Special Article

Guidelines for personal exposure monitoring of chemicals: Part VI

Expert Division of Occupational Hygiene & Ergonomics, the Japan Society for Occupational Health, “The Committee for Personal Exposure Monitoring”
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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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Key words: Chemicals, Control, Exposure monitoring, Occupational hygiene, Risk assessment, Workplace

Chapter 3: Characteristics and Utilization of Personal Exposure Monitoring-Conclusion

1. Role and responsibility of expert
1-1 Risk assessment supervisor and monitoring staff

A risk assessment supervisor is a facilitator who comprehensively supervises the entire process of personal exposure monitoring (steps 1 to 9 in Fig. 2.1). They are thus required to exhibit appropriate flexible determination in the various stages. The supervisor is also in the position of advising appropriate risk reduction measures to the manager and, from an expert point of view, to actively
Measuring Reference to duty, a role that also requires adequate education. The
procedures in the appendix (please refer to Appendix 29).

Descriptions of occupational hygienists are
management of risk, a professional whose task is similar to
is a professional who supervises the assessment and man-
agement supervisor (steps 3 to 6 in Fig. 2.1) is also required
with others to enhance friendly competition. Personal ex-
posure monitoring in Japan has not been widespread;
ence professional decisions. This entails a heavy responsibility. For this reason, adequate un-
derstanding of, and compliance with, established profes-
ional ethics are required. Table 3.1 summarizes the pri-
mary code of ethics required for performing duties.

These ethics are almost the same as those necessary for
occupational hygienists. For instance, the Japan Associa-
tion for Working Environment Measurement1,2, and the Ameri-
can Board of Industrial Hygiene (ABIH)3, and the Inter-
national Occupational Hygiene Association (IOHA)4
have strictly stipulated the professional ethics required for
occupational hygienists.

A risk assessment supervisor and a monitoring staff
member are, to the best of their abilities, responsible for
the performance and recording of the assessment as well
as the accurate, conscientious and ethical monitoring of
personal exposure, with the precise reporting to the em-
ployer. When they are required to engage in flexible de-
termination, what the decisions are based on shall be
clarified and recorded. On the other hand, it is the em-
ployer’s responsibility to accept and understand the re-

Table 1. Major ethical considerations in the course of performing duties by experts involved in personal exposure monitoring

| 1. Recognize the first mission to protect workers’ health and welfare. |
| 2. Comply with laws, regulations, policies, social, and ethical standards. |
| 3. Avoid a conflict of interest with employers, customers, workers or the public. |
| 4. Assure that a conflict of interest does not compromise the essential purpose of employers, customers, workers or the public (attainment of health and welfare) and does not influence professional decisions. |
| 5. Deliver good quality services based on the best efforts in accordance with professional and objective decisions. |
| 6. Recognize the limitations of one’s professional abilities based on his/her knowledge, skills, experience, and other relevant considerations, and provide services within such scope. |
| 7. Follow appropriate health and safety procedures in the course of performing duties. |
| 8. Maintain and respect the confidentiality obtained in the course of professional activities, unless the information implies anti-social contents or failure to disclose the said information would likely harm the health and welfare of workers or the public. |

Reference: ABIH Code of Ethics. Code of Ethics for Occupational Hygienists by the Japan Association for Working Environment Measurement (see References 1, 2) in Chapter 3 for quotation.

support the manager in terms of the risk reduction mea-
ures advised. In other words, a risk assessment supervisor
is a professional who supervises the assessment and man-
agement of risk, a professional whose task is similar to
that of experts in the field of industrial hygiene and ergo-
nomics in Europe and the USA, known as occupational hygienists. Descriptions of occupational hygienists are
provided in the appendix (please refer to Appendix 29).

A risk assessment supervisor is therefore required to
possess the relevant expertise and judgment to fulfill his/ her duty, a role that also requires adequate education. The
first requirement needed is education in the methodolo-
gies of the personal exposure monitoring, which is de-
scribed in this Guideline. Required education also in-
cludes knowledge of toxicity and toxicology of chemical
substances, actual measuring methods, instantaneous measurement and real-time monitoring, engineering im-
provement measures and personal protective equipment.
Furthermore, risk assessment supervisors require an atti-
tude toward occupational hygiene with which they seek
not to discover problems but rather to “solve problems”.

