Bioenvironmental Engineering Site Assessment I

Unit 4: Sampling

Unit Description: For this unit, you will be stationed at Jenks AFB in Oklahoma City. As you participate in various sampling situations around the base, you'll be learning how sampling and the development of a sampling strategy relate to the HRA process and OEHSA. You'll learn to develop a sampling strategy, collect and perform field analysis on soil and solid samples, and interpret sampling results.

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Lesson 1: Overview of Sampling Strategy Development

Lesson Description

Before performing your sampling duties at Jenks AFB, you need to understand how to develop a sampling strategy. Upon completion of this lesson, you will be able to describe how sampling and the development of a sampling strategy relate to the HRA process and OEHSA.

Lesson Overview (Page 1 of 5)

Before you perform sampling, you must develop a sampling strategy, which is an overall plan or framework for sampling that includes the details of the entire sampling process from beginning to end.

While preparing to answer your OIC's questions, you will:

- Explain the relationship of sample strategy development to the HRA process and OEHSA.
- Explain how routine and special assessments affect the development of the sampling strategy.

Audio Script

OIC: As you know, one of your primary responsibilities on the base is sampling. But, of course, you can't just go out to a site and start collecting samples - you have to develop a strategy to guide your efforts. To make sure you understand the fundamentals of sampling strategy development, I'm giving you some information to read. Be prepared to answer any questions I may have when you get done.

Sampling Strategy (Page 2 of 5)

Sampling is conducted during **routine (initial)** or **special** assessment as a part of the OEHSA process. Sampling is also necessary in order to identify and analyze health threats and risks while conducting an HRA.

Sampling strategies are used to analyze chemical, biological, radiological, and nuclear (CBRN) hazards in various environmental media to include air, soil, solids, water, and non-aqueous phase liquids (NAPLs). Occupational and environmental health sampling is critical to assist in the assessments of health threats to personnel not only during expeditionary settings, such as beddown decisions, but also to assist with decision-making to protect personnel in garrison.

If multiple health hazards that pose a threat to workers and/or the public exist within an AOC, it will be necessary to develop several sampling strategies to address the multiple health risks for a given similar exposure group (SEG).

Routine Assessment

Routine assessment is a qualitative and/or quantitative assessment that identifies health hazards and associated risks to focus limited resources in a prioritized manner.

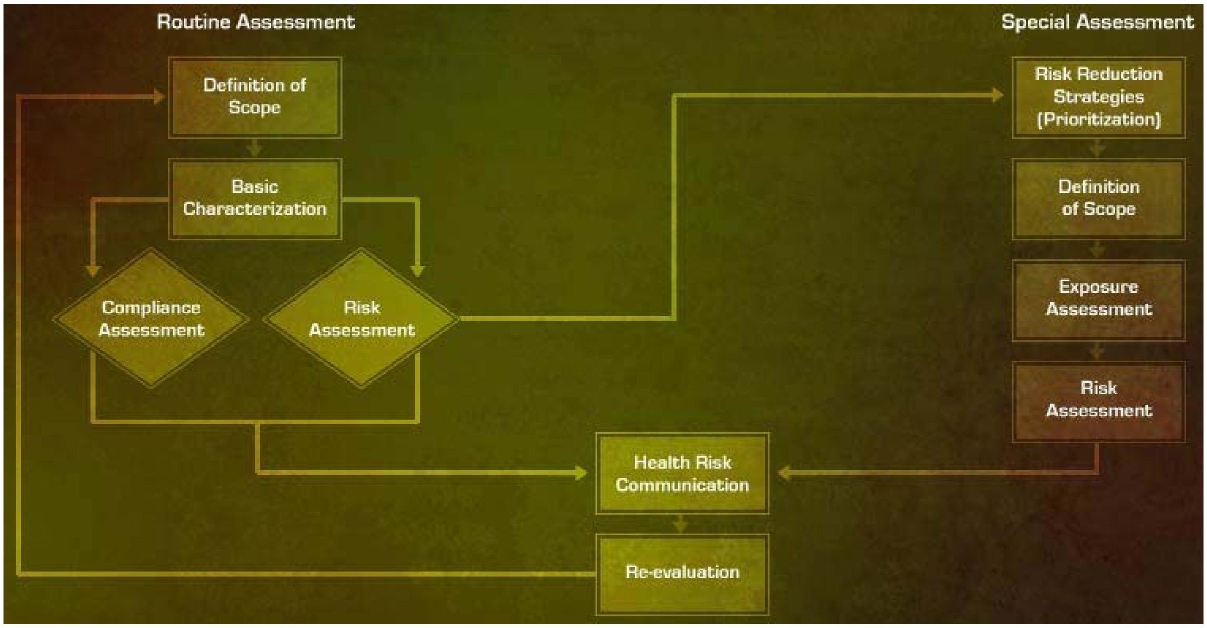
Please note, as assessment is discussed relative to HRA and OEHSA you may notice a slight difference in terminology. Initial assessment and routine assessment are both used to refer to the preliminary sampling approach.

Special Assessment

Special assessment is typically a quantitative assessment that focuses resources on hazards related to Occupational and Environmental Health (OEH) that require additional evaluation or classification based on information gained during routine assessment.

The OEH Assessment Model (Page 3 of 5)

You will develop your sampling strategy as you work within the framework of the OEH Assessment Model. Following are descriptions of each of the components of the model represented in the graphic.



Definition of Scope

When conducting routine assessment, first you must define the scope of support and resources needed. You must perform routine assessment in newly identified industrial shops within three months of identification to establish a foundation upon which to base future assessments. You may need to meet with commanders of organizations or their representatives to identify their mission requirements, relative pace of military operations ("ops tempo"), and concerns for the health of their members.

At times, you will receive unscheduled requests regarding potential health risks identified from outside the routine assessment process which must be prioritized for appropriate evaluation. Examples of unscheduled requests are occupational illness or injury reports, pregnancy evaluations, and individual complaints.

Defining the scope involves programming and budgeting for required manpower, equipment, and supplies, as well as scheduling and suspensing.

Basic Characterization

Next, characterize the health threat by reviewing previously collected data, performing a quality assessment of the data, identifying applicable processes and evaluating existing controls designed to address each health threat. As a part of this step, you will also establish the similar exposure group (SEG) based on the processes performed by each affected group and/or associated potential exposures of personnel.

Compliance Assessment

Compliance assessments are performed where required by program management regulations such as for respiratory protection, hazard communication, confined spaces, and others. These assessments are to determine program status and are only performed in garrison as a part of the routine assessment. However, specific compliance standards, such as drinking water standards, must also be adhered to during deployment settings.

Compliance assessments are performed with three objectives:

- To protect and enhance human health.
- To assist commanders in complying with federal, state, local, and Air Force OEH regulations, standards, and policy.
- To increase mission effectiveness through fact-based risk management decision making.

Risk Assessment

Assess the exposure to the health threat using confidence in existing controls and threat characterization. Then, determine the operational health risk based on severity and probability of exposure. As a part of this step, you will also identify OEH risk reduction strategies such as implementation of administrative controls, engineering controls, and personal protective equipment (PPE).

Risk Reduction Strategies (Prioritization)

Prioritize assessment needs in order to maximize the time and resources you have available. This prioritization of viable exposures is used as the basis for the overall sampling strategy. Once the Areas of Concern (AOCs) and their respective exposure hazards have been identified and infeasible exposure pathways eliminated, you should determine the risk rating and rank of each exposure pathway.

Only AOCs with complete or potentially complete exposure pathways are evaluated and given a risk rating. For the exposure pathway to be complete, the media, activity or point of exposure, and exposure route all must be present. A potentially complete pathway is one in which a gap in the data exists so that a follow-up assessment, such as sampling or biological monitoring, is required to determine whether the pathway is complete. Incomplete pathways are documented but eliminated from further evaluation.

Definition of Scope

Just as in routine assessment, you must define the scope of support and resources needed. This includes identifying organizations to be served, prioritizing unscheduled requests, budgeting manpower and equipment, and scheduling visits for conducting exposure assessments.

Exposure Assessment

The next step in the special assessment process is collecting exposure assessment data. The primary reason for performing an assessment is to increase confidence in controls or hazard characterization. Confidence in controls is a qualitative (and sometimes quantitative) assessment of how well and how consistently the hazard is controlled. In some ways, this measures the probability of the control to prevent exposures.

In determining your confidence in hazard characterization, a number of factors should be considered. These factors include sampling and analytical error, variability in sampling results, similarity to results from similar operations, and representation of the activity analyzed.

Risk Assessment

A risk assessment will be conducted in the same manner as described for routine assessment for those risks with a completed exposure pathway. The assessor will reevaluate risk rationale for selecting the appropriate confidence in controls and characterization, and document if confidence levels change.

Health Risk Communication

Health risk communication is a mechanism to convey health hazard information, workplace exposures, compliance assessments, and other health risks to workers, commanders, and medical staff. Health risk communication is performed at all levels of the assessment process through a multitude of means and can be as simple as making a phone call or as detailed as completion of an initial survey report describing all facets of an industrial operation.

The unit or squadron commander must be well-informed to make decisions regarding control strategies. You also need to remain informed about new or changed workplaces or processes, illness or injury data, adverse occupational health exam trends, or concerns raised by members of the unit. Remember to document all health risk communication.

Reevaluation

The final step of the process is to determine when and how reassessment will occur. Depending on the risks identified, you must repeat the health risk assessment process, including reassessment of control effectiveness, and establish procedures for identifying significant process changes.

Scenario Challenge Point (Page 4 of 5)

Now that you have read the training information your OIC has some questions for you.

During which part of OEHSA is sampling conducted?

A Site Reconnaissance

B Predeployment/Baseline Activities

C Conceptual Site Model

D Routine or Special Assessment

In what two ways does the assessment type affect sampling strategy development?

A	With special assessment, you must prioritize the assessment needs by determining the risk rating and rank of each exposure pathway.
B	Health threats identified during routine assessment can determine the need for more in-depth sampling during special assessment.
C	When conducting special assessment, it is not necessary to define the scope of support and resources, including manpower and equipment, needed.
D	Compliance assessments are conducted only for deployed settings to enable fact-based risk management decision-making and ensure adherence to regulations.

Lesson Summary (Page 5 of 5)

You have learned how sampling is affected by the type of assessment being performed.

Remember that the development of the sampling strategy is necessary to identify and analyze OEH health threats and risks during an HRA, and is a significant component of any OEHSA.

In this lesson you:

- Explained the relationship of sample strategy development to the HRA process and OEHSA.
- Explained how routine and special assessment affect the development of the sampling strategy.

Audio Script

OIC: Now you should be prepared to develop some strategies for the various sampling needs around the base.

Lesson 2: Air Sampling

Lesson Description

Jenks AFB provides depot maintenance on the Air Force's most sophisticated weapons systems and other special aircraft when needed. In this lesson, you will evaluate workers' exposure to paint they are using on a one-of-a-kind aircraft, NASA's 377SGT-F "Super Guppy." Upon completion of this lesson, you will be able to explain the procedures for developing an air sampling strategy.

Lesson Overview (Page 1 of 18)

Air sampling is critical to identifying and analyzing health threats and risks. Remember that it is important to develop a sampling strategy before collecting samples.

As you complete the assessment of the corrosion control shop workers' exposure, you will:

- Determine the exposure assessment goal.
- Select air sampling tactics.
- Select the appropriate standard.
- Summarize the various types of standards.
- Calculate equivalent Occupational Exposure Limits (OELs).

Audio Script

OIC: As you may have heard, our Air Logistics Center is performing depot maintenance on the Super Guppy for NASA. Someone else from the BE Office has already been over at the hangar while the aircraft was being de-painted. The workers will be ready to start painting soon, and I'd like you to collect air samples during that process.

They're using the same hangar they typically use for the E-3 AWACS, which is about the same size as the Super Guppy, so we're fairly confident in the ventilation system's capabilities. But we still need to monitor the workers' exposure because it's a new aircraft in this space. They'll also be using a new kind of paint specifically requested by NASA. I'm not sure what kind – you'll need to check with someone at the shop.

Jenks AFB Scenario (Page 2 of 18)

After you arrive at the corrosion control shop, you interview the shop supervisor.

Audio Script

BE Tech: Good afternoon. So that's the Super Guppy, huh?

Shop Supervisor: Sure is. We've got it all masked up right now, but just wait until we get it painted – we're using custom paint and even creating the templates for the stencils. When we get done with it, it's going to be really nice. Definitely one of a kind.

BE Tech: Cool. Actually, the painting is what I wanted to talk to you about. I've been told you're using a new kind of paint. I need to get some information from you so I know what chemicals are in it.

Shop Supervisor: No problem. The paint is actually a mixture of three components. We'll mix two parts color to one part each of the activator and hardener. The folks from NASA already gave us the MSDS information. I'll go get that for you.

Scenario Challenge Point (Page 3 of 18)

While the shop supervisor is getting the Material Safety Data Sheets, you begin thinking about the sampling strategy you will use. What are the two primary assessment goals for this sampling strategy?

A You must determine if workers are performing the work properly.

B You must identify the health risks posed by the chemicals being used.

C You must determine whether the workers are performing similar tasks off-duty.

D You must determine whether existing controls are sufficient to control the health threat.

Strategy Considerations (Page 4 of 18)

Remember that before you begin collecting samples, you must develop a sampling strategy. The strategy will include who, what, when, where, and how to sample, as well as how many samples to take. Select each tab to learn about the factors that affect the sampling strategy.

Tab: Sampling Objectives

When determining your sampling strategy, you must keep in mind the purpose of the sampling and how immediate or critical the need is. The purpose for sampling, also known as the exposure assessment goal, plays a vital role in the selection of a sample method and will also define the type of air sampling you use.

Potential objectives include:

- **Identifying the degree of health threat.**
- **Evaluating existing controls.**
- **Assessing compliance.**
- **Fulfilling a special purpose.**

Remember that the primary reason you would want to collect air samples is to increase your confidence in the health threat characterization or controls. Once your confidence level and objectives have been met through sufficient and accurate information, you can decrease the number of samples you take or stop sampling.

When making the decision whether to continue sampling, there are several **questions** you should keep in mind.

Identifying the Degree of Health Threat

In order to identify the degree of health threat, you must determine the concentrations of materials in the air that may cause acute or chronic damage to a worker's health. It is important to know as much as possible about the chemicals or substances with which you are dealing, such as their vapor density and toxicological properties.

Along with typical health threats, you must also keep in mind that many chemicals can be explosive, or they can be asphyxiants (i.e., they displace oxygen). Other chemicals may pose health risks without exhibiting warning properties.

Additionally, it is important to remember that even if a standard does not exist, or if concentrations in the air fall below acceptable standards, health effects may occur anyway. A situation in which health effects are occurring would require further attention.

Evaluating Existing Controls

Air sampling is useful for determining whether existing ventilation and respiratory protection are effective for controlling the contaminants and protecting the health of the workers.

Assessing Compliance

Sampling is used to document the compliance or noncompliance of worker exposures with health regulations. Compliance means ensuring that the requirements of regulations and standards designed to protect workers are met.

Fulfilling a Special Purpose

At times, you will perform surveys for a special purpose. For instance, a worker may request an evaluation of an exposure he or she believes to be a health threat. Workers also have the right to know everything they can about the substances they work with and the effects of exposure.

Questions

Some questions you may ask when determining if air sampling is needed include:

- Are there significant changes to the activity or process?
- Is the variation in existing or historical data high?
- Are sampling parameters well-defined and documented from previous evaluations?
- Is there sufficient existing data?

The answer to all of these questions can affect how confident you are in the characterization. You would want to sample whenever you need more confidence and time or circumstances allow.

Tab: Resources, Time, and Conditions

You must consider resources, time, and conditions when developing your sampling strategy.

Consider the equipment and manpower available to you, as well as lab capabilities and availability of other resources. Also, the type of media you choose will be dependent on the chemical or substance you are sampling. For example, the media for gases and vapors differs from the media used for wood dust and particulates. The media you use affects the frequency and duration of the samples you can take, considering the media's saturation points and other limitations.

Time available to conduct the assessments will affect the type and number of analyses that will be conducted during each sampling event. It is beneficial to understand the contribution of each work activity to the overall exposure during a work shift. Sampling may be conducted for the time period that the activity is actually performed or for the entire work shift, covering one or more activities repeated throughout the day.

Changing environmental conditions such as contaminant migration or weather will also affect the sampling strategy. Additionally, where the sampling is being done has a great effect on the sampling strategy you may use. For example, at overseas locations, host country sensitivity should be taken into account when doing off-base sampling.

Tab: Assessment Type

Remember from the previous lesson, your sampling strategy is influenced by whether you are conducting routine or special assessment. Your sampling may be performed for **screening** purposes, providing a very quick and rough estimate of a concentration either in an acutely hazardous situation or to determine if there is a need for special surveillance.

Alternatively, you may need detailed sample collection procedures for **compliance** purposes.

Screening

Screening can be thought of as a quick snapshot to provide an initial estimate of worker exposure. Screening samples should evaluate each potential health threat to a similar exposure group (SEG). Professional judgment dictates the number of screening samples to be taken.

Screening samples are often collected using direct reading instruments (DRIs) with the understanding that there are errors and limits of detection involved. An integrated sample collected over only a short term, using a NIOSH method, can also be considered a screening sample.

Screening samples can be used to gauge exposure without compliance or specialized sampling or to determine prioritization of sampling efforts. They may also be appropriate during emergency response situations.

Compliance

Compliance sampling provides a tool to ensure that regulations and standards are met and provides support for documentation of compliance or noncompliance. It is used to get a more accurate evaluation of the worker's exposure than screening can provide and is an indirect method consistent with OSHA or NIOSH.

BE must ensure that the sample volume and sample duration provide meaningful results. Compliance samples should be collected in accordance with applicable standards for the duration of the shift minus one hour, as a minimum.

Samples are collected over periods of time representing all parts of the day that a worker can be exposed. This means you must calculate a time-weighted average using the results of the air samples in order to compare them to the occupational exposure limit.

All compliance samples must be analyzed by a lab certified by the American Industrial Hygiene Association (AIHA) unless the major command (MAJCOM) or equivalent allows the use of a specific noncertified laboratory.

Tab: Standards

You are required to sample the airborne concentrations of substances when potentially hazardous occupational exposures are identified. Whenever you take air samples to assess inhalation exposure, you should look toward an exposure limit to guide you in your assessment.

The Occupational Exposure Limit (OEL) is the limit to which nearly every worker may be exposed without adverse health effects for airborne concentrations of a specified substance for a specified time. OELs are used to define hazardous inhalation exposures to chemical substances so these health threats can be controlled or eliminated.

Keep in mind that exposure limits will not adequately protect all people. Some individuals may experience discomfort or even more serious adverse health effects when exposed to a substance at or below the OEL. Increased susceptibility to a chemical substance can be affected by factors such as age, gender, ethnicity, genetic factors, lifestyle choices, and medications.

Communicating results relative to existing standards allows commanders, workplace supervisors, and affected personnel to understand the comparison to a measurement that is set as acceptable.

Appraisal (Page 5 of 18)

Build a list of the factors that affect the sampling strategy.

Word Bank	List
Health Threat Characterization	______________________________
Sampling Objectives	______________________________
Confidence in Controls	______________________________
Assessment Type	______________________________
Standards	
Resources, Time, and Conditions	

Scenario Challenge Point (Page 6 of 18)

What tactics would be *best* to collect air samples for determining the health threat to the corrosion control shop workers while they are painting the Super Guppy?

Choose the type(s), technique(s), and location(s) appropriate for this sampling situation. Select all that apply.

	Types
	Screening
	Compliance

	Techniques
	Instantaneous
	Integrated

	Locations
	Area
	Personal

Strategy Considerations (Page 6a of 18)

Air sampling tactics refer to how you go about collecting samples at a particular time as part of your overall sampling strategy. The type of sampling you are conducting, whether screening or compliance, can determine the technique you use, sampling equipment selected, and the locations you will sample.

Tab: Techniques

The technique you use to collect samples will vary depending on the purpose of the sampling. If you need instant results, you may choose to perform **instantaneous sampling**, which primarily uses **Direct Reading Instruments (DRIs)**.

For more accurate results from a lab, you can choose **integrated sampling**, which is performed with **indirect reading instruments**.

Instantaneous Sampling

Instantaneous sampling involves taking single samples or measurements at a specific time or over as short a period as feasible. This technique, also referred to as grab sampling, is often used during screening to see if more extensive sampling may be required.

Direct Reading Instruments (DRIs)

Direct Reading Instruments (DRIs) allow an immediate measurement of the concentration of a contaminant and are often used for screening. Air contaminants are analyzed within the instrument and the concentration results are read through a digital or analog readout.

DRIs are very beneficial in that they can provide on-the-spot information and are ideal when you need immediate data. DRIs can profile fluctuations in contaminant concentrations that are lost when performing traditional integrated sampling.

When appropriate, DRIs may be used in compliance sampling, but confirmatory analysis must be provided by a lab.

The selection of the appropriate DRI will depend on the application for which it will be used and no single instrument can be used to measure all contaminants in the air. It is important to remember that the DRIs available for in garrison and deployed operations can often be used to assess the health risk. All instruments are designed to be used within a designated detection range so you need to calibrate it according to the manufacturer's instructions before use.

