Confined Space Entry Policy

Description

OBJECTIVE

This policy establishes minimum requirements designed to protect the health and safety of University staff that must enter and work in confined spaces..

AUTHORITY

By authority delegated from the University President, the Vice-President for Business Affairs is responsible for the safety of all University facilities. Under this authority, policies are developed to provide a safe teaching, research, service, housing and recreational environment.

[su_spoiler style="fancy" icon="chevron" title=" Reference "] OSHA 29 CFR 1910.146, Permit Required Confined Spaces; OSHA 29 CFR 1926 Subpart AA, Confined Spaces in Construction; Governor's Executive Order 2000-92
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POLICY

All employees, students, volunteers and contractors working under direct UF supervision shall comply with all elements of the UF Confined Space Entry Program.

A permit, as described in the PROCEDURES section of this program, shall be reviewed and filled out prior to any confined space entry.

Work areas identified as confined spaces shall be tested and verified as safe prior to entry. If testing determines that the space does not have a safe atmosphere, forced air ventilation shall be introduced until the space is safe and continued until all work within the space is complete. Continuous atmospheric monitoring shall be conducted while personnel are in the space.

Only trained and authorized personnel are allowed to enter a confined space, to supervise work activities involving confined space entry or to serve as an outside attendant during confined space work.

RESPONSIBILITIES

[su_spoiler style="fancy" icon="chevron" title=" Environmental Health and Safety (EH&S) "] EH&S serves as the primary point of contact and resource for issues pertaining to confined space entry. EH&S shall develop and provide training to campus organizations required to participate in this

program.

EH&S will assist in the field assessment and identification of confined spaces.

EH&S shall have stop work authority for any confined space entry observed as not following the requirements of this program.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Physical Plant Division and Other Division Maintenance and Facilities Departments "] All divisions are required to comply with the requirements described in this program.

The supervisor, authorized entrant and the attendants must be designated, in writing, for each confined space entry.

Provide and maintain all required health and safety equipment, including air monitoring instruments, necessary to provide safe entry into a confined space.

Ensure that the required training is received by participating staff before assignment to work involving confined space entry.

Verify the availability of a trained confined space rescue team for responding to emergencies involving confined space entry.

Enforce disciplinary procedures as needed to ensure compliance with this program.

Notify outside contractors if their work involves designated confined spaces and review their written confined space entry program for compliance with OSHA regulations.
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PROCEDURES

The following program defines the potential hazards and the required safe entry procedures for confined space work. All covered employees are expected to comply with these stated procedures.

[su_spoiler style="fancy" icon="chevron" title=" Background "] A confined space is an area that is large enough to bodily enter and perform work, has limited means of entry or exit and is not intended for continuous occupancy. All three of these criteria must apply for an area to be classified as a confined space. Confined spaces are characterized by poor ventilation and have the potential for having a hazardous atmosphere. The configuration of a confined space may restrict rescue efforts and can often result in the injury or death of poorly prepared or trained rescuers.
The following table notes areas meeting the definition of a confined space at the UF main campus and at affiliated off-campus research sites. This is not a complete list and every space must be reviewed prior to entry for adherence to the confined space criteria.

Manhole access points – all (sewer, storm drain, steam/chilled water, electrical)	Utility tunnels – all, regardless of means of manhole, walk-in)
Wastewater treatment plant digester tanks	Electrical vaults
Elevator pits	Fuel tanks

Boilers	Agricultural pits
Silos	Air handlers
Attics	Crawlspaces
Sump pits	Pipe chases

A pre-entry assessment of every confined space job is imperative to ensure worker health and safety. This assessment must include atmospheric monitoring and a visual inspection of the area around the entry point. All work involving confined spaces must be considered hazardous and all appropriate precautions must be followed.

Confined space hazards typically fall into three main categories:

- Atmospheric: oxygen deficient or rich, explosive or toxic
- Physical: temperature extremes, high noise levels, engulfment
- Biological: infectious agents, stray animals, insects or poisonous plants

[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Confined Space Classification and Permits "] Confined Space Classification and Permit | Word

Entry into a confined space shall be by permit only. The entry form can be accessed above. The permit serves as written authorization and documentation specifying the location and type of work to be done and certifies that all necessary protective measures have been taken to ensure the safety of each employee. The Entry Supervisor shall be responsible for completing the permit and shall sign off on the permit only after all requirements have been fulfilled.

