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CONTENTS

B - Air Sampling Equipment and Media/Devices

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1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides guidance in developing and implementing sampling plans to assess the impact of hazardous chemicals on ambient or indoor air. It presents a standard approach to air sampling and monitoring and identifies equipment requirements. It is not within the scope of this SOP to provide a generic air sampling plan. Experience, objectives, site characteristics, and chemical characteristics will dictate sampling strategy.

Air monitoring or sampling involves measuring the air impact at selected locations during specific time periods. These measurements can be used to document actual air impacts during specific time intervals (i.e., during cleanup operations) or to extrapolate the potential "worst case" concentrations at that and similar locations over a longer time period than was sampled.

This SOP addresses issues associated with air monitoring or sampling, and discusses the typical monitoring instruments, air sampling kits, and approach to air sampling and monitoring.

A Quality Assurance Project Plan (QAPP) in Uniform Federal Policy (UFP) format describing the project objectives must be prepared prior to deploying for a sampling event. The sampler needs to ensure that the methods used are adequate to satisfy the data quality objectives listed in the QAPP for a particular site.

The procedures in this SOP may be varied or changed as required, dependent on site conditions, equipment limitations or other procedural limitations. In all instances, the procedures employed must be documented on a Field Change Form and attached to the QAPP. These changes must be documented in the final deliverable.

2.0 METHOD SUMMARY

Air monitoring is defined as the use of direct-reading instruments and other screening or monitoring equipment and techniques that provide instantaneous (real-time) data on the levels of airborne contaminants. There are numerous types of monitors for real-time air measurements. Examples of some widely used air monitoring equipment are hand-held photoionization detectors (PID), flame ionization detectors (FID), oxygen/combustible gas detectors, and toxic chemical sensors. These instruments are both manufactured individually and combined into multi-gas monitors.

Air sampling is defined as those sampling and analytical techniques that require either off- or on-site laboratory analysis, and therefore, do not provide immediate results. Typically, air sampling occurs after use of real-time air monitoring equipment has narrowed the number of possible contaminants and has provided some qualitative measurement of contaminant concentration. Air sampling techniques are used to more accurately detect, identify and quantify specific chemical compounds relative to the majority of air monitoring technologies.

Some typical situations where air monitoring and/or sampling provides useful data include the following: emergency responses, site assessments, and removal activities. Each of these activities has a related air monitoring/sampling objective that is used to determine the potential hazards to workers and/or the community.

- Emergency Response

  Emergency responses are immediate responses to a release or threatened release of hazardous substances presenting an imminent danger to public health, welfare, or the environment (i.e., chemical spills, fires, or chemical process failures resulting in an uncontrolled release of hazardous substances). Generally these situations require rapid on-site investigation and response. A major part of this investigation consists of assessing the air impact of these releases.

- Removal Site Assessment

  Removal site assessments (referred to as site assessments) are defined as any of several activities undertaken to determine the extent of contamination at a site and which help to formulate the appropriate response to a release or threatened release of hazardous substances. These activities may include a site inspection, multimedia sampling, and other data collection.

- Removal Actions

  Removal actions clean up or remove hazardous substances released into the environment. Removal actions include any activity conducted to abate, prevent, minimize, stabilize, or eliminate a threat to public health or welfare, or to the environment.

Personal risk from airborne contaminants can be determined by comparing the results of on-site monitoring and sampling to health-based action levels such as the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) and Acute Exposure Guideline Levels (AEGLs). Residential risk can be determined by comparing the results of off-site monitoring or sampling to health-based action levels such as those developed by the Agency for Toxic Substance and Disease Registry (ATSDR) or the EPA Risk-Based Regional Screening Levels (RSLs).

The extent to which valid inferences can be drawn from air monitoring/sampling depends on the degree to which the monitoring/sampling effort conforms to the objectives of the event. Meeting the project's objectives requires thorough planning of the monitoring/sampling activities, and implementation of the most appropriate monitoring/sampling and analytical procedures. These issues will be discussed in this SOP.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Preservation, containers, handling and storage for air samples are discussed in the specific SOPs for the technique selected. In addition, the analytical method (i.e., EPA, National Institute for Occupational Safety and Health [NIOSH], and OSHA Methods) may be consulted for storage temperature, holding times and packaging requirements. After sample collection, the sampling media (e.g., cassettes or tubes) are immediately sealed. The samples are then placed into suitable containers (e.g., whirl-paks, re-sealable bags, or culture tubes) that are placed into a shipping container.

Bubble wrap or another suitable material will be used when packing air samples for shipment. Vermiculite is not to be used due to potential asbestos content. Additional information may be found in Environmental Response Team (ERT) SOP, *Sample Packing and Shipment*.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Upwind sources can contribute to sample concentrations. Natural sources, such as biological waste, can produce hydrogen sulfide and methane that may contribute to the overall contaminant level. Extraneous anthropogenic contaminants (e.g., burning of fossil fuels; emissions from vehicular traffic, especially diesel; volatile compounds from petrochemical facilities; and effluvia from smoke stacks) may also contribute to the overall contaminant level. Air sampling stations, therefore, should be strategically placed to identify contributing sources.