Integrated Sampling

Integrated sampling, also called indirect reading or continuous sampling, is used to estimate the worker's exposure to a certain chemical by collecting one or more personal air samples for the duration of the process or the workshift. Multiple integrated samples can be time-weighted as an average exposure.

When using integrated sampling for compliance, samples must be analyzed by an American Industrial Hygiene Association (AIHA) certified lab.

Indirect Reading Instruments

Indirect reading instruments can be used in conjunction with DRIs for screening. When using an indirect reading instrument for compliance sampling, the samples must be sent to a certified laboratory for analysis.

Tab: Locations

Where you perform sampling depends on where the health threat exists and affects whether you can use the results to properly assess the health risk. Depending on the situation, you may perform **personal** or **area** sampling.

Personal Sampling

Personal sampling is the most accurate method of evaluating and quantifying a worker's exposure to airborne chemicals, as it is representative of the worker's exposure to a contaminant throughout the day.

During personal sampling, the worker wears a sampling device that collects an air sample. The sampling device is placed as close as possible to the route of entry in the breathing zone of the worker, within 6–9 inches of the nose and mouth, so the data collected closely represents the concentration being inhaled.

Because personal samples are collected over a period of time according to a standard, they can be used for compliance purposes.

Area Sampling

Area sampling, also known as general air sampling, can be used to:

- Evaluate background concentrations.
- Locate sources of exposure, including exposures from adjacent work areas or upwind off-base activities.
- Evaluate the effectiveness of control measures (e.g., paint booth ventilation system).

The sampling device is strategically placed in a fixed location in the area of interest. For example, if an airborne chemical release is suspected in an activity, several area samples taken at key locations could be used to pinpoint the source.

Another way area sampling can be used is to determine changes in the air quality throughout a workday. For instance, if you take background area samples in a welding shop before the process, those results will help you identify the increase of contaminants within that shop while the process is being performed.

In general, area sampling is not used to provide an estimate of worker exposure because conditions at the fixed location may not be the same as those experienced by the worker. Rather, it is used as a screening tool to determine the presence or absence of a contaminant. It cannot be compared to established breathing zone standards and is not typically used for compliance purposes.

Components of the Strategy (Page 7 of 18)

Remember that the sampling strategy is the overall plan or framework of the sampling process from beginning to end. After considering the factors that affect the sampling strategy and appropriate sampling tactics, you will identify how many samples to take and how often, where to sample, and under what conditions follow-up sampling should occur.

Tab: Number and Duration

The **number of samples** taken is affected by your confidence in how well the sample results represent the **true exposure** of the task being sampled. This determination is made through professional judgment and in accordance with AIHA guidelines.

The duration of samples are influenced by whether you are taking a compliance sample over a full shift or sampling to quantify worker exposure during a particular task. Duration also depends on the process length and the minimum collection time required for the media being used to sample a particular contaminant.

Number of Samples

In this context, the number of samples refers to samples taken of different personnel or on different days. Numerous samples taken over the course of one workshift are considered one sample.

True Exposure

One sample cannot provide an accurate measurement of a worker’s true exposure. Consider an example of a highway patrol officer using a radar gun. One measurement taken by this instrument may tell the officer that you’re driving under the speed limit, when, in actuality, you had been speeding a few moments before the reading was taken.

Just as one reading by a radar gun cannot tell the officer if you *ever* speed, one sample cannot tell you whether a worker is ever exposed to harmful levels of a contaminant. Multiple samples are needed to gain an understanding of the worker’s true exposure.

Tab: Personnel and Location

Whenever the possibility for exposures at or above the **action level (AL)** exists, personal samples should be taken to measure employees' exposure.

You should randomly select at least one member of the similar exposure group for sampling purposes. You should randomly select when to perform your sampling as well. For example, knowing that a particular process occurs only on Thursdays in the shop, you may randomly select the graveyard shift on the third Thursday of the month and then determine that you will randomly sample one worker on that shift.

If a process only occurs once, random selection of when to sample is not feasible. If only one worker performs a given task, random selection of who to sample is not possible.

It is important to remember if the task being sampled is performed in multiple locations you may need to sample all locations.

Action Level (AL)

The AL is a substance-specific exposure level which requires certain actions such as air sampling, employee training, medical monitoring, or record keeping.

As related to air sampling, the AL is usually one-half the OEL, unless otherwise specified by OSHA. You may also use your professional judgment to establish an AL for a particular contaminant. Keep in mind that, as variability in the task performance increases, the AL decreases.

Tab: Need for Follow-up for Recurring Sampling

Whether you are conducting initial, routine, or special assessment, there may be a need for follow-up sampling. Determine any follow-up or recurring sampling needs by considering the results, compliance requirements, and applicable standards based on the health threat identified, as well as your confidence levels in the health threat characterization or confidence in controls. If new controls have been established, you must perform follow-up sampling to verify that they are working. You must also perform additional sampling if processes or task locations change.

Whether follow-up sampling is for compliance or control verification purposes, a new sampling strategy must be developed.

Appraisal (Page 8 of 18)

Following is a series of questions to check your understanding of sampling tactics. For each example you see, select the appropriate tactics.

Screening samples indicate exposures above the AL. Which choice lists the actions you will perform in order to evaluate and quantify the workers' exposure?

A Compliance / Personal Sampling

B Screening / Personal Sampling

C Personal / Instantaneous Sampling

D Area / Integrated Sampling

You need to get a quick estimate of a worker's exposure to determine if further action is needed. Which choice lists the actions you will perform?

A Compliance / Area Sampling

B Screening / Integrated Sampling

C Compliance/ Integrated Sampling

D Screening / Instantaneous Sampling

You need to evaluate background concentrations of an airborne chemical and determine changes in air quality. Which choice lists the actions you will perform?

A Personal / Screening Sampling

B Area / Integrated Sampling

C Compliance / Instantaneous sampling

D Area / Instantaneous Sampling

Selecting a Standard (Page 9 of 18)

As mentioned previously, selecting standards to which you will compare your sampling results is a critical component of your strategy. You must consider the type of health threat that is present when selecting which standard to use.

Typically, air sampling done in garrison settings is related to chemical health threats. When determining the standard to use for a chemical workplace exposure, you must use the most stringent OELs from one of the following sources:

- **OSHA PELs.**
- **ACGIH TLVs.**

If neither of these references provides a limit to use, request guidance through USAFSAM, MAJCOM/SG, or AFMSA/SG3PB.

There are also additional guidelines for **non-routine exposures** of the general public and for **deployment situations**.

Occupational Safety and Health Administration (OSHA) Permissible Exposure Levels (PELs)

OSHA standards exist for a number of substances, with specific requirements that apply where these substances are used. All elements of Air Force exposure prevention programs shall be at least as stringent as those outlined by OSHA. You can find this information in Title 29 Code of Federal Regulations (CFR) 1910, Subpart Z, Toxic and Hazardous Substances.

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs)

These values, written by a private organization of professionals, represent recommended levels or guidelines for airborne concentrations. The Air Force uses personnel contaminant exposure results and compares them to the standards set by ACGIH TLVs to make HRA decisions. The ACGIH TLVs can be found in the most recent *Threshold Limit Values (TLVs®) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs®)* book published by ACGIH.

Non-routine Exposures

Short Term Public Emergency Guidelines (SPEGLs) and Emergency Exposure Guidelines (EEGLs) are the preferred standards to use for emergency exposure to the public, but where they are not available, the AIHA Emergency Response Planning

Guidelines (ERPGs) will be used. ACGIH TLVs and OSHA PELs are the limits of last choice for emergency evacuation of personnel.

Deployment Situations

When deployed, you need to consider the military exposure guidelines (MEGs) listed in USACHPPM Technical Guide 230, Chemical Exposure Guidelines for Deployed Military Personnel.

You should also be aware of any additional governmental requirements. When operating in a foreign location, refer to the final governing standard (FGS) or the Overseas Environmental Baseline Guidance Document (OEBGD) when no FGS exists. Contingency sampling needs could also encompass biological and radiological health threats.

The NIOSH Pocket Guide

Using the NIOSH Pocket Guide, you can look up a particular chemical and find the applicable standards. NIOSH has also developed recommended exposure limits (RELs) which are not standards, but science-based recommendations.

National Ambient Air Quality Standards (NAAQS) (Page 10 of 18)

In addition to the guidelines that exist for non-routine exposures of the general public, the U.S. Environmental Protection Agency (EPA) has developed National Ambient Air Quality Standards (NAAQS).

The NAAQS address exposures to the following common air pollutants considered harmful to public health and the environment:

- Lead (Pb)
- Carbon Monoxide (CO)
- Nitrogen Dioxide (NO2)
- Ozone (O3)
- Sulfur Dioxide (SO2)
- **Particulate Matter (PM)**

Particulate Matter (PM)

Particulate matter (PM) is a complex mixture of solid particles and liquid droplets found in air. These small particles can lead to a variety of health problems because they can be respired into the deep lung.

These solid and liquid particles come in a wide range of sizes. Inhalable coarse particles are less than 10 micrometers in diameter (PM10). Fine particles, which are less than 2.5 micrometers in diameter (PM2.5), are believed to pose the greatest health risks, including long-term exposure effects.

For both fine and coarse particles, the EPA has set two types of standards: primary standards, to protect public health; and secondary standards, to protect the public welfare from effects including visibility impairment, damage to building and national monuments, and damage to ecosystems.

Scenario Challenge Point (Page 11 of 18)

The shop supervisor has given you the Material Safety Data Sheets (MSDS), found in the Appendix, for each component of the paint that the corrosion control shop workers will be using on NASA's Super Guppy.

Although the paint contains many chemicals which you must consider, you begin by looking up information about methyl ethyl ketone (MEK). Review the information about this chemical by consulting the NIOSH Pocket Guide to Chemical Hazards. Then choose the appropriate OEL to use for an 8-hour exposure.

A 200 ppm

B 300 ppm

C 590 ppm

D 885 ppm

Considerations for Determining the OEL (Page 11a of 18)

When determining which OEL to compare to the sampling results, consider the following:

- **Time Weighted Average (OEL-TWA)**
- **Equivalent OELs**
- **Action Level (AL)**
- **Short-Term Exposure Limit (OEL-STEL)**
- **Ceiling Limit (OEL-C)**
- **Excursion Limit (OEL-EL)**

Skin notation and **chemical mixtures** are additional indicators for exposure and should be considered when making an evaluation as to the health risks present.

Time Weighted Average (OEL-TWA)

The time-weighted average (TWA) is the concentration to which it is believed that nearly all workers may be repeatedly exposed, 8 hours per day, 40 hours per week, without adverse health effects. This means you must average the results of any air samples you have taken over the workshift in order to compare them to the OEL-TWA. The OEL-TWA is established for chemicals with long term (chronic) health effects.

Equivalent OELs

Equivalent OELs must be calculated when an employee is working an unusual shift—more than 8 hours per day or more than 40 hours per week. Several mathematical models have been proposed for adjusting exposure standards for use during altered work shifts.

Action Level (AL)

The AL typically equals one-half the OEL-TWA, except where 29 CFR 1910 Subpart Z designates a different concentration or where the statistical variability of sample results indicates that a lower fraction of the OEL should be used as the AL. If the upper confidence limit (UCL) of a screening sample exceeds the AL, additional sampling should be done using compliance procedures.

Short-Term Exposure Limit (OEL-STEL)

The Short-Term Exposure Limit (OEL-STEL) is a concentration to which workers can be exposed continuously for a short period of time without suffering from irritation, chronic or irreversible tissue damage, or debilitating narcosis. The OEL-STEL represents a 15-minute time-weighted average (TWA) exposure which should not be exceeded at any time during the workday, even if the 8-hour TWA is within OEL-TWA limits. If the chemical of concern has both an OEL-STEL and an OEL-TWA listed, neither of the two can be exceeded.

The ACGIH TLV book delineates OEL-STELs that allow short exposures to concentrations somewhat higher than allowed by the OEL-TWA. Exposures within this range should occur less than four times per day, and there should be at least 60 minutes between successive exposures in this range.

Generally, only one sample is included in a 15-minute time period, but when multiple samples must be combined, you use the following formula to calculate a 15-minute TWA:

$$\text{15-min TWA} = \frac{C_1T_1 + C_2T_2 + \ldots C_nT_n}{15 \text{ min}}$$

Where C = concentration and T = time

Ceiling Limit (OEL-C)

The Ceiling Limit (OEL-C) represents the concentration that must never be exceeded during any part of the workday. Instantaneous readings (i.e., using DRIs) should be taken whenever possible, and the exposure can be assessed with a sampling period of 15 minutes or less. If instantaneous monitoring is not feasible, the OEL-C should be evaluated during the worst-case 15-minute exposure period, or for a minimum period of time sufficient to detect exposures at or above the ceiling value. Many substances which do not have TLVs have Ceiling Limits listed in the 29 CFR 1910.1000 Table Z-1, *Limits for Air Contaminants*, indicated by the letter “C” in parentheses next to the OEL.

Excursion Limit (OEL-EL)

The Excursion Limit is a control limit established for chemicals without published STELs or Ceiling Limits. These limits are based on statistical rather than toxicological considerations. The worker’s exposure may exceed three times the OEL, but for no more than a total of 30 minutes, provided that the 8-hour TWA does not exceed the OEL standard. The worker’s exposure must never exceed five times the OEL.

Excursion limits are not intended to be used as OELs. Exposures in excess of these limits indicate potential variations in exposure which should be further evaluated to verify compliance with the OEL-TWA. Experienced judgment is needed to properly apply these limits.

Skin Notation

Although not an OEL, skin notation identifies chemicals that have a significant route of entry by absorption through the skin, mucous membranes, and eyes. The “skin” designation after the chemical name in the standard alerts you that overexposure may occur following dermal contact even when airborne exposures are at or below the OEL. If large areas of the skin are exposed for a long period, it is difficult to know how much contaminant is getting into the body. The skin notation is intended to suggest proper personal protective measures, such as gloves and aprons, to prevent cutaneous absorption. Biological monitoring should be used to evaluate exposure through skin absorption, where possible.

Chemical Mixtures

The exposure limits set by the standards are established for a pure form of the chemicals. However, when more than one chemical is used, there is a potential for health effects that are greater than each chemical used alone would cause. For example, spray paint has many ingredients, and you must assess the exposure not only to each chemical individually, but also to the mixture of chemicals.

Appraisal (Page 12 of 18)

Match each standard or term related to determining the OEL with its description by marking the appropriate block in the table.

Description	Equivalent OEL	OSHA PELs	OEL-TWA	OEL-STEL
Concentration to which workers can be exposed continuously for a short period of time.				
Exposure limit that has been adjusted for unusual work schedules.				
Substance-specific requirements found in Title 29 CFR 1910, Subpart Z.				
Concentration to which workers may be exposed 8 hours per day, 40 hours per week.				

Equivalent OELs (Page 13 of 18)

Sometimes you will need to adjust the OEL because the length of time a worker is exposed is dependent on whether he or she has an unusual work schedule—more than 8 hours per day or more than 40 hours per week.

For example, if the work schedule is 10 hours per day, you must calculate a 10-hour TWA by dividing the actual exposure time by 10 hours instead of the usual 8 hours. Additionally, a 10-hour OEL-TWA must be calculated for comparison, as shown later in this lesson.

Adjustment of OELs based on unusual work shifts is important because length of exposures may be longer and/or recovery time between exposures may be shorter, potentially causing an increased negative health effect to personnel. Making these adjustments ensures that workers on varying schedules are provided the same degree of protection as those employees on normal workshifts.

Not all substances should have an equivalent OEL calculated. There are certain rules that you must follow very carefully in determining which OELs should and should not be adjusted. A summary of situations for which you would <u>not</u> calculate equivalent OELs is as follows:

- You can establish that there are no cumulative effects.
- Exposures during full shifts that total less than 7 hours per day or 35 hours per week.
- Exposures are 8 hours or less even though the shift is over 8 hours.
- Exposures are continuous – 24 hrs a day.

As important as equivalent OELs can be, keep in mind that there is no substitute for keeping exposures to a minimum.

Calculating Equivalent OELs (Page 14 of 18)

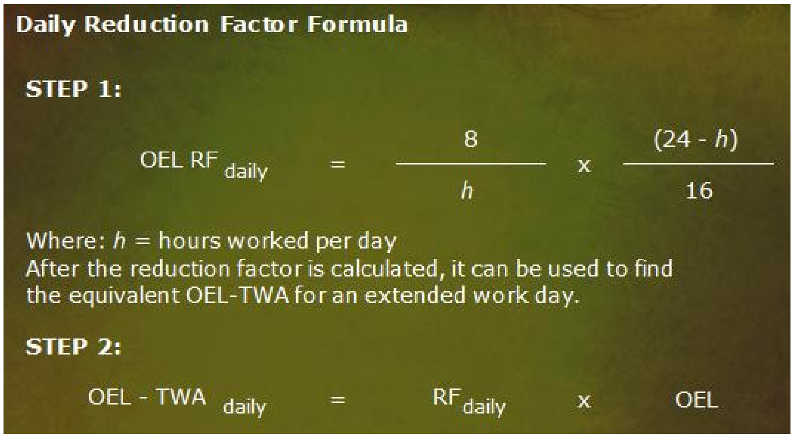
The OEL-TWA should be adjusted for work shifts that exceed 8 hours of exposure per day or 40 hours per week using models such as the Brief and Scala and OSHA models.

Tab: Brief and Scala Model

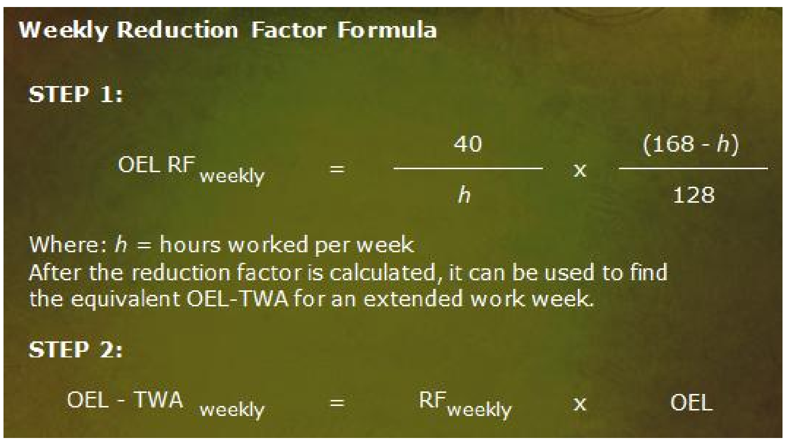
The Brief and Scala Model is primarily used to calculate adjustments of 8-hour TWA exposure standards when the COCs involved are internalized and are metabolized or eliminated by the body. This model is easy to use, takes into account both increased hours of exposure and decreased exposure-free time (recovery time), and is the more conservative of the models. It is intended to ensure that the daily dose of the toxic agent during a “non-standard” work shift is below what it would have been for a traditional 8-hour workday.

The formula you use depends on the length of the workday and the work week. You can calculate the OEL reduction factor for an extended daily work shift, where the work week is no more than 5 days, by using the **daily reduction factor formula**. When you need to determine the equivalent OEL-TWA for a work week greater than 5 days, you use the **weekly reduction factor formula**.

Daily Reduction Factor Formula



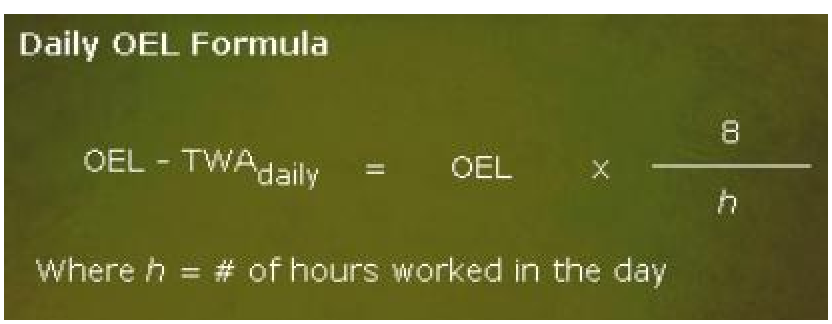
Weekly Reduction Factor Formula



Tab: OSHA Model

The OSHA Model is primarily used for COCs that accumulate in the body and are intended to ensure that daily or weekly doses obtained during an altered work shift do not exceed doses obtained in a conventional 8-hour work shift. For substances with acute toxicity, use the **daily OEL formula**. For substances with chronic toxicity, use the **weekly OEL formula**.

Daily OEL Formula



Weekly OEL Formula

Scenario Challenge Point (Page 15 of 18)

As you continue with sampling strategy development, you need to determine if calculating equivalent OELs for the paint exposure is necessary.

Audio Script

BE Tech: What's the work schedule for this shop?

Shop Supervisor: We work a 10-hour shift, 4 days per week. We're on a bit of a tight timeline with the Super Guppy, so it looks like we may have to put in some extra hours. I've been thinking of switching to a 6-day week with 8-hour shifts while we're doing the painting, but I haven't decided yet.

Narrator: Remembering that for MEK, the OEL-TWA for an 8 hour shift is 200 ppm, what is the OEL-TWA for a 10-hour shift?

