Guidelines for personal exposure monitoring of chemicals: Part II

Expert Division of Occupational Hygiene & Ergonomics, the Japan Society for Occupational Health, “The Committee for Personal Exposure Monitoring”

Haruo Hashimoto¹, Kenichi Yamada², Hajime Hori³, Shinji Kumagai³, Masaru Murata¹, Toshio Nagoya⁵, Hirohiko Nakahara⁶ and Nobuyuki Mochida⁷

¹University Management Center, Tokyo Institute of Technology, ²Occupational Health Research and Development Center, Japan Industrial Safety and Health Association, ³Department of Environmental Management, School of Health Sciences, University of Occupational and Environmental Health, ⁴Faculty of Science and Engineering, Waseda University, ⁵Professor Emeritus, Waseda University, ⁶Safety Health and Environment Department, JXTG Nippon Oil & Energy Corporation and ⁷Environment and Safety Group, Kawasaki Refinery, JXTG Nippon Oil & Energy Corporation

Abstract: This Document, “Guidelines for personal exposure monitoring of chemicals” (“this Guideline”), has been prepared by “The Committee for Personal Exposure Monitoring” (“the Committee”) of the Expert Division of Occupational Hygiene & Ergonomics, Japan Society for Occupational Health. Considering the background of the growing importance of personal exposure monitoring in risk assessment and the need to prepare for the introduction of monitoring using personal samplers from an administrative perspective in recent years, the Committee was organized in November 2012. The Committee has prepared this Guideline as a “practical guideline” for personal exposure monitoring, so as to offer proposals and recommendations to the members of the Japan Society for Occupational Health and to society in general. The scope of this Guideline covers all chemical substances and all related workplaces regarded as targets for general assessment and the management of risk. It thus is not to be considered to comment on legal regulations and methodology. The main text provides the basic methods and concepts of personal exposure monitoring, while 31 “Appendices” are provided in this Guideline throughout the series; technical descriptions, statistical bases, and actual workplace examples are provided in these appendices, to assist better understanding. The personal exposure monitoring described as per this Guideline is equivalent to an “expert-centered basic method to reasonably proceed with the assessment and management of risk at workplaces.” It is considered that practicing and expanding on this method will significantly contribute in reforming the overall framework of occupational hygiene management in Japan.

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Chapter 2: Method for Personal Exposure Monitoring

1. General procedure for personal exposure monitoring

1-1 Overall framework of personal exposure monitoring

The term personal exposure monitoring used in this guideline shall not be taken to mean merely measurement in the narrow sense of the word. More generally it is to be understood as an integrated process (or overall framework) by which the assessment and management of exposure is performed. Measurement, in the narrow sense of the word, is only one part of personal exposure monitoring.

The general process for personal exposure monitoring is shown in Fig. 2.1. This figure illustrates a typical procedure for personal exposure monitoring. Expressed another way, the overall process is seen to be the assessment and management of exposure, or the assessment and management of risk. This process is divided into nine steps
Fig. 2.1. Entire process of personal exposure monitoring

| No. | Step (unit procedure)                        | Stage and flow                        |
|-----|---------------------------------------------|---------------------------------------|
| 1   | Basic characterization of the workplace     | Basic characterization                 |
| 2   | Planning of measurement                     |                                       |
| 3   | Measurement                                 |                                       |
| 4   | Analysis                                    |                                       |
| 5   | Assessment of measurements                  |                                       |
| 6   | Determination of control class              |                                       |
| 7   | Formulation of control measures             |                                       |
| 8   | Reporting                                   |                                       |
| 9   | Follow-up (*)                               |                                       |

(*): Execution of control measures, re-assessment and measurement

(known as unit procedures). The first step is the basic characterization of the workplace, and proceed through to the conclusion of the follow-up (the implementation of control measures and re-assessment and measurement after a certain period of time). These steps can be broadly classified into three groupings or stages: basic characterization (step 1), measurement (in the narrow sense) (steps 2 to 6), and risk reduction measures (steps 7 to 9).

In performing personal exposure monitoring, (Fig. 2.1 Flow A) the procedure to be followed moves from basic characterization through measurement (in the narrow sense) and concludes with risk reduction measures. The goal of this procedure is to adequately control risks. This is seen in the risk reduction measures (stage 3). The measurement (in the narrow sense) is not an object in itself. In other words, the measurement stage can be omitted if risk management can be adequately ensured without measurement. This is seen in the alternative (Fig. 2.1 Flow B). This flow moves from the basic characterization directly through to the risk reduction measures. In this manner, depending on the result of basic characterization, personal exposure monitoring can be completed without performing measurements (in the narrow sense). As mentioned above, this is the reason why measurement (in the narrow sense) is only one part of the personal exposure monitoring.

