

INTERNATIONAL LABOUR OFFICE GENEVA

ENCYCLOPAEDIA  
OF  
OCCUPATIONAL  
HEALTH  
AND SAFETY

THIRD (REVISED) EDITION

VOLUME 1

A-K

INTERNATIONAL LABOUR OFFICE GENEVA

# ENCYCLOPAEDIA OF OCCUPATIONAL HEALTH AND SAFETY

THIRD (REVISED) EDITION

Technical editor:  
Dr. Luigi Parmeggiani

VOLUME 1

**A-K**

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## Errata

In a certain number of copies of Volume 1 misprints appeared in the article **Cadmium and compounds**, on page 357.

Left column

Last line; read: 0.01 mgCd/m<sup>3</sup>

Right column

Line 36; read: 10 ngCd/ml

Line 48; read: 5 ng/ml

Line 49; read: 5 µg/g

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# PREFACE TO THE SECOND EDITION

Occupational accidents and diseases remain the most appalling human tragedy of modern industry and one of its most serious forms of economic waste. The best estimates currently available on a world basis reckon the number of fatal injuries at the workplace at close to 100 000 annually. In some highly industrialised countries industrial accidents are responsible for the loss of four or five times as many working days as industrial disputes. In certain cases their cost is comparable to that of national defence. Industrialisation and the mechanisation of agriculture have made the problem acute in a much wider range of countries and occupations.

The economic burden on the community cannot be expressed in compensation costs alone. It also includes loss of production, disruption of production schedules, damage to productive equipment and—in the case of large-scale accidents—major social dislocations. But the economic burden is by no means the full measure of the human cost.

Protection “against sickness, disease and injury arising out of ... employment” is one of the essential aims of the ILO as defined in its Constitution. It calls for a far more vigorous effort than has yet been devoted to it.

Originally, the main thrust of preventive action was to improve the unhealthiest working conditions and remedy the appalling lack of physical protection against the most dangerous occupational hazards. The first international standards were designed either to do away with the more flagrant abuses impairing health, such as the employment of very young children, over-long hours of work, the absence of any form of maternity protection, and night work by women and children, or to combat the risks most commonly encountered by industrial workers—anthrax, and lead or chronic phosphorus poisoning.

When the ILO passed beyond formulating these basic standards to grapple with the problem of social security, the first question it considered was compensation for occupational accidents and diseases. Workmen’s compensation legislation already existed in many countries; it was developed on the basis of ILO standards and its financial implications gave a powerful impetus to preventive measures. The ILO did much to bring about the standardisation of industrial injury and occupational disease statistics and the systematic collection of data on accident frequency.

Special attention was given at an early stage to the industries with the highest incidence of accident and disease. The prevention of accidents and elimination of dust in the mining industry had a high priority. In nearly every country, mines have the highest incidence of serious accidents, not to mention disasters; they are also one of the main sources of pneumoconiosis and silicosis, the occupational diseases which cripple more workers than any other. Docks and building were also given special consideration by reason of their high accident rates.

Gradually this concentration of attention upon the most flagrant abuses and the highest accident and disease rates broadened into a more comprehensive approach designed to promote the highest standards of safety and health in all industries and occupations. The monumental Model Code of Safety Regulations for Industrial Establishments for the Guidance of Governments and Industry, first issued in 1949 on the basis of work initiated during the Second World War and periodically revised since, was an important step in this direction. It furnished an impetus which has now found expression in a wide range of codes of practice and guides to practice which are complementary to it. In the 1950s this broader approach was reflected in new comprehensive international standards for the protection of workers’ health, welfare facilities and occupational health services.

In the 1960s these were supplemented by a new series of specific provisions dealing with particular risks which had assumed increased importance. In factories, one accident in six is caused by machinery; hence the importance of international standards on the guarding of moving parts which regulate not only the use, sale and hire of machinery having dangerous parts but also its manufacture. Ionising radiations require stringent safety precautions and preventive measures, and the ILO, in collaboration with the International Atomic Energy Agency and the World Health Organisation, plays its part in ensuring that

such measures are taken in member countries, especially in general industry, which is much less well equipped in this respect than the nuclear industry.

In more recent years, ILO action in respect of industrial safety and health has also taken new forms. Technical co-operation with the developing countries is increasingly covering the field of occupational safety and health. The Industrial Committees, which bring together government representatives and delegates from employers' and workers' organisations, play an important role in the exchange of information on safety and health and in the solution of some of the problems arising at the plant level. The introduction of modern machinery and new chemicals, particularly pesticides, in agriculture has given a new urgency to the problem in the greatest of the world's industries.

