Guidelines for personal exposure monitoring of chemicals: Part I

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” 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 later 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.

Key words: Chemicals, Control, Exposure monitoring, Occupational hygiene, Risk assessment, Workplace

Introduction

This Document, “Guidelines for personal exposure monitoring of chemicals (Expert Division of Occupational Hygiene & Ergonomics)” (hereinafter referred to as “this Guideline”) has been prepared by “The Committee for Personal Exposure Monitoring” of the Expert Division of Occupational Hygiene & Ergonomics, Japan Society for Occupational Health, for use as a guide to personal exposure monitoring, wherein the activities conducted by the above Committee are reported.

In recent years, the importance of personal exposure monitoring has been growing in line with the promotion of risk assessment. At the same time, from an administrative perspective, an examination has been being conducted in order to facilitate the introduction of personal exposure monitoring (monitoring using personal samplers). It is thus expected that in the near future personal exposure monitoring may be officially legislated for. It was in consideration of such an eventuality that in No-
The purpose of the Committee was to enable the Expert Division of Occupational Hygiene & Ergonomics to prepare a “practical guideline” for personal exposure monitoring, in order to offer proposals and recommendations to members of the Japan Society for Occupational Health and to society in general. It should be noted here that the less strict representation “practical guideline” is used instead of the slightly more rigorous terms “standard regulation” and “basic procedure.” With respect to personal exposure monitoring, several major standards have been proposed overseas. However, in many cases, detailed procedures are not specified. This is suggestive of the fact that the technical contents of these standards are relatively complicated, and, thus, a variety of options and decision elements need to be taken into account, depending on which aspect is in force at the time that exposure monitoring is taking place. The contents of this Guideline should be seen less as stereotypes and not treated as a “textbook” but, rather, should remain as a reference “guideline” that is useful for indicating basic concepts. It is on this basis that a reasonable judgment may be made depending on the actual situation under consideration, in order to ensure appropriate assessment and the management of risk. The above is our standpoint for the preparation of this Guideline. At the same time, it should be emphasized that this Guideline is not intended to be seen as a systematic theory. Rather, it shall be of real and practical use in workplaces.

The scope of personal exposure monitoring treated by the Committee covers all chemical substances and all related workplaces. Legal regulations and methodology are not discussed. Therefore, the contents of this Guideline are intended neither to comment on the existing special regulations nor to be viewed as their alternatives. Rather, they are to be used as a means for general assessment and the management of risk relative to all types of chemical substances.

The Committee held a series of discussions about ensuring reasonable risk-based and scientific management serving as the basis of a practical and easily executable proposal. The Committee also held discussions regarding the practicability of existing methods and the application of associated information concerning appropriate personal exposure monitoring in Japan and in other countries. Consideration also was given to prevent excessive emphasis being placed on specifying too many details of the personal exposure monitoring method and to leave some flexibility for individual determination by monitoring staff. Since personal exposure monitoring essentially involves a variety of options and decision elements, it was considered that leaving such room for freedom of flexible determination to be practiced by the practitioners would be a good form of skill-training in a short period of time. It is considered that the above method would result in a beneficial accumulation of technical knowledge that would reinforce proficiency, and also, for employers, the motivation to secure and foster such qualified monitoring staff as necessary. In the medium to long term, it will prove beneficial because these staff will be able to manage the risks in the workplace reasonably, voluntarily, and proactively. Consequently, it is hoped that it will come to be understood that reasonable promotion of personal exposure monitoring, while making the most of self-flexible determination, will make a great contribution to the entire process of occupational hygiene management in Japan.

Both through the series of 10 meetings that the Committee held from November 2012 to February 2014 and by means of e-mail communication, the Committee discussed details concerning individual issues.

The main text of this Guideline provides the basic methods and concepts that are required for the execution of personal exposure monitoring, while the 31 “Appendices” that are provided later in this Guideline provide technical descriptions, reference information, examples, and statistical bases, in order to deepen understanding. It would be considered our great pleasure if this Guideline were to contribute in even a small manner to increasing knowledge of personal exposure monitoring and eventually to have been seen to be helpful in furthering the improvement of occupational hygiene management in Japan. Readers are respectfully requested to seek to develop better understanding as to the purpose and contents of this Guideline, so as to actively make full use of it.

Finally, we would like to express our appreciation toward Dr. Kenji Nakaaki, honorary professor of Azabu University, and also Dr. Shigeru Tanaka, professor of Jumonji University. Both were kind enough to offer to attend meetings on a voluntary basis in order to provide their valuable advice.

