Cartridge Change Schedule

How to establish a Cartridge Change Schedule

Exposure Assessment for Respirator Selection and Chemical Cartridge Changeout Schedule

An exposure assessment is a process used to evaluate whether exposure to a chemical or physical agent (e.g., noise) is excessive. This means that an estimate of dose must be compared to some limit of exposure, commonly called an exposure limit. An exposure assessment can take on many forms, depending on the intended use of the information. An exposure assessment is vital for two reasons: proper respirator selection and for gases and vapors, establishing a cartridge change schedule when chemical cartridges are selected.

The basic steps in an exposure assessment are:

- Basic characterization: identify what is present, who may be exposed, where and when they are exposed;
- Qualitative assessment and prioritization: rank exposure groups for monitoring;
- Quantitative assessment: collect data;
- Interpretation and decision making;
- Recommendations, reporting, and documentation;
- Periodic reevaluation.

Basic Characterization

- Gather list of materials: determine identity, composition, exposure limits, health effects, and protective equipment requirements for each material;

- Write process description: identify materials present at each stage of the process, including raw materials, intermediates, and finished products;

- Determine likely exposure groups based on commonality of exposures (referred to as Homogeneous Exposure Groups or HEG);

- Write a job description for each exposure group: include the materials present, a description of duties, and a brief description of the process.

Qualitative Assessment

1. Develop list of exposure groups and materials based on the process and job descriptions.

2. Assign an exposure magnitude using a simple ranking scheme, such as:

   - None or trivial (0) = work with closed systems;
   - Low (1) = infrequent exposure under controlled conditions, such as work in a lab hood, handling small amounts of material;
   - Moderate (2) = sporadic exposure with ventilation;
   - High (3) = exposure to an open process such as material loading, unloading.
   - Very High (4) = uncontrolled exposures, such as sand blasting, chipping and grinding of paint
3. Assign each material a health effects rating, such as:

- Trivial (0) = nuisance materials e.g., non toxic dust;
- Low (1) = little effect, transient irritation;
- Moderate (2) = reversible, non-serious effects (eye irritation);
- High (3) = non-reversible serious effects (corrosives, sensitizers);
- Very high (4) = Chronic effects or fast acting life threatening chemicals (e.g., carcinogens, cyanides).

4. Develop list of priorities by combining rankings.

Relative Ranking Scheme (1)

(1) From AIHA’s “A Strategy for Occupational Exposure Assessment”

Quantitative Assessment and Documentation

Currently there is no single accepted method to determine whether an exposure is acceptable. OSHA assesses compliance with a permissible exposure limit (PEL) by simply determining if a measurement is statistically greater than the PEL. Three suggested methods to determine acceptability of exposures are:

- Determination that the mean is less than the PEL (e.g., 95% confidence that the mean is less than the limit)
- Tolerance limit test (e.g., 95% of data is below PEL)
- Risk of overexposure (AIHA’s LOGAN)

Compliance with a tolerance limit test or LOGAN will reduce the risk of OSHA finding an exposure that is over the PEL and will reduce the risk of employee impairment.
Rules of Thumb:

- If the mean is less than about one-quarter of the exposure limit, then not more that 5% of the exposures from the distribution are expected to exceed the exposure limit regardless of the level of variability. Such an exposure would generally be considered acceptable.

- If two or more samples are greater than the exposure limit (in a group of twenty samples), then exposures are likely to exceed the exposure limit more than 5% of the time and are generally considered unacceptable.

Air Sampling

Sampling Methods

The method used to collect samples will vary with the chemical and the duration of the sample. Information on sampling methods can be obtained from an analytical chemist or the chemical supplier. Common methods are:

Colorimetric Detector Tubes

These are easy to use, direct reading indicator tubes. The tubes are designed for specific gases or vapors; each tube is filled with a different chemical. A sample of air containing a gaseous air contaminant is drawn through the tube with a hand pump. The air contaminant reacts with the chemical in the tube to produce a color change. The length of the color stain indicates the concentration of the contaminant in the air.

Advantages of detector tubes include instantaneous reading, ease of use and relatively low cost. The short sampling time, low accuracy and interfering gases and vapors are among the disadvantages of detector tubes.