As the human factor has become ever more prominent, it has become apparent that safety and health must be treated as an indivisible whole. This has made closer co-operation between the ILO and WHO ever more necessary.

The organisation of occupational health services within the undertaking lies at the heart of a positive policy to promote workers' health that was formulated by the ILO-WHO Joint Committee on Occupational Health in 1950. Ergonomics is perhaps the most recent expression of this approach, bringing results both socially in the form of improvements in workers' physical and mental well-being, and economically in the form of higher productivity.

Modern industrial medicine has outgrown the stage where it merely involved first aid in the event of an accident and the diagnosis of occupational diseases; nowadays it is concerned with all the effects of work upon physical and mental health, and even with the impact of man's physical or psychological disabilities upon his work. Such a broadening of the field has inevitably led to a rapid growth in the volume of research and publication by national institutes; more than 10 000 publications on occupational safety and health are issued every year by some 1 000 institutes all over the world.

The need to supplement the reference facilities provided by certain national institutions prompted the ILO to set up an international documentation service, catering in a practical way for industry's needs and covering every area of economic activity in which workers' health problems arise. Since 1959, the International Occupational Safety and Health Information Centre (CIS) has been collating, sifting, analysing and disseminating the material assembled by its network of national centres. The usefulness of this written material is enhanced by special symposia and technical meetings at which individual topics are explored thoroughly and the ground prepared for future action at the international level.

The impact of this periodical information is necessarily limited unless it can be used in the context of the whole body of existing knowledge and experience. A general encyclopaedia is therefore a necessary foundation for the effective use of a current information service.

To provide a comprehensive survey of the whole question of workers' health and safety the ILO published, between 1930 and 1934, its first encyclopaedia, *Occupation and Health*, the value of which was widely recognised. Since then, the whole concept of industrial medicine has changed; scientific knowledge itself has, of course, made enormous strides, particularly in such fields as biochemistry, toxicology, radiobiology and physiology and therapeutics. Yet this new *Encyclopaedia of Occupational Health and Safety* is not a scientific treatise designed to add to the sum of knowledge; its aim is to make the knowledge now available more readily accessible to those directly responsible for promoting improved conditions for the worker. Its approach is eminently practical, stress being laid throughout on risks and their prevention. It includes the basic essentials of occupational safety for the benefit of all persons concerned with workers' protection, and deals with the specific problems facing the industrialising countries. For this reason, too, the information, presented in summary form, is purposely free of theoretical digressions and excludes points about which too little is known. The encyclopaedia sets out, first, to provide industrial physicians and nurses with a compendium of the available practical knowledge in their field and to familiarise them with the technical features of prevention, and secondly, to make technicians aware of the more important biological and social aspects of their work. It is not intended exclusively for specialists, but for all who are responsible in one way or another for workers' health—employers, workers or their organisations, public authorities or inspectors. Matters which are of special interest to the developing countries, but about which adequate knowledge is often lacking, have been dealt with in detail. The reader will thus have at his disposal material only rarely found in standard reference books.

This is the first work on occupational safety and health with contributions from as many as 60 countries all over the world. The eminent specialists without whose help this new edition could not have been prepared made their services available virtually free of charge. In expressing to them the gratitude of the International Labour Organisation I am confident that I also speak for all whose suffering will be averted or relieved by the knowledge which they have made available. The ILO is also grateful to the many international and regional organisations which have collaborated with us in this important task,



and in particular to the World Health Organisation, which has revised a number of the articles dealing with general medical questions.

In the preface to the first encyclopaedia, Albert Thomas wrote:

"It was a difficult task, and one which was bound to be open to the reproach of being neither complete nor final. But how could it be otherwise? No one can hope to fix once for all something which is living, evolving, progressive. Although ... the evolution of technical practice in industry may create new dangers for the worker every day, yet the progress of this same technique and of industrial hygiene may, on the following day, do away with certain existing dangers, which must, notwithstanding, be recorded and analysed in this work. One of the virtues of this work is just the fact that it is not final. It seizes one moment in social life and in the progress of industrial hygiene, but it requires to be kept constantly up to date precisely because it is a scientific as well as a practical work."