University employees are only allowed to enter confined spaces that have been determined to be hazard free at the time of the pre-entry assessment or that have hazards that can be controlled through the use of forced air ventilation.

The completed permit for all confined space entries shall be kept at the job site for the duration of the entry. The original entry permit shall be kept on file for a minimum of one year in the department office with a copy forwarded to EH&S.

For the purposes of this program, there are two types of confined space – Permit Required Confined Space and Non-permit Required Confined Space.

Information pertaining to the correct classification of a space can be found on the following table. A confined space is considered "permit required" if it exhibits or has the potential to exhibit any one of the noted hazard conditions.

Parameter	Permit Required Confined Space	Non-permit Required Confined Space
Oxygen	<19.5% or >23.5%	19.5 to 23.5%
Flammability	>10% lower flammable limit (LFL)	<10% lower flammable
Toxicity	>50% permissible exposure limit (PEL) or threshold limit value (TLV)	<50% of PEL or TLV

Examples	Manhole entry points; WWTP digester tanks	Air handlers, attics, crav

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Air Monitoring and Testing

- Direct reading, intrinsically safe multi-gas confined space monitoring instruments must be used to conduct air monitoring of confined spaces. All monitoring instruments must possess an audible alarm that signals when parameter levels exceed safe levels. The instrument shall be equipped with the appropriate toxic gas sensor for the specific job.
- EH&S must approve all monitoring instrumentation prior to purchase and can assist in the selection of the appropriate equipment.
- Individuals performing atmospheric monitoring of confined spaces must be trained in the use of and be able to demonstrate proficiency in the use of the monitoring instrument. Instruments shall be “bump tested” in accordance with the manufacturer’s instructions prior to each use. The date and time of the bump test shall be recorded on the entry permit.
- Each hazard parameter shall be measured for at least thirty seconds or until the instrument reading is stable. The sequence for parameter measurement is as follows:

First: Oxygen levels
Second: Flammability/Explosivity
Third: Toxicity

- When monitoring, readings must be taken every two feet from top to bottom in order to account for a stratified atmosphere.
- The atmosphere shall be monitored on a continuous basis until work in the space is complete.
- The entrant must wear a personal, direct reading oxygen meter if work in the space is to take place beyond the point of entry.

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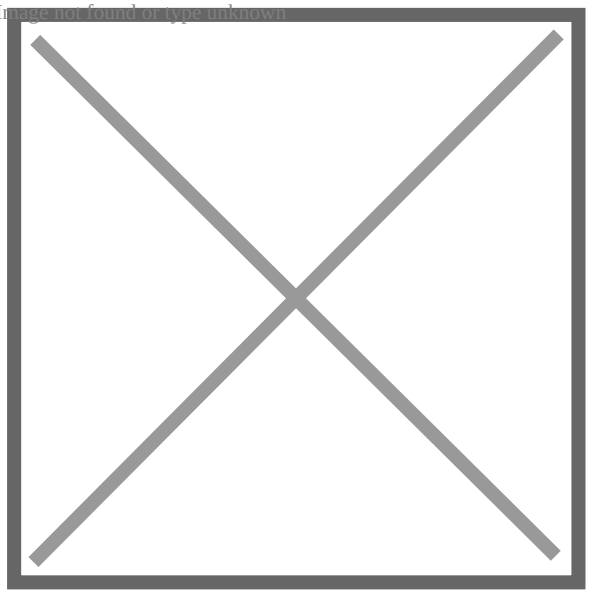

Spaces meeting the definition of a confined space shall be marked with the appropriate signage

warning of the potential dangers. For example:

Entry Procedures

The entry permit shall be completed by the supervisor and be definitive for all possible hazards. Before entering a confined space, employees shall review the specific entry permit for safe entry and emergency exit information.

Openings (i.e. manholes) must be promptly guarded by the placement of railings, temporary covered or other effective barriers that will prevent an accidental fall through the opening and that will protect employees working in the confined space from foreign objects entering the work area. The use of traffic cones, unless coupled with a railing system, is prohibited as a method of guarding an opening.

