Comparative Analysis on Full-Shift vs Process Based Sampling

Introduction

Occupational Safety and Health (OSH) professionals have been conducting air sampling for decades to quantify the degree of exposure to workers in the workplace. OSH professionals use objective sampling data to evaluate workplace hazards, quantify worker exposures, which allows them to make informed decisions to determine adequate controls (i.e., engineering, personal protective equipment or administrative).

This comparative analysis will discuss sampling methods, sampling strategies, risks for enforcement action, and further discuss full-shift versus process based sampling, so OSH professionals can determine which sampling protocol/method is best for their situation and end goal.
Sampling Methods

The Occupational Safety and Health Act of 1970 charged the National Institute for Occupational Safety and Health (NIOSH) with the responsibility to develop and evaluate sampling and analytical methods for workplace compliance determinations. In May 1995, NIOSH published the “Guidelines for Air Sampling and Analytical Method Development and Evaluation”. According to NIOSH, the purpose of this guideline document was to “refine the original protocol for sampling and analytical method development and evaluation research with additional experiments to more fully evaluate method performance”. This is a great guidance document to reference for additional details and information on air sampling and analytical methods (link to document).

Air sampling is defined as the collection and analysis of samples of air to measure the amounts of various pollutants or other substances in the air. Occupational health samples are generally collected in conjunction with a health risk assessment (HRA) of hazards generated in the industrial workplace. OSH professionals can collect air samples in the immediate or general area where the potential air contaminant is present to quantify levels or assess the migration of contaminants from adjacent industrial processes. For worker exposure evaluations, the preferred method is to collect breathing zone personal samples using a pump attached to an employee. In the next section, we will further discuss the sampling strategy.

Sampling Strategy

An important part of an industrial hygiene sampling plan is to have a well-thought out sampling strategy, so you can successfully capture a sampling event. The sampling plan should answer the following questions:

1. What is the sampling objective?
2. Where are you sampling?
3. What are you sampling?
4. What type of sample will you collect?
5. Who are you sampling?
6. What is the sample duration?

Defining the sampling objective will help you with the desired outcome. Prior to air sampling, you must define the purpose of the sampling, whether it is for health risk assessment, compliance determinations, etc. The sampling plan must identify the expected exposure site(s) (e.g., in a building, aircraft hangar, particular room) and consider adjacent work areas that may be affected by the process. You can define the potential hazards by discussing the process with the workers; review safety data sheets, then research and evaluate the toxicity, determine exposure pathways, hazard quantity, task duration, task frequency, and physical state of the contaminant (i.e., gas, vapor or aerosol). Next, determine who to sample - the maximum risk worker or random sampling of a similar exposure group. Next, determine what type of sample to collect - single grab sample using a direct reading instrument, air sample using low or high flow sampling pumps, personal samples or area monitoring. As previously mentioned, personal samples are the preferred method of evaluating worker exposure to airborne chemicals. The sampling pump and collection device are directly attached to the employee and worn continuously during all work and rest operations. Area monitoring uses a sampler placed in a fixed location in the work area (also referred to as “general air”). Sample durations may vary from a few seconds to 8 hours or more. The time period for sample collection depends on a variety of factors including the sampling and analytical method, the expected concentration of the contaminant being measured, the type of exposure limit to which the sample will be compared to, the number of consecutive samples to be collected on a single employee during a single work shift, and whether the work shift is longer than 8 hours. We recommend that OSH professionals coordinate with their analytical laboratory to verify correct sampling methods, sample media, and to ensure they are capable of analyzing the air sample. Below is an example exposure assessment strategy flowchart utilized by the United States Air Force industrial hygiene community. There are slight terminology differences but the concept is the same for non-military organizations. Note: OEEEL is the occupational and environmental exposure limit (equivalent to OSHA’s permissible exposure limit (PEL).
The NIOSH Occupational Exposure Sampling Strategy Manual states “proper evaluation of employee exposures necessitate taking valid quantitative exposure measurements, interpreting these measurements in the light of experience, and exercising professional judgment”. Keep in mind that sampling strategies and statistical analysis are tools to assist OSH professionals responsible for protecting the health of workers in the design and implementation of occupational exposure monitoring programs. NIOSH also cautions OSH professionals to avoid the trap of falling into a numbers game and keep in proper perspective what the data
represent in relation to what the worker is exposed to. The decision procedures regarding compliance and noncompliance based on exposure measurements will differ depending on how the samples were obtained in relation to the period of the standard, duration of the samples, and number of samples. Compliance exposure (classification) meaning that there is a 95% confidence (based on measurements) that a worker’s exposure is below the standard (using statistical criterion lower confidence level (at 95%) > standard). Non-compliance exposure (classification) meaning that there is 95% confidence (based on measurements) that a worker’s exposure is above the standard (using statistical criterion upper confidence level (at 95%) ≤ standard). The method of data analysis should assist in making better decisions regarding the relation of employee exposure measurement results to standards of safe exposure. The decision criteria should be based on assumptions of normal and lognormal distribution models for sampling/analysis errors and for environmental fluctuations, respectively. In the next section, we will explore full-shift sampling and process based sampling.

