

European Standardization: Guidance on the Assessment of Occupational Exposure to Chemical Agents*

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Working group 1 of CEN TC 137 has produced a draft proposal for the assessment of exposure to chemical agents and measurement strategy. A review of the standard is given. The purpose is to give practical guidance to those who have to carry out these assessments. A systematic approach allows the number of measurements to be reduced. The report of the work done allows communication in an efficient way with interested parties: workers, occupational physicians and the labour inspectorate.

Keywords: Occupational chemical exposure assessment; European standardization; CEN guidelines

Introduction

The use of limit values is an important tool for the protection of the health of workers exposed to chemical agents. Several national and international bodies propose occupational exposure limits. At EEC level, two different types of limit values exist: binding limit values for asbestos, lead and vinyl chloride; and 'indicative limit values' for 27 substances so far. The European Commission intends to publish more limit values.

Directives that may be adopted by the Council of Ministers or by the Commission, depending on the procedure, have to be translated by Member States into their legislation. Legislation regarding health and safety at work at European Community level is based on Article 118A of the Treaty. This means that these rules have to be considered as minimum requirements. Member States may adopt stricter regulations, which in terms of limit values mean that they may promulgate lower limit values. In principle, the described procedure can be used for any type of limit value.

It is not practical to provide every worker with measuring equipment permanently in order to be able to guarantee that his or her exposure does not exceed the limit values. By using some formalized approaches and techniques, it is possible to reduce the measuring effort drastically. In many instances it is even not necessary to rely on measurements.

Basic requirements for such formalized approaches can be found in legislation, e.g., Directive 88/642/EEC amending Directive 80/1107/EEC. Directive 80/1107/EEC contains basic preventive measures to reduce workers' exposure to chemical, physical and biological agents. Directive 88/642/EEC introduces the two different types of limit values and the principle of the formal assessment of exposure.

On 17 May, 1993, the European Commission made a proposal for a Council Directive on the protection on health and safety of workers from the risks related to chemical agents at work. If adopted, this Directive will become an individual

Directive under the framework Directive 89/391/EEC, and Directives 80/1107/EEC and 88/642/EEC will be repealed. In some countries some legislation, guidelines or standards already exist on this subject, e.g., in the UK, Germany and Belgium.

Working group (WG) 1 of CEN TC 137 started its activities in November 1988. In May 1991 it was able to present a draft proposal to the Technical Committee. The document was circulated as a prEN standard for voting in the CEN Member States from March to September 1992. In December 1992 a meeting took place in Antwerp to discuss the comments received during the circulation of the draft proposal. The formal vote will probably take place in 1994.

At the beginning of the activities of WG 1 it appeared that it was very difficult to find a direction that could meet the different expectations of the experts from different countries.

However, at each meeting mutual understanding between the experts increased and this has resulted in a document that gives practical guidance to those who have to carry out assessments of exposure on the workfloor. The standard contains a number of informative annexes.

It is stressed that the standard deals only with exposure by inhalation. A global health risk assessment has to take into account all exposure routes.

Procedure

The procedure includes two phases:

- (1) An occupational exposure assessment (OEA): at the start of the procedure the exposure is compared with the limit value. The OEA has to be repeated when a new limit value is proposed or when a relevant change in exposure conditions occurs.
- (2) Periodic measurements (PM): to check regularly if exposure conditions have changed.

Terminology and Definitions

A number of definitions are given. Some of them are the same definitions as those in Directive 88/642/EEC. No attempt is made to define 'compliance' as this is a matter for legislation.

The topic of definitions is often controversial; the question is how far one should go in trying to define some terms without becoming too trivial. At the level of the Technical Committee it was decided that a working group with Mr. J. C. Guichard (INERIS, France) as the convenor should look at the definitions of the various working groups in order to avoid contradictions. There was a consensus that the different working groups would not be forced to adopt definitions that they do not like or do not need.

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Occupational Exposure Assessment (OEA)

The occupational exposure assessment consists of three steps. First, potential exposures are identified. An inventory of all products and chemicals in the workplace is made and information on these substances is collected (physico-chemical properties, health hazards, limit values, *etc.*). In many countries such an inventory should already be available in order to comply with regulations on chemical hazards, medical surveillance, *etc.*

Second, the work processes and procedures in which the chemical agents are involved are studied.

