



## Toward WHO-recommended occupational exposure limits

M.I. Mikheev

*Occupational Health, World Health Organization, CH-1211 Geneva 27, Switzerland*

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### Abstract

The WHO Project on Recommended Health-based Limits in Occupational Exposure resulted in the development of occupational exposure limit (OEL) values for a few groups of widely used industrial chemicals. A comparative analysis of the WHO-recommended OEL and existing OEL in selected countries has been made. It was shown that in the OEL's development, there is need for harmonization of methodology, approaches and definitions. Therefore, a new WHO project on guiding principles and guidance values for health-based occupational exposure limits has been established.

*Keywords:* Occupational exposure limit; Health risk assessment; Exposure-effect and exposure-response relationships

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### 1. Introduction

The occupational exposure limit (OEL) is an important instrument for reduction of exposure to occupational hazards and prevention of occupational diseases. Existing experience in the world shows that they may have different names, such as Threshold Limit Value (TLV) in the US American Conference of Governmental Industrial Hygienists (ACGIH), which is also used in some other countries, or Maximum Concentration at the Workplace (MAK) in Germany, or Maximum Allowable Concentrations (MAC) in the Russian Federation and Poland. Different names of OELs resulted from their different definitions. However, the objective of OELs is the same, namely protection of the health of working people from over-exposure to harmful occupational hazards.

TLV refers to airborne concentrations of substances and present conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Because of the wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously [1].

The MAK value is defined as the maximum permissible concentration of a chemical compound present in the air within a working area, which according to current knowledge generally does not impair the health of the employee nor cause undue annoyance. As a rule, the MAK value is integrated as an average concentration over a period of up to 1 work day or 1 shift. Scientifically based criteria

for health protection, rather than their technical or economical feasibility, are employed [2]. The Russian and Polish definition of MAC refers to the prevention of any adverse effects in the worker or his descendants [3].

The development of OELs has its history. In some countries the first limit values for occupational exposure to a few widely used chemicals were established in the 1920s and 1930s [3]. Therefore, one can mention that the worldwide experience on OELs and their role in the prevention of occupational poisonings and diseases is available in many countries of the world. Therefore, in 1979, the WHO Office of Occupational Health established a project on Internationally Recommended Health-based Limits in Occupational Exposure.

## 2. Definition of OEL and criteria for selection of chemicals

The WHO Study Group (1979) has proposed to use the term 'recommended health-based occupational exposure limits'. This term was in accordance with the International Convention No. 148 adopted by the International Labour Conference [4]. This term represents levels of harmful substances in workroom air at which there is no significant risk of adverse health effects; this does not take into account technological and economic considerations and thus should be distinguished from operational exposure limits.

It is well known that the number of harmful industrial chemicals is so vast that it is virtually impossible to set OELs for all of them and as a matter of fact in many cases, particularly at the international level, there is no need to do so. It was therefore necessary to select priority substances. This selection has been done on the basis of the following criteria:

- the distribution and abundance of the agent, and the frequency of exposure (or potential exposure) to it;
- the potential of the agent to cause serious functional disability; and
- the availability of reliable scientific evidence

based on epidemiological and experimental studies.

A group of 4 heavy metals [5]: cadmium, lead, manganese and mercury; 4 organic solvents [6]: toluene, xylene, carbon disulfide and trichloroethylene; respiratory irritants [7]: chlorine, formaldehyde, nitrogen oxide and sulfur dioxide; mineral dusts [8]: silica and coal; vegetable dusts [9] were selected. The information available on health effects was assessed and health-based occupational exposure limit values were recommended when appropriate. In addition to the recommended health-based occupational exposure limits for workroom air, the corresponding recommended health-based biological limits (i.e. the no-adverse-effect level of toxic substances or their metabolites in human biological material) have also been defined for the same selected chemicals when the appropriate information was made available.

## 3. The 'two-step' procedure

The WHO Expert Committee on Methods Used in Establishing Permissible Levels in Occupational Exposure to Harmful Agents [10] concluded that "... occupational toxicologists, physicians and hygienists have reached a broad agreement on the approaches and the methods to be used for providing the basic scientific information needed to recommend, evaluate, and revise permissible levels for occupational exposure". This was regarded as a major step towards developing international recommendations for permissible levels, but it was pointed out that "... differences exist in the way Member States translate health-based permissible levels for occupational exposure into educational, technical, compliance and enforcement measures directed towards protecting workers' health".

