40-Hr HAZWOPER Module 7

Air Monitoring

Section 7.1 Air Monitoring Overview

The presence of hazardous materials at a site, as well as actions taken to address these materials, can result in the release of hazardous substances into the air. This can occur through chemical fires, transportation accidents, open or leaking containers, wind-blown dust, and site clean-up activities. These emissions pose a rapid threat to the health and safety of response personnel and the public.

7.1.1 Types of Hazardous Atmospheres

Hazardous atmospheres can manifest in different ways, including:

- Explosive atmospheres, which are characterized by the presence of ignitable or explosive vapors, gases, aerosols, and dust
- Toxic atmospheres, which are characterized by the presence of harmful vapors, gases, particulates, and aerosols
- Oxygen-deficient atmospheres, which result from the displacement of breathable air
- Radioactive atmospheres, which are characterized by the presence of radioactive gases and aerosols

The presence of such hazards may dictate necessary operations to mitigate the likelihood of incidents and ensure the safety of response personnel.

7.1.2 Objectives and Importance of Air Monitoring

While predictions can be made about airborne hazards based on the substance involved and weather conditions, air monitoring is essential to confirm these predictions, identify or measure contaminants, and detect unknown pollutants. Specific requirements for air monitoring are outlined in 29 CFR 1910.120(h), and effective practices to meet these requirements are further discussed in this module.

Objectives of air monitoring include:

- Identifying and quantifying airborne contaminants both on-site and off-site
- Tracking changes in air contaminants throughout the incident
- Ensuring the selection of appropriate work practices and engineering controls
- Determining the level of worker protection required
- Assisting in the definition of work zones
- Identifying additional medical monitoring needs in different areas of the site

7.1.3 Initial Entry and Continuous Monitoring

During initial entry, air monitoring must be conducted wherever there is a possibility of employee exposure to hazardous substances. Representative air monitoring is performed to identify exposures exceeding Permissible Exposure Limits (PELs), IDLH concentrations, potential sources of skin and eye irritation, explosion sensitivity and flammability ranges, and oxygen deficiency. Additionally, air monitoring is necessary to confirm the cleanliness of the designated

Support Zone. If there are any concerns of contaminant migration, then air and/or surface soil samples should be collected and compared with on-site and off-site background samples. The results of the initial air monitoring survey, visual characterization of site hazards, properties of on-site contaminants, and potential pathways of dispersion should be evaluated to determine if further monitoring is needed to designate work zones. This evaluation may include the use of direct-reading instruments, visible indicators, other sources of information, and limited air sampling if time permits.

In cases where elevated levels of hazardous substances are detected, continuous monitoring should be undertaken, along with the implementation of additional site control measures, to safeguard employee health and safety. Continuous monitoring is essential to accurately characterize their exposure levels. If these exposures surpass the permissible or published limits, monitoring should be extended to all potentially affected employees. Representative sampling, based on initial results, can also be employed to assess the average exposure levels in specific areas or around waste piles.

7.1.4 Selecting the Air Monitoring Method

When selecting equipment for air monitoring, several factors need to be considered. These factors include:

- **Hazards**: The equipment must be suitable for monitoring the specific hazard or chemical in question.
- **Selectivity**: Selectivity refers to an instrument's ability to detect and measure a specific chemical. Interferences from other chemicals can affect the accuracy of the instrument reading. In some cases, an instrument that responds to multiple chemicals may be desired.
- **Sensitivity**: Sensitivity is crucial when even slight changes in concentration can be hazardous. It indicates an instrument's ability to accurately measure small concentration changes.
- **Accuracy**: Accuracy measures how close instrument readings are to the true values. It is typically expressed as a percentage bias. NIOSH recommends that portable direct-reading instruments should be within 25% of the true value 95% of the time.
- **Precision**: Precision indicates the grouping of data points and measures the variability of measurements compared to their average value. It is expressed by the standard deviation and is typically presented with a ± qualifier.
- **Calibration**: Proper calibration is essential for instruments to function accurately in the field. Calibration involves adjusting the instrument readout to correspond with an actual concentration. Instruments should be calibrated with known concentrations of gas or vapor to ensure proper response. Manufacturers provide calibration information, and adjustments may be necessary if readings are inaccurate.

