

Confined Space Entry Program

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Purpose

INTRODUCTION

The ABC Company Confined Space Entry Program is provided to protect its authorized employees that will enter confined spaces and may be exposed to hazardous atmospheres, engulfment in materials, conditions which may trap or asphyxiate due to converging or sloping walls, or contains any other safety or health hazards. Reference: *OSHA-Permit-Required Confined Spaces* (29 CFR 1910.146).

This written program is intended to describe the ABC Company confined space entry program as required by 29 CFR 1910.146. This plan will serve as the required written confined space program for ABC Company when serving as the prime contractor or as a sub-contractor operating on a job site under the supervision of general contractor. Project-specific confined space requirements will be added by addendum to this program for a specific project. Addendum's to this written program will include ABC Company's confined space classification and entry permit (Addendum A) and ABC Company's Confined Space Entry Log (Addendum B).

SCOPE

The following program will apply to any ABC Company employee, contract employee or sub-contractor employee that may enter into a space identified as a confined space. Contractors will be included only in terms of maintaining compliance with the OSHA regulations, although other contractors must have a program equivalent to this program.

This written program will be provided to the general contractor or other contractors who have employees requiring entry to confined spaces and will be made available to any employee, contractor or governmental agency representative upon request. This written program will also be available to the general contractor prior to ABC Company's entry into any confined spaces.

RESPONSIBILITIES

ABC Company

ABC Company will be responsible for carrying out the Confined Space Entry program in accordance with this written program and for funding program expenses including but not limited to equipment, employee training and attendants expenses. ABC Company will also be responsible for new employees who will need required training, requesting necessary retraining, enforcing compliance with the permit system and notifying other contractors or the general contractor of issues related to confined spaces on the job or project site.

Onsite Supervisor

Supervisors will be responsible for identifying employees who will enter defined confined spaces, maintaining employee training records, assuring employees are aware of and following this written program, and immediately notifying management, the general contractor and other contractors on the job site of any incidents that occur in connection with any confined space entry. Additionally, the supervisor will be responsible for administering and managing the confined space entry program, assisting employees in evaluating our compliance with the confined space entry program, and arranging and conducting training for employees to be authorized attendant/rescuers and authorized entrants.

All ABC Company Management

- Ensure proper training for entry personnel
- Provide proper equipment for entry personnel
- Ensure confined space assessments have been conducted
- Ensure all permit required confined spaces are posted
- Annually review this program and all Entry Permits

All ABC Company Employees

- Follow this program s requirements
- Report any previously un-identified hazards associated with confined spaces to management/supervisor immediately

Entry Supervisor (Designated Authorizer of entry)

Entry supervisors are responsible for the overall permit space entry and must coordinate all entry procedures, tests, permits, equipment and other relevant activities. The following entry supervisor duties are required:

- Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure

Verifies, by checking that the appropriate entries have been made on the permit, all test specified by the permit have been conducted and that all procedures and equipment specified by the permit are in place before endorsing the permit and allowing entry to begin

Terminate the entry and cancel the permit when the entry is complete and there is a need for terminating the permit

Verify that rescue services are available and that the means for summoning them are operable

Remove unauthorized persons who enter or attempt to enter the space during entry operations

Determine whenever responsibility for a permit space entry operation is transferred and at intervals dictated by the hazards and operations performed within the space that entry operations remain consistent with the permit terms and that acceptable entry conditions are maintained.

Entry Attendants

At least one attendant is required outside the permit space into which entry is authorized for the duration of the entry operation. Responsibilities include:

To know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure

To be aware of possible behavioral effects of hazard exposure on entrants

To continuously maintain an accurate count of entrants in the permit space and ensures a means to accurately identify authorized entrants

To remain outside the permit space during entry operations until relieved by another attendant (once properly relieved, they may participate in other permit space activities, including rescue if they are properly trained and equipped).

To communicate with entrants as necessary to monitor entrant status and alert entrants of the need to evacuate.

To monitor activities inside and outside the space to determine if it is safe for entrants to remain in the space and orders the entrants to immediately evacuate if: the attendant detects a prohibited condition, detects entrant behavioral effects of hazard exposure, detects a situation outside the space that could endanger the entrants; or if the attendant cannot effectively and safely perform all the attendant duties.

To summon rescue and other emergency services as soon as the attendant determines the entrants need assistance to escape the permit space hazards.

To perform non-entry rescues as specified by that rescue procedure and entry supervisor

Not to perform duties that might interfere with the attendants' primary duty to monitor and protect the entrants.