However, in accordance with the Working Environment Measurement regulation, measurement must be conducted. In a broader sense, Working Environment Measurement (area monitoring) is a means of risk assessment and management as in the case of personal exposure monitoring. Therefore, depending on the characterization result of the workplace, there should be two options: either measurement should be conducted (seen in Fig. 2.1 Flow A) or measurement should not be (seen in Fig. 2.1 Flow B). However, due to the necessity to comply with legal requirements, measurement must in principle be performed without fail. As a consequence, even after a series of the first control class in succession, situations may indeed occur in which a specified measurement will need to be periodically repeated. (Note: As is described in a later chapter, if especially good control is maintained, this guideline allows for a part of the re-monitoring to be omitted, but only on the condition that an expert re-examines the workplace after an appropriate interval). In the case of Working Environment Measurement, there may exist the need to perform measurement due to the degree of fixed thinking. In consideration of the above background however, it is seen that personal exposure monitoring requires flexible thinking.

In the exposure assessment methods used in Europe and the USA, the necessity of conducting measurements is determined in a similar way. As described in Appendix 1, the exposure assessment method in the NIOSH, AIHA, and European Standards stipulates that a basic characterization be performed first; on the basis of the result of this measurement shall be conducted as needed. This is further organized in the supplementary document (please refer to Appendix 4).

1-2 Personnel performing personal exposure monitoring

In order to proceed with the entire process of personal exposure monitoring (steps 1 to 9 in Fig. 2.1) personnel are required to comprehensively supervise the process. These personnel are defined as risk assessment supervisors. Since one responsible member of the personnel generally carries out all the steps in the case of personal exposure monitoring, it is normally considered possible for the risk assessment supervisor to perform the entire process. That is, the risk assessment supervisor is called upon to perform a basic characterization, to plan measurements on the basis of the characterization result, to evaluate the result of the measurement, and to recommend the necessary risk reduction measures to the workplace itself. Consequently, the risk assessment supervisor is required to be an expert and to be able to analyze potential outcomes.

Assistants who are under the instruction and supervi-
sion of the risk assessment supervisor may also be engaged in measurement (steps 3 to 6 in Fig. 2.1). For this purpose, these assistants are known as monitoring staff and they are also required to possess expertise concerning the measurement (in the narrow sense), analysis, and assessment of the result.

It is not a requirement that either the risk assessment supervisor or the monitoring staff be employed by the workplace in question.

2. Purpose and method of basic characterization

2-1 Overview and importance of basic characterization

Basic characterization, as the first step of personal exposure monitoring, is very important both in the determination of which of the follow’s, either A or B (seen in Fig. 2.1), should be chosen, and in the planning of the measurement should flow A be selected.

The major purposes of basic characterization (important items to be determined) are summarized in Table 2.1. First, on the basis of a survey of hazards in workplaces (chemical substances), the chemical substances requiring assessment (if any) shall be identified. Second, a similar exposure group (SEG), as a target of assessment and management, shall be set. Section 3-1 provides a detailed description of an SEG. Then, for each SEG and targeted chemical substance, the presence or absence of exposure and the degree of exposure for eight hours (one shift) shall be estimated. A similar estimation shall also be made, as needed, for short duration tasks, and, on the basis of this result, the necessity for monitoring is to be determined. Furthermore, if the risk assessment supervisor has identified potential overexposure, it is recommended that he consider about candidate proposal for necessary risk reduction measures.

Basic characterization shall be performed on an actual workplace. Preliminary documentary investigation, if available, prior to site survey will be useful.

Table 2.1. Purpose of workplace basic characterization (important items to be determined)

| Order | Important items to be determined | General timing               |
|-------|----------------------------------|------------------------------|
| 1     | Chemical substances to be assessed | Before and during workplace visit |
| 2     | Similar exposure group (SEG)     | During workplace visit       |
| 3     | Presence or absence of exposure and its degree (estimated exposure) (for each SEG and each chemical substance, 8 h/short term) | ditto |
| 4     | Necessity for measurement        | During or after workplace visit |
| 5     | Candidate proposal for necessary risk reduction measures | ditto |

Table 2.2 summarizes the major methods and contents of basic characterization. Since basic characterization of workplaces is also important in the case of Working Environment Measurement, many measurement experts will be familiar with basic characterization. The basic characterization method is similar to that of Working Environment Measurement in that it consists of obtaining information prior to a site visit, the survey of documents and records at the workplace, discussions with managers and with industrial hygiene experts as needed (such as Working Environment Measurement experts, health supervisors, occupational physicians, etc.), and, finally, observation of the workplace. Preparation of a recording sheet, as shown in Fig. 2.2, would also assist an effective and efficient basic characterization.

