations, particularly in the SSA, MEC and LAC regions. These differences reflect difficulties in getting accurate statistics. If the occupational fatality rates were calculated on the basis of the numbers of employed people, the rates for developing countries would be even higher.

Most EME countries do not count traffic crash deaths as occupational injury fatalities, even if the crash happened while the worker was on duty. The reason for this situation is the assignment of traffic crash deaths to this category without any investigation of whether the person killed was actually working when they died. One could say that this is convenient, because the causation of the death is kept within the sphere of driver-vehicle-road-environment interactions and employers are not “blamed”. In countries such as Sweden, where complete data are collected, it can be seen that the driving fatalities at work are increasing as a proportion of all occupational fatalities (in 2000 about one third), and that fatal accidents that occur during commuting to and from work create another significant source of work related deaths. This factor adds to the under-reporting worldwide.

The estimates for developing countries in Figure 12.2.1, generally do not include traditional work or other informal work that may

in fact be inherently more dangerous than paid employment in the same country. This is another way in which the role of work in the health status of countries is under estimated.

The largest single disease category listed in Figure 12.2.1 is cancer (about 610 thousand). The numbers are estimates based on the relative proportion of these diseases in total mortality by Leigh et al. in 1999 and the assumed attributable risk from occupational hazards. This method involves large uncertainties. For hazardous substances in the workplace an estimate of the associated mortality was made for Australia. The resulting number (2,290 deaths) was four times higher than that caused by occupational accidents. When the same methodology is applied globally, exposure to hazardous substances could cause some 315 thousand cancer deaths per year, Figure 12.2.4. Note that this is for hazardous substance exposures only, and does not include other causes of occupational cancer, such as solar UV-radiation which causes skin cancer in outdoor workers, are not included. This is one explanation for the higher figure (610 thousand) in Figure 12.2.1.

Cardiovascular diseases, respiratory disease and pneumoconiosis are three other important effects of hazardous substances contributing to the estimated total of 438 thousand deaths. For 1990 Takala at ILO estimated that the total was 341 thousand. The difference reflects new methodology, larger populations and possibly an increasing trend.

Again, these figures are approximate and only indicate the magnitude of the occupational disease mortality problem. Figure 12.2.1 reveals some other inconsistencies, apart from the number of cancers. However, as Figure 12.2.4 was an estimate for hazardous substances only, the numbers for a particular disease should be lower than in Figure 12.2.1. Occupational can-

cers are difficult to record accurately due to the long latency between exposure and effect. The best data available for an occupational cancer are likely to be the mesothelioma data. Many studies have shown the clear link between mesothelioma mortality and asbestos exposure 20-40 years earlier.

Another example of problems with the different estimates is the number of pneumoconiosis disease cases, Figure 12.2.4. Considering that the global number (36 thousand) represents annual deaths (incidence), and assuming that a victim is likely to have lived with the disease for 10 years before death, and assuming that half of the victims die of this occupational disease, one can calculate that the global prevalence would have to be 720 thousand cases. However, in Southern Africa alone it has been estimated that there could be 480 thousand cases of silicosis. Loewenson calculated that in Southern Africa uncontrolled dust hazards are common, particularly in mines, quarries and foundries, and silicosis and silico-tuberculosis are growing problems. Based on prevalence surveys of silicosis, and generalising the results to an estimated 2 million former miners in Southern Africa, indicates that there would be 480 thousand cases of silicosis. Considering the large populations working in in these occupations in China, India and other Asian countries, 720 thousand appears like a major underestimate. China alone has about 3 million mine workers.

Workers with silicosis have an increased risk of tuberculosis, and the surge of HIV infections adds considerably to this risk. The emergence of multi-drug resistant tuberculosis creates major public health and health service concerns, in addition to the occupational health concerns.

Causes of death	No. of deaths, whole world (thousands)		Estimated percentage attributed to hazardous substances		No. of deaths attributed to hazardous substances (thousands)
	Men	Women	Men	Women	
Cancer (Total)					315
Lung cancer and mesothelioma	996	333	15 %	5 %	166
Liver cancer	509	188	4 %	1 %	22
Bladder cancer	128	42	10 %	5 %	15
Leukemia	117	98	10 %	5 %	17
Prostate cancer	253		1 %		2.5
Cancer of mouth	250	127	1 %	0.5 %	3.1
Cancer of oesophagus	336	157	1 %	0.5 %	3.5
Stomach cancer	649	360	1 %	0.5 %	8.3
Colorectal cancer	308	282	1 %	0.5 %	4.5
Skin cancer	30	28	10 %	2 %	3.6
Pancreas cancer	129	99	1 %	0.5 %	1.8
Other and unspecified cancer	819	1 350	6.8 %	1.2 %	72
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Cardiovascular disease, 15–60 years	3,074		1 %		31
Nervous system disorders, 15 + years	658		1 %		6.6
Renal disorders, 15 + years	710		1 %		7.1
Chronic respiratory disease, 15 + years	3 550		1 %		36
Pneumoconioses estimate	36		100 %		36
Asthma 15 + years	179		2 %		3.6
TOTAL					438

Figure 12.2.4. Estimated global annual average number of deaths attributable to occupational exposure to hazardous substances by condition. Source: Takala, ILO, 2000.

World Region	Economically active population (millions)	Total occupational mortality (thousands)	Total occupational fatality rate/100,000
EME	409	298	<b>72.7</b>
FSE	185	166	<b>90.0</b>
IND	459	310	<b>67.6</b>
CHN	708	460	<b>65.0</b>
OAI	404	247	<b>61.0</b>
SSA	261	258	<b>98.9</b>
LAC	193	138	<b>71.2</b>
MEC	113	126	<b>111.3</b>
<b>WORLD</b>	<b>2,732</b>	<b>2,002</b>	<b>73.3</b>

Figure 12.2.5. Total occupational mortality and mortality rates by region. (rate per 100,000 in economically active population) Source: ILO.

Considering the overall occupational mortality again and calculating the rates for different world regions, Figure 12.2.5, we find that the some developing country regions (notably China and India) have surprisingly low rates compared to EME countries. These numbers do not match the picture given by Figure 12.2.3 for occupational accident injuries. One logical reason for the difference is that occupational diseases mainly affect older people and often are only diagnosed after many years latency (e.g. cancers). However, it is likely that the occupational fatality rates in Figure 12.2.5 are underestimated for each region.

Another way to analyse this issue is to compare rates in different economic sectors. Few countries provide enough detail in their reports to ILO to make such comparisons. Figure 12.2.6 attempts to give an impression of the relative dangers in different sectors. The codes for the different categories in the International Standard Industrial Classification of all Economic

Activities, (ISIC – Revision 3), are included in the table. This is a revision from 1993, which creates some difficulty in comparing with earlier years.

Nevertheless, the comparison between four countries, Figure 12.2.6, provides a snapshot of the higher occupational injury fatality rates in developing countries and in certain sectors, such as agriculture, fishing, mining, construction and transport. As these are sector-specific rates, they are not affected by different numbers of workers in the industry in each country.

Mining and transport are linked to the most extreme risks in Zimbabwe, while Argentina has the highest rate for construction. In light of the under-reporting mentioned earlier it is likely that the true rates are even higher. The trends over time are difficult to ascertain, however, more detailed comparisons of this type can assist in identifying which groups of workers should receive priority when OSH programs are established.



Sector (ISIC code)	Fatality rates, different countries			
Country	Sweden	USA	Argentina	Zimbabwe
All occupations	2	5	15	20
Agriculture and fishing (A+B)	20	23	31	20
Mining and quarrying (C )	14	26	27	69
Manufacturing (D)	1.6	3.4	13	7.5
Electricity, gas, water supply (E)	5.6	---	28	13
Construction (F)	5.4	15	39	21
Trade and restaurants (G+H)	0.7	---	8.8	9.0
Transport (I)	4.4	13	32	65
Financial and business (J+K)	0.8	1.4	11	4.4
Administration, education, health, and other (L – O)	1.0	2	6.5	15

Figure 12.2.6. Occupational injury fatality rates in different economic sectors, average 1995-2000 (unit: deaths per 100,000 economically active workers in sector). Source: ILO.

### HAZARDS OF IMPORTANCE IN NEW WORKPLACES OF DEVELOPING COUNTRIES

Detailed information on specific occupational exposures in different work situations can be found in the previous chapters of this book and a number of recent textbooks and reference volumes, e.g. the ILO Encyclopaedia of Occupational Safety and Health. This section will refer briefly to some key issues concerning important hazards for globalising economies.

It is important to point out that some of the changes in the structure of the workforce in developing countries, as an outcome of globalisation, may lead to less dangerous workplaces and reduced exposures to hazards. In addition, the investments in new workplaces can be used to introduce newer, more modern and safer technologies. OSH professionals are well placed to

monitor developments and to identify and communicate information on hazards to employers, planners and decision-makers.

Mechanical factors such as unguarded machinery, unsafe workplace structures or dangerous tools, are among the most prevalent hazards in both industrial and developing countries, affecting the safety and health of a high proportion of the workforce. The limited comparisons that can be made, e.g. Figure 12.2.6, indicate that injury hazards are particularly common in certain economic sectors of developing countries. Most occupational injuries could be prevented by relatively simple preventive measures in the work environment including improved working practices and safety systems and through appropriate behavioural and management practices. Such measures would significantly reduce accident rates within a relatively short period of time, however, the experience

and safety knowledge that helps to prevent injuries needs time to accumulate, and the introduction of new technologies can have serious impacts. The injury risk is usually much higher among inexperienced workers so the responsibility of workplace supervisors and managers/owners to target prevention activities at new workers is particularly relevant. Accident prevention programs in high-risk situations can be highly cost-effective and yield rapid results. Unfortunately, ignorance of such precautions, particularly in sectors where production has grown rapidly, has led to increasing rates of occupational accidents.

Between 10% and 30% of the workforce in industrial countries and between 50% and 70% in developing countries may be exposed to heavy physical workload or to un-ergonomic working conditions such as lifting and moving of heavy items or repetitive manual tasks according to WHO. Repetitive tasks and static muscular load are found in many industrial and service occupations. In industrial countries musculo-skeletal disorders are the main cause of both short-term and permanent work disability, potentially causing economic losses of up to 5% of the GNP.

Most exposures can be eliminated or minimized through mechanization, safety barriers, ergonomic improvement and better organization of work and training. In addition, the growing numbers of elderly workers require constant vigilance from those responsible for the work organization in order to avoid injuries.

An important aspect of mechanization, assembly line production and repetitive tasks, such as continuous computer keyboard work, is the wear on muscles, tendons and joints that may eventually lead to “repetitive strain injury (RSI)” or “occupational overuse syndrome (OOS)”. This syndrome also has many other names, depending on the exact anatomical location of the injury and the pathological change that has

been diagnosed. The symptoms are pain and lack of strength in key muscles, which limits the ability of the worker to perform essential job tasks or to continue working at all. OOS is a common outcome of the rapid work pace imposed in mechanized industries, often in export processing zones. Prevention requires appropriate ergonomic design of the workplace in order to reduce strain on muscles and joints in addition to a system of management that establishes regular working hours and rest breaks.

Chemical hazards are an increasingly important concern as countries develop new industries as an outcome of globalisation. About 100000 different chemical products are currently used in work environments, and the number is increasing constantly. The extent of exposure varies widely according to the industry, activity and the country. However, it should be stressed that among the 100 000 chemicals there are a few that still cause most hazardous exposures, such as lead, organic solvents, organo-phosphate pesticides, etc.

The most common health effects of chemical exposures at work are damage to the central nervous system, liver, skin, respiratory system, cancers and reproductive disorders, as well as specific poisoning effects of metals, solvents and pesticides, are among the health effects of chemical exposures at work. Pesticide exposure is the major chemical hazard in tropical developing countries where personal protection is particularly difficult to use due to heat exposure and where preventive means should be implemented. Some pesticides should be banned and ideally, if a product was banned in an industrial country, it would then be viewed as hypocritical if its use in developing countries was allowed to continue. However, the globalisation of trade and the agriculture industry does not necessarily create globalised prevention paradigm.

A case-study that illustrates this point is given by LaDou in 1999 in his analysis of the use of DBCP (dibromochloropropane), a chemical pesticide banned for use in the USA in the 1980s due to its ability to reduce fertility in men. However, the USA continued to produce DBCP and the pesticide continued to be exported to developing countries for many years. The responsibility for occupational health problems,

through enforcement of regulations and other means, was shifted to the developing countries using DBCP while the USA continued to import the agricultural products treated with DBCP. There are often alternative, less toxic methods of pest control available (see Box) . Local access to information about the hazards and the options is an essential element in effective OSH programs.

### Alternative pesticides

Toxic chemical pesticides have important applications when insects, fungi, and plant diseases seriously reduce harvest yields. However, on average, the potential yield enhancement from the use of chemical pesticides is often exaggerated by those selling pesticides. Alternative methods of pest control can often maintain the yield at 90% or more of the yield using chemicals. A similar case has also been demonstrated by farmers who switch to organic farming when the higher price that can be achieved for organic food items in Europe and North America more than compensates for any yield loss.

One way of reducing toxic chemical pesticide use is to apply “Integrated Pest Management” (IPM) techniques as recommended by FAO. These techniques combine the careful monitoring of plant pests with systematic use of low intensity chemicals, when and as required. This technique requires farmers to be trained and to be prepared to take the necessary time to monitor their plants, instead of spraying set volumes of pesticides defined dates in the stage of plant growth, thus reducing the unnecessary use of pesticides. The IPM approach also uses carefully designed “companion planting” which works because different insects are attracted to, or repelled by, different plants. For example, careful mixture of maize and grass planting in Kenya increased the maize yield by 30%.

Another important way to reduce pesticides poisonings is for farmers to use the least toxic pesticide that does the job and to take the specific precautions required for each pesticide. A voluntary code of practice developed by FAO and international chemical industry organizations is intended to ensure that appropriate hazards and safety information is provided throughout all stages of production, shipment, wholesale, retail and application of pesticides. Local OSH professionals can use this code of practice to request information.

Other means of ensuring that the information reaches the users of the pesticides include the Pesticide Information System in Malaysia and similar government operated systems in many developing countries. Poison Control Centres are another source of information. In addition, there are a number of NGOs active in the prevention of chemical poisoning through the provision of information, including internet websites.

(see: <http://turva.me.tut.fi/iloagri/case/case.htm>)

An important OSH concern is the export of agrochemicals, already banned in developed countries due to high human toxicity or eco-toxicity, to developing countries. An analysis of the export of highly toxic banned or never registered pesticides showed that 14 000 kg per day were exported from the USA to developing countries. The receiving countries usually have very limited resources to develop and/or enforce effective national regulations concerning pesticide safety. Toxicology expertise is limited and the primary health care facilities that are the first contact point for poisoned agricultural workers and their families are likely to have very limited possibilities for appropriate tests and effective treatment. Such practices go against official USA declarations and restrictive policies on pesticide exports. This is a problem that cannot be solved solely by action in the developing country receiving the pesticides. High risk groups for exposure are

women and children. It should be pointed out that the chemical industry itself several years ago adopted a voluntary code of conduct under the auspices of FAO. If followed, this code should reduce the risk of poisonings.

Many other “historical” chemical exposure situations from affluent countries have been shifted to developing countries. The concept of “export of hazard” is well established and, in some cases, whole factories using out-of-date technologies are moved from affluent countries to developing countries. This aspect of globalisation is particularly detrimental to effective development of OSH in developing countries. One example of this is the problem of use of very toxic solvents in glues used in shoe manufacture and other industries in developing countries, even in production units that have been recently installed as part of the process of globalisation.

### Replacing hazardous solvents with less toxic varieties

Organic solvents are some of the more toxic compounds widely used in industry, primarily in glues, paints and cleaning fluids (e.g. for cleaning oil and grease of metal items). Benzene was one of the first solvents used in workplaces, but it is very toxic and carcinogenic (leukaemia) and has now been eliminated from routine use in industrial countries. However, it is still used in some shoe factories in developing countries, and is highly hazardous for workers. The multinational company NIKE, was embarrassed some years ago when it was found that their sub-contractors (usually Korean or Taiwanese owned factories in other countries, such as Vietnam), were using benzene-containing glues, a process long seen as obsolete process in industrial countries. NIKE changed to water-based glues, and also implemented other OSH improvements to avoid further embarrassment. However, other shoe factories in Vietnam, many of them owned by the Vietnamese government, are still using the very toxic glues.

Solvents that are less toxic than benzene include (in order of descending toxicity): toluene, xylene, kerosene, and water. The level of toxicity is determined not only by the mechanism of toxicity, but also by the degree of volatility of the compound which determines how much of the solvent will be found in the workroom air. The ranking of solvents in order of descending toxicity is sometimes called the solvents ladder, and good OSH practice would check that the least toxic solvent is always used.

Occupational dust diseases are also a common and increasing concern in developing countries, partly caused by the growth of mining and quarrying industries in these countries, linked to the growth of the construction industry and to the development of exports from mines and metal smelting industries. Estimates from epidemiological studies have indicated that many thousand of silicosis cases are found each year in China alone, and the situation in other countries with many mines, e.g. India, is likely to be similar.

Asbestos exposure continues to be an ongoing global problem, even though all industrial countries have placed severe restrictions on the use of asbestos or totally banned its use, e.g. Sweden and Australia. Asbestos has technically useful properties for fibre-cement building materials and in motor vehicle brake linings and gaskets but alternatives do exist, and are used in all

affluent countries. In this context, it is disturbing that corporations from affluent countries manufacture asbestos products in their subsidiary companies in developing countries. These products are then sold only in developing countries. For example, a German company produces asbestos brake linings in Brazil, solely for developing country markets. This practice totally ignores the future health impacts of asbestos in developing countries.

Sweden has reported only a few new cases of silicosis or asbestosis during the last decade. This is due to a major national campaign in the 1970s on the prevention of dust exposures with high silica content and the banning of asbestos imports in 1975. However, asbestos-induced mesothelioma and lung cancers continue to occur and the incidence has actually increased due to long latency periods for most cancers. Eventually, the incidence will decrease.