March 2017
Expert Division of Occupational Hygiene & Ergonomics, Japan Society for Occupational Health
The Committee for Personal Exposure Monitoring
Chairman
Haruo Hashimoto, Professor
University Management Center, Tokyo Institute of Technology

Executive Summary

This Document, “Guidelines for personal exposure monitoring of chemicals (Expert Division of Occupational Hygiene & Ergonomics)” (hereinafter referred to as “this Guideline”), has been prepared by “The Committee
for Personal Exposure Monitoring” of the Expert Division of Occupational Hygiene & Ergonomics, Japan Society for Occupational Health, as a guide to be used to determine appropriate personal exposure monitoring, wherein the activities conducted by the above Committee are reported.

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 “Expert Division of Occupational Hygiene & Ergonomics” organized the establishment of “The Committee for Personal Exposure Monitoring” (hereinafter referred to as “the Committee”) in November 2012. Subsequently, up to February 2014, the Committee held 10 meetings. The purpose of the Committee was to prepare 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 personal exposure monitoring in 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 later in this Guideline; technical descriptions, statistical bases, and actual workplace examples are provided in these appendices, for better understanding.

In this Guideline, personal exposure monitoring is not to be regarded as being the same as “measurement,” in the narrow sense of the word, but, rather, is to be recognized—as an integral process of performing “assessment and management of exposure.” This process is divided up into nine steps, starting from the basic characterization of workplaces and continuing all the way up to the follow-up (the implementation of control measures, as well as reassessment and monitoring). These steps are roughly classified into the following three categories: “basic characterization,” “monitoring (in the narrow sense)” and “risk reduction measures.” Personnel who comprehensively supervise the process as a whole are defined as “risk assessment supervisors.” Those engaged as assistants in the actual monitoring are defined as “monitoring staff.”

The basic characterization consists of grasping the general situations of the workplaces in question, selection of the chemical substances and workers to be assessed, and estimation of exposure, each of which constitutes an important step. A group of workers subject to a similar degree of exposure is known as a “similar exposure group” (abbreviated as SEG) for assessment and monitoring.

In principle, monitoring is performed on the basis of the results of this basic characterization, but, depending on the situation, it is possible to choose not to perform any monitoring. Basically, the number of samples is at least five, and the monitoring duration is eight hours (one shift). However, depending on the situation, the number of samples and the monitoring duration may be reduced. Workers to be monitored are selected at random from among a SEG, and there will be no numerical adjustments made after monitoring with regard to the day-to-day variance of exposure or the worker-to-worker variance. In addition, short-term (15 min) monitoring will be conducted in parallel if required.

Based on the monitoring results, statistical index values (arithmetic mean and 95th percentile of distribution) are obtained and are compared with the occupational exposure limit. This will allow assessment of the exposure class (control class). The control classes are subdivided into six classes in the superiority order “1A, 1B, 1C, 2A, 2B, 3.” The control classes “1A, 1B, 1C” correspond to the “first control class” in accordance with the Working Environment Measurement, “2A, 2B” to the “second control class,” and “3” to the “third control class.” For the control classes 2B and 3, “control measures” shall be incorporated, while for the control class 2A, “further exposure reduction measures shall be taken”; these responses are more stringent than the Working Environment Measurement regulations. The division of the “first control class” into 1A, 1B, and 1C is undertaken with a view to allowing the class results to be reasonably reflected in the frequency for reassessment and monitoring. Either the American Conference of Governmental Industrial Hygienists Threshold Limited Value (ACGIH-TLV), or the permissible concentration of the Japan Society for Occupational Health (whichever is the smaller) shall be the occupational exposure limit.

On the basis of the assessment result, the risk assessment supervisor shall, if necessary, recommend risk reduction measures to the manager of the workplace. In this case, the order of priority is management of the workplace environment, followed by work practice management and then by health management (as appropriate).

After a certain period of time, “reassessment (re-survey of workplace)” and “re-monitoring” shall be conducted. The frequency with which these shall be conducted is six months to two years for reassessment and six months to three years for re-monitoring, with the control interval being longer the higher the control class. Depending on the situation, it is acceptable either to perform only reassessment without re-monitoring or to extend the interval. Moreover, a mechanism (management of changes) should be introduced that allows a risk assessment supervisor to make reassessment at each case whenever any changes are incorporated into a workplace. This is to ensure safety in extending the interval for reassessment and re-monitoring.