Full-Shift Sampling Versus Process Based Sampling

For compliance sampling, the Occupational Safety and Health Administration (OSHA) require that an employee’s exposure be measured by any combination of long-term or short-term samples that represent the employee’s actual exposures. The three basic types of sample collection techniques include personal samples, breathing zone, and area monitoring. While they are all acceptable, personal samples provide the best information in determining an employee’s actual exposure. Full-shift samples should be taken to evaluate Time-Weighted Average (TWA) exposures whenever possible and must be used when determining compliance with OSHA Permissible Exposure Limits (PELs). Full-shift sampling is defined as a minimum of the total time of the shift less 1 hour (i.e., 7 hours of an 8-hour shift or 9 hours of a 10-hour work shift). OSHA has given citations to employers who did not conduct full-shift sampling; OSHA’s argument is that the exposure for the period not sampled cannot be assumed to be zero. Many OSHA expanded standard chemical regulations specifically require characterizing full-shift exposure. For example, 29 CFR 1910.1026, Hexavalent Chromium, states:
1910.1026(d)(1) “Each employer who has a workplace or work operation covered by this section shall determine the 8-hour TWA exposure for each employee exposed to chromium (VI). This determination shall be made in accordance with either paragraph (d)(2) or paragraph (d)(3) of this section”.

1910.1026(d)(2)(i) “The employer shall perform initial monitoring to determine the 8-hour TWA exposure for each employee on the basis of a sufficient number of personal breathing zone air samples to accurately characterize full shift exposure on each shift, for each job classification, in each work area. Where an employer does representative sampling instead of sampling all employees in order to meet this requirement, the employer shall sample the employee(s) expected to have the highest chromium (VI) exposures”.

1910.1026(d)(3) “Performance-oriented option. The employer shall determine the 8-hour TWA exposure for each employee on the basis of any combination of air monitoring data, historical monitoring data, or objective data sufficient to accurately characterize employee exposure to chromium (VI)”. If the performance-oriented option is used, we recommend reviewing the “Letter of Interpretation” for (d)(3). Key points are listed below:

- Where objective data are used to satisfy the exposure determination requirement, the employer must establish and maintain an accurate record of all the information it relied on. This record must include: the specific chromium-containing material in question; the source of the objective data; the testing protocol and results of testing or analysis of the material that releases chromium (VI); a description of the process, operation, or activity involved and how the data support the determination; and any other data relevant to the process, operation, activity, material, or employee exposures (71 FR 10370).