### Asbestos alternatives

There is very limited need to continue the use of asbestos in building products, brake linings and insulation materials given the extremely hazardous nature of asbestos. Wood-fibre can replace asbestos in fibre cement product and insulation materials can use glass-fibres and other less hazardous fibres. However, each replacement material must also be used with caution as almost any fibres can cause some detrimental health effects if exposure is high. The web-site of the London Hazards Centre, (<http://www.lhc.org.uk/members/pubs/factsht/59fact.htm>), lists the hazard of each asbestos alternative and stresses the need for dust control in all jobs with potential fibre exposure. It is important to note that all the alternatives to asbestos are considered to have lower risk of cancer and pneumococcosis than asbestos.

The alternatives listed include Ceramic fibre; Glass fibre; Glass and stone wool; Wollastonite; Perlite; Cotton fibres; Shredded paper; Cellulose fibres (wood fibres); Kevlar (para-aramid) fibre; Polyvinylalcohol (PVA) Fibre; Polystyrene;

Detailed information on the health hazards of different fibres is available from the World Health Organisation (WHO), the International Agency for Research on Cancer (IARC) and the UK Health and Safety Executive (HSE).

However, in a number of developing countries, e.g. China, Viet Nam, Indonesia, and Brazil, asbestos fibres continue to be used in production of fibre-cement building products such as roofing panels, and brake linings. This is likely to lead to significant and dangerous exposures, in spite of alternative safer products being available. In most of these countries it is either too early to be able to record an increase of asbestos induced mesothelioma due to the long latency, or the data for analysis just doesn't exist. Some information from Hanoi in Viet Nam gives an indication of what may be on the horizon, when compared with Sweden, Australia and New Zealand, Figure 12.2.7.

The mortality rate is going up dramatically in the three industrial countries during the first years. In Sweden there is an indication that the increase is slowing down, but this is not in evidence in Australia and New Zealand. The Hanoi data appear to follow a similar pattern

of increase, but with a 20 year delay. There are 7 000 asbestos-cement product manufacturing workers in Viet Nam and many more who use the products in their daily work according to Viet Nam Ministry of Health. The future epidemic of asbestos related cancers in the developing countries is likely to become a real burden on the health care systems of these countries, in addition to the pain and suffering of the affected workers and their families.

Various biological hazards, including viruses, bacteria, parasites, fungi, moulds and organic dusts, are common causes of occupational diseases in developing countries. Exposures in traditional subsistence work are of particular importance. Lung infections, organic dust diseases such as bagassosis (from sugar dust) and occupational asthma occur among persons exposed to organic dust. Hepatitis B, Hepatitis C and tuberculosis infections occur particularly among health care workers. The global spread of

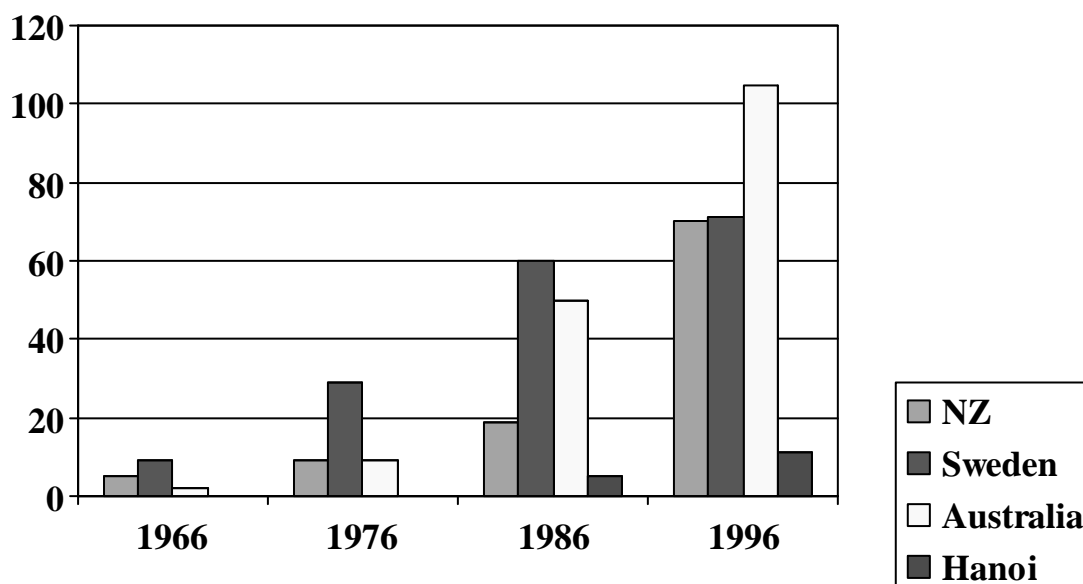


Figure 12.2.7. Mesothelioma (or pleural cancer) mortality rates (crude, per million people) in three countries and Hanoi city at different times.



improved health care methods and technology would assist in controlling these occupational diseases, but the lack of resources allocated to health services in many developing countries mitigates against such OSH improvements.

It should also be noted that vector-borne tropical diseases such as malaria and schistosomiasis are common in the general population of many developing countries and are likely to be a particular risk for agricultural, forestry and other outdoor workers. The opportunities to apply protective devices against mosquitoes or other insects spreading these diseases can be very limited when work has to be carried out at a time and place where the vectors are prevalent. Protective devices are too expensive for most workers to buy and these devices may make the physical workload greater or at least slow the work down. Supervisors and workers may prefer that protective devices are not used as the demands of globalised agriculture require the highest possible production output per worker. Unskilled workers who become ill are easily replaced.

Other occupational diseases such as leptospirosis, brucellosis and psittacosis, are caused by biological factors and spread from domestic animals to farm workers. In addition, new diseases from mutating viruses spread from farm animals, have become a major concern. One example is SARS, (severe acute respiratory syndrome), which emerged out of farms in southern China at the end of 2002. SARS spread from person to person, and then spread rapidly to other countries across the globe, via air travel.

Physical factors, such as noise, vibration, ionizing and non-ionizing radiation and microclimatic conditions are major occupational health hazards. Noise-induced hearing loss is one of the most prevalent occupational diseases in both developing and industrial countries. Personal

protection, such as ear plugs or ear muffs, is the most common approach to prevention, but it is less effective than reduction of the noise at source. Modern, quieter manufacturing technology can be introduced when new industries are established in developing countries, but in many cases old technology is exported to these countries bringing with it the noise problems that previously affected workers in industrial countries. An emerging new concern about noise is the so-called “acoustic shock syndrome” caused by high pitch noise peaks due to malfunctioning equipment or wilful noise exposures by the person at the other end of the phone line. With the increasing number of people, mainly women, employed as telephone operators in call centres and telephone marketing firms, these problems are likely to increase in the future.

An issue that has received little attention, is the effect of high temperature and humidity on people's ability to work both in traditional and modern occupations. This is of particular importance in tropical countries, where temperatures and other climate variables in the work environment, are already within the danger zone. Global warming will exacerbate this hazard in many parts of the world. The human body needs to maintain a balance between surplus heat created through muscular work and the heat loss or heat uptake from the surrounding environment. Sweating is an important mechanism to release heat from the body, but the cooling effect of sweat evaporation is less efficient when the humidity outside the body is high making heavy work difficult.

The International Standards Organization (ISO) standard for work in hot environments prescribes reduction of work time and increasing the length and number of rest periods as the temperature and humidity get higher, Figure 12.2.8. The figure shows how “work ability” is

decreased when the WBGT increases (wet bulb globe temperature, which is a heat stress index of temperature, humidity and heat radiation). Even a small increase of WBGT of only one degree can cause a dramatic reduction of 20 % in work ability. The effect of heat exposure starts at a lower temperature for people who carry out very heavy work (500 Watts) compared to office workers (200 Watts), Figure 12.2.8. It should be pointed out that “work ability” as expressed here does not mean absolute ability to work – clearly many people in tropical countries are working even if the temperature is higher than 34-39 degrees C. However, such work activity cannot

continue for many hours without the risk of heat stress effects on the individual.

This particular occupational health hazard is related to current, global workforce developments and the globalisation process. One issue is the increasing number of workers in construction and manufacturing jobs in tropical developing countries. In addition, one effect of the Western economic development model, that includes high energy consumption, is increased greenhouse gas emissions and global climate change. The increasing temperatures and more violent weather patterns associated with global climate change have now been documented all

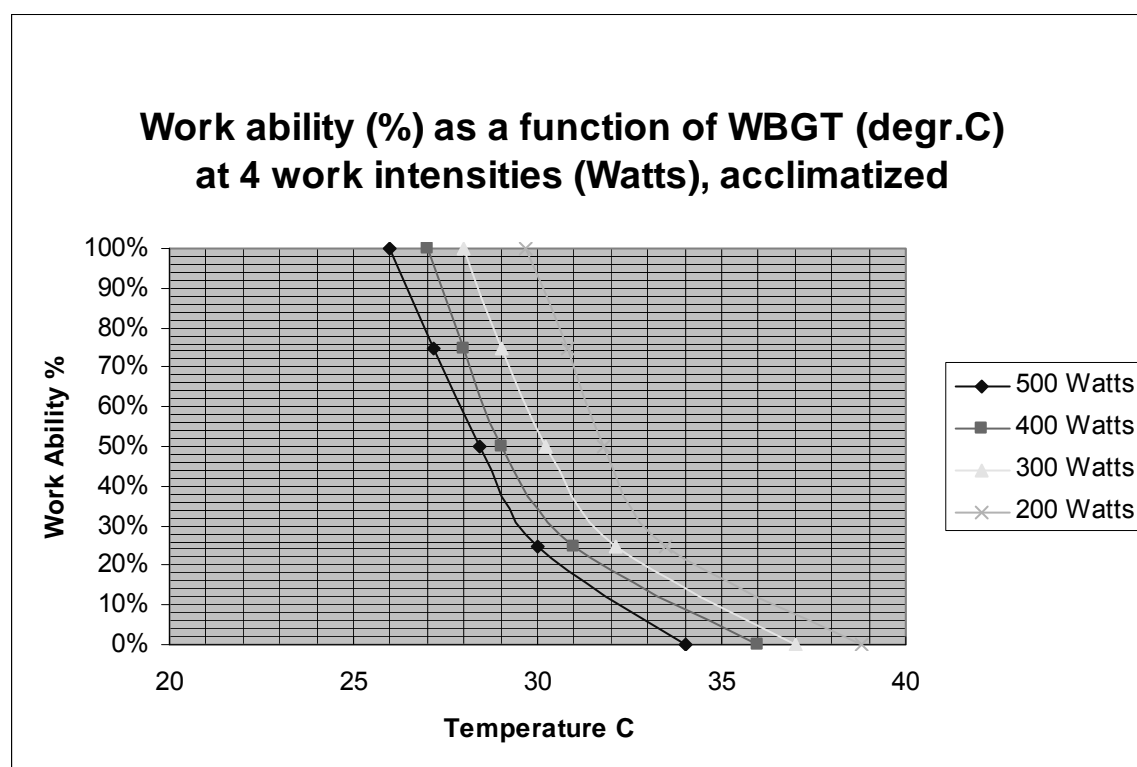


Figure 12.2.8. Relationship between the percentage of a work hour that a person can work according to international guidelines (“work ability”) and the heat stress index (WBGT in degrees C) Source: Kjellstrom, 2000.

over the world. The effect on workers will be increased heat stress and lower productivity. The latter may be seen as a production obstacle for employers, but in fact the worker may suffer the consequences by having to work longer hours (see Box).

Since the 1990's there has been intense concern about the possibility of increased cancer risk from electromagnetic fields (EMF) associated with "cellular phone" technology or high voltage power lines. Some reports indicate a small risk increase of leukaemia among children living close to power lines, but the exposures have to be high, and the conclusions by international review groups are that these risks have not yet been proven. It is still too early to fully evaluate the potentially harmful effects of the exposure to cellular phones and large scale research efforts are ongoing. This hazard is mentioned here because the future development of telecom-

munications in developing countries may rely heavily on mobile phone technology, and the issue of safety will undoubtedly become a concern. To be able to respond to any such concerns, the OSH professional will need to seek out the latest reliable information. New evidence may change the current thinking about this hazard.

Psychological stress caused by such things as time pressure, the high speed of work, and insecure employment, (part time, casual, contract), has become more prevalent during the past decade. Globalisation has created a new emphasis on "competitiveness" between enterprises and countries, which has lead to increased pressure on workers and employees at all levels to work harder and faster. Workers are unable to adapt their workload and working hours to other needs, such as family needs, because of long working hours and less flexibility. So called work flexibility, such as weekend work or split

Heat and work in Viet Nam

A shoe factory in Haiphong, Viet Nam, employs 2 900 young women producing sports shoes for the European markets. Haiphong is very hot with temperatures of 30-38C degrees inside the factory in the summer, with relatively cool temperatures of 15-20C degrees in the winter. The factory is not air conditioned so during the summer the workers have to work longer hours to maintain the daily production quota. On hot summer days, workers have to spend at least two hours longer at the workplace, including at least one hour of extra work, in order to reach their production targets.

A comparison of typical working days in winter and summer:.

• WINTER	• SUMMER
<ul style="list-style-type: none"><li>• 7.30 start work</li><li>• 10 - 10.15 break</li><li>• 11.30 - 12.30 break</li><li>• 15 - 15.15 break</li><li>• Finish at about 18.00 (when production target reached. Same target in winter and summer)</li></ul>	<ul style="list-style-type: none"><li>• 6.30 start work</li><li>• 10 - 10.30 break</li><li>• 11.30 - 13.00 break (employer provides complimentary bean soup)</li><li>• 15 - 15.30 break</li><li>• Finish later at about 19.00 because of heat</li></ul>

shifts, may be convenient for enterprises but often means the opposite for workers, leading to mental and physical stress. The problem of heat highlighted (see Box) is just one example of enterprise requirements causing stress in the form of time demands on workers.

The type of work organization and management of workplaces that goes with the current form of globalisation creates uncertainty and often a sense of failure within a very competitive environment. The flexibility of work organization is associated with societal trends towards individualization and a loss of social capital. The result is that young people in modern industrial society worry more about the future and achievement of their goals and aspirations than young people do in traditional societies. The effect on mental health can be seen through drug use, suicide, and depression.

Other factors that may have adverse psychological effects include heavy responsibility for human or economic concerns, monotonous work or work that requires constant concentration. Those who work shift-work, in isolation or have jobs where violence is threatened, e.g. in security, police or prison work, are also prone to psychological stress.

Psychological stress and overload have been associated with sleep disturbances, burn-out syndromes, stress, nervousness and depression. There is also epidemiological evidence of an elevated risk of cardiovascular disorders, particularly coronary heart disease and hypertension. The European Commission distributed a guide on work related stress, subtitled “Spice of life or kiss of death”. The guide provides a checklist for work related sources of stress and examples of successful intervention programs.

These hazards will be of particular concern where proper OSH services are not in place to monitor exposures and work practices. It could

therefore be argued that lack of OSH services is in itself a work hazard in newly developing workplaces. Only 5-10% of workers in developing countries and 20-50% of workers in industrial countries (with a few exceptions) are estimated to have access to adequate OSH services. In the USA, for example, 40% of the workforce of approximately 130 million employed people, does not have such access. A consequence is that even in advanced economies, a large proportion of work sites are not regularly inspected for occupational health and safety.

### UNEMPLOYMENT AS A HEALTH HAZARD

This chapter and previous chapters describe a number of OSH hazards and their effects while people are working. It should be pointed out that lack of income due to unemployment or under-employment is another important health hazard related to work, particularly in countries where the social security system is poorly developed. ILO estimates that the number of people unemployed or underemployed in the world today exceeds 800 million, almost one-third of the global labour force.

It is therefore relevant to consider the role globalisation has in employment and unemployment. As was pointed out in Chapter 12.1, globalisation may increase economic activity or employment in certain sectors, while other sectors shrink. While the quantity of available work is an issue, the quality of work also affects various OSH issues. One of the key features of globalisation is the requirement for a “flexible” labour market, which in plain language means that the employer should be able to increase or reduce the workforce at short notice so that only the number of workers needed for production requirements are paid - a system akin to the “just-in-time production” paradigm. This kind of system creates great insecurity for workers as

the number who gain or lose income may vary dramatically depending on short term production requirements.

The implementation of flexible labour market principles has led to a rapid increase in the number of part-time workers in many countries, for instance in the USA. For many families with young children, a part-time job is often the only solution to get into the labour market, but the limited income this creates may not be sufficient for the family's needs. Affordable childcare is a key issue linked to the entry by women into the labour market. This has been an essential issue for government policy in most industrial countries, in e.g. Sweden. Part-time work may represent an aspect of under-employment, which can have similar negative impacts on workers health as unemployment does.

While a flexible labour market may cut costs for the employer, it can also create considerable difficulties if it takes time to find new and/or skilled workers when production needs to increase. Employers are more likely to retain highly skilled workers during leaner times because they are harder to replace.

The public sector has experienced specific impacts on employment from globalisation. Clearly, in some countries the government has employed too many people in obsolete jobs and a restructuring of public workplaces to create more meaningful output at reasonable cost is a positive change. However, globalisation incorporates a general notion that public services are always inefficient and that the private enterprise can do a better job of providing water, electricity, mass transport, etc. Tax cuts are promoted along with privatisation but this often means a reduction in public services and higher costs for service users. Numerous examples illustrate how privatisation has created more problems than it has solved. Public sector workforce reductions have often

led to protracted unemployment for groups of people, already vulnerable in the labour market. Financial and job cuts in the public sector have damaged public health. Cuts in the public health sector were often demanded by the IMF as a part of economic re-adjustments in heavily indebted countries in the 1980s and 1990s.