The personal exposure monitoring presented in this
Guideline has many advantageous features, the most significant among them being the ability to allow direct assessment of health risks by comparison of the airborne concentration of a given chemical for the breathing zone of a worker with the occupational exposure limit. Other advantages include the adaptability to a variety of forms of work (approach, movement, intermittent work, etc.); flexible utilization of instantaneous measurement methods for basic characterization (using detector tubes and real-time monitoring); and the flexibility that a risk assessment supervisor has to judge and select the need for monitoring, its contents (number of samples, monitoring interval), and the frequency for reassessment and monitoring—all of which depend on the particular situation in a given workplace. As a result, an overall mechanism is established that allows reasonable management to be applied for a given risk. It is thus necessary for a risk assessment supervisor to have achieved an appropriate level of education and training that will ensure the application of the appropriate expertise and judgment in combination with the ability to act ethically in order to perform with the appropriate level of flexible determination.

The above mechanism enables a risk assessment supervisor to proceed with reasonable management using the supervisor’s discretion, judgment, and ingenuity. In this manner, motivation is introduced to improve the supervisor’s own access to and use of technology. For an employer, on the other hand, improvement of control levels in his/her workplace would reduce the load of assessment and monitoring; this in turn will create a motivation to cultivate and make the best use of risk assessment supervisors, thus allowing voluntary and proactive management. These motivations will allow fully fledged academic activities to be conducted in sharing the educational mechanism for risk assessment supervisors, university- and postgraduate-level professional curriculums, qualification systems, good practices, and high-risk examples. As a result, it is expected that occupational hygienists, equivalent to those currently practicing in Western countries, will be cultivated as a functional group in Japanese society. It is also believed that employers will be assisted to move from their previous passive posture of “performing only the requirements of regulations” into an attitude of a voluntary posture of “managing risks on their own.”

The personal exposure monitoring described as per this Guideline is equivalent to an “expert-centered basic method to reasonably proceed with assessment and management of risk in workplaces”. It is considered that practicing and expanding on this method will significantly contribute to reforming the overall framework of occupational hygiene management in Japan and to also substantially strengthen this management in general.

It would be considered our great pleasure if this Guideline were to come to be seen as making even a small contribution to the understanding and spreading of personal exposure monitoring into the future and eventually be helpful in furthering the improvement of occupational hygiene management in Japan. Those who will read this Guideline are kindly requested to understand its purpose, and to actively make full use of it.

Terminology and Abbreviations

Personal exposure monitoring: All actions related to the monitoring of exposure in the breathing zone of workers (survey, planning, monitoring, assessment, control measures, etc.)

Risk assessment: Assessment of risks.

Risk management: Performance of risk reduction measures (based on the result of risk assessment.)

Working Environment Measurement: Working Environment Measurement according to Article 65 of the Industrial Safety and Health Act.

Similar exposure group: A group of workers subjected to a similar level of exposure.

Risk assessment supervisors: Personnel who manage the overall personal exposure monitoring.

Monitoring staff: Personnel who are to be engaged only in practical monitoring under the risk assessment supervisor (monitoring, analysis, etc.)

Control class: A classification related to the magnitude of exposure that is set for assessment from the result of personal exposure monitoring.

Management of change: Assessment and management of risk to be performed in relation to the effects caused by any change in the workplace or work.

SEG: Similar Exposure Group

AM: Arithmetic Mean

GM: Geometric Mean

GSD: Geometric Standard Deviation

X95: Upper 95th percentile of a log normal distribution

OEL: Occupational Exposure Limit

PEL: Permissible Exposure Limit

ACGIH: American Conference of Governmental Industrial Hygienists

TLV: Threshold Limited Value

TWA: Time Weighted Average

STEL: Short Term Exposure Limit

log: Logarithm with “e” as its base

In: Logarithm with “e” as its base

Chapter 1 Purpose and Background of “Guidelines for personal exposure monitoring of chemicals (Expert Division of Occupational Hygiene & Ergonomics)”

1. Background and scope of targets

In recent years, significant occurrences related to personal exposure monitoring are as follows. In 2006, the
“Guidelines for investigating the danger or toxicity due to chemical substances” were issued in line with the revision of the Industrial Safety and Health Act. As such, risk assessment of all dangerous or toxic chemical substances has become an obligation since 2014. Risk assessment of substances (640 kinds) seen as targets requiring notification was made mandatory. Since personal exposure monitoring is the most basic means of health risk assessment for chemical substances, the importance of personal exposure monitoring has been enhanced by such occurrences.