Photoreactivity or reaction of the parameters with non-related compounds of concern may occur resulting in a positive or negative bias to the analytical results. Some sorbent media/samples should not be exposed to light during or after sampling due to photochemical effects (e.g., polycyclic aromatic hydrocarbons [PAHs]). Always refer to the analytical method or SOP for interferences, potential problems, and any special sample preservation requirements.

Various environmental factors, including humidity, temperature and pressure, also impact the air sampling methodology, collection efficiency and detection limit. Since the determination of air contaminants is specifically dependent on the collection parameters and efficiencies, the collection procedure is an integral part of the analytical method.

Detection limits (DLs) and reporting limits (RLs) depend on the contaminants being investigated and the particular site situation. It is important to know why the data are needed and how the data will be used. Care should be taken to ensure the DLs and/or RLs are adequate for the intended use of the final data.

Some equipment may be sensitive to humidity and temperature extremes.

5.0 EQUIPMENT/APPARATUS

5.1 Direct Reading Instruments (Air Monitoring Instruments)

There are two general types of direct reading instruments: portable screening devices and specialized analytical instruments. Generally, all these techniques involve acquiring, for a specific location or area, continuous or sequential direct air concentrations in either a real-time or semi-real-time mode. The document, "Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Waste Sites" (OIML 1991), provides additional information about air sampling and monitoring. The hazard levels for airborne contaminants vary. See the ACGIH TLVs and the OSHA PELs for safe working levels. Common screening devices are described in Appendix A.

In years past older instruments were not capable of acquiring simultaneous concentration readings at multiple locations. USEPA-ERT has developed the VIPER wireless sensor communication system utilizing commercially available hardware in conjunction with standard air monitoring instrumentation. The VIPER system allows data from multiple instruments and multiple types of instrumentation to be collected and displayed in a common platform in near real-time.

VIPER is a wireless network-based communications system designed to enable real time transmission of data from field sensors to a local computer, remote computer, or enterprise server and provide data management, analysis, and visualization enhanced by ERT custom software. Additional information is available to epa.gov employees on the EPA On-Scene Coordinator (OSC) Response website located at https://response.epa.gov/site/site_profile.aspx?site_id=5033 or by contacting ERTSupport@epa.gov.

5.2 Air Sampling Equipment and Media/Devices

The following sources of analytical methods are used for most environmental air sampling applications: *Manual of Analytical Methods* (NIOSH 2016), *American Society for Testing and Materials (ASTM) Methods*, *U.S. EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air* (U.S. EPA 1999), and *OSHA Methods* (OSHA 1990, 1991).

Additional air sampling references include *Industrial Hygiene and Toxicology, Fourth Edition* (Patty 1994) and *Air Sampling Instruments for Evaluation of Atmospheric Contaminants* (ACGIH 2001). These methods typically specify equipment requirements for sampling. Since air sampling is such a diverse technology, no single method or reference is best for all applications. Common sampling equipment and media/devices are described in Appendix B.

5.3 Tools/Material and Equipment List

In addition to equipment and materials identified in Appendices A and B, the following equipment and materials may be required to conduct air sampling and monitoring at hazardous waste sites:

- Site logbook
- Clipboard
- Chain of custody records
- Custody seals
- Air sampling worksheets
- Air monitoring worksheets
- Sample labels
- Small screwdriver set
- Aluminum foil
- Extension cords
- Glass tube cracker
- Multiple plug outlet
- Whirl-pak™ bags or culture tubes
- Teflon tape
- Calibration devices
- Tygon and/or Teflon tubing
- Surgical gloves
- Lint-free gloves
- Ice
- Sample container
- Camera
- Scribe Printer with paper

Use the following additional equipment when decontaminating glassware or air sampling equipment on site:

- Protective equipment (i.e., gloves, splash goggles, etc.)
- Paper towels
- Five-gallon buckets
- Scrub brushes and bottle brushes

6.0 REAGENTS

Impinger sampling involves using reagents contained in a glass vial to absorb contaminants of concern (for example, NIOSH Method 3500 for formaldehyde uses 1 percent [%] sodium bisulfite solution). Impinger solutions vary and are method-dependent.

Reagents such as acetone and hexane are required to decontaminate glassware and some air sampling equipment. Decontamination solutions are specified in ERT SOP, *Sampling Equipment Decontamination*.

7.0 PROCEDURES

7.1 Air Monitoring Design

7.1.1 Initial Surveys

In general, the initial survey is considered to be a relatively rapid screening process for collecting preliminary data at hazardous waste sites. However, initial surveys may require many hours to complete and may consist of more than one entry.

Some information is generally known about the site; therefore, real-time instrumentation for specific compounds (i.e., detector tubes and electrochemical sensors) can be used to identify hot spots. Sufficient data should be obtained with real-time instruments during the initial entry to screen the site for various contaminants. When warranted, intrinsically safe or explosion-proof instruments should be used. An instrument capable of a broad-spectrum measurement of volatile organic compounds (VOCs) is also typically used during this survey. These gross measurements may be used on a preliminary basis to (1) determine levels of personal protection, (2) establish site work zones, and (3) map candidate areas for more thorough qualitative and quantitative studies involving air sampling.

In some situations, the information obtained may be sufficient to preclude additional monitoring. Materials detected during the initial survey may call for a more comprehensive evaluation of hazards and analyses for specific compounds. Since site activities and weather conditions change, a continuous program to monitor the ambient atmosphere must be established.

