# Bioenvironmental Engineering Site Assessment I

## *Unit 7: Confined Space Hazards*

**Unit Description:** For this unit, you will be stationed at Lyman AFB in Tampa Bay, FL. During your assignment, you'll participate in monitoring confined spaces to ensure that personnel are working in safe conditions. When you're finished, you'll be able to explain the process of analyzing and interpreting confined space hazards in order to classify the space as permit required or non-permit required.

# Table of Contents

# Lesson 1: Analyzing and Interpreting Confined Space Hazards

## Lesson Description

In this lesson, you will participate in classifying a confined space. Upon completion of this lesson, you will be able to explain the process of analyzing and interpreting confined space hazards in order to classify the space as permit required or non-permit required.

## Lesson Overview (Page 1 of 10)

As part of health risk assessments, you may encounter situations where you're involved in analyzing and classifying confined spaces.

While you complete your assessment of the KC-767 Advanced Tanker fuel compartments, you will:

- Recall characteristics and hazards associated with confined spaces.
- Determine why and when a confined space is analyzed and classified.
- Recall BE's role in the process of analyzing and classifying a confined space.
- Recall the characteristics of permit and non-permit required confined spaces.

**Audio Script**

**Narrator:** Lyman AFB is home to one of the largest aircraft refueling wings in the Air Force. The primary mission of this base is to support the KC-10A for refueling aircraft between the Atlantic coastline and allied bases in Europe.

Recently, Lyman has received 7 new KC-767 Advanced Tankers. The tankers were flown into the base and work must be performed to outfit this aircraft with the proper refueling boom, hose, and drum units so they can be used to refuel several types of aircraft in flight. This work will require personnel to enter the fuel compartments of the aircraft to install specialized components. The fuel compartments meet AFOSH Std 91-25 criteria to be categorized as a confined space, but since this is a new type of aircraft for Lyman and procedures have not been established in the appropriate Technical Order, the compartments have not yet been classified as permit or non-permit required.

Before classifying the fuel compartments as a permit or non-permit required confined space, you need to recall characteristics and hazards associated with confined spaces and describe the process of analyzing and classifying a confined space.

## Characteristics and Hazards of Confined Spaces (Page 2 of 10)

When working in a **confined space**, personnel may encounter a variety of potential hazards. However, just because it is a confined space, the area is not necessarily hazardous. Workers must consider that, overall, confined spaces may contain the most unfavorable and unsafe conditions and they should not work in these areas until tests and evaluations are performed to analyze whether hazards are present.

### Confined Spaces

As you should recall from AFOSH Std 91-25, for an area to be considered a confined space, it must:

1. Be large enough and configured so that a worker can enter with all or part of his/her body to perform assigned tasks.
2. Have limited or restricted means for entry and exit.
3. Not be designed for continuous occupancy.

The variety of atmospheric and physical hazards that personnel can encounter in confined spaces are described below.

### Tab: Atmospheric Hazards

Atmospheric hazards personnel may encounter in a confined space include:

- **Lack of sufficient oxygen to support life.**
- **Excessive oxygen levels that increase the danger of fire or explosion.**
- **Presence of flammable or explosive atmospheres and materials.**
- **Presence of toxic gases or materials.**

Many of these hazards are not readily apparent, detectable by odor, or visible, which may result in workers entering confined spaces without consideration of the potential dangers.

#### Lack of Sufficient Oxygen

An atmosphere that lacks sufficient oxygen to support life is called an oxygen-deficient atmosphere. Any time the oxygen level in a confined space drops below 19.5%, that atmosphere is considered to be oxygen-deficient.

Oxygen-deficient atmospheres can occur in confined spaces because oxygen is:

- Consumed by chemical reactions like oxidation.
- Displaced by inert gases like argon, carbon dioxide, or nitrogen.
- Absorbed by porous surfaces such as activated charcoal.