- Since objective data may be used to exempt the employer from provisions of the standard or provide a basis for selection of respirators, it is critical that this determination be carefully documented. Reliance on objective data is intended to provide the same degree of assurance that employee exposures have been correctly characterized as air monitoring would have. Records must demonstrate a reasonable basis for the underlying exposure determination (71 FR 10370).
• OSHA's term "closely resemble" that appears in this standard's definition for both "objective data" and "historical monitoring data" (note that historical data may be used as objective data) in the standard's paragraph (b) has been defined in other standards as circumstances where the major workplace conditions which have contributed to the levels of historic exposure are no more protective than in the current workplace. OSHA's intent is to allow data reflecting past exposures to be used to predict current exposures only when the conditions of the earlier job were not more protective, i.e., employees were not better trained, work practices were not used more consistently, and no more supervision was present (reference 59 FR 40977, 29 CFR Parts 1910, et al., Occupational Exposure to Asbestos; Final Rule, August 10, 1994).

• The burden is ultimately on the employer to show that the objective data comply with the requirements of the standard. OSHA's intent is to allow employers the greatest possible flexibility in selecting methods used to determine employee exposures to chromium (VI), so long as the methods used are accurate in characterizing employee exposures (71 FR 10342).

Air sampling during the duration of the process or processes (i.e., prepping, stripping, painting, etc.) describes process based sampling, which the sampling period may be 2-4 hours. Process based sampling does not account for the entire work shift but it does capture the exposures during the process being evaluated. As mentioned above, many OSHA expanded standard chemical regulations call for full-shift air sampling (examples listed below, list is not all inclusive):

- Chromium (VI) 29 CFR 1910.1026(d)(2)(i)
- Cadmium 29 CFR 1910.1027(d)(1)(iii)
- Benzene 29 CFR 1910.1028(e)(1)(ii)
- Formaldehyde 29 CFR 1910.1048(d)(1)(iii)

Even though regulations specifically mention full-shift air sampling, many OSH professionals will argue the fact that they have enough “objective air sampling data” to thoroughly characterize worker exposures. OSHA rules and regulations are
difficult to understand and many OSH professionals will have to read standard
interpretations (i.e., Letters of Interpretation) and clarification documents to fully
understand the intent of the law.

There is various exposure assessment strategies used in the OSH community. The
Air Force uses an Air Force exposure assessment model, which recommends three
air samples, and then three additional samples (for a total of six) for processes that
warrant an air sampling characterization. This exposure strategy is not used for
processes that are either so short in duration or present so little risk as to not
warranting air sampling when evaluated in relation to other risk-prioritized exposure
assessment needs.

Many OSH professionals follow guidance from the
American Industrial Hygiene Association (AIHA)
Exposure Assessment Strategies Committee and
use tools such as “IH Mod”, which is an Excel
spreadsheet with 12 algorithms/models developed from the book “Mathematical
Models for Estimating Occupational Exposure to Chemicals”. There are many other
tools available for the practicing industrial hygienist such as IHSTAT, IH SkinPerm,
IH Data Interpretation Game (DIG) app, etc., and are available for download from the
AIHA website at no cost (hyperlinked above).

The decision to perform full-shift versus process based sampling may come down to
your risk for OSHA enforcement action vulnerability, which will be discussed in the
next section.

Risk for Enforcement Action Vulnerability

OSHA’s core mission is to ensure safe and healthy
workplace conditions for every working man and
woman in the Nation by setting and enforcing
standards and providing training, outreach,
education and compliance assistance. In the late
1990’s, OSHA pushed out a new initiative to
combine targeted enforcement with partnerships and compliance assistance. From
this initiative, OSHA has developed a broad range of successful partnership programs such as the Safety and Health Achievement Recognition Program and Voluntary Protection Program, and OSHA is continuing to do more to promote cooperative partnership efforts between employers, workers and government. OSHA is committed to protecting workers from toxic chemicals and deadly safety hazards at work, ensuring that vulnerable workers in high-risk jobs have access to critical information and education about job hazards, and providing employers with vigorous compliance assistance to promote best practices that can save lives.