7.1.2 Off-Site Monitoring

Typically, perimeter monitoring with the same instruments employed for on-site monitoring is utilized to determine site boundaries. Because air is a dynamic matrix, physical boundaries like property lines and fences do not necessarily delineate the site boundary or area influenced by a release. Whenever possible, atmospheric hazards in the areas adjacent to the on-site zone should be monitored with direct-reading instruments. Monitoring at the fenceline or at varying locations off site provides useful information regarding pollutant migration. Three to four locations downwind of the source (i.e., plume) at breathing-zone height can provide a basic fingerprint of the plume. Negative instrument readings off site should not be interpreted as the complete absence of airborne toxic substances; rather, they should be considered another piece of information to assist in the preliminary evaluation. The interpretation of negative readings is instrument dependent. The lack of instrument readings off site should not be interpreted as the complete absence of all airborne toxic substances; rather, it is possible that the particular compound or class of compounds to which the monitoring instrument responds is not present or that the concentration of the compound(s) is below the instrument's DL.

7.2 Air Sampling Design

7.2.1 Air Sampling Strategy

The goal of air sampling is to accurately assess the impact of a contaminant source(s) on ambient air quality. This impact is expressed in terms of overall average and/or maximum air concentrations for the time period of concern and may be affected by the transport and release of pollutants from both on- and off-site sources. The location of these sources must be taken into account as they impact the selection of sampling locations. Unlike soil and groundwater concentrations, air concentrations at points of interest can easily vary by orders of magnitude over the period of concern. This variability plays a major role in designing an air sampling strategy.

Downwind air concentration is determined by the amount of material being released from the site into the air (the emission rate) and by the degree that the contamination is diluted as it is transported. Local meteorology and topography govern downwind dilution. Contaminant emission rates can also be heavily influenced by on-site meteorology and on-site activities. All of these concerns must be incorporated into an air sampling strategy.

A sampling strategy can be simple or complex, depending on the sampling program objectives. Programs involving characterization of the pollutant contribution from a single point source tend to be simple, whereas sampling programs investigating fate and transport characteristics of components from diverse sources require a more complex sampling strategy. In addition, resource constraints may affect the complexity of the sampling design.

An optimal sampling strategy accounts for the following site parameters:

- Location of stationary as well as mobile sources
- Analytes of concern
- Analytical RL to be achieved
- Rate of release and transport of pollutants from sources
- Availability of space and utilities for operating sampling equipment
- Meteorological monitoring data
- Meteorological conditions in which sampling is to be conducted

The sampling strategy typically requires that the concentration of contaminants at the source or area of concern as well as background contributions be quantified. It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks, as well as various other types of quality assurance/quality control (QA/QC) samples, can be utilized to determine other sources. The impact of extraneous sources on sampling results can frequently be accounted for by placing samplers upwind, downwind and crosswind from the subject source. The analytical data from these different sampling locations may be compared to determine statistical differences.

7.2.2 Sampling Objectives

The objectives of the sampling must be determined prior to developing the QAPP. Does the sampling strategy verify adequate levels of protection for on-site personnel, or address potential off-site impacts associated with the site or with site activities? In addition, the assumptions associated with the sampling program must be defined. These assumptions include whether the sampling is to take place under "typical," “worst case”, or "one-time" conditions. If the conditions present at the time of sampling are different from those assumed during the development of the sampling plan, the quality of the data collected may be affected. The following definitions have been established:

- Typical: routine daily sampling or routine scheduled sampling at pre-established locations.

- Worst case: sampling conducted during meteorological and/or site conditions that have the greatest potential to result in elevated ambient concentrations.

- One-time: only one chance is given to collect a sample without regard to time or conditions. Qualitative data acquired under these conditions are usually applicable only to the time period during which the data were collected and may not provide accurate information to be used in estimating the magnitude of an air impact during other periods or over a long time interval.

The sampling objectives also dictate the DLs or RLs. Sampling methods for airborne contaminants will depend upon the nature and state (solid, liquid or gas) of the contaminant. Gases and vapors may be collected in aqueous media or adsorbents, in molecular sieves, or in suitable containers. Particulates and aerosols are collected by filters or impactors. The volume of sample to be collected is dependent upon an estimate of the contaminant concentration in the air, the sensitivity of the analytical method, and the standard or desired DL or RL. A sufficient amount of sample must be collected to achieve the desired DL without interference from other contaminants. Most importantly, the selected method must be able to detect the target compound(s).

7.2.3 Location and Number of Individual Sampling Points

Choose the number and location of sampling points according to the variability, or sensitivity, of the sampling and analytical methods being utilized, the variability of contaminant concentrations over time at the site, the level of precision required, and cost limitations. In addition, determine the number of locations and placement of samplers by considering the nature of the response, local terrain, meteorological conditions, location of the site (with respect to other conflicting background sources), size of the site, and the number, size, and relative proximity of separate on-site emission sources and upwind sources. The following are several considerations for sampler placement:

- Location of potential on-site emission sources, as identified from the review of site background information or from preliminary on-site inspections.

- Location of potential off-site emission sources upwind of the sampling location(s). Review local wind patterns to determine the location of off-site sources relative to wind direction.

