Guidelines for Air Monitoring Tactics for Emergency Response

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1 Introduction

This guide provides a framework for air monitoring in response to releases of chemicals related to the petroleum industry. Although each individual response will have its own unique characteristics, this guide provides a broad approach that reflects the most successful air monitoring practices, based on reviewing past events' positive and negative outcomes.

1.1 Intended Audience

This document is intended to guide first responders on how to conduct air monitoring during chemical releases. The intended audience includes members of the emergency response community, such as police, fire, hazardous materials specialists, and regulators, and the producers, transporters, and owners of chemicals that may be involved in an accidental release scenario. The principles in this document are intended to be reviewed and practiced, so that during an emergency, the strategies and tactics summarized throughout the guide may be seamlessly and effectively implemented to help ensure a positive outcome for all stakeholders.

1.2 Safety—People are the First Priority

Air monitoring is important to safety, and organizing air monitoring resources quickly and effectively is important for a successful outcome—namely, preventing stakeholders involved in an accidental release of a chemical from being harmed. Managing chemical exposures requires a good understanding of the potential toxicity of the chemicals involved, as well as an effective strategy to measure exposure and to institute protective actions if warranted. The collection of quality air monitoring data is a key element to making these life-critical decisions. The priorities for a response are:

— **People:** safety of response personnel and the public;

— **Environment:** prevention of environmental, human health, and welfare effects;

— **Assets:** minimizing damage to structures and equipment; and

— **Relations:** keeping customers, community, and federal, state, and local government agencies informed.

Responder safety and health should never be compromised for tactical considerations. Likewise, the response should be conducted to maximize safety around health impacts to responders, the public, and the surrounding areas of a release.

1.3 How to Use the Guide

This guide could be used in training and may be used during responses to releases of chemicals to guide the user in regard to air monitoring: how resources should be prioritized, how to respond to environmental conditions, when to employ certain technologies, and what strategies should be implemented.

2 Terms, Definitions, and Abbreviations

2.1 Terms and Definitions

2.1.1
entrant
An individual who is authorized and assigned to enter a confined space as part of their job duties.

2.1.2
confined space permit
An official document or written authorization that is typically issued by an organization, employer, or relevant authority to ensure safe entry and work within a confined space.

2.1.3
hazard
An inherent physical or chemical characteristic (e.g., flammability, toxicity, corrosivity) or set of conditions that has the potential to cause harm to people, property, or the environment.

2.1.4
micrometer
One-millionth of a meter. Micrometer and “micron” are synonymous terms. Micron is more commonly used in the response community, both in common conversation and reference literature.

2.1.5
olfactory fatigue
The degradation of the ability to smell.

2.1.6
oxygen-deficient atmosphere
An atmosphere containing less than 19.5 percent oxygen by volume.

2.1.7
risk
A combination of the probability of an exposure to a hazard that could result in harm to personnel, the environment, or the general public, and the magnitude of the injury or loss should the exposure occur.

2.1.8
sensitive receptor
A location, area, or entity that is particularly vulnerable or sensitive to experiencing adverse effects from exposure to pollutants, contaminants, or hazards.

2.1.9
stakeholder
Any individual, group, organization, or entity that has a vested interest, concern, or stake in a particular situation.

2.1.10
stratification
The separation and layering of atmospheric products based on their density.

2.2 Abbreviations

ACGIH American Conference of Governmental Industrial Hygienists

AEGL Acute Exposure Guideline Level

AIHA	American Industrial Hygiene Associates
AMP	air monitoring plan
API	American Petroleum Institute
APR	air purifying respirator
Cl	chlorine
CIH	certified industrial hygienist
CO	carbon monoxide
COI	constituents of interest
ERPG	emergency response planning guideline
H_2S	hydrogen sulfide
IDLH	immediately dangerous to life and health
LEL	lower explosive limit
NAAQs	National Ambient Air Quality Standards
NH_3	ammonia
NIOSH	National Institute for Occupational Safety and Health
NO_X	nitrogen oxides
NRC	National Research Council
OSHA	Occupational Safety and Health Administration
PAC	protective action criteria
PAHs	polycyclic aromatic hydrocarbons
PEL	permissible exposure limit
PID	photoionization detector
PM	particulate matter
PM_{10}	inhalable particles, with diameters that are generally 10 micrometers and smaller
$PM_{2.5}$	respirable particles, with diameters that are generally 2.5 micrometers and smaller
PPE	personal protective equipment
PRP	potentially responsible party
RP	responsible party

SDS safety data sheet

SO_X sulfur oxides

STEL short-term exposure limit

SWA stop work authority

TLV threshold limit value

TWA time-weighted average

UEL upper explosive limit

USEPA United States Environmental Protection Agency

VOC volatile organic compound

3 Air Monitoring Principles

Air monitoring activities serve the purpose of assessing the presence or absence of response-related constituents of interest (COIs) in the air. These activities are central to safely conducting response, inspection, mitigation, and remediation tasks, and to the protection of the response workers and members of surrounding communities. Air monitoring should be conducted in the first phase of response activities and should continue throughout work areas and in the surrounding community during emergency and post-emergency response activities until sufficient data indicate monitoring is no longer necessary.

This section outlines the process of identifying potential chemical hazards, determining their presence, and establishing the safety measures and conditions to help ensure a safe environment.

NOTE Consult applicable safety data sheets (SDS) to identify response-specific COIs for the product(s) present during the response. This information is essential for comprehensive hazard assessment and safety planning.

3.1 Potential Exposure from Released Petroleum Constituents

The primary COIs posing risks to response workers and community members from a petroleum product release typically include volatile organic compounds (VOCs), benzene, hydrogen sulfide (H_2S), and potentially explosive atmospheric conditions that are measured as the percentage of the lower explosive limit (%LEL). Understanding the response-specific COIs is crucial in assessing the potential risks and implementing measures to reduce exposure and health hazards.

In addition, a detailed understanding of both the LEL and the upper explosive limit (UEL) can be a complex task. LEL represents the minimum concentration of a flammable substance in the air needed for an explosive mixture, while UEL signifies the maximum concentration beyond which the mixture becomes too rich to ignite (see Figure 1). These limits vary significantly between different COI and can be affected by factors like temperature, pressure, and the presence of other gases or constituents. An understanding of the relationship between LEL and UEL is crucial in assessing and managing potential explosion or ignition hazards (see Figure 1).

NOTE Continuous exposure to COIs can lead to the loss of the ability to smell, known as olfactory fatigue. This is common with exposure to ammonia, chlorine, and H_2S. Because of this risk, relying on the sense of smell alone should not be considered a reliable method for detecting COIs.

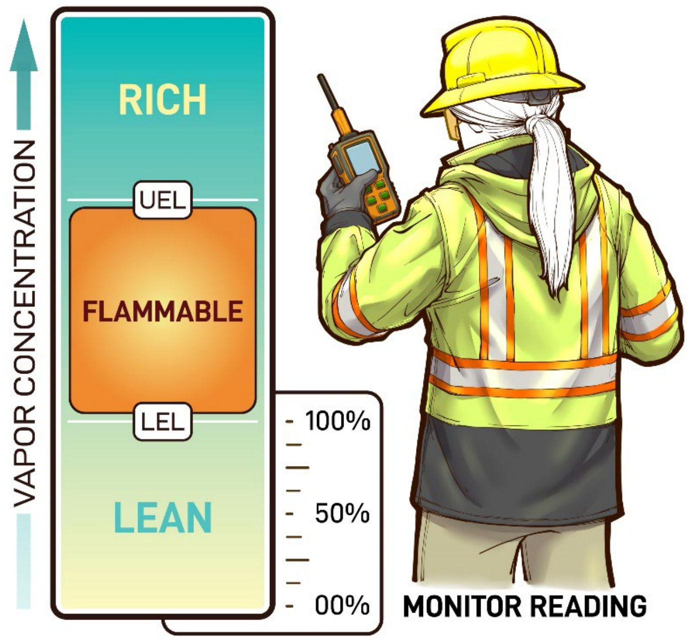

Figure 1—LEL and UEL Vapor Concentrations

3.2 Potential Exposure from Petroleum Product Combustion

In addition to the exposure risks mentioned above, the combustion of petroleum products can lead to potential exposure to other harmful substances, such as carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter (PM), and elemental carbon.

PM refers to a diverse range of solid particles and liquid droplets suspended in the air, varying widely in size and composition (see Figure 2). These particles can originate from many sources. Combustion particles, stemming from the burning of petroleum products, are typically among the smallest, measuring less than 2.5 micrometers in diameter ($PM_{2.5}$). Pollen and dust particles, often released from plants and soil (road dusts), vary in size but typically measure less than 10 micrometers in diameter. Larger particles, with a diameter of about 50 to 70 micrometers, have a size comparable to the diameter of a human hair. Sand particles, originating from soil erosion or a beach, can vary widely in size but are typically 90 micrometers in diameter.