Insecure employment and the lack of income during periods of unemployment, are both stress factors detrimental to the health of workers. Studies of mortality and morbidity among unemployed people in industrial countries regularly show that unemployed people have poorer health than employed people. This effect is likely to be even stronger in developing countries, even though informal and temporary work can be a way to maintain income during periods of unemployment. The dramatic changes in Thailand after the currency crisis in 1997, caused a drop of employment in manufacturing but a simultaneous increase in the number employed in agricultural work. This was reversed over the next few years, indicating that manufacturing workers temporarily moved back to farming as an alternative to living in poverty in the cities.

A key issue is whether globalisation is a solution to unemployment in developing countries or whether it creates unemployment - both scenarios are claimed. As pointed out in earlier, it is the way in which globalisation is implemented that determines its influence on employment and related health issues. Factors that may destroy more employment than create it, include rapid social change due to reduced capital flow restrictions across borders, manufacturing industries that are itinerant and move at the whim of the multinational corporations, transfer of all added value (profits) of production to industrial countries, the undermining of traditional economic activities, etc.

## THE OCCUPATIONAL BURDEN OF DISEASE AND INJURY

The measurement of the extent of occupational disease and injury, globally, regionally, nationally and locally, has become increasingly important in a world where quantification and cost-benefit analysis is demanded. The common measures of mortality and morbidity cannot be added together to give an integrated full picture of the impact of occupational health hazards. The DALY (DALY = disability-adjusted life years lost) method, has been widely applied during recent years, primarily because the World Bank, and later the WHO, provided major financial support for its development and application in major international reports, e.g. The World Bank in 1993 and WHO in 2002.

The DALY method calculates for each death, the number of years of life that has been lost (YLL) in comparison with the theoretical life expectancy at the age of death. Thus, even a person who dies at age 100 will contribute some YLLs to the calculation, because according to a “life-table” he/she could have lived longer. This is different from some other methods of estimating the burden of disease, such as the quality-adjusted life years method (QALY) or the Potential-years-of-life-lost method (PYLL), where usually a maximum age of 65, 75 or 85 years is assumed. The DALY method applies a difference in the assumed life expectancies at birth of men (80 years) and women (82.5 years), creating higher DALYs for a female death at a certain age than for a male death at the same age.

The DALY method also includes morbidity data, i.e. the incidence and severity of key diseases. For each type of disease a weight is applied equivalent to the degree of disability compared with death. The duration of disease (disability) before death times the weight will add up to the years of life lost to disability (YLD). In addition,

each year of life lost will be given a weight according to the age of the person, so that a very young and a very old person is given a lower weight than is given for a young to middle age adult (a year lost at these extreme ages is considered to be worth less than a year in middle life). As the aim of this method is to calculate years lost in such a way that these can be converted into lost economic value, each lost year in the future is also discounted, based on interest rates, in order to get the final DALY numbers.

In order to quantify the contribution of occupational health hazards to the global burden of disease and injury, a detailed review of available data and epidemiological studies was carried out for the World Health Report (WHO, 2002). Five major occupational hazard groups, for which it was considered that meaningful quantifications could be made, were selected. This would create a “conservative” low estimate of the global occupational burden of disease in DALYs. These were:

- work-related risk factors for injuries
- work-related carcinogens
- selected airborne particles
- work-related ergonomic stressors
- work-related noise

The distribution of world-wide DALYs for each of these hazard groups and the percentage of the total for men and women is presented in Figure 12.2.9. It is seen that overall it was estimated that about 1.6% of all DALYs were due to these occupational hazards. The order of importance was injuries, air particles, noise, carcinogens and ergonomic factors, Figure 12.2.9.

The figure shows the great difference in estimated occupational health burden between men and women. This is logical, as it is assumed that more men are in employment and that they are working in occupations where more serious



OHS hazards occur, but this analysis has the drawback of excluding health problems, particularly in women, caused by health hazards in traditional and informal work arrangements.

Other important occupational hazards are also excluded, such as pesticides, heavy metals, infectious organisms, agents causing occupational asthma or COPD, and stress at work causing increased cardiovascular diseases. To make estimates of their contribution, one may consider the number of DALYs per death as a conversion factor. The estimated 355 thousand injury deaths, Figure 12.2.1, are associated with 13.1 million DALYs. Thus, each injury death was associated with approximately 40 DALYs, which may apply to other occupational health impacts that affect relatively young people.

Pesticides alone cause major public health impacts. It was estimated by WHO in 1990 that at a global level occupational exposures may cause each year 700 000 acute pesticides poisonings, about 770 000 chronic poisonings and 12 000 deaths. Population increase alone may have increased this to 16 000 in the year 2000. A conversion to DALYs has not been made, but

based on the number of deaths and 40 DALYs per death, this could add 640 000 DALYs to the occupational burden of disease and injury; increasing the OHS contribution to the total DALYs from 1.63% to 1.70%, Figure 12.2.9.

Health service personnel are exposed to sharp objects that can spread Hepatitis B or HIV/AIDS, and thousands of such occupationally caused cases occur each year.

The health consequences of stress are more difficult to quantify, but a recent review in industrial economies by Nurminen & Karjalainen, 2001, has shown “that a substantial proportion of ischaemic heart disease results from the combined occupational factors of shift work, noise, exposure to engine exhausts, and environmental tobacco smoke”. The proportion expressed as the “attributable fraction” was 19% for men and 9% for women, (combined 17%). As cardiovascular diseases contributes 9.8% of all DALYs globally, 17% of this would be equivalent to 1.7% of the total global DALYs, which would increase the occupational burden of disease and injury from 1.7% to 3.4%.

Occupational hazard	World, both sexes		World, males		World, females	
	DALYs (millions)	%	DALYs (millions)	%	DALYs (millions)	%
<b>Total, all DALYs</b>	1 467	100	768	100	699	100
<b>Injury factors</b>	13	0.89	12	1.57	1.1	0.15
<b>Carcinogens</b>	1.4	0.10	1.1	0.15	0.3	0.04
<b>Workplace air pollutants</b>	3.0	0.20	2.7	0.35	0.3	0.04
<b>Ergonomic factors</b>	0.8	0.06	0.5	0.06	0.3	0.05
<b>Noise</b>	4.2	0.28	2.8	0.36	1.4	0.19
<b>Occupational hazard DALYs, total (WHO)</b>	22.4	1.53	19.1	2.5	3.4	0.47
<b>Occupational DALYs (our revised estimate)</b>		> 3.27				

Figure 12.2.9. Burden of disease and injury from occupational hazards: whole world, 2000, millions of DALYs. Source: WHO, 2002.

	Global occupational DALYs (millions) by age group		
	Total, all ages	15-59 years	60+ years
<b>Total, all DALYs</b>	1 467	602	168
<b>Injury factors</b>	13	13 (2.1% of 602)	not calculated
<b>Carcinogens</b>	1.4	not calculated	not calculated
<b>Air pollutants</b>	4.4	not calculated	2.0 (1.2% of 168)
<b>Ergonomic factors</b>	0.8	not calculated	not calculated
<b>Noise</b>	4.2	not calculated	not calculated
<b>Total, occupational</b>	24	not calculated	not calculated

Figure 12.2.10. DALYs by age group, % of attributable DALYs in two age groups. Millions of DALYs (calculated from WHO, and Murray and Lopez, 1996).

The material used by WHO in these calculations in 2002, estimated that there had been 709 000 occupational deaths. An estimate by ILO in 2002 gives a much higher figure, 2 million with a range from 1.92 to 2.33 million. WHO or ILO give no reasons for this difference in their reports which implies that the WHO figures may be almost three times too low. The difference would include the missing burden of disease and injury due to pesticides and stress mentioned above. If the new estimates are correct, it is likely that the previous undervaluing occurred mainly in developing countries. A death in those countries leads to more DALYs, as the deaths usually occur at younger ages than in industrial countries so the occupational DALY numbers may be more than three times undervalued by WHO.

The distribution of the burden of disease and injury by hazard types, Figure 12.2.9, is another interesting feature. Injuries dominate, but air pollutants in the workplace also take on a major role in the developing countries that have low overall mortality rates. These are countries that have large mining and other metal production activities, and it is logical that occupational dust

diseases, etc. play a more prominent role. These countries also have the largest estimated occupational proportion of the total DALYs (WHO, 2002).

Another way to express the importance of occupational hazards for the global or country burden of disease and injury, is to analyse it by age group, Figure 12.2.10. The proportion of total DALYs for the 15-59 year age group due to occupational injuries is 2.1%, much higher than the 0.89% for all ages, Figure 12.2.9. The figure for air pollutants in the 60+ age group is also much greater (1.2%) than the average for all age groups, 0.30%, Figure 12.2.9.

By definition, no occupational DALYs occur before age 15 in the WHO calculation (thereby excluding the health impact of child labour). In industrial countries, about 30% of 15-19 year olds are economically active, and in developing countries the figure is about 50%. The equivalent number of fulltime workers in this age group may be about 5% of the number in the 15-59 year age group, based on population size and likely prevalence of part-time work among the youth. Injuries will be the dominant problem, and because many young workers are

Risk factor		Rank	DALYs (millions)	% of total
<b>External</b>	<b>Internal</b>			
Underweight, malnutrition		1	138	9.5
Unsafe sex		2	92	6.3
Occupational hazards (revised here)			81	5.4
	Blood pressure	3	64	4.4
Tobacco		4	59	4.1
Alcohol		5	58	4.0
Unsafe water, sanitation and hygiene		6	54	3.7
	Cholesterol	7	40	2.8
Indoor smoke from solid fuels		8	39	2.6
Iron deficiency		9	35	2.4
Overweight, over-nutrition		10	33	2.3
Occupational hazards (original figures)			24	1.6

Figure 12.2.11. Ranking of risk factors in Global Burden of Disease and Injury calculation. Source: WHO, 2002.

inexperienced, their injury rate may be higher than that of older workers. One may assume that injury hazards contribute about 10% as many DALYs for the young as for the older workers so child workers could add another 1,312 thousand DALYs to the total, Figure 12.2.9, or another 0.09%.

The occupational burden of disease and injury is one way to express the importance of occupational hazards in the overall analysis of public health risk factors. The estimated figure of 1.6% that occupational hazards contribute to global DALYs, may be a considerable underestimate, particularly if one focuses on the burden for adult age groups. The DALY ranking list of the ten most important risk factors globally starts with “underweight” and ends with “overweight”, Figure 12.2.11.

It can be seen that occupational hazards may be ranked much higher. This would be further accentuated if the burden of disease and injury is

calculated for the working age groups, as the risk factors with rank 1, 6, 8 and 9 are of particular importance for very young children. In addition, the “internal” risk factors of high blood pressure and cholesterol are not independent of other risk factors on the list, (e.g. over-nutrition and tobacco smoking), and it may be argued that their DALYs may overlap with some of the other risk factor DALYs. If estimates are made for an individual country, in order to provide information that gives decision-makers a valid picture of the role of OSH hazards, it is important to present different scenarios for the calculations which take account of the issues raised here.

It is important to note that trends in adult health are major factors in general population health whereas for life expectancy and the burden of disease and injury, child health has the greatest influence. The reduction of infant and child mortality goes hand-in-hand with the lengthening of average life span. However, one

of the most important factors for good child health, is the good health and survival of the child's parents. The achievement of good adult health requires a decent working environment and OSH practices.

An analysis of adult ill health in developing countries, showed that there are great differences between industrial and developing countries in the chance of survival, from age 15 to 60. A 15-year old boy in India has three times higher probability of dying before age 60 than a boy in Sweden. A focus on child health in analysis of health statistics can easily hide such health gaps between rich and poor. When estimates are made of the contribution to the burden of disease and injury from different risk factors, it is important that the situation for different age groups is presented separately but the detailed data required to do this is seldom available.

One of the main arguments for making "burden of disease" calculations, using the DALY method, was that these estimates could be used in calculations and comparisons of the economic cost of different health problems in different countries. The cost of illness and deaths based on the "value of statistical life" are substantial, and "the cost per DALY" is a way to summarize these costs. In addition, there are direct treatment costs. The health status of the workforce and any associated absence from work will reduce productivity and have a direct impact on the local and national economy.

The estimated total global economic losses due to occupational illnesses and injuries are enormous:

- The International Labour Organization (ILO) has estimated that in 1997, the overall economic losses resulting from work-related diseases and injuries were approximately 4% of the world's Gross World Product (US\$

31 000 billion in the year 2000), or US\$ 1 200 billion.

- In 1992, the direct cost paid out in compensation for work-related diseases and injuries in European countries, reached Euros 27 billion (= US\$ 30 billion).
- In 1992, total direct and indirect costs associated with work-related injuries and diseases in the USA were estimated to be US\$ 171 billion (or about 3 % of the total GDP in the USA), surpassing those of AIDS and on a par with those of cancer and heart disease.

### IMPROVING THE QUALITY OF DATA

Effective planning of policy setting and action for OSH requires meaningful information about the extent of problems, time trends, special problems for vulnerable groups, links between interventions and changes in OSH status. Good quality data on health status, occupational hazards exposures, size of working populations and timing and extent of interventions taken is important to achieve this. No country has complete and accurate data available for this purpose so improvements are required everywhere. OSH professionals are important participants in the process of improving the quality of OSH data and general health data, as they have opportunities to record, collate and transmit field data that can contribute to local or national datasets. They also use OSH data in their daily work and can lobby for improved quality of data collected by other. Data offices for health statistics are often isolated from the field work and feedback and other communication from users of the data may be welcomed.

Occupational hazards and their health effects are linked to economic factors, legislation, and basic development trends (including globalisation), in any country. In order to get good quality OSH data that can be interpreted for policy

development, it is important to collect information on the driving forces behind OSH problems in addition to statistics on health. WHO developed a framework (DPSEEA) for environmental health analysis in 1990. It visualizes the links between different variables by identifying *Driving* forces that create *Pressures* on the working environment, which in turn influences the *State* of that environment. The State of the environment links *Exposures* to the different hazards, which in turn cause *Effects* that we are concerned about. *Actions* to reduce the health risks can be taken at each level of the framework.

The main reason for the poor quality of occupational mortality data in many countries is incomplete and out-of-date mortality data systems. This can be a major obstacle for efficient health system planning and priority-setting. WHO and the UN Statistical Office have developed a number of programs and guidelines to help countries improve their situation. The efforts to improve routine data collection systems can be supported by OSH professionals, through their requests for valid mortality data on population groups and causes of death of particular interest to OSH. If users of the general mortality recording systems are not making demands for better quality data, the producers of the data may not be motivated to improve on their work. The same approach can be used for hospital admissions data, but the privatization of the hospital services, commonly emerging from globalisation, may create difficulties in getting comprehensive datasets. For individual data, valid ethical concerns about privacy issues also creates limitations to what data is made available, but these problems can be overcome as OSH work usually needs only aggregated statistical data rather than individual data.

Specific OSH data that should be collected includes workplace and local level data on oc-

cupational injuries and diseases, numbers of workers, hazard exposure levels and implemented interventions. Routine data collection systems that use modern computer technologies to record, edit, store and analyze data are at the heart of better quality data. Policies for high quality and complete OSH data need to be established by both employers and workers in collaboration. Systems for collecting the data and the resources and time needed to carry out the collection are also essential. This work is greatly helped by modern computer hardware and standard software. Such software can automatically check for typographical errors and erroneous coding, which speeds up the work and makes the data more accurate. The software can also be designed to produce automatic reports in standard formats, which makes it possible for OSH professionals to share interim reports of new data without delay.

Another type of OSH data, which can strongly enhance the quality of information available for decision-making, is surveys of workers, usually carried out with questionnaires, either self-administered or completed by interviewers (see following section for examples). In situations where OSH data is not collected routinely or is not available, it will take a long time to establish such systems. Good quality data are best collected through a combination of worker surveys, and information from employers and other key participants in OSH, such as government officers. Important information is provided by both qualitative data, (which describes opinions and experiences of individuals), as well as quantitative data, (which summarizes questionnaire answers from groups of people in numerical form). The qualitative approach can provide invaluable information to complement statistical data as in-depth information from individuals can show linkages between attitudes, behaviors, the work

### Items included in European Foundation (2003) survey of working conditions in different countries.

#### *Factors affecting working conditions*

- Physical environment of the workplace (exposure to risks, ergonomic design and the availability of information on risks.)
- Organisation of work:
  - o job content;
  - o autonomy and control;
  - o pace and intensity of work;
  - o working time patterns;
  - o flexibility.
- Social and psychosocial environment:
  - o participation and consultation;
  - o issues of age, gender, race and disability;
  - o harassment and violence.
- Management of human resources
  - o skills and training;
  - o employment status of workers and their incomes.
- Labour law, collective agreements and systems of industrial relations.

#### *Working conditions have implications in terms of*

- health;
- equal opportunities;
- company performance (in both large enterprises and SMEs, including micro-firms)
- and ultimately for the economic performance of regions and states as well as for the quality of life of citizens.

environment and OSH risks and is often an invaluable complement to statistical information.

### **SURVEYS OF WORKING LIFE AND HEALTH**

One way to get a picture of the status of OSH in a country, a local area or a workplace, is to carry out a survey of the attitudes and experiences of a representative group of people. National working life and health surveys of this type have been carried out in a number of countries, including Sweden. These surveys are usually carried out

by government agencies but the same survey methods can also be used at local level by OSH professionals and/or interested groups.

In recent years, standardised surveys about working conditions and health impacts have been carried out in the 15 European Union (EU) Member States (1990, 1995, 2000) and the 12 EU Candidate Countries (2001). Each survey questioned more than 10 thousand workers in a variety of occupations, about the working environment, work organization, and the im-



pacts on health and other issues (see Box). The methods and questionnaires are available on the European Foundation website and could be used for comparable surveys in other countries or local populations.

The results of these surveys give an indication of differences between countries and time trends. There was an increase of reported noise and ergonomic hazard exposures, an increase of work pace and time pressures, with an apparent small increase in some potentially related health effects, Figure 12.2.12. The intention is to continue to carry out regular surveys in order to develop policy proposals for prevention of OSH effects, and to monitor the impacts of such policies and working life risk factors.