#### Excessive Oxygen Levels

An atmosphere that contains excessive oxygen levels (i.e., >23.5%) is called an oxygen-enriched atmosphere.

Oxygen-enriched atmospheres can occur due to poorly designed or malfunctioning oxygen storage and dispensing equipment that allows too much oxygen into the space. In addition, human error can cause this type of atmosphere if oxygen is used to ventilate a space under the assumption that oxygen and air are one in the same.

### Flammable or Explosive Atmospheres or Materials

A flammable or explosive atmosphere can result from an oxidation reaction that occurs when a sufficient quantity of oxygen is present and adequate fuel is available. Flammable atmospheres can also occur when chemicals react or combine to form flammable gases.

### Toxic Gases or Materials

The presence of toxic gases or materials can occur from a variety of sources such as a manufacturing process, storing a toxic product, or operations performed in a confined space. Toxic atmospheres can often lead to asphyxiation, or oxygen deprivation, for the personnel in a confined space.

To determine if a confined space has a potentially toxic atmosphere, you should consider the following questions:

- What did the space previously contain?
- What reactions could have occurred in the space?
- What operations will be performed in the space?
- What materials will be brought into the space?
- What materials may have inadvertently entered the space?

### Tab: Physical Hazards

In addition to atmospheric hazards, the confined workspace may include electrical or mechanical hazards that must have restricted access.

It is also important to consider the probability of the space providing a risk of engulfment or entrapment to personnel. This could include situations where loose soil or unstable supports may cause the space to enclose around the workers or prevent them from escaping

## Appraisal (Page 3 of 10)

Match each situation with the type of confined space hazard to which it applies by marking the appropriate block in the table.

| Situation | Atmospheric Hazard | Physical Hazard |
|---|---|---|
| Carbon dioxide has built up and displaced the oxygen in the space. | | |
| A chemical reaction has occurred causing methane gas to accumulate in the space. | | |
| The electrical panel is exposed to personnel working in the confined space. | | |
| Unstable supports have broken and caused the space to enclose around the workers. | | |
| Oxygen dispensing equipment has malfunctioned, allowing too much oxygen into the space. | | |

## Analyzing and Classifying Confined Spaces (Page 4 of 10)

Why is it important to analyze and classify confined space hazards?

It is important to **evaluate** and analyze the space to ensure safe conditions exist before entry and that the safe conditions can be maintained while personnel are in the space.

The functional manager or commander, in coordination with the **Confined Space Program Team (CSPT)**, is responsible for analyzing and classifying confined spaces for both routine and non-routine situations.

Once the potential hazards are known and the analysis of the space is complete, a classification can be assigned which provides information about requirements for entry into the area.

### Evaluating a Confined Space

When evaluating a confined space, the Confined Space Program Team (CSPT) will consider the following factors:

- The location and configuration of the space.
- The current or previous contents of the space.
- Potential hazards from the external environment.
- Types of operations conducted within the space.
- Fixtures, devices, or equipment within the space that may create or contribute to hazardous conditions.
- The presence of other hazards such as slippery surfaces, deteriorated or unstable portable ladders, and irritant or caustic materials.
- Hazards in adjacent spaces (e.g., fire hazards).

### Confined Space Program Team (CSPT)

The primary purpose of the CSPT is to assist the functional managers and commanders in developing and administering confined space programs. The membership of the CSPT includes representatives of Installation Ground Safety; Civil Engineering Fire Protection; Bioenvironmental Engineering; and the functional manager, commander, or their designated representative.

The CSPT, IAW AFOSH Std 91-25, will:

- Assist in the identification, evaluation, and classification of all confined spaces, with the participation of the functional managers and commanders.
- Develop and provide a CSPT train-the-trainer program for entry supervisors (if limited resources prohibit the CSPT from providing this program, the CSPT will identify acceptable external training sources).
- Assist in developing local controls and procedures for confined space entries.
- Develop a master entry plan (MEP) when requested by the functional manager or commander.
- Determine atmospheric monitoring requirements.