The health impacts of PM depend largely on the size of the particles (see Figure 3). The smallest particles ($PM_{2.5}$) possess the ability to penetrate deep into the respiratory system, reaching the alveoli in the lungs. Due to their small size, $PM_{2.5}$ particles can bypass the body's natural defense mechanisms in the upper respiratory tract and are capable of entering the bloodstream, posing significant health risks. Larger particles, such as those with diameters comparable to human hair and sand, are generally filtered out in the upper respiratory system or expelled through coughing and sneezing, reducing their likelihood of causing adverse health effects. Understanding the diverse nature of particulate matter is crucial for addressing air quality concerns and developing effective strategies to mitigate its adverse effects on human health.

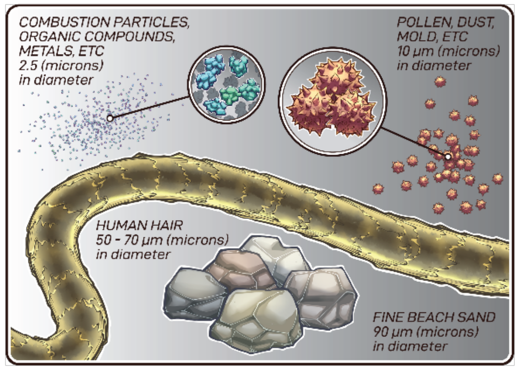

Figure 2—Particulate Matter Sizes

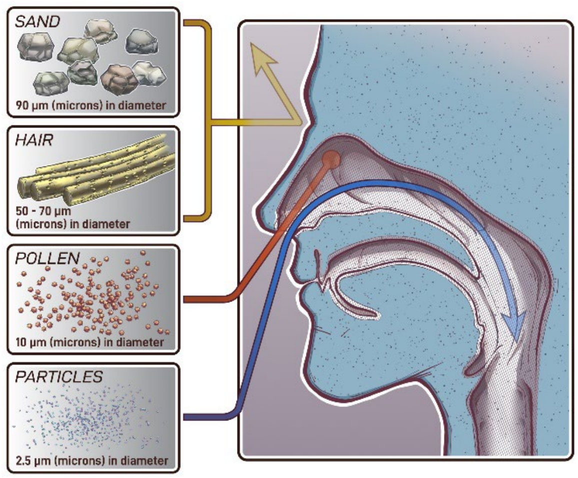

Figure 3—Inhalation of Particulate Matter

3.3 Potential Exposure to Other Dangerous Atmospheres

In certain response scenarios, additional exposure risks may need to be considered. For example, refinery responses could involve solvents and catalysts, while pipelines may contain anhydrous ammonia (NH_3) or carbon dioxide (CO_2). Enclosed spaces such as tanks can present the risk of oxygen-deficient atmospheres. Other potential COIs to be aware of include polycyclic aromatic hydrocarbons (PAHs), benzene (C_6H_6), chlorine (Cl), hydrogen sulfide (H_2S), and acid gases.

3.4 Air Monitoring Strategies

Air monitoring strategies can differ based on various factors, including the response location, environmental conditions, specific work tasks, and the information requested by stakeholders. Helping to ensure the safety of response personnel and neighboring communities requires thoughtful planning regarding the collection of air monitoring data, considering the unique aspects of the situation.

It is important to recognize that air monitoring is different from air sampling:

— **Air monitoring** involves the use of single-point or continuous .reading instruments to directly read the concentration of COIs in the air and return values in real-time (if a single-point reading instrument identifies a risk or concern, continuous reading instruments may then be used to identify exclusion zones and maintain worker and community safety)

— **Air sampling** involves the collection of samples for laboratory analysis. More information on air sampling can be found in Section 5.2.

3.4.1 Breathing Zone Monitoring

Breathing zone monitoring is used for assessing human exposure to inhalation hazards from COIs. Monitoring the air within about 10 in. around the face is recommended to get an accurate representation of the inhaled COI concentration.

In the initial phase of a response, it is important to conduct initial breathing zone air monitoring to gauge COI levels. This data helps establish safety zones, protective equipment requirements, and compliance plans.

As demonstrated in Figure 4, regular breathing zone air monitoring is used for evaluating changing conditions and helping to ensure the safety of response personnel and neighboring communities.

Figure 4—Monitoring at Breathing Zone Height

3.4.1.1 Stationary Air Monitoring

Stationary monitoring entails the deployment of air monitoring equipment at specific locations for continuous data collection. As shown in Figure 5, these stationary meters are typically placed in work areas, along response perimeters, in neighboring communities, and in proximity to sensitive receptors (i.e., schools, parks, hospitals, occupied businesses). These meters may be placed on tripods or affixed to fences or other stationary structures so that they are reading at a breathing zone height.

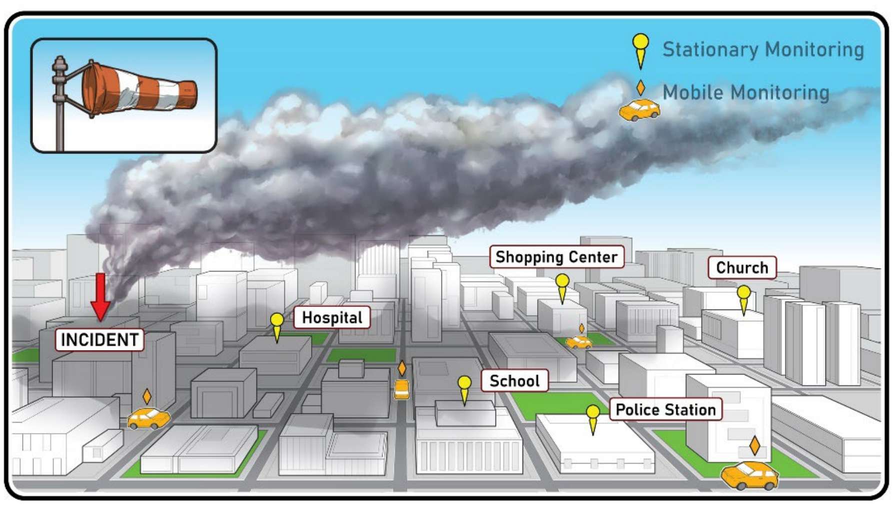

Figure 5—Stationary and Mobile Monitoring

3.4.1.2 Mobile Air Monitoring

Mobile air monitoring involves the use of portable equipment for collecting air quality data while moving through an area (see Figure 5). This method can involve walking or driving, depending on the specific area being monitored. When conducting mobile air monitoring, it is important to log readings while stationary for at least one minute or as long as required by the equipment manufacturer before continuing to move, unless it is unsafe to remain in one place. This dynamic approach to air quality assessment allows for data collection at multiple locations, as opposed to stationary monitoring methods. Mobile monitoring data is valuable for identifying potential sources of COIs, establishing safety zones, and gathering comprehensive data across various response zones, including work sites, response perimeters, and neighboring communities.

NOTE When conducting mobile air monitoring, readings should be taken while temporarily stationary. If you are on foot, be in a safe area away from any moving equipment. If you are driving, pull over in a safe location before collecting and logging your data. While moving between data logging points, maintain situational awareness and focus on your travel path and surroundings. Isolate any operating internal combustion engines (ICE) or provide sufficient separation to avoid erroneous readings due to exhaust gases.

3.4.2 Confined Space Monitoring

The atmosphere within a confined space, such as storage or frac tanks, should be monitored using equipment specifically designed to detect the COIs that may be present. When monitoring for atmospheric hazards in a confined space, the first parameter to be assessed is the oxygen level. It is important to note that combustible gas sensors rely on the presence of oxygen and won't function accurately in an oxygen-deficient atmosphere.

Accurate air monitoring data for combustible gases and vapors is important because of the potential risk of fire or explosion in confined spaces containing petroleum products.

Before entering a confined space, perform an initial or baseline assessment to determine the existing levels of COIs. The data from this initial screening is used to establish the requirements for protective equipment for employees entering confined spaces (such as air-moving equipment) and to develop written compliance plans.

Consistent and routine air monitoring must be conducted during confined-space occupation as outlined in the confined space permit[1]. This ongoing monitoring assesses evolving conditions and helps to ensure the safety of confined-space entrants.

Additionally, it is important to consider and monitor all operations that will occur within the confined space, including any activities that may introduce additional potential atmospheric hazards, such as welding fumes or solvent vapors, as well as oxygen consumption by workers or equipment within.

3.4.3 Investigative Monitoring

During a response, the atmosphere may exhibit layering, commonly known as stratification, or experience shifts influenced by environmental variables, such as temperature and wind speed. Particularly, certain COIs have vapors that are denser than air, causing them to accumulate in lower-lying areas and follow terrain features in low- or no-wind conditions. Investigative monitoring, which involves targeted monitoring at specific locations, may be used to assess these types of conditions. Investigative monitoring may also be used to assist in assessing structural integrity. As demonstrated in Figure 6, potential locations of interest for investigative monitoring are along pipeline seams, valves, or suspected areas of damage of a pipeline or tank. Another potential investigative monitoring point is a storm drain. When there is a possibility that hazardous substances have entered sewer systems, inspect for the presence of explosive

[1] 29 CFR 1910.146(d)(5)(i)

gases in drainage structures, such as stormwater structures or sanitary sewer catchments. This can be accomplished by extending tubing attached to air monitoring devices into these areas, helping to ensure that workers are not exposed to potentially dangerous atmospheric conditions.