Technological progress now moves far more swiftly than it did 40 years ago. There is every reason to believe that the pace will quicken still further. This new encyclopaedia will therefore be merely the next stage in our work. But each stage is the indispensable foundation for its successor. During the coming years the *Encyclopaedia of Occupational Health and Safety* will be an essential tool for humanising the working environment and improving the lot of workers the world over. In human and economic terms alike higher health and safety standards are a primary responsibility of enlightened social policy and efficient management. Neither can be effective without the comprehensive body of knowledge necessary to appraise the relevance of current information to policy and action. The present encyclopaedia, which was prepared under the technical responsibility of Dr. Luigi Parmeggiani, Chief of the Occupational Safety and Health Branch, is designed to make readily accessible to all the comprehensive knowledge of these matters which is now available. In editing the encyclopaedia, Dr. Parmeggiani has worthily maintained the traditions established by Dr. Luigi Carozzi, who laid the foundations of the industrial health work of the ILO.

Geneva, 1971

WILFRED JENKS,  
*Director-General.*

# PREFACE TO THE THIRD EDITION

The decision to publish the second edition of the *Encyclopaedia of Occupational Health and Safety* was taken some 15 years ago, and its preparation lasted throughout the years 1966 to 1971. Since then a great deal of progress has been made in the knowledge and activities covered by this publication. Side by side with technological progress there have been great advances in methods of identifying, evaluating and controlling occupational hazards and providing health protection in the workplace. Toxic substances, dust in industry, mineral fibres, non-ionising radiation, allergy and occupationally induced cancer have been the subject of intensive experimental research and important epidemiological studies. Nevertheless, the changes that took place in working environments in the 1970s were not due merely to wider technical knowledge and awareness; a new trend began to take shape: the workers' claim for a better quality of life at work and the increasing involvement of trade unions in health and safety protection in the workplace; the fuller support by employers of comprehensive occupational health and safety programmes; and increasing efforts by governments to apply far-reaching measures in this field. This trend has been reflected in national and international legislation concerning the working environment and working conditions, which has advanced to an unprecedented extent. Thus the panorama of occupational health and safety, industrial hygiene and ergonomics has undergone profound changes in many member countries of the ILO; not only as regards the state of the art, but also as regards the practical application of these disciplines in the workplace.

The International Labour Office has been encouraged to publish this new edition of the encyclopaedia on account of the success of the first edition, which exceeded all expectations—it was reprinted five times, and orders for copies are still flowing in.

The basic criteria for this work are still the same, particularly its over-all practical nature giving priority to preventive action in the field of occupational health and safety; most of the authors are the same as those who contributed to the previous edition. The encyclopaedia is still intended for all those who have administrative or moral responsibilities for safeguarding workers' health and safety, especially in the developing countries, and for all those who have technical responsibilities in this field but do not have at their disposal adequate library facilities or international selections of recent documents on the many and vast fields covered by, or related to, occupational health and safety. Each article from the first edition has been revised, updated, supplemented or in some cases entirely rewritten. Approximately 200 new articles have been added covering new knowledge or new subjects, particularly in the fields of toxicology and occupational hygiene, occupational cancer, occupational diseases of agricultural workers, occupational safety, psycho-social problems, and institutions and organisations active in the field of occupational health and safety. There are a number of annexes of a practical nature, and over 6 000 bibliographical references to the world-wide literature published in this field over the last five years. More than 1 000 authors from the member States of the ILO and over 15 specialised international organisations have generously and gratuitously participated in this joint effort to promote occupational health and safety throughout the world. The ILO is much indebted to them. Once again, the WHO has given its support, and several of its specialists have undertaken to revise articles on medical questions of a general nature. Many members of the Permanent Commission and International Association on Occupational Health are to be found among the authors who have contributed to this work. The present edition was planned and revised by Dr. Luigi Parmeggiani, who was also the Technical Editor of the second edition.

It is 63 years since the ILO first established as one of its basic objectives "the protection of the worker against sickness, disease and injury arising out of his employment". The objective is still the same, but the form and methods of this protection have evolved along with technical progress and economic development. In particular a broader approach is henceforth given to this protection through the International Programme for the Improvement of Working Conditions and Environment (PIACT) launched by the ILO in 1976. International dissemination of the most recent scientific and practical

knowledge in this field is an integral part of ILO activity—together with the traditional modes of action: standard-setting and technical co-operation—to promote the increased effectiveness of health and safety protection at work throughout the world. The new edition of the encyclopaedia will make an important contribution to that great endeavour.