These types of surveys are not common in developing countries, but a detailed report is available for one such survey of the informal and rural sector in Zimbabwe in 1997, by Loewenson (1998). The survey included 1 587 workers interviewed in their households. Most

were young and self-employed, working in the most common sectors in Zimbabwe: agriculture, manufacturing and retail/services. Questions were asked about work organization, hygiene, ergonomic problems, chemical exposures, and other hazards. The most commonly reported health hazards and problems were: work that required bending forward, exposure to direct sun, poorly organized workplaces, handling heavy loads, and other basic work environment and hygiene hazards, Figure 12.2.13. Other concerns raised were poor housekeeping, poor lighting, long work hours, poor workplace design, and lack of awareness of chemical risks. The hazards listed in Figure 12.2.13 indicate the type of questions about hazards likely to be relevant in a developing country setting. The survey had an important impact on the workers themselves, by highlighting common concerns that needed collective solutions.

Loewenson's survey found a much higher burden of ill health than that reflected in most

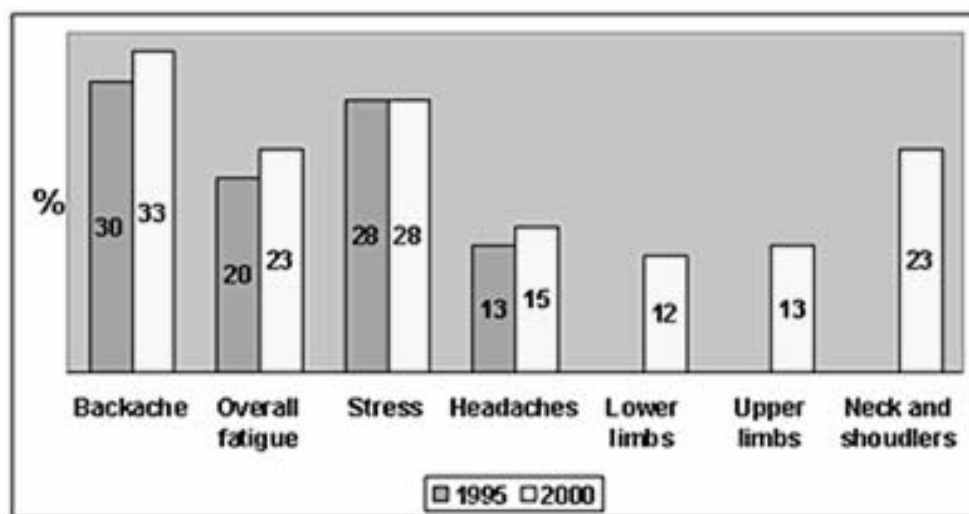


Figure 12.2.12. Perceived health effects of work hazard exposures in surveys of 15 EU countries. Source: European Foundation, 2003.

national databases. The survey showed 131 work-related injuries per 1000 workers, and 116 illnesses per 1000 workers in the informal sector, which exceed the officially reported rates in the formal employment sector by a factor of 10 for injuries and 100 for illnesses. Permanent disability was reported in 19% of injuries and 25% of illnesses. Almost none of these workers had the benefit of any occupational health service.

This example highlights the very large hidden work-related injury and illness burden that may exist in many countries. Surveys of self-reported hazard exposures and health problems may exaggerate the work-related effects, because of “over-reporting”, but they can also guide the occupational health practitioner to issues where further more precise data needs to be collected, and preventive action may need to be intensified.

ILO has supported surveys in certain developing countries, but a systematic picture of work-related injuries and diseases for all countries, based on surveys, is not yet available.

### PUTTING TOGETHER THE FULL PICTURE

This chapter indicates that there are major, important gaps in our knowledge about the global impact of workplace hazards on injuries and diseases. To establish the true figure requires significantly more effort to improve recording of basic mortality and morbidity data at workplace, local, and national level. The global situation is the aggregate of the information that comes from local and national level so it can never be of good quality if the source data is deficient. OSH professionals contribute to both the creation and validation of the data as well as to the interpretation of information and decision-making about policies and actions. Assembling the fullest possible picture is an important task, but it is not an easy one. This chapter has given examples of the type of information required for the full picture and while the chapter has offered a critical analysis, the problems with current data should not be seen as a reason for despair.

The first approach, at national level, may be to assemble a tentative national summary of work related injuries and diseases from pub-

Agriculture	Manufacturing	Retail/Service
Exposed to direct sun, 90%	Work bending forward, 78%	Poorly organized workplace, 76%
Work bending forward, 90%	Work with sharp tools, 77%	Toilets inadequate/dirty, 62%
Handling heavy loads, 77%	Poorly organized workplace, 76%	Exposed to direct sun, 60%
Toilets inadequate/dirty, 73%	Eating inside workplace, 75%	Heat/noise/dust pollution, 60%
Long hours of standing, 67%	Toilets inadequate/dirty, 70%	Handling heavy loads, 52%
Biological hazards, 67%	Long hours of standing, 70%	Long hours of standing, 50%
Clean water unavailable, 59%	Exposed to direct sun, 63%	Seat uncomfortable, 50%
Work with sharp tools, 52%	Repetitive movements, 62%	
	Handling heavy loads, 62%	
	Heat/noise/dust pollution, 58%	
	Clean water not available, 58%	

Figure 12.2.13. The most common work hazards by sector in Zimbabwe survey. Source: Loewenson, 1998.

lished mortality and morbidity data. The following guidelines may be of help:

- \* don't accept the number without checking any alternative sources
- \* assemble data from different sources: census records, mortality records, workers insurance records, hospital records, etc.
- \* check whether the numbers make sense compared with data from other countries, and ILO statistics; calculate rates to check that they make sense
- \* complement routine statistics with surveys that can be interpreted beyond the survey population

Exposure variables need to be assembled to be able to interpret the data. Population distribution by occupation, and/or industry sector, and by age and sex for each occupation category helps to identify special risk groups. Changes over time give indications of which work-related health issues are increasing or decreasing. Descriptive data of this type also helps in the interpretation of sample surveys or targeted studies of specific health issues. For instance, a study of respiratory symptoms and diseases in young mine workers, can be translated into quantitative needs for dust monitoring and health surveillance in the mining industry if the population at risk is known.

National sample surveys of working life and health are another way of getting a more complete picture. This enables inclusion of data on self-assessed exposure and health effects and makes it possible to analyse associations between different variables. If such surveys are repeated at regular intervals using the same method, valuable information about trends in problem exposures and effects can be collected.

Increased use of health impact assessment and projections/scenarios for future work-related

health problems, is another way of complementing the information base. These assessments/projections should be evaluated after some time in order to see whether the health situation developed as estimated. This type of trend analysis, or before-and-after-analysis, can also be a useful tool when estimating the impact of implementation of preventive interventions.

In all this work it is important to include some quality assurance programs in order to estimate the extent of measurement error in the data. Reality checks help, but additional spot-checks of coding and recording of data are useful.

# International governance and partnerships

*Christer Hogstedt & Tord Kjellström*

## GLOBAL GOVERNANCE ORGANIZATIONS WITH OSH RESPONSIBILITIES

The most important agencies dedicated to improving occupational safety and health at international level are the International Labour Organization (ILO) and the World Health Organization (WHO). The term governance primarily refers to governments, which represent the will of the people in democratic societies. However, civil society also has an important place in modern governance, representing various interest groups (stakeholders) views on issues that affect their society. In the case of OSH, the main stakeholders are government, employers and workers. Health services, insurance companies, and the community at large may also be considered to be stakeholders.

The *International Labour Organization* (ILO), based in Geneva, Switzerland, is a member of the United Nations “family” of organizations. ILO has a special mandate for the promotion of social justice and internationally recognised human and labour rights that encompass the right to safe and decent work in all countries of the world. Detailed information about ILOs programs and the activities mentioned in the text can be found on the ILO website ([www.ilo.org](http://www.ilo.org)). ILO is the only organization within the

UN family that has a tri-partite structure where governments, employers and workers participate as equal partners. ILO formulates international labour standards in the form of Conventions and Recommendations, which set minimum standards of basic labour rights. To take effect at national level, these standards must be adopted by the member countries and implemented in a systematic way. Adoption involves “ratification” by the highest legislative authority in a member state, e.g. parliament, but this is often blocked or complicated by existing legislation that conflicts in some way with the text of a specific Convention, (a situation that occurs in both developed and developing countries). The conflict may be a minor one, but if the parliament does not see the point of making a law change, the Convention will not be ratified. Unfortunately, many valuable ILO Conventions on OSH have not been ratified because of this situation; only a small number of countries have actually adopted these Conventions.

The ILO Conventions and Recommendations on OSH are listed on the ILO website: <http://www.ilo.org/public/english/protection/safe-work/standard.htm>. They define the rights of workers and allocate duties and responsibilities to the “competent authority” in each country,

as well as to employers and workers organizations. Two international Conventions Number 148/1977 and 151/1981, and their accompanying Recommendations 156/1977 and 164/1981, provide for the adoption of national occupational safety and health policies and describe the actions needed at national and at enterprise level to promote occupational safety and health and to improve the working environment. A number of Conventions deal with specific industries, e.g. agriculture, construction and mining, while others deal with specific hazards, e.g. chemicals, asbestos and radiation.

The Occupational Health Services Convention 161/1985 and Recommendation 171/1985, provide for the establishment of occupational health services at country and local level. Such services contribute to the implementation of national OSH policies and guide OSH functions at enterprise level. One major objective of ILO in relation to OSH, is to enable countries to extend social protection to all groups in society and to improve working conditions and safety

and health at work. The ILO “In Focus” Programme covers working conditions in general and the “SafeWork” Programme has specific OSH objectives:

- 1) to create worldwide awareness of the dimensions and consequences of work-related accidents, injuries and diseases;
- 2) to promote the goal of basic protection for all workers in conformity with international labour standards; and
- 3) to enhance the capacity of Member States and industry to design and implement effective preventive and protective OSH policies and programmes.

The website for Safe Work lists all relevant Conventions, Recommendations, Codes of Practice, etc.

The International Safety and Health Information Centre (CIS) is also located within the ILO (<http://www.ilo.org/public/english/protection/safework/cis/>). CISs principal objective is to be a worldwide service dedicated to the collection

### Items on the “Safe Work” website.

This website provides direct links to most recent ILO documents of importance for the development of OSH policy at national and local level.

Policy documents	Areas of Action	Resources
<b>Decent Work, Safe Work</b> and the related <b>ILO Report</b> on the XVIth World Congress	<ul style="list-style-type: none"><li>• Accident and Disease Information</li><li>• Hazardous Work</li><li>• Chemical Safety</li><li>• Occupational Health</li><li>• Workers’ Well-being</li><li>• Gender Issues</li><li>• Radiation Protection</li><li>• Labour Inspection</li></ul>	<ul style="list-style-type: none"><li>• Standards</li><li>• Documents of the ILC90</li><li>• Codes of Practice</li><li>• Legislative texts</li><li>• Papers</li><li>• Publications</li><li>• Databases</li><li>• Management Systems</li><li>• Economic Aspects</li><li>• Capacity Building</li></ul>
<b>Scope and mandate of Safe Work</b>		
<b>Interregional Consultation Report</b>		
<b>Contacts</b>		

and dissemination of information on the prevention of occupational accidents and diseases. It is one of the key sources of practical advice on OSH for developing countries.

A new umbrella policy for the ILO work on working conditions and OSH was launched in 1999. The “Decent Work” policy was developed as an ILO response to globalisation and was based on the ILO “Declaration on Fundamental Principles and Rights at Work”, also called the “Social Declaration”. The concept of “Decent work” goes beyond the aim of job creation but aspires to create jobs of a quality which will deliver a fair income and decent working conditions.

“The quantity of employment cannot be divorced from its quality. All societies have a notion of decent work, but the quality of employment can mean many things. It could relate to different forms of work, and also to different conditions of work, as well as feelings of value and satisfaction. The need today is to devise social and economic systems which ensure basic security and employment while remaining capable of adaptation to rapidly changing circumstances in a highly competitive global market.”

There are criticisms that the role of workers’ organizations, and NGOs representing the informal sector, is too weak inside the ILO. There is also concern that individual societies are given too much leeway in deciding what constitutes decent work. Globalisation tends to increase informal relationships between employers and workers, and this tendency is likely to reduce, rather than enhance, the quality of jobs.

The Decent work policy does not emphasize the large number of Conventions of relevance to working conditions and OSH that have been adopted by ILO. It would appear that there is an intention to blunt these instruments and make the recommendations for Decent Work

less prescriptive and easier to comply with by countries that would not challenge the corporate agendas for globalisation. This also means that ILO Conventions have been left outside of the domain of trade policies and WTO enforcement. Sanctions against countries that do not meet requirements of ILO Conventions have been considered “protectionist” by many developing countries and attempts to include a “social clause” in WTO agreements have failed. This is also in line with the interests of multi-national corporations, which can avoid costs by not providing levels of OSH protection considered “normal” in industrial countries. Nevertheless, under the policy umbrella of Decent Work, OSH has an important role under the “Safe Work” programme.

If the guidance and information from ILO was implemented at workplaces in all countries, a large amount of ill health would be prevented. The challenge for OSH at national and local level is to extend awareness of OSH issues, create willingness among employers, politicians, government officials and industry leaders, to take action on identified problems, and to provide the time and resources required for remedial action. While ILO is a key information provider, it should be remembered that for a number of controversial issues, e.g. asbestos in the working environment, trade unions and NGOs in the occupational health field have more highly developed policies on prevention.

A major initiative, which may assist in the development of better occupational health protection in agriculture and industry during economic development of less affluent countries, was the report of the ILO World Commission on the Social Dimension of Globalisation in 2003. The Commission’s goals were to make globalisation processes more attuned to human needs, particularly in the area of work and employment. It



was hoped that dialogue between various representatives with different interests and opinions on the globalisation process will bring clarity to the issues in a non-confrontational atmosphere. The Commission was comprised of 26 individuals from Government, trade unions, civil society and academia. However, the conflicts between the provision of safe and healthy workplaces and the cost-cutting efforts of modern industry, particularly in industries being established in developing countries, were not possible to resolve even within a high level Commission. Strong statements about the needs for protection of the social aspects of work have been made by the Commission, but unless this is backed up by some sort of enforcement system, the “race to the bottom” for social protection and OSH may still occur.

The *World Health Organization (WHO)*, is another United Nations organization with its headquarters in Geneva, Switzerland ([www.who.int](http://www.who.int)). The Ministries of Health of all countries are “members” of this organization, which also has official relations with some other organizations, e.g., the EU and NGOs, e.g. the International Commission on Occupational Health (ICOH), international trade unions and employers organizations. All issues concerning health are on its’ agenda, including occupational health.

Traditionally, many countries have placed responsibility for occupational safety, largely focused on injuries, with the Ministry of Labour while occupational health, focused primarily on the prevention of occupational diseases, remains the concern of the Ministry of Health. An increasing number of industrial countries, e.g. USA, UK, Sweden, Australia, have centralized all work-related health and safety issues under the Ministry of Labour, or its equivalent, through specific OSH legislation. In many developing countries the Ministry of Health still has a role in occupational health and their link with WHO programmes is important.

The coordination of OSH activities by Labour and Health Ministries can become a problem at both national and international level. However, mechanisms for ILO-WHO collaboration have been strengthened during recent years and many information and guidance materials are now produced jointly. The difference in the governance structures of the two organizations, i.e. ILO = tri-partite, WHO = governments only, means that some parallel activities cannot be avoided.

WHO policies recognize the importance of improving the health status of working populations. It supports international cooperation in this area primarily through a strong network of

### Internationally agreed occupational health and safety advices

In the 1980s WHO published several reports on “Health based permissible exposure levels”, in the Technical Report Series. These exposure levels still prescribe the most protective levels, (compared to other available national or international guidelines), for exposure to solvents, lead, other metals and selected other chemicals. WHO has also produced a series of “Environmental Health Criteria”, (many of them as a part of the International Programme on Chemical Safety), with advice on protection against chemical and physical hazards. The criteria for noise, for instance, recommends that 75 dB should be considered a maximum exposure level for effective protection of workers, while most countries still use 85 or 90 dB as their safety standard.

collaborating centres for occupational health. The WHO Occupational and Environmental Health Program (OEH) includes data collection and analysis, development of guidelines, research, strategies for hazard prevention and control, and human resource development. A special emphasis is placed on work in developing countries. However, in terms of staff and funding, the OEH programme is small compared to others in WHO.

On the specific issue of globalisation and OSH, WHO has primarily contributed to the development of global guidance and information exchange. Analysis of the health effects of globalisation has been carried by other WHO programmes.

As with all other WHO programmes, OEH has activities at the global, regional and national level. Regional activities in Europe focus on capacity-building in Eastern Europe and the newly independent states of the previous USSR. Much of that work is developed in both English and Russian. The American region develops training and intra-regional collaboration, primarily for Latin America, with much of their work produced in Spanish. Work for the Eastern Mediterranean region comes from the Alexandria office and is available in Arabic and English.

One important means of implementing country level programmes, particularly in relation to training and technical/scientific collaboration, is the engagement of the WHO Collaborating Centres in Occupational Health which number about 40 in different parts of the world. These are usually national research and training institutions that have substantial staff resources and experience in investigations and capacity-building in the field. The Centres have regular, joint meetings to evaluate and plan global activities.

WHO has also initiated a Commission on Social Determinants of Health, which produced

the final report in September 2008. Several of the reports to the commission are relevant for the labour sector and work environment issues.

In addition, there are international collaborative programmes on specific issues such as chemical safety, between the UN and other agencies,. The International Programme on Chemical Safety, (IPCS), (<http://www.who.int/pcs/>) started in 1976 and is a collaborative effort between UNEP, WHO and ILO. It has produced a large number of reports and advisory booklets on the hazards of specific chemicals and physical hazards, and has promoted training in this area in most developing countries. In order to develop stronger policy impact for international work on chemical safety, the International Forum on Chemical Safety, (IFCS), (<http://www.who.int/ifcs/>) was started in 1994 with about 100 member states. A third collaborative mechanism is the Inter-Organization Programme for the Sound Management of Chemicals, (IOMC), (<http://www.who.int/iomc/en/>), which includes FAO, UNIDO and OECD.