NOTE 1 It is important to recognize that the air being monitored in the context of investigative monitoring does not represent the breathing zone of workers. Instead, it serves to investigate areas that may contain a source of hazardous substances (i.e., leaking seal, inside a sewer drain, etc.). These readings should be clearly logged as "investigative."

NOTE 2 When investigating deep trenches, tanks (from above), and storm/sewer drains, it is important to understand the amount of time needed for the air to be pulled from the end of the tube/hose to get into the monitor to make an accurate reading. In some cases, this may take many seconds to allow the monitor to return a good reading. The return is not immediate. Guidance should be available from the manufacturer.

Figure 6—Examples of Investigative Monitoring

3.5 Chemical Exposure Standards and Guidelines

This section outlines the applicable standards and guidelines for helping to ensure the safety of workers exposed to COIs and for helping to safeguard neighboring communities during response situations. These standards and guidelines serve as the foundation for the development of action levels (ALs) and air monitoring plans (AMPs). The exposure guidelines are created using rigorous scientific assessment, public input, and regulatory input.

3.5.1 Response Workers

The U.S. Occupational Safety and Health Administration (OSHA) has established regulatory permissible exposure limits (PELs)[2] for a worker exposed to hazardous chemical substances. In addition to regulatory

[2] PEL: An 8-hour time weighted average. An exposure to any material listed in 29 CFR 1910.1000, Tables Z1 and Z2, in any 8-hour work shift of a 40-hour workweek shall not exceed the 8-hour time weighted average limit given for that material in the table.

requirements, threshold limit values (TLVs)[3] established by the American Conference of Governmental Industrial Hygienists (ACGIH) are additional guidelines for assessing inhalation exposures for workers. The National Institute for Occupational Safety and Health (NIOSH) has also established immediately-dangerous-to-life-and-health (IDLH)[4] limits for certain chemicals. The most applicable guideline values should be considered to best protect response personnel working within the vicinity of a release and provide a basis for air monitoring teams to assess the safety of response personnel in the area.

3.5.2 Community

Government agencies have created several standards and guidelines that can be used when considering neighboring communities and other nearby sensitive receptors during an emergency response; each is tailored to specific needs and circumstances. Acute exposure guideline levels (AEGLs)[5] offer immediate insight into safe exposure levels to protect both workers and the public. Emergency response planning guidelines (ERPGs)[6] assist in planning response strategies when chemical releases occur. Temporary emergency exposure limits (TEELs)[7] fill the gaps when the previous guidelines are unavailable. Protective action criteria (PACs)[8] may also be used when the above guidelines are not available for a particular chemical. The choice of which guidelines and criteria to use depends on the nature of the response, the data available, and the need to protect both workers and neighboring community members. Additionally, there may be state-specific standards that need to be considered.

3.6 Establishing Action Levels

Setting response-specific ALs is used for establishing prompt and appropriate actions in response to COI detections. Action levels are set in consultation with air monitoring consultants and the potentially impacted community. Typical Als are one-half of established exposure limits or guidelines. This helps ensure that if ALs are reached, response personnel or community members can be promptly notified and necessary action can be taken.

Once ALs have been established, it's important to compile them into a response-specific AMP. This AMP will serve as the guiding document for response personnel, providing instructions and information regarding air quality management during the response. A template AMP that may be utilized during the initial response (24–48 hours) of an incident is provided in Annex B.

NOTE The evaluation of air monitoring readings relative to the established ALs should be based on a sustained (usually approximately one minute) average of levels measured by real-time air monitoring instruments. If the readings of a COI are greater than the AL and are sustained for the associated averaging period, they should be considered an exceedance. Note that some sampling and monitoring methods require longer averaging periods.

3.6.1 Action Level Mitigation Measures

If readings of COIs are sustained above the ALs, the hazard should be promptly communicated to response leadership, potentially affected receptors, and response safety personnel. When possible,

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[3] TLV: The TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect (ACGIH, 2020).

[4] IDLH: Indicates an exposure to airborne contaminants that is likely to cause death or immediate or delayed permanent adverse health effects, or prevent escape from such an environment.

[5] AEGL: Calculated for five relatively short exposure periods (10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours) as differentiated from air standards based on longer or repeated exposures. AEGL “levels” are dictated by the severity of the toxic effects caused by the exposure, with Level 1 being the least and Level 3 being the most severe.

[6] ERPG: If the average concentration of a COI is exceeded over a 1-hour period, exposed community members should be notified and mitigation measures should be implemented. Evacuation or shelter-in-place decisions should be discussed with the appropriate authorities.

[7] TEEL: Chemical exposure guidelines to use for emergency planning (if no AEGL or ERPG is available).

[8] PAC: If the average concentration of a COI is exceeded over the 1-hour period, exposed community members should be notified and mitigation measures should be implemented. Evacuation or shelter-in-place decisions should be discussed with the appropriate authorities.

mitigation measures should be put in place to reduce the risk of worker and community exposure. Mitigation measures may include:

Stop work authority: Work operations cease immediately, and response personnel evacuate the affected area to an area upwind from the source until air monitoring data indicate it is safe to return.

Work activity modification: This could involve relocating workers upwind or crosswind in relation to the hazard or implementing enhanced ventilation measures, such as use of fans, removal of physical barriers, or opening doorways.

Source identification and removal: The source of the hazard is relocated downwind or, if feasible, completely removed from the area.

Vapor suppression: Apply an approved vapor suppression foam or water to a source hazard to reduce evaporation (vaporization) of a source.

Respiratory protection: Safely continuing work activities requires the use of a respirator. A detailed description of respiratory protection is provided in Section 4 of this document.

Community evacuation: Community members are made aware of the unsafe conditions and advised to evacuate the affected area to an area upwind from the source until air monitoring data indicates it is safe to return.

Community shelter-in-place: Community members are made aware of the unsafe conditions and advised to remain in their homes with windows and doors closed and A/C off.

4 Respiratory Protection

When concentrations of COIs in the breathing zone exceed ALs, the use of respirators may become necessary to safeguard response workers. This section outlines the various types of respiratory protection available, their applications, and their limitations.

NOTE The medical evaluation section of OSHA's respiratory protection standard, 1910.134(e), states that the employer will determine each employee's fitness to wear a respirator by way of either the administration of a medical questionnaire or a physical examination that elicits the same information as the questionnaire, or both. OSHA also states that the employer is required to make arrangements with a physician or other licensed health care professional to make the evaluation and provide a written opinion to the employer concerning the employee's ability to use a respirator.

4.1 Air Purifying Respirators

Air purifying respirators (APRs) are designed to cleanse breathing air via filtration, absorption, or neutralization with various purifying components that address specific types of constituents. These purifying components include:

- **Particulate filters** are designed to remove particulate matter as small as 0.3 micrometers suspended in the air:
  - **N-Series:** These filters are designated for the removal of non-oil-based aerosols.
  - **P-Series:** These filters are designated for the removal of non-oil- and oil-based aerosols.
- **Cartridges that remove gas or vapors** are designed to remove harmful gases and vapors from the surrounding air. APR cartridges are color coded for added ease when selecting the appropriate cartridge for the hazards present (see Figure 7).

— **Combined cartridge systems:** These versatile combinations are engineered to mitigate particulate matter, gas, and vapors, providing protection against a range of airborne hazards.

— **Cartridge Identification:** Cartridges may have a combination of colors or have a single-color coded label to indicate the types of constituents they can protect against. For example, a combination cartridge designed to protect against organic vapors and particulates may have both black and white sections. Consult the manufacturer-supplied reference literature to be certain that the cartridge selected provides the required protection.

Although APRs provide a level of protection against specific types of constituents, all filters and cartridges come with a threshold limit at which point the wearer is no longer protected. It is recommended that APR-specific ALs be established based on the manufacturer's specifications and guidelines.

NOTE Filters and cartridges may not be used indefinitely and should be changed on a regular schedule depending on the concentrations of COIs detected and the manufacturer's specifications and guidelines.

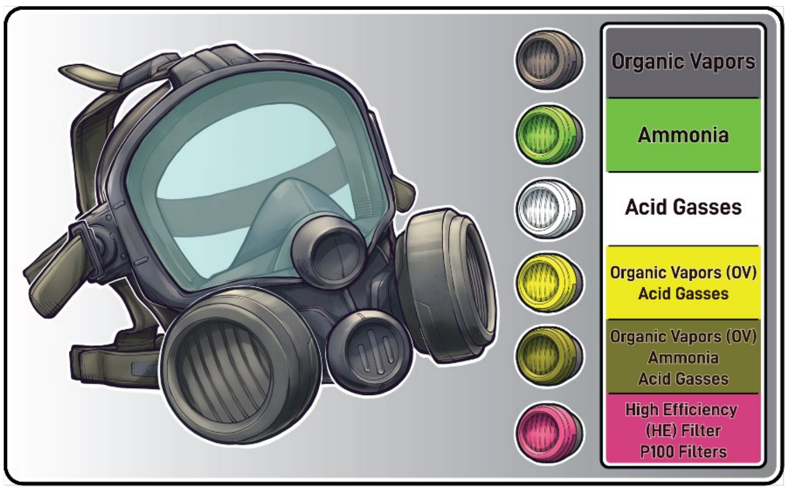

Figure 7—APR Cartridges

4.2 Supplied Air Respirators and Self-Contained Breathing Apparatuses

Supplied air respirators (SARs) and self-contained breathing apparatuses (SCBAs) are used for situations where the atmosphere may include oxygen-deficient or IDLH conditions. Since SARs/SCBAs provide clean breathing air from a source independent of the work area, SARs/SCBAs may be used when atmospheric constituents are unknown (other than LEL) or when concentrations exceed the limitations of APRs. Portable monitoring should still occur during use of supplied air/SCBA entry activities, as the need to help ensure compliance with established AL values for potentially explosive atmospheres (LEL) is important. Neither supplied air nor SCBA provide significant protection from a flammable atmosphere combined with an ignition source.