Third, the combination of these two steps allows an assessment of the exposure to be made. A structured approach is required in this process, which may be conducted in three stages: an initial appraisal, a basic survey and a detailed survey.

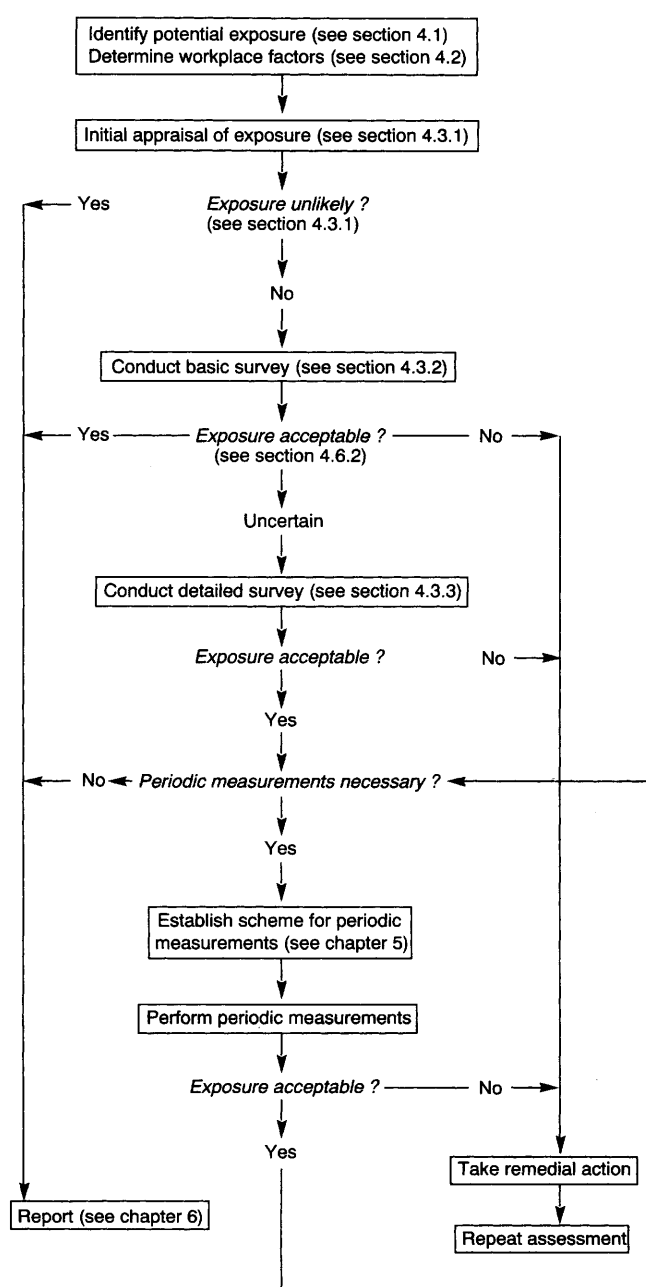


Fig. 1 Schematic overview of procedure

Data about the temporal and spatial distributions of the concentrations of the substances in the workplace have to be collected. The procedure that is proposed does not require that every stage of the assessment is used. If it is expected that the exposure exceeds the limit value or if it is clearly determined that exposure is well below the limit value, then the occupational exposure assessment can be concluded and appropriate action taken.

Initial Appraisal

In this stage, the list of chemicals and the workplace factors yield a consideration of the likelihood of exposure. Variables that affect personal exposure have to be looked at. These variables are influenced by the emission sources, the dispersion of air pollutants, the actions and behaviour of the individuals.

If this initial appraisal shows that the presence of an agent in the air at the workplace cannot be ruled out for certain, it needs further consideration.

Basic Survey

The basic survey provides quantitative information about exposure of workers with particular account of tasks with high exposure. Possible sources of information are earlier measurements, measurements from comparable work processes and reliable calculations based on relevant quantitative data. When calculations are used, care should be taken not to overlook aspects that are difficult to quantify: concentration gradients, diffusive emissions from spills, waste tins, contaminated clothing, *etc.*

If the information obtained is insufficient to enable a valid comparison to be made with the limit values, it must be supplemented by workplace measurements.