- **Relative Response**: Instruments may detect multiple chemicals, but their responses may vary for equal concentrations of different substances. The relationship between an instrument's response and the actual concentration is referred to as relative response. Relative responses can vary with the chemical and instrument used.
- **Operating Range**: The operating range of an instrument includes the lower detection limit and saturation concentration. The lower detection limit is the lowest concentration to which the instrument will respond accurately. It's important to use an instrument with an operating range that covers the concentrations of interest.
- **Response Time**: Response time is the duration between initial sample contact and the display of the full chemical concentration. Rapid response time is desirable for Direct-Reading Instruments. For methods involving sample collection and laboratory analysis, the response time is referred to as the turnaround time.
- **Mobility**: Air monitoring equipment can be categorized as portable, fieldable, or mobile based on their size, power requirements, and ease of transportation. Considerations such as size, durability, and power supply determine the mobility of an instrument.
- **Ease of Operation**: Instruments should be easy to operate, considering factors like wearing protective equipment, such as gloves or respirators. User-friendliness and the learning curve for operating the instrument correctly should also be taken into account.

7.1.5 Air Monitoring Methods

Identifying and quantifying airborne contaminants can be achieved through two primary methods:

1. *On-Site Use of Direct-Reading Instruments:* provides real-time data and rapid response.
2. *Laboratory Analysis of Air Samples:* provides compound or class-specific results but requires additional time for analysis and may necessitate specialized equipment.

Direct-Reading Instruments Method

Direct-Reading Instruments (DRIs) can provide approximate total concentrations of many organic and some inorganic substances. When specific contaminants have been identified, calibrated DRIs can be used for more accurate on-site assessment. DRIs can be used in survey mode or as gas chromatographs, providing cost-effective on-site evaluation of airborne organic hazards. Examples of DRIs include combustible gas detectors, oxygen meters, particulate monitors, photoionization detectors, flame ionization detectors, infrared analyzers, indicator tubes, toxic atmosphere monitors, radiation meters, and mercury vapor analyzers.

Air Sampling Method

To obtain more comprehensive information about air contaminants, air sampling devices with appropriate collection media (discussed in the next section) should supplement measurements obtained with DRIs. These samples provide detailed air quality information and indicate the presence and concentrations of contaminants over the duration of site operations. Adjustments should be made in the type and number of samples, sampling frequency, and analysis requirements as data is obtained. In addition to air samplers, sampling stations may include DRIs with recorders operating as continuous air monitors.

Sampling stations should be placed in the following locations:

- **Upwind**: Samples must be taken upwind of the site and other potential sources of contaminants to establish background levels of air contaminants.
- **Support Zone**: Samples must be taken near the command post or support facilities to ensure they are located in a clean area and remain clean throughout site operations.
- **Exclusion Zone**: The Exclusion Zone, with the highest risk of exposure, requires extensive air sampling. Sampling stations should be located based on hot spots or source areas detected by DRIs, the types of substances present, and the potential for airborne contaminants. The data from these stations, along with intermittent surveys using DRIs, verify the selection of appropriate levels of PPE and establish Exclusion Zone boundaries, as well as provide a continual record of air contaminants.
- **Fenceline/Downwind**: Sampling stations should be placed downwind from the site to determine if any air contaminants are migrating. Additional samplers should be placed downwind if there are indications of airborne hazards in populated areas.

It's important to note that while air sampling and laboratory analysis provide accurate detection and quantification, they have two disadvantages: cost and time. Analyzing a large number of samples in laboratories can be expensive, especially when quick results are needed. On-site laboratories can reduce turnaround time but may be cost-prohibitive.