## **TRADE AND ECONOMIC DEVELOPMENT ORGANIZATIONS INFLUENCING OSH**

The activities of international economic development agencies such as the World Bank, the International Monetary Fund (IMF), the World Trade Organization (WTO), and the United Nations Development Program (UNDP), also have an important bearing on OSH in many countries. The general economic development level of a country significantly influences the mix of occupations and hazard types that exist. More specifically, the extent to which loans and development aid includes support for relevant OSH activities related to a specific industrial or agricultural investment, can greatly affect the provision of protection for workers. Until recently, investments from international sources have not

been guided by Environmental Impact Assessments. The inclusion of health in Impact Assessments is still in its infancy, and specific Occupational Health Impact Assessments are rare. When investments come from private sources, so-called Foreign Direct Investment (FDI), it is likely that OSH protection is reduced to the minimum required by the government of the recipient country. In many cases, governments are desperate for investment and will allow sub-quality OSH standards in order to procure the foreign capital investment.

Agencies, and individual staff members from those agencies, that provide loans or development aid grants for industrial or agricultural development, e.g. UNDP, the World Bank, Asian Development Bank, Inter-American Development Bank, have a very important role in ensuring that OSH programs are supported and to ensure occupational health impact assessment are included in project plans and budgets.

Other inter-country organizations for economic cooperation, such as the OECD, EU and ASEAN, have opportunities to influence the implementation of OSH. These organizations have websites which include information about international projects. The OECD (Organization for Economic Cooperation and Development), (<http://www.oecd.org>) is a “rich country club” whose membership is all the high-income countries, plus Mexico.

Other specialized United Nations organizations contribute in some way to knowledge and advice relevant to OSH, particularly, the FAO (Food and Agriculture Organization of the United Nations), UNIDO (United Nations Industrial Development Organization), and UNEP (United Nations Environment Programme). UNIDO primarily provides advice to industry on control of environmental pollution, but some of their projects include OSH items.

FAO advises the agriculture industry on pesticides use and has developed and promoted an international convention on this subject together with UNEP.

Countries that ratify the treaty are obliged to enforce the agreement at national level and to create enforcement mechanisms that will control commercial exports and exporters. Disputes between countries regarding the implementation of the Convention will be settled either by arbitration or by the International Court of Justice. According to UNEP, the Convention will help solve several major human health and environmental problems. There are large stockpiles of unwanted and obsolete pesticides and other chemicals in virtually every developing country. Each year, thousands of people are poisoned by severely hazardous pesticides. There are also a number of highly toxic chemicals that persist in the environment, accumulate in both wildlife and people, persist for long periods of time, and are spread all over the world when emitted into the environment. These persistent organic pollutants (POPs), are a major problem.

The global market for pesticides continues to grow and is estimated by FAO to be worth approximately \$50 billion per year. Companies based in Western Europe are currently the world's largest chemical producers. The fastest growing markets are in developing countries, particularly in Latin America and Asia. Africa is increasingly using pesticides on export crops.

### **INTERNATIONAL TRADE UNION ORGANIZATIONS AND NGOS**

International associations of workers trade unions are also important organizations for OSH. The peak body is the International Conference of Free Trade Unions, ICFTU (<http://www.icftu.org/>), but there are several large, specialised associations of this type, sometimes called

## Press Release 98/19 UNEP/FAO (shortened)

**Source:** [http://www.fao.org/WAICENT/OIS/PRESS\\_NE/PRESSENG/1998/pren9819.htm](http://www.fao.org/WAICENT/OIS/PRESS_NE/PRESSENG/1998/pren9819.htm)

### 95 COUNTRIES AGREE ON NEW INTERNATIONAL CONVENTION ON DANGEROUS CHEMICALS AND PESTICIDES

Brussels, 16 March, 1998-- After two years of negotiations 95 countries unanimously agreed on a legally binding Convention on international trade and hazardous chemicals and pesticides, the UN Environment Programme (UNEP) and the Food and Agriculture Organization (FAO) announced today. Through this treaty governments honoured their commitment made at the 1992 Rio Earth Summit to negotiate a convention to curb the trade in certain hazardous chemicals and pesticides.

"The aim of the Convention is to enable importing countries to decide what chemicals they want to receive and to keep out the ones they cannot manage safely," said Maria de Azevedo Rodrigues, Chairperson of the Conference. "It is expected that trade can be better controlled and that the risks of these dangerous chemicals can be reduced to benefit people and the environment. Countries also are expected to put national legislation into force. Until the industry can substitute hazardous chemicals with safer products, especially those exported to developing countries, a damage control system - as provided by the Convention - is needed."

The Convention requires that harmful pesticides and chemicals that have been banned or severely restricted in at least two countries shall not be exported unless explicitly agreed by the importing country (this is called Prior Informed Consent Procedure, PIC). The treaty is not a worldwide ban on these chemicals.

Under the new treaty, exporting countries will also be legally bound to inform importing countries about exports of chemicals banned or severely restricted in the exporting country. This export notification shall be provided prior to the first export and be repeated for the first export every year.

The PIC list includes the following pesticides: 2,4,5-T, Aldrin, Captafol, Chlordane, Chlordimeform, Chlorobenzilate, DDT, Dieldrin, Dinoseb, 1,2-dibromoethane (EDB), Fluoroacetamide, HCH, Heptachlor, Hexachlorobenzene, Lindane, Mercury compounds, certain formulations of Monocrotophos, Methamidophos, Phosphamidon, Methyl-parathion, Parathion. The industrial chemicals are: Crocidolite, Polybrominated Biphenyls (PBB), Polychlorinated Biphenyls (PCB), Polychlorinated Terphenyls (PCT), Tris (2,3 dibromopropyl) phosphate.

"international trade secretariats" (ITSs), with OSH activities for member unions at regional and country level. Figure 12.3.1 lists all the ITSs. The ILO website has links to all of them.

Trade unions are particularly relevant for the implementation of good OSH practices at local and national level. To support these efforts, the international trade union federations have developed their own policies, information, training and action programs on OSH. The focus is different for each organization. For instance, the

International Metalworkers Federation (IMF), puts much of its effort into negotiating and implementing framework agreements with large multinational corporations, principally with large, vehicle manufacturing companies. These agreements cover all aspects of working conditions, including OSH, which prevents OSH issues from becoming isolated from mainstream union activities. The ICEM has emphasized chemical safety activities and supported the formulation of protective safety guidelines for the

Organization name	Location of global office
Education International (EI)	Belgium
International Federation of Chemical Energy, Mine & General Workers' Unions (ICEM)	Belgium
International Federation of Journalists (IFJ)	Belgium
International Textile, Garment & Leather Workers' Federation (ITGLWF)	Belgium
Public Service International (PSI)	France
International Transport Workers' Federation (ITF)	Great Britain
International Federation of Building and Woodworkers (IFBWW)	Switzerland
International Metalworkers' Federation (IMF)	Switzerland
International Union of Food Agric. Hotel Rest. Cater. Tobac.& Allied Work. Assoc. (IUF)	Switzerland
Union Network International (UNI)	Switzerland

Figure 12.3.1. International trade union organizations involved in OSH activities and affiliated to the ICFTU (country location of global office indicated).

users of individual chemicals. PSI has focused on the protection of public services, including national government services on OSH, e.g. labour inspection.

Many of these organizations also have special activities on the impacts of globalisation on their union members and their OSH conditions. PSI is particularly interested in the downgrading or privatization of public services frequently carried out in conjunction with globalisation. ICEM is concerned about the transfer and use of banned chemicals in developing countries. Given that these union organizations must respond to membership demands for better salaries and other conditions, OSH issues are generally only brought forward when it is a priority for their membership. ICFTU has been in the forefront for analysis and reports on the OSH consequences of global economic trends. For example, the impact of World Bank and International Monetary Fund activities, are of prime interest, [www.icftu.org](http://www.icftu.org).

It should also be pointed out that larger trade unions in some industrial countries have tra-

ditionally been very active in supporting OSH activities in developing countries. In Sweden, the combined union international cooperation program (LO-TCO joint program) has supported training and union strengthening programs in a number of other countries. In the USA, the United Auto Workers (UAW), the Construction Workers Union, the Union of Chemical and Atomic Workers, and the central union (AFL/CIO) are some of the unions that have been actively involved in OSH. Unions from, for instance, Canada, UK, Netherlands and other European countries have also been involved.

A number of international professional organizations are also involved in OSH. These include, for instance, the International Commission on Occupational Health (ICOH), the International Occupational Hygiene Association (IOHA), and the International Ergonomics Association (IEA).

A number of non-governmental organizations are specifically interested in analyzing and taking action on globalisation issues. ATTAC International has branches in many countries, oper-

ates in a variety of languages and runs a number of websites, e.g. [www.attac.org](http://www.attac.org). ATTAC has a non-hierarchical structure and works through networks devoted to providing information and organizing public demonstrations against the negative aspects of globalisation. A number of other anti-globalisation organisations and networks also operate at national level within various countries.

Business organizations and other business-friendly NGOs are also active promoting a positive picture of business friendly globalisation. The World Business Council for Sustainable Development is one of the more important organizations (<http://www.wbcsd.ch>) and discussions about alternative economic development paths have also been on the agenda at the World Economic Forum in Davos.

### THE IMPACT OF MAJOR GLOBAL CONFERENCES

*The United Nations Conference on Environment and Development* in Rio 1992 (UNCED or the Earth Summit) adopted Agenda 21, which has a chapter/section that discusses the increased role of workers and trade unions. Among the activities to be implemented by the year 2000 were:

- promotion of the right to establish trade unions
- promotion of ratification of relevant ILO-conventions
- establishment of bipartite and tripartite bodies for safety, health and sustainable development
- an increase in the number of treaties concerning the environment, between the labour market partners
- reduction of the number of work accidents and occupational diseases. Improvements in reporting and statistics of work accidents and diseases

- increased training for employees, particularly in occupational safety and health.

In 2002 the ICFTU made a progress report on OSH developments following the Earth Summit, <http://www.icftu.org>. The report was generally pessimistic but made some positive statements about the role of trade unions in OSH and the environment:

- Almost 10 years after the UN Earth Summit in Rio de Janeiro, governments have yet to adopt effective measures for worldwide action to counter the alarming pace of environmental degradation. At the same time, the pressures of increased competition and budget cuts are leading to a steady erosion of existing health and safety standards and programmes.
- Trade unions are taking a leading role in fighting these trends by extending occupational health and safety rights into the wider arena of environmental protection. Together with the employers, unions are breaking new ground in collective bargaining in the areas of health, safety and environmental protection, and forging new alliances with environmental NGOs. Governments at the UN Commission on Sustainable Development (CSD) have proposed that core labour standards and a link to health and safety should become key features of Agenda 21. The next step is to insist that governments, together with employers, trade unions and NGO's translate these principles into concrete programmes of work.

A five year evaluation of the results of the UNCED process was performed in 1997 at a special UN General Assembly meeting (UNGASS). WHO summarized the health experiences in a major report in 1997, which emphasised the importance of workplace hazards for general health development. This part of the report was developed in collaboration with ILO



and encouraged research to find more accurate estimates of the number of people killed and injured by work hazards around the world. Accurate numbers are still not available, but ILO estimates that there are approximately 2 million occupational deaths per year worldwide, with no indication that the number is decreasing. In fact, updated numbers indicate substantial increases over just a few years. Contributing factors include increasing population and an apparently growing number of risks in developing countries. Nevertheless, available information is uncertain.

Both ILO and WHO, have developed global strategies for decent work and occupational health that complement the more general statements and conclusions from the global conferences on development. If these strategies were implemented, and integrated into the general development policies, OSH would have a higher profile.

The most recent major global conference on development issues was the World Summit on Sustainable Development (WSSD) in Johannesburg, 2002. It became a controversial affair, with the major industrial countries focused on making the conference a forum for discussion of trade liberalisation – an important issue for them – while developing countries focused on the general imbalance of resources between industrial and developing countries. The impact on developing countries from changes in trade regulations and the lack of aid were other issues of disagreement. The conference did not specifically deal with OSH issues, but the result of general development and trade policies in the process of globalisation does impact on OSH.

One of the key outcomes of the WSSD, was that trade negotiations within the WTO should be more amenable to the needs for developing countries to produce essential drugs at low cost,

e.g. for treatment of diseases such as HIV/AIDS, Tuberculosis and Malaria. Unfortunately, a follow-up meeting at Doha and subsequent negotiations have failed to reach full agreement on the waiving of patent royalties for drug companies on some of the key drugs. Some concessions have been made by the industrial countries and the negotiations continue.

The WSSD also made statements about the need to increase efforts on water and sanitation supply, but this would require many billion dollars of additional financing each year. If this financing was extended in the form of loans to developing countries, it would burden them with additional debt. One proposal was to get more private-public partnerships for water and sanitation supply, but this too has drawbacks as privatisation of water supplies will not necessarily bring the services to the poor, but may just improve supply for the middle class who are the only people who can afford to buy water.

The war on Iraq has undermined the stated intentions from the WSSD, the Millennium Goals and Agenda 21, as industrial countries divert development aid funds into activities to “rebuild” Iraq.

### **A GLOBAL STRATEGY ON “OCCUPATIONAL HEALTH FOR ALL”**

Meaningful action on OSH means the translation of international conference recommendations and international agency programmes, into national policies and programmes. The network of WHO Collaborating Centres in Occupational Health has published a “Global strategy on occupational health for all” with 10 priorities, that translate global visions into national policies and actions. This strategy was later adopted by the World Health Assembly. The 10 priority areas for action include those listed in the Box. The

## Ten priority action areas in the WHO “Global strategy on occupational health for all”.

1. Strengthening of national policies and policy tools
2. Development of a healthy work environment
3. Healthy work practices and individual health promotion
4. Strengthening of Occupational Safety and Health Services
5. Establishment of support services for occupational health
6. Occupational health standards based on risk assessment
7. Development of human resources for occupational health
8. Establishment of information systems
9. Strengthening of research
10. Collaboration in occupational health and with other activities

following text is based on the strategy but has been shortened and updated.

### Strengthening of national policies and policy tools

Major occupational health risks in traditional industries such as agriculture, mining, construction, etc. are global hazards. In addition, policy considerations should be given to the new occupational health needs that have appeared due to rapid changes in economic structures, technologies and demography. National policies and programmes for the development of occupational health should be reviewed and prepared in collaboration between government and social partners. Special concern should be devoted to enhancing possibilities to integrate continuous improvement of the work environment with the overall development of enterprises and organisations. The principles of “sustainable development” should be taken into account.

Successful prevention requires: a) information on the causal relationship between a risk factor and health outcome and knowledge of the mechanism of causation, b) knowledge of how the causal relationship can be influenced, c) resources, tools and mechanisms for the implementation of preventive measures, and d) political, managerial and target group support for the preventive programme.

Without prejudicing the primary responsibility of the employer for ensuring safety at work, government policy, legal actions and enforcement are needed to ensure minimum levels of health and safety in all sectors of the economy, including small-scale enterprises, the informal sector, agriculture and the self-employed. OSH programmes should be integrated as vital components of socio-economic development. However, this may be undermined by the development trends characteristic of globalisation.

## Healthy Workplaces; a setting for supportive environments

The idea of “healthy workplaces” emerged from the application of the 1986 Ottawa Charter for Health Promotion to different “settings” where health promotion could be carried out. It was initially considered as an extension of health promotion activities, (largely focused on lifestyle), into the workplace where workers are a “captive audience” for health messages. The concept was further developed at the International Health Promotion conference in Sundsvall, Sweden, in 1991, where the concept of “supportive environments for health” was established. The concept then became an integral part of the WHO activities to promote “Healthy Cities”.

The workplace became one of the settings within which the promotion of positive health can be carried out. Other settings include “healthy market-places” (for food safety and nutrition), “healthy schools” (for a healthy school environment and an integration of health education into school curricula) and “healthy health services”. For each “setting”, guidance documents have been developed on how a local project can be established and implemented. Steps towards “health-promoting workplaces” include: health-promoting policies (e.g. through vision and mission statements and strong directions from top management), concerted actions to create a safe and healthy work environment (the traditional domain of occupational health and safety), effective worker participation, training and personal skills development, and strengthening of occupational health services (which may also serve families of workers).

### Development of a healthy work environment

Most OSH activities naturally focus on the wide variety of OSH hazards that still need attention, however, the workplace can also be a place for health promotion. A healthy work environment is not only free from hazards that cause injuries and diseases, but also promotes health through the varied physical activity it provides - the sense of achievement and learning work fosters, the sense of pride in a good product, and the sense of community from being part of a work team. A suitable job can provide considerable positive effects on mental health. Unemployment is very poor for health.

The above ideas fit well with the aims of the “Healthy Workplace” or “Health-promoting Workplace”, concepts promoted by WHO.

### Healthy work practices and individual health promotion

Many occupational hazards can be avoided and controlled when workers adopt appropriate working practices. This is possible when workers are provided with information, tools, work organization and work aids that enable a safe and healthy workplace. This requires knowledge of health hazards at work and how to avoid them. In some instances, personal protective equipment may be needed and workers should be actively involved in decision-making about when such devices should be used, if a high level of compliance is to be met.

Workers’ lifestyles, unrelated to work itself, may have specific or general impact on their occupational health and safety and working capacity. Health education should be provided on ways to avoid the negative effects of combined lifestyle factors and occupational exposures. A classical example is smoking cessation education

for workers with past and/or present exposure to harmful dusts, e.g. asbestos. Even low asbestos exposures may increase the workers lung cancer risk, which would be further increased by smoking.

A health-promoting workplace should not only contribute to better health for staff, but also for consumers and the neighbouring community. A workplace can create health risks beyond those that directly affect their staff so there is a need to prevent such community risks by considering the following:

1. The impact of the production facility on the local environment via environmental pollution.
2. The impact of the production technology and materials on the local and wider environment.
3. The impact on consumers and the wider community from product use and/or disposal.
4. The impact of the production facility and its associated infrastructure (extraction and transport of materials, need for utilities, distribution and sales, disposal and recycling) on the social and economic conditions of a community.