Remembering that for MEK, the OEL-TWA for an 8 hour shift is 200 ppm, you need to determine the OEL-TWA for a 10-hour shift.

First, you'll need to figure the OEL reduction factor using the following equation where the value of h is the number of hours in the workday.

$$\text{OEL RF}_{\text{daily}} = 8/h \times (24-h)/16$$

To begin, provide the calculated values in the equation below.

$$\text{OEL RF}_{\text{daily}} = \boxed{\_.\_} \times \frac{\boxed{\_\_.\_}}{16}$$

Next, divide the number of exposure-free hours in a 10-hour workday by the number of exposure-free hours that would occur with a normal 8-hour workday. Round your answer to the nearest hundredth.

$$\text{OEL RF}_{\text{daily}} = 0.8 \text{ X } 14/16$$

OEL RF $_{\text{daily}}$ = 0.8 x -.--

Then multiply the two values to arrive at the daily OEL reduction factor.

OEL RF $_{\text{daily}}$ = -.--

Finally, you will use the daily OEL reduction factor to calculate the equivalent OEL-TWA for MEK exposure during a 10-hour shift. To do this, you insert the OEL for an 8-hour exposure to MEK (200 ppm) into the formula and multiply it by the reduction factor for a 10-hour shift (0.7).

$$\text{Equivalent OEL - TWA}_{\text{daily}} = 0.7 \text{ X } 200 \text{ ppm}$$

Equivalent OEL - TWA $_{\text{daily}}$ = ---.- ppm

Scenario Challenge Point (Page 16 of 18)

If the shop supervisor decides to change the schedule to 8 hours per day, 6 days per week, how will that affect the OEL?

To figure the weekly OEL reduction factor, you'll use the following equation where the value of h is the number of hours in the work week. Remember that the supervisor is considering changing the work schedule to 8 hours per day, 6 days per week.

$$\text{OEL RF}_{\text{weekly}} = 40/h \text{ X } (168-h)/128$$

Divide the number of exposure hours in the normal work week by the number of hours actually exposed in the extended work week. Subtract the number of hours worked from the number of hours in the week. Enter your values in the equation below, remembering to round to the nearest hundredth when necessary.

$$\text{OEL RF}_{\text{weekly}} = \text{-.--} \times \frac{\text{---.-}}{128}$$

Next, divide the number of exposure-free hours in a 48-hour work week by the number of exposure-free hours that would occur with a normal 40-hour work week. Please round your answers to the nearest hundredth.

$$OEL\ RF_{weekly} = 0.83 \times 120/128$$

$OEL\ RF_{weekly}$ = 0.83 x -.--

Then multiply the two values to arrive at the weekly OEL reduction factor.

$OEL\ RF_{weekly}$ = -.--

Finally, you will calculate the equivalent OEL for MEK exposure during an extended work week by multiplying the 8-hour OEL-TWA for MEK (200 ppm) by the weekly reduction factor for a 48-hour work week (0.78).

OEL_{weekly} = ---.- ppm

Jenks AFB Scenario (Page 17 of 18)

You continue developing your air sampling strategy by gathering information about each COC, identifying the potential health effects, and determining whether each chemical has established OELs and NIOSH sampling methods. You use this information to prioritize the sampling needs.

After you develop the sampling strategy, you go to the shop and collect samples.

Lesson Summary (Page 18 of 18)

You've completed this lesson and learned the factors you should consider when developing an air sampling strategy. You've also found that air sampling is an important task for increasing confidence in health threat characterization and controls.

In this lesson, you:

- Defined the exposure assessment goal.
- Selected air sampling tactics.
- Selected the appropriate standard.
- Summarized the various types of standards.
- Calculated equivalent Occupational Exposure Limits (OELs).

Audio Script

OIC: You've done a nice job developing the sampling strategy for the corrosion control shop. By collecting integrated samples in the personal breathing zone of the workers, you'll be able to quantify the exposure and ensure that standards are being met. Now we just have to wait for the results to come back from the lab.

Lesson 3: Soil and Solid Sampling

Lesson Description

In this lesson, you will learn the procedures for developing a soil and solid sampling strategy. You will also learn about collecting and analyzing soil and solid samples through an investigation of soil contamination on the bases golf course. Upon completion of this lesson, you will be able to: Outline the procedures for developing a soil and solid sampling strategy; Collect soil and solid samples; Perform field analysis on soil and solid samples.

Lesson Overview (Page 1 of 13)

In addition to air sampling, one of your primary responsibilities is collecting soil samples to identify and analyze health threats and risks as part of the HRA process. Whether you are at an established base or a deployed location, soil sampling is also an important part of completing the OEHSA and helps ensure the health and well-being of personnel and the community.

In this lesson, while developing a soil sampling strategy and performing field analysis on collected samples, you will:

- Cite the considerations for developing a soil and solid sampling strategy.
- Define various soil and solid sampling approaches and methods.
- Determine why and when to collect samples.
- Outline the steps required to field analyze soil and solid samples.

Audio Script

OIC: Some of the grounds maintenance workers have complained about a smell like rotten eggs on the golf course. I talked to their supervisor, and he said he heard something about a landfill on that part of the base years ago. I want you to look into it. To get you started, I've made a list of the workers you could talk to so you can pinpoint the location of the odor. Then do some research on the prior uses of the land and collect some samples. Keep me posted.

Considerations for Developing a Sampling Strategy (Page 2 of 13)

Before you begin investigating and collecting samples, you need to develop a sampling strategy. Select each tab to learn about the factors that affect the soil and solid sampling strategy.

Tab: Sampling Objectives

In order to develop a sampling strategy, you must understand the goals of the sampling.

Some potential goals include:

- Identifying health risks to workers and the community.

- Defining the area of concern (AOC).
- Quantifying exposure.
- Analyzing and reducing health risks.
- Assessing compliance.
- Making health control decisions.

Tab: Situational Requirements

Your role, related to soil and solid sampling, is to identify and quantify the contaminants posing a health risk to workers and the public during an **HRA**. Contaminated soil can pose a health threat through either contact or inhalation both at the site and downwind. It may also result in groundwater contamination.

Many regulators require responsible parties to perform an HRA known as a **site-specific risk assessment**. In most cases, this will be through a contract operation. Depending on the results of the assessment, **remediation** may be required. Although sampling is performed during remediation, this type of sampling for environmental compliance purposes is not a BE responsibility.

Before you proceed with any soil sampling plan, it is very important that you contact the appropriate regulatory office to ensure that you use their approved methods.

Health Risk Assessment (HRA)

When hazardous materials are released into the environment, it is important to identify, evaluate, and control the health threat.

The basic processes involved in a risk assessment include estimating the type of contamination, the pathways in which people or other living organisms can be exposed to the contamination, the toxic effects of the contaminants, and the risk associated with the exposure to the contaminants.

Site-Specific Risk Assessment

A site-specific risk assessment is a scientific estimation of a human health or ecological hazard required by regulators. Although BE is not responsible for conducting a site-specific risk assessment, your installation may be required to collect representative samples from the spill site and have the samples analyzed for hazardous substances. This assessment sampling is done prior to any remediation.

The ultimate outcome of the site-specific risk assessment is the degree of risk, which is then compared to acceptable risk values established by regulators. The risk assessment identifies the degree of site control needed, cleanup goals, type of treatment, and an estimate of the health threat

Remediation

Remediation sampling is performed during or after a cleanup process in order to determine the success of cleanup operations and to determine whether the levels of contamination pose a risk to public health or the ecosystem.

Although there are generally no specific federal guidelines to follow when conducting soil sampling, numerical standards have been developed by regulators to establish criteria for some soil cleanup operations that are similar in nature. For example, the EPA has established specific corrective action levels for lead in soil located in residential communities. If specific numerical standards don't exist, the regulator may choose to apply Resource Conservation and Recovery Act (RCRA) Toxicity Characteristic Leaching Procedure (TCLP) levels to the site and treat the soil as a potential hazardous waste. TCLP is an analysis procedure used to demonstrate how much contaminant leaches from the soil due to normal weathering.

Remember, verifying compliance with remediation regulations is not a BE role.

Tab: Resources, Time, and Conditions

You must consider the equipment and manpower available to you, including lab capabilities, DRIs, and other resources. Time available to conduct the assessments will affect the type and number of analyses conducted during each sampling event. Changing environmental conditions such as contaminant migration or weather will also affect the sampling strategy.

Appraisal (Page 3 of 13)

Which one of the following factors will NOT affect the development of your soil and solid sampling strategy?

Word Bank	Answer
Sampling Objectives	______________________________
Situational Requirements	
Resources, Time, and Conditions	
Health Threat Characterization	

Jenks AFB Scenario (Page 4 of 13)

So you can identify the health threat(s) on the golf course, you start gathering information. To begin your research, you call the grounds maintenance supervisor.

Audio Script

BE Tech: Good afternoon, Mr. Jernigan. I'm with the BE Office, and I'd like to ask you a few questions about the odor you and your crew have noticed on the golf course.

Supervisor: Well, I really don't know much about it. I haven't smelled it, personally. You'll want to talk to Jamie Tucker about that – she's mentioned the smell a few times. Oh, and Bob Andrews. He seems to think there used to be a landfill over here.

BE Tech: Okay, thanks. I'll call them and see what else I can find out.

After speaking with the supervisor, you call the two grounds maintenance workers. You start with Jamie Tucker.

Audio Script

BE Tech: I'm investigating the odor you reported on the golf course. Could you tell me where you were when you noticed the smell?

Worker 1: Well, the last time, I was out on the driving range. Bob and I were out there trimming some Bradford Pears that got beat up in those storms last week. We weren't out there very long before the smell really got to us. We thought for sure there was a nest of rotten eggs in the trees, but we looked all around and couldn't find anything. We couldn't figure out where it was coming from.

BE Tech: You've noticed a smell like that on the course before?

Worker 1: Yeah, once before. About a month ago – come to think of it, that was at the driving range too. I was putting in some new flowerbeds along the path. That time, Sam was with me, and he couldn't smell it. He has such bad allergies.

BE Tech: All right, thank you for your time, Ms. Tucker. I'll look into this for you.

Next, you call Bob Andrews.

Audio Script

BE Tech: Hi, Mr. Andrews. I'd like to ask you about the odor you noticed on the golf course.

Worker 2: Sure thing. What do you want to know?

BE Tech: Mr. Jernigan tells me you believe the driving range sits on a landfill. Can you tell me where you got that information?

Worker 2: My dad told me about it. See, when I started this job a few months ago, my dad kept telling people I was working at the landfill. I thought he was crazy, but he swore there was a landfill right next to the golf course. Anyway, I got curious and did a search for "landfill" in the archives of the base newspaper online. Sure enough, Dad was right. I didn't think of it at the time when Jamie and I were out there trimming the trees, but I bet that's where the smell was coming from. I didn't think to print the article, but I guess if you do the same search, you'll find it.

BE Tech: I'll do that, thanks.

You decide to search the base newspaper archives as Mr. Andrews suggested.

Landfill to Become Driving Range

July 15, 1990

The site of a former landfill just north of the golf course is going green—literally. A new driving range and parking area will be built on a ten-acre site that was used twenty years ago for dumping trash. The driving range will feature 15 floodlit practice stalls and a grass hitting area. For golfers who need work on their short game, the range will also offer a practice green and chipping area.

That section of the base has gone virtually unused since 1970, when the landfill was closed and simply filled in with dirt, as was common practice in those days. The layers of garbage under the soil were then forgotten until last year, when a small explosion caused by methane gas buildup inside a maintenance building injured a worker and prompted an investigation. The discovery of the landfill, in which general refuse and possibly some industrial wastes had been deposited, prompted the base to take action to clean up the land.

Officials want to assure base personnel that the land's previous use is no cause for concern. The contamination was capped in 1983 with three feet of clay and covered with a layer of earth. To construct the driving range, everything will be built up, including the irrigation system, so the cap is not disturbed. Vents will also be installed to release trapped methane, and "no smoking" signs will be posted nearby.

Turning closed landfills into golf courses is somewhat of a trend, according to developer Matt Stevens. "It really is the best use of the land. A lot of communities are looking at this option because, once a landfill is full, there's not much else you can do with it. Building anything is highly restricted, and you can't plant trees because the roots could disturb the cap. A golf course just makes sense."

Area golfers seem to agree. "As long as they do things the right way, I don't see a problem," said Captain Taylor Marks, who was found teeing off at Jenks Golf Course on Sunday afternoon. Another golfer added, "Turning an old pile of trash into a place to have fun seems like a great idea to me."

The new driving range should be completed by the fall of 1991.

Jenks AFB Scenario (Page 5 of 13)

You print the article and make some notes, considering what the workers have told you. Then you conduct more research based on your notes. You find additional information on the circled areas of the document.

> That section of the base has gone virtually unused since 1970, when the landfill was closed and simply filled in with dirt, as was common practice in those days. The layers of garbage under the soil were then forgotten until last year, when a small explosion caused by methane gas buildup inside a maintenance building injured a worker and prompted an **investigation**. The discovery of the landfill, in which general refuse and possibly some **industrial wastes** had been deposited, prompted the base to take action to clean up the land.
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Investigation

You locate an EBS report dated January, 1989, that summarizes the actions taken when the landfill was investigated. As you review the document, you discover the following information:

- Air sampling was conducted inside a golf course maintenance building in which a small explosion had occurred when a worker lit a cigarette. Samples indicated methane gas levels above its lower explosive limit (LEL).
- Soil gas samples taken near the maintenance building revealed low levels of volatile organic compounds (VOCs) and elevated levels of methane gas.
- The report includes a recommendation to remove the maintenance building and install vents in the area where the building stood.

Industrial wastes

Concerned about what contaminants you may be dealing with, you conduct additional research and find that, at the time the capping was performed, two drums of trichloroethylene (TCE) were discovered buried in the landfill.

Vents

You are not aware of a gas extraction system in place on the golf course, but you haven't been at Jenks very long, so you start to ask around and conduct research.

It takes you a while, but you eventually learn that, after the landfill was monitored for twenty years, the base was authorized to remove all the vents.

The final decision was that the landfill no longer posed any apparent public health hazard, but future construction was prohibited on the site due to concerns about compromising the cap.

Trees

According to the article, trees cannot be planted over landfills because the roots could disturb the cap. However, the golf course maintenance workers were trimming trees when they noticed the foul odor. You call the grounds maintenance supervisor and find out that the trees were planted last spring. Consulting a map, you confirm the trees' location - in the area previously used for the landfill.

Scenario Challenge Point (Page 6 of 13)

Considering the information you have, should your sampling strategy for the golf course indicate use of a statistical or non-statistical approach for the sampling you will perform?

A Statistical

B Non-statistical

Considerations for Developing a Sampling Strategy (Page 6a of 13)

The approach you use in your sampling strategy includes determining the location, **number**, and frequency of samples. Depending on the availability of information and resources, you may use a statistical or non-statistical approach. Select the tabs to learn about each approach.

Number

The number of samples needed varies according to the particular sampling approach that is being used. For example, in grid sampling, one sample is generally collected at each grid node, regardless of grid size.

The sample number also depends on variability. Use Tables 1-5 and 1-6 of the BE Field Manual as a general guide to determine the number of samples needed to achieve the desired confidence level.

Tab: Statistical

A statistical approach uses probability assess contamination at a site. Some common statistical sampling strategies are:

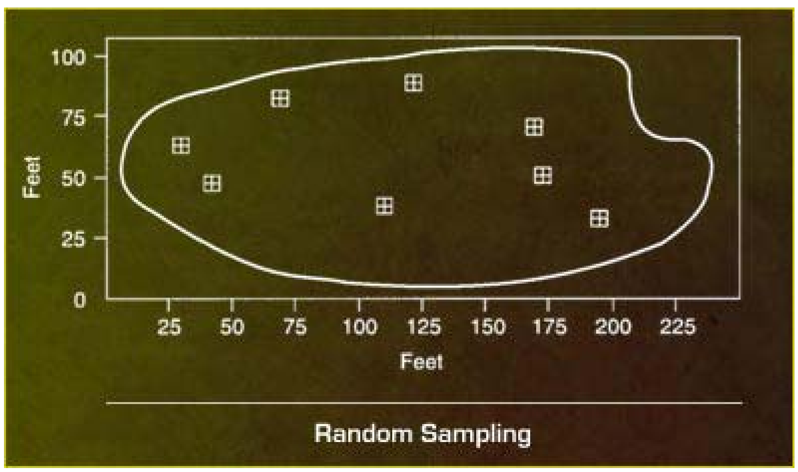
- **Simple random.**
- **Stratified random.**
- **Systematic grid.**

Simple Random Sampling

Simple random sampling is the most basic statistical approach and is usually applied when minimal site background information is available and visible signs of contamination are not evident during the initial site survey. This strategy uses the theory of random chance probabilities to choose representative sampling locations. Each location is chosen independently of any previously chosen sample location. It is most effective when the number of available sampling points is large enough to lend statistical validity to the random selection process.

To perform random sampling, you will divide a map of the area into a set amount of equal grids and then number the grids. You will select the sampling spots and sequence using a random number table or a random number generator.

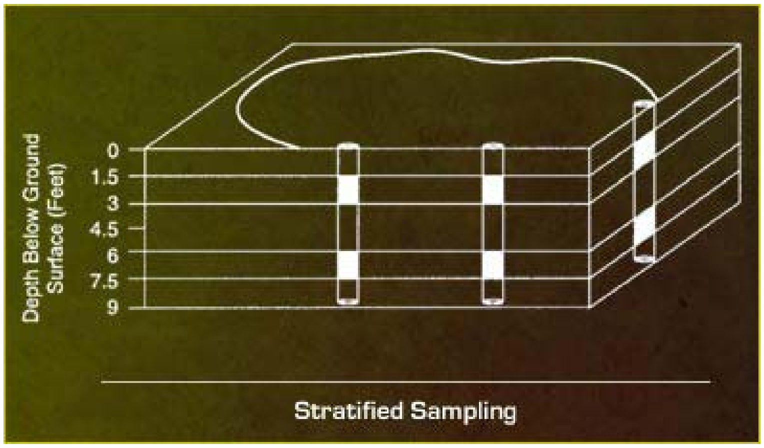
The simple random approach may be more costly than other statistical methods since a larger number of samples may be required to characterize the site.



Stratified Random Sampling

Another statistical sampling approach is stratified random sampling, in which you apply existing data or background information to divide a site into different sampling areas or strata that are internally homogenous. This technique is useful for investigating large sites that encompass a number of soil types, topographic features, or land uses. The division of the site is based on the assumption that each stratum is more internally homogenous than the site as a whole. Strata can be defined based on various factors including sampling depth, contaminant concentration levels, and contaminant source areas.

The data from each stratum may be used to determine the mean or total contaminant concentration within the stratum and comparisons between the different strata, or it may be combined to provide information about the entire site. The same random site selection procedures are used within each stratum as in simple random sampling.



Stratified Sampling

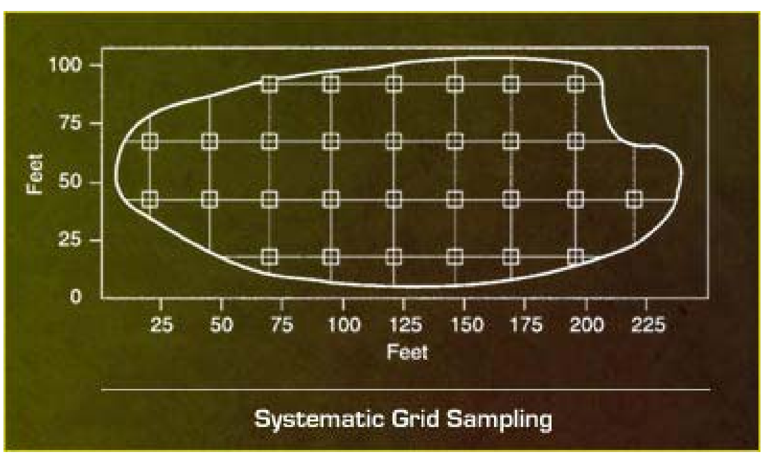
Systematic Grid Sampling

The most common statistical approach is systematic grid sampling. This method involves collecting samples at predetermined, regular intervals. The location of the first sampling point is selected at random, and all subsequent sampling locations are determined using a systematic pattern from that point. The grid-based option minimizes bias, provides complete site coverage, and is especially useful for large sites. The most basic grid system is a straight line between two points on which regularly spaced sampling locations are designated. However, most sampling requires a two-dimensional grid system, such as square or triangle grids, for locating sampling points.

You can also tailor a systematic grid sampling strategy to search for hot spots, which are areas characterized by high contaminant concentrations. A hot spot sampling plan should consider grid spacing and geometry to be successful. A triangular grid pattern increases the efficiency of the hot spot search.

Background data from events such as spills or leaks usually triggers the need for hot spot sampling and drives the selection of the sampling area and grid pattern in order to identify the extent of the contamination.

Validity of search sampling depends on accuracy of prior information on when and where to begin the search and accuracy of measurements over time or space to guide the search.