- Evaluate and approve MEPs.
- Review the installation confined space program, at least annually.
- Establish procedures with the contracting office to review all new construction projects to identify, record, and classify confined spaces.
- Permit the use of the AF Form 1024, Confined Spaces Entry Permit or may authorize the use of an automated product or letter format for the MEP.
- Periodically monitor permit-required space entry operations, when possible.

## Considerations for Analyzing a Confined Space (Page 5 of 10)

**BE has specific responsibilities** to ensure the functional manager and/or CC and the CSPT adequately protects the health and safety of entrants into a confined space.

Oxygen, flammability, and toxicity are the three primary considerations addressed when analyzing a confined space with a potentially hazardous atmosphere. Each consideration is used to determine the proper classification and controls for working in and around the confined space.

To **analyze a confined space** you will check for oxygen, flammability, and toxicity using atmospheric monitoring equipment.

DRIs, such as a Combustible Gas Indicator (CGI) or an $O_2$ /LEL meter, are primarily used to monitor the atmosphere of a confined space.

### BE Specific Responsibilities

Bioenvironmental Engineering (BE), IAW AFOSH Std 91-25, will:

- Be a member of the CSPT.
- Enroll all personnel who may enter confined spaces in the installation respiratory protection program, when required by AFOSH Std 48-1, Respiratory Protection Program.
- Ensure the BE representatives on the CSPT are trained in confined space requirements.
- Provide local training on the use, calibration (user), and care of atmosphere testing and monitoring equipment. Certify organizational personnel, as required, to test confined spaces. (If unable to support this requirement, the Bioenvironmental Engineer (BEE) should assist in identifying a training resource.)
- Document the location of each confined space in the appropriate case file with the information provided by the functional manager.
- Review and approve non-routine entry permits which are not contained in an organization MEP.
- Assist in training personnel for confined space duties.
- Evaluate worker exposure to hazardous chemicals.
- Assist in the selection of appropriate respiratory equipment and other PPE, as the office of primary responsibility (OPR) for the installation respiratory program.

- Assist functional managers and entry supervisors in the selection of proper PPE.
- Assist entry supervisors in the interpretation of monitoring results.
- If certified organizational personnel are not available:
    - Evaluate confined spaces for hazardous atmospheres and Immediately Dangerous to Life and Health (IDLH) conditions as necessary to meet mission requirements.
    - Sample the atmosphere in the confined space as often as may be required to ensure changing conditions do not result in unacceptable atmospheres.

**Analyze a Confined Space**

Use the following guidelines in your analysis of oxygen, flammability, and toxicity:

- The oxygen content should be between 19.5% and 23.5%.
- Flammability must be less than or equal to 10% of the Lower Explosive Limit (LEL).
- Identify toxicity by determining the occupational exposure limit (OEL), signs/symptoms, and target organs affected for chemicals present in the atmosphere of the space.

## **Appraisal** (Page 6 of 10)

Following are several questions to check your knowledge about analyzing confined spaces. Select the correct answer for each question.

Which one of the following is the purpose for analyzing a confined space?

A To identify and document appropriate processes for operations to be performed in the space.

B To determine appropriate compliance standards to use for heath threat analysis and identification.

C To validate personal protective equipment utilized by workers.

D To ensure safe conditions exist before entry and can be maintained while in a confined space.

Which type of equipment or materials should be used to conduct the analysis of a confined space?

A Indirect Sampling Devices

B Direct Reading Instruments

C Integrated Sampling Instruments

D Checklists and Diagrams

Which one of the following is NOT a primary consideration when analyzing a confined space?

A Flammability

B Oxygen

C Humidity

D Toxicity

Which group is responsible for analyzing and classifying a confined space?

A SEG

B AFRAT

C CSPT

D CE EM

Which one of the following is NOT a BE-specific responsibility related to analyzing confined spaces?

A Coordinate the installation confined space program.