— **Oxygen-deficient or IDLH environments:** Full-face SAR with auxiliary self-contained air supply or SCBA is used when working in environments where the concentration of oxygen is insufficient to sustain human life or when the atmosphere contains constituents exceeding the limitations of APRs.

— **Unknown constituents:** In some emergency situations, airborne constituents may not be immediately identifiable. SARs/SCBAs are designed to handle a wide range of potential hazards, making them suitable for situations where the atmosphere is uncertain. Portable air monitoring is still used to help ensure that LEL concentrations are within AL values.

— **Exceeding thresholds:** When faced with COI concentrations that surpass the limitations of APRs, SARs/SCBAs are used. Portable air monitoring is used to help ensure LEL concentrations are within AL values.

In situations where the conditions necessitate the use of SARs/SCBAs, work activities should be restricted to essential tasks that can be accomplished within a relatively short time frame (usually less than one hour). For essential tasks that may require more time, it is advisable for personnel to work in rotations, with each shift lasting no longer than one hour due to equipment limitations and worker fatigue. While actively using SAR/SCBA, medical monitoring of personnel is recommended.

5 Air Monitoring and Sampling Equipment

Knowledge of the potential COIs is needed for the selection of the appropriate air monitoring equipment. This section outlines the types of air monitoring and air sampling equipment likely to be used on petroleum release and/or fire responses.

It is important to keep track of the monitoring and sampling equipment being used and develop a plan for maintaining a sustainable inventory of supplies. This includes regularly charging or replacing batteries and maintaining a sufficient stock of consumable items, such as tubes, filters, and calibration gas. Additionally, there should be a system in place for ordering these supplies as needed.

NOTE All air monitoring equipment employed on a response should be maintained in accordance with manufacturer specifications. A calibration or bump test (challenge test), per manufacturer's recommendations, should be completed before each use to help ensure accuracy of readings.

5.1 Air Monitoring Devices

Air monitoring devices are essential tools used to measure the concentration of specific COIs in the ambient air and to investigate atmospheres of concern. These devices come in various types and models, each designed to cater to different requirements and applications:

— **Personal single-sensor monitors:** Small, lightweight devices designed to be worn by an individual, providing real-time monitoring of a single gas or vapors. They are typically attached to clothing or personnel protective equipment (PPE) in the breathing zone of the wearer to provide continuous monitoring and alerts for single-gas exposure.

— **Handheld multi-sensor monitors:** Multi-sensor monitors can simultaneously monitor for and measure multiple gases or vapors, providing comprehensive information about potential COIs. These meters are small and can easily be carried or attached to PPE.

One of the most utilized devices is commonly referred to as a "four-gas"; this device monitors for CO, oxygen, LEL, and H_2S. Another multi-sensor monitor is a "five-gas," which is typically equipped with sensors specific for CO, LEL, H_2S, and oxygen, and a photoionization detector (PID) capable of monitoring for VOCs.

Specialized sensors such as ammonia, sulfur dioxide, etc., may be interchanged in these devices.

— **Stationary multi-sensor monitors:** These devices are placed at specific locations within work areas, equipment cabs, response perimeters, in proximity to sensitive receptors, or other areas where continuous monitoring for COIs is required. These devices utilize wireless technology to transmit COI concentration data to a central monitoring system or a mobile device. They are equipped with sensors similar to the handheld multi-sensor monitors.

— **Particulate monitors:** These handheld or stationary devices are designed to measure the concentration of particulate matter in ambient air. Particulate matter monitors are real-time monitors that utilize light scattering, light blocking, or gravimetric methods to capture the concentration of airborne particles. Particulate matter monitors can be designed to measure a specific range of particle sizes, such as PM_{10} or $PM_{2.5}$.

— **Benzene-specific monitoring:** Benzene is a VOC and is typically monitored for using a portable PID. Some variations of multi-sensor monitors may be equipped with a benzene-specific sensor alongside other gases or benzene-specific VOC isolation tubes, allowing for the real-time detection of benzene.

— **Gas detection tubes:** Gas detection tubes operate on the principle of colorimetric analysis, utilizing a manual or electrically operated vacuum pump to collect an atmospheric sample. Each tube contains a chemical reagent that reacts with the target gas or vapor to produce a color change in the presence of the gas or vapor. The color change is proportional to the concentration of the gas or vapor. Tubes are available for a wide range of gases and vapors, including toxic, flammable, and inert gases.

NOTE All air monitoring devices have their limitations. Factors like extreme temperatures and sensor/tube saturation can significantly affect the accuracy of readings, or may cause equipment failure. It is necessary to be aware of these limitations and to review the manufacturer's guidelines for use. Bump test and recalibration should be performed according to manufacturer's recommendations.

5.2 Analytical Air Sampling

Analytical sampling allows for a broader analysis of airborne constituents, identifying a wide range of gases, vapors, particulate matter, and volatile organic compounds, including those not specifically targeted by real-time monitors. Analytical sampling is utilized in air monitoring for a variety of reasons, including:

— identifying unknown hazards;

— confirming and validating real-time air monitoring results;

— regulatory compliance;

— chemical identification.

Several types of analytical sampling can be conducted. Below are a few of the common types of analytical sampling utilized in petroleum responses:

— **Whole air analytical sampling:** A method used to capture a snapshot of air conditions, including all of its constituents, at a specific location and time. This approach is valuable in monitoring and characterizing potentially unknown air hazards, allowing the preservation of the air sample for laboratory professionals to test for a wide variety of potentially hazardous air conditions.

— **Passive air analytical sampling:** An effective method for collecting air samples over extended periods without the need for active sampling devices or pumps. Passive air sampling can be conducted at a stationary location or through a monitor worn by a person. Passive air sampling can provide a time-weighted average for specific COIs and may provide lower detection limits than portable gas monitors.

— **Active air analytical sampling:** Active air sampling utilizes pumps or other mechanical devices to actively draw air through sampling media. This method allows for precise control of sampling flow rates, utilized for similar reasons as the passive air analytical sampling, but various analytical methods require a pumped sample with precise control of sampling flow rates.

6 Initial Response

When initially responding to a petroleum release or fire, it is typical for the unknown variables to outnumber the known ones. Maintaining the safety of responders and the nearby community while gaining a comprehensive understanding of the situation's scope and severity is an evolving process. This section outlines the main objectives of air monitoring during an initial response and strategies for helping to reduce the risks associated with an unfamiliar situation.

6.1 Hazard Assessment and Size-up

— **Identify the constituents of concern:** During the initial response phase, the primary goals are to gather information about the COIs involved; estimate the point(s) of release, release volumes, and wind direction; and identify potential pathways for migration. Reviewing the SDS for the product(s) involved will serve as a vital source of information regarding their properties and associated hazards. This enables response personnel to assess the necessary resources and plan their approach effectively.

— **Take immediate precautionary measures (evacuations or sheltering):** The Emergency Response Guidebook (ERG)—in paperback, online, or in the ERG app—is distributed by the U.S. Department of Transportation (DOT) and Pipeline and Hazardous Materials Safety Administration (PHMSA), and provides guidance on protective action distances (evacuation, shelter-in-place, or combination) for the initial phase of a hazardous substance release.

6.2 Develop an Initial Air Monitoring Plan

— **Types of responses:** Emergency events involving petroleum releases or fires can be generally divided into two types:

  — an event at a facility where facility personnel are the first on-scene responders and can assume some degree of air monitoring duties;

  — an event at an unstaffed facility or along a right-of-way where the local fire responders will be the first to arrive and assume air monitoring duties.

— **Initial air monitoring plan—staffed facilities:** Before air monitoring activities begin, it is advisable to create and have an AMP in place. This plan should outline the specific COIs relevant to the response, their corresponding Als, and the corresponding actions. The AMP can be pre-planned and include potential scenarios, COIs, monitoring points, uses, and limitations of air monitoring equipment, and integration with responding agencies.

— **Initial air monitoring plan—right of way:** In most scenarios, local fire departments will be the first to arrive and assume community protection duties. Fire officials may rely on the ERG to set evacuation or sheltering duties or may rely on air monitoring to establish community protection actions. Early arriving fire units may only possess four-gas meters, which may be incapable of detecting chemicals such as benzene. In some cases, rural or volunteer fire units may have no portable air monitoring capabilities and rely only on the ERG to set evacuation or sheltering duties. The initial AMP includes all initially available resources and ALs, including the lack of available resources.