Systematic Grid Sampling

Tab: Non-statistical

A non-statistical approach involves targeted sampling based on known information. Non-statistical sampling strategies do not rely on statistical interpretation of the sampling results; therefore, they are less reliable for decision-making. They require additional background information or professional judgment based on past similar scenarios or personal knowledge of the contamination site. Non-statistical sampling may be:

- **Biased / Haphazard.**
- **Judgmental.**

Biased / Haphazard Sampling

Biased sampling, also known as haphazard sampling, is used when information is available that suggests specific contamination exists in specific areas of a site. The sampling locations are chosen based on that information; therefore, this type of sampling often leads to biased results. This approach is typically used as a preliminary screening technique to identify a possible problem before full-scale sampling is done.

Judgmental Sampling

Judgmental sampling is the subjective selection of sampling locations at a site based on historical information, visual inspection, and the professional judgment of the sampling team. Use judgmental sampling to identify contaminants present at high concentration areas. Judgmental sampling has no randomization associated with the sampling strategy, precluding any statistical interpretation of the sampling results.

Appraisal / Scenario Challenge Point (Page 7 of 13)

Match each sampling approach with its corresponding description by marking the appropriate block in the table.

Descriptions	Stratified Random	Simple Random	Judgmental	Systematic Grid
Uses the theory of chance probabilities to choose representative sampling locations.				
Applies existing data or background information to divide a site into internally homogenous areas.				
Selects locations based on historical information, visual inspection, and professional judgment.				
Collects samples from locations at regular intervals from one randomly selected sampling point.				

Scenario Challenge Point (Page 8 of 13)

After you determine the sampling approach you will use to identify and quantify contaminants on the golf course, you need to determine how you will collect the samples.

Based on what you know about the contaminants that could be present, should you plan to homogenize the samples?

A Yes

B No

Sample Collection (Page 8a of 13)

How a sample is collected can affect how accurately it represents the characteristics of the site contaminants and their concentrations. Proper sample preparation and handling help to maintain sample integrity and may include several methods.

- **Removing Extraneous Material**
- **Homogenzing Samples**
- **Compositing Samples**
- **Sieving Samples**
- **Splitting Samples**
- **Final Preparation**

Improper handling can result in a sample becoming unsuitable for the type of analysis required. For example, splitting, homogenizing, sieving, and compositing samples all result in a loss of volatile constituents and are therefore inappropriate when volatile contaminants are the concern. For sample collection procedures when volatile organic analysis is to be performed, refer to EPA SOP 2012.

Regardless of the method used, it is very important to minimize cross-contamination of sample media and samples by properly decontaminating the equipment you use.

Removing Extraneous Material

Identify and discard materials in a sample which are not relevant or vital for characterizing the sample or the site, since their presence may introduce an error in the sampling or analytical procedures.

Examples of extraneous material in soil samples can include glass pieces, twigs, or leaves. However, not all non-soil material is extraneous. Collect samples of any material thought to be a source of contamination for a laboratory extraction procedure.

Homogenizing Samples

Homogenization is the mixing or blending of a soil sample in an attempt to provide uniform distribution of contaminants. Ideally, proper homogenization ensures that portions of the containerized samples are equal or identical in composition and are representative of the total soil sample collected. Incomplete homogenization will increase sampling error.

In order to manually homogenize samples, use a stainless steel spoon or scoop and a stainless steel bucket (or use a disposable scoop and pan) and follow these steps:

1. Form a cone of the sample on a hard, clean surface.
2. Flatten the cone and divide the sample into quarters.
3. Remix opposite quarters and reform a cone.

Repeat a minimum of 5 times.

Compositing Samples

Compositing is the process of physically combining and homogenizing several individual soil aliquots, or portions, in order to provide an average concentration of contaminants over a certain number of sampling points. This technique can be very useful, reducing the number of required lab analyses, but it must always be implemented with caution.

Since compositing dilutes high concentration aliquots, the applicable method detection limit (MDL) should be reduced accordingly. If the composite value is to be compared to a selected limit, then the limit must be divided by the number of aliquots that make up the composite in order to determine the appropriate MDL. For example, if the limit for a particular substance is 50 ppb, a limit of 10 ppb should be used when analyzing a 5-aliquot composite. The MDL need not be reduced if the composite area is assumed to be homogeneous in concentration.

Sieving Samples

Sieving is the process of physically sorting a sample to obtain uniform particle sizes, using sieve screens of predetermined size. Be aware of the intent of the sampling when deciding whether to sieve a sample prior to analysis.

Prior to sieving, samples may need to be oven-dried. Discarding non-soil or non-sieved materials, as well as the sieving process itself, can result in physical and chemical losses. Analyze the discarded materials, or a fraction thereof, to determine their contribution to the contamination of the site being investigated.

Splitting Samples

Splitting samples after collection and field preparation into two or more equivalent parts is performed when portions of the same sample need to be analyzed separately. Split samples provide a measure of the analytical and extraction errors.

Before splitting, follow homogenization techniques. Fill two sample collection jars simultaneously with alternate spoonfuls or scoopfuls of the homogenized sample.

Final Preparation

Select sample containers on the basis of compatibility with the material being sampled, resistance to breakage, and volume. Appropriate sample volumes and containers will vary according to the parameter being analyzed, and this information can be provided by the laboratory.

It is sometimes possible to ship samples to the laboratory directly in the sampling equipment. For example, the ends of a Shelby tube can be sealed with caps, taped, and sent to the laboratory for analysis. The shipping requirements will be dependent on the material and/or sampling and analysis method you use. Package all samples in compliance with Department of Transportation (DOT) or International Air Transport Association (IATA) requirements.

Appraisal (Page 9 of 13)

You will be presented a series of questions to check your understanding of sampling methods. For each question, select the correct answer.

Why would you homogenize a sample?

A To ensure that portions of the containerized sample are representative of the total sample collected.

B To provide a measure of the sample variability and a measure of analytical and extraction errors.

C To provide an average concentration of contaminants over a certain number of sampling points.

D To separate fine particles from courser ones to ensure that all particles in the sample are of a uniform size.

If the contaminant of concern is volatile, which of the following sampling methods is an appropriate action to be taken?

A Sieving the sample.

B Compositing the sample.

C Homogenizing the sample.

D Removing extraneous material.

How can you minimize cross-contamination of sample media and samples?

A By homogenizing and splitting the sample.

B By removing extraneous material from the sample.

C By properly decontaminating the equipment you use.

D By collecting a sufficient number and volume of samples.

Number of Samples Needed (Page 10 of 13)

The greater the number of samples collected from a site, the more representative the analytical results will be. However, the number is often constrained by available resources.

You can identify the number of samples needed to achieve the desired confidence level by using table 1-5 from the BE Field Manual and applying your professional judgment to check your assumptions and adjust the number of samples, as appropriate.

Confidence in Characterization (Consistency in hazard levels or environmental variability throughout the process)		*High (Low Variability)*	*Moderate (Medium Variability)*	*Low (High Variability)*	*Very Low (Very High Variability)*
Confidence Result Will Yield Correct Decision	**Decision Error (p)**	**GSD= 1.02**	**GSD=1.3**	**GSD=2**	**GSD=54**
		Standard Deviation =15%	**Standard Deviation =50%**	**Standard Deviation =80%**	**Standard Deviation =200%**
99%	**1%**	5	25	59	350
95%	**5%**	3	13	30	175
90%	**10%**	2	8	18	106
80%	**20%**	1	4	8	46
70%	**30%**	1	2	3	18

Selecting Equipment (Page 11 of 13)

Soil sampling equipment should be selected according to the objectives of the sampling activity. Soil samples may be collected using a variety of methods and equipment depending on the **depth** of the desired sample, the **type of sample**, and the **soil type**. Near-surface soils may be easily sampled using a spade, trowel, and scoop. Sampling at greater depths may be performed using a hand auger, continuous flight auger, trier, split-spoon, or backhoe. If you would like to view information about different types of soil sampling equipment, see the sampling equipment document in the Appendix.

As you conduct the sampling, remember to use the appropriate personal protective equipment (PPE) and take necessary safety precautions. In addition to health threats posed by the contaminant of concern (COC), you must be aware of environmental threats and conditions that could be hazardous to you.

Depth

Soil contamination by elemental heavy metals, such as lead, or by chemicals that are relatively insoluble in water, such as pesticides, may be limited to the top few inches of soil. However, the area that is contaminated can be affected by soil erosion, weather, vehicular movement, or disturbance of the soil.

Soil contamination by soluble metals (e.g., plating wastes) or by spills of concentrated organic chemicals (e.g., gasoline, aviation fuel, solvents, or transformer oil) may extend to considerable depths. The concentration of the chemicals at any depth may not be easily predictable.

Depending on the analytes being investigated, samples are collected at the surface (0-3 in.), extended surface (0-6 in.), and/or at one-foot depth intervals.

Type of Sample (Disturbed or Undisturbed)

Depending on your method, the sample you collect may be disturbed or undisturbed.

A disturbed sample is one whose internal structure has been damaged to such a degree that it does not reasonably approximate that of the material in situ (in its original position).

An undisturbed sample is a sample obtained and handled in such a way that disturbance of its original structure is minimal so that the sample is suitable for laboratory tests of material properties that depend on in situ soil structure.

Soil Type

The sampling equipment you can use is affected by the type of soil. For example, you may not be able to use tube samplers in rocky soils. Also, because some soil types do not absorb contaminants, you must know what type of soil you're dealing with in order to sample the correct locations. For example, chemicals may be found several hundred feet from the source of contamination if the soil is a porous, non-organic type such as sand that allows for rapid movement of liquids.

The subsurface lithology (the presence and location of different types of soil, bedrock, or groundwater) of the site strongly influences the transport of hazardous chemicals. Soil features such as color, texture, and structure should be described as a function of depth at each sample location. Soils high in organic material can absorb and concentrate some hazardous chemicals. For example, a layer of peat may be more contaminated than the soil layers above or below it.

Scenario Challenge Point (Page 12 of 13)

When using a systematic grid approach to establish a threat or identify sources, you should also use field analytical screening. As part of your sampling strategy, you begin thinking about the procedures you'll use for analyzing the soil once you arrive at the golf course. Put the field analysis steps in the order in which you would perform them.

Steps	Order
Characterize the potential exposure routes and frequency of personnel exposure.	1. ______________________________
Document results and reprioritize additional sampling based on results.	2. ______________________________
Prioritize each AOC.	3. ______________________________
Conduct routine and special sampling, assessments, and monitoring.	4. ______________________________
Screen for the elements of highest risk.	5. ______________________________

Steps for Performing Field Analysis (Page 12a of 13)

As you are collecting soil samples at the golf course, you will perform each of the following field analysis steps:

1. **Prioritize each AOC.**
2. **Screen for the elements of highest risk.**
3. **Characterize the potential exposure routes and frequency of personnel exposure.**
4. **Conduct special and routine sampling, assessments, and monitoring.**
5. **Document results and reprioritize additional sampling based on results.**

Prioritize Each AOC

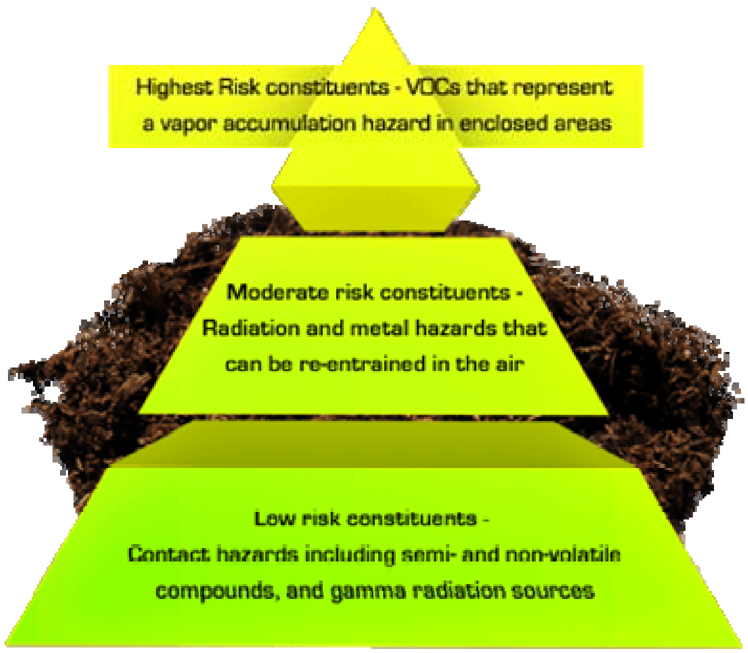
You carefully consider the map you have showing the location of the landfill and the characteristics such as surface flow that affect the areas on base likely to be contaminated.

You determine that the area of highest concern is the location where maintenance workers have experienced the odor on two separate occasions. You choose a point between the line of Bradford Pear trees and the flowerbeds along the pathway and lay out an area using that point to draw a 900 m radius.

Screen for the Elements of Highest Risk

You've decided to use a systematic grid approach to determine the areas of highest contaminant concentrations. You randomly choose a location inside the AOC as your first sampling point and then divide the area into grids. You use plastic scoops for surface sampling from each grid node.

You then perform screening to identify the contaminants in the soil. You use a Victoreen 451P to detect the presence of radioactive substances and a TVA-1000B, which contains a photoionization detector (PID) and flame ionization detector (FID), to detect the presence of volatile organic compounds (VOCs). You use a 4-gas meter to determine if hydrogen sulfide is present. You also use a portable X-ray fluorescence (XRF) analyzer to screen for metals in the soil.



Characterize the Potential Exposure Routes and Frequency of Personnel Exposure

You consider the ways in which personnel and members of the community could be exposed to any contaminants present in the soil. You determine that potential exposure routes include direct or indirect contact with the soil or groundwater

Conduct Special and Routine Sampling, Assessments, and Monitoring

You conduct additional sampling of the hot spots indicated by screening results, collecting samples at greater depths using augers. You perform screening of the samples to limit the number of samples to be sent for laboratory analysis.

Document Results and Reprioritize Additional Sampling Based on Results

You document the results of your screening samples. Screening results for VOCs are negative.

Based on the workers' complaints of a "rotten egg" odor, you screened for hydrogen sulfide but did not detect its presence (the 4-gas meter detection limit is 1 ppm). You suspect that concentrations less than 1 ppm but above the odor threshold of .008 ppm are likely present.

Based on the presence of the "rotten egg" smell and the results of the 1999 landfill investigation, you decide to take additional samples for lab analysis even though screening samples did not detect hydrogen sulfide or VOCs.

When the results come back from the lab, you will document them and consider whether additional sampling is required.

Soil Gas Screening Procedures

Listed below are procedures you should follow when screening for soil gas:

1. Grid the site location or AOCs into approximately 900 m2 areas. Each grid should be a rough estimate of 30-meter by 30-meter square. The grid layout is dependent on the size of site and professional judgment is necessary in order to collect sufficient data for assessment.
2. Don nitrile gloves and collect soil samples from each corner of the grid and the center of each grid (five samples per grid).
3. Collect the soil samples from the top six to twelve inches of soil using stainless steel tools, or disposable shovels if available.
4. Place in a plastic bag and seal.
5. Gently shake to release soil vapors.
6. Allow the soil to remain in the bag for approximately 30 seconds.
7. Document the temperature and humidity.
8. Insert the PID/FID sample probe into the bag and record the results.
9. If the PID/FID reading equals or exceeds 5.0 ppm a contaminant source shall be considered present.
10. If a HAPSITE is available, use it to identify the constituents and estimate the concentration.

Lesson Summary (Page 13 of 13)

You have learned that developing a sampling strategy is vital for ensuring the health and well-being of personnel and the base community.

In this lesson, you:

- Cited the considerations for developing a soil and solid sampling strategy.
- Defined various soil and solid sample collection approaches and methods.
- Determined why and when to collect samples.
- Outlined the steps required to field analyze soil and solid samples.

Audio Script

OIC: You've done a good job at getting to the bottom of those complaints from the grounds maintenance workers and developing a sampling strategy based on the information you found. Based on what you've told me, it looks like those trees may be causing some serious problems.

We don't really know if the cap has been penetrated, but we'll understand more about the situation after the sampling results come back from the lab. In the meantime, we should start thinking about how this situation may affect the base's water supply.

Lesson 4: Liquid and Water Sampling

Lesson Description

In this lesson, you will learn the factors you must consider when developing a water sampling strategy, and you will assist in developing a sampling strategy for investigating potential contamination of the base's groundwater, which is the source of drinking water for the base. Upon completion of this lesson, you will be able to outline the procedures for developing a liquid and water sampling strategy.

Lesson Overview (Page 1 of 11)

As you have learned, sampling is a vital component of the Health Risk Assessment (HRA) and Occupational and Environmental Health Site Assessment (OEHSA) processes. It is the foundation of any water monitoring program and is also needed when identifying potentially hazardous liquids and any health effects associated with them.

Preliminary lab results from soil sampling at the golf course have come back. No further soil sampling is required. However, lab results show low levels of hydrogen sulfide and levels of TCE above the action level in the soil. Because of possible leaching into the groundwater, water sampling is also required.

While preparing your water sampling strategy for the groundwater beneath the base golf course, you will outline the considerations for developing a liquid and water sampling strategy.

Audio Script

OIC: Based on the screening results from the soil sampling you did on the golf course, it sounds like you also need to develop a strategy for sampling the groundwater to determine if the plume poses a threat to the well. With TCE levels in the soil above the AL, we need to make sure the base's water supply hasn't been affected. There are some monitoring wells on that part of the base, so you should be sure to sample those. Work on that component of your strategy and let me know your plan.

Considerations for Developing a Liquid and Water Sampling Strategy (Page 2 of 11)

Remember that the sampling strategy is the overall plan which includes details of the entire sampling process from beginning to end. What your sampling strategy includes partly depends on whether you're conducting **routine sampling** as part of an existing potable water monitoring plan, sampling water sources in a **high-threat environment**, or sampling **non-aqueous phase liquids (NAPLs)**.

Regardless of the sampling situation you are involved with, in general, the sampling program must consider the following factors:

- Sampling objectives.
- Potential contaminants.
- Types of samples.
- Sample collection methods.

- Sampling point locations.
- Flow measurements, as appropriate.
- Sampling procedures.
- Documentation, communication, and follow-up.

As you work on your water sampling strategy, you will learn more about each of these considerations.

Routine Sampling

Routine sampling is typically conducted for potable water systems. You will not need to develop a new strategy for this type of sampling because it is part of a water monitoring plan already in place and is focused on bacteriological sampling.

High-Threat Environment

New sampling strategies are required in higher threat situations such as deployed environments or where potential areas of contamination require investigation outside of routine surveillance. When developing the sampling strategy for these kinds of situations, it is important to consider source water as well as target areas in the water system as areas that may require sampling.

Non-aqueous Phase Liquids (NAPLs)

While non-aqueous sampling for the purposes of disposal or compliance is not a BE responsibility, sampling unknown liquids for identification purposes and to assess potential health effects is a BE function.

Scenario Challenge Point (Page 3 of 11)

As you sit down to work on your strategy for sampling the groundwater beneath the golf course, you consider your sampling objective.

Which of the following best describes the *primary* reason for this sampling?

A Process Control

B Routine Surveillance

C Compliance Monitoring

D Health Risk Assessment

Sampling Objectives (Page 3a of 11)

As you'll recall, before any other aspect of a sampling strategy can be determined, the sampling objective must be identified.

Whether you are operating from an established sampling strategy or are developing a new one, your primary objective for a liquid or water sampling strategy is either to monitor drinking water safety as part of routine surveillance or to assess a health risk.

Potential Contaminants (Page 4 of 11)

Another vital consideration when developing your liquid or water sampling strategy is to determine each potential **contaminant of concern (COC)** for which you are sampling.

When sampling in-garrison based on an established sampling program, bacteria that could affect the potability of the water are the primary COCs. In a deployed setting, you will conduct water sampling for the purposes of identifying possible water sources, addressing other site selection considerations, and/or assessing the continued safety of the water system.

To determine the COCs for your sampling strategy, you should use existing reports, intelligence sources, experience, and professional judgment to determine if any past or current industrial or non-industrial activities or processes could pose a health threat to personnel.

The COC can affect the types of equipment to be used, prioritization, and sampling method. Remember to check with federal, state, local, and Air Force regulations and guidance on how to sample for specific contaminants.

Contaminant of Concern (COC)

Some examples of major contaminants typically found in non-potable water are:

- Sediment such as soil, sand, and debris.
- Solids/residues such as chlorides, sulfates, and iron oxide.
- Toxic substances such as heavy metals, polychlorinated biphenyls (PCBs), pesticides, and solvents.
- Oil and grease such as gasoline and fuel oil.
- Detergents such as aircraft, vehicle, and laundry washwaters.
- Acids/alkalies such as metal plating wastes, paint strippers, and dyes.
- Nutrients such as phosphate and potassium from sewage, fertilizers, and detergents.
- Organic wastes, such as steroids and plasticizers, polynuclear aromatic hydrocarbons, and pesticides from sewage, or wastes from food processing, animals, wood and paper mills, and agriculture.
- Excessive heat such as that produced by power plants, nuclear reactors, boilers, and heated dip tanks.

Scenario Challenge Point (Page 5 of 11)

After determining the objective and potential COCs to be addressed by your sampling strategy for the golf course groundwater, you begin to think about the type and method of sampling that would be appropriate for this sampling strategy.

Which two of the following represent the type and method of sampling that you should conduct at the golf course? Select one type and one method.