### **Strengthening of occupational safety and health services**

The emerging problems of occupational health call for the development of Occupational Safety and Health Services, OHS, for all workers in all sectors of the economy and in all enterprises, as well as for the self-employed. Modern OHS services should draw from relevant professions, e.g. occupational medicine and nursing, occupational hygiene, work physiology, physiotherapy, ergonomics, safety and work psychology.

Tripartite collaboration between government, employers and trade unions for implementation of occupational health activities, should be ensured through the establishment of formal links.

The preventive approach should be given the highest priority. Due consideration should be given to the needs of OHS for the self-employed, agricultural workers, persons employed in small-scale enterprises, migrant workers and those in the informal sector. Sometimes such services can be provided by primary health care units specially trained in occupational health.

### **Establishment of support services for occupational health**

Many countries have organized such services in Institutes of Occupational Safety and Health while others rely on services provided by universities, large industries or individual consultancies. Governments and authorities responsible for occupational health should ensure the availability of expert services for OSH by guaranteeing that institutions have the necessary capacity and staffing levels.

The potential shortage of experts must be considered in the planning of the training curricula and programmes for OHS. A national quality assurance and quality management element should be included in OHS programmes and appropriate training should be provided to responsible personnel.

### **Occupational health standards based on risk assessment**

To ensure the application of minimum levels of health and safety at work, standards which define the safe levels of various exposures and other conditions of work are needed. These standards also serve as references for assessment of results from monitoring and provide guidelines for planners. When standards are further developed, the high variation in workers' sensitivity to occupational exposures should be considered. A relevant scientific basis for setting standards

should be ensured through collaboration with research organizations.

### **Development of human resources for occupational health**

There is a universal shortage of both expert resources and training in developing and newly industrialized countries, principally due to three reasons:

- a) Minimal employment opportunities for experts because of lack of effective legislation and lack of demand from authorities and employers
- b) In the absence of demand, vocational training institutions and universities have not organized and developed curricula to train OHS experts.
- c) Where training is available, it is oriented to clinical occupational medicine. While this is important, occupational medicine expertise does not satisfy the needs for expertise in a preventive, workplace-oriented occupational health service.

It was recommended by WHO in 1995 that each country should include an element of training of sufficient numbers of experts to implement the national programme and to ensure sufficient personnel resources for OHS, as part of its national programme on occupational health. Governments should ensure that the necessary elements of occupational health are included in the basic training curricula of all those who may deal with occupational health issues in the future.

Training in occupational health should also be given in connection with vocational training and in training programmes for workers, employers and managers. The need for a multidisciplinary approach in occupational health should be taken into consideration in all training, ensuring involvement of occupational medicine and nurs-

ing, occupational hygiene, ergonomics and work physiology, occupational safety, work organisation and other relevant fields.

### **Establishment of information systems**

Analysis of reliable data, establishment of trends in occupational health and recognition of priorities at national and local levels, are of utmost importance for policy making and occupational health practice. Each country should review its data and registration systems of occupational diseases and accidents. The comparability of data should be ensured through collaboration between countries.

### **Strengthening of research**

Research is essential to provide the evidence base for prevention. Each government should establish or strengthen its national centre for occupational health and, if appropriate, a network of centres. A national centre should be given the responsibility for research, information, training, and appropriate advisory, analytical and measurement services that support occupational health practices.

A national research programme should conduct surveys of the OSH situation, develop competence and methodology in occupational health research and respond to the needs of national occupational health programmes. Effective international collaboration in research should be ensured.

### **Collaboration in occupational health and with other activities**

When developing occupational health practices for special groups, e.g. farmers, the self-employed, small-scale industries and home industries, collaborative links may be needed with various extension organizations, industrial associations and several types of nongovernmental

voluntary organizations. Such links may facilitate the implementation of occupational health programmes among economic activities that are more informal and difficult to reach than conventional industry and service enterprises.

The Sixtieth World Health Assembly 2007 adopted a global plan of action on workers' health 2008-2017 with a similar and up-dated but less detailed content.

Occupational safety and health activities have a number of links with other parallel activities, such as environmental health and environmental protection (see Box ), primary health care and specialized hospital-based health care. In all such collaborations, the role of occupational health experts is to provide expert knowledge on potential hazards and their effects on the health of those exposed to them in the work environment.

### Linking occupational health and environmental awareness

There are numerous examples of local pollution causing health risks outside and inside workplaces. E.g. lead-smelters, other metal smelters, cement factories, paper pulp factories, and other basic processing industries have a great potential to create local pollution that exposes both staff and the surrounding community to health risks. The wider and global environment can be affected by inefficient energy consumption which contributes to greenhouse gases and climate change, and by the use of chemicals that damage the wider environment, e.g. ozone layer depletion. Products that affect consumers include paints containing lead, which were widely used in the past and are now affecting those removing the paint as well as children living in lead-painted houses. Social and economic conditions can be affected by major relocation of people when industrial facilities are built, or when facilities are closed as a part of industry "restructuring", often resulting from the globalisation process.

In recent years, a number of approaches have been developed to encourage and facilitate the integration of environmental consciousness into business and industry decision-making. A general aim of these schemes is to "internalize the externalities", or to make sure that the full impact on the environment of a business activity is taken into account. In Life-cycle Analysis (UNEP, 1996), the inputs of raw materials, their conversion into product, and the fate of the waste from the production or use of the product is described and quantified.

Another approach which describes the environmental impact of the modern, consumption-oriented way of life, has been to estimate the ecological footprint. "The ecological footprint is the land that would be required on this planet to support our current lifestyle forever." (Wackernagel, 1993). If the ecological footprint greatly exceeds the area available for a particular population, their livelihood and lifestyle cannot be sustained without depleting the resources of another population.

A number of environmental management tools have been devised to promote these principles e.g. Cleaner Production (UNEP, 1994), The Natural Step (The Natural Step, Stockholm ([www.natural-step.org](http://www.natural-step.org)), Toxic Use Reduction, Waste Minimization, Zero Waste, etc. Hawken lists organizations in the USA that have been active in promoting these principles, including Business for Social Responsibility, Social Venture Network, Coalition for Environmentally Responsible Economics.

At the international level, UNEP has been in the forefront of promotion of these principles. A number of other international agencies have had their own programmes targeted at their special constituencies; e.g. WHO, ILO, UNIDO, FAO, UN/CSD (UN Commission on Sustainable Development), WWF (World Wide Fund for Nature), IUCN (International Union for the Conservation of Nature).



### GLOBAL RESEARCH NEEDS FOR OSH

Worldwide, health research is characterized by the 10/90 phenomenon, which means that only 10% of the research effort is devoted to the 90% of the global burden of disease primarily affecting poor people. That part of the burden includes much of the occupational burden of disease. OSH research is an important step towards reducing health inequalities, and occupational health conferences have called for the incorporation of occupational health evidence into the requirements for environmental impact assessment of loans and other investments in workplaces in developing countries.

Priorities for occupational health research vary by country, but generally the most useful would be implementation-research that documents the impact of preventive interventions in the field. Research on OSH problems for women, children and young workers, as well as elderly workers, has been largely neglected so far. For many of the work hazards described in previous chapters of this text, basic knowledge about action mechanisms, dose-response relationships, and potential preventive approaches is

already available. A focus for new OSH research would be the description and quantification of the extent of the problem in a particular population and to document the impact of preventive actions or policies. Participatory research, with the study population as a partner rather than a mere object of study, is preferable. Recommendations for ways to strengthen occupational health research have been published in many different contexts.

OSH research needs at local level are driven to a great degree by the “body-count mentality”; OSH hazards already known to have major health impacts in industrial countries in the past, need to be demonstrated to have effects in local workplaces (the body count) if they are to be taken seriously by local OSH personnel. This phenomenon also occurs in industrial countries, e.g. in New Zealand when the risks from asbestos were not taken seriously because local asbestos cancer research was not yet available even though international research had clearly demonstrated the risks of asbestos.

Another area of research of importance for OSH in developing countries, is the study of the impact of different preventive interventions in a

#### Recommended actions from the Bangkok Occupational Health Research Workshop 2000 (WHO Collaborating Centres meeting)

Research on occupational safety and health risks needs to be carried out in all countries, for all working people. Special attention should be paid to high-risk branches, such as agriculture and mining, and small and medium-sized enterprises, and vulnerable groups such as female workers, who are under-served and under-researched.

“Preventive measures and applied research linked to development processes, e.g. in infrastructural projects, heavy industry, agriculture and the health care system, might prove successful. Economic research on occupational health prevention would also be useful.”

“The World Bank should produce, with the help of the WHO and particularly with the network of the WHO Collaborating Centres in occupational health, evidence-based occupational and environmental health assessments as compulsory elements of all its programmes, and require the necessary preventive actions as a condition for funding.”

local context. Such research can lead to broader application of preventive interventions.

At the global level, research is needed to show the impact of different approaches to OSH as globalisation is implemented at country level. Such research would record successes and failures at the general policy level that could be “ammunition” in the debate about how to get positive OSH outcomes from globalisation.

In the global perspective, more refined analysis of the importance of OSH to global health, particularly to the burden of disease and injury, is needed. Such analysis can help to put OSH on the agenda of general policies on health determinants, which may in turn, raise the profile of OSH within the health sector.

The role of national institutes of occupational safety and health is of great importance if these areas of research are to be developed and to provide researcher training. A number of countries, both developing and industrial, have substantial institutions with expertise in different areas. Many of these institutions are participants in the WHO network of Collaborating Centres, which includes industrial countries as well as Mexico, Costa Rica, China, India, VietNam, Egypt, Thailand, South Africa, and others. In industrial countries, some of the institutes have long experience of supporting research activities in developing countries, particularly the institutes in Finland (FIOH), Denmark (DIOH), Singapore and USA (NIOSH). In the USA, a special program for collaborative research training through the Fogarty International Centre has been established. Collaboration in OSH between Sweden, Nicaragua and Costa Rica has led to a long-term research, education and action program (SALTRA). This OSH program for seven countries in Central America is funded by Sida, Sweden, and was launched in 2003. A

similar program (WAHSA) for 14 countries in Southern Africa was launched in 2004.

## **FINANCIAL RESOURCES FOR OSH DEVELOPMENT**

Reference has been made in previous sections to the financial and other resources needed for positive OSH development in developing countries. A major source of these resources should come through investments in agricultural and industrial development, whether they be governmental or private loans or aid. OSH must be seen as an essential component of the investment, just like transport and energy supply are for any major investment. Parts of the many billions of US\$ in foreign direct investment each year should be used for OSH development.

Aid funding can play a role in upgrading OSH in existing facilities but OSH will then compete for attention with many other basic needs, such as water and sanitation. The total global aid flow from industrial countries increased until 1990 and then stagnated. In 2005 it was approximately US\$ 60 billion. The current aid flow is only 0.4 % of the GDP in the industrial countries, even though in 1970 it was agreed at a UN meeting that they would achieve aid at 0.7 % of their GDP by 1975. It should also be remembered, that much aid actually supports military costs, which make no contribution to health or OSH development in the recipient country. The case for a doubling of aid, focusing on health, education and poverty reduction, in order to achieve the Millennium Development Goals has been made repeatedly.

Multilateral aid, through the UN system, was only US\$ 5 billion in 2002, and much of the remaining bilateral aid is tied to the purchase of equipment or services from the donor country. This reduces the value of the aid, as the most cost-effective procurement of the materials

cannot be used. For instance, many developing countries could potentially supply goods to other developing countries, but “tied” aid means that this route cannot be used.

An interesting possibility to raise funds for aid could be through the so-called “Tobin Tax”, first proposed by Professor James Tobin at Cambridge University in the 1970s, that would tax foreign exchange transactions. His idea was that such a tax would discourage speculative foreign exchange transactions, which involves the movement of billions of dollars from one currency to another, and then moving them back when the exchange rates have changed to a level, advantageous to the currency speculator. It is like a large global gambling casino, where the money market managers are playing with billions of dollars. The Tobin tax proposed a low tax of 0.1% or less, for each currency exchange transaction, that would have little impact on normal business activities, where foreign exchange is transferred for the original investment and transferred back later as return on the investment.

The daily turnover of foreign exchange transactions is about US\$ 1 500 billion, which is equivalent to US\$ 550 trillion per year, or about 20 times the global GDP! A tax of 0.1% would raise US\$ 550 billion per year, (assuming that the daily turnover would remain the same), equating to 10 times more than current foreign aid contributions or, 50 times more than the total cost of the whole UN system. This idea has been politically dead for more than 30 years, because industrial countries have resisted any tax that could impede foreign exchange transactions. Such a small tax is, however, much smaller than the daily fluctuations of exchange rates, so it is difficult to see how it could harm legitimate foreign investment and trade activities. It would be a global tax that could be set to meet the needs

of infrastructure, education and health (including OSH) in line with the Millennium Development Goals. To achieve the goals, “only” US\$ 50 billion per year is needed until 2015, so a Tobin tax of only 0.01% in each foreign exchange transaction would be sufficient.

### AN INTEGRATED APPROACH FOR SUCCESS

Occupational diseases and injuries are essentially preventable. Approaches to prevention include, developing awareness of OSH hazards among workers and employers, assessing the nature and extent of hazards, and introducing and maintaining effective control and evaluation measures. International or global policies, statements, guidelines, etc., are also important to facilitate good OSH development at local level.

Historically, OSH strategies and programmes have been developed along with the improvement of social conditions for workers. Although there is an abundant literature on seemingly simple solutions to many workplace hazards, e.g. in the ILO Encyclopaedia on Occupational Health and Safety, there is a need for adequate and systematic approaches to implement solutions.

Solutions to OSH problems will vary substantially according to national and local needs and conditions, cultural influences, resources and other local factors. Regional cooperation between neighbouring countries for training, research and information can save resources and contribute to more effective national systems. Support from ILO and WHO can be very helpful for regional initiatives.

Globalisation adds new challenges as the dominant culture of the multinational corporations may clash with local workplace practices. Corporations from the USA are greatly influential, and this is a country where employers for a long time have been particularly hostile to

trade unions. Non-unionised workplaces are the norm in the USA, and this is being promoted as the norm when new workplaces are established as a result of foreign investment in developing countries.

Because of the complex layers of financial and production responsibilities which characterises many globalised industries, confusion is created about who is responsible for OSH. For instance, a major, high-profile brand named sports shoe corporation transfers its' production to Viet Nam. The local factory is not owned by the major corporation, but owned by a Korean company, which may in fact, be partly owned by the major corporation. This company then sub-contracts companies to perform specific parts of its' production so people are working for several different employers, with their financial base in different countries, on the same worksite. The question then is, who is responsible for OSH in that workplace? The situation could potentially become even worse if the factory is located in an "export processing zone" where national OSH legislation does not apply by decree of the Vietnamese government. Naturally, organizing workers into a union has not happened, partly because all the workers are young women who have migrated to this factory from rural areas and are totally dependent on the company for work, housing and other services.

Effective occupational health programmes cannot work in isolation and, while priorities need to be identified, many issues have to be dealt with in an integrated way to create good results. For developing countries, information, encouragement and guidance from other countries, both developing and industrial, can be a great asset in OSH development – in this way globalisation can be made into a positive force.

# Suggestions for further reading

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### CHAPTER 12.3

Up-dated information on international organizations can preferably be found at the web pages, especially as new documents are produced all the time and reorganizations often occur.





# Actions for change

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# Strategies for change

*Lennart Svensson*

How can occupational safety and health be promoted? How can accidents and diseases be prevented? While we know much about what is needed to create a healthier working environment, we know less about how to do this. Measuring and analysing the risks and causes behind occupational accidents and diseases is not enough – we must also find solutions.

This chapter will focus on a number of strategies which can be employed when organising change at work.

## INDIVIDUAL VERSUS ORGANISATION CHANGE

Changes can be analysed at an individual, organisational, national or international level and often occurs because of a combination of activities at various levels. This chapter focuses on an analysis of change at the organisational level as work is a social activity where different groups work together to accomplish an objective. It is essential that any change strategy takes the social character of work into account and uses a collective strategy, which includes leadership, organisational changes, management, learning capacities, and human resource development etc.

While this chapter focuses on change at the workplace level, questions must be asked about individual aspirations, ambitions, objectives,

intentions, emotions and values, etc? On one hand, all change has to include the individuals concerned, as any organisation is nothing without its individual members. On the other hand, we can never understand a change process only by an examination of the combination of individual actions. There is something more than individuals – in terms of decision-making structure, corporate culture, access to expertise, planning systems, time-schedules, networks with customers, suppliers, etc.

I am very critical of the increasing tendency to individualise and privatise problems of working life, especially when it comes to risks to safety and health. Many theories of change consider the individual as a major problem; for example individuals are said to be resistant to change, have bad habits, need expert information, and to be indecisive on complicated matters. A common explanation for occupational accidents is ‘the human factor’, which in reality says that workers cause accidents through their own mistakes and ignorance rather than through poor working conditions.

Such individualised perspectives can be seen as an expression of an ideology, which rationalises and legitimates unequal and unsatisfactory working conditions and can also be used as an excuse for doing nothing about complex prob-

lems in working life. Instead, it is important to understand both the obstacles and possibilities for individuals to change their situation. If such possibilities are missing, any strategy based on discussion, information and education, which attempts to affect attitudes towards OSH, are meaningless. Individual behaviour will not be affected if the situation is not genuinely open for change, e.g. if participants are not given sufficient resources like training, time, or professional support to implement change.

It is not enough to focus on the organisational level in order to implement a sustainable change. Conflicts of interest between different groups – such as between the employer and employees, different professional groups, or gender or ethnic groups – limit possibilities for a sustainable change because of the existing power structure at the workplace level. One option in this situation is to enlist support from different national organisations – such as OSH agencies, and researchers – and to use relevant legislation.