— **Approach from an upwind/uphill/upstream direction:** Once the response-specific COIs have been identified, the next step is to ascertain the extent of the affected area(s). Response personnel should deploy air monitoring teams to conduct air quality assessments at various locations, approaching from an upwind direction and, as most flammable vapors are heavier than air, an uphill direction. When performing initial air monitoring on water, the approach should be made from the upstream side of the potential hazard. In all cases, initial air monitoring teams should approach slowly to help ensure that accurate readings from the ground to breathing zone are taken, while also paying close attention to atmospheric trending. Should air monitoring results continue to increase at each step of an investigation, there is no need to continue to the point where the AL is reached. Consider action level mitigation measures (see 3.6.1) and re-evaluate the approach based on response safety and priorities.

Depending on the concentrations of COIs present, it may be necessary to use respiratory protection to help ensure the safety of those approaching the scene (Section 5 of this document outlines the use of respiratory protection). It is advisable to gradually advance toward the release and/or fire while conducting real-time air monitoring. This step-by-step approach allows for a thorough evaluation of airborne constituents.

Environmental factors, such as wind speed and direction, can change unexpectedly, potentially leading to significant fluctuations in COI concentrations at a specific location. Consequently, the initial response personnel approaching a release or fire should maintain a heightened level of situational awareness. The deployment of windsocks along the approach path offers a continuous visual reference for monitoring wind direction and speed**.**

When selecting monitoring equipment, consider the specific COIs and information from the SDS for the chemicals involved. The air monitoring equipment should be suitable for the response. If initial responders lack the necessary air monitoring equipment for a proper assessment, it is best that they wait for the appropriate equipment before approaching a release or fire. Once comprehensive monitoring data can be collected, establishing safety zones and defining the roles and activities within each zone will help to ensure safety during the response operation.

6.2.1 Release Site or Work Sites—Establishing Safety Zones

In the initial stages of a response, the full scope of a release or fire might not be clear. An evaluation should be performed to understand the extent of the event and determine if more responders and resources are required. As response personnel arrive at the scene, a hazard assessment is conducted to devise strategies to protect workers and communities. Safety zones should be established based on air monitoring readings and any additional safety concerns. In the absence of air monitoring, the initial exclusion zone recommended in the ERG should be maintained. Prior to beginning response operations and before each ongoing operational work period, all response personnel should be briefed (operations briefing) on the specific hazards present and PPE requirements for each zone. Examples of safety zones are shown in Figure 8 and typically include the following:

— **Hot zone:** Also known as the “exclusion zone,” this area is closest to the release or fire location, where there are elevated concentrations of COIs and other hazards that necessitate workers to wear enhanced PPE or bunker gear. It is recommended that this zone be clearly marked and delineated with red DANGER or yellow CAUTION tape to signal the risk and the need for caution when entering this area.

— **Warm zone:** Also known as the “contamination reduction zone,” this is the transition area between the hot zone and cold zone. This area is where responders enter and exit the hot zone and where decontamination activities take place.

— **Cold zone:** Also referred to as the “support zone,” this area provides a secure working environment where concentrations of COIs are not expected to exceed ALs. Typically, the cold zone serves as a central hub for operational activities, allowing responders to gather, coordinate their efforts, and access or exit the response area.

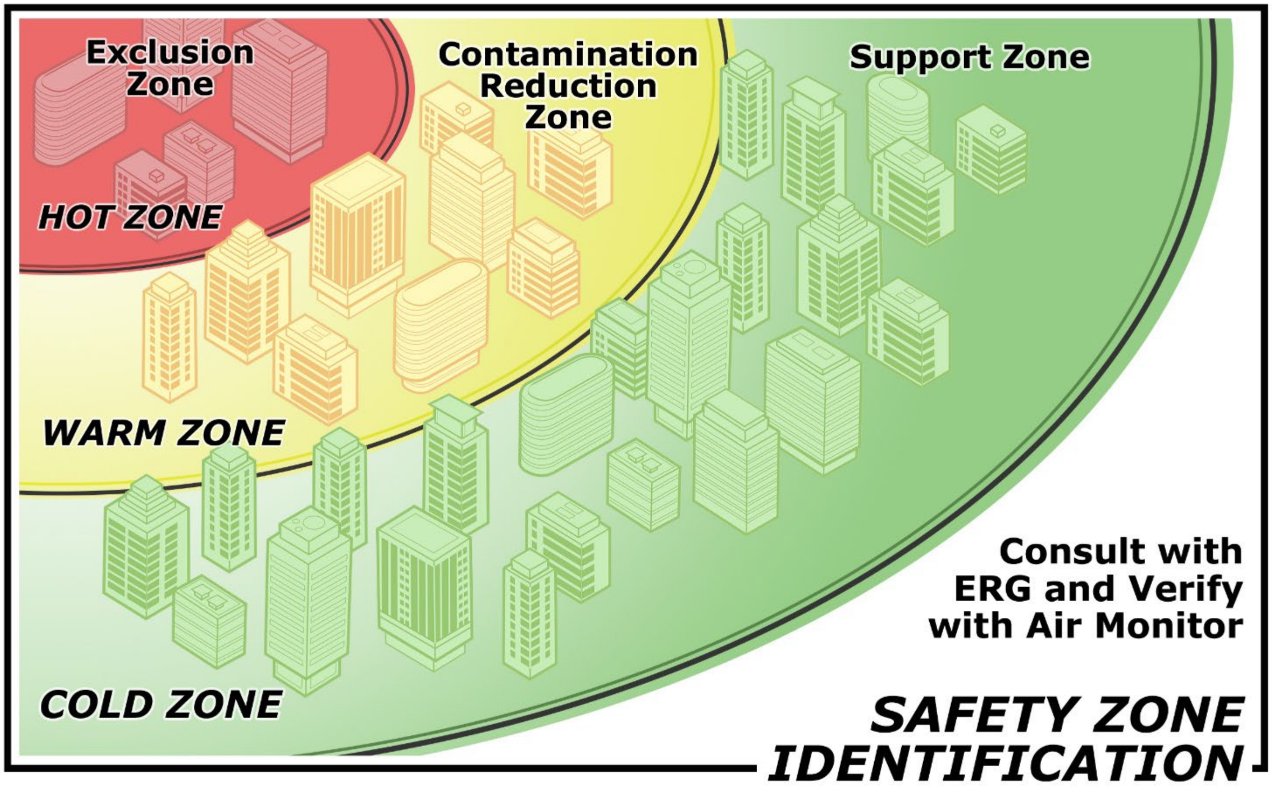

Figure 8—Safety Zone Identification

6.2.2 Community Air Monitoring

While it is likely that initial responders will rely heavily on the ERG to determine initial exclusion zones and downwind evacuations, they should supplement this effort with actual air monitoring data collected with whatever equipment is readily available, whether it is from the local fire agency or responsible party. A short-term plan should be developed that includes locations to be monitored, data collection, ALs, and reporting structure. Particular attention should be paid to locations with higher populations or sensitive populations, such as hospitals, nursing homes, schools, and any other location with congregations of people. In urban areas, monitoring should be conducted in a complete circle around the response area. However, in rural areas, access to the surroundings may be restricted or require permission from property owners.

6.3 Develop a Long-term Air Monitoring Plan

For events that have the potential to last more than several hours, responders should develop a robust AMP to supplement the initial plan. This plan should be developed with input from participating agencies and approved by the unified command, and, ideally, by a Certified Industrial Hygienist (CIH). The AMP should include maps and locations of areas to be monitored, COI, their hazards and ALs, and actions to be taken in the event of readings exceeding ALs. As described in Section 7, this plan should include air monitoring roles and responsibilities. The overall goal of the plan is to provide competent and definitive air information to decision makers that will allow them to make decisions that help protect the community and workers.

7 Air Monitoring Roles and Responsibilities

In emergency response scenarios, initial responders often temporarily assume crucial roles until more suitable personnel or groups become available to assume these responsibilities. This pattern extends to the assignment of air monitoring roles, as well. Additionally, the jurisdiction of responding agencies can influence which stakeholders require specific air monitoring data. This section outlines the appropriate air monitoring roles and the associated responsibilities expected of various response stakeholders. Responders with air monitoring equipment may include:

— local fire departments with four-gas meters (H_2S, LEL, oxygen, CO) and/or PIDs;

— responsible parties with four-gas meters and/or PIDs;

— hazmat teams with advanced air monitoring equipment;

— public health teams with advanced air monitoring equipment;

— state air teams with advanced air monitoring equipment;

— federal environmental teams with advanced air equipment;

— air monitoring contractors with advanced air equipment.

This equipment can include PIDs, stationary multi-sensor monitors, mobile vans, airplanes, drones, helicopters.

7.1 Air Monitoring Roles

The first individuals to arrive who are equipped with air monitoring capabilities will typically carry out the initial air monitoring activities. The steps that should be followed by initial responders are outlined in Section 6.