- Topographic features that affect the dispersion and transport of airborne toxic constituents. Avoid natural obstructions when choosing air sampling station locations, and account for channelization around those obstructions.

- Large water bodies, which affect atmospheric stability and the dispersion of air contaminants.

- Roadways (dirt or paved), which may generate dust that could mask site contaminants.

- Vegetation, such as trees and shrubs, which stabilizes soil and retards subsurface contaminants from becoming airborne. It also affects air flow and scrubs some contaminants from the air. Sometimes thick vegetation can make an otherwise ideal air monitoring location inaccessible.

Consider the duration of sampling activities when choosing the location and number of samples to be collected. For example, if the sampling period is limited to a few hours, one or two upwind and several downwind samples may be adequate, especially around major emission sources.

A short-term monitoring program ranges from several days to a few weeks and generally includes gathering data for site assessments, removal actions, and source determination data (for further modeling). Activities involved in a short-term sampling strategy must make the most of the limited possibilities for data collection. Consider moving upwind/downwind locations daily based on National Oceanic and Atmospheric Administration (NOAA) weather forecasts. Weather monitoring becomes critical where complex terrain and local meteorological effects frequently change wind direction. A number of alternatives can often fulfill the same objective.

Prevailing winds running the length of a valley usually require a minimum number of sampler locations; however, a complex valley may require more sampler locations to account for the wide variety of winds. At sites located on hillsides, wind will move down a valley and produce an upward fetch at the same time. Sampling locations may have to surround the site to measure the wind's impact.

Off-site sources may affect on-site monitoring. In this case, on-site meteorological data, concurrent with sampling data, is essential to interpreting the acquired data, and additional upwind sampling sites may be needed to fully characterize ambient background contaminant levels. Multiple off-site sources may require several monitoring locations, but if the sources are at a sufficient distance, only one monitoring location is needed.

Topography and weather are not the only factors to consider when selecting a sampling location; the sampling sites must be secure from vandals and mishap. Secure all sampling locations to the best extent possible in order to maintain chain of custody, and to prevent tampering with samples or loss of sampling units. High-volume sampling methods often require the use of 110 volt alternating current (VAC) electric power. When portable generators are used, the power quality may affect sampler operation. In addition, be aware that the generators themselves could be a potential pollution source if their placement is not carefully considered (i.e., use of a gas generator when collecting VOC samples).

7.2.4 Time, Duration and Frequency of Sampling Events

After choosing appropriate sampling or monitoring locations, determine the sampling frequency and the number of samples to be collected. The time of day, duration and frequency of sampling events is governed by:

- The effects of site activities and meteorology on emission rates
- The diurnal effect of the meteorology on downwind dispersion

- The time period(s) of concern as defined by the objective
- The variability in the impact from other non-site-related sources
- Cost and other logistical considerations

The duration of the removal action and the number of hours per day that site work is conducted determine the time, duration, and frequency of samples. Short-term sampling programs may require daily sampling, while long-term programs may require 24-hour sampling every sixth or twelfth day. If the site will be undergoing removal activities 24 hours a day, continuous air monitoring or sampling may be warranted. However, if the site activities will be conducted for only eight hours a day and there are no emissions likely to occur during the remaining 16 hours, sampling would be appropriate prior to the start of daily activities, continuing during operations, and end at the conclusion of the daily activities. An off-peak sample collection can ensure that emissions are not persisting after the conclusion of daily cleanup activities. For some sites, emissions are still a factor several hours after daily site activities have been completed. Because of the typically decreased downwind dispersion in the evening, higher downwind concentrations than were present during daytime site activities may be detected. For sites where this is possible, the sampling duration needs to be lengthened accordingly.

Sampling duration and flow rate dictate the volume of air collected, and to a major degree, the RL. The analytical method selected will provide a reference to flow rate and volume. Flow rates are limited to the capacity of the pumps being employed and the contact time required by the collection media.

The duration or period of air sampling is commonly divided into two categories: (1) samples collected over a brief time period are referred to as "instantaneous" or "grab" samples that are usually collected in less than five minutes; and (2) average or integrated samples are collected over a significantly longer period of time. Integrated samples provide an average concentration over the entire sampling period. Integrated samples are not suited to determining cyclical releases of contaminants because periodic or cyclical events are averaged out by the proportionally long sampling duration.

7.2.5 Meteorological and Physical/Chemical Considerations

A meteorological monitoring program is an integral part of site monitoring activities. Meteorological data, which define local terrain impacts on air flow paths, are needed to interpret air concentration data. Meteorological data may be available from an existing station located near the site (i.e., at a local airport), otherwise a station should be set up at the site. These data will document the degree that samples actually were downwind and verify whether other worst-case assumptions were met. Meteorological parameters to be monitored are, at a minimum, wind speed, and wind direction. The remaining parameters primarily affect the amount of a contaminant available in the air.

- Wind Speed

  When the contaminant of concern is a particulate, wind speed is critical in determining whether the particulate will become airborne, the quantity of the particulate that becomes airborne, and the distance the particulate will travel from the source. Wind speed also contributes to the volatilization of contaminants from liquid sources.

- Wind Direction

  Wind direction significantly influences the path of airborne contaminants. In addition, variations in wind direction increase the dispersion of pollutants from a given source.