A Grab

B Manual

C Composite

D Automatic

Types of Samples (Page 5a of 11)

Another step you will take when defining the scope of your liquid or water sampling strategy is determining the type of sample you will collect. Based on your COCs, you may have to consult a laboratory to determine the type of sample needed.

The most common types of sampling are **grab samples** and **composite samples**. The type you choose will help to determine the number and frequency of the samples.

Grab Samples

The most common type of sample used is the grab sample, which is an individual sample. A grab sample characterizes the water quality at a particular time, and multiple grab samples taken at different times or locations can provide information on minimum and maximum concentrations of constituents.

Grab samples should be used when:

- Parameters to be analyzed such as pH, dissolved oxygen (DO), and temperature are likely to change with storage.
- Information on maximum, minimum, or variability of concentration of COCs is desired.
- The history of water quality is to be determined.

Composite Samples

Composite samples are formed by mixing discrete samples taken at periodic points in time or as a continuous proportion of the flow. In this type of sampling, either the entire composite sample is measured, or random subsamples from the composite are measured.

Composite sampling is especially useful when:

- Preservation is not required.
- You are trying to determine the average concentrations of constituents.
- You need to calculate mass per unit of time loading.
- Identification of the contaminant cannot be obtained through grab sampling.

Sample Collection Methods (Page 5b of 11)

When defining your strategy, you will also choose a method for collecting samples.

Both grab samples and composite samples can be collected **manually** or **automatically**. Whichever technique is adopted, the success of the sampling strategy is directly related to the care exercised in the sample collection. Optimum performance will be obtained by using trained personnel.

Along with determining whether to use manual or automatic sampling, you must determine what PPE may be required, the type of containers that may be used, and how much of the sample is required.

Selecting sampling methods for **non-aqueous phase liquids** (NAPLs) requires special considerations.

Manual Sampling

There is minimal initial cost involved in manual sampling. The human element is the key to the success or failure of manual sampling programs. It is well suited to a small number of samples but is costly and time-consuming for routine and large sampling programs

Automatic Sampling

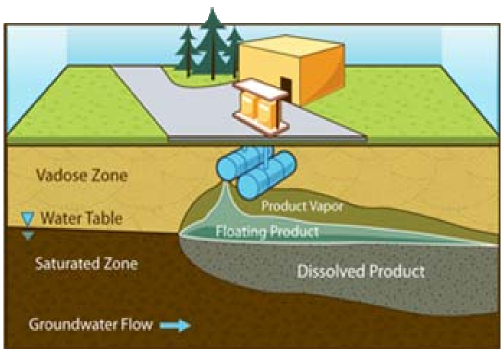
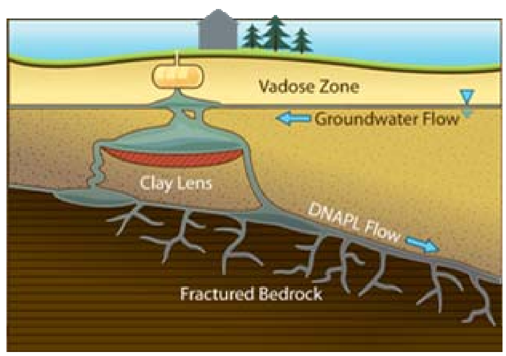
Automatic samplers are being used increasingly because of their cost effectiveness, versatility, reliability, and capabilities. Automatic samplers are available with widely varying levels of sophistication, performance, mechanical reliability, and cost. No single automatic sampling device is ideally suited for all situations. For each application, the following variables and factors should be considered in selecting an automatic sampler:

- Variation of water or wastewater characteristics with time.
- Variation of flow rate with time.
- Specific gravity of liquid and concentrations of suspended solids.
- Presence of floating materials.
- The range of intended use.
- The skill level required for installation of the automatic sampler.
- The level of accuracy desired.

Comparison of Manual and Automatic Sampling		
	Manual	**Automatic**
Cost	☑ Low capital cost ☒ High labor cost	☑ Low labor cost
Flexibility	☑ Able to compensate for various situations	☒ Inflexible
Variability	☒ Probability of increased variability due to sample handling	☑ Probability of decreased variability caused by sample handling
Consistency	☒ Inconsistent handling	☑ Consistent samples
Capabilities	☑ Able to collect extra samples in a short time when necessary ☑ Able to note unusual conditions	☑ Capable of collecting multiple bottle samples for visual estimate of variability and analysis of individual bottles ☒ Restricted in size to the general specifications
Maintenance	☑ No maintenance required	☒ Considerable maintenance for batteries and cleaning because of susceptibility to plugging by solids
Other	☒ Repetitious and monotonous task for personnel	☒ Potential for sample contamination ☒ Subject to damage by vandals

Non-aqueous Phase Liquids (NAPLs)

NAPLs are classified by their density, as shown below.

<table>
<tr><th>LNAPLs</th><th>DNAPLs</th></tr>
<tr><td>Light non-aqueous phase liquids (LNAPLs) are generally considered to be low density, immiscible organics, including gasoline, petrochemicals, and other chemicals which have specific gravities less than water and therefore float on the water.</td><td>Dense non-aqueous phase liquids (DNAPLs) have specific gravities greater than water and include chlorinated solvents and other chemicals. DNAPLS tend to sink in water.</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

See the Resources section at the end of this document for guidance from the EPA regarding sampling strategies for NAPLs.

Common Sampling Devices

The following are some common devices used for grab and composite sampling.

- When the site must be accessed from a boat or a structure (such as a bridge or pier), a Kemmerer bottle or a Bacon Bomb sampler may be used to collect grab samples.
- If a sample is to be recovered from a site where direct access is limited, such as an outfall pipe or along a lagoon bank, a dip sampler may be used to collect grab samples.
- For monitoring wells, a manual bailer is generally used.

Whatever equipment is selected, you should read the manufacturer's specifications to ensure that it meets your requirements and that you are using it properly.

Sampling Point Locations (Page 6 of 11)

Defining the scope of the sampling plan includes selecting the location of each sampling point. Usually, the reasons for sampling, historical data, and intelligence will help you determine the approximate locations for sampling.

When you are using an established sampling plan for a potable water system, the locations for routine surveillance will typically be specified and should include loops, dead-ends, low pressure areas, and points that serve mass populations.

No specific guidelines can be given on the exact sampling locations you will use when developing a new sampling strategy; however, you must ensure that the locations allow for **representativeness** and **homogeneity**. Other considerations are pronounced degradation of water quality in specific areas, convenience, and accessibility.

Representativeness

It is important for the sample to accurately characterize the condition of the water or liquid being sampled.

When sampling an unknown substance, collecting a representative sample can be influenced by the sampling equipment you use. For example, when using a Composite Liquid Waste Sampler (COLIWASA), you can sample specific layers within a liquid.

In a deployed setting where BE conducts non-potable water sampling, you can help ensure a representative sample by choosing the most appropriate sampling locations, such as the following:

- Representative sites in the main stream of rivers, estuaries, coastal areas, lakes, or impoundments.
- Major water use areas, such as public water supply intakes, commercial fishing areas, and recreational areas.
- Representative sites in the individual waste streams.
- Mouths of major or significant tributaries to mainstreams, estuaries, or coastal areas.

The analyte of interest will affect your choice of sampling locations. For example, if you are interested in an oils and grease sample, you would collect the sample from the top of the water. On the other hand, if you are interested in knowing the concentration of heavy metals in an area, you may take a sample from the bottom of a surface water source.

When choosing sampling locations, keep in mind that contaminant migration can occur due to current or flow direction.

Homogeneity

Uniform distribution of constituents, or homogeneity, is a desired effect of turbulence (e.g., that produced by a hydraulic jump) and good mixing (e.g., from the spring and fall turnovers of a lake).

Poor mixing (e.g., stratification in lakes or a slow-moving river downstream of a waste discharge) results in different densities of the constituents, such as floating oils or settling suspended solids. Chemical or biological reactions, such as growth of algae in upper layers of the body of water, cause changes in pH.

In order to ensure homogeneity, you should sample from several locations to obtain the required information. Suggested areas to collect samples include:

- Significant outlets and inputs of lakes, impoundments, estuaries, or coastal areas that exhibit eutrophic characteristics (i.e., nutrient-rich water with an abundance of plant life and reduced oxygen content).
- Upstream and downstream of major population and/or industrial centers which have significant discharges into a flowing stream.
- Upstream and downstream of representative land use areas.

Flow Measurements (Page 7 of 11)

Flow measurements are taken when monitoring surface water conditions and should be accounted for in your sampling strategy if surface waters are part of the sampling situation. You must exercise care when selecting the location from which to conduct flow measurements to ensure that the sample is representative of the majority of the surface water source. Inaccurate measurements will lead to inaccurate flow proportional composite samples which, in turn, will lead to inaccurate results. The ideal site provides desired flow measurement to meet program objectives, ease of operation and accessibility, safety of personnel and equipment, and freedom from vandalism.

Flow measurements can be taken manually or with electronic direct-reading instruments, or they can be estimated using a mathematical equation.

Flow measurement methods can be broadly grouped into four categories:

- Closed conduit flow measurement.
- Flow measurement for pipes discharging to atmosphere.
- Open channel flow measurement.
- Miscellaneous methods of flow measurement.

Scenario Challenge Point (Page 8 of 11)

Which of the following sampling procedures should you include in your strategy for the golf course groundwater sampling? Select all that apply.

A Clean the sample bottles to avoid contamination.

B Store the samples in a sunlit place at room temperature.

C Check the operating condition of the sampling equipment.

D Do not add chemical preservatives to the sampling containers.

Liquid and Water Sampling Procedures (Page 8a of 11)

The sampling strategy should specify the various analyses to be performed and the corresponding analytical methods to be used.

Throughout the entire sampling effort - from sample collection to laboratory analysis - standard procedures and methods for handling and analyzing samples must be used. This is done to maintain sample identification, integrity, and representativeness at all times.

The key to the success of a sampling strategy lies in:

- Documentation and management.
- Collection of representative samples.
- Proper handling and preservation of samples.

Documentation and Management

The following are some ways to maintain effective sampling operations:

- Compose written instructions on sampling procedures.
- Maintain the equipment in proper condition.
- Hold training sessions for sampling teams.
- Prior to use, check sampling equipment to ensure proper operating conditions and cleanliness. Also, keep the equipment ready for use by cleaning the equipment after each sampling event and following the manufacturer's maintenance specifications.

Representative Samples

You've already learned that samples must be taken in such a way that they characterize or approximate the quality or condition of the water body or nonaqueous liquid.

The following are some guidelines you can follow to obtain representative water samples:

- Collect the sample where water or liquid is well mixed.
- In a channel, collect the sample in the center at a depth that avoids bottom bed loads and top floating materials, unless you are sampling for those particular analytes.
- In a wide channel, divide the channel cross section into different vertical sections so that each section is of equal width. Take a representative sample in each vertical section.
- In a deep stream or lake, collect the samples at different depths.
- When manual sampling with jars, place the mouth of the collecting container below the liquid surface and facing flow to avoid an excess of floating material. Keep your hand as far as possible away from the mouth of the jar.
- If samples are taken from a closed conduit via a valve or faucet arrangement, allow sufficient flushing time to ensure that the sample is representative of the supply, taking into account the diameter, length of the pipe to be flushed, and the velocity of the flow.

When sampling containerized liquids, you can ensure representative sampling by using equipment that collects a sample from the full depth of the drum, such as the COLIWASA.

Handling and Preservation

When immediate analysis of the collected sample is not possible, take precautions so that the sample characteristics are not altered.

Proper handling of the samples includes following the storage requirements listed in the analytical method description and the appropriate chain of custody procedures. A good sampling habit is to keep the number of people who handle the sample to a minimum.

Most water samples are preserved by pH and temperature adjustments; however, you should consult the specific storage and preservation directions listed in the analytical method description.
These guidelines will help ensure quality handling and preservation:

- Before you begin sampling, plan how and when you will transport the samples back to the laboratory so that all samples are preserved and delivered to the laboratory as quickly as possible and within recommended holding times. This is especially important for samples like Nitrate/Nitrite that have holding times of 24 hours or less.
- Coordinate with the receiving laboratory to ensure that the samples will be held at the correct temperature and analyzed within the appropriate timeframe.
- Store the samples in a manner which ensures that the parameters to be analyzed are not altered, and use appropriate preservation methods and holding times.
- Ensure that the container material does not interfere with the analysis of the specific parameters.
- Check all sample bottles for integrity (i.e., no cracks, dirty caps/bottles, etc.), and clean the exterior of the bottles to avoid spreading contamination to other people and equipment involved with the analysis process.

Because samples collected from drums are usually of an unidentified nature, you should not add preservatives due to the potential reaction of the sample with the preservative. Samples should, however, be cooled to 4°C and protected from sunlight.

Communication, Documentation, and Follow-Up (Page 9 of 11)

As with other sampling plans, when developing your liquid or water sampling plan, you must consider how you will **document** your findings, when and how to **address follow-up needs**, and how you will **communicate** with all appropriate parties.

Document

Detailed sample documentation is an integral part of the overall sampling strategy. Without documentation, vital information is lost, which can result in time, resources, and money being spent rebuilding the lost data or experience. You must record parameters before and after taking groundwater samples.

Information that must be recorded for all samples includes:

- Date, time, and weather conditions.
- Collected by and method used.
- Specific sampling location and source.
- Sample volume and type (e.g., grab).
- Sample identification number.
- Direct reading instrument readings (as appropriate).
- Sampling rationale (i.e., Why was the sample collected? Area screening sample or follow-up to personnel over-exposure?)

Address Follow-Up Needs

As part of the OEHSA process, you should identify the need for follow-up sampling and develop a plan for reassessment, including sampling frequency.

If you are sampling as part of an established sampling strategy, frequency and follow-up needs should already be identified and should only change if circumstances affecting the potable water system change. Reassessment frequency is determined by categorizing the risk associated with the area of concern (AOC) as high, medium, or low and may need to be reevaluated after all risks have been fully characterized.

Communicate

Communication is a key component of the HRA process. You must be proactive in communicating risks and recommendations to commanders about controlling those risks. Initially, the commander will typically ask you for a recommendation or input; however, after a decision is made, commanders will likely assume that the recommendation remains valid unless they are told otherwise. Therefore, it is important for you to provide on-going recommendations, updates, alternatives, and courses of action as needed based on routine and special surveillance.

You must also communicate health risks to personnel or community members whenever their health and safety are or may be affected.

Appraisal (Page 10 of 11)

For this question set, you will be matching several descriptions with the sampling strategy considerations listed. Read each description you see and select the consideration to which it corresponds in the list.

Statements
These can be either manual or automatic.
Selecting these helps ensure representativeness and homogeneity of the sample.
The most common are grab and composite.
An example is storing samples in a manner which ensures the parameters to be analyzed are not altered.
Categories include closed conduit or open channel, for example.
This includes providing recommendations to commanders about controlling health risks.
These include routine surveillance and health risk assessment.
Some examples are sediment, oil, and detergents.

	Considerations for Developing a Sampling Strategy
________________________________	Sampling program objectives
________________________________	Potential contaminants
________________________________	Sampling point locations
________________________________	Types of samples
________________________________	Sample collection methods
________________________________	Flow measurements
________________________________	Sampling procedures
________________________________	Communication, documentation, and follow-up

Lesson Summary (Page 11 of 11)

You have learned that your sampling strategy will be affected by whether you're conducting routine sampling as part of a potable water monitoring plan that's already in place, sampling water sources in a high-threat environment, or sampling nonaqueous liquids.

Regardless of the situation for which you're considering a liquid or water sampling strategy, the sampling program should generally consider the following factors:

- Sampling objectives.
- Potential contaminants.
- Types of samples.
- Sample collection methods.
- Sampling point locations.
- Flow measurements, as appropriate.
- Sampling procedures.
- Documentation, communication, and follow-up.

Audio Script

OIC: I've looked over your water sampling plan for the groundwater under the golf course, and it looks good. Go ahead and start your sampling. When you get the results from the lab, let me know if you have any questions about the interpretation.

Lesson 5: Interpreting Sampling Results

Lesson Description

In this lesson, you will interpret results of sampling you conducted previously in this unit. This lesson provides refresher information about total exposure health risk and the relationship of results to standards, mission, and effects.

Upon completion of this lesson, you will be able to explain how sampling results are interpreted.

Lesson Overview (Page 1 of 10)

After you have conducted sampling, you must interpret the results in order to assess the health risk. When analyzing the results from the sampling conducted earlier in this unit, you will:

- Recall the facts related to total health risk exposure.
- Recall the relationship of results to standards, mission accomplishment, and health effects.
- Interpret sampling results for a given scenario.

Audio Script

OIC: The confirmatory results of the air sampling you conducted in the corrosion control shop have come back from the lab. Even though the workers were allowed to continue their mission to paint the Super Guppy based on the screening results, you need to use the lab information to complete your assessment of the exposure and confirm that the controls in place are adequate for similar work in the future.

The results from the environmental sampling you did on the golf course should also be coming back any time now. I'll get those to you as soon as they come in.

Remember to consider the effects of the total exposure in your assessments of the health risk. SrA Wright will be assisting you. He's new at this and may need you to provide some guidance.

Scenario Challenge Point (Page 2 of 10)

Audio Script

BE Tech (SrA): What did the major mean when she said to consider the effects of the total exposure?

Before you address SrA Wright's concern, check your own understanding.

Which choice lists the factors that have the most impact on the total exposure health risk?

A Psychological effects, media pathway, and worker habits

B Physiological effects, media pathway, and exposure limits

C Physiological effects, form of contaminant, and worker habits

D Psychological effects, form of contaminant, and exposure limits

Audio Script

BE Tech: Don't forget, you have to think about all the factors that might influence how someone could be affected by a contaminant. Different substances have different effects on the body depending on what form they're in and whether they're mixed with other chemicals. You also have to keep in mind the impact of a person's habits and daily routines on both the exposure and its effects on the body.

Considerations for Developing a Sampling Strategy (Page 2a of 10)

In order to effectively protect the health and well-being of workers and the community, you must understand how they can be affected by the substances to which they are exposed. The physiological effects and physical form of the contaminant(s) will influence biological responses, and the habits and environment of the workers affect the exposure.

Tab: Physiological Effects

Chemicals affect personnel differently depending on an individual's susceptibility to the chemical and the combined physiological effects of multiple chemicals.

If a person has had a previous exposure to a chemical, he or she may experience **cumulative** effects which cause adverse health effects to occur more quickly for that person than would normally be anticipated. Some people can become sensitized to certain substances after one exposure and other people will never become sensitized to it, even after years of working with the substance.

A worker exposed to multiple chemicals may experience interactive effects such as **additive** or **synergistic** effects. Whenever there is a possibility of exposure to multiple chemicals, you must also consider how **antagonism** and **potentiation** may impact the total exposure health risk. When determining the potential for any of these interactive effects, you must consider whether the chemical affects the same target organ(s) or organ systems.

Cumulative

A cumulative effect is an overall adverse change which occurs when repeated doses of a harmful substance or physical agent have biological consequences which are mutually enhancing. While the contaminant's effect after the initial exposure may be equal to its anticipated effect *(1=1),* the cumulative effect of repeated exposure may be much greater than anticipated *(1=15).*

Additive

An additive effect is a combined effect of two or more chemicals that is equal to the sum of their individual effects. Neither one of the contaminants enhances *or* diminishes the effect of the other. Additive effects are the most common interactive effects among chemicals and can be thought of as a simple *1+1=2* relationship.

Synergistic

A synergistic effect is a combined effect of two or more chemicals that is greater than the sum of their individual effects. Each contaminant amplifies the effects of the other. A synergistic effect results in a *1+1=10* kind of relationship.

Antagonism

Antagonism refers to the interference or inhibition of the effect of one chemical by the action of another chemical. Therefore, the combined effect of the chemicals is less than the sum of their individual effects. When antagonism occurs, one contaminant could reduce the effect of the other chemical, or both contaminants could interfere with each other, in effect canceling each other out. This effect could be represented by the equation, *1+1= 0*.

Potentiation

Potentiation is a dependent action in which a substance or physical agent at a concentration or dose that does not itself have an adverse effect enhances the harm done by another substance. In other words, a contaminant that does not normally have a toxic effect could become toxic when combined with another contaminant. This kind of effect could be represented as *0+1= 5*.

Tab: Contaminant

You may have heard the saying, “the dose makes the poison.” Sometimes the physical form of the contaminant can determine the dose – and in turn, the toxicity. Whether the substance exists in a gaseous, solid, or liquid form can determine the exposure route, thereby influencing how quickly the exposure affects the body and what health effects the substance may cause.

Consider, for example, a chemical that may cause dermatitis with repeated or prolonged skin contact as well as respiratory irritation and cough when inhaled. This same chemical has been used for illegal bomb-making because of its combustible nature when it exists as fine dust particles. Would you want to ingest this chemical? Chances are you have eaten it many times. That chemical is sucrose — better known, of course, as sugar. The physical form of the substance, along with how a person is exposed to it, has a significant impact on the physiological effects of the substance.

Tab: Worker / Environment

When analyzing the total health risk, you must consider not only workday exposures and habits such as use of controls and PPE, but also off-duty habits and exposures. For example, a person who smokes is typically more likely to experience adverse health effects than a non-smoker, especially when inhalation hazards are the concern. Also, an exposure at a second job may add to the effects of an otherwise acceptable exposure in the primary workplace.