[su_spoiler   ve and Allowable Methods of Guarding an Opening “] Employees entering a permit required confined space shall wear a full body harness at all times while in the space. The harness shall be hooked to a retrieval line leading to a winch and tripod system. The entrant shall remain attached to the retrieval line at all times unless the retrieval equipment would increase the overall risk of entry or would not contribute to the rescue of an entrant.

All hazardous energy sources associated with the confined space that may expose the entrants to potential injury must be isolated prior to entry in accordance with the UF Lock Out/Tag Out policy.

The use of volatile chemical products such as PVC cement or other products containing organic solvents in a confined space can rapidly change the atmospheric conditions and create an immediately dangerous environment. The Material Safety Data Sheet (MSDS) for any chemical product used during a confined space entry must be kept at the job site.

Other activities such as welding, soldering or spark producing cutting, when done within the confined space, can create a hazardous atmosphere. Vehicle or generator exhaust, depending on their proximity to an opening, may also be drawn into the confined space resulting in potentially hazardous conditions.

Where necessary, as determined by monitoring, the type of work planned or comfort, forced air ventilation shall be provided to the confined space. The supplied air must be drawn from a clean source and once started, ventilation must be provided continuously until work is complete.
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Confined Space Entry Participant Responsibilities

[su_spoiler style=”fancy” icon=”chevron” title=” Entry supervisor “]

- Is responsible for the overall entry procedure and must coordinate all monitoring, permits, equipment and other relevant activities
- Ensure that all personnel involved in the job have received the proper training and are physically fit to perform the required tasks.
- Evaluate for possible hazards that may be encountered during entry and know the mode, signs, symptoms and consequences of exposures
- Verify that all tests specified by the permit have been conducted and that all procedures and equipment are in place before signing the permit and allowing entry to begin.
- Assign responsibilities and entry roles to all personnel prior to entry.
- Terminate the entry and cancel the permit when the entry is complete or there is a need to terminate the permit.
- Verify that rescue services are available and that the means for summoning them are operable
- Prevent unauthorized access and verify the effectiveness of the barricade system around any openings.

[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Entry Attendant “]

- Must have received the required training and know the hazards that may be encountered during a confined space entry including the mode, signs or symptoms and consequences of exposure.
- Shall remain outside of the confined space during entry operations until relieved.
- Perform no activities that may interfere with the primary responsibility of monitoring and protecting the authorized entrant.
- Maintain communication with entrants as necessary to monitor entrant status and to alert entrants of any condition changes or the need to evacuate.
- Must be able to accurately identify the authorized entrants and maintain a count of entrants in the space.
- Continuously monitor for hazards both inside and outside of the work area including the atmospheric conditions in the space.
- Must never enter the confined space during entry operations unless their designation is reassigned by the entry supervisor.
- Perform a non-entry rescue and/or initiate the rescue process by summoning emergency services and providing essential information as required to facilitate a rescue.

[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Authorized Entrants “]

- Must have received the required training and be authorized by the Entry Supervisor to enter the confined space.
- Must use assigned personal protective equipment and entry tools and supplies.
- Must be aware of any hazards that may be encountered during an entry and know the warning signs indicating a potential exposure.
- Maintain communication with and alert the Entry Attendant whenever a change in space conditions is noted or when warning signs are recognized.
- Must exit the space immediately when the Entry Attendant or Entry Supervisor gives an order to evacuate or when the entrant recognizes any warning signs or symptoms of exposure.

[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Contractors “]

- The responsible department will advise the contractor of any hazards identified and of any experience with the space and will make note of special precautions or procedures necessary for

employee protection.
- Contractors are expected to comply with the OSHA Permit Required Confined Space Standards and all other applicable health and safety standards.
- The contractor is expected to have a written confined space entry program in place that meets the OSHA requirements. The written program shall be available for review by the Project Manager or EH&S representatives upon request.
- Contractors shall ensure that their employees are properly training and have the equipment and resources available to ensure safe confined space work.

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Training Requirements

All participants in confined space activities shall receive training that provides the understanding, knowledge and skills necessary for the safe performance of the duties required for confined space entry. The training shall include an overview of the confined space program requirements and the potential hazards that may be encountered. Specific training on confined space monitoring and on the requirements of each entry team member shall be covered in detail.