- Temperature

  Higher temperatures increase the rate of volatilization of organic and some inorganic compounds and affect the initial rise of gaseous or vapor contaminants. Therefore, worst-case emission of volatiles and semi-volatiles will likely occur at the hottest time of day, or on the hottest day of the site activities.

- Humidity

  High humidity affects water-soluble chemicals and particulates. Humid conditions may dictate the sampling media used to collect the air sample or limit the volume of air sampled and thereby increase the detection limit.

- Atmospheric Pressure

  Migration of landfill gases through the landfill surface and through surrounding soils is governed by changes in atmospheric pressure. In addition, atmospheric pressure will influence upward migration of gaseous contaminants from shallow aquifers into the basements or first floors of overlying structures.

  In many cases, the transport and dispersion of air pollutants is complicated by local meteorology. Normal diurnal variations (i.e., temperature inversions) affect dispersion of airborne contaminants. Terrain features can enhance or create air inversions and can also influence the path and speed of air flow, complicating transport and dispersion patterns.

  The chemical characteristics of a contaminant (i.e., molecular weight, physical state, vapor pressure, aerodynamic size, temperature, reactive compounds, and photodegradation) affect its behavior and can influence the method used to sample and analyze it.

8.0 CALCULATIONS

Volume is obtained by multiplying the sample time in minutes by the average flow rate. Sample volume should be indicated on the chain of custody record. Adjustments for temperature and pressure differences may be required.

Results are provided in parts per million (ppm), parts per billion (ppb), milligrams per cubic meter (mg/m^3) or micrograms per cubic meter ($\mu g/m^3$).

Refer to the analytical method or regulatory guidelines for other applicable calculations.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific QA/QC activities that apply to the implementation of these procedures will be listed in the QAPP prepared for the applicable sampling event. The following general QA procedures will also apply:

1. All data must be documented on approved field data sheets, in a site logbook, and/or recorded electronically.

2. All instrumentation must be operated in accordance with operation instructions as supplied by the manufacturer, unless otherwise specified in the QAPP. Equipment checkout must be performed prior to operation and must be documented.

3. Records must be maintained, documenting the training of the operators that use instrumentation and equipment for the collection of environmental information.

9.1 QA/QC Samples

QA/QC samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error or potential sources of sample bias. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of field and/or analytical discrepancies. Following the QA/QC sample analysis, a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, trip blanks and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and blank spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives. Refer to ERT SOP, *Quality Assurance/Quality Control Samples*, for further details, and suggested frequencies for submittal of QA/QC samples.

9.2 Sample Documentation

All sample and monitoring activities should be documented legibly in ink. Any corrections or revisions should be made by lining through the incorrect entry and by initialing the error. All samples must be recorded on an Air Sampling Worksheet or logbook. A chain of custody record must be maintained from the time a sample is taken to the final deposition of the sample. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples. Enter all pertinent data into Scribe and print a COC record from Scribe. Refer to ERT SOP, *Sample Documentation*, for further information.

10.0 DATA VALIDATION

Data verification (completeness checks) must be conducted to ensure that all data inputs are present for ensuring the availability of sufficient information. These data are essential to providing an accurate and complete final deliverable. The ERT contractor's Task Leader (TL) is responsible for completing the UFP-QAPP verification checklist for each project. The data generated will be reviewed and processed by the TL prior to distribution.

Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives.

11.0 HEALTH AND SAFETY

Based on OSHA requirements, a site-specific health and safety plan (HASP) must be prepared for response operations under the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard, 29 CFR 1910.120. Field personnel working for EPA's ERT should consult the Emergency Responder Health and Safety Manual currently located at https://response.epa.gov/_HealthSafetyManual/manual-index.htm for the development of the HASP, required personal protective equipment (PPE) and respiratory protection.

The majority of physical precautions involved in air sampling are related to the contaminant sampled. Attention should be given when sampling in potentially explosive, flammable or acidic atmospheres. On rare occasions, the collection media may be hazardous; for example, in the instance where an acidic or basic solution is utilized in an impinger.

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13.0 APPENDICES

A – Portable Screening Devices and Specialized Analytical Instruments
B - Air Sampling Equipment and Media/Devices

APPENDIX A
Portable Screening Devices and Specialized Analytical Instruments
SOP: ERT-PROC-2008-20
October 2020

PORTABLE SCREENING DEVICES

The following represent typical examples of air monitoring technologies. These monitoring devices may exist as a stand-alone instrument utilizing a single technology or may be combined into a multi-gas meter.

- Total Hydrocarbon Analyzers

Total hydrocarbon analyzers used to detect a variety of VOCs at hazardous waste sites principally employ either a PID or an FID. Compounds are ionized by a flame or an ultraviolet lamp. PIDs depend on the ionization potential of the compounds of interest. PIDs are sensitive to aromatic and olefinic (unsaturated) compounds such as benzene, toluene, styrene, xylenes, and acetylene. Greater selectivity is possible by using low-voltage lamps (i.e. fewer compounds will be detected). The ionization potential of individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards or from the specific instrument manufacturer. These instruments are not compound-specific and are typically used as screening instruments. FIDs are sensitive to volatile organic vapor compounds such as methane, propanol, benzene and toluene, but FIDs respond poorly to organic compounds lacking hydrocarbon characteristics.