In 2010, the report prepared by the Ministry of Health, Labour and Welfare concerning the “Investigation commission on the future policy of the management of chemical substances in the workplace” proposed the introduction of personal exposure monitoring (using personal samplers). Furthermore, the 12th Occupational Safety & Health Program, introduced in 2013, stipulated “considering introducing personal samplers to measure the concentrations of chemical substances in the workplace environment”. Moreover, for four years after 2010, the Ministry of Health, Labour and Welfare promoted investigation into personal exposure monitoring by means of a consignment contract with the Japan Industrial Safety and Health Association. As part of the above occurrences, the guidelines for the basic elements of performing personal exposure monitoring were prepared. On the basis of those guidelines, workshops were held several times in various locations nationwide.

The current situation is such that in the near future personal exposure monitoring may be officially legislated for. In consideration of the above, the Expert Division of Occupational Hygiene & Ergonomics of the Japan Society for Occupational Health organized the establishment of “The Committee for Personal Exposure Monitoring” (hereinafter referred to as “the Committee”). The results of investigations elaborated by the above Committee are summarized in “Guidelines for personal exposure monitoring of chemicals (Expert Division of Occupational Hygiene & Ergonomics)” (hereinafter referred to as “this Guideline”).

The scope of the target for personal exposure monitoring described in this Guideline covers all chemical substances and all related workplaces. It includes substances regarded as targets for Working Environment Measurement regulation, indoor workplaces handling these substances, and other substances and workplaces, including the outdoor environment. However, this Guideline does not deal with legal regulations and methods; this is because it is first and foremost to be regarded as a means for performing personal exposure monitoring for general assessment and the management of risk related to chemical substances.

2. Background of personal exposure monitoring

2-1 Existing domestic and overseas methods

Since assessment of the results of personal exposure monitoring is positioned as a basic means of risk assessment in Europe and the USA, many proposals have been offered regarding the risk assessment methods of chemical substances9]. One basic example is a proposal offered in 1977 by the National Institute for Occupational Safety and Health (NIOSH)7. In 1991, the American Industrial Hygiene Association (AIHA) established an exposure assessment method which was revised in 1998 and 200610. Comité Européen de Normalisation (CEN) established in 1995 an exposure assessment method for chemical substances in the workplace as a European standard11. Moreover, in 2011, the British Occupational Hygiene Society (BOHS) and the Nederlandse Vereniging voor Arbeidshygiëne (NVvA) jointly published a new assessment method12 (please refer to Appendix 1).

In Japan, on the other hand, personal exposure monitoring and its assessment methods have not been reviewed to a great extent, simply because periodic monitoring of the concentration of certain chemicals in the workplace environment is legally stipulated. Thus, only in relatively recent years have several assessment methods been proposed13. In 2005, the Ministry of Health, Labour and Welfare enacted the “Guideline on the workplace environment control in outdoor workplaces” (March 31, 2005; LSB Notification No.03310177). Also in 2005, the Working Environment Measurement investigation committee of the Japan Society for Occupational Health proposed an airborne concentration monitoring and assessment method that included assessment of personal exposure concentration” (please refer to Appendix 2).

2-2 General features of personal exposure monitoring

When performing risk assessment of safety and the environment, a risk is represented as the product of “importance of hazard (accident)” and “probability of the occurrence of accident”. This risk is estimated by assessing various elements. In the case of risk assessment of the health effects caused by chemical substances, “magnitude of hazard (of chemical substances)” and “amount of exposure” are used as factors in the assessment corresponding to the above safety and environment risk assessment; a combination of them will be used for risk estimation. In this case, “occupational exposure limit” as the index value of health-related safety is used as “magnitude of hazard,” while “amount of exposure” is used as the result of personal exposure monitoring of workers in the breathing zone of the environment air. This is considered the most typical and basic method8]. The “occupational exposure limit” is defined as that value beneath which workers who are exposed for eight hours a day, five days a week, for a long period of time will suffer almost no health effects (as defined by ACGIH-TLV-TWA). This value is set on the basis of epidemiological or toxicologi-
The result of personal exposure monitoring (airborne concentration of a given chemical in the breathing zone) is to be compared with this “occupational exposure limit.” Thus, personal exposure monitoring is a method of directly and correctly assessing the risk to workers and is an essential means for risk assessment of health. Because of such a background, personal exposure monitoring has long been used in Europe and the USA, and it has gone on to become a global standard as an exposure assessment method. Another basic method of health risk assessment consists of comparing the result of biological monitoring with the biological exposure index. However, this method’s use is limited because of the small number of substances whose biological exposure index has been established.