At the start, this role may be taken on by firefighters, facility personnel, government agencies, representatives of the responsible party (RP) or potentially responsible party (PRP), or a combination of available individuals. As more resources arrive at the response, the response roles will likely change. Two possible scenarios are outlined in 7.1.1 and 7.1.2.

7.1.1 RP/PRP Leads Air Monitoring

In a situation where the RP/PRP possesses adequate air monitoring capabilities, they or their contractors may take on the lead air monitoring role. This entails initiating and overseeing ongoing air monitoring activities within work areas and neighboring communities, as well as reporting air monitoring data to relevant government agencies and other stakeholders as required.

For government agencies and additional stakeholders, their role would involve conducting supplementary air monitoring within their jurisdictional boundaries for the purposes of quality assurance and quality control (QA/QC). The AMP should identify the particular assignments for each entity with air monitoring duties or responsibilities.

7.1.2 Integrated Air Monitoring Responsibilities

When the response takes place in an area where local fire departments or regulatory agencies have air monitoring resources, the responsibilities for air monitoring may be shared. The AMP will determine how to best place each agency and equipment to maximize effectiveness. The AMP will outline contaminants of interest, technologies to be used, ALs, and metering technology.

7.2 Air Monitoring in an Incident Command Structure

In response scenarios that employ the incident command system (ICS), in a single command it is a standard procedure for all AMPs to be subjected to review and approval by appropriate members of the command and general staff. In the case of a unified command, the members of the unified command will also review and approve the plan. The ICS 207 Organizational Charts in Figure 9 outline the following scenarios:

— **Unified command:** The on-scene coordinator (OSC) serves as part of the unified command along with the RP, and may bring in their own air monitoring contractors to complement RP operations. This is most likely when community air monitoring is a heightened concern.

— **Single command:** The OSC, whether onsite or remote, acts in an observer or oversight role during the incident, and a unified command is not established. In this case, the OSC may request to review air monitoring or other plans associated with the RP's response.

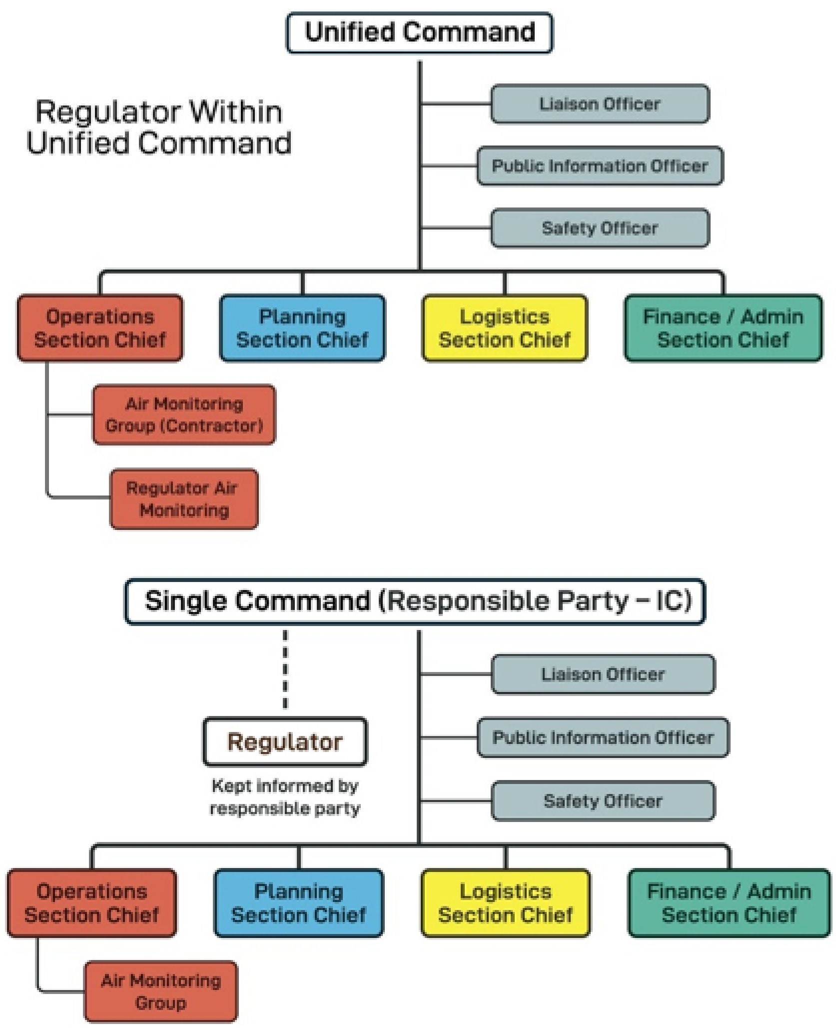

Figure 9—Air Monitoring in an Incident Command Structure

Air monitoring ICS roles may include the following positions:

— **Air monitoring technician:** Whether from the RP, first responder, third party, etc., this role is to perform initial and/or ongoing air monitoring assessments and contribute to the development of the AMP. This is done through onsite capture of real-time air monitoring results and the documentation and assessment of those results to develop the AMP.

— **Air monitoring group/division supervisor:** Should there be more than five to seven AMTs (span of control), the introduction of an air monitoring supervisor should be considered. The AMS will manage one or multiple AMTs and consolidate all air monitoring data for review and action by the unified or single command.

— **Air monitoring data analyst:** This may be an onsite or offsite specialist who compiles field air monitoring data and develops reports for updates to the AMP and use of the unified/single command in continuous implementation of safety protocols/procedures based on data results.

— **Air monitoring technical specialist:** This role is often a toxicologist and typically onsite to support the safety officer, interpret air monitoring results, and develop enhancements to the AMP. This role will work directly with the AMS in the field and report to the safety officer in the command post.

7.3 Documentation

Air monitoring documentation is needed to keep track of potential exposures and display progress made during the response. Detailed air monitoring notes should be collected and include:

— location (GPS coordinates, if possible);

— time/date;

— any relevant activities taking place;

— weather information, including wind direction;

— any odors observed;

— relevant photos;

— sustained reading (one-minute average);

— peak readings (not sustained, but noteworthy);

— investigative readings.

The primary methods for recording air monitoring data are digital or app-based programs, field notebooks, and standardized forms. Examples of standardized field forms that can be used by response personnel can be found in Annex C. If a handwritten method is used, air monitoring records should be backed up digitally to help ensure that no records are lost. Several apps are available to scan notes into a PDF for safekeeping.

7.3.1 Data Management

During a response, data collection typically begins at the notification stage and increases exponentially as the response progresses. Given the large volume of data collected, it is helpful to standardize the data collection methods for the response. All raw data collected during the initial phase should undergo a review for QA/QC purposes before being reported. This process involves identifying and addressing any erroneous or inaccurate data entries, and may include the following steps:

— removing inaccurate or incomplete records;

— removing duplicate readings;

— removing non-representative readings that may have been recorded during equipment calibration.

If air monitoring data is being published in real-time, it should be considered preliminary until adequate QA/QC has been performed.

NOTE Unedited, raw data should be retained separately for legal purposes.

7.3.2 Data Reporting

Air monitoring data should be communicated to regulatory agencies and stakeholders at agreed-upon intervals, typically ranging from 12 to 24 hours, or following the ICS operational period. These reporting periods can be adjusted as response conditions change and data trends emerge.

To present air monitoring data effectively, the information can be summarized in a table format. Any exceedances of Als; work activities influencing air monitoring; required PPE; and any mitigation measures implemented during the reporting period can be elaborated upon in the accompanying text following the table.

Data reporting requirements will be response-specific, but typical information reported include:

— total readings collected;

— peak recorded values;

— number of AL exceedances (one-minute average);

— mitigation measures used in the case of any AL exceedances.

When discussing air monitoring readings, use clear and unambiguous language to help ensure accurate communication. The following are examples of ambiguous language and more appropriate alternatives:

— instead of "high readings," use "exceeding AL";

— instead of "low readings," use "below AL";

— instead of "zero," use "non-detect."

8 Environmental Considerations

8.1 Terrain

Certain gases and vapors may collect in low-lying areas, such as ditches, culverts, or valleys near spilled products. The propensity of gases and vapors to exhibit this behavior is defined by their vapor density. A vapor density less than 1.0 indicates a gas or vapor will rise and disperse under normal conditions; a vapor density greater than 1.0 indicates a propensity for that gas or vapor to sink, and potentially collect in low-lying areas. Table 1 lists the vapor densities for common petroleum gases and vapors.

Table 1—Common Gases and Vapor Densities

Compound	Vapor Density
Gasoline	3.5
Crude oil	3.5
Liquid petroleum gas	1.6
Benzene	2.8
Hydrogen sulfide	1.2
Methane	0.5
Hydrogen	0.7

8.1.1 Two-phased Releases

Several COIs transported by pipeline, rail, or truck may exhibit two-phased release properties, releasing both a liquid and a gas at the same time. This can potentially result in a gas that is moved by the wind and a liquid that follows the terrain.