The Entry Supervisor is responsible for verifying that the required training has been received by staff prior to conducting any work related to confined space entry.

Due to the potentially hazardous nature of confined space work, UF policy requires that any employees involved in confined space entry activities receive training every two years.

All training must be documented in writing.

Depending on the type of hazards encountered during confined space work, additional training and the participation in other EH&S programs may be required. Examples of areas requiring additional training include:

- Lock Out/Tag Out
- Electrical Safety
- Respiratory Protection
- Hearing Conservation
- Bloodborne Pathogens
- Hot Work
- Heat Stress

Department Supervisors should determine whether additional training in these areas is required or contact EH&S for additional information.

Rescue and Emergency Services

Appropriate means for rescue must be determined prior to the start of any confined space entry activities. Rescue options available to UF confined space program participants are described below.

[su_spoiler style=”fancy” icon=”chevron” title=” Self-Rescue “] Self-rescue must be implemented

whenever an entrant or attendant determines a potentially hazardous change in atmospheric conditions within the space or when signs or symptoms of an exposure are noted.

Self-rescue requires the entrant to stop what they are doing and to safely exit the space as quickly as possible.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Non-Entry Rescue "] If self-rescue is not an option, the next consideration is whether a non-entry rescue can be carried out. This requires the use of a tripod, winch and non-conductive retrieval cable that is attached to the full body harness worn by the entrant. This type of rescue is only effective in simple vertical or clear horizontal spaces. The opening must not be too large to accommodate a tripod and the surface around the opening must be able to support the weight of the tripod and the attached entrant. If the entrant is injured or cannot perform self-rescue, the attendant can remove the entrant through the use of the tripod and winch.

If neither self rescue nor non-entry rescue is possible, an entry rescue will be required. UF staff are not trained or authorized to perform entry rescues in confined spaces. The local fire rescue authority must be contacted by calling 911 directly from the job site. A description of the location and nature of the required assistance must be provided to the dispatcher.
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Record Keeping

All impacted departments shall maintain written records of training including entry/rescue exercises and equipment inspections for at least one year or until the date of the next scheduled training. In addition, entry permits shall be retained for at least one year. Where medical monitoring is conducted for respiratory protection or for hazard exposure, records shall be retained for the duration of employment plus thirty years. Where atmospheric testing indicates the presence of a toxic substance, records shall be maintained in accordance with existing Federal regulations.

References and Resources

- **American Conference of Governmental Industrial Hygienists.** [Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.] 1994. Cincinnati, OH 45240.
- **American Industrial Hygiene Association.** [Confined Space Entry, An AIHA Protocol Guide.] 1995. AIHA, Fairfax, VA.
- **American National Standards Institute.** [Safety Requirements for Confined Spaces.] 1989. ANSI.
- **U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR 1910.146.** [Permit Required Confined Spaces, Final Rule.] Federal Register Vo. 5, No. 9, January 1993.
- **U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health.** [Criteria for A Recommended Standard: Working in Confined Spaces.] December 1979. NIOSH #80-106.
- **U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health.** [Worker Deaths in Confined Spaces. A summary of Surveillance Findings and Investigative Case Reports.] January 1994.

NIOSH #94-103.