The OSH Act covers most private sector employers and their workers, in addition to some public sector employers and workers in the 50 states and certain territories and jurisdictions under federal authority such as the District of Columbia, Puerto Rico, the Virgin Islands, American Samoa, Guam, Northern Mariana Islands, Wake Island, Johnston Island, and the Outer Continental Shelf Lands as defined in the Outer Continental Shelf Lands Act either directly through Federal OSHA or through an OSHA approved state plan.

OSHA enforcement activities play an important part in OSHA’s efforts to reduce workplace injuries, illnesses, and fatalities. Inspections are initiated without advance notice, conducted using on-site or telephone or facsimile investigations, performed by highly trained compliance officers and scheduled based on the following priorities:

- Imminent danger
- Catastrophes – fatalities or hospitalizations
- Worker complaints and referrals
- Targeted inspections – particular hazards, high injury rates and
- Follow-up inspections

Current workers or their representatives may file a written complaint and ask OSHA to inspect their workplace if they believe there is a serious hazard or that their employer is not following OSHA standards. Workers and their representatives have the right to ask for an inspection without OSHA telling their employer who filed the complaint. It is a violation of the OSH Act for an employer to fire, demote, transfer or in any way discriminate against a worker for filing a complaint or using other OSHA rights thanks to the Whistleblower Program. OSHA carries out its enforcement activities through its 10 regional offices and 90 area offices. Unless your company or
employer falls into one of OSHA’s priorities listed above, it is not likely your company or employer will be inspected by OSHA.

**Conclusion**

In closing, OSH professionals work in this industry to promote a safe and healthy work environment, and the decision to conduct full-shift versus process based sampling may be an on-going debate for decades to come. OSHA rules and regulations are difficult to read and require clarification through letters of interpretations to explain the intent of the standard can be frustrating and difficult to accept. OSH professionals will continue to conduct process based sampling and will continue to argue the fact that they have enough objective air sampling data to thoroughly characterize worker exposures. The decision to go with one sampling strategy over another may come down to the risk for enforcement action vulnerability. The decision to conduct full-shift sampling to ensure compliance with OSHA’s Regulations without any added benefit may leave the employer vulnerable for future OSHA enforcement action, but it may be a risk the employer is willing to accept. Always remember that the “burden is ultimately on the employer to show that the objective data comply with the requirements of the standard”.
ASG Team Leader Biographies

**Alliance Solutions Group, Inc. (ASG)** is a global leader in delivering health and safety solutions through consultation, training and analysis. Over the last decade, ASG has conducted 171 audits, 59 compliance assessments, has customized OSH training, and has assisted hundreds of clients worldwide. Our unprecedented experience in occupational safety and health sets us apart from training companies, vendors and large businesses. To learn more, visit us on the web at [www.asg-inc.org](http://www.asg-inc.org) or call +1.757.223.7233.

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**Mr. Robert Campbell, PE** leads ASG with 20 years of environmental, health, safety and emergency management experience. He was responsible for orchestrating an enterprise-wide implementation of an occupational health management system assessment and audit program for 90 sites worldwide. He has also managed the planning, design and implementation of a large-scale preparedness program consisting of emergency response plans, equipment, training and exercises for the U.S. military world-wide – this included 82 hospitals comprised of 20 response teams each, 150 CBRN/Hazmat response teams, 50 mobile laboratories and 52 decontamination teams. Over the last 10 years, he has grown ASG to serve over 100 clients to include a large government enterprise with 170 sites worldwide. In 2014, he published a summary of lessons learned and best practices from 1,800 global exercises and real-world response incidents in the Handbook of Emergency Response: A Human Factors and Systems Engineering Approach. This unprecedented scope and scale of experience has enabled ASG to gain the trust and confidence of the most elite clients in order to build large-scale environmental, health, safety and emergency preparedness capabilities.

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