While it is true that Working Environment Measurement experts may be familiar with the examples of the contents of the characterization shown in Table 2.2, some parts of the contents and viewpoints of the basic characterization for personal exposure monitoring vary greatly from those of Working Environment Measurement. It is very important to note the important items to be determined (the five items seen in Table 2.1). This viewpoint is characteristic and is explained in detail in the following sections.

In the case of Working Environment Measurement, target substances are specified by the regulations. In contrast, chemical substances as assessment targets are required to be selected for personal exposure monitoring. Surprisingly, a large number of chemical substances are present in workplaces. For instance, a workplace consisting of about ten workers often contains more than several tens of kinds of chemical substances. Based on the information obtained in basic characterization, substances as assessment targets shall be selected from among these substances in terms of hazard and potential exposure.

At this stage, chemical substances that are evidently unlikely to produce exposure or are less toxic may be excluded from such targets. Such examples may include the following: less toxic aqueous solutions, high boiling point oils, solid substances that do not emit particles, trace amounts of certain substances, and substances that are to be handled only in a closed system. For this sort of rough classification (screening), in the initial stages a simplified risk assessment technique (control banding) may be arbitrarily employed depending on the situation. For those substances that can be excluded, a record taken of them including a simple reason for its rejection shall be maintained as a part of the record of the basic characterization itself.

For the chemical substances remaining (substances
with exposure potential), basic characterization (items 2 onward in the order column of Table 2.1) needs to be performed.

Anything noted in the basic characterization of workplaces is summarized separately (please refer to Appendix 5).

2-2 Estimation of exposure

Estimation of exposure is vitally important from the standpoint of performing a survey where the alternative no measurement (Flow B in Fig. 2.1) is used.

Let us take as an example the estimation of exposure for eight hours (one shift). We would estimate the presence or absence of and the degree of exposure for each chemical substance to be assessed for a certain SEG (i.e., for each substance individually if three kinds of chemical substances are to be handled). That is, we make this estimation for each combination of SEG-chemical substance (please refer to Fig. 2.2). When protective respiratory equipment is used, the exposure estimation is based on the assumption of not using it. The result of this assessment also informs the later selection of the respiratory protective equipment.

If, as a result of the survey, exposure assessment for a short duration task is found to be necessary, we assume the exposure for the task in question is similar to the above. That is, for short term exposure, an assumption is made for each combination of SEG-chemical substance-short duration task.

If the exposure class (control class) is set before exposure estimation, it would be easier to determine which control class a specific substance shall belong. Table 2.3 shows the control class recommended in this guideline. The details of this class are described in Sections 2-3 and 5-6 of Chapter 2.

The basis for exposure estimation and examples are listed in Table 2.4, which the past assessment and measurement results are primarily important. If past data of an SEG to be surveyed or of a similar workplace are avail-

| Method | Examples of contents of characterization (’1) |
|--------|---------------------------------------------|
| Advance acquisition of information (such as documented information) | Part of contents of general survey at workplaces |
| General survey at workplaces (such as documents and records) | Organization of business establishment and workplaces |
| | Production process |
| | Major chemical substances handled and their SDS |
| | Records on past exposure assessment and management |
| | Results of past measurement (including Working Environment Measurement) |
| | Records of medical surveillance |
| | Records of past accidents and complaints |
| Hearing from managers of workplaces (’2) | Chemical substances as assessment targets |
| | Work division in workplaces (setting of SEG) |
| | Typical work and its procedure (substances handled, frequency, duration, etc.) |
| | Presence or absence of exposure, work associated with exposure |
| | Past accidents and complaints |
| | Non-routine work |
| Observance of workplaces | Process, substances to be handled and general work situation |
| | Situation of generation sources (amount to be handled, temperature, hood, etc.) |
| | Situation of propagation of hazard substances (dilution ventilation, local exhaust ventilation, air current, etc.) |
| | Work method (changes in work, movement, proximity work, dermal permeation, personal protective equipment, etc.) |
| | Keeping things tidy and in order (contaminated tools, chemical cleaning cloth, wastes, etc.) |
| | Hearing from workers (realization and anxiety of exposure, etc.) |
| | Presence or absence of exposure and its degree (for each hazard, for each eight hours/short duration) |
| | Necessity for monitoring |
| | Major causes of exposure (source of generation, diffusion situation, etc.) |
| | Candidate proposals for necessary risk reduction measures (including control measures for management of workplace environment) |

’1: These are typical examples; they are not exhaustive neither are they mandatory.