Evaluating the total exposure of a worker means looking at the worker's daily life from a holistic perspective in order to understand the potential for additive, synergistic, and cumulative effects. In a deployed setting, every exposure encountered in a 24-hour period should be assessed.

Appraisal (Page 3 of 10)

To check your understanding of the facts related to total exposure health risks, here is a series of questions.

Which of the following terms refers to a combined effect of two or more chemicals that is greater than the sum of their individual effects?

A Additive effect

B Synergistic effect

C Antagonism

D Potentiation

A maintenance shop worker reports severe kidney pain and difficulty urinating. She uses Toluene daily, but you find that her workday exposure is below the OEL. Upon further investigation, you learn that she recently did some work at home on her car, using a cleaner containing Xylene, a chemical that also affects the kidneys. Which of the following effects is the worker likely experiencing?

A Additive effect

B Synergistic effect

C Cumulative effect

D Antagonistic effect

Which of the following terms refers to the interference or inhibition of the effect of one chemical by the action of another chemical?

A Additive effect

B Synergistic effect

C Antagonism

D Potentiation

An electronics worker becomes dizzy and begins having difficulty breathing after briefly working with heat shrink tubing, a material which releases Dichloromethane when heated. He is using the material properly in a well-ventilated area and has worked with it many times before with no problems. Which effect is he likely experiencing?

A Additive effect

B Synergistic effect

C Cumulative effect

D Antagonistic effect

Relationship of Results to Standards, Mission Accomplishment, and Health Effects (Page 4 of 10)

To complete an exposure assessment, you must compare sampling results to standards to identify whether the exposure is at or below the accepted limit from a physiological standpoint. When making the assessment of whether the result is at an acceptable level, you must consider the total exposure and risk of adverse health effects in context of the mission.

Therefore, intelligence, mission details, and other dynamics of the environment affect how the sampling results are interpreted. Results are communicated to the commander, who makes decisions about whether to accept the risk based on anticipated effects, mission criticality, and other factors.

Example of Considering Standards, Mission Accomplishment, and Health Effects

Because the Super Guppy had not been repainted in over ten years, the corrosion control work on this aircraft was a high priority. The Super Guppy is the only aircraft of its kind and is necessary to transport components of the Space Station, as well as other large items critical to the space program.

Based on the Super Guppy's importance to NASA's mission and a comparison of the screening results with applicable standards, the Commander chose to allow the workers to continue the painting process without having the lab results in hand.

Appraisal (Page 5 of 10)

Build a list of statements that reflect the relationship of sampling results to standards, mission accomplishment, and health effects.

Word Bank	List
Intelligence and mission details affect the interpretation of results and acceptance of risk.	________________________________
The BE Tech makes risk acceptance decisions based on the mission.	________________________________
The total exposure and risk of adverse health effects must be noted in context of the mission.	________________________________
When interpreting results, only the workday exposures should be considered.	________________________________
Results are compared to standards to see if the accepted exposure limit is exceeded.	
Sampling results are communicated to the commander.	

Scenario Challenge Point (Page 6 of 10)

You and SrA Wright are ready to interpret the lab results from air samples taken in the corrosion control shop while workers were painting NASA's Super Guppy.

First, review the sampling results:

Results of Air Sampling Conducted in the Corrosion Control Shop During the Painting of NASA's Super Guppy Aircraft			
Chemical	***8-hr TWA OEL (ppm)***	***8-hr TWA Range for SEG (ppm)***	***8-hr TWA Mean for SEG (ppm)***
2,4-Pentanedione	NA	ND – 0.05	0.02
Methyl n-Amyl Ketone	50	18 - 24	20
2-Ethylhexyl Acetate	NA	ND	ND
Ethylbenzene	100	8 - 33	25
Xylene	100	12 - 39	20
Hexamethylene Diisocyanate	0.005	ND	ND
Methyl Ethyl Ketone	200	58 - 146	120

When you developed your sampling strategy for the corrosion control shop, you selected the appropriate standard and calculated the equivalent OEL for the chemicals in the paint being used by personnel. One of the chemicals to which the workers were exposed was Methyl Ethyl Ketone (MEK), and you found that the equivalent OEL for the workers' MEK exposure in a 10-hour shift is 140 ppm.

The sampling results you received from monitoring three workers over several days show that the MEK exposure was 120 ppm. Based on the action level and the OEL, are the results of the sampling in compliance?

A Yes. The results are in compliance.

B The results represent a possible overexposure.

C No. The results represent a noncompliance overexposure.

D There is insufficient information to make this determination.

Considering that the sampling results indicated a possible overexposure, and personnel are currently wearing respiratory protection while painting the aircraft, what two follow-up actions are required?

A Establish a regulated area.

B Recommend a change in PPE.

C Recommend employee training.

D Conduct follow-up screening sampling.

After receiving the sampling results, within how many calendar days must you notify the shop supervisor of the results?

A 10

B 15

C 20

D 30

According to the MSDS for the activator, MEK may increase the nervous system effects of the other solvents in the paint. You consult the NIOSH Pocket Guide and verify that MEK, ethylbenzene, and xylene all affect the central nervous system.

Based on this information, you consider the health effects of the total exposure. Realizing that you need to adjust the OEL to account for a 10-hour workday, you **calculate the equivalent OELS**.

Calculate the Equivalent OEL

To adjust the OEL for an extended workday, you multiply the 8-hour OEL by the daily reduction factor, which is 0.7 for a 10-hour workday.

Next, you will use the information below and the compliance factor formula to determine the combined exposure to the chemicals.

Chemical	Sampling Results (ppm)	Adjusted OEL (ppm)
Methyl Ethyl Ketone	120	140
Ethylbenzene	25	70
Xylene	20	70

Compliance Factor Formula

$$CF_{TWA} = \frac{TWA_1}{OEL_1} + \frac{TWA_2}{OEL_2} + \dots \frac{TWA_n}{OEL_n}$$

Next, you insert the sampling results and the adjusted OELs into the compliance factor formula to determine the combined exposure to the chemicals.

$$CF_{TWA} = \frac{120}{140} + \frac{25}{70} + \frac{20}{70}$$

Which of the following values represents the combined exposure for the workers painting the Super Guppy aircraft?

A 0.5

B 1.0

C 1.5

D 2.0

Interpreting Occupational Air Sampling Results (Page 6a of 10)

Follow these steps to interpret air sampling results for occupational analysis:

1. Ensure that all results are received from the lab and review the results.
2. Calculate any applicable averages such as an 8-hour or 15-minute TWA or **confidence limits**, depending on the sampling strategy you used.
3. Compare the results with standards or guidelines you selected when developing your sampling strategy, using the most stringent standard available. Remember that you may need to **convert units** in order to make the comparison.
4. Determine whether the results are in compliance. If your results and confidence limits are below the OEL, they represent compliance and workers are not overexposed. If the results are over or close to the OEL, based on confidence, there is a noncompliance overexposure. If the results and confidence limits are between the OEL and AL, there is a possible overexposure.
5. Consider the total exposure health effects in context of the mission and determine any necessary follow-up actions such as establishing a **regulated area**.
6. Notify personnel of the sample results within 15 calendar days of receiving the results.

Confidence Limits

The lower confidence limit (LCL) and upper confidence limit (UCL) represent the lowest and the highest value, respectively, that a true exposure could be, within a 95% confidence interval. You will use sampling and analytical error (SAE) factors to obtain these limits.

Although the SAE can be obtained from OSHA technical manuals or NIOSH, it is ideal to use the values provided by the analyzing lab so you know the exact number they used to correct your sample results and compensate for any errors associated with a particular air sampling method.

The formula to compute the UCL and LCL varies depending on how many samples were taken.

For a single sample, you will use these simple formulas:

$$\text{LCL (95\%)} = \text{TWA} - (\text{OEL} \times \text{SAE})$$
$$\text{UCL (95\%)} = \text{TWA} + (\text{OEL} \times \text{SAE})$$

For multiple samples taken at the same sample time, you will use the following formulas:

$$\text{UCL (95\%)} = \text{TWA} + \frac{(\text{OEL} \times \text{SAE})}{\sqrt{n}}$$

$$\text{LCL (95\%)} = \text{TWA} - \frac{(\text{OEL} \times \text{SAE})}{\sqrt{n}}$$

And for multiple samples taken at different times, you will use the formulas shown below.

$$\text{UCL} = \text{TWA} + \text{SAE}\,\frac{\sqrt{C_1^2T_1^2 + C_2^2T_2^2 + \ldots C_n^2T_n^2}}{T_1 + T_2 + \ldots T_n \text{ (\#hrs)}}$$

$$\text{LCL} = \text{TWA} - \text{SAE}\,\frac{\sqrt{C_1^2T_1^2 + C_2^2T_2^2 + \ldots C_n^2T_n^2}}{T_1 + T_2 + \ldots T_n \text{ (\#hrs)}}$$

Conversion

The sampling results may be expressed in different units than the appropriate standard uses. In those cases, you will need to convert the units. For example, to convert ppb to ppm, you must divide the ppb concentration by 1,000.

One of the most common conversions you will need to perform is from mg/m3 to ppm (or vice versa), using the formulas shown in the graphic.

Consider, for example, that you have a result that shows a concentration of benzene in the air at 10 mg/m3, and you want to convert to ppm. The molecular weight of benzene is 78.1. Substituting the values in the formula, you have (10 x 24.45) ÷ 78.1 = 3.13 ppm.

$$mg/m^3 = \frac{MW \times ppm}{24.45}$$

$$\mu g/m^3 = 0.0409 \times ppb \times MW$$

$$ppm = \frac{mg/m^3 \times 24.45}{MW}$$

$$ppb = \frac{24.45 \times \mu g/m^3}{MW}$$

Regulated Area

A regulated area shall be established in an area in which:

- A known carcinogen without a known OEL is being used.
- A known carcinogen is being used and is over the OEL.
- PPE is used to avoid skin or eye contact hazards.
- Respiratory protection is required to prevent exposure.
- Unmonitored access to a hazardous exposure could occur.

You will define the regulated area when one is required and describe the limits of each regulated area in writing to the shop supervisor, who will establish and monitor access to the regulated area.

Calculating Equivalent OELs for Chemical Mixtures (Page 6b of 10)

When multiple chemical health threats are present, there is a potential for interactive effects; therefore, using the OELs for each individual chemical is insufficient to determine the risk posed by the mixture.

The sum of the fractional exposures will be combined for substances that have similar toxicological effects. Ordinarily, exposures to substances that affect the same target organ or system will be added together by **calculating the compliance factor** to determine the combined exposure.

Calculating the Compliance Factor

In case of a mixture of air contaminants, the equivalent exposure shall be computed as follows:

$$CF_{TWA} = \frac{TWA_1}{OEL_1} + \frac{TWA_2}{OEL_2} + \ldots \frac{TWA_n}{OEL_n}$$

Where:

- TWA is the time-weighted average concentration of a particular contaminant.
- OEL is the exposure limit for that substance specified in Subpart Z of 29 CFR Part 1910.

If the value of CF_{TWA} is greater than one, unity has been exceeded. If the result is less than one, unity has not been exceeded.

To illustrate the formula above, consider the following exposure:

Substance	Actual concentration of 8-hour exposure (ppm)	8-hour TWA PEL (ppm)
Chemical A	500	1,000
Chemical B	45	200
Chemical C	40	200

Substituting the values into the formula, we have:

- CF_{TWA} = (500 ÷ 1,000) + (45 ÷ 200) + (40 ÷ 200)
- CF_{TWA} = 0.500 + 0.225 + 0.200
- CF_{TWA} = 0.925
- Since CF_{TWA} is less than unity (1), the exposure combination is within acceptable limits.

Follow-up Actions (Page 6c of 10)

When interpreting occupational air sampling results, the actions you take depend on whether the results are **below the AL**, between the AL and OEL, or **above the OEL**.

Results Below the AL

If sampling results are below the AL, the following actions are triggered:

- Validation of the process, through routine surveillance, to ensure that the process has not changed from previous sampling events. If the process changes, additional sampling may be needed.
- Employee training, depending on the chemical being used, as dictated by regulation.

Results Above the AL

If sampling results are between the AL and OEL, or if they are above the OEL, the following actions are triggered:

- Validation of the process, through routine surveillance, to ensure that the process has not changed from previous sampling events. If the process changes, additional sampling may be needed.
- Employee training, depending on the chemical being used, as dictated by regulation.
- Initial, periodic, and termination medical monitoring, as appropriate or required by 29 CFR 1910 or 29 CFR 1926.
- Recommendation of controls and additional sampling to determine if the implementation of controls is effective to reduce exposures to below the AL
- Compliance sampling to determine reasons for possible overexposures.

Jenks AFB Scenario (Page 7 of 10)

After finishing the interpretation of the sampling results for the corrosion control shop, you go to the OIC's office to turn in your report.

Audio Script

BE Tech: Good afternoon. SrA Wright and I finished the interpretation of the air sampling results you gave us.

OIC: So are we good to paint the Super Guppy the next time it needs it?

BE Tech: Yes, Ma'am. Although the readings were above the AL, the exposure is being controlled with PPE. Here's the report.

OIC: Your timing couldn't be better. We just got the results back from the soil and water sampling you did on the golf course. I don't think SrA Wright has done environmental sampling interpretation before, so I'd like for you to go over the steps in the process with him.

Scenario Challenge Point (Page 8 of 10)

As you and SrA Wright review the final sampling results for the landfill contamination on the golf course, you explain the process you will follow when interpreting them. Put the steps for interpreting sampling results for environmental analysis in the correct order.

Steps	Order
Ensure that units of measure are the same.	1. ________________________________
Identify abnormal results/variations and perform trend analysis.	2. ________________________________
Select the applicable standard.	3. ________________________________
Determine follow-up actions needed, if necessary.	4. ________________________________
Investigate abnormal results, trends, and variations.	5. ________________________________
Compare results to a standard for compliance, if applicable.	6. ________________________________

Interpreting Environmental Health Sampling Results (Page 8a of 10)

The steps for interpreting sampling results for environmental analysis are:

1. Select the applicable standard.
2. Ensure that units of measure for results and criteria are the same. Convert the units of measure, if necessary.
3. Compare results to a standard for compliance, if applicable.
4. Identify abnormal results and variations and perform a trend analysis by comparing results with historical data for that sampling site. By doing so, you can determine historical trends, and you may determine abnormalities even if the standard is not exceeded.
5. Investigate abnormal results, trends, and variations.
6. Determine follow-up actions needed as a result of trend analysis results or non-compliance, if necessary.

Jenks AFB Scenario (Page 9 of 10)

You and SrA Wright work through the interpretation of the sampling results from the golf course. The primary COCs for which you conducted sampling were hydrogen sulfide, methane gas, and TCE.

Your soil gas sampling results confirm that hydrogen sulfide is present at 0.8 parts per billion (ppb). Because this is a community exposure, you use the EPA's reference concentration (RfC) as the standard for comparison to determine if the gas poses a potential hazard to the community. The EPA RfC for hydrogen sulfide is 1.43 ppb. Therefore, 0.8 ppb is a safe level of exposure. It also explains why the workers smelled the rotten egg odor at the golf course because the concentration is greater than the odor threshold.

The results also indicate the presence of methane at levels that could explode if initiated in a confined space. Because building is prohibited on this section of the base, the methane gas does not appear to pose a substantial explosive threat, but you decide to recommend monitoring the situation. The lab results for the water sampling do not indicate any TCE contamination.

You work together to write up a report of your findings, as well as recommendations which include further monitoring of the situation and training for the grounds maintenance workers. You also recommend removing the trees from the driving range to prevent further problems with the buried landfill.

Lesson Summary (Page 10 of 10)

You have learned that interpreting sampling results involves consideration of the health risk posed by total exposure. Results are compared to a standard, and any recommendations made to the commander should include consideration of the mission context as well as potential adverse health effects if the standards are exceeded.

In this lesson, you:

- Recalled the facts related to total health risk exposure.
- Recalled the relationship of results to standards, mission, and effects.
- Interpreted sampling results for a given scenario.

Audio Script

OIC: Thanks for getting this report to me so quickly. It's too bad the news from the environmental sampling isn't as good as it was for the corrosion control shop, but at least we know what we're dealing with now.

Resources

- **Air Force Manuals, Instruction, and Guidance**
  - AFI 48-145, Occupational and Environmental Health Program
  - AFMAN 48-153, Health Risk Assessment
  - AFMAN 48-154, Occupational and Environmental Health Site Assessment
  - AFMAN 48-155, Occupational and Environmental Health Exposure Controls
  - Bioenvironmental Engineering Field Manual
  - Environmental Health Site Assessment Guide
- **Environmental Protection Agency References**
  - EPA 9360.4-02, Compendium of ERT Soil Sampling and Surface Geophysics Procedures
  - EPA SOP 2009, Drum Sampling
  - EPA SOP 2012, Soil Sampling
  - EPA SOP 2013, Surface Water Sampling
  - EPA/540/P-91/007, Compendium of ERT Groundwater Sampling Procedures
  - OSWER Directive 9360.4-10, Superfund Program: Representative Sampling Guidance, Vol. 1: Soil
  - EPA 9355.4-16FS, DNAPL Site Characterization
  - EPA/540/S-95/500, Ground Water Issue: Light Nonaqueous Phase Liquids
  - EPA National Ambient Air Quality Standards (NAAQS)
- **Other Department of Defense References**
  - DoD 3150.8-M, Nuclear Weapon Accident Response Procedures (NARP)
  - NAVSEA TO300-AZ-PRO-010, Navy Environmental Compliance Sampling and Field Testing Procedures Manual
  - Standard Operating Procedures for Environmental Health Site Assessments. Navy Environmental Health Center
  - Strategies to Protect the Health of Deployed U.S. Forces: Detecting, Characterizing, and Documenting Exposures. Division of Military Science and Technology and Board on Environmental Studies and Toxicology, National Research Council. National Academy Press, 2000
  - USACHPPM Technical Guide 230, Chemical Exposure Guidelines for Deployed Military Personnel
- **National Institute for Occupational Safety and Health References**
  - NIOSH 2005-149, Pocket Guide to Chemical Hazards
  - NIOSH 77-173, Occupational Exposure Sampling Strategy Manual

- **Other Resources You Might Need**
  - 29 CFR 1910, Subpart Z
  - ACGIH Threshold Limit Values and Biological Exposure Indices book or CD
  - Armstrong Laboratory Services Guide
  - ASTM E2318-03, Standard Guide for Environmental Health Site Assessment Process for Military Deployments
  - DNALP Site Evaluation. Cohen & Mercer, 1993.
  - Patty's Industrial Hygiene and Toxicology
  - RCRA Ground-Water Monitoring: Draft Technical Guidance (EPA/530-R-93-001)
  - USACHPPM Technical Guide 251, A Soldier's Guide to Environmental and Occupational Field Sampling for Military Deployment
  - NIOSH Manual of Analysis Methods (NMAM)
  - Standard Methods for the Examination of Water and Wastewater, 20th edition
  - Visual Sample Plan (VSP)
  - Electronic Code of Federal Regulations

Answer Key: Appraisals / Scenario Challenge Points

Lesson 1: Overview of Sampling Strategy Development

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During which part of OEHSA is sampling conducted?

D Routine or special assessment

Rationale: Sampling is conducted during routine (initial) or special assessment as a part of OEHSA. Sampling is also necessary in order to identify and analyze health threats and risks while conducting an HRA.

In what two ways does the assessment type affect sampling strategy development?

A With special assessment, you must prioritize the assessment needs by determining the risk rating and rank of each exposure pathway.

B Health threats identified during routine assessment can determine the need for more in-depth sampling during special assessment.

Rationale: The health threats you identify during routine assessment will determine the need for special assessment, at which time you will have to prioritize the assessment needs and define the scope of support and resources. Compliance assessments are conducted in garrison settings only.

Lesson 2: Air Sampling

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While the shop supervisor is getting the Material Safety Data Sheets, you begin thinking about the sampling strategy you will use. What are the two primary assessment goals for this sampling strategy?

B	**You must identify the health risks posed by the chemicals being used.**
D	**You must determine whether existing controls are sufficient to control the health threat.**

Rationale: Although the workers in the corrosion control shop routinely paint large aircraft, they have never performed work on the Super Guppy and have never used the type of paint they will be using. An assessment is needed for this new process to determine whether the existing measures are adequate to control the health threat under current circumstances and to identify the health risks posed by the chemicals in the paint. Remember that the primary goal of an exposure assessment is to increase confidence in threat characterization and controls.

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Build a list of the factors that affect the sampling strategy.

List
Resources, Time, and Conditions
Assessment Type
Sampling Objectives
Standards

Rationale: The sampling strategy can be affected by the objectives; resources, time, and conditions; assessment type; and standards that apply to the situation at hand. Sampling is conducted to obtain a characterization of the health threat and to increase confidence in controls.

Page 6 of 18

What tactics would be *best* to collect air samples for determining the health threat to the corrosion control shop workers while they are painting the Super Guppy?

Choose the type(s), technique(s), and location(s) appropriate for this sampling situation. Select all that apply.