Useful Definitions Relevant to Confined Space Safety

[su_spoiler style="fancy" icon="chevron" title=" Atmosphere "] Refers to the gases, vapors, mists, fumes and dusts within a confined space.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Attendant"] A person trained in emergency rescue procedures and assigned to remain on the outside of the confined space in constant communication with those working inside the confined space. The attendant shall be approved and assigned by the qualified entry supervisor.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Ceiling Level"] The maximum airborne concentration of a toxic agent to which an employee may be exposed for any period of time.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Combustible Dust "] A dust capable of undergoing combustion or burning when subjected to a source of ignition.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Confined Space "] Refers to a space which by design has limited access, unfavorable natural ventilation resulting in potential dangerous concentrations of air contaminants and which is not intended for continuous human occupancy.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Hot Work "] Any work involving burning, welding, riveting, or similar high temperature producing operations as well as work which produces a source of ignition, such as drilling, abrasive blasting and space heating/drying.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Immediately Dangerous to Life and Health (IDLH) "] Those atmospheres containing sufficient concentrations of airborne materials to cause irreversible health effects upon exposures without respiratory protective equipment.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Inerting "] Displacement of the atmosphere in a confined space by a non-reactive gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Isolation "] A process whereby the confined space is removed from service and completely protected against the inadvertent release of material by the following means: blanking of supply lines, misaligning sections of all lines and pipes, a double block and bleed system, electrical lockout of all sources of power, and blocking or disconnecting all mechanical linkages.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Lower Flammable Limit (LFL) "] The minimum concentration of a combustible gas, vapor or dust in air (expressed in percent volume), which will ignite if an ignition source is present.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Non-permit Required Confined Space "] A confined space that does not contain or have the potential to contain any hazard capable of causing death or serious physical harm.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Oxygen Deficiency "] Refers to an atmosphere with a partial pressure of Oxygen (PO2) less than 132 mm mercury (Hg). Normal air at sea level contains approximately 21% Oxygen at a PO2 of 132mm Hg. For the purposes of this program, an atmosphere containing less that 19.5% Oxygen by volume shall be considered oxygen deficient.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Oxygen Enriched Atmosphere "] Any oxygen concentration greater than 23.5% at normal atmospheric pressure.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Permit Required confined Space "] Confined spaces that possess potential hazards that could result in serious injury or death. A written permit that includes atmospheric characterization, must be completed prior to entry. Spaces identified as have an IDLH atmosphere shall not be entered by UF employees.

[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Permissible Exposure Limit (PEL) "] The maximum 8-hour time weighted average (TWA) concentration of an airborne contaminant to which an employee may be exposed by law as listed in the Occupational Safety and Health Act, 29 CFR 1910 Sub Part Z.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Purging "] The method(s) by which gases, vapors or other airborne impurities are displaced from a confined space. The method usually involves injecting fresh air into the confined space using a compressor or blower, thereby forcing contaminated air out.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Qualified Entry Supervisor "] A person designated by the department, as capable (by education, training, or both) of anticipating, recognizing, evaluating, and controlling employee exposures to hazardous substances or circumstances in a confined space. This person shall be capable of specifying necessary control or protective actions and equipment to ensure employee safety. This person shall certify the confined space entry permit and be approved by EH&S per the above criteria.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Respirator "] A device designed to protect the wearer from inhalation of harmful atmospheres. The device shall meet the requirements of the UF Respiratory Protection Program, the Mine Safety and Health Administration (MSHA) and the National Institute for Occupational Safety and Health (NIOSH).
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Threshold Limit Value (TLV) "] The maximum 8-hour time weighted average (TWA) concentration of an airborne contaminant to which an employee may be exposed. To be used in absence of PEL as recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).
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Additional Information Pertaining to the Potential Hazards Encountered in a Confined Space

[su_spoiler style="fancy" icon="chevron" title=" Hazards of Confined Spaces "] Hazards specific to a confined space are dictated by the material stored or used in the space, the activity to be carried out in the space and the external environment. These can be categorized as atmospheric, physical, and biological hazards.
Hazardous atmospheres encountered in confined spaces can be further divided into four distinct categories: flammable, toxic, irritant\corrosive and asphyxiating.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Flammable Atmospheres "] A flammable atmosphere generally arises from enriched oxygen atmospheres, vaporization of flammable liquids, byproducts of work, chemical reactions, combustible dusts or desorption of chemicals from inner surfaces of the confined space.

An atmosphere becomes flammable when the ratio of oxygen to combustible material in the air is neither too rich nor too lean to burn. Combustible gases or vapors will accumulate when there is inadequate ventilation in areas such as a confined space. Flammable gases such as hydrogen sulfide, acetylene, butane, propane, hydrogen, methane, natural or manufactured gases or vapors from liquid hydrocarbons can be trapped in confined spaces. Since many of these gases are heavier than air, they will seek the lowest levels. In a closed top tank, it should also be noted that lighter than air gases may rise and develop a flammable level at the top of the confined space.