Detector tubes are primarily used to obtain a quick assessment of relative exposure levels. Some tubes are made to be used with low flow air pumps to provide long duration exposure measurements.

Passive and Active Adsorption Samplers

Passive and active adsorption samplers are longer term devices which trap gaseous air contaminants for laboratory analysis. Commonly, tubes and passive samplers (badges) are filled with activated charcoal and analyzed by gas chromatography. Other adsorbents, such as silica gel, are used for some materials.

Advantages of these samplers include the relatively low cost of the tubes and the capability to determine a wide variety of materials in the air, often simultaneously. Disadvantages include analytical expense and, for active samplers, the need for an air sampling pump.

Filters

Filters are used to collect particulate materials in the air. A sampling pump is used to draw air through a filter, which collects the material to be analyzed. Analysis may involve weighing the filter before and after sampling to determine the mass of material collected, or laboratory analysis by one of a number of analytical methods.

The advantage of sampling with filters is the capability to determine the concentration of a wide variety of particulate materials in the air. Disadvantages of filter sampling include analytical costs and the need for an air sampling pump.

Other Methods

Other sampling methods may be used for specific air contaminants. These include direct reading instruments and absorption methods.
Costs

The primary factor in how much an assessment will cost is the number of samples needed to estimate the exposure. The AIHA Exposure Assessment Strategies Committee recommends at least six random samples to characterize the exposure for each HEG.

Typically analytical costs are in the range of $35 - 45 per contaminant, but can be more expensive if a non-routine analytical procedure is required. Chemical suppliers have sampling experience with their materials and can usually provide advice on how to obtain analytical services.

Sample analysis

Before collecting samples, contact a laboratory to determine appropriate sampling methods, sample storage conditions, and shipping instructions. Some samples may require special storage and shipping conditions, such as cold temperatures or darkness.

Laboratories may also provide collection media and shipping containers.

Recommendations, Reporting and Record Keeping

An important step in an exposure assessment is the preparation of a report describing the findings of the assessment, even if no serious problems are found. The report should include enough detail to allow others to recreate the exposure conditions. Information required in the report includes the purpose for collecting the sample(s); a summary of materials; monitoring and analytical methods, including quality assurance (i.e., blanks, spiked samples); a summary of job and process descriptions, employees monitored, a tabulation of results, conclusions and recommendations; references used; and the exposure limit upon which decisions were made.

Reevaluation

The final stage of an exposure assessment is a periodic reevaluation. This may be as simple as reevaluation of the data collected for the basic characterization, with a conclusion that nothing has changed, to the collection of samples and statistical evaluation of the data. A reevaluation should be done whenever significant changes in a process are made, when employees express concerns, or health effects are noticed in the employee population. Some regulations, such as OSHA's substance - specific health standards (e.g., lead, cadmium, and asbestos), require reevaluation of employee exposures at specific frequencies.

Cartridge Selection

After assessing your contaminant exposure levels, the next step is to select an appropriate respirator. This must be done before a chemical cartridge can be selected because in many cases the most appropriate respirator will not be a chemical cartridge air-purifying respirator. For example, if there are no effective chemical cartridges for your contaminants, an atmosphere-supplying respirator will have to be selected. Other workplace factors like the workplace temperature or work rate may indicate that atmosphere-supplying respirators may be more appropriate even when there are effective chemical cartridges. In either case, cartridge change schedules do not need to be implemented because chemical cartridges are not being used.

To select an appropriate respirator you must know the names and forms of the contaminants and their airborne concentrations. You also need to identify relevant workplace and respirator user factors (e.g., presence of facial hair) and base respirator selection on these factors. This information can be used in conjunction with our free on-line 3M Select Software to identify an appropriate respirator. If a chemical cartridge respirator is selected from those that are appropriate, a change schedule must be established. To do this you must obtain an estimate of the cartridge service life for your workplace situation. If more than one type of chemical cartridge can be used, you might want to obtain service life estimates for each to help determine which may be the more cost-effective chemical cartridge to use. If the cartridge service life estimate is too short for your workplace, meaning you would have to replace the chemical cartridges very frequently, you may want to consider selection of an atmosphere-supplying respirator.
Factors to Consider When Establishing a Chemical Cartridge Change Schedule

The estimated service life is one piece of information to consider in establishing a change schedule. An appropriate change schedule can only be established after consideration of service life for the selected breakthrough point (e.g., TLV, 0.5 TLV) and additional safety factors to account for:

The estimated Service Life for the selected breakthrough point
The quality of the service life estimate needs to be considered when establishing a change schedule. The closer the conditions for determining the service life are to the workplace, the smaller the safety factors will need to be. Thus actual cartridge testing performed in the workplace under the conditions of use provides an estimate of service life most applicable for establishing the change schedule.

