INDUSTRIAL HYGIENE

5 Steps to Successful Exposure Assessments

BY JEROME E. SPEAR, CSP, CIH

The better our understanding of exposures and the risks they pose, the more assurance we have that we are controlling the most important (highest risk) exposures first. Control efforts (such as engineering, work practice, or personal protective equipment) are often costly to implement and maintain. Therefore, it is critical that those efforts be appropriately prioritized, deployed, and managed. Implementing a systematic exposure assessment and control process, allows prioritization of exposure monitoring and control efforts to use limited funds wisely. The strategy is cyclic in nature and is used most effectively in an iterative manner that strives for continuous improvement (Ignacio and Bullock, 2006). The basic steps include the following:

1. Gather information and data to characterize the project site (or facility), process, operations, work force, and environmental agents.
2. Define similar exposure groups (SEGs) by process, task, environmental agents, and engineering controls.
3. Make your best "judgment" on the exposure profile for each SEG based on available information.
4. Determine the acceptability of exposure and/or need for additional exposure monitoring.
5. Collect additional data and re-assess the exposure profiles as needed.

1) GATHER AVAILABLE INFORMATION AND DATA

The first step in assessing exposures to environmental agents is to have a thorough understanding the processes, tasks, and contaminants to be studied. Information may be obtained through observations and possibly the use of direct-reading devices. Interviews with workers, managers, maintenance personnel and other relevant personnel (such as technical experts) provide an additional source of information and knowledge. In addition, a review of records and documents (including past exposure monitoring data), relevant industry standards, and/or other literature can provide some insights on the magnitude of exposures for given processes and tasks performed at the work site. The information gathered is then used to both define similar exposure groups (SEGs) and also to make the initial judgments on exposures.

2) DEFINE SIMILAR EXPOSURE GROUPS

The goal of defining SEGs is to minimize the variability of exposure monitoring data. For highly dynamic work sites where activities and related exposures may vary significantly from day-to-day (e.g., activities performed on construction sites), SEGs should be categorized by the tasks or activities being performed. Categorizing SEGs by process, task, environmental agent, and engineering controls are often the preferred option as opposed

to defining SEGs by title and/or occupation. For example, welding has the potential of generating metal fumes and fluorides in addition to other gases. For this example, the SEGs may be defined by the specific welding technique, the type of material being welded and welding consumable, the welding task, the environmental agent, and the engineering controls. The objective in defining SEGs is to minimize the variation between air-sampling results.

3) PROFILE THE EXPOSURE

After the SEGs are defined and categorized by process, task, environmental agent, and engineering controls, a judgment can be made about the exposure profile for each SEG, using the information collected on the agent's toxicity and relevant sampling data that is available. The exposure judgment consists of assigning an exposure rating, health effects rating, and uncertainty rating to each SEG. These qualitative ratings are used to determine the acceptability of the exposure profile, identify the need of additional exposure monitoring, and prioritize the data collection needs.

An exposure rating is an estimate of exposure level relative to the applicable occupational exposure limits (OELs). Exposure ratings assist with streamlining the assessment process, particularly during initial assessments when monitoring data are often sparse.

If there is a lack of exposure monitoring data available, the initial exposure profile may merely be a "best guess" based on professional judgment and assumptions, which leads to a highly uncertain exposure rating. The exposure rating may also be based on the relative exposure levels, surrogate data (i.e., exposure data from another SEG), and/or exposure modeling but the method of judging the exposure level affects the uncertainty rating.

Uncertainty is a function of 1) confidence in the health effects data; 2) confidence in exposure rating; and 3) reliability of existing controls. For each SEG, an uncertainty rating is qualitatively assigned. A high uncertainty rating usually corresponds to uncertain judgments made when significant information on the exposure profile or health effects is missing. Assigning exposure ratings on merely subjective information and/or assumptions tends to lead to a highly uncertain exposure rating as discussed above.