B Review and approve non-routine entry permits.

C Certify organizational personnel to test confined spaces.

D Assist in the interpretation of monitoring results.

## **Lyman AFB Scenario** (Page 7 of 10)

Organizational personnel are unavailable to perform the initial analysis of the fuel compartments in the new KC-767s because of other mission responsibilities. You've been asked to assist the unit by conducting the atmospheric monitoring and analysis of the aircraft's fuel compartments. When you arrive at the flightline, you observe the fuel compartments are currently being controlled through force ventilation.

Using the TVA-1000 and the $O_2$ LEL meter, you begin the monitoring process.

## **Scenario Challenge Point** (Page 8 of 10)

Consider the activity being performed in the aircraft's fuel compartment. Using the readings from your instruments (shown below) and the confined space decision flow chart (in the appendix), how should you classify the fuel compartments for this new aircraft?

- PID: 5429PPB
- FID: 0.99PPM
- 5% LEL, 21.4

A Permit-Required Confined Space

B Non-Permit Required Confined Space

## **Classifying a Confined Space Hazard as Permit or Non-Permit Required** (Page 8a of 10)

Once a confined space has been analyzed and the appropriate data collected, it must be classified as either a permit-required or a non-permit required confined space according to **classification guidelines**. Classification is based on the hazards present and the measurements of oxygen content, flammability, and toxicity in the space. Select each tab to learn more about the characteristics of permit-required or non-permit required confined spaces.

### Classification Guidelines

AFOSH Std 91-25 Table 3.1, Confined Spaces Classification-Atmospheric Conditions

| Criteria | Permit Required | Non-Permit Required |
|---|---|---|
| **Characteristics** | Immediately dangerous to life and health. Has potential to contain a hazardous atmosphere. | No hazardous atmosphere and has no credible potential for a hazardous atmosphere, engulfment, or entrapment. |
| **Oxygen** | Less than 19.5% or greater than 23.5%.* | 19.5% – 23.5%.* |
| **Flammability** | Lower Explosive Limit (LEL) of greater than 10%.* | Less than or equal to 10% of LEL.* |
| **Toxicity** | An atmosphere concentration of any chemical substance over the occupational exposure limit (OEL) which is capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects. | An atmospheric concentration of any chemical, regardless of OEL, which is *not* capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects. |

* Based upon a total atmospheric pressure of 760 mm Hg (sea level)

### Tab: Permit-Required Confined Space

A permit-required confined space is described as hazardous to enter unless special precautions are taken. A permit-required confined space has one or more of the following characteristics:

- Contains or has the potential to contain hazardous atmospheres.
- Contains a material that has the potential to engulf an entrant.
- Has an internal configuration such that an entrant could be trapped or become asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-sectional area.
- Contains any other recognized serious safety or health hazard.

**Tab: Non-Permit Required Confined Space**

Non-permit required confined spaces do not actually, or potentially, contain hazards that could cause death or serious physical harm to an entrant.

If hazards exist but can be eliminated before personnel entry, the confined space can be classified as a non-permit required space. However, if the space is configured in such a way that it requires entry to evaluate or eliminate a hazard, the initial entry would be considered a permit-entry.

Once the hazards are eliminated and air monitoring confirms the absence of atmospheric hazards, the space may be reclassified as a non-permit space. This reclassification remains valid only as long as all hazards are eliminated.

It is important to remember that all confined spaces are considered permit-required until they can be classified as non-permit required through testing or inspection.

## Appraisal (Page 9 of 10)

Match each description with the appropriate confined space classification by marking the appropriate block in the table.

| Description | Permit-Required | Non Permit- Required |
|---|---|---|
| Immediately dangerous to life or health (IDLH). | | |
| Less than 19.5 % or greater than 23.5% oxygen concentration. | | |
| Less than or equal to 10 % LEL. | | |
| 19.5 % to 23.5% oxygen concentration. | | |
| Contains or has the potential to contain hazardous atmospheres. | | |

## Lesson Summary

Overall, confined spaces may contain the most unfavorable and unsafe conditions. The functional manager or commander, in coordination with the CSPT, is responsible for analyzing and classifying confined spaces. BE has specific responsibilities as a member of the CSPT to ensure adequate protection of the health and safety of entrants into a confined space.