	Types
	Screening
X	Compliance

	Techniques
	Instantaneous
X	Integrated

	Locations
	Area
X	Personal

Rationale: To ensure that regulations and standards are being met, you must conduct compliance sampling which involves collecting integrated samples of the employee's personal breathing zone. Area samples are not generally used to estimate a worker's exposure. While instantaneous sampling can provide you preliminary information, integrated methods provide the least analytical variability.

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Following is a series of questions to check your understanding of sampling tactics. For each example you see, select the appropriate tactics.

Screening samples indicate exposures above the AL. Which choice lists the actions you will perform in order to evaluate and quantify the workers' exposure?

A Compliance / Personal Sampling

Rationale: Personal sampling will give you the most accurate reading of the worker's exposure, and quantifying exposure is done as part of compliance sampling.

You need to get a quick estimate of a worker's exposure to determine if further action is needed. Which choice lists the actions you will perform?

D Screening / Instantaneous Sampling

Rationale: Collecting screening samples using an instantaneous technique will give you a quick estimate of the worker's exposure.

You need to evaluate background concentrations of an airborne chemical and determine changes in air quality. Which choice lists the actions you will perform?

D Area / Instantaneous Sampling

Rationale: Area sampling is used to evaluate background concentrations and to determine changes in the air quality throughout a workday. Instantaneous sampling will measure the air quality at given times throughout the day, allowing you to evaluate changes through the course of the workshift.

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The shop supervisor has given you the Material Safety Data Sheets for each component of the paint that the corrosion control shop workers will be using on NASA's Super Guppy.

Although the paint contains many chemicals which you must consider, you begin by looking up information about methyl ethyl ketone (MEK). Review the information about this chemical by consulting the provided reference materials. Then choose the appropriate OEL to use for an 8-hour exposure.

A 200 ppm

Rationale: The OEL for MEK is 200 ppm as an 8-hour time-weighted average (TWA).

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Match each standard or term related to determining the OEL with its description by marking the appropriate block in the table.

Description	Equivalent OEL	OSHA PELs	OEL-TWA	OEL-STEL
Concentration to which workers can be exposed continuously for a short period of time.				X
Exposure limit that has been adjusted for unusual work schedules.	X			
Substance-specific requirements found in Title 29 CFR 1910, Subpart Z.		X		
Concentration to which workers may be exposed 8 hours per day, 40 hours per week.			X	

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$$\textbf{OEL RF}_{\textbf{daily}} = \boxed{0.8} \times \frac{\boxed{14}}{16}$$

$$\textbf{OEL RF}_{\textbf{daily}} = 0.8 \times \boxed{0.88}$$

$$\textbf{OEL RF}_{\textbf{daily}} = \boxed{0.70}$$

$$\textbf{Equivalent OEL - TWA}_{\textbf{daily}} = \boxed{140}\ \text{ppm}$$

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$$\textbf{OEL RF}_{\textbf{weekly}} = \boxed{0.83} \times \frac{\boxed{120.0}}{128}$$

$$\textbf{OEL RF}_{\textbf{weekly}} = 0.83 \times \boxed{0.94}$$

$$\textbf{OEL RF}_{\textbf{weekly}} = \boxed{0.78}$$

$$\textbf{OEL}_{\textbf{weekly}} = \boxed{156}\ \text{ppm}$$

Lesson 3: Soil and Solid Sampling

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Which one of the following factors will NOT affect the development of your soil and solid sampling strategy?

Health Threat Characterization

Rationale: When developing the soil and solid sampling strategy, you must consider the objectives of the sampling and any situational requirements. You must also consider the resources and time available, as well as environmental conditions. Characterization of the health threat is an outcome of the sampling and not a factor that affects the development of the strategy.

Page 6 of 13

Considering the information you have, should your sampling strategy for the golf course indicate use of a statistical or non-statistical approach for the sampling you will perform?

A Statistical

Rationale: Based on the available information, you should use a statistical approach. Although you believe you know the source of the contamination, a statistical approach, such as systematic grid sampling, would be best to narrow down the specific areas of concern on the golf course.

Page 7 of 13

Match each sampling approach with its corresponding description by marking the appropriate block in the table.

Descriptions	Stratified Random	Simple Random	Judgmental	Systematic Grid
Uses the theory of chance probabilities to choose representative sampling locations.		X		
Applies existing data or background information to divide a site into internally homogenous areas.	X			
Selects locations based on historical information, visual inspection, and professional judgment.			X	
Collects samples from locations at regular intervals from one randomly selected sampling point.				X

Page 8 of 13

After you determine the sampling approach you will use to identify and quantify contaminants on the golf course, you need to determine how you will collect the samples.

Based on what you know about the contaminants that could be present, should you plan to homogenize the samples?

B No

Rationale: The grounds maintenance workers smelled a "rotten egg" odor on the golf course, which indicates the potential for hydrogen sulfide. Also, the investigation of the landfill in 1989 indicated that there may be low level volatile organic chemicals (VOCs) present. Therefore, you should not homogenize, split, or composite the samples because of the possibility for contaminant loss.

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Why would you homogenize a sample?

A To ensure that portions of the containerized sample are representative of the total sample collected.

Rationale: Homogenizing the sample ensures that, if the lab tests only a small portion of the sample, it is representative of the entire sample. Homogenization is not appropriate for volatile contaminants, which also should not be sieved or composited due to the potential for loss of chemicals.

If the contaminant of concern is volatile, which of the following sampling methods is an appropriate action to be taken?

D Removing extraneous material.

Rationale: Removal of extraneous material should be a part of most sampling protocols. Homogenization is not appropriate for volatile contaminants, which also should not be sieved or composited due to the potential for loss of chemicals.

How can you minimize cross-contamination of sample media and samples?

C By properly decontaminating the equipment you use.

Rationale: Cross-contamination can best be avoided by proper decontamination of your equipment.

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When using a systematic grid approach to establish a threat or identify sources, you should also use field analytical screening. As part of your sampling strategy, you begin thinking about the procedures you'll use for analyzing the soil once you arrive at the golf course. Put the field analysis steps in the order in which you would perform them.

Steps	Order
Characterize the potential exposure routes and frequency of personnel exposure.	**1. Prioritize each AOC.**
Document results and reprioritize additional sampling based on results.	**2. Screen for the elements of highest risk.**
Prioritize each AOC.	**3. Characterize the potential exposure routes and frequency of personnel exposure.**
Conduct routine and special sampling, assessments, and monitoring.	**4. Conduct routine and special sampling, assessments, and monitoring.**
Screen for the elements of highest risk.	**5. Document results and reprioritize additional sampling based on results.**

Lesson 4: Liquid and Water Sampling

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As you sit down to work on your strategy for sampling the groundwater beneath the golf course, you consider your sampling objective.

Which of the following best describes the *primary* reason for this sampling?

D Health Risk Assessment

Rationale: The primary objective for this sampling strategy is to assess the health risk associated with potential contamination of the groundwater beneath the golf course. Although determining whether the drinking water is safe will be another objective associated with the strategy, routine surveillance of the established water system is not the primary purpose at this time. Compliance monitoring and process control are not BE responsibilities related to liquid or water sampling.

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After determining the objective and potential COCs to be addressed by your sampling strategy for the golf course groundwater, you begin to think about the type and method of sampling that would be appropriate for this sampling strategy.

Which two of the following represent the type and method of sampling that you should conduct at the golf course? Select one type and one method.

A Grab

B Manual

Rationale: A grab sample should be collected because you are trying to gather information on the concentration of VOCs in the groundwater. Bailers are used to sample wells, and bailers are manual samplers.

Page 8 of 11

Which of the following sampling procedures should you include in your strategy for the golf course groundwater sampling? Select all that apply.

A Clean the sample bottles to avoid contamination.

C Check the operating condition of the sampling equipment.

Rationale: Before you begin sampling, you need to ensure that the equipment is in good operating condition. To prevent contamination, you should check all sample bottles and clean them appropriately. Most water samples are preserved by pH and temperature adjustments.

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For this question set, you will be matching several descriptions with the sampling strategy considerations listed. Read each description you see and select the consideration to which it corresponds in the list.

	Considerations for Developing a Sampling Strategy
These include routine surveillance and health risk assessment.	Sampling program objectives
Some examples are sediment, oil, and detergents.	Potential contaminants
Selecting these helps ensure representativeness and homogeneity of the sample.	Sampling point locations
The most common are grab and composite.	Types of samples
These can be either manual or automatic.	Sample collection methods
Categories include closed conduit or open channel, for example.	Flow measurements
An example is storing samples in a manner which ensures the parameters to be analyzed are not altered.	Sampling procedures
This includes providing recommendations to commanders about controlling health risks.	Communication, documentation, and follow-up

Lesson 5: Interpreting Sampling Results

Page 2 of 10

Which choice lists the factors that have the most impact on the total exposure health risk?

C Physiological effects, form of contaminant, and worker habits

Rationale: Physiological effects, the form of the contaminant, and individual worker habits and environment all contribute to the effect that a contaminant may have on a person.

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Which of the following terms refers to a combined effect of two or more chemicals that is greater than the sum of their individual effects?

B Synergistic effect

Rationale: A synergistic effect is a combined effect of two or more chemicals that is greater than the sum of their individual effects.

A maintenance shop worker reports severe kidney pain and difficulty urinating. She uses Toluene daily, but you find that her workday exposure is below the OEL. Upon further investigation, you learn that she recently did some work at home on her car, using a cleaner containing Xylene, a chemical that also affects the kidneys. Which of the following effects is the worker likely experiencing?

A Additive effect

Rationale: This worker is most likely experiencing additive effects from a combined exposure to Toluene and Xylene, which are both volatile organic compounds and behave similarly toxicologically.

Which of the following terms refers to the interference or inhibition of the effect of one chemical by the action of another chemical?

C Antagonism

Rationale: Antagonism is the interference or inhibition of the effect of one chemical by the action of another.

An electronics worker becomes dizzy and begins having difficulty breathing after briefly working with heat shrink tubing, a material which releases Dichloromethane when heated. He is using the material properly in a well-ventilated area and has worked with it many times before with no problems. Which effect is he likely experiencing?

C Cumulative effect

Rationale: This worker is most likely experiencing a cumulative effect as a result of multiple exposures to Dichloromethane.

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Build a list of statements that reflect the relationship of sampling results to standards, mission accomplishment, and health effects.

Word Bank	List
Intelligence and mission details affect the interpretation of results and acceptance of risk.	**Intelligence and mission details affect the interpretation of results and acceptance of risk.**
The BE Tech makes risk acceptance decisions based on the mission.	**Results are compared to standards to see if the accepted exposure limit is exceeded.**
The total exposure and risk of adverse health effects must be noted in context of the mission.	**The total exposure and risk of adverse health effects must be noted in context of the mission.**
When interpreting results, only the workday exposures should be considered.	**Sampling results are communicated to the commander.**
Results are compared to standards to see if the accepted exposure limit is exceeded.	
Sampling results are communicated to the commander.	

Rationale: When interpreting results, you must compare them to standards which identify the acceptable levels of exposure. You must also consider the total exposure and risk of adverse health effects in context of the mission. Intelligence, mission details, and other dynamics of the environment affect how the sampling results are interpreted. The commander will use the information you provide to make decisions based on the anticipated effects of the exposure, the mission, and other factors.

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The sampling results you received from monitoring three workers over several days show that the MEK exposure was 120 ppm. Based on the action level and the OEL, are the results of the sampling in compliance?

B The results represent a possible overexposure.

Rationale: The measured concentration of 120 ppm is greater than the AL, so the results of the MEK sampling represent a possible overexposure.

Considering that the sampling results indicated a possible overexposure, and personnel are currently wearing respiratory protection while painting the aircraft, what two follow-up actions are required?

A Establish a regulated area.

C Recommend employee training.

Rationale: The measured concentration of 120 ppm is greater than the AL, so the results of the MEK sampling represent displayed. The exposure is currently being controlled with PPE, but you need to ensure that employees are properly trained so that their individual exposures do not exceed healthy levels. You also need to establish a regulated area and ensure that the process remains the same so that exposure levels don't change.

After receiving the sampling results, within how many calendar days must you notify the shop supervisor of the results?

B 15

Rationale: You must notify personnel of the sampling results within 15 calendar days of receiving them.

Which of the following values represents the combined exposure for the workers painting the Super Guppy aircraft?

C 1.5

Rationale: The measured concentration of 120 ppm is greater than the AL, so the results of the MEK sampling represent a possible overexposure.

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As you and SrA Wright review the final sampling results for the landfill contamination on the golf course, you explain the process you will follow when interpreting them. Put the steps for interpreting sampling results for environmental analysis in the correct order.

Steps	Correct Order
Ensure that units of measure are the same.	1. **Select the applicable standard.**
Identify abnormal results/variations and perform trend analysis.	**2. Ensure that units of measure are the same.**
Select the applicable standard.	**3. Compare results to a standard for compliance, if applicable.**
Determine follow-up actions needed, if necessary.	**4. Identify abnormal results/variations and perform trend analysis.**
Investigate abnormal results, trends, and variations.	**5. Investigate abnormal results, trends, and variations.**
Compare results to a standard for compliance, if applicable.	**6. Determine follow-up actions needed, if necessary.**

Course Glossary

Acronyms

AAR
After Action Report

ACADA
Automatic Chemical Agent Detection Alarm

AFI
Air Force Instruction

AFMIC
Armed Forces Medical Intelligence Center

AFMS
Air Force Medical Service

AFMSA
Air Force Medical Support Agency

AFOSH
Air Force Occupational and Environmental Safety, Fire Prevention and Health

AFRRAD
Air Force Radiation and Radioactive Recycling and Disposal

ALARA
As Low As Reasonably Achievable

AMC
Aerospace Medicine Council

amu
Atomic Mass Unit

AO
Area of Operations

AOC
Area of Concern

AOR
Area of Responsibility

BE
Bioenvironmental Engineering Flight

CBRN
Chemical, Biological, Radiological, Nuclear

CE
Civil Engineering

COA
Course of Action

COC
Contaminant of Concern or Constituent of Concern

CONUS
Continental United States

CSM
Conceptual Site Model

CV
Coefficient of Variability

DIA
Defense Intelligence Agency

DF
Duty Factor

DOD
Department of Defense

DOE
Department of Energy

DOS
Department of State

DOT
Department of Transportation

D_{pel}
Estimated Hazard Distance

DRI
Direct Reading Instruments

EHF
Extremely High Frequency (Occurs between 30 and 300 GHz)

EMR
Electromagnetic Radiation

EPA
Environmental Protection Agency

EPD
Electronic Personal Dosimeters

FPWG
Force Protection Working Group

G_{abs}
Absolute Gain

HF
High Frequency (Occurs between 3 and 30 MHz)

HRA
Health Risk Assessment

HRE
Health Risk Estimate

HRM
Health Risk Management

IATA
International Air Transport Association

IPE
Individual Protection Equipment

LCL
Lower Confidence Limits

LET
Linear Energy Transfer

LF
Low Frequency (Occurs between 30 and 300 kHz)

MAJCOM
Major Command

MEDIC CD
Medical Environmental Disease Intelligence and Countermeasure CD

MIO
Medical Intelligence Officer

MF
Medium Frequency (Occurs between 300 and 3,000 kHz (3MHz))

MOPP
Mission Oriented Protection Posture

MPE
Maximum Permissible Exposure

MSP
Mission Support Plan

NFB
Near-Field Boundary

NGIC
National Ground Intelligence Center

NHZ
Nominal Hazard Zone

NIOSH
National Institute for Occupational Safety and Health

NOHD
Nominal Ocular Hazard Distance

NRC
Nuclear Regulatory Commission

OCONUS
Outside the Continental United States

OEH
Occupational and Environmental Health

OEHSA
Occupational and Environmental Health Site Assessment

OEL
Occupational Exposure Limits

OEL-C
Occupational Exposure Limits-Ceiling

OEL-STEL
Occupational Exposure Limits-Short Term Exposure Limit

OEL-TWA
Occupational Exposure Limits-Time Weighted Average

OH
Occupational Health

ORM
Operational Risk Management

OSHA
Occupational Safety and Health Administration

OSI
Office of Special Investigation

P_{avg}
Average Power

PEL
Permissible Exposure Limit

PH
Public Health

P_p
Peak Power

PPBS
Planning, Programming and Budgeting System

PPE
Personal Protective Equipment

PPM
Parts per million

PRF
Pulse Repetition Frequency

PW
Pulse Width

RFR
Radio Frequency Radiation

RSO
Radiation Safety Officer

S
Main-Beam Power Density

SAR
Specific Absorption Rate

S_{avg}
Power Density Average

SEG
Similar Exposure Group

SHF
Super High Frequency (Occurs between 3 and 30 GHz)

SLM
Sound Level Meter

S_{max}
Maximum Power Density

SPL
Sound Pressure Level

TLD
Thermoluminescent Dosimeters

TWG
Threat Working Group

UHF
Ultra High Frequency (Occurs between 300 and 3,000 MHz)

USACHPPM
United States Army Center for Health Promotion and Preventive Medicine

UTC
Unit Type Code

VA
Vulnerability Assessments

VHF
Very High Frequency (Occurs between 30 and 300 MHz)

VLF
Very Low Frequency (Occurs between 3 and 30 kHz)

Definitions

Absolute Gain (G_{abs})
The ratio of the power that would be required at the input of an ideal isotropic radiator to the power actually supplied to the given antenna, to produce the same radiant intensity in the far-field region.

Action Level
An airborne exposure level that dictates active air monitoring, medical monitoring, and employee training. The Action Level is one-half the Occupational Exposure Limit for time-weighted average (OEL-TWA) exposures, except where 29 CFR 1910 Subpart Z designates a different concentration or where the statistical variability of sample results indicates that a lower fraction of the OEL should be used as the Action Level.

Activity
The number of disintegrations or transformations of radioactive material per unit of time (usually expressed in seconds).

Antenna
The point on an RFR emitter where RFR energy radiates into free space.

Asbestos
A natural material that is made of tiny threads or fibers. The fibers can enter the lungs as a person breathes. Asbestos can cause many diseases, including cancer. Asbestos was used to insulate houses from heat and cold. It has also been used in car brakes and for other purposes. Some old houses still have asbestos in their walls or ceilings.

Asbestosis
A lung disease caused by breathing asbestos fibers over a period of time. The fibers eventually scar the lungs and make breathing difficult. Symptoms are similar to asthma.

Atomic Mass Unit (amu)
Approximately equal to the mass of a proton or a neutron and is used to describe the mass of an atom.

Becquerel (Bq)
The international standard for the unit of measurement for activity.

Breathing Zone
The location where exposure is measured in air sampling. The breathing zone is located forward of the shoulders within 9 inches of the nose and mouth. Breathing zone measurements are taken beneath a welder's helmet or face piece but outside of any respiratory protective devices.

Bremsstrahlung
An interaction that causes a form of x-ray production in which high-speed beta particles penetrate the electron cloud and interact with the nucleus.

Carcinogens
Hazardous materials that stimulate the formation of cancer.

Ceiling Limit (OEL-C)
The limit for an employee's exposure which shall not be exceeded during any part of the work day. If instantaneous monitoring is not feasible, the OEL-C will be evaluated during the worst-case 15-minute exposure period.

Chrysotile
The most common asbestos type. Chrysotile asbestos fibrils may appear crinkled, like permed or damaged hair, under plane-polarized light.

Coefficient of Variation (CV)
For an air sampling method, the CV is the standard deviation of the sampling and analytical error divided by the mean of the sample results. The CV is used to calculate the confidence limits for sampling. OSHA uses the term sampling and analytical error (SAE) to account for the total variation or error in the method.

Compton Scatter
A gamma/x-ray interaction which takes place between a photon and an outer electron where the photon has more energy than the electron can accept, so it imparts only a portion of its energy to the electron.

Conceptual Site Model (CSM)
Articulates the health threats and exposure pathways and begins when data or information is gathered during Predeployment and Baseline Activities.

Confidence Limits
The upper confidence limit (UCL) and lower confidence limit (LCL) are the boundaries for a single sample or a series of samples that have a specified probability (usually 95 percent) of including the true value of the level of exposure.

Controlled Environments
An area where personnel are aware of the potential for RFR exposures associated with their employment or duties.

Counts per minute (cpm)
The amount of radiation detected by an instrument each minute.

Diffuse Reflection
Situations where a laser beam is bounced off a dull or uneven surface that breaks the beam apart.

Disintegration per minute (dpm)
The number of atoms that decay or transform in a given amount of material per minute.

Disintegration per second (dps)
The number of atoms that decay or transform in a given amount of material per second.

Dose
The quantity of radiation absorbed.

Dose Rate
The quantity of radiation absorbed per unit of time.

Duty Factor (DF)
A unit-less number which only applies to pulsed wave systems that describes the ratio of time an RFR emitter is on to the total operating time.

Electromagnetic Radiation (EMR)
Waves of energy that can travel through space and matter.

Electromagnetic Spectrum
The entire frequency range of electromagnetic waves, or wave radiation.

Energy
The ability to do work.

Estimated Hazard Distance (D_{pel})
The distance from the antenna to the point where the power density equals the permissible exposure limit (PEL).

Excitation
Occurs when there is an addition of energy to an atomic system, changing the atom from a “ground” state to an excited state.