Variation in workplace concentrations
The contaminant concentration in the workplace can vary greatly. Consideration must be given to the quality of the estimate of the workplace concentration for use in service life calculation. Underestimating the workplace concentration will result in a longer estimated service life.

Accuracy of workplace concentration measurements
You must consider the accuracy of your workplace concentration measurements. Underestimating the workplace concentration will result in a longer estimated service life.

The presence of mixtures
The presence of more than one vapor can have dramatic and unpredictable effects on cartridge service life. Cartridge breakthrough may occur earlier in the presence of mixtures than would have been predicted from data for a single compound. The breakthrough times for weakly adsorbed compounds are decreased significantly by exposures to mixtures. Service life estimates for individual components of a mixture may be helpful in establishing a change schedule or determining if a chemical cartridge is appropriate. If a component of a mixture has a very short service life estimate, an airline respirator for the mixture should be considered. Another alternative for mixtures of organic vapors is to use the method suggested by OSHA in CPL 2.0-120 “Inspection Procedures for the Respiratory Protection Standard,” 9/18/98 pp. 13-14. The appropriateness of this method is not known.

Relative Humidity (Organic Compounds)
Relative humidity (RH) greater than 50% (especially greater than 65%) can have a dramatic effect on service life of organic vapor chemical cartridges. The effect of relative humidity on service life of organic vapor cartridges will depend on the relative humidity level, the chemical concentration, volatility of the chemical and the chemical's miscibility (ability to dissolve) in water.

Relative Humidity (Inorganic Compounds)
For inorganic compounds, service life decreases as relative humidity decreases. The change schedule should be adjusted to account for the effect.

The potential for contaminant migration through the carbon bed
Organic vapors adsorbed on an organic vapor cartridge can migrate through the carbon bed without airflow. Desorption of the contaminant can occur after a short period (hours) without use (e.g., overnight). Partial use of the chemical cartridge and subsequent reuse could potentially expose the user to the contaminant. This is most significant for the most volatile and poorly retained organic vapors (e.g., boiling point < 65° C). For organic vapors with a boiling point less than 65° C, it is recommended that the organic vapor cartridge never be used longer than one shift even if the estimated service life is greater than 8 hours and the cartridge is used for only a short time during the shift. For more information on bed migration see 3M Technical Data Bulletin #142 “Reuse of Organic Vapor Chemical Cartridges.”

Warning Properties
The quality of the warning properties should be considered when establishing the chemical cartridge change schedule. Change schedules for organic vapors with poor warning properties may require a greater safety factor than an organic vapor with good warning properties. Good warning properties may provide a secondary or back-up indication for cartridge change out.
Documenting a Change Schedule

If a cartridge or canister air-purifying respirator is being used for protection against gases and/or vapors and does not have an ESLI (End-of-Service-Life Indicator), then you must implement a cartridge/canister change schedule.

The change schedule must be based on objective information that will ensure that the cartridges or canisters are changed before the end of their service life.

The purpose of a change schedule is to establish the time period for replacing respirator cartridges and canisters. The data and information relied upon to establish the schedule must be included in the respiratory protection program.

Change schedules have been addressed in the requirements for several of OSHA’s substance specific standards and do not have to be developed by you. Change schedules for all other gases and vapors must be established and implemented by you.

You are not required to research and analyze experimental breakthrough data, but may obtain information from sources that have expertise and knowledge that can help you to develop reasonable change schedules. One example is 3M Service Life Software. It is available on this 3M website under Software in either a web-based version or a downloadable version. To help you describe and document the information and the basis for reliance on the data in your respiratory protection program, we have also developed a Change Schedule Form.