To make a change process more transparent, the following questions may be asked: For whom is the change being made? Why is it being made? Where is it being directed? What will the short and long-term outcomes for different groups be?

It is important to look beyond the rhetoric often used by management or consultants who present simple and pre-determined solutions. People involved in a change process often have hidden motives for taking part so care must be taken to distinguish between what people say and what they actually mean. A partial solution is often presented as a general solution which will benefit everyone. An analysis of the intentions and motives of different actors in a change process can be useful to foresee future problems and conflicts.

If an analysis includes a “power perspective”

(an examination of who has the power to make meaningful decisions) it will be easier to see what options are available for different groups in a specific situation. An important question to ask is in what way can OSH changes be combined to enhance production. If both these objectives can be combined a successful change process becomes more realistic, e.g. through OSH being integrated with production planning and personnel policy. However, there is also a risk with a consensus-based integrated perspective on OSH. Conflict can be seen as something atypical, strange and disturbing. Energy and activities in a change process can be created when a constructive and open dialogue is maintained.

The widespread assumption that it is possible to find solutions that combine productivity with improved health and safety can be seriously questioned. Since the early 1980's we have seen a period of downsizing, intensive rationalisation, work intensification and reorganisation. For large segments of the labour market the consensus model seems to be an expression of a dominant ideology or of wishful thinking promoted by the gurus of management, who have dominated organisational thinking. These theories often focus on the more subjective aspects of work life such as culture, management styles, communication, experiences, constructions and commitment, while neglecting more objective facts such as workload, intensification of work and rights and responsibilities of employees.

There is an astonishing lack of research with a critical perspective, using more objective methods to assess the influence and participation of employees, which is detrimental to organising long-term and sustainable change. The dominance of this new productivity paradigm will have negative effects on the work environment and subsequently on absenteeism from sickness, injuries, early retirement, stress, etc, but many

of these outcomes are made invisible. Such a perspective is short-term and opportunistic and is motivated purely by economics, while other values are put aside.

The discussion of OSH regulations must include a global perspective as currently a lot of unhealthy work is exported to developing countries where the legislation is weaker and control systems are less developed. What is needed is a united strategy based on international solidarity with ILO, WHO and other public institutions playing a central role.

This chapter focuses on general change strategies at the organisational level illustrated by the following practical examples of local change.

## STRATEGIES FOR CHANGE

Three different strategies for change will be described, summarised in Figure 13.1.1.

### The planning strategy

The planning strategy can be seen as a way to organise projects ‘top-down’ through planning

techniques, steering methods, follow-up systems and so on. It is primarily used in result-oriented projects carried out within defined time periods. The methods used are well tested and total responsibility is taken by management to carry them out. The participants are often already accustomed to working in goal-oriented projects with strict time schedules and deadlines.

Projects steered by planning strategies are traditional and natural to construction industries and technically oriented projects. They are demanding and strict in terms of timing, plans, cost projections and various specifications – such as quality. In the last decade there has been a breakthrough, as planning strategies became used in increasingly diverse areas such as company development, community planning, local and regional development and labour policy.

The expanding use of planning strategies might seem strange against the background of the shortcomings of these strategies being exposed by comprehensive research. These shortcomings have become increasingly obvi-

	A Planning Strategy	An Activating Strategy	A Networking Strategy
<i>Control</i>	From above	From below	Horizontal
<i>Energy</i>	Formal responsibility	Involvement	Common interest
<i>Method</i>	Readymade solutions	Participants' own solutions	Common solutions
<i>Perspective</i>	Closed	Open	Focused
<i>Arena</i>	Varying	Local development	Local or regional
<i>Leadership</i>	Bureaucratic	Enthusiastic	Coordinating
<i>Time-perspective</i>	Often short	Short or middle term	Variable, often long-time
<i>Theory</i>	Rational theories	Individual, group theories	Network theories, system theories

Figure 13.1.1. Different strategies for change.



ous when applied to new and unknown areas because they are not flexible and cannot adapt to local conditions. There is no motivation for development among those concerned when the goals and methods are decided in advance. Participants will be passive, resulting in a lack of involvement that is necessary both for learning processes and for taking responsibility during and after completion of the project. In this way, because of the passivity among the people concerned, conditions for self-development after completion of a project will be lacking. A sustainable change cannot be organised in such a linear and mechanical way, because the involvement of participants is essential for sustainable way.

### **The activating strategy**

The activating strategy, based on changes from the ‘bottom-up’, was developed as a reaction to the imperfections of the planning strategy. The activating strategy emphasises the involvement and influence of participants in the change process. Often there is an involved and strong project leader who acts as the driving force. This strategy is primarily applied in local development work, e.g. in peace and environmental work; in organisational development in companies; organisation within the women’s movement; rural development. It is a transparent process based on an open dialogue, which avoids programming and planning instruments.

The importance of participation is strongly emphasised in most current organisational theories by both scientists and consultants. However, the popularity of a theory is not proof of its validity or usefulness. It is difficult to even talk about a theory in this case because the concept of participation is vague and can mean anything – from information to codetermination in management issues.

The inadequacies of the activating strategy are increased vulnerability to unforeseen events; lack of long-term thinking; decreasing involvement over time; isolation from the local environment; the absence of support from those higher up in the hierarchy; a lack of long-term viability; an absence of reflection and critical analysis.

Real participation in decision-making by those concerned is important and necessary to create a sustainable change process, but broad participation is costly and even more difficult to sustain long-term. There is also a risk that a local change process becomes isolated, which makes the dissemination of change extremely difficult.

### **The networking strategy**

The networking strategy builds on horizontal collaborative relationships, and can be viewed as an attempt to reconcile the weaknesses of both planning and activating strategies. The networking strategy can be seen as an attempt to combine the ‘bottom-up’ approach of the activating strategy with a voluntary and widespread spirit of collaboration between different units. A networking strategy is used when the projects are more open, i.e. when the goal and the expected result are less distinct than in a planning strategy. The goals of the project can vary from different forms of collaboration between companies, improving the climate for innovation, contributing to regional change developing and testing new business ideas and improving customer/client relations in a company or administrative organisation.

The role of the expert is different for networking and activating strategies compared to a planning strategy. Collaboration in a network requires experts to have good knowledge of the production system and an ability to work closely on the process with employers, production

managers and workers. The coordination role is central.

The current interest in networking as a developmental strategy has been growing by leaps and bounds but recent research also indicates problems with this strategy. It is difficult to organise networks, which should be of an informal and flexible character. It is also problematic to create conditions for learning and critical reflection, because the networking will often be of a more supportive kind, which reinforces existing conditions instead of changing them.

There are different varieties of this strategy e.g. development coalitions of vertical networks or innovative systems which combine networks and the Triple Helix, a cooperation between companies, universities and public institutions. These new strategies for change attempt to make the networks less vulnerable by connecting them to other networks, actors and organisations. It is not yet known whether these more developed forms of the network strategy are successful.

### **How can planning, activating and networking strategies be used?**

The above strategies should not be seen as models that prescribe different ways of organising a change process. Instead, they should be seen as theoretical constructions, presented in a pure form as ideal types. Such theories can guide action by showing a range of alternatives for reflection on what is possible to accomplish in a specific situation, which depends on the content of the change, the size of the company, the tradition and culture, the power structure, etc.

The planning strategy can be criticised because goals are set without appropriate reflection and because planning and evaluation is conducted in a linear way. Planning is important when organising a sustainable change, but it must be flexible. The planning strategy is a very

useful instrument in certain situations, e.g. for a change project focusing on prevention of physical, chemical or biological risks. These risks can be measured and goals can be formulated in objective terms. Different means for attaining the goals can be assessed and agreed upon. The systematic surveillance and control of the risk factors can be used for a planned process of continuous improvement. The outcomes of the change can be evaluated during the process and new steps for improvement taken. Experts will play a significant role in such a project.

The planning strategy is often used when taking steps to manage safety at work starting with the identification of the hazard, assessment of the risk and consideration of a number of different actions to lessen the risks. Risk management is often done in a similar analytical and systematic way through the selection and implementation of activities, risk communication and surveillance.

If, on the other hand, the goal is to prevent stress by creating a better psychosocial work environment, an activating change strategy will be more useful. In this situation it will be necessary to change the design of work, the content of work, the social relationships in the workplace, etc. Participation of employees will be necessary as such changes cannot be organised from outside or from above in a predetermined way, but have to be discussed, tested and evaluated as part of an innovative process. The role of the experts will be different and based on support, facilitation and structuring of the change process.

Successful change requires an eclectic approach where strategies are combined. For a complex issue like OSH improvements, it is not sufficient to use only one of these strategies. Planned changes initiated from above are not flexible enough and do not involve the people concerned. Changes from 'below' can create

participation but such a change can often be isolated and difficult to disseminate. It also takes a lot of effort to keep a high level of long-term involvement in an activation strategy. The networking strategy tries to handle the problems of dissemination of successful changes by organising cooperation and learning between different workplaces. A perspective on learning is central to such a joint approach, but reflective and critical learning is difficult to accomplish.

It is a complicated endeavour to initiate, carry through and disseminate a change process successfully. In any specific situation, a combination of different change strategies must be used but the combination of strategies can also vary over the different phases in a change process, which makes the change even more complicated to organise.

The difficulties outlined above should not make us pessimistic but inspire us to find new ways to make working life safe and healthy. Below are two examples, one from India and the other from Sweden, which present a practical analysis and implementation of the different change strategies. These are illustrative examples, not models for change.

## CASE STUDIES

### **Improving OSH and productivity in leather tanning in India**

The tanning of hides and skins is a big industry in India, employing almost 300,000 people. There are major environmental problems in this industry for both employees and the external environment. Most units are small and medium-scale tanneries, which lack the most basic facilities required for a safe work environment. The United Nations have initiated a number of projects to improve working conditions and work practices in South East Asia.

This project was part of a regional programme designed in an integrated way through simultaneous consideration of productivity and environmental issues. The approach was based on participation and active involvement of all concerned parties from the very beginning of the project. Individual tanners and representatives from tannery associations participated and were consulted in the development of the strategy and the preparation of an action plan. The craft tradition and the number of small and medium scale tanneries were important situational factors to be addressed. The strategy was based on an approach termed as 'know-how through show-how'. The idea was to use good examples, based on an integrated concept of productivity, environment and OSH, for training and demonstration in the dissemination process.

The main elements in the strategy for sustainable change can be summarised as follows:

1. Practical solutions (the know-how) were developed and implemented by the tanners and their staff.
2. Establishment of demonstration sites in operational tanneries (show-how).
3. Preparation of a specific manual for the tanning industry and on-site training programme using the demonstration sites as training bases.
4. Involvement of leading tanners as trainers and key promoters of the OSH standards and practices.
5. Coordination of activities in each country by the local Tanners Association, while the experts from the regional programme mainly provided technical guidance.

The overall assessment of the programme was very positive, particularly in creating awareness and the response of the tanners. I believe that the successful outcome can be mainly attributed

to the combination of an activating and a networking strategy due to:

- a focus on local problems and practices (activating)
- an emphasis on the improvement of practices already in use (activating)
- the fostering of close involvement of all concerned parties and external experts (networking)
- making a few proactive entrepreneurs active advocates for the change programme (networking).

In this case study, flexible and informal planning was used to create a link between the OSH work and management goals. The organisers of this change process did not consciously use the above strategies but they did act in a reflective way to balance the need for active involvement, cooperation (networking), and flexible planning.

By making these elements in the change process visible, they can be used for reflection and learning. The next time a change is organised, a more developed strategy can be used which will increase the probability for a more sustainable development.

### **Improving OSH for municipal employees caring for elderly people**

The second case study is about municipal employees working as home-helpers for elderly people in Sweden. Caring for elderly people as a home helper is hard work both physically and mentally. Employees often work alone, are forced to do heavy lifting, are victims of strict time constraints, and are constantly put into unexpected, high demand situations from their clients and clients' relatives, politicians and management. The majority of home-helpers are women who also have a lot of responsibilities and demands for work in their own homes as

well as in their caring work.

In the first municipality the management organisation was hierarchical and centralised (with ten organisational layers), while it was flat and decentralised (with only three hierarchical levels) in the second municipality.

A team organisation was introduced in two municipalities to strengthen the cooperation between the employees, but there were many differences in the way work was organised in the two municipalities. The first municipality had large teams with 15–20 members, a strong leadership role inside the teams and a highly hierarchical and centralised management structure (8–10 layers). The second municipality had small teams of 5–8 members with coordination from inside the group, rotating between all team members.

The research showed important differences between the two municipalities. The second municipality had much better OSH in terms of stress, involvement in OSH issues, absenteeism due to sickness, autonomy, competence development, etc. The relationship between the home-helpers and the clients was more personal, mainly because of improved continuity of carers working for the same clients.

When we compared the different results from the change in organisation in the two municipalities, a number of questions arose about what could be done to promote OSH in the municipality with the hierarchical organisational structure. What change strategy could be used? Should it be a planning, activating or networking strategy? In what way could a researcher be of any help in the change process?

Of primary importance is the understanding that any change must be owned and driven by the home-helpers themselves. They must define, analyse and decide what should be done but without interfering with the interests of the

clients. To support an activating strategy we presented a number of alternatives for change which resulted in a joint dialogue and learning experience between the two municipalities. Four home-helpers from each municipality exchanged jobs with each other for two weeks. They met before to prepare and plan the exchange and afterwards to evaluate their experiences and quickly agreed on the advantages of the more decentralised organisation with the small teams. The next step saw the home-helpers functioning as change agents in meetings and discussions with the rest of the employees in their own municipality. In this way a change process that had a long-term effect on work organisation and on OSH was initiated.

A networking strategy was then used in a dissemination process to other municipalities. The home-helpers took part in a variety of conferences and seminars with employees, union representatives, service users, managers and politicians. Their intention was not to present a model of best practice for a healthy work organisation but to inspire various solutions that could be discussed by the participants based on their own experiences and needs. These conferences stimulated innovation and learning and were often followed by study visits and local seminars in various municipalities.

To summarise, what started as a limited project with eight home-helpers using an activating strategy developed into a networking strategy for joint learning between municipalities nationwide. The expert's role was mainly to support, structure and evaluate the change process.

The findings point to a number of important factors: involvement of the people concerned; giving them time and resources; starting from their own experiences; stimulating innovation with ideas and examples from other workplaces;

going ahead step-by-step; getting positive feedback from colleagues; learning and reflecting on the results; getting support from management and professional groups from both inside and outside the company.

### THE ROLE OF EDUCATION, RESEARCH AND CHANGE

There are often simplistic assumptions about how education, research and development relate to each other, often focusing on the role of universities in introducing change in the workplace. Basic research on OSH is thought to produce results that are delivered to experts who will then use this knowledge in their professional roles by organising rational ways of solving problems. Such a linear, mechanistic and long-term perspective on change i.e. a planning strategy will not be useful in coming to grips with pressing OSH risks in a rapidly changing society which is becoming globalised, is information based, adaptable and experienced in networking.

Instead, what is needed is a flexible, simultaneous and interactive approach based on joint learning. Experts and universities must work in a new way where they cooperate with the practitioners in an open, equal and adaptable way. This developmental support should not be seen as something that conflicts with traditional university tasks, but as something that supports them.

The ambition is to integrate change with learning, and developmental work with research, in order to create a synergy between the different tasks. Change can be put at the centre of an interactive system between a university and various local and regional actors (companies, trade unions, schools, consultants, associations). With an action-oriented approach, change will be a natural component of all research projects. If an experience or problem based pedagogy is used in

university education, specific, well-documented case studies are necessary components.

The main idea of interactive research is to 'open up' universities for cooperation with wider society. In this way, university teachers and researchers can use their expertise in a more direct and fruitful process to improve OSH through joint learning and development of working life.

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# Project guidelines

*Nils F Petersson & Kaj Elgstrand*

## WHY CONDUCT PROJECTS?

Activities that fall outside the normal core business of an enterprise or an organisation may be carried out as one or multiple projects. The establishment of a special project may be motivated by a need that demands a wider approach and deeper collaboration than what can normally be applied during normal daily duties or within an existing organisation. A project can be initiated by a newly discovered problem, and/or an idea for an improvement. A project may facilitate cooperation between different groups or departments beyond ordinary organisational borders. If a project is well planned and properly executed, it can be carried out in parallel with the core business without causing disturbance or interruptions.

## CHARACTERISTICS OF A PROJECT

The main characteristics of a project are that it has a defined objective, and is a one off activity with a defined time frame, its own budget and specific organisation.

### Defined objective

Projects may include activities such as the implementation of new technology or organisation,

the planning of a new building, the start of new production, or the prevention of a particular OSH risk. All projects must have an objective that is well defined before the project is decided upon. Any objective needs to be expressed in such a way that it can be measured or easily evaluated at the end of the project to see how well the objective has been achieved.

### One off issue

A project is ideal for a one off activity. On the other hand, activities that will be repeated several times as part of the core business of an organisation or company, are better achieved if there is a permanent organisation taking care of the work.

### Defined timeframe

A project always has a starting point and an end point. When the objective of a project is achieved, the final evaluation made and reported (in writing if requested), the project is finished. Estimates of costs normally require the deadline for a project to be set in advance as well as total number of work hours needed.

### Budget

A project must be given its own budget. As a project often involves experts from different departments, their time costs normally have to be calculated and covered by the project budget. The budget should be calculated before a project starts and management has to set aside the necessary money. If possible, the project budget should be broken down into different phases or activities that can be assessed during the project allowing corrective action to be taken if needed.

### Organisation

When a project is designed and the objectives defined, a decision about what experts are needed will be taken. There must always be a project leader who is responsible for the running the project, including the budget. Depending on the character of the project, experts from different disciplines may be included in the project team. Their roles and the amount of time they require for the project need to be defined. It is also desirable to identify the stakeholders in a project before the design is finalised. Stakeholders are not part of the project team, but they may facilitate or obstruct the running of a project.

Although project organisation is predefined, it may be found that other experts or more human resources are needed once the project is underway.