Examples of instruments included under this grouping include the TVA 1000 & TVA 2020 (FID and PID), and AreaRAE/AreaRAE Pro/MultiRAE Pro (PID as part of multi-gas meter).

- Oxygen and Combustible Gas Indicators

Combustible Gas Indicators (CGIs) provide efficient and reliable methods to test for potentially explosive atmospheres. CGI meters measure the concentration of a flammable vapor or gas in air and present these measurements as a percentage of the lower explosive limit (LEL). The measurements are temperature-dependent. The properties of the calibration gas determines sensitivity. LELs for individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards or from the specific instrument manufacturer. If readings approach or exceed 10% of the LEL, extreme caution should be exercised in continuing the investigation. If readings approach or exceed 25% LEL, personnel should be withdrawn immediately.

CGIs typically house an electrochemical sensor to determine the oxygen concentration in ambient air. Normally, air contains approximately 20.9% oxygen by volume. Oxygen measurements are of particular importance for work in enclosed spaces, low-lying areas, or in the vicinity of accidents that have produced heavier-than-air vapors that could displace ambient air. The meters are calibrated for sea level and may indicate a false negative (i.e., oxygen [O_2] content) at higher altitudes. Since the air has been displaced by other substances, these oxygen-deficient areas are also prime locations for taking additional organic vapor and combustible gas measurements. Oxygen-enriched atmospheres increase the potential for fires by their ability to contribute to combustion or to chemically react with flammable compounds and promote auto-ignition.

Examples of instruments included under this grouping include the AreaRAE/AreaRAE Pro/MultiRAE Pro (LEL and O_2 as part of multi-gas meter).

- Toxic Gas Sensors

Toxic gas sensors are compound-specific electrochemical sensors, designed and calibrated to identify and quantify a specific compound or class of compounds in either gaseous or vapor form. Cross-sensitivity to air pollutants not of interest may lead to erroneous results. Common toxic gas sensors include carbon monoxide, hydrogen sulfide, sulfur dioxide, nitric oxide, nitrogen dioxide, ammonia, chlorine, hydrogen cyanide, and phosphine.

Examples of instruments included under this grouping include the AreaRAE/AreaRAE Pro and MultiRAE Pro (user-selected toxic sensors are components of multi-gas meter).

- Aerosol/Particulate Monitors

Aerosol/particulate monitors are utilized when the contaminant of concern is associated with particulates, and when responding to fires. The Thermo Scientific DataRAM-4 (DataRAM-4) is a Real-time Aerosol/Particulate Monitor that uses a dual-wavelength nephelometer whose light scattering sensing configuration has been optimized for the measurement of the fine particle fraction of airborne dust, smoke, fumes and mists in ambient, atmospheric, industrial, research, and indoor environments. The DataRAM-4 also has an integrated datalogger.

The Met-One e-BAM beta attenuation monitor employs the absorption of beta radiation by solid particles extracted from the airflow.

Both the DataRAM-4 and the e-BAM can be configured to measure total particulates, or PM_{10} or $PM_{2.5}$ fractions.

The TSI Dusttrak DRX is a light-scattering laser photometer that uses both particle cloud and single particle detection to differentiate mass fraction measurements of PM_1, $PM_{2.5}$, PM_{10} and total particulates. It will output and log data from all four size categories at the same time.

- Colorimetric detectors

Colorimetric Tubes
A chemical detector tube is a hollow, tube-shaped, glass body containing one or more layers of chemically impregnated inert material. To use, the fused ends are broken off and a manufacturer-specified volume of air is drawn through the tube with a pump to achieve a given detection limit. The chemicals contained within the packing material undergo a chemical reaction with the airborne pollutant, if present, and produce a color change during the intake of each pump stroke. The concentration of a pollutant is indicated by the length of discoloration on a calibrated scale printed on the detector tube.

The instruments included under this grouping consist of Dräger Tubes.

Chemically-impregnated tapes (i.e. Chemcassettes)

A chemcassette is a chemically impregnated tape that reacts with a specific chemical or class of chemicals in a sample stream, if present, to generate a colorimetric response. The response is measured by an optical scanning device programmed to provide ppb or ppm results of a particular gas.

The instruments included under this grouping consist of the Single Point Monitor (SPM) or SPM Flex.

- Radiation Detectors

Radiation detectors determine the presence and level of radiation at a site. The meters use a gas or solid ion detection media that becomes ionized when radiation is present. The meters are normally calibrated to one probe. Meters that detect alpha, beta, and gamma radiation are available.

Examples of instruments included under this grouping consist of the Ludlum 2241 and AreaRAE Gamma.

- Gold Film (Hydrogen Sulfide and Mercury Vapor) Monitors

  Hydrogen sulfide (H_2S) and mercury (Hg) monitors operate on the principle that electric resistivity increases across a gold film as a function of H_2S or Hg concentration. These monitors provide rapid and relatively low detection limits for H_2S or Hg in air. After extensive sampling periods or exposure to elevated airborne concentrations of H_2S and Hg at a site, the gold film must be heated to remove contamination and return the monitor to its original sensitivity.

  The instruments included under this grouping consist of the Jerome 431-X (Hg), Jerome 405 (Hg) and Jerome 631-X (H_2S).