To take the following action when unauthorized persons approach or enter a permit space while entry is under way:

- Warn the unauthorized persons that they must stay away from the permit space,
- Advise unauthorized persons that they must exit immediately if they have entered the space, and
- Inform the authorized entrants and the entry supervisor if unauthorized persons have entered the permit space.

Entrants

All entrants must be authorized by the entry supervisor to enter permit spaces, have received the required training, used the proper equipment, and observes the entry procedures and permit. The following entrant duties are required:

Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure;

Properly use the equipment required for safe entry;

Communicate with the attendant as necessary to enable the attendant to monitor the status of the entrants and to enable the attendant to alert the entrants of the need to evacuate the space if necessary;

Alert the attendant whenever; the entrant recognizes any warning signs or symptoms of exposure to a dangerous situation, or any prohibited condition is detected; and

Exit the permit space as quickly as possible whenever; the attendant or entry supervisor gives an order to evacuate the permit space, the entrant recognized any warning signs or symptoms of exposure to a dangerous situation, the entrant detects a prohibited condition, or an evacuation alarm activated.

Hazards

Explosive / Flammable Atmospheres

Toxic Atmospheres
Engulfment
Asphyxiation
Entrapment
Slips & falls
Chemical Exposure
Electric Shock
Thermal / Chemical Burns
Noise & Vibration

Hazard Control

Engineering Controls

Locked entry points
Temporary ventilation
Temporary Lighting

Administrative Controls

Signs
Employee training
Entry procedures
Atmospheric Monitoring
Rescue procedures
Use of prescribed PPE

Each Permit-Required Confined Space onsite will be clearly marked "Confined Space - Entry Permit Required".

ABC Company Entry Standard Operating Procedures

A Standard Operating Procedure (SOP) has been developed for non-permit required confined space to standardize the entry procedure. This SOP outlines:

Definitions

Duties/Responsibilities
Hazards
Hazard Control & Abatement
Acceptable Entry Conditions/Rules
Permitting Requirements
Means of Entry
Entry Equipment Required
Emergency Procedures

DEFINITIONS

"Authorized attendant/rescuer" means an individual stationed outside the permit required confined space who is trained as required by this standard and who monitors the authorized entrants inside the permit required confined space.

"Authorized entrant" - means an employee who is authorized by ABC Company to enter a permit required confined space.

Confined space is -

Large enough or so configured that an employee can bodily enter and perform work.

Has limited or restricted means for entry or exit (i.e. tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).

Is not designed for continuous employee occupancy.

"Engulfment" - means the surrounding and effective capture of a person by a liquid or finely divided solid substance.

"Entry" - means the act by which a person passes through an opening into a permit required confined space and includes ensuing work activities in that space. The entrant is considered to have entered as soon as any part of the entrant's body breaks the plane of an opening into the space.

"Designated Entry Authorizer" - means a person who has been designated by ABC Company management to authorize entry into a confined space with the issuance of a permit. This person has received training as both an authorized entrant and attendant.

"Hazardous atmosphere" - means an atmosphere which exposes employees to a risk of death, incapacitation, injury or acute illness from one or more of the

following causes: a flammable gas, vapor or mist in excess of 10 percent of its lower flammable limit, an airborne combustible dust at a concentration that obscures vision at a distance of five feet or less, an atmospheric oxygen concentration below 19.5 percent or above 23.5 percent, an atmospheric concentration of any substance for which a permissible exposure limit exists and could result in employee exposure in excess of its permissible limits or, any atmospheric condition recognized as immediately dangerous to life or health.

"Hot work permit" - means the written authorization to perform operations that could provide a source of ignition.

"Lead Person" - Any person designated by the authorizer when authorizer will not be continuously on the scene.

"Permit required confined space" - means an enclosed space which a) is large enough and so configured that an employee can bodily enter and perform assigned work, b) has limited or restricted means for entry or exit (e.g. storage bins, vaults, pits), c) is not designed for continuous employee occupancy **and** has one or more of the following characteristics; i) contains or has a known potential to contain a hazardous atmosphere, ii) contains a material with the potential for engulfment of an entrant, iii) has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls, or a floor which slopes downward and tapers to a smaller cross-section or, iv) contains any other recognized serious safety or health hazard.

GENERAL REQUIREMENTS

ABC Company will initially assess all confined spaces on the job site that their employees would be required to enter in the performance of their job. Using criteria established by the Confined Space Standard, it is the intention of ABC Company to classify confined spaces within which their employees work as non-permit required because all potential hazards have been eliminated.