A “monitoring staff” member who performs actual
monitoring work under the supervision of a risk assess-
ment supervisor (steps 3 to 6 in Fig. 2.1) is also required
to receive education according to his/her role. Since
Working Environment Measurement experts have already
attained to a certain level of knowledge, it is considered
appropriate that they would be involved in the monitoring
of chemicals according to the category of their qualifica-
tion after receiving specific education on personal expos-
ure monitoring.

To promote future personal exposure monitoring in Ja-
pan, it is necessary to develop the curricula, methodology
and operational organizations required for the above ex-
pert education.

It is also necessary for both risk assessment supervisors
and monitoring staff to receive continuous education even
after the completion of their training. Because the scope
of the necessary education is broad, and because toxico-
logical information and monitoring techniques concerning chemicals are evolving fast, the initial education alone is
not necessarily sufficient. It is thus strongly recom-
mended that they actively disseminate their experience
and knowledge through academic conferences and re-
search presentation meetings, and also by sharing them
with others to enhance friendly competition. Personal ex-
posure monitoring in Japan has not been widespread;
hence, accumulation of experience at a wide variety of
workplaces will come to constitute a universal property of
domestic industrial hygiene and thus will contribute to the
fostering of the risk assessment supervisors and monitor-
ing staff.

1-2 Ethics and responsibility of experts on personal exposure monitoring

Personal exposure monitoring involves a variety of freedom for the expert’s flexible determination. This en-
tails a heavy responsibility. For this reason, adequate un-
derstanding of, and compliance with, established profes-
essional ethics are required. Table 3.1 summarizes the pri-
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ployer. When they are required to engage in flexible de-
termination, what the decisions are based on shall be
clarified and recorded. On the other hand, it is the em-
ployer’s responsibility to accept and understand the re-
Table 2. Features of personal exposure monitoring—“Monitoring techniques” (including features of area monitoring for reference)

<table>
<thead>
<tr>
<th>Item</th>
<th>Personal exposure monitoring (monitoring in breathing zone)</th>
<th>Area monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct assessment of “health risk”</td>
<td>Possible (*1)</td>
<td>Impossible</td>
</tr>
<tr>
<td>Contribution of work hours</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>Response to movement of workers and diversity of work (proximity, intermittent, complex, etc.)</td>
<td>Possible</td>
<td>Difficult</td>
</tr>
<tr>
<td>Cases where monitoring is difficult (narrowness, danger, etc.)</td>
<td>Almost none</td>
<td>Sometimes yes</td>
</tr>
<tr>
<td>Burden on workers (weight of samplers etc.)</td>
<td>Sometimes yes</td>
<td>None</td>
</tr>
<tr>
<td>Identification of source of generation</td>
<td>Generally possible (*2)</td>
<td>Generally possible</td>
</tr>
</tbody>
</table>

Note: The above is based on the assumption of eight-hour/short-term monitoring, and A-measurement/B-measurement.

*1: Possible by comparing the results of measurements with the occupational exposure limit.
*2: Generally identified with the observation results of workplaces (please refer to Appendix 20).

2. Features of personal exposure monitoring and its significance in occupational hygiene

2-1 Features of personal exposure monitoring

Features of personal exposure monitoring include technical features as a monitoring method and system or operational features.

Table 3.2 shows features of monitoring techniques, including features of area monitoring as a reference. Since personal exposure monitoring compares the measurement results of workers’ breathing zone with the occupational exposure limit, the greatest strength is its capacity to directly assess the health risk, which constitutes the core method for health risk assessment. Other advantages of personal exposure monitoring include assessment covering work hours and adaptability to the diversity of work (proximity, intermittent, complex, etc.). Thus it is often pointed out that when there is a high concentration of hazardous substances in the work environment, the resultant area monitoring can lead to an overestimation compared to personal exposure monitoring. This is because workers stay in the workplace for a very short time. By contrast, when there is a low concentration of hazardous substances in the work environment, the resultant area monitoring can lead to an underestimation due to the fact that workers are subjected to high exposure in other workplaces. In personal exposure monitoring, the contaminant generation sources can be often identified through workplace observations. This is described separately (Appendix 20).