7.1.6 Air Sampling Equipment and Media

Various air sampling equipment can be used to collect samples of potentially dangerous substances that may become airborne at hazardous waste sites. Sampling systems typically include a calibrated air sampling pump that draws air into selected collection media. Some common types of sampling and collection media include:

- **Sorbents for Organic Vapors**: Activated carbon is an excellent sorbent for most organic vapors. Other solid sorbents may be used for specific organic compounds or classes of compounds that do not adsorb well on activated carbon.
- **Wet Collection Methods for Inorganic Gases**: Inorganic gases at a site, primarily polar compounds like haloacid gases and ammonia, can be adsorbed onto silica gel tubes or collected using impingers filled with liquid reagents for subsequent analysis.
- **Filters for Aerosols**: Sampling aerosols, whether solid or liquid particulates, can be done by collecting them on a particulate filter such as a glass fiber or mixed cellulose ester fiber membrane. A backup impinger filled with a selected absorbing solution may also be necessary.

Section 7.2 Air Monitoring Practices and Procedures

7.2.1 The Sampling Pattern

A comprehensive air sampling pattern should be implemented to identify major classes of airborne contaminants and their concentrations. The following sampling pattern can serve as a guideline:

- **Visual identification**: Begin by visually identifying possible sources of contamination. Air samples should be collected downwind from the designated source along the axis of the wind direction.
- **Work upwind**: Proceed upwind as close as possible to the source while wearing Level B protection during the initial sampling. Subsequent sampling levels of protection should be based on the obtained results and the potential for unexpected chemical releases.
- **Cross-axis sampling**: After reaching the source or identifying the highest concentration, collect samples along the cross-axis of the wind direction to determine the degree of dispersion. Smoke plumes or instrument-detectable airborne substances can be released to assist in this assessment.
- **Background sampling**: Collect air samples upwind from the source to ensure there is no interference from background contaminants and to confirm that the detected substance(s) originate from the identified source.

7.2.2 Perimeter Monitoring and Personal Monitoring

Fixed-location monitoring at the perimeter or fence line, where PPE is no longer required, enables the measurement of contaminant migration away from the site. Wind speed and direction data are necessary to interpret the sample results as they may reflect exposures either upwind or downwind from the site.

Personal air monitoring is the selective monitoring of high-risk workers (those closest to the source of contaminant generation) and is required by 29 CFR §1910.120(h). Personal air sampling is not necessary until site operations begin. Personal monitoring samples should be collected in the breathing zone and, if workers are wearing respiratory protective equipment, outside the facepiece. Sampling should occur frequently enough to characterize employee exposures. If an employee is exposed to concentrations over PELs, monitoring must continue to ensure the safety of all employees likely to be exposed to concentrations above those limits. Multiple sampling media may be needed for personal monitoring, and alternative methods such as assigning different monitoring devices to team members or placing multiple sampling devices on heavy equipment can provide representative exposure information.

7.2.3 Periodic Monitoring and Long-Term Monitoring

Periodic monitoring should be conducted when there is a possibility of a dangerous condition or when there is reason to believe that exposures may have exceeded PELs since prior monitoring was conducted. Significant changes in site operations, handling of different contaminants, or working in areas with obvious liquid contamination should prompt consideration for periodic monitoring.

Long-term air monitoring programs should be designed to effectively detect a wide range of airborne compounds. Several factors need to be considered, including equipment type, costs, personnel, analytical accuracy, turnaround time for results, and availability of accredited laboratories.

7.2.4 Variables in Hazardous Waste Site Air Monitoring

Accurately assessing airborne contaminants in complex environments like hazardous waste sites requires considering various independent and uncontrollable variables. Important variables include:

- **Temperature:** Higher temperatures increase the vapor pressure of most chemicals.
- **Wind speed**: Increased wind speed affects vapor concentrations near free-standing liquid surfaces and particulate-bound contaminants.
- **Rainfall**: Water and rainfall can reduce airborne emissions by capping or plugging vapor emission routes.
- **Moisture**: Moisture content affects the sensitivity and accuracy of sampling results, particularly for dusts and finely divided hazardous solids.
- **Vapor emissions**: Saturated vapor displacement can lead to short-term, high vapor concentrations, while continuing evaporation and diffusion may result in long-term low vapor concentrations.
- **Work activities:** Mechanical disturbance of contaminated materials during work activities can alter airborne contaminant concentrations.