Geneva, 1983

FRANCIS BLANCHARD,  
*Director-General.*



# INTRODUCTION

The ILO's first encyclopaedia, entitled *Occupation and Health*, was published between 1930 and 1934 in accordance with a resolution adopted by the First Session of the International Labour Conference in 1919—the year in which the International Labour Organisation itself was founded. It was prepared under the supervision of Dr. L. Carozzi, in close collaboration with the Correspondence Committee on Industrial Hygiene, and contained 416 articles by 95 contributors in 16 different countries. Its appearance was widely welcomed, especially by industrial physicians, who found it an invaluable reference work and the only international publication in their field. Before long the Office was receiving requests to bring it up to date and by 1944 it had issued six supplements containing 52 articles. With the Second World War, however, there were so many changes in techniques as well as in living and working conditions that the need for a complete recasting became apparent.

Accordingly the ILO Governing Body decided in 1966 that a new encyclopaedia should be prepared. The work was carried out under the editorship of Dr. Luigi Parmeggiani and the *Encyclopaedia of Occupational Health and Safety* was issued in 1972-73 in the English version and in 1973-74 in the (partially revised and expanded) French version. In 1974-75 a Spanish version was published by the Instituto Nacional de Previsión of Spain. The new encyclopaedia differed from the first by its wider scope, which embraced principles and examples of occupational safety, ergonomics, physiology and psychology at work, as well as various medico-social topics related to occupational health and safety. It included 851 articles in the English version (872 in the French) and nine appendices. It was prepared with the collaboration of 714 authors from 60 countries and a dozen international organisations and with the assistance of the World Health Organisation. The publication was mainly designed for all those concerned with the protection of workers at the workplace, whether with or without a medical or technical background, and gave special consideration to the conditions prevailing in developing countries. It was well received and widely distributed, the English version being reprinted five times.

As a result of continuing developments, technical and social progress and the emergence of new knowledge in the field of occupational health and safety, much of the information contained in the encyclopaedia has become outdated. The present, second edition accordingly contains approximately 50% more matter than the previous edition; in addition, all former articles have been reviewed, many entirely recast and the remainder updated; and new bibliographies have been compiled. It has been prepared with the collaboration of 913 authors. All this work has again been carried out under the editorship of Dr. L. Parmeggiani.

## How to use the encyclopaedia

Articles are classified in strict alphabetical order. When a title consists of several words, the most significant of these is used as a heading. Because of their complexity the different aspects of some subjects, such as "Accidents", are dealt with in several articles, which are, as far as possible, usually grouped together.

Wherever necessary for the understanding of the subject, the articles themselves contain cross references to other articles, in particular to those whose direct relation to the entry might escape the reader.

However, the analytical index remains the main tool for guiding the reader to a given item. It lists, again in strict alphabetical order, the subjects dealt with in the articles, including those which, though treated more briefly or sometimes even only mentioned in the bibliography attached to an article, are nevertheless of some importance for occupational health and safety. The page indicated against each entry in the index is the first page of the article concerned.

## Chemical and physical data

Normally, the nomenclature of chemical substances follows that of the International Union of Pure and Applied Chemistry, with the exception of a few products for which the old terminology is still very widely used in occupational safety and health practice. For organic compounds the main synonyms have also been provided.

Certain physical and chemical data of interest from the standpoint of occupational safety and health are given at the beginning of articles dealing with dangerous substances. For the sake of uniformity the main sources of these data have been the following publications: *CRC handbook of chemistry and physics*. Weast, R. C., and Astle, M. J. (eds.) (West Palm Beach, CRC Press Inc., 59th ed., 1978-79); *Dangerous properties of industrial materials*. Sax, I. N. (New York, London, Toronto, Melbourne, Van Nostrand Reinhold Company, 5th ed., 1979); *Handling chemicals safely* (Amsterdam, Het Veiligheidsinstituut, 2nd ed., 1980).

The information given is usually as follows:

m.w. molecular weight

or alternatively

a.w. atomic weight

sp.gr. specific gravity (water = 1) or density ( $\text{kg/m}^3$ )

m.p. melting point

b.p. boiling point

fr.p. freezing point

v.d. vapour density (air = 1)

v.p. vapour pressure

f.p. flash point (closed cup, unless indicated oc = open cup)

e.l. explosive limits in % by volume, lower and upper

i.t. auto-ignition temperature

Solubility: slightly soluble = less than  $10 \text{ g/100 cm}^3$ ;

soluble =  $10\text{-}100 \text{ g/100 cm}^3$ ;

very soluble = more than  $100 \text{ g/100 cm}^3$

Description

Exposure limits for concentrations of toxic substances in the air

(see below).