Oxygen, flammability, and toxicity are the three primary considerations addressed when analyzing a confined space. Once the potential hazards are known and the analysis of the space is complete, a classification of permit required or non-permit required can be assigned.

In this lesson you:

- Recalled characteristics and hazards associated with confined spaces.
- Determined why and when a confined space is analyzed / classified.
- Recalled BE's role in the process of analyzing and classifying a confined space.
- Recalled the characteristics of permit and non-permit required confined spaces.

**Audio Script**

**Narrator:** Because trained organizational personnel were not available at the time the fuel compartments of the KC-767 Advanced Tanker were initially analyzed, you participated as part of the CSPT and conducted atmospheric monitoring for oxygen levels, flammability, and toxicity. As a result of the analysis, the fuel compartments have been classified as a permit-required space. As workers enter the compartments to outfit this aircraft with the proper refueling boom, hose, and drum units, the atmosphere should continue to be monitored to ensure that safe conditions can be maintained.

## Resources

- AFOSH STD 91-25, Confined Spaces

# Answer Key: Appraisals / Scenario Challenge Points

## Lesson 7: Confined Space Hazards

### Page 3 of 10

Match each situation with the type of confined space hazard to which it applies by marking the appropriate block in the table.

| Situation | Atmospheric Hazard | Physical Hazard |
|---|---|---|
| Carbon dioxide has built up and displaced the oxygen in the space. | **X** | |
| A chemical reaction has occurred causing methane gas to accumulate in the space. | **X** | |
| The electrical panel is exposed to personnel working in the confined space. | | **X** |
| Unstable supports have broken and caused the space to enclose around the workers. | | **X** |
| Oxygen dispensing equipment has malfunctioned, allowing too much oxygen into the space. | **X** | |

Rationale: Atmospheric hazards personnel may encounter in a confined space include deficient or excessive oxygen levels, or the presence of flammable, explosive, or toxic gases and materials. In addition to atmospheric hazards, the confined workspace may include electrical, mechanical, engulfment, or entrapment hazard.

### Page 6 of 10

Following are several questions to check your knowledge about analyzing confined spaces. Select the correct answer for each question.

Which one of the following is the purpose for analyzing a confined space?

**D** **To ensure safe conditions exist before entry and can be maintained while in a confined space.**

Which type of equipment or materials should be used to conduct the analysis of a confined space?

**B** **Direct Reading Instruments**

Which one of the following is NOT a primary consideration when analyzing a confined space?

**A Flammability**

Which group is responsible for analyzing and classifying a confined space?

**C CSPT**

Which one of the following is NOT a BE-specific responsibility related to analyzing confined spaces?

**A Coordinate the installation confined space program.**

**Page 8 of 10**

Consider the activity being performed in the aircraft's fuel compartment. Using the readings from your instruments (shown below) and the confined space decision flow chart (in the appendix), how should you classify the fuel compartments for this new aircraft?

**A Permit-Required Confined Space**

Rationale: The aircraft fuel compartment should be classified as a permit-required confined space because the atmospheric conditions are being controlled through forced ventilation; even though the hazard has been reduced, it has not been eliminated.