- Differential Zeeman Atomic Absorption Spectroscopy Analyzers

  These high sensitivity and selectivity instruments are portable multifunctional differential atomic absorption spectrometers with the direct Zeeman effect for interference-free measurement of mercury and benzene vapor concentrations in air and gases. The mercury analyzer uses atomic absorption spectrometry at 254 nanometers (nm) with Zeeman correction for background absorption and does not require gold amalgam pre-concentration and subsequent regeneration steps. The BA-15 uses differential absorption spectrometry with the direct Zeeman effect. Both instruments are intended for measuring mercury or benzene vapor concentrations in ambient air and in the air of residential and production areas, and can be used in stationary and continuous modes.

  The instruments included in this grouping are the RA-915M and the RA-915+ mercury vapor analyzers as well as the BA-15 benzene vapor analyzer.

APPENDIX B
Air Sampling Equipment and Media/Devices
SOP: ERT-PROC-2008-20
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AIR SAMPLING EQUIPMENT

- High-Volume PS-1 Samplers

  High-volume PS-1 samplers draw a sample through polyurethane foam (PUF) or a combination foam and XAD-2 resin plug, and a glass quartz filter at a rate of 5-10 cubic feet per minute (CFM; ft^3/min) (144 to 282 liters per minute [L/min]). This system is excellent for measuring low concentrations of Semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, or chlorinated dioxins in ambient air.

- Area Sampling Pumps

  These pumps provide flow-rate ranges between 2-20 L/min and have a telescopic sampling mast associated with the sampling train. Because of the higher volume that this pump is able to collect, this pump is suitable for sampling low concentrations of airborne contaminants (i.e., asbestos sampling). These pumps are also used to support metals, pesticides, and PAH sampling methods, which require large sample volumes.

- Personal Sampling Pumps

  Personal sampling pumps are reliable portable sampling devices that draw air samples through a number of different types of sampling media including resin tubes, impingers, and filters. Flow rates are usually adjustable from 1 to 4 L/min (or 0.01 to .75 L/min with a restrictive orifice) and can remain constant for up to 8 hours on one battery charge or continuously with an alternating current (AC) charger/converter.

- Canister Samplers

  Evacuated canister sampling systems use the pressure differential between the evacuated canister and ambient pressure to bleed air into the canister. The sample is bled into the canister at a constant rate over the sampling period using a critical orifice, a mechanically compensated regulator, or a mass flow control device until the canister is near atmospheric pressure.

AIR SAMPLING MEDIA/DEVICES

If possible, before employing a specific sampling method, consult the laboratory that will conduct the analyses. Many of the methods can be modified to provide results that best support the project objectives or to provide a wider range of analytical results.

- SUMMA Canisters

  SUMMA canisters are highly polished passivated stainless steel cylinders. The SUMMA polishing process brings chrome and nickel to the surface of the canisters, which results in an inert surface. This surface restricts adsorption or reactions that occur on the canister's inner surface after collection. Alternatively, a fused-silica lining may be incorporated on the canister’s inner surface (e.g. Silocan, Silcosteel). At the site, the canister may be paired with a flow controller to collect a time-weighted average sample over a given sample period (e.g. 24-hours) or opened directly to collect a grab sample. Typical applications use 6-liter Summa canisters for VOC and/or permanent gas analysis.

- Passive Dosimeters

  Passive dosimeters are clip-on vapor monitors (samplers) in which the diffused contaminants are adsorbed on specially prepared active surfaces. Industrial hygienists commonly use dosimeters to obtain time-weighted averages or concentrations of chemical vapors, as they can trap over 130 organic compounds. Selective dosimeters have also been developed for a number of chemicals including formaldehyde, ethylene oxide, hydrogen sulfide, mercury vapor, nitrogen dioxide, sulfur dioxide, and ozone. Dosimeters must be sent to a laboratory for analysis.

- Polyurethane Foam (PUF)

  PUF is a sorbent used with a glass filter for the collection of SVOCs such as pesticides, PCBs, chlorinated dioxins and furans, and polycyclic aromatic hydrocarbons (PAHs). Fewer artifacts (chemical changes that occur to collected compounds) are produced than with some other solid sorbents. Polyurethane foam (PUF) is used with the PS-1 sampler and U.S. EPA Method TO-13. PUF can also be used with personal sampling pumps when sampling for pesticides and PCBs following EPA Method TO-10A. Breakthrough of the more volatile PCBs and PAHs may occur when using PUF.

- Sampling Bags (Tedlar)

  Sampling bags, like canisters, transport air samples to the laboratory for analysis. Samples are generally collected using a lung system, in which a pump creates a vacuum around the bag in a vacuum box (lung box), causing the sample to flow from a source into the bag. This method is used for VOCs, fixed gases (carbon dioxide [CO_2], O_2 and nitrogen [N_2]), sulfur compounds, and methane. If samples are shipped to an off-site laboratory, it is good practice to collect duplicate bags for each sample, minimizing sample loss due to sample bags breaking or leaking.

- Impingers

  An impinger allows an air sample to be bubbled through a solution, which collects a specific contaminant by either chemical reaction or absorption. For long sampling periods, the impinger may need to be kept in an ice bath to prevent the solution from evaporating during sampling. The sample is drawn through the impinger by using a sampling pump or more elaborate sampling trains with multiple impingers.