Therefore, the 'two-step procedure' has been considered. The first step was the development of health-based occupational exposure limits on the basis of scientific evidence judged by experts. The main scientific judgement was the information on exposure-effect and exposure-response relationships. An exposure-effect relationship was defined as the relationship between quantified exposure

and quantified severity of health effect, in an individual or group. A definition of exposure-response relationship was the relationship between quantified exposure and the percentage of individuals with an effect of specified severity. The second step was specified as the translation of these health-based occupational exposure limits after discussion between the governments and representatives of employers and workers into operational OELs or standards. At the international level, there can be no mechanism for incorporating economic and technological factors into decision-making process related to the operational OELs. The basic objectives in establishing health-based OELs were similar to OELs of the WHO Member States: to ensure that no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of the work experience.

#### **4. WHO health-based occupational exposure limits: comparative analysis**

National commissions or other types of national bodies responsible for the establishment of national OEL values, for the development of policy and philosophy, as well as methodology have been created by many countries worldwide. On the basis of appropriate legislation, a national list of OELs for toxic chemicals has been created in these countries.

The WHO health-based occupational exposure limit values have been derived from the integrated information of health risk assessment. Toxicity, acute, subacute and chronic toxic effects, metabolism and other toxicokinetic criteria, exposure-effect and exposure-response relationship, critical adverse effects have been taken into consideration as the main criteria for health-based OEL value development. Two types of OEL have been recommended by the WHO Study Group. One for short-term exposure (15 min) and another for long-term exposure to selected chemicals. Further, our analysis is based on comparison of OELs recommended by the WHO Study Group for long-term exposure for selected heavy metals, organic solvents and existing OELs for the same substances in selected countries. Both the OEL for short- and long-term

exposure will be considered for respiratory irritants.

Concerning the OEL for free crystalline silica and coal-mine dust, the analysis is limited by the following WHO Study Group statement in which it was said that the tentative recommended limit for free crystalline silica is 0.04 mg silica per m<sup>3</sup>. For coal-mine dust with a free silica content ≤ 7% (mass) of the respirable mixed dust fraction, the range of 0.5–4.0 mg dust per m<sup>3</sup> is recommended, tentatively. Limits above 0.5 mg dust per m<sup>3</sup> should be applied only when there is sufficient epidemiological evidence to show that the particular coal-mine dust is relatively harmless, and there is a limited risk of developing radiographic category 1 simple pneumoconiosis during the whole working life. In the absence of such epidemiological data (e.g., new mines), a limit in the range of 0.5–4 mg dust per m<sup>3</sup> may be used by comparing the new mine with others with a similar grade and composition of coal and similar working conditions. For coal-mine dust with a free crystalline silica content > 7% (mass) of the respirable mixed dust, the limit for free crystalline silica should be applied (i.e. 0.04 mg silica per m<sup>3</sup>). It was believed that under these levels of exposure, massive fibrosis does not occur during the working life.

Information on health risk assessment of selected industrial substances was available worldwide, thus it is assumed that the same biomarkers, which were recently well defined [11], have been used by experts of the WHO Study Group and international experts. However, the OEL values in selected countries for the substances reviewed by the WHO Study Group varied significantly [1,2,12].

OELs for metals as well as for organic solvents in the majority of selected countries are considered as Time-Weighted Average (TWA) concentrations. In some countries, as for example the Russian Federation, for some substances, OELs are considered as Maximum Permissible Concentrations, which cannot be exceeded at any time; however, there is no need to specify them in this analysis.

Values of health-based OELs recommended by

the WHO Study Group for selected metals and organic solvents are inbetween values of the Russian Federation and values of OELs of other countries, except the OEL for cadmium, the WHO-recommended value of which is the same as the value established in the Russian Federation. OELs of the analyzed substances in Australia, Finland, Germany, Japan and the USA are the same or varied slightly. OELs established in Poland for metals and organic solvents under consideration are higher than the lowest OELs of Russia and lower than the OELs in other countries, such as Australia, Finland, Germany and Japan.