The byproducts of work procedures can generate flammable or explosive conditions within a confined space. Specific kinds of work such as spray painting can release explosive gases and vapors.

Welding in a confined space will burn up oxygen and can release explosive gases thereby changing the conditions in the space to those conducive to explosion.

Chemical reactions forming flammable atmospheres occur when surfaces are initially exposed to the atmosphere, or when chemicals combine to form flammable gases. This condition can arise when dilute sulfuric acid reacts with iron to form hydrogen gas or when calcium carbide makes contact with water to form acetylene. Other examples include acetylene-metal compounds, peroxides and nitrates. In a dry state these compounds have the potential to explode upon percussion or exposure to increased temperature. Another class of chemical reactions that form flammable atmospheres arise from deposits of pyrophoric substances (carbon, ferrous oxide, ferrous sulfate, iron, etc.) that can be found in tanks used by the chemical and petroleum industry. These tanks containing flammable deposits, can spontaneously ignite upon exposure to air.

Combustible dust concentrations are usually found during the process of loading, unloading and conveying grain products, fertilizers, finely ground chemical products and other combustible materials. High charges of static electricity, accumulating during periods of low humidity (below 50%), can cause certain substances to accumulate sufficient energy to produce sparks and ignite a flammable atmosphere. These sparks may also cause explosions when the right air or oxygen to dust or gas mixture is present.

Desorption of chemicals from the inner surfaces of a confined space is another process that can produce a flammable atmosphere. This is often a natural phenomenon in which the partial pressure at the interface between the surfaces and the stored chemical is radically reduced. For example, after liquid propane is removed from a storage tank the walls of the vessel can desorb the remaining gas from the porous surface of the confined space.
[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Toxic Atmospheres “] The substances to be regarded as toxic in a confined space can cover the entire spectrum of gases, vapors fumes, aerosols and finely divided airborne dust. The sources include manufacturing processes, product storage and operations performed in the space.

Toxic gases can be evolved when acids are used for cleaning. Hydrochloric acid can react with iron sulfide to produce hydrogen sulfide (H2S). H2S is also formed from the decay of organic matter such as leaves, silage, and sewage. During loading, unloading, formulating and production, toxic gases can be produced which are not part of the planned operation.

Toxic solvents such as trichloroethylene, methyl chloroform and dichloromethane are used for cleaning and degreasing. Acrylonitrile has been encountered as an ingredient in protective coatings applied to tank interiors. Trichloroethane and dichloroethane are widely used as cleaning agents because they are among the least toxic of the chlorinated aliphatic hydrocarbons. However, deaths have occurred from asphyxiation and explosions from failure to thoroughly purge and inert confined spaces.

The compatibility of materials must be considered when structural members and equipment are introduced into confined spaces. The previous history of the space must be carefully evaluated to avoid reactions with residual chemicals, wall scale and sludge, which can be highly reactive. Cases of

incompatibility have occurred during the use of chemical cleaning agents. The initial step in chemical cleaning usually is the conversion of the scale or sludge into liquid state, which may cause poisonous gases to be liberated.

Another hazardous gas that may buildup in a confined space is carbon monoxide (CO). This odorless, colorless gas having the same density as air is formed from incomplete combustion of organic materials such as wood, coal, gas, oil and gasoline. It can also be formed from microbial decomposition of organic matter in sewers, silos and fermentation tanks. CO is an insidious gas because of its lack of warning properties mentioned above. Early stages of intoxication are nausea and headache. CO can be fatal at 1000 parts per million (ppm) in air and is considered dangerous at 200 ppm. It acts to bind with the hemoglobin of the blood in the place of oxygen resulting in death through asphyxiation.

CO is relatively abundant and any untested atmosphere must be suspect. It must also be noted that a safe reading on a combustible gas indicator (explosimeter) does not ensure that CO is not present.