Detailed Survey

The detailed survey is aimed at providing validated and reliable information on exposure when it is close to the limit value.

Measurement Strategy

Bearing in mind that measurements are expensive, it is important to take an approach that permits the most efficient use of resources. This means that it should be possible to stop the procedure in an early stage by using techniques that are easily applied and that may be less accurate. Other possibilities may be worst case measurements, sampling near emission sources or screening measurements. The requirements and measuring ranges for these different measurement tasks should be defined in such a way that they allow the occupational exposure assessment to be completed without further investigation.

In other instances, where exposures are suspected to be close to the limit value, it will be necessary to undertake a more accurate investigation, making full use of the capabilities of instrumental and analytical techniques.

Selection of Workers for Exposure Measurements

Some general guidelines are given for selection of workers for exposure measurements. If workers are sampled purely on an at random basis large number of samples are needed.

Some techniques such as sub-dividing the exposed population into homogeneous groups, critical examination of the work-pattern, examination of preliminary measurement results allow the sampling effort to be reduced considerably compared with sampling on a 'blind' purely statistical basis.

Representative Measurements

Measurement conditions shall be selected in such a way that measurement results give a representative view of exposure under working conditions. This means that personal sampling should be carried out for an entire working period, or a time period that is representative of it.

Fixed-point measurements may be used when they allow personal exposure to be assessed. In some instances no personal measuring or sampling device is available.

Measurements should be carried out on sufficient days and during specific operations. It is important to consider different episodes during which exposure conditions may vary (night and day cycles, seasonal variations). Care should be taken to avoid auto-correlation between different measurement results. This implies that measurements should be spread over a sufficient time period.

Worst Case Measurements

When it is possible to identify clearly episodes where higher exposures occur, *e.g.*, a high emission due to certain working activities, one can select sampling periods containing these episodes. Sampling efforts can be concentrated on these periods with relatively unfavourable conditions. If the concentrations measured this way are presumed to apply for the whole of the working period, a safety factor will be built in.

Measurement Pattern

A number of practical issues play an important role in the pattern of sampling: frequency and duration of a particular task, optimum use of occupational hygiene and analytical resources. Representativeness of the data for the identified tasks and periods is essential.

In many workplaces work is varied throughout the working period, which itself may be interrupted. The duration of an individual sampling is often dictated by constraints of the method of sampling and analysis in practice, *e.g.*, the time needed to collect a sufficient amount of analyte.

Unsampled time remains a serious weakness in the credibility of any exposure measurement. During this time careful observation is always necessary. The assumption that changes have not occurred in the unsampled period must always be critically examined.

Annexe 1 of the draft standard contains a table that can be used as a guide for the minimum number of samples to take as a function of sampling duration in the case of a homogeneous working period. The table is a combination of practical experience and statistical arguments.

Measurement Procedure

The measurement procedure should give results representative of worker exposure. The management procedure contains the agents, the procedure for sampling and analysis, the sampling locations(s), the jobs to be monitored, the duration of sampling, the timing and duration between measurements and technical instructions concerning the measurements.

Annexe 2 of the draft standard contains examples of calculations of the occupational exposure concentrations from individual analytical values. The occupational exposure concentration is the arithmetic mean of the measurements in the same shift with respect to the appropriate reference period of the limit value of the agent under consideration. WG 2 has already proposed general requirements for measurement procedures.²

Conclusion of the Occupational Exposure Assessment

The prescribed procedure has to come to a conclusion. No unique formal scheme is proposed in the standard. Annexes 3 and 4 of the draft standard give examples of formal schemes that might be used. Other countries may propose others. In Belgium a scheme proposed by Tuggle based on one-sided tolerance limits has been used.^{3,4}

Whatever scheme is used, one of three conclusions should be determined.

(1) The exposure is above the limit value: the reasons for the overexposure should be determined and remedial action taken. The occupational exposure assessment should be repeated.

(2) The exposure is well below the limit value and is likely to remain so on a long-term basis owing to the stability of conditions at the workplace and the arrangement of the work process. In this case periodic measurements are not needed. However, it must be regularly checked whether the occupational exposure assessment leading to that conclusion is still applicable.

(3) The exposure does not fit into categories 1 or 2. Although the exposure may be below the limit value, periodic measurements are still required.