7.2.5 Using Vapor/Gas Concentrations to Determine PPE Level

Total atmospheric vapor/gas concentrations can be used as a numerical criterion for selecting the appropriate level of PPE such as Level A, B, or C. This approach is useful in situations where the presence of vapors or gases is unknown, or if the individual components are unknown. Total vapor/gas concentration can guide the selection of PPE until more definitive criteria are established based on the constituents and atmospheric concentrations. However, caution should be exercised in interpreting total vapor/gas concentration measurements due to instrument sensitivities, potential overestimation or underestimation of unknown gases or vapors, and the presence of substances not detected by the instruments. Consideration should be given to suspected carcinogens, highly hazardous substances, and other known or suspected hazards.

When using total atmospheric vapor/gas concentrations as a guide for monitoring the selected level of protection, several factors should be considered:

- Understand the limitations and characteristics of monitoring instruments.

- Recognize the presence of other hazards that may not be detected by the instruments.
- Be aware that low TLV or IDLH values may be associated with certain vapors and gases.
- Weigh the risk to personnel against the need to enter an unknown environment.
- Evaluate on-site activities to determine the appropriate level of PPE.

It's important to evaluate multiple factors, including potential exposure, the characteristics of materials present, and the limitations of monitoring instruments and PPE when selecting the correct level of protection for on-site activities.

7.2.6 Levels of Protection Based on Contaminant Concentrations

Level A Protection (500 to 1,000 ppm)

Level A protection offers the highest level of respiratory tract, skin, and eye protection, provided the limitations of the PPE are not exceeded. While Level A protects against air concentrations greater than 1,000 ppm for most substances, an operational restriction of 1,000 ppm serves as a warning flag. This restriction prompts the evaluation of environments with unknown constituents exceeding 1,000 ppm, identification of specific chemical constituents and their toxic properties, precise determination of constituent concentrations, assessment of instrument calibration and sensitivity errors, and evaluation of instrument sensitivity to environmental factors.

Level B Protection (5 to 500 ppm)

Level B protection is the minimum recommended level for initial entry into an open site where the type, concentration, and presence of airborne vapors are unknown. This level provides a high degree of respiratory protection, while also protecting the skin and eyes, with some exposed areas like the neck and sides of the head. The use of a separate hood or hooded, chemical-resistant jacket can further reduce exposure to these areas. It's important to consider several factors when selecting Level B protection, including the need to enter environments with unknown constituents exceeding 500 ppm, the severity of potential skin hazards, the nature of work and increased exposure probability, the requirement for qualitative and quantitative identification of specific components, limitations of air monitoring instruments, and instrument sensitivity to environmental factors.

Level C Protection (Background to 5 ppm)

Level C protection provides skin protection equivalent to Level B when wearing the same type of chemical protective clothing but offers lesser protection against inhalation hazards. It is recommended for concentrations ranging from background levels to 5 ppm above ambient background concentrations of vapors/gases in the atmosphere. Concentrations approaching or exceeding 5 ppm of unidentified vapors/gases would require upgrading respiratory protection to a self-contained breathing apparatus. A full-face air-purifying mask with an organic vapor canister (or combined organic vapor/particulate canister) provides protection against low concentrations of most common organic vapors/gases. However, it's important to note that full-face canister-equipped masks may not protect against substances with very low TLV or IDLH concentrations. Such substances are often gases or liquids in their normal state and may not be commonly found in standard containers or drums.

Level D Protection

Level D protection is primarily a work uniform intended for nuisance contamination situations only. It requires coveralls and safety shoes/boots. Other PPE, such as gloves, is based on the specific situation. Level D protection should not be worn in environments where respiratory or skin hazards exist.