## Exposure limits

These include the United States Occupational Safety and Health Administration (OSHA) values and when they differ or are the only ones in existence, those of the National Institute of Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH), as well as the MAC values (maximum allowable concentrations) fixed by the Ministry of Public Health in the USSR. The values quoted are those valid in 1980. They are subject to periodical adjustment and should not be taken over-rigidly.

The following further details may be given:

TWA time-weighted average for a normal 8-h work-day and 40-h work-week, unless otherwise indicated;

TLV time-weighted average adopted by the ACGIH for a normal 8-h work-day and 40-h work-week;

ceil ceiling, i.e. the concentration that should not be exceeded even instantaneously;

skin possibility of absorption in significant amounts through the skin, mucous membranes and eye;

STEL short-term exposure limit of the ACGIH, i.e. the maximum concentration to which workers can be exposed for a period of up to 15 min continuously, provided that no more than four excursions per day are permitted, with at least 60 min between exposure periods and provided that the daily TLV/TWA is not exceeded;

IDLH concentration immediately dangerous to life or health from which a worker could escape without any escape-impairing symptoms or any irreversible health effects (NIOSH/OSHA Standards Completion Programme);

MAC USSR maximum allowable concentration not to be exceeded;

TSRAL USSR temporary safe reference action level.

In view of their general usefulness for preventive purposes, the above-mentioned exposure limits have been added by the editor; their inclusion in an article does not imply that the author of the article accepts their accuracy.

## Units of measurement and abbreviations

The units of measurement used in the encyclopaedia are those of the International System (SI), with the exception of a few that are recognised by the International Organisation for Standardisation and still widely used. A list of the symbols for units and of their abbreviations, together with conversion tables, is to be found in appendices to the second volume.

Abbreviations other than those of units or measurement and the physical and chemical data mentioned above are given alongside the full expression the first time they are used in an article.

Some abbreviations commonly used in occupational health and safety are, however, employed without further amplification. These include:

mmHg	millimetres of mercury
ppm	parts per million
ppb	parts per billion
ppcm <sup>3</sup>	particles per cubic centimetre
ppcf	particles per cubic foot
LC <sub>50</sub>	lethal concentration 50
LD <sub>50</sub>	lethal dose 50
%w/w	percentage, weight in weight, i.e. number of grammes of active substance in 100 g of product

## Text of articles

Almost 70% of the entries consist of revised articles from the 1972 edition. Any significant addition to or alteration of the author's original text by the editor is included in square brackets. In several articles use has been made of the bibliography in order to enlarge the scope of the entry beyond the treatment given by the author; thus, on controversial matters that have not yet been settled, suggested readings may express views different from those of the author.

Throughout the encyclopaedia, whenever workers in general are referred to, for the sake of brevity only pronouns of the masculine gender have been used. Unless the context requires a restrictive interpretation any such reference should be read as applying equally to both women and men.

## Transliteration

The recommendations of the ISO's International System for the Transliteration of Slavic Cyrillic Characters (2nd ed., R 9-1968) have been followed throughout the encyclopaedia.

## Bibliographical references

Each article is usually accompanied by a short bibliography of suggested readings, the purpose of which is much more to supplement the information in the article and to develop individual points or different approaches than to support statements or figures quoted by the author.

Where possible and appropriate, care has been taken to include documents published in different countries so as to cater for as wide a circle of readers as possible. No mention is usually made of sources of general information, such as textbooks and standard works of reference; the information concerned is generally easily accessible. References preceded by a CIS number have been abstracted by the International Occupational Safety and Health Information Centre (CIS), and in those areas the CIS is available for further bibliographical research and services.

In addition to the language of publication, the choice of the reader may be further guided by the details given of the length of the suggested reading, the number of references it contains, and whether it is illustrated or not. Furthermore, in a number of cases the references have been grouped under subject headings according to their main content.

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- Contagious ecthyma
- Control devices, isolating and switching
- Control technology for occupational safety and health
- Copper, alloys and compounds
- Copra
- Copy paper, carbonless
- Coral and shell
- Cork
- Corrosive substances
- Cosmetics
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