- Sorbent Tubes/Cartridges

A variety of sampling media are available in sorbent tubes, which are used primarily for industrial hygiene. A few examples are carbon cartridges, carbon molecular sieves, Tenax tubes, and tubes containing the XAD-2 polymer. Depending upon the sorbent material, tubes can be analyzed using either a solvent extraction or thermal desorption. The former technique uses standard laboratory equipment and allows for multiple analyses of the same sample. The latter technique requires special, but readily available, laboratory equipment and allows only one analysis per sample. In addition, thermal desorption typically allows for lower detection limits by two or more orders of magnitude. Whenever sorbent tubes are being used for thermal desorption, they should be certified as "clean" by the laboratory doing the analysis.

Thermally Desorbed Media

During thermal desorption, high-temperature gas streams are used to remove the compounds collected on a sorbent medium. The gas stream is injected and often cryofocused into an analytical instrument, such as a gas chromatograph (GC), for compound analysis:

- Tenax Tubes

  Tenax tubes are made from commercially available polymer (p-phenylene oxide) packed in glass or stainless steel tubes through which air samples are drawn or sometimes pumped. These tubes are used in U.S. EPA Method TO-1 and volatile organic sampling trains (VOST) for volatile nonpolar organic, some polar organic, and some of the more volatile semivolatile organics. Tenax is not appropriate for many of the highly volatile organics (with vapor pressure greater than approximately 200 millimeter (mm) Hg).

- Carbonized Polymers

  The carbon molecular sieve (CMS), a carbonized polymer, is a commercially available, carbon sorbent packed in stainless-steel sampling tubes through which air samples are drawn or sometimes pumped. These are used in U.S. EPA Method TO-2 for highly volatile nonpolar compounds that have low-breakthrough volumes on other sorbents. When high-thermal desorption temperatures are used with CMS, more variability in analysis may occur than with other sorbents.

- Mixed Sorbent Tubes

  Sorbent tubes can contain two type of sorbents. Combining the advantages of each sorbent into one tube increases the possible types of compounds to be sampled. The combination of two sorbents can also reduce the chance that highly volatile compounds will break through the sorbent media. An example of a mixed sorbent tube is the combination of Tenax and charcoal with a carbonized molecular sieve. A potential problem with mixed sorbent tubes is the breakthrough of a compound from an earlier sorbent to a later sorbent from which it cannot be desorbed.

Solvent-Extracted Media

Solvent-extracted media use the principle of chemical extraction to remove compounds collected on a sorbent media. The chemical solvent is injected into an instrument, such as a GC, for analysis of compounds. Examples of solvent-extracted media follow:

- Chemically Treated Silica Gel

  Silica gel is a sorbent that can be treated with various chemicals. The chemically treated silica gel can be used to sample for specific compounds in air. Examples include the 2,4-dinitrophenylhydrazine (DNPH)-coated silica gel cartridge used with EPA Method TO-11A.

- XAD-2 Polymers

  XAD-2 polymers usually are placed in tubes, custom-packed sandwich-style with polyurethane foam, and prepared for use with EPA Method TO-13 or the semi-VOST method. The polymers are used for the collection of semivolatile polar and nonpolar organic compounds. The compounds collected on the XAD-2 polymer are chemically extracted for analysis.

- Charcoal Cartridges

  Charcoal cartridges, consisting of primary and backup sections, trap compounds by adsorption. The design of the cartridges enables ambient air to be drawn through both the primary and backup sections, but the backup section is used to verify that breakthrough of the analytes captured in the first section did not occur (and the sample collection was quantitative). Quantitative sample collection is evident by the presence of target chemicals on the first charcoal section and the absence of target chemicals on the second section. The adsorbed compounds must be eluted, usually with a solvent extraction, and analyzed by GC with a detector, such as a Mass Spectrometer (MS).

- Tenax Tubes

  Cartridges are used in OSHA and NIOSH methods in a manner similar to charcoal cartridges but typically for less volatile compounds.

Particulate Filters

Particulate filters are used by having a sampling pump pass air through them. The filter collects the particulates present in the air, and the filter is analyzed for particulate mass, chemical composition, or radiological composition. Particulate filters are made from different materials that are described below.

- Mixed Cellulose Ester (MCE)

  MCE is manufactured from mixed esters of cellulose which are a blend of nitro-cellulose and cellulose acetate. MCE filters are often used for metals sampling.

- Glass Fiber

  Glass fiber is manufactured from glass fibers without a binder. Particulate filters with glass fiber provide high flow rates, wet strength, and solid holding capacity. Generally, the filters are used for gravimetric analysis of particulates.

- Polyvinyl Chloride

  Particulate filters made with polyvinyl chloride are resistant to concentrated acids and alkalis. The low moisture pickup and light tare weight of these filters make them ideal for gravimetric analysis.

- Teflon

  Teflon is manufactured from polytetrafluoroethylene (PTFE). Particulate filters with Teflon are easy to handle and exceptionally durable. PTFE is the optimal choice for particle size-selective samplers.

- Cellulose

  Particulate filters made with cellulose contain less than 0.01% ash. These filters are used to collect particulates.