In Japan, to the contrary, regulations stipulate the working environment measurement, and so only area monitoring is used as a workplace measurement. Because of this, personal exposure monitoring has not been popularized to such a great degree. There is no disagreement of this, personal exposure monitoring has not been popularized to such a great degree. There is no disagreement about the role Working Environment Measurement regulation has played in improving workplace environments in Japan. However, since area monitoring is essentially intended to detect sources of generation of hazardous chemicals and to verify the effectiveness of equipment, it is used on relatively fewer occasions than personal exposure monitoring is used in Europe and the USA. This is largely because of the fact that area monitoring is often used as a simplified alternative to personal exposure monitoring. In the case of Working Environment Measurement regulation, the measurement method, such as the number of samples and sampling duration, is specified in detail. This is so that the term “measurement” may cause a strong awareness of the need for solemn conduct according to the specified method.

As personal exposure monitoring allows continuous monitoring of the breathing zone of workers, it is easy to follow the workers’ motion and diversity of work (movement, intermittent work, multiple instances of works, etc.) Moreover, there is a large number of monitoring targets (up to almost 1,000 substances) that have their occupational exposure limit set, and there is almost no restriction as to the target workplaces where personal exposure monitoring could be applied. Depending on the risk and situation, it is possible to conduct a reasonable assessment and management of risk with ample flexibility, in order to determine whether or not to perform monitoring and also what monitoring method (number of samples and monitoring duration, etc.) may be required, and the time interval required before re-monitoring needs to be performed. The procedure and the concept are very different from Working Environment Measurement. For this purpose, there must be experts in place possessing a certain degree of skill so as to perform overall supervision and to proceed with judgment as appropriate. Such experts are called occupational hygienists abroad (or industrial hygienists in the USA specifically).

In the USA, European countries, and Australia, as well as in other countries, regulations stipulate the occupational exposure limits in order to ensure the exposure of workers to values below these limits. Because of this, employers have assessed exposure by use of personal exposure monitoring and via use of occupational hygienists, and then they have applied risk reduction measures according to the results obtained. It is for this reason that personal exposure monitoring has been so widely used and developed.

Up until now, various studies have been conducted into the correlation between the results of personal exposure monitoring and those of Working Environment Measurement. It is generally observed that personal exposure monitoring produces higher concentration values. The commonly accepted reason for this is that, in personal exposure monitoring, air with a relatively high concentration of the given chemical is often sampled by following the movement of workers. A detailed explanation in this regard is provided in the appendix (please refer to Appendix 3).

In the case of personal exposure monitoring, the distribution of exposure is said to take on a log normal distribution, as is the case for Working Environment Measurement. This is supported by a large number of historical domestic measurement results. All the exposure assessment methods used in Europe and the USA as described in Section 2-1 are also based on this concept. Thus, the same concept is followed in this Guideline.

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

References

1) Kumagai S. Workplace environment assessment and personal exposure monitoring to learn from the basic statistics. Tokyo: the Institute for Science of Labor; 2013. (in Japanese).
2) Leidel NA, Busch KA, Lynch JR. Occupational exposure sampling strategy manual (NIOSH Publication No. 77-173). Washington, D.C: Government Printing Office; 1977.
3) American Industrial Hygiene Association. In: Bullock WH, Ignacio JS, editors. A strategy for assessing and managing occupational exposures. 3rd ed. Fairfax: American Industrial Hygiene Association; 2006.
4) CEN. European Standard EN689: 1995. Workplace atmospheres - Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy. Brussels: Comité Européen de Normalisation; 1995.
5) British Occupational Hygiene Society, Nederlandse Vereniging voor Arbeidshygiëne. Testing Compliance with Occupational Exposure Limits for Airborne Substances. [Online]. [cited 2017 Aug. 8]; Available from: URL: http://search.yahoo
6) Japan Association for Working Environment Measurement. Guidebook for Working Environment Measurement 0, Generals. Tokyo: the Japan Association for Working Environment Measurement; 2010. (in Japanese).

7) Japan Society for Occupational Health and Working Environment Measurement Committee. Report by the Working Environment Measurement Committee. Sangyo Eiseigaku Zasshi 2005; 47: A74-76 (in Japanese).

8) General guidebook on industrial health, 2016. Tokyo: the Japan Industrial Safety and Health Association; 2016. p. 255 (in Japanese).

9) Sakurai H, et al. Exposure limit values of permissible concentrations. In: Kogi K, et al, editor. Handbook of occupational safety and health. Kawasaki: the Institute for Science of Labor; 2013. p. 560-563 (in Japanese).

Journal of Occupational Health is an Open Access article distributed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License. To view the details of this license, please visit (https://creativecommons.org/licenses/by-nc-sa/4.0/).