In certain cases, the periodic measurements can be omitted, depending on the properties of the agents on the workprocess. Technical guidelines can provide criteria for deciding whether or not to carry out periodic measurements. Annexe 5 of the draft proposal gives an example of a procedure for considering if and when periodic measurements are required.

The purpose of the periodic measurement is to check the validity of the occupational exposure assessment and to recognize changes of exposure with time.

The occupational exposure assessment is only concluded when a report has been made of the results of the assessment and a record of any remedial action deemed necessary.

Periodic Measurements (PM)

The emphasis of periodic measurements is on longer term objectives such as checking that control measures remain effective. Information is likely to be obtained on trends or changes in pattern of exposure so that action can be taken before excessive exposures occur.

For the results of a periodic sampling programme to be of real use, it must be possible to compare consecutive sets of results. This implies that the methodology used for collecting the samples needs to be rigorously planned to ensure that the over-all error can be estimated and that genuine change in the exposure pattern can be recognized.

The interval between measurements has to be established after consideration of a number of factors such as the process cycles, closeness to the limit value and the temporal variability of the results. Together with other considerations, this may lead to intervals between periodic measurements varying from less than 1 week to more than 1 year.

Annexe 6 of the draft proposal gives an example of a scheme for determining intervals between periodic measurements.

Reporting

Reports have to be written of the occupational exposure assessment and of any periodic measurement. Each report should give reasons for the procedures adopted in the particular workplace. The content of the report is described. It is clear that such a report is very valuable for the labour inspectorate, for the workers who should have information on their exposure and for the occupational physician.

Handling of Data

It is evident that an important amount of data will be generated during the OEAs and the PMs. In order to prevent accumulation of a large number of unused data and in order to obtain a high return from the time and effort invested, it is necessary to use appropriate statistical techniques. Annexe 7 of the draft proposal gives two examples of statistical analysis of data: the moving weight average and the probability plot. The data can be useful for epidemiological studies and the evaluation of occupational exposure limits.

Automated Measuring Systems

During the discussions of WG 1, some participants felt it was necessary to deal with automated measuring systems. Such measuring systems are used in vinyl chloride production and polymerization plants, sterilization processes with ethylene oxide, *etc.* It proved to be difficult to insert this concept into the working document in preparation without lengthy discussions that would cause further delay. A joint working group was set up with CENELEC to deal with direct-reading instruments.

Discussion and Conclusions

The draft standard prEN 689 on monitoring strategy is clearly a compromise between different approaches. Experts from industry or from government bodies from different countries come to such a working group with the conviction that their own approach is the right one. In general, the willingness to adopt new or different approaches is very low.

Exposure measurements are not a common practice yet in many countries of the EEC. Even in countries where legal requirements on exposure monitoring exist, the application of these requirements is not general, especially in small and medium undertakings.

In Belgium, for instance, there is an extensive system of medical surveillance of workers with strict tariffs that is applicable for every employer, even with only one employee. The costs of medical surveillance do not cover air monitoring. Some employers consider measurements only as an extra cost, in addition to medical surveillance.

There needs to be a change in the perception of workers' health protection from secondary to primary prevention. This will certainly take some time.

A system to help the small and medium undertakings to carry out assessments of exposures will certainly improve the widespread application of this kind of procedure.

The prescribed procedures often tend to minimize the number of measurements by focusing on high exposures and compare these with limit values. It is clear that this kind of 'compliance monitoring' will not give a complete or correct picture of the exposure situation in a certain industry.

In the end, there is a conflict between the process of gathering exposure data and the will to reduce exposures to a level at which exposure measurements are no longer relevant from the standpoint of preventing health effects. A healthy workplace is a workplace where measurements are no longer needed!

Fortunately (or unfortunately, depending on the position) there will be sufficient opportunities to assess and often measure exposures in future years in Europe.

Questions such as how to deal with exposures to more than one substance and the minimum sampling frequency in a periodic measurement programme do not receive a clear answer in the standard. It was accepted that these matters have to be dealt with in legislation, which normally is adopted only after consultation between employers' and employees' representatives and takes into account economic and social factors. In the process of standardization, no such formal consultation takes place. Standardization cannot be used as a kind of back-door entry to give solutions to problems that are not solved elsewhere.

References

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