All projects, independent of their size, can be divided into different phases. It is essential to spend sufficient time on planning in order to avoid problems during implementation. Sometimes it can be useful to extend the planning phase to a pilot project that tests project ideas before full implementation.

## PROJECT MANAGEMENT

### Project phases

The planning and running of a project can normally be divided in five phases.

During the *design phase* the subject and title of a project is decided upon. A detailed problem analysis is then carried out. This analysis should give the justification for the project, stating why it is important and who will benefit from it. The objectives are defined to express what will be achieved by the end of the project should it succeed. In many cases, too little time is spent on the problem analysis and the definition of objectives that leads to difficulties in later phases.

During the *planning phase*, a project organization and a work plan are set up. The project activities to be carried out are described and a time plan set up. This includes a starting date, a schedule for the different activities, and the finish date. An analysis of needed resources (personnel, time, money, equipment, etc) and available resources must be undertaken. If the required resources are greater than the resources available, adjustments must be made to the project (less ambitious objectives, for instance) or more resources found.

*Implementation* of project activities may deepen the knowledge about the problems to be solved by the project. This experience may require adjustments to the project plan (objectives, activities, time plan, resources needed), or may stimulate the establishment of new projects, or even motivate termination of the project before the objectives have been achieved.

Achievements are reported during the *reporting phase*, usually in writing and orally. Sometimes it may be of value to describe the activities that led to achievements. It is always important during reporting to relate, discuss and document how project objectives have been fulfilled. If spe-

cific questions have been formulated during the design phase of a project, these questions should be answered in the reporting.

*Evaluation* of projects should be focused on how well the project objectives have been achieved. Evaluation is easy if the objectives are well defined and the project has been successful. An evaluation should not only include measurement components but comment on judgments and decisions. As the decisions based on the evaluation often involve different stakeholders, the evaluation needs to be documented in writing to allow for common interpretation and understanding.

### Planning techniques

There are very many different techniques for the planning and running of projects. Here a few examples.

*Goal Oriented Project Planning* (GOPP) is a participatory approach to analyse and prepare a project in a group. *The Gantt chart* is one way to plan different project activities to find the quickest way to carry out the project and avoid costly waiting periods. Activities that can be done in parallel are distinguished, as are

those that depend on each other so requiring a sequential approach. *Critical Path Analysis* (CPA) is another powerful method for bigger projects, similar to Gantt. *The Program Evaluation and Review Technique* (PERT) is similar to the CPA but less “optimistic” in its time calculation as it considers not only the shortest time requirement but the most likely and the longest time the project may take.

In this chapter we will go into detail only in relation to one such planning technique: *the Logical Framework Approach*, LFA. It is a step by step method to prepare, plan, carry out and evaluate projects. LFA integrates a number of different planning techniques (Problem Tree Analysis, Objectives Analysis including defining of objective indicators, SWOT Analysis, etc), and has been used widely for more than ten years by several development cooperation agencies including Norad in Norway and Sida in Sweden.

The first step is a *problem analysis* that may be done by setting up a “problem tree” that identifies the effects of the problem. The following uses the high noise level in a mechanical workshop as an example of the main problem. Figure 13.2.1 outlines some of the primary effects.

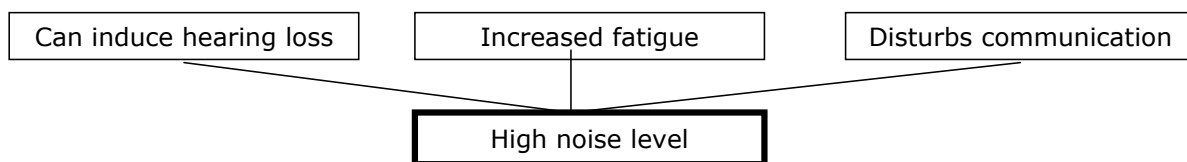


Figure 13.2.1. Some of the primary effects of a high noise level in a workshop.

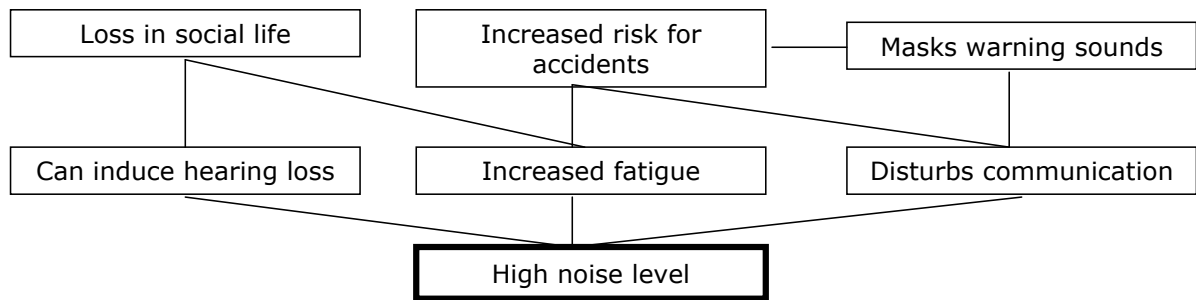


Figure 13.2.2. Primary and secondary effects of a high noise level in a workshop.

These problems may cause other problems, secondary effects, and Figure 13.2.2 shows added examples of such effects, some of which may be linked to each other.

The next step in the problem analysis is to identify the causes of the problems, and Figure 13.2.3 gives some examples. When you have found all the effects and causes you have created a complete problem tree.

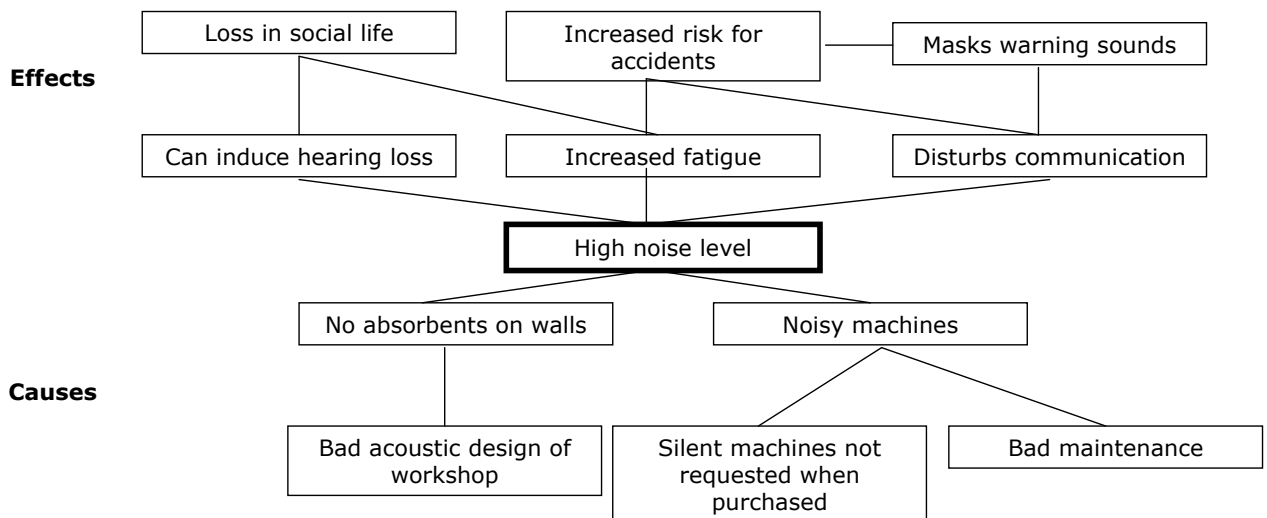


Figure 13.2.3. A problem tree with effects and causes.

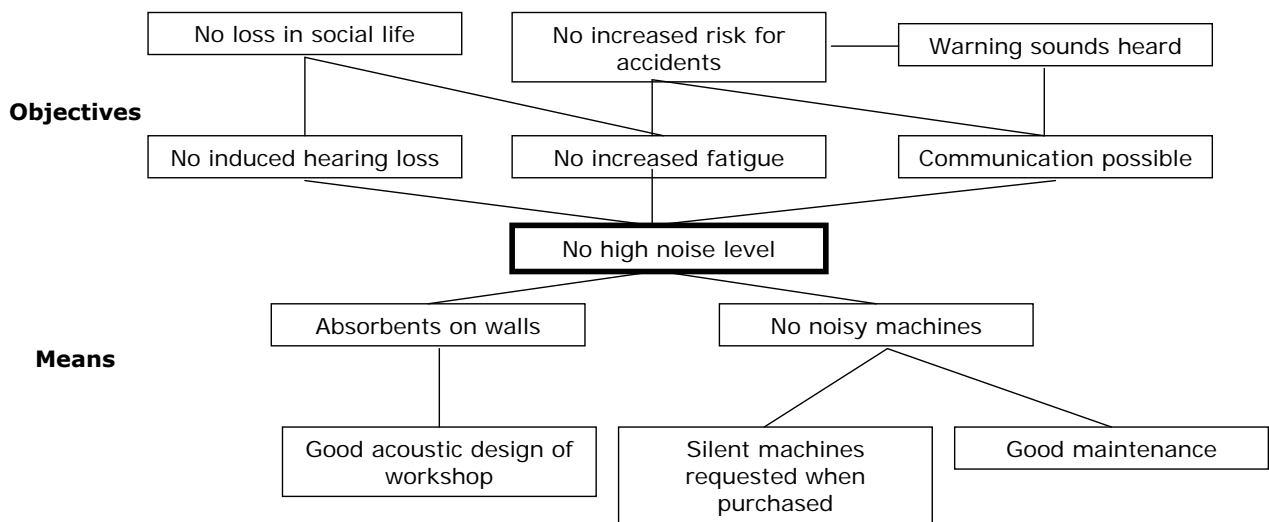


Figure 13.2.4. The objective tree.

The *objective analysis* is carried out by turning the problem tree into an objective tree which is done in Figure 13.2.4. The effects and causes in the problem tree are now turned into objectives and means. In an objective tree you can find the most important problem(s) and at the same time establish the most appropriate means to eliminate them. Your tree may also indicate that you don't have the necessary means to carry out the project and should cancel the project at an early stage.

*Stakeholder analysis* identifies stakeholders, examples of which are shown in Figure 13.2.5. Stakeholders can often be placed in one of the following groups according to their roles in the project:

- Beneficiaries
- Implementers
- Financing agents
- Decision makers.

When you have identified the stakeholders and their roles you will have a clear view how they can facilitate or obstruct your project. Based upon your objective tree, and stakeholder analysis, you may now find the most appropriate means to obtain your objective. Figure 13.2.5 shows this relationship.



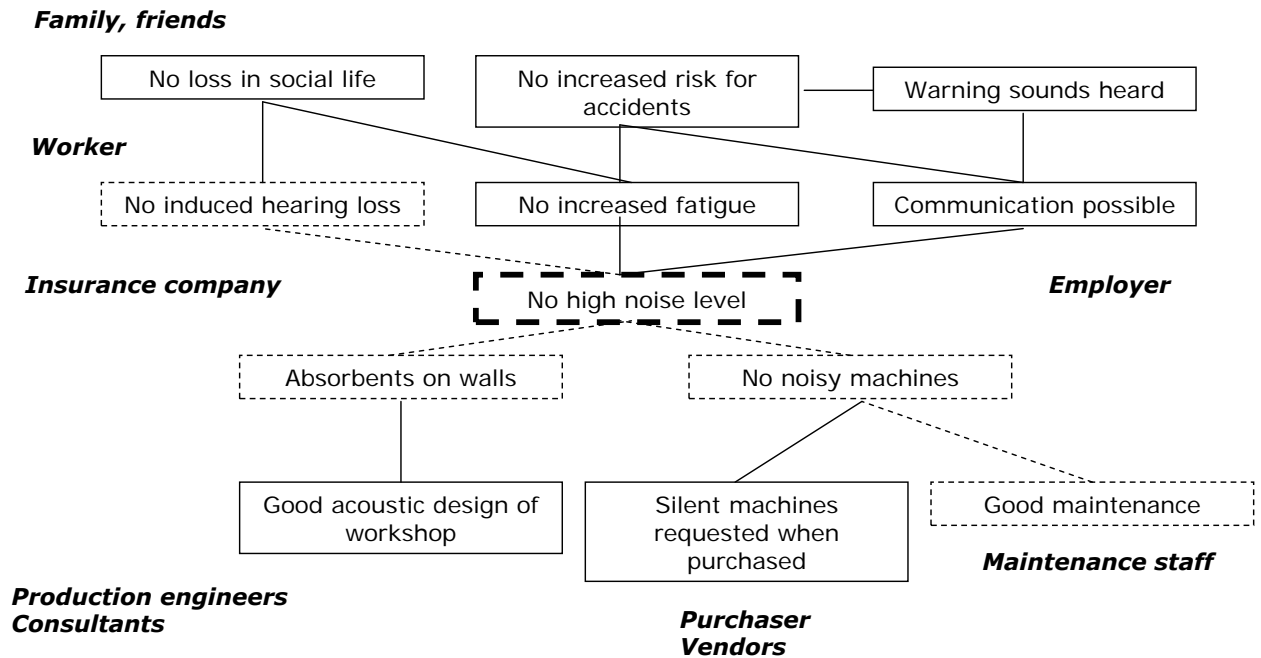


Figure 13.2.5. Stakeholders in an objective tree, and the project objectives and means chosen (dotted).

The objective in this example may then be specified:

“Eliminate hearing loss due to high noise level in the workshop by undertaking, regular machine maintenance and insulating the walls.”

Indicators for the attainment of project objectives may be needed if the objectives are not specific enough. Such indicators should specify:

- what?
- where?
- for whom?
- how much?
- how?
- when?

In our example about noise, an indicator may be formulated as:

“The noise level in the workshop will be below 85dB(A) for all workers before the end of the next year by mounting insulation on the walls and performing regular machine maintenance.”

A complete LFA also includes a Strength-Weakness-Opportunities-Threats (SWOT) analysis. When you have created your objective tree and decided what objectives are to be achieved through a project, including the means to achieve them, you try to identify and describe the strength, weakness, opportunities and threats presented by your project. What is the strength with this particular project compared to another way of carrying out this work e.g. is it cheaper,

faster, more sustainable? Weaknesses in a project may include reliance on uncertain stakeholders, untried methods or weak support from management. Aside from the main objective(s) a project may also present opportunities for other benefits such as attracting experienced personnel or finding improvements that can be implemented in other departments. Finally, threats can make a project impossible to finalize e.g. if external funders change their rules for support and stop financing a project.

## PROJECT PITFALLS

### Overly ambitious planning

There are many problems to be solved in efforts to prevent occupational accidents and diseases so it is natural to be ambitious when designing and planning a project. However, it is common and disastrous to be overly ambitious by including very wide ranging objectives that are unreasonable in terms of the time and other resources available. The following short checklist may be helpful to avoid being overly ambitious:

1. If the project is decided by someone else than yourself, check what is required before designing or accepting the project. What has to be achieved? When does it have to be completed?
2. Spend ample time on problem analysis.
3. Spend ample time on defining objectives to ensure that they are clear and realistic.
4. Analyze carefully whether the necessary time and resources (money, personnel, etc) match the available time and resources. If not, what can be done?

### Weak support from managers or stakeholders

OSH projects aiming to prevent accidents and diseases require the support and engagement of managers and workers so consultations with concerned managers and other stakeholders should be held at an early stage of project planning. If managers and stakeholders are approached and consulted about the design of the project, including the decision about its objectives, they are more likely to have and feel ownership of the project. A lack of such ownership by management and workers means their support for the project activities and the acceptance of its result is likely to be weak.

### Conflicts within the project team

Although conflicts can appear in any workplace or team, the risks are more common within a project team for a number of reasons.

Generally project team members are expected to carry out their normal work duties as well, so there is competition for their time. If project members have to make their normal work duties a priority, this can cause a delay in the project and be an obstacle for the other project members to fulfil their duties.

A second reason is that project members often have different professional backgrounds and professional languages which may lead to misunderstandings. This is often apparent when OSH professionals and production staff try to cooperate in a project.

Finally, a project member may feel that his/her arguments are not sufficiently considered, and that other project members have too much influence in running the project.

All these reasons for conflicts must be dealt with by the project leader. It is important that at the beginning of a project enough time is given to all members to express their ideas, and to

socialize within the group. Continual information for all team members is important, and they all need to have the same information about the progress and problems of the project.

### **Lack of information**

It is very important to keep all stakeholders informed about project objectives and progress. If all the stakeholders are not convinced about the value of a project, they may feel threatened and try to stop it. Early information and discussion meetings with stakeholders are essential in order to get better acceptance to implement changes.

### **Poor control over costs**

Underfunding due to over optimism when designing a project, may result in that the project has to be stopped before the objectives are attained. Under calculating of costs is very common in project planning, sometimes done deliberately to get agreement to run a project. However, if additional funds cannot be raised the invested money is often lost. The financing body may be an external funder that divides the project into several phases and will not release money for the next phase until the earlier one is fulfilled and evaluated.

For large projects that involve several departments it is very important to keep track of costs on an almost daily basis. If project members work much longer on a project than the hours foreseen in a project plan, costs exceed the budget so it is necessary to have a financial system allowing for continuous and easy control.

### **SUGGESTIONS FOR FURTHER READING**

A detailed description of the Logical Framework Approach can be downloaded from: [www.sida.se/sida/jsp/sida.jsp?d=118&a=2379&language=en\\_US](http://www.sida.se/sida/jsp/sida.jsp?d=118&a=2379&language=en_US)

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## English language editors

Adrienne Taylor has been the English language editor for the main part of this book. She has also assisted the editors by reviewing the technical content of many of the chapters. Roger Tanner has edited 11 chapters (4.7, 8.1-7, 9.2, 10.3, and 11.2). It has been a challenging task being the English language editors for this book because of both the number of authors and the fact that many authors don't have English as their mother tongue. We have done our best to put the text into readable plain English (rather than Queen's English!) in the hope that readers will find the text comprehensible and readable.

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