8.1.2 Vapors and Sewers

Events in urban areas have the potential to affect sewer systems. Responders should identify whether sewers are impacted and conduct air monitoring as required, especially for flammable products. In these cases, the AMP should include a storm sewer map, if available. Responders should note that flammable products with vapors that are lighter than air pose a particular hazard, as the liquid will follow the drainage pattern of the sewer, while the vapors, being lighter than air, may move uphill through the sewer system.

8.2 Weather

The weather may have a significant impact on petroleum releases and their resultant air concentrations. The most important weather phenomenon that will affect air concentrations is the diurnal rising and setting of the sun. When the sun rises, it heats the earth’s surface, which warms the air immediately above the surface of the earth. This warm air tends to rise, then cools as it rises, and then fall once cooled. During the day, this rising and falling occurs between zero and approximately 1,000 meters above the earth's surface. This portion of the atmosphere becomes well-mixed through the resulting turbulence, which aids in dispersion, and is described as being an “unstable” atmosphere. At night, the Earth cools and radiates its heat into the atmosphere above. This creates warm air at elevation and cooler air near the surface of the earth, a situation that is described as “very stable.” The stability of the atmosphere is graded from 1 to 6, with 1 being “very unstable” and 6 being “very stable.” Surface wind speeds can also affect atmospheric stability, with increasing wind speed causing an increase in atmospheric stability.

8.2.1 Thermal Inversion Effect on Plumes

In extreme situations, with very cold air near the surface of the earth, and warm air at elevation, a thermal inversion may result. An inversion will create a concentrated, still atmospheric condition near ground level, and will prevent dispersion of any released product, maximizing the air concentrations of any compounds of interest and potentially creating a greater hazard to receptors downwind of the release.

8.2.2 Smoke Clouds

Smoke clouds from petroleum fires are driven by winds and the fire itself. A hotter fire will send particulate matter higher into the atmosphere. As a fire burns down, it loses heat and particulate matter does not travel as far. The AMP should be flexible enough to account for these stages in a fire event. Data collection may be used by decision makers to determine the need to extinguish a fire instead of allowing it to burn itself out.

8.3 Plume Modeling

Plume modeling may be used to estimate air concentrations before air monitoring is available at the incident scene. Plume modeling uses well-established mathematical principles to estimate air concentrations using information available from the site, including the type of commodity spilled, vapor pressures, temperatures, meteorological information (wind speed, direction, sunlight intensity, and other parameters used to determine atmospheric stability), pressures, pool sizes of pooled liquids, etc. This information can be used to produce quite accurate estimates of air concentrations to help establish hot, warm, and cold zones prior to any air monitoring taking place. A plume model is useful in understanding how certain factors, such as an atmospheric inversion, may influence how far a release might travel. Inversions trap emissions in a smaller vertical space and cause them to travel further downwind. There may be conditions in which vapors are moving in the opposite direction of liquids spilled in a ditch, and plume modeling can be employed to provide estimates of atmospheric concentrations. Figures 10 and 11 illustrate the same release amount under both normal atmospheric and inversion conditions.

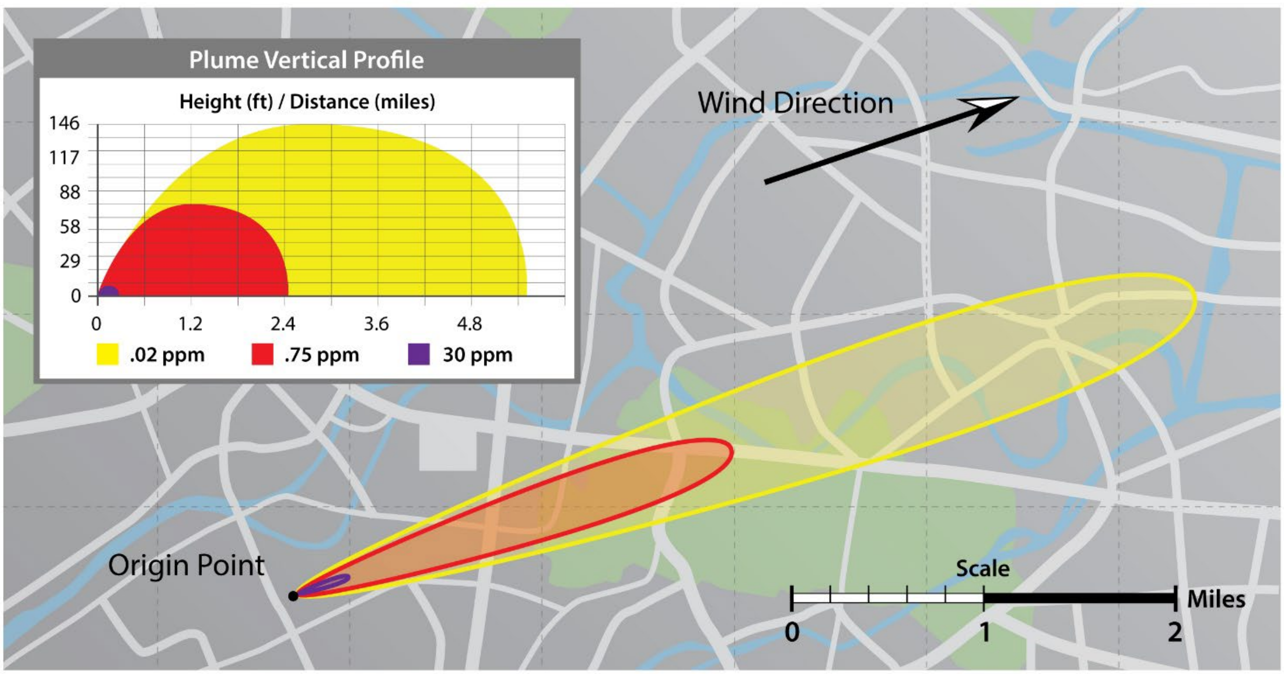

Figure 10—Normal Atmospheric Conditions

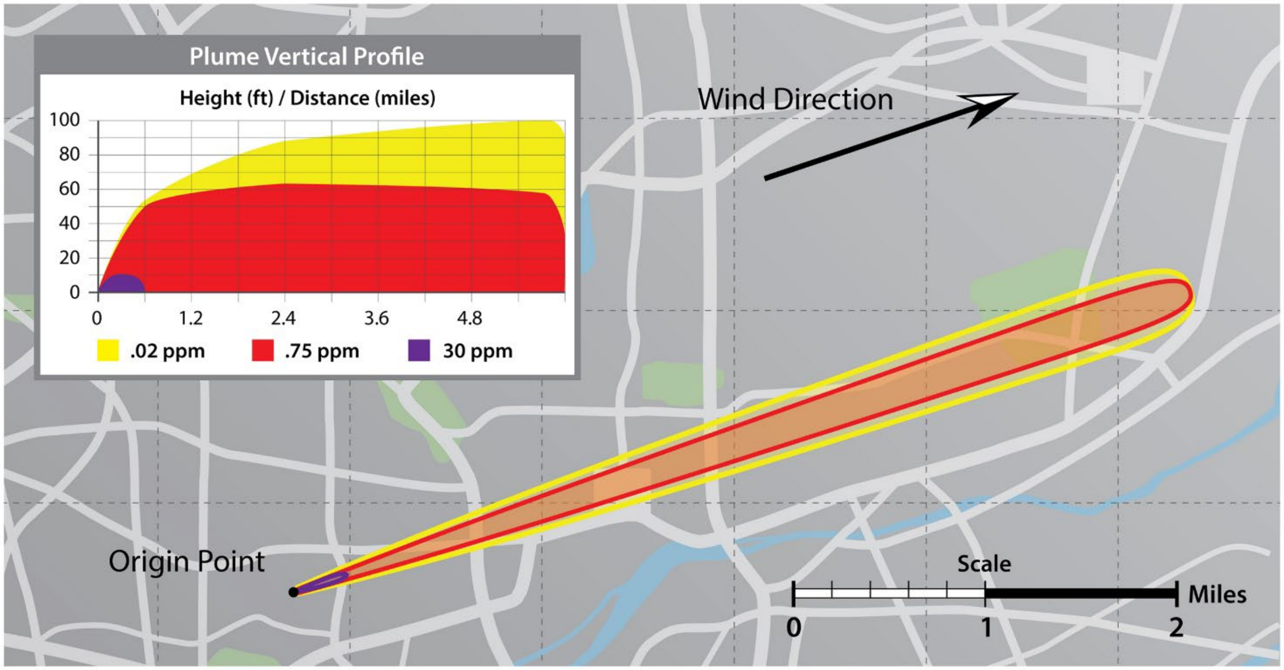

Figure 11—Inversion Conditions

Annex A
Example Community Air Monitoring Response

Community air monitoring assesses air quality during incidents involving hazardous chemicals. In this section, we will explore a real-world example of community monitoring implemented during an emergency situation.

A.1 Incident Overview

A pipeline carrying petroleum products ruptured in a rural, mountainous community (incident). The incident occurred close to multiple residents in the community and approximately one mile from the center of the small town. Due to the close proximity to the town and the presence of multiple nearby residents, immediate concerns were raised about hazardous levels of petroleum-related chemicals negatively affecting air quality.