The health effects rating is based on the toxicity of the environmental agent and is a factor in assessing the exposure risk and prioritizing additional exposure monitoring needs. For example, the health effects rating of carcinogenic substances (such as hexavalent chromium) would be higher than the health effects rating of a substance that primarily has irritating effects (such as ozone). A rating scheme for categorizing exposure judgments, health effects, and uncertainty level is provided in **Figure 1,** which is based on AIHA's *A Strategy for Assessing and Managing Occupational Exposures, Third Edition.*

FIGURE 1

Exposure Assessment Rating Scheme

Category	Exposure Rating
4	Greater than the applicable occupational exposure limits (OEL).
3	50% to 100% of the applicable OEL.
2	10% to 50% of the applicable OEL.
1	Less than 10% of the applicable OEL.
Category	**Health Effects Rating**
4	Life-threatening or disabling injury or illness.
3	Irreversible health effects of concern.
2	Severe, reversible health effects of concern.
1	Reversible health effects of concern.
0	Reversible effects of little concern, or no known or suspected adverse health effects.
Category	**Uncertainty Rating**
2	**Highly Uncertain:** The acceptability judgment was made in the absence of significant information on the exposure profile and/or health effects.
1	**Uncertain:** There is enough information to make a judgment, but further information gathering is warranted to verify the exposure assessment.
0	**Certain:** The environmental agent's exposure profile and health effects are well understood. The industrial hygienist has high confidence in the acceptability judgment.

Based on AIHA's A Strategy for Assessing and Managing Occupational Exposures, Third Edition (Ignacio and Bullock, 2006)

4) DETERMINE THE ACCEPTABILITY OF EXPOSURE

For each SEG, categorize the exposure profile as being acceptable, unacceptable, or unknown (i.e., not enough information). For unacceptable exposure profiles, determine and prioritize appropriate control measures by risk of exposure (i.e., exposure level and health effects). For acceptable exposure profiles, determine whether routine monitoring is required to ensure the exposure profile remains acceptable. A threshold of 10% of the OEL is recommended (by AIHA) as a trigger for beginning to collect exposure-monitoring data to support the exposure judgment in order to establish adequate confidence in the exposure assessment.

For SEGs that have uncertain exposure profiles, prioritize further exposure monitoring and/or information gathering needs by both the risk of exposure and the uncertainty rating of the exposure profile. The information gathering priority rating is calculated by the following:

Information gathering priority rating =
(Exposure Rating) x (Health Effects Rating) x (Uncertainty Rating)

For example, a particular painting task may be expected to exceed the OELs and would be assigned an exposure rating of "4" accordingly. Based on a review of the material safety data sheet and health effects of the organic vapor constituents associated with this paint, a health effects rating of "3" was assigned. Since the initial exposure judgment was made based on exposure monitoring data collected for a similar task but involving a different paint product, an uncertainty rating of "2" was assigned. As a result, the priority rating was calculated to be 24 (i.e., 4 x 3 x 2). The purpose of calculating the priority rating is to establish an information gathering priority ranking among SEGs so that you can efficiently utilize your resources.

5) COLLECT ADDITIONAL INFORMATION AND EXPOSURE MONITORING DATA

Further information gathering needs may include conducting additional exposure monitoring, gathering additional information about the health effects of the agent, and/or obtaining other information that would lower the uncertainty rating. A consideration when collecting additional exposure monitoring data is the sampling strategy. Exposure monitoring can either incorporate a worst-case sampling strategy or a random sampling strategy (Spear, 2005). A worst-case sampling strategy involves subjectively selecting and collecting personal air samplings that are considered to represent the worst-case exposure for each SEG. A random sampling approach is a more quantitative exposure monitoring strategy in which 6 to 10 random samples within the SEG are collected and statistically analyzed and used to calculate an upper confidence limit of the mean concentration for the SEG. A random sampling approach results in higher confidence level (i.e., a low uncertainty rating) for the exposure judgment than a worst-case exposure monitoring strategy since a worst-case sampling strategy relies on subjectively identifying the "worst-case" exposure. The additional exposure monitoring data also allows for the comparison of the exposure profiles of each SEG to determine if any of the SEGs should be re-classified.

OPTIMAL LEVEL OF PROTECTION

Quality control guru, W. Edwards Deming, taught us that "improvement is not a one-time effort; management is obligated to improve continually." Continuous improvement in occupational health is no exception. Assessing occupational exposures to environmental agents should be a continuous process so that engineering and other exposure control efforts can be continuously improved. The process of gathering basic information about potential exposures, defining similar exposure groups, profiling the exposures, determining the acceptability of exposure, and prioritizing and gathering additional exposure monitoring data provides a systematic method of achieving an optimal level of protection for your employees.

Jerome E. Spear, CSP, CIH
President

Safety, Health, and Environmental
spear consulting, LP
19314 Timber Ridge Drive, Suite 100
Magnolia, Texas 77355
Phone (281) 252-0005 Fax (281) 252-0092
www.jespear.com
jerome.spear@jespear.com

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