Table 3.3 shows system or operational features, including features of area monitoring as a reference. Personal exposure monitoring involves a large number of substances (there are around 1,000 kinds of substances with occupational exposure limits) and can be used widely in any target workplaces. Workers are grouped into similar exposure groups (SEGs) for each substance.

Personal exposure monitoring allows instantaneous measurement (using detector tubes or real-time monitors) as a mean for basic characterization of workplaces. This is considered a significant benefit due to the fact that instantaneous measurement can be recognized as a screening assessment of exposure, allowing flexible utilization to contribute to efficient exposure monitoring, responding to irregular and intermittent work in the research laboratories, as well as improving monitoring practices in small
Table 3. Features of personal exposure monitoring—“System and operation” (including features of area monitoring for reference)

<table>
<thead>
<tr>
<th>Item</th>
<th>Personal exposure monitoring (this Guide)</th>
<th>Working Environment Measurement (statutory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Risk assessment</td>
<td>Management of workplace environment</td>
</tr>
<tr>
<td>Substances to be monitored</td>
<td>Many (*1)</td>
<td>Specified substances (90 kinds or a bit more)</td>
</tr>
<tr>
<td>Target workplace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Categorization of objects to be monitored</td>
<td>Similar exposure group (SEG)</td>
<td>Indoor only (*2)</td>
</tr>
<tr>
<td>Instantaneous measurement</td>
<td>Widely available</td>
<td>Unit work area</td>
</tr>
<tr>
<td>Method of monitoring</td>
<td>Eight-hour monitoring, short-term monitoring</td>
<td>Detector tube partly usable</td>
</tr>
<tr>
<td>Monitoring duration (eight hours or A-measurement)</td>
<td>Eight hours (basically), but may be shortened to two hours</td>
<td>10 minutes or more for one point, one hour or more in total</td>
</tr>
<tr>
<td>Number of samples (ditto)</td>
<td>Five (basically), but one to four also allowed</td>
<td>Five or more</td>
</tr>
<tr>
<td>Statistical assessment value</td>
<td>Arithmetic mean, 95 percentile</td>
<td>Estimated value of arithmetic mean, 95 percentile</td>
</tr>
<tr>
<td>Control class</td>
<td>Six classes</td>
<td>Three classes</td>
</tr>
<tr>
<td>Involvement of monitoring staff in the formulation of control measures</td>
<td>Strongly recommended</td>
<td>Not required</td>
</tr>
<tr>
<td>Format of report</td>
<td></td>
<td>Model format</td>
</tr>
<tr>
<td>Management of change in workplace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reassessment and re-monitoring</td>
<td>Reassessment and re-monitoring</td>
<td>Periodic measurement</td>
</tr>
<tr>
<td>Monitoring practitioner</td>
<td>Risk assessment supervisor, monitoring staff</td>
<td>Working Environment Measurement expert</td>
</tr>
<tr>
<td>Procedure for monitoring</td>
<td>Much room for flexible determination</td>
<td></td>
</tr>
<tr>
<td>Easiness of monitoring</td>
<td>Requiring knowledge, experience, and skill</td>
<td>As per the stipulated procedure</td>
</tr>
<tr>
<td>Burden on employer</td>
<td>Lowers as time passes</td>
<td>Nearly constant</td>
</tr>
<tr>
<td>Reasonable management according to risk</td>
<td>Possible</td>
<td>Difficult</td>
</tr>
<tr>
<td>Motivation to employer</td>
<td>Large</td>
<td>Very small</td>
</tr>
</tbody>
</table>

*1: In principle, substances having occupational exposure limit, about 1,000 kinds.

*2: Outdoor workplaces are subject to the guideline on the workplace environment (LSB Notification No.0331017).

and medium-sized workplaces.

The basic assessment method of measurement results consists of using the arithmetic mean and the 95 percentile, which is similar to the case of Working Environment Measurement. However, personal exposure monitoring is characterized by the fact that the control class is divided into six classes. In these six classes, the control class 2B (about 10 to 40% of the workers potentially exceeding the occupational exposure limit) requires control measures, while control measures are not necessarily required in the Working Environment Measurement. This is the unique feature of this guideline.