Exposure
Exposure occurs when an employee is subjected to a hazardous material through any of these routes: inhalation, ingestion, skin contact, or skin absorption. Airborne exposures are specified as the duration and concentration of hazardous materials measured in the breathing zone of an individual worker without regard for personal protective equipment used by the worker.

Exposure Assessment
An exposure assessment is a process of estimating or calculating potential exposure of a health threat for an individual or population at risk. The assessment includes professional judgment, calculations based on estimates or models, actual measurements, collection and analysis of samples, and statistical evaluation.

Exposure Pathway
Includes a threat and the opportunity for the population to come into contact with the threat.

f
Algebraic express that means, “a function of.”

Fission
The splitting of the nucleus of an atom into nuclei of lighter atoms, accompanied by the release of energy.

Frequency
A value of how often a wavelength cycle occurs in a second.

Gain
The antenna’s ability to concentrate its energy in a certain direction.

Hazardous materials
Materials that pose a hazard and require a Material Safety Data Sheet as defined in FED-STD 313, Federal Standard, Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Governmental Activities.

Health Risk
The health risk equals threat “combined with” vulnerability (health risk = (threat) + (vulnerability)). A health risk is an identified health threat and the vulnerability of the population at risk of coming into contact (i.e., completion of an exposure pathway) with the health threat.

Health Risk Assessment (HRA)
Health risk assessment is the process of identifying and analyzing or evaluating (exposure and toxicity assessments) OEH threats in populations or at locations over time (HRA = f [(health risk) “+” (HRE) “+” (COA)]). The HRA “product” is the validated health threat, qualified by the HRE, and the COA which includes overall mission impact, recommended control options, associated uncertainties, risk mitigation estimate(s), and a cost-benefit analysis if applicable.

Health Risk Communication
Health risk communication is the process of effectively communicating potential health effects, outcomes, and control measures to all stakeholders (i.e., commanders, supervisors, AF personnel, military, families, and the public). It provides detailed information about the HRA and should occur throughout the HRA process.

Health Risk Estimate (HRE)
Health Risk Estimate is the probability and severity of loss from exposure to the health threat. The HRE is a function of probability and severity when either or both increase the Health Risk Estimate increases. The HRE is also referred to as a health risk level.

Health Risk Management (HRM)
Health risk management is a decision-making process to evaluate and select COAs, minimize OEH risks, and maximize benefits for operations and missions. HRM is the health component of the ORM process and health risk management recommendations and decisions are integrated into the commander's ORM decision-making.

Health Threat
A health threat is a potential or actual condition that can cause short or long-term injury, illness, or death to personnel. A health threat can be occupational or environmental in origin; internal or external to the installation; or continuous, intermittent, or transient; and includes enemy capability and intent.

Ionization
Occurs when beta particles interact with nearby atoms causing an electron to be removed, creating an ion pair.

Ionizing Radiation
Radiation which has enough energy to change the atomic structure of matter.

Isotope
Elements with the same number of protons, but a different number of neutrons.

Kinetic Energy
Energy of motion.

Laser
Light amplification by stimulated emission of radiation.

Linear Energy Transfer (LET)
Energy lost by particles along the path through which they are traveling.

Mass
Description of how much matter there is present in an object.

Maximum Permissible Exposure (MPE)
The level of laser radiation to which a person may be exposed without hazardous effects or adverse biological changes in the eyes or skin.

Mesothelioma
Cancer that generally occurs in the chest, abdominal region, and areas surrounding the heart. It is typically associated with exposure to asbestos.

n
Algebraic express that means, "Number of samples."

Nominal Hazard Zone (NHZ)
The area within a laser workplace in which the exposure from direct beam, specular reflection, and diffuse reflection could exceed the Maximum Permissible Exposure (MPE).

Nominal Ocular Hazard Distance (NOHD)
The distance along the laser beam beyond which the exposure is not expected to exceed the appropriate Maximum Permissible Exposure (MPE).

Non-aqueous Phase Liquids (NAPLs)
Non-aqueous phase liquids are liquids that are sparingly soluble in water. Because they do not mix with water, they form a separate phase. For example, oil is an NAPL because it does not mix with water, and oil and water in a glass will separate into two separate phases. NAPLs can be lighter than water (LNAPL) or denser than water (DNAPL). Hydrocarbons, such as oil and gasoline, and chlorinated solvents, such as trichloroethylene, are examples of NAPLs.

Non-ionizing Radiation
Radiation which does not have enough energy to change the atomic structure of matter.

Nuclear Stability
Describes the certain combinations of neutrons and protons within a nucleus of an atom which are required for that atom to be considered stable.

Occupational and Environmental Health Site Assessment (OEHSA)
The key operational health tool for producing data or information used for health risk assessments (HRA) and to satisfy Occupational and Environmental Health (OEH) surveillance requirements.

Occupational Exposure Limit (OEL)
The limit for the airborne concentrations of a specified substance for a specified time. Employees will not be exposed to concentrations greater than the OEL. The term OEL includes all OEL-TWAs, OEL-STELs, OEL-Cs, and acceptable ceiling concentrations, that apply to a specific substance. For each hazardous material, the OELs are the most stringent limits found in the latest edition of the TLV Booklet published annually by the American Conference of Government Industrial Hygienists, in 29 CFR 1910 Subpart Z, and in AFOSH Standards for specific substances. OELs apply to occupational exposures for each individual worker for a single 8-hour work shift except where 29 CFR 1910 Subpart Z allows 40-hour averages. Exposure during work shifts that exceed 8 hours must be adjusted before applying an OEL.

Operational Risk Management (ORM)
A systematic process of identifying hazards, assessing risk, analyzing risk control options and measures, making control decisions, implementing control decisions, accepting residual risks, and supervising/reviewing the activity for effectiveness.

Optical Cavity
The component that houses the laser.

Pair Production
Occurs when a photon disappears in the vicinity of a nucleus, and an electron and positron appear in its place.

Particulate Radiation
Fast-moving atomic or subatomic particles that may be charged positively or negatively or not at all.

Peak Power (P_p)
The maximum power density during the on time for a pulsed wave system.

Permissible Environment
Operational environment in which host country military and law enforcement agencies have control as well as the intent and capability to assist operations that a unit intends to conduct.

Permissible Exposure Limit (PEL)
The value to which an individual may be exposed without exhibiting damaging biological effects and is based on the emitter's frequency.

Photochemical Reaction
A chemical reaction which is induced by the absorption of energy in the form of visible, infrared, or ultraviolet radiation.

Photoelectric Effect
An "all or none" energy loss where gamma rays impart all of their energy into an electron.

Pleural Effusion:
When too much fluid collects between the lining of the lung and the lining of the inside wall of the chest.

Positron
Created when a proton changes into a neutron and a positron because there are too many protons in the n:p ratio.

Potential Energy
Energy of position.

Pulse Repetition Frequency (PRF)
The number of times the signal is on per unit of time.

Pulse Width (PW)
The length of time the signal is on for a pulsed wave system.

Quality Factor (Q)
A dimensionless quantity assigned to each type of radiation that allows doses to be normalized in relation to each other.

Radiation
Energy in the form of waves or moving subatomic particles emitted by an atom or other body as it changes from a higher energy state to a lower energy state.

Radiation Absorbed Dose (RAD)
The amount of radiation absorbed by the tissue.

Radioactive Decay
The spontaneous disintegration or transformation of an atom in an attempt by that atom to reach a stable state.

Radioactive Material (RAM)
Material which contains unstable (radioactive) atoms that give off radiation as they decay or transform.

Radioactivity
The spontaneous emission of matter or energy from the nucleus of an unstable atom.

Radioisotopes
Unstable isotopes that, in an attempt to become a stable atom, emit energy in the form of radiation.

Regulated Area
An area under the supervisor's control where entry and exit are restricted and controlled to prevent exposure to hazards. An area shall be established when a requirement in 29 CFR 1910 or 29 CFR 1926 exists, or when BE determines that employees entering the area might be exposed to a hazard unless access is controlled.

Short Term Exposure Limit (OEL- STEL)
A time-weighted exposure for a 15 minute (or shorter) period which shall not be exceeded during the work day. The definition of STEL is different in 29 CFR 1910.1000 (a) (5) (ii) and in the TLV Booklet. The definition must correspond to the reference being cited. As with other OELs, OEL-STELs are the most stringent limits found in the latest TLV Booklet, in 29 CFR 1910 Subpart Z, and in AFOSH Standards for specific substances.

Short-Term Public Emergency Exposure Guideline (SPEGL)
An acceptable peak concentration for unpredicted, single, short-term emergency exposures of the general public. These limits do not apply to occupational exposures.

Specific Absorption Rate (SAR)
An expression of how much RFR energy is imparted to each kilogram of biological body mass per second. SAR is expressed in units of watts per kilogram (W/kg).

Specular Reflection
Situations where a laser beam is reflected from shiny, mirror-like surfaces.

Spontaneous Fission
Spontaneous fission is a natural mode of decay in which nuclei disintegrate.

Stakeholders
Any individual who is affected by the content of the communication and/or will be making decisions based on the information provided.

Stratigraphy
The layering of rock or ice strata, from which information on succession, age relations, and origin can be deduced.

Threshold Limit Values—(TLVRs)
Exposure guidelines published annually by the American Conference of Governmental Industrial Hygienists (ACGIH) in Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. TLVRs are employed as OELs when they are more stringent than the OSHA PELs.

Time-Weighted Average (OEL-TWA)
Eight-hour average concentration for which the average is mathematically adjusted for the duration of exposure. The method for calculating OEL-TWAs is shown in 29 CFR 1910.1000 (d) and in the TLV Booklet.

Toxicology Assessment
Process of estimating the human toxicological impact of a specific material based on published and unpublished literature sources and taking into consideration: uptake, metabolism/biotransformation, transport and storage, and excretion including acute (short-term) and chronic (long-term) human health endpoints.

Transmission Line
Carries the RFR signal from the transmitter to the antenna.

Transmitter
The part of an RFR emitter that generates the RFR signal.

Uncontrolled Environments
An area where exposures may be incurred by people who have no knowledge or control of the hazard.

Wavelength
The distance from one peak of a wave to the next peak of a wave.

Appendices

- Material Safety Data Sheets for NASA Super Guppy Paints
- Soil Sampling Equipment Examples

MATERIAL SAFETY DATA SHEET

CM0818H10
05 00

Section 1 -- PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NUMBER	DATE OF PREPARATION	HMIS CODES	
		Health	2
CM0818H10	17-JUN-08	Flammability	2
		Reactivity	0

PRODUCT NAME
JET GLO® High Solids Hi-Temp Primary Color Activator, 10 Hour

MANUFACTURER'S NAME
THE SHERWIN-WILLIAMS COMPANY
101 Prospect Avenue N.W.
Cleveland, OH 44115

TELEPHONE NUMBERS and WEBSITES
Regulatory Information
(216) 566-2902
Medical Emergency
(216) 566-2917
Transportation Emergency
(800) 424-9300
for Chemical Emergency ONLY (spill, leak, fire, exposure, or accident)

Section 2 -- COMPOSITION/INFORMATION ON INGREDIENTS

% by WT	CAS No.	INGREDIENT	UNITS	VAPOR PRESSURE
4	78-93-3	Methyl Ethyl Ketone		
		ACGIH TLV	200 ppm	70 mm
		ACGIH TLV	300 ppm STEL	
		OSHA PEL	200 ppm	
		OSHA PEL	300 ppm STEL	
26	123-54-6	2,4-Pentanedione		
		ACGIH TLV	Not Available	7 mm
		OSHA PEL	Not Available	
21	110-43-0	Methyl n-Amyl Ketone		
		ACGIH TLV	50 ppm	3.855 mm
		OSHA PEL	100 ppm	
19	103-09-3	2-Ethylhexyl Acetate		
		ACGIH TLV	Not Available	0.4 mm
		OSHA PEL	Not Available	
24	90438-79-2	Oxo-Heptyl Acetate		
		ACGIH TLV	Not Available	0.8 mm
		OSHA PEL	Not Available	
6	108419-35-8	Oxo-Tridecyl Acetate		
		ACGIH TLV	Not Available	0.011 mm
		OSHA PEL	Not Available	

Continued on page 2

Section 3 -- HAZARDS IDENTIFICATION

ROUTES OF EXPOSURE
INHALATION of vapor or spray mist.
EYE or SKIN contact with the product, vapor or spray mist.
EFFECTS OF OVEREXPOSURE
EYES: Irritation.
SKIN: Prolonged or repeated exposure may cause irritation.
INHALATION: Irritation of the upper respiratory system.
May cause nervous system depression. Extreme overexposure may result in unconsciousness and possibly death.
Prolonged overexposure to solvent ingredients in Section 2 may cause adverse effects to the liver, urinary, blood forming, immune and reproductive systems.
SIGNS AND SYMPTOMS OF OVEREXPOSURE
Headache, dizziness, nausea, and loss of coordination are indications of excessive exposure to vapors or spray mists.
Redness and itching or burning sensation may indicate eye or excessive skin exposure.
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
None generally recognized.
CANCER INFORMATION
For complete discussion of toxicology data refer to Section 11.

Section 4 -- FIRST AID MEASURES

EYES: Flush eyes with large amounts of water for 15 minutes.
Get medical attention.
SKIN: Wash affected area thoroughly with soap and water.
Remove contaminated clothing and launder before re-use.
INHALATION: If affected, remove from exposure. Restore breathing.
Keep warm and quiet.
INGESTION: Do not induce vomiting.
Get medical attention immediately.

Section 5 -- FIRE FIGHTING MEASURES

FLASH POINT	LEL	UEL
102 F PMCC	0.8	11.4

FLAMMABILITY CLASSIFICATION
Combustible, Flash above 99 and below 200 F
EXTINGUISHING MEDIA
Carbon Dioxide, Dry Chemical, Foam
UNUSUAL FIRE AND EXPLOSION HAZARDS
Closed containers may explode when exposed to extreme heat.
Application to hot surfaces requires special precautions.
During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.

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SPECIAL FIRE FIGHTING PROCEDURES

Full protective equipment including self-contained breathing apparatus should be used.

Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat.

Section 6 -- ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Remove all sources of ignition. Ventilate the area.

Remove with inert absorbent.

Section 7 -- HANDLING AND STORAGE

STORAGE CATEGORY

DOL Storage Class II

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

Contents are COMBUSTIBLE. Keep away from heat and open flame.

Consult NFPA Code. Use approved Bonding and Grounding procedures.

Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally. Keep out of the reach of children.

Section 8 -- EXPOSURE CONTROLS/PERSONAL PROTECTION

PRECAUTIONS TO BE TAKEN IN USE

Use only with adequate ventilation.

Avoid contact with skin and eyes. Avoid breathing vapor and spray mist.

Wash hands after using.

VENTILATION

Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section 2 is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.

RESPIRATORY PROTECTION

If personal exposure cannot be controlled below applicable limits by ventilation, wear a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section 2.

PROTECTIVE GLOVES

Wear gloves which are recommended by glove supplier for protection against materials in Section 2.

EYE PROTECTION

Wear safety spectacles with unperforated sideshields.

OTHER PRECAUTIONS

Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.

Continued on page 4

Section 9 -- PHYSICAL AND CHEMICAL PROPERTIES

PRODUCT WEIGHT	7.32 lb/gal	877 g/l
SPECIFIC GRAVITY	0.88	
BOILING POINT	174 - 545 F	78 - 285 C
MELTING POINT	Not Available	
VOLATILE VOLUME	99 %	
EVAPORATION RATE	Slower than ether	
VAPOR DENSITY	Heavier than air	
SOLUBILITY IN WATER	N.A.	

VOLATILE ORGANIC COMPOUNDS (VOC Theoretical - As Packaged)

7.30 lb/gal	875 g/l	Less Water and Federally Exempt Solvents
7.30 lb/gal	875 g/l	Emitted VOC

Section 10 -- STABILITY AND REACTIVITY

STABILITY -- Stable

CONDITIONS TO AVOID

None known.

INCOMPATIBILITY

None known.

HAZARDOUS DECOMPOSITION PRODUCTS

By fire: Carbon Dioxide, Carbon Monoxide

HAZARDOUS POLYMERIZATION

Will not occur

Section 11 -- TOXICOLOGICAL INFORMATION

CHRONIC HEALTH HAZARDS

No ingredient in this product is an IARC, NTP or OSHA listed carcinogen.

Methyl Ethyl Ketone may increase the nervous system effects of other solvents.

Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage.

TOXICOLOGY DATA

Continued on page 5

CAS No.	Ingredient Name				
78-93-3	Methyl Ethyl Ketone				
		LC50	RAT	4HR	Not Available
		LD50	RAT		2740 mg/kg
123-54-6	2,4-Pentanedione				
		LC50	RAT	4HR	Not Available
		LD50	RAT		55.0 mg/kg
110-43-0	Methyl n-Amyl Ketone				
		LC50	RAT	4HR	Not Available
		LD50	RAT		1670 mg/kg
103-09-3	2-Ethylhexyl Acetate				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
90438-79-2	Oxo-Heptyl Acetate				
		LC50	RAT	4HR	Not Available
		LD50	RAT		5000. mg/kg
108419-35-8	Oxo-Tridecyl Acetate				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available

Section 12 -- ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION

No data available.

Section 13 -- DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD

Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261.

Waste must be tested for ignitability to determine the applicable EPA hazardous waste numbers.

Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State/Provincial, and Local regulations regarding pollution.

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Section 14 -- TRANSPORT INFORMATION

US Ground (DOT)
1 Gallon and Less may be Classed as CONSUMER COMMODITY, ORM-D
Larger Containers are Regulated as:
UN1992, FLAMMABLE LIQUIDS, TOXIC, N.O.S. (N-AMYL METHYL KETONE, PENTANE-2,4-DIONE), 3 (6.1), PG III, (ERG#131)

Bulk Containers may be Shipped as:
UN1992, FLAMMABLE LIQUIDS, TOXIC, N.O.S. (N-AMYL METHYL KETONE, PENTANE-2,4-DIONE), 3 (6.1), PG III, (ERG#131)

Canada (TDG)
UN1992, FLAMMABLE LIQUIDS, TOXIC, N.O.S. (N-AMYL METHYL KETONE, PENTANE-2,4-DIONE), CLASS 3 (6.1), PG III, LIMITED QUANTITY, (ERG#131)

IMO
UN1992, FLAMMABLE LIQUIDS, TOXIC, N.O.S. (N-AMYL METHYL KETONE, PENTANE-2,4-DIONE), CLASS 3, (6.1), PG III, (39 C c.c.), EmS F-E, S-D

Section 15 -- REGULATORY INFORMATION

SARA 313 (40 CFR 372.65C) SUPPLIER NOTIFICATION

CAS No.	CHEMICAL/COMPOUND	% by WT	% Element

No ingredients in this product are subject to SARA 313 (40 CFR 372.65C) Supplier Notification.

TSCA CERTIFICATION
All chemicals in this product are listed, or are exempt from listing, on the TSCA Inventory.

Section 16 -- OTHER INFORMATION

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

The above information pertains to this product as currently formulated, and is based on the information available at this time. Addition of reducers or other additives to this product may substantially alter the composition and hazards of the product. Since conditions of use are outside our control, we make no warranties, express or implied, and assume no liability in connection with any use of this information.

Soil Sampling Equipment

Equipment	Applicability	Advantages & Disadvantages
Trier	Soft surface soil	▪ Inexpensive ▪ Easy to use and decontaminate ▪ Difficult to use in stony, dry, or sandy soil
Scoop, trowel, spoon, or spatula	Soft surface soil	▪ Inexpensive ▪ Easy to use and decontaminate ▪ Trowels with painted surfaces should be avoided
Tulip bulb planter	Soft soil, 0 to 6 inches	▪ Easy to use and decontaminate ▪ Uniform diameter and sample volume ▪ Preserves soil core (suitable for volatile organic analysis (VOA) and undisturbed sample collection) ▪ Limited depth capability ▪ Not useful for hard soils
Spade or shovel	Medium soil, 0 to 12 inches	▪ Easy to use and decontaminate ▪ Inexpensive ▪ Can result in sample mixing and loss of volatile organic compounds (VOCs)
Vehimeyer soil outfit	Soil, 0 to 10 feet	▪ Difficult to drive into dense or hard material ▪ Can be difficult to pull from ground
Soil coring device and auger	Soft soil, 0 to 24 inches	▪ Relatively easy to use; preserves soil core (suit able for VOA and undisturbed sample collection) ▪ Limited depth capability ▪ Can be difficult to decontaminate
Thin-walled tube sampler	Soft soil, 0 to 10 feet	▪ Easy to use; preserves soil core (suitable for VOA and undisturbed sample collection) ▪ May be used to help maintain integrity of VOA samples ▪ Easy to decontaminate ▪ Can be difficult to remove cores from sampler
Split-spoon sampler	Soil, 0 inches to bedrock	▪ Excellent depth range ▪ Preserves soil core (suitable for VOA and undisturbed sample collection) ▪ Acetate sleeve may be used to help maintain integrity of VOA samples ▪ Useful for hard soils ▪ Often used in conjunction with drill rig for obtaining deep cores

Note: Samplers may not be suitable for soils with coarse fragments. Augers are suitable for soils with limited coarse fragments; only the stoney auger will work well in very gravelly soil.

Source: Table 5-1: “Soil Sampling Equipment” from EPA SOP, *Soil Sampling*, Env 3.13, August 1997