A.2 Initial Three Hours of Response

First on the scene were local emergency response agencies that used a combination of the ERG and four-gas and/or five-gas monitors to determine exclusion zones. Once the pipeline company arrived with additional air monitoring resources, the emergency agencies and the pipeline company prepared an initial air plan that covered the release site, worksites, and the neighboring community. Any evacuations were performed by the local emergency response agencies.

In addition to responding to the event, the pipeline company notified its contracted third-party company's air monitoring team to respond and independently assess air quality in the surrounding community and at the location of the incident. Members of the air monitoring team immediately started mobilizing to the incident with all applicable equipment, including handheld monitoring devices, stationary monitoring devices, and colorimetric tubes capable of measuring all constituents of interest (COIs). During the mobilization phase, a preliminary air monitoring plan and a health and safety plan were created by the air monitoring team leader and support staff. This plan incorporated action levels that were determined by the jurisdiction having authority (JHA). It also included information on how those actions would be performed—who would be making community notifications, what the message would be, who would carry out evacuations or sheltering-in-place operations, and how those decisions would be made. The plans would be approved by the unified command prior to being implemented.

NOTE Third-party monitoring by specialized companies is helpful to ensure data quality (due to the higher level of experience and preparedness provided by such companies) and objectivity.

In the incident, hazardous air quality may have affected the nearby town, nearby residents, and roadways leading in and out of the area. An air monitoring perimeter was established to encompass all areas identified as potential receptors. Initial monitoring was focused downwind of the incident to establish the furthest extent of potential impacts from the incident site.

The initial air monitoring professionals to arrive at the incident documented air monitoring readings of COI in the surrounding community above the action levels outlined in the air monitoring plan. Real-time air monitoring data was relayed to local fire and police departments, and an evacuation of the surrounding community followed. All decisions in regard to evacuation were made by the JHA (in this case, the local fire department). All information shared in regard to response activities was conducted through a formal unified command using incident command structure (ICS) principles of cooperation between the responsible party (RP) and regulatory agencies.

A.3 Initial 24 Hours of Response

Within 24 hours, additional air monitoring professionals mobilized to the incident, providing more equipment and resources. Stationary air monitoring devices were deployed in the nearby town and at the closest residence to the incident to continuously assess air quality within the community.

Real-time air monitoring conducted within the first 24 hours indicated a safe atmosphere in the surrounding community. Once these readings were communicated to the unified command, the evacuation order was lifted and residents returned to their homes. Multiple air monitoring professionals continued to collect community air monitoring data using handheld and stationary air monitoring devices to ensure that changing conditions would be detected and appropriate action would be taken.

Real-time air monitoring data collected was summarized in 12-hour periods and provided to the RP and regulatory agencies for review within the unified command, and for public distribution as warranted.

A.4 Initial 72 Hours of Response

Real-time air monitoring data collected beyond the first 24 hours of the response continued to indicate a safe atmosphere in the surrounding community. As the incident stabilized and uncontrolled atmospheric releases of COI were controlled and contained, stationary air monitoring devices positioned in the community were reduced and relocated closer to the incident.

Atmospheric levels of petroleum-related COI were still present at the location of the incident and had the potential to affect the surrounding community. Air monitoring professionals continued to monitor the surrounding community using handheld real-time air monitoring instruments while cleanup activities were ongoing at the location of the incident.

Real-time air monitoring data were moved to 24-hour data summaries and continued to be provided to the RP and regulatory agencies for review within the unified command, and for public distribution as warranted.

A.5 72 Hours to Response Completion

Work activities leading to the completion of the response involved pipeline inspections, cleaning and purging, and other cleanup activities. Real-time air monitoring readings continued to be collected from handheld or stationary devices until all COI were transferred away from the area and there was no longer a potential for community air quality hazards resulting from the incident.

Annex B
Template Air Monitoring Plan

Site Name / Location: ____ **Date:** ________________
Prepared By: ___________________ **Approved By:** ____________________ **Version:** ________
Background Information: Briefly describe the location (urban, rural), landscape (mountains, bodies of water), hazards (fire, vapors), historical uses of the location, and what caused the release.

____
____
____
____
____

Occupational Exposure Limits and Guidelines and LEL and UEL Concentrations

Airborne Hazards	OSHA PEL		ACGIH TLV		NIOSH-IDLH	Units	LEL/UEL Concentration (% by volume)
	TWA	STEL	TWA	STEL			
Example: Benzene	*1*	*5*	*0.5*	*2.5*	*500*	*Ppm*	*1.2% / 7.8%*

Occupational Air Monitoring Action Levels

Airborne Hazards	Action Level[1] – 1	Action Level – 2	Action Level – 3	Units
Example: Benzene	*< 0.25*	*≥ 0.25 and < 2.5*	*≥ 2.5*	*ppm*

Action Level	Mitigation Measure
Action Level: 1	**Below:** No action required. **Above:** Notify industrial hygiene specialist and implement site control activities.
Action Level: 2	
Action Level: 3	

Notes:

1. It is recommended that Action Level 1 levels are based on half of the lowest OEL guidelines.
2. The evaluation of air monitoring readings relative to the established ALs should be based on a sustained (usually approximately one minute) average of levels measured by real-time air monitoring instruments. If the readings of a COI are greater than the AL and are sustained for the associated averaging period, they should be considered an exceedance.

Example Mitigation Measures:

Action Level 2: Relocate upwind, ventilate, don APR, apply vapor suppression, etc.

Action Level 3: Communicate confirmed readings to appropriate personnel and initiate stop work, don SCBA, etc.

Real-Time Air Monitoring Instrumentation

Equipment Utilized	Detection Method	Parameter	Detection Limit	Units	Serial Number	Correction Factor (if applicable)
Example: MultiRAE	*Photoionization Detector*	*Benzene*	*0.1*	*ppm*	*MO1EA14260*	*0.48*

Community Monitoring Required? (Circle One) Yes / No

Summary of Protective Action Criteria

COI	PAC-1 Concentration[1,2]	PAC-2 Concentration[1,3]	PAC-3 Concentration[1,4]	Units
Example: Benzene	*52*	*800*	*4,000*	*ppm*

Notes:
1. If the average concentration of a COI is exceeded over the 1-hour period, exposed community members should be notified, and mitigation measures should be implemented. Evacuation or shelter-in-place decisions should be discussed with the appropriate authorities.
2. PAC-1: Mild, transient health effects.
3. PAC-2: Irreversible or other serious health effects that could impair the ability to take protective action.
4. PAC-3: Life-threatening health effects.

Community Real-Time Air Monitoring Action Levels

Airborne Hazards	Action Level[1] – 1	Action Level[1] – 2	Action Level[1] – 3	Units
Example: Benzene	*< 0.25*	*≥ 0.25 and < 2.5*	*≥ 2.5*	*ppm*

Action Level	Mitigation Measure
Action Level: 1	**Below:** No action required. **Above:** Notify industrial hygiene specialist and implement site control activities.
Action Level: 2	
Action Level: 3	

Notes:
1. Work zone and perimeter action levels will be used for airborne hazards where community action levels have not been established.

Example Mitigation Measures:
Action Level 2: Initiate vapor suppression on site, relocate the hazard, etc.
Action Level 3: Communicate confirmed readings to appropriate personnel and =initiate community evacuation or shelter in place.

Annex C
Field Forms

Site Map/Diagram Form

Page___of___

Personnel/Company: ______________________

Site Name: ______________________________

Location: _______________________________

Release Type: ___________________________

Date: ___________________________________

North Arrow

Wind Direction

Approximate Area of Incident and Site

(Include location of air readings (coordinates), potential nearby receptors, wind direction, notable features, and buildings)

Equipment Information

Page___of___

Personnel/Company: ______________________

Site Name: _______________________________

Location: ________________________________

Release Type: ____________________________

Equipment:_____________________ Calibration Date: ______________

Serial Number:___________________

Model no: ______________________ Calibration Time: ______________

Calibration Tolerance: ____________

Calibration Gas Type	Calibration Gas Lot Number	Calibration Gas Supplier	Calibration Gas Expiration Date

Calibration	Fresh Air	Span	Bottle Value
LEL (%)			
Oxygen (%)			
H2S (ppm)			
CO (ppm)			
Isobutylene (ppm)			
Other:			

Notes:

Colorimetric Detection Tubes Utilized			
Tube Analyte	Tube Lot Number	Tube Manufacture	Tube Expiration Date

Additional Field Notes:

Personnel/Company: ______________________
Site Name: ______________________________
Location: _______________________________

Real-Time Air Monitoring Log										
Date/Time	Location Description (Diagram Reference)	Oxygen (%)	LEL (%)	CO (ppm)	H_2S (ppm)	VOC (ppm)	Other:	Colorimetric Detection Tube Reading	Photo Taken	Comments

Example										
04/23/23 16:00 CT	*Work Area near Frac Tank (Location A)*	*20.9*	*0*	*0*	*1.5*	*0*	*0*	*Benzene: 0 ppm, standard range*	*Yes*	*Suggested Comments: Odors, respiratory protection status, downwind/upwind, worker status*