CO must be tested for specifically as formulation can result from chemical reactions or work activities and fatalities are not confined to any specific industry. There have been accidents in sewage treatment plants, paint and varnish industry, and welding operations.
[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Irritant (corrosive) Atmospheres ?”] Irritant or corrosive atmospheres can be divided into primary and secondary groups. The primary irritants exert no systemic effects because the products formed by them on tissues of the respiratory tract are non-irritant and other effects are so violent as to obscure any systemic action. Examples of primary irritants are chlorine, ozone, hydrochloric acid, hydrofluoric acid, sulfuric acid, nitrogen dioxide, ammonia and sulfur dioxide. A secondary irritant is one that may produce systemic toxic effects in addition to surface irritation. Examples of secondary irritants include benzene, carbon tetrachloride, ethyl chloride, trichloroethane, trichloroethylene, and chloroprene.

Irritant gases are widely used throughout all areas of industrial activity. They can be found in plastics plants, chemical plants, the petroleum industry, tanneries, refrigeration industries, paint manufacturing and mining operations.

Prolonged exposure to irritant or corrosive concentrations in a confined space may produce little or no evidence of irritation. This has been interpreted to mean that the worker has become adapted to the harmful agent involved. In reality, it means there has been a general weakening of the defense reflexes from changes in sensitivity, due to damage of the impacted nerve system. The danger in this situation is that the worker is usually not aware of any increase in his exposure to toxic substances.
[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Asphyxiating Atmospheres ?”] The normal atmosphere is composed approximately of 20.9% oxygen, 78.1% nitrogen and 1% argon with small amounts of various other gases. Reduction of oxygen in a confined space may be the result of either consumption or displacement.

The consumption of oxygen takes place during combustion of flammable substances, as in welding, heating, cutting, and brazing. A more subtle consumption of oxygen occurs during bacterial action, as in the fermentation process. Oxygen may also be consumed during chemical reactions as in the formation of rust on the exposed surface of the confined space. The number of employees in a confined space and the amount of work will also influence the oxygen consumption rate.

A second factor in oxygen deficiency is displacement by another gas. Examples of gases that are used to displace air, and therefore reduce the oxygen level are helium, argon and nitrogen. Carbon dioxide may also be used to displace air and can occur naturally in sewers, storage bins, wells, tunnels, wine vats and grain elevators. Aside from the natural development of these gases or their use in the chemical process, certain gases are also used as inerting agents to displace flammable substances and retard pyrophoric reactions. Gases such as nitrogen, argon, helium and carbon dioxide are frequently referred to as non-toxic inert gases but have claimed many lives by asphyxiation. The use of nitrogen to inert a confined space has claimed more lives than carbon dioxide. The total displacement of oxygen with nitrogen will cause immediate collapse and death.

Carbon dioxide and argon are both heavier than air and can lie in a tank or manhole for hours or days after opening. Since these gases are colorless and odorless, they pose an immediate hazard to health unless appropriate oxygen measurements and ventilation are adequately carried out.

Oxygen deprivation is one form of asphyxiation. While it is desirable to maintain the atmospheric oxygen level at 21% by volume, the body can tolerate deviation from this ideal. When the oxygen level falls to 17%, the first sign of hypoxia is a deterioration of night vision which is not noticeable until a normal oxygen concentration is restored. Physiologic effects are increased breathing volume and accelerated heartbeat. Between 14-16% the physiologic effects are increased breathing volume, accelerated heart beat, very poor coordination, rapid fatigue and intermittent respiration. Between 6-10% the effects are nausea, vomiting, inability to perform and unconsciousness. Less than 6% results in spasmodic breathing, convulsive movements and death in minutes.
[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Mechanical Safety Hazards ?”] If activation of electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated to prevent inadvertent activation before work in a confined space commences. The interplay of hazards associated with a confined space, such as the potential of flammable vapors or gases being present and the build-up of static charge due to mechanical cleaning, such as abrasive blasting, all influence the precautions that must be taken.

To prevent vapor leaks, flashbacks and other hazards, employees should completely isolate the space. To do so means closing all valves and disconnecting or blanking all pipes. Other special precautions must be taken in cases where flammable liquids or vapors may re-contaminate the confined space.