’2: In addition, discussions with Working Environment Measurement experts, health supervisors, and occupational physicians of the workplaces shall take place as needed.
Table 2.3. Control class and interpretation

| Control class | Definition                                      | Interpretation (judgment)                      |
|---------------|------------------------------------------------|-----------------------------------------------|
| 1A            | $X_{95} < OEL$ And $X_{95} < (OEL \times 10\%)$ | Excellent                                     |
| 1B            | $AM < (OEL \times 10\%)$                       | Sufficiently good                             |
| 1C            | $(OEL \times 10\%) \leq AM$                     | Good                                         |
| 2A            | $AM \leq OEL \times X_{95}$ And $AM \leq (OEL \times 50\%)$ | Close investigation of the effectiveness of current control measures and efforts for further reduction of exposure are needed |
| 2B            | $(OEL \times 50\%) \leq AM$                     | Perform risk reduction measures               |
| 3             | $OEL < AM$                                      | Perform risk reduction measures without delay |

(OEL: Occupational Exposure Limit. AM: Arithmetic Mean. $X_{95}$: Upper 95 percentile of log normal distribution)

Fig. 2.2. Recording format for workplace survey (for example: eight-hour exposure)

able, the reliability of judgment is relatively high in general. As a matter of course, a close examination of the correlation between these data and the current situation of the SEG should be performed prior to utilizing them.

Instantaneous measurement methods are often an effective means for exposure estimation in basic characterization and are thus recommended for active utilization. Details of these instantaneous measurement methods are given in Section 4-2 of Chapter 2. Depending on the situation, the result of exposure modeling (simulation) may be applied. A common sense decision as to how substances are handled in a closed system may also be used.

When a decision is made on the basis of exposure estimation, a safety margin (allowance) shall be secured according to the degree of reliability. For instance, consideration shall be given so that judgment of measurement conditions to be simplified or no measurement may be conducted only when the result of the exposure estimation is lower than the occupational exposure limit by a certain degree.

For estimation of exposure, a brief record describing the basis for the estimation should be made (please refer to Fig. 2.2). Since exposure assessment is an important matter that directly affects the necessity of monitoring and risk reduction measures, assessors are responsible for the faithful execution of the assessment within their capability. Documentation of their assessment clarifies this responsibility and will, if required, also be helpful in clearly
Table 2.4. Basis of exposure estimation and examples

| Basis                                      | Examples                                                                 |
|--------------------------------------------|--------------------------------------------------------------------------|
| Past assessment and measurement result     | Past results obtained in the target SEG                                  |
| Alternative data                           | Past results obtained in similar workplaces or SEG                       |
|                                             | Results obtained from other chemical substances of target SEG           |
|                                             | Results obtained in area monitoring (such as Working Environment Measurement) |
| Result of instantaneous measurement        | Detector tube                                                           |
|                                             | Direct reading instrument, real-time monitoring device                   |
| Exposure modeling                          | Exposure simulation                                                      |
| Situation of workplace (experience-based judgment) | Equipment (exhaust and ventilation equipment)                         |
| Common sense judgment                      | Workplace environment (source of generation, distance, work contents, etc.) |
|                                            | Amount of substance to be handled is very small. To be handled in a closed system or nearly closed system |

Exposure estimation may appear to be a difficult task at the beginning. If a risk assessment supervisor is less experienced in measurement, or is not confident in the decision, it is recommended that the supervisor simply perform measurement. In such a case, it is often effective to first conduct an instantaneous measurement. As the risk assessment supervisor accumulates experience in exposure estimation and measurement at workplaces, it will soon become easier to estimate concerning similar workplaces or work tasks, with improved accuracy.

2-3 Exposure class (control class)

In this guideline, the control class is divided into six subclasses as shown in Table 2.3.

Then the control class is roughly divided into three classes; 1, 2, 3. The classes are identical with the control classes 1, 2, 3 in the case of Working Environment Measurement; indeed they have a fairly similar statistical significance. Control class 3 corresponds to an inadequate situation, which requires the immediate implementation of risk reduction measures. Control class 2 is divided into two classes. The subclass (2B) that is closest to the control class 3 essentially needs risk reduction measures. Control class 1 is divided into three classes. This is in order to distinguish between their goodness so as to allow reasonable selection to be made, such as re-assessment and measurement frequency. Details such as the calculation of control class, the significance of each class, and the response method for each control class are described later in Section 5-6.

Appropriate assignment of six control classes at the stage of exposure estimation may at first appear difficult, especially if a risk assessment supervisor has not had adequate experience. In such a case, only the three control classes (classes 1, 2, 3) may be employed, or, further, terms such as high, intermediate, low, and minimum may be useful.

If estimation could not be made because the degree of exposure is not well identified (a situation that in many cases corresponds to a gray zone in which exposure is neither too large nor too small), estimation unable to be made shall be recorded. This will assist in identifying it as a priority for later measurement.

Conflicts of interest: The authors declare that there are no conflicts of interest.