With respect to reassessment and monitoring, significant features can be seen. One of these is that reassessment and re-monitoring are separated, each having its own basic frequency and modifiable range. Since the better the control class, the lower the frequency becomes, it is considered to be a big motivation for employers to implement exposure reduction measures. Even for the same control class, there is a room for mitigation of the frequency, depending on the risk assessment supervisor’s decisions based on the stability over time, etc. Moreover, the management of change is required prior to the reassessment and monitoring, and it guarantees the restriction of risk associated with changes in the equipment and contents of work.

In terms of the overall procedure of monitoring, personal exposure monitoring offers flexibility, such as execution or non-execution of monitoring, sampling method (number of samples, monitoring duration, etc.), and frequency of re-monitoring depending on the risks of SEGs estimated in the basic characterization or reassessment, thus allowing reasonable progress of risk assessment and management.
Concerning ease of monitoring, a risk assessment supervisor requires a certain level of knowledge, experience, and skills for personal exposure monitoring because there is a room for flexible determination and because the supervisor shall be proactively involved in the design of control measures.

The burden on employers (in terms of labor costs and other expenses) may be relatively heavy at the introduction of personal exposure monitoring method. This is due to the fact that the increase in the number of samples and longer duration, and also because of the lack of experience of a risk assessment supervisor and the lack of past measurement results. However, for instance, within a short term of 1 to 3 years, a sharp reduction in this burden may be anticipated because the frequency of reassessment and monitoring would be reduced with improved control class and because the supervisors’ efficient decision-making would be expected based on the experience and the accumulated past data.

Detailed considerations in this regard are provided in the appendix (please refer to Appendix 30).

Summarizing all of the above, personal exposure monitoring has definite beneficial features from the viewpoint of the reasonable risk-based control. For employers, personal exposure monitoring as a mean of risk assessment and risk management shall be a big motivation.

2-2 Social effects and future prospects of personal exposure monitoring

In the case of personal exposure monitoring, a risk assessment supervisor can reasonably proceed with risk assessment and risk management by exercising his/her flexible determination as well as their originality and ingenuity. Thus the supervisor has a motivation to improve his/her own skills and to enhance their judgment. However, when there is no room for originality and ingenuity, and the supervisor shall follow the existing protocols, such motivation may not arise. From the point of view of employers, improvement in the control situation of workplaces would reduce the load of assessment and monitoring. Securing of a risk assessment supervisor of good quality and the utilization in full of his/her judgment would ensure such improvement. Consequently, it will come to be a motivation for employers to foster risk assessment supervisors and to control the risk of workplaces voluntarily and proactively through continued employment of a risk assessment supervisor.

Based on the above two benefits, various social developments can be expected. Firstly, a mechanism for educating risk assessment supervisors and monitoring staff is required. For the foreseeable future, lecture classes are conceivable. The need for professional education courses at a university or postgraduate level may also increase. At the same time, a qualification system (e.g., certification) of such engineers may become necessary. In order to proceed with control of workplaces through originality and ingenuity, the importance of mutually reporting and sharing knowledge among other workplaces (such as good practices around assessment and management, or high-risk work) would arise. This would lead to more active academic social activities. Through such activities, the overall level of industrial hygiene in Japan will improve, and the accumulated industrial hygiene knowledge will then be disseminated to related engineers through various media. Moreover, local academic societies of industrial hygiene could deliver key information, such as emerging risks and case reports, and enlighten the administration and employers. Within business establishments, on the other hand, as a risk assessment supervisor proactively controls the workplaces, their responsibility and influence will become stronger. Then, it is expected that, even without legal regulations, risk reduction measures against problems will be implemented under the leadership of risk assessment supervisors.