The lines that are disconnected\blanked should be inspected and tested for leaks to check the effectiveness of the procedure. Other areas of concern are steam valves; pressure lines and chemical transfer pipes. A less apparent hazard is the space referred to as a void, such as double walled vessels, which must be given special consideration in blanking off and inerting.
[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Communication Problems ?”] Communication between the employee inside the space and the standby person outside is of utmost importance. If the employee should suddenly feel distressed and not be able to summon help, an injury could become fatal. Frequently, the body positions that are assumed in a confined space make it difficult for the standby person to detect an unconscious employee. When visual monitoring of personnel is not possible because of the design of the space, a voice activated explosion proof communication system shall be instituted.
[/su_spoiler] [su_spoiler style=”fancy” icon=”chevron” title=” Entry and Exit ?”] Entry and exit time is of major significance as a physical limitation and is directly related to the potential hazard of the space.

The extent of the precautions taken and the standby equipment needed to maintain a safe work area will be determined by the means of access and rescue.

The following must be considered:

- Type of confined space to be entered
- Access to the entrance
- Number and size of openings or barriers within the space
- The occupancy load
- The time requirement for exiting in the event of fire or vapor incursion
- The time required to rescue injured entrants.

[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Physical Hazards ?"] The hazards described in this section are non-chemical, physiologic stressors. These include thermal, noise, vibration and fatigue while working in a confined space.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Thermal Effects ?"] Four factors effect the interchange of heat between man and the environment. These include air temperature, air velocity, moisture content of the air and radiant heat. Because of the nature and design of most confined spaces, moisture content and radiant heat are difficult to control. As the body temperature rises progressively, employees will continue to function until the body temperature reaches about 100.9°F to 102.9°F. When this body temperature is exceeded, employees are less efficient and are prone to heat exhaustion, heat cramps or heat stroke. In a cold environment, certain physiologic mechanisms come into play which tend to limit heat loss and increase heat production. The most severe strain in cold situations is chilling of the extremities so that activity is restricted. Special precautions must be taken in cold environments to prevent frostbite, trench foot and general hypothermia.

Protective insulated clothing for both hot and cold environments will add additional bulk to the employee and must be considered in allowing for movement in the confined space and exit time.

Therefore, air temperature of the space becomes an important consideration when evaluating working conditions.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Noise ?"] Noise problems are usually intensified in confined spaces because the interior tends to cause sound to reverberate and thus expose the employee to higher sound levels than those found in an open environment. This intensified noise increases the risk of hearing damage, which could result in temporary or permanent loss of hearing. Noise in a confined space, which may not be intense enough to cause hearing damage, may still disrupt verbal communication with the emergency standby person on the exterior of the space. If the employees inside are not able to hear commands or danger signals due to excessive noise, the probability of severe accidents will increase.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" Vibration ?"] Whole-body vibration may be regarded as a generalized stressor and may affect multiple body parts and organs depending upon the vibration characteristics. Segmental vibration, unlike whole-body vibration, is more localized in creating injury to the fingers and hands of employees using tools like pneumatic hammers and rotary grinders.
[/su_spoiler] [su_spoiler style="fancy" icon="chevron" title=" General ?"] Some physical hazards cannot be eliminated because of the nature of the space or the work to be performed. These hazards include such items as scaffolding, surface residues and structural hazards. The use of scaffolding in confined spaces has contributed to many accidents caused by employees or materials falling, improper use of

guardrails and lack of maintenance to insure employee safety. The choice of material used for scaffolding depends upon the type of work to be performed, the calculated weight to be supported, the surface on which the scaffolding is placed and the substance previously stored in the confined space.

Surface residues in confined spaces can increase the already hazardous conditions of electrical shock, reaction of incompatible materials, liberation of toxic substances and bodily injury due to slips and falls. Without protective clothing, additional hazards to health may arise due to surface residues.

Structural hazards within a confined space such as baffles in horizontal tanks, trays in vertical towers, bends in tunnels, overhead structural members, or scaffolding installed for maintenance constitute physical hazards, which are exacerbated by the physical surroundings. In dealing with structural hazards, employees must review and enforce safety precautions to assure safety.

Rescue procedures may require withdrawal of an injured or unconscious person. Careful planning must be given to the relationship between the internal structure, the exit opening and the employee. If the employee is above the opening, the system must include a rescue arrangement operated from outside the confined space by which the employee can be lowered and removed without injury.

Confined spaces present many hazards that are inherent by design and exacerbated by definition. However, through proper training, evaluation and controls, duties can be conducted in a safe and efficient manner.
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