# 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.

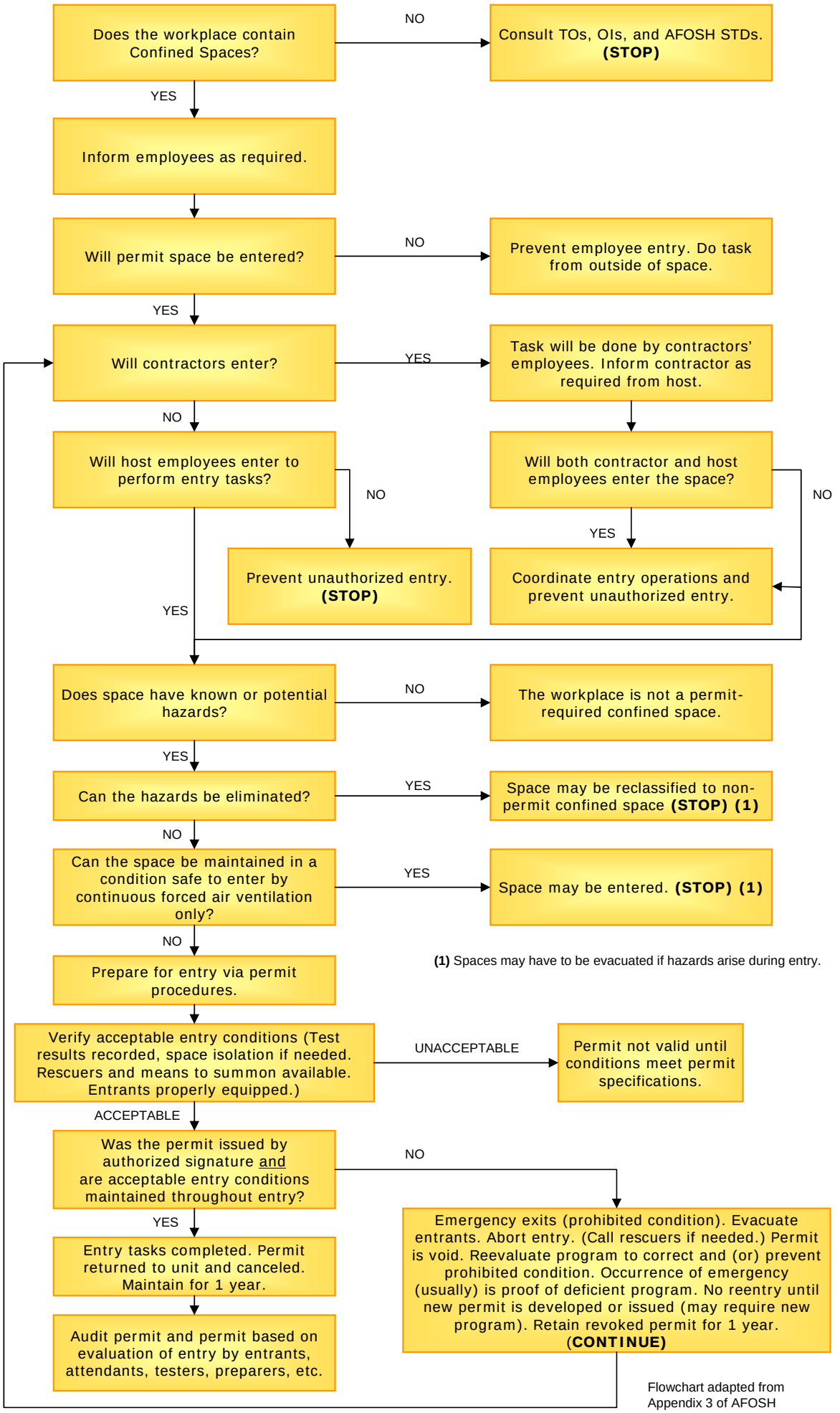
**Uncontrolled Environments**
An area where exposures may be incurred by people who have no knowledge or control of the hazard.

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

# Appendix

- Attachment 3 of AFOSH STD 91-25, Confined Spaces

# PERMIT-REQUIRED CONFINED SPACE DECISION FLOWCHART




**(1)** Spaces may have to be evacuated if hazards arise during entry.

Flowchart adapted from Appendix 3 of AFOSH Std 91-25, *Confined Spaces.*