As mentioned in the previous section, personal exposure monitoring has technical and system/operational features. In order to ensure the motivations and social propagation effects based on personal exposure monitoring, it is necessary to make use of the latter, system/operational features, where risk assessment supervisors perform with flexible determination. As a management technique, this corresponds to the methodology, in which the goal is set, and the process toward the goal is left entirely up to a practitioner (this is referred to as ‘management with performance standards’). If, by contrast, all implementation details are defined (this is referred to as “management with specification standards”), a practitioner will simply follow the rote procedures. In this case, neither motivations nor the afore-mentioned beneficial social effects can be expected. And therefore, in order to make a real use of the advantages of personal exposure monitoring in the field of occupational health, it is necessary to fully harness not only the monitoring techniques but also the system/operational features. (However, although flexibility in the system and operation is desirable, it may be intentionally misapplied (please refer to Section 1-2 in Chapter 3). Employers and risk assessment supervisors, therefore, should keep this in mind and prevent it).

In the legal systems concerning exposure control in the USA, European countries, Australia as well as in other countries, this performance standards concept has already been incorporated, under which personal exposure monitoring with professional flexible determination has become widely adopted. As a result, during the last 40 years or so, professional engineers’ groups called occupational hygienists or industrial hygienists have grown to a great extent. This has enhanced the level of nationwide occupa-
tional hygiene and has become an important social function. This is an example of the successful social propagation effect where the personal exposure monitoring has been adopted. Details on this are provided in the appendix (please refer to Appendix 31).

Thus, it is expected that an appropriate application of personal exposure monitoring would enhance the level of nationwide control of chemical substances. This can have a propagation effect over controlling all hazardous factors, including not only chemical substances but also physical, biological, and human engineering aspects. Since many physical factors (noise, radiation, etc.) have their own exposure reference values, the method of personal exposure monitoring may be applicable as a fundamental concept. Although such a method is not directly applicable to the other hazardous factors, the personal exposure monitoring presented in this Guideline shall be a “basic method used by the experts for the reasonable risk assessment and risk management,” and this concept itself may be applicable. In other words, promotion of the personal exposure monitoring presented in this Guideline would eventually bring the enhancement of the entire occupational hygiene control in Japan.

As mentioned above, the personal exposure monitoring (the entire process presented in this Guideline) is not just a monitoring technique. It may be regarded as a “problem-solving method” with a potential to build the subject of occupational hygiene nationwide, leading to a “paradigm shift (i.e., a complete change in the framework of thinking)” of occupational hygiene.

3. Conclusion

As repeatedly described in this Guideline, personal exposure monitoring is the most basic and accepted method, toward the risk assessment and management of chemical substances. In Japan, the implementation of personal exposure monitoring has been very much limited. It must be better highlighted for the proper implementation and further adoption in the future.

In this Guideline, personal exposure monitoring is not regarded as a mere measurement in the narrow sense of the word. It is to be recognized comprehensively as a process of the risk assessment and risk management. And on that basis, the procedure and judgment criteria for each factor are shown as a guideline. Moreover, a responsible professional is assigned as a risk assessment supervisor, and the freedom of his/her flexible determination is adequately secured to promote the precision and simplicity depending on the risk. Promulgation of personal exposure monitoring such a procedure would lead to not only the effective control of each workplace but also to overall improvement, on a nationwide level, of occupational hygiene.

It is conceivable that personal exposure monitoring will be officially incorporated into the legal system in future. It would be our great pleasure if, in the process of system design in the administrative organizations, the contents of this Guideline, the reasonable procedures with respect to expert flexible determination, were used as references.

At the present moment, this Guideline has been summarized and published only once. But this “first edition” will be subjected to future revisions as needed. Japan does not have adequate accumulation of insights into personal exposure monitoring. It is expected that this Guideline shall be developed into a more complete form based on the actual outcomes and experience. In this sense, the offering of valuable opinions, particularly those based on experience, will be highly appreciated.

Those involved in national occupational hygiene are kindly requested to thoroughly understand the contents of this “GUIDELINES FOR PERSONAL EXPOSURE MONITORING (Expert Division of Occupational Hygiene & Ergonomics)” as a base for the procedure for personal exposure monitoring and to positively make the best use of it. We hope that personal exposure monitoring will become widely propagated and utilized in Japan.

Conflicts of interest: None declared

Supplementary material: This article contains supplementary material (Appendix), which is available in the online version (doi: 10.1539/joh.2018-0121-RA).

References