The above-mentioned metals and solvents are of systemic effect, thus expert judgement results may fluctuate more than expert assessment of respiratory irritants for which the same critical effect (irritation) was used. The difference between WHO-recommended health-based OELs and OELs for irritants in selected countries was lesser than in the case with metals and solvents. The variation of OELs for respiratory irritants between their values in selected countries was also lesser. However, when for example the MAC values of the Russian Federation were compared with STEL (Short-term Exposure Limits) of Australia, Finland or USA, the difference was increasing again.

It is known that Western European countries, USA, Australia and Japan have a similar philosophy and policy of OEL establishment which serves as a basis for definition of OELs which consequently leads to a similar or same definition and quantification of the critical criteria for OEL value derivation, such as: (i) adverse effect level; (ii) lowest-observed-adverse-effect level; (iii) no observed-adverse-effect level; (iv) uncertainty factor. All these determinants require expert judgement which depends on the philosophy and methodology accepted in the country. Therefore, internationally agreed definitions of these critical indicators may foster harmonization of methodology, approaches and philosophy, harmonization of criteria documents and finally harmonization of OELs in Member States.

This task became a component of a new WHO project on Guiding Principles and Guidance

Values for Occupational Exposure Limits with the main objective to develop general scientific bases for Health-based Occupational Exposure Limits. It is envisaged to define, at the international level, the scope and content of criteria documents as well as scientific bases and principles for health-based occupational exposure limits. It is expected that it will help and stimulate countries to develop appropriate legislation and to create national lists of occupational exposure limits for toxic chemicals and to develop a mechanism for OEL enforcement in those countries which still do not have a national list of OELs for toxic chemicals.

In conclusion, mention should be made that there is a need for harmonization and internationally accepted definitions of OELs, critical criteria for OEL value derivation, harmonization of approaches, methodology and health risk assessment procedure which serve as scientific bases for OEL establishment. Commonly accepted definitions, approaches and procedures will lead to the harmonization of criteria documents which would foster the achievement of the final objective of occupational health practice which is the improvement of health risk management in the workplace.

## References

- [1] American Conference of Governmental Industrial Hygienists (1991) Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Limits, (1991–1992), Cincinnati.
- [2] Deutsche Forschungsgemeinschaft (1993) List of MAC and 8AT Values. Maximum Concentrations at the Workplace and Biological Tolerance Values for Working Materials. Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area. Report No. 29, VCH Verlagsgesellschaft mbH, D-69451 Weinheim.
- [3] Szerczak, S., Induski, J.A. and Kowalski, Z. (1993) Occupational exposure standards. Historical outline and present state. *Polish J. Occup. Med. Environ. Health* 6(1), 1–18.
- [4] International Labour Organisation (1979) Conventions and Recommendations, ILO Document No. D.15, Geneva.
- [5] WHO Study Group (1980) Recommended Health-based Limits in Occupational Exposure to Heavy Metals. Technical Report Series No. 647.
- [6] WHO Study Group (1981) Recommended Health-based Limits in Occupational Exposure to Selected Organic Solvents. Technical Report Series No. 664.

- [7] WHO Study Group (1984) Recommended Health-based Occupational Exposure Limits for Respiratory Irritants. Technical Report Series No. 707.
- [8] WHO Study Group (1986) Recommended Health-based Limits in Occupational Exposure to Selected Mineral Dusts (Silica, Coal). Technical Report Series No. 734.
- [9] WHO Study Group (1983) Recommended Health-based Occupational Exposure Limits for Selected Vegetable Dusts. Technical Report Series No. 684.
- [10] WHO Expert Committee with participation of ILO (1977) Methods Used in Establishing Permissible Levels in Occupational Exposure to Harmful Agents. WHO Technical Report Series No. 601.
- [11] World Health Organization (1993) Biomarkers and Risk Assessment: Concepts and Principles. Environmental Health Criteria No. 135, Geneva.
- [12] International Labour Organisation (1991) Occupational Exposure Limits for Airborne Toxic Substances. Third Edition. International Labour Office, Geneva.