All permit required spaces, except for manholes and vaults should be posted with a sign reading *"Danger - permit-required confined space, DO NOT ENTER"*. Entrant and attendant/rescuer training will include advising that all manholes and vaults will be consider a permit required confine space unless otherwise reclassified in accordance with the OSHA regulation.

It is the responsibility of ABC Company to communicate with the general contractor or controlling agency on the job site for the specific location of all permit-required confined spaces that may exists. This should occur during pre-operational briefings and while exchanging confined space safety programs.

PERMIT SYSTEM

A confined space entry permit will be required to be obtained from a designated entry authorizer prior to the entry into any space designated as a confined space.

Only confined space entry permits approved by ABC Company or supplied by the general contractor/job site controlling agency will be used (see addendum A). Regardless of which permit used, ABC Company's Confined Space Entry Log shall be used to track entry and permits. The permit will be fully filled out before the space will be entered and the original entry permit will be maintained on the job site until the work shift and/or the job is completed. At that time the permit will be canceled by the authorizer and removed.

The designated entry authorizer may or may not be present during the duration of the entry. In cases where the entry authorizer will not be present for the duration of the entry and there is no required attendant/rescuer, a lead person among the authorized entrants will be designated by the entry authorizer. In either case, the entry authorizer will sign the permit before the entry begins, but not until all actions and conditions necessary for safe entry into the permit space have been performed (see specific confined space procedures). Upon completion of the entry covered by the permit, and after all entrants have exited the permit space, the individual authorizing the entry will cancel the permit.

ABC Company supervisors will serve as the record keepers for the program. Terminated permits will be sent to ABC Company supervisors within 24 hours and shall be retained for a year.

TRAINING AND DUTIES OF AUTHORIZED ENTRANTS

Prior to being eligible to obtain an entry permit, authorized entrants will be trained in the following areas and will be required by ABC Company to perform the following duties:

1. Recognition of hazards, which may be faced during an entry. This includes the signs and symptoms of an exposure to a hazard as well as an understanding of the consequences of that exposure.
2. When attendant/rescuers are required, authorized entrants will maintain communication with attendant/rescuer and will notify the attendant/rescuer in the event the entrants initiate evacuation.
3. Authorized entrants will be provided with and use appropriate personal protective equipment as designated by the entry authorizer. In cases respiratory protection is required, the entrant must have evidence of current fit testing and training. Entrants will be instructed in the use of the designated personal protective equipment. Any external barriers needed to protect entrants from external hazards will be explained and used.
4. When an attendant/rescuer is required, authorized entrants will be instructed to exit the space, when the attendant/rescuer orders an evacuation, when an automatic alarm (e.g., gas meter, fire alarm) sounds, or when the authorized entrant perceives that they are in danger. The only exception to the entrants

following these directions would occur when the entrant is unable physically to evacuate on their own power.

TRAINING AND DUTIES OF THE AUTHORIZED ATTENDANT/RESCUER

Prior to being eligible to be an authorized attendant/rescuer, employees will obtain training in the following areas and be required by ABC Company to perform the following duties:

1. The attendant/rescuer will continuously maintain an accurate count of all persons in the space.
2. The attendant/rescuer will be able to recognize hazards, which the entrants may face in the permitted space as well as monitor activities inside and outside the permit space to determine if it is safe for entrants to remain in the space.
3. The entrants will be provided with and maintain an effective and continuous means of contact with the authorized attendant/rescuer during entry. This may range from voice communication to radio communication. Other means may be used as deemed appropriate and effective by the authorizer. The attendant/rescuer will order immediate evacuation of entrants from permitted spaces in the following conditions:
 - a) when the attendant/rescuer observes a condition which is not allowed in the entry permit,
 - b) the attendant/rescuer detects behavioral effects of hazard exposure,
 - c) the attendant/rescuer detects a situation outside the space which could endanger the entrants,
 - d) the attendant/rescuer detects an uncontrolled hazard within the permit space or,
 - e) the attendant/rescuer must leave the work station.
4. Be trained as an authorized entrant.
5. Receive instruction on and demonstrate proficiency with the evacuation equipment.

Attendant/rescuers will only be allowed to monitor one permit entry space at a time.

All attendant/rescuers will have continuous communication capabilities with other parties. The attendant/rescuer will notify all present when an escape is ordered due to imminent safety hazards. In all ordered evacuations the authorizer will be notified immediately either through other ABC Company supervision/management or employees.

The attendant/rescuer will take the following actions as necessary when an unauthorized person approaches or enters a permit space while entry is underway:

- a) warn the unauthorized person to exit immediately if they have entered the permit space,
- b) inform the authorized entrants and the designated authorizers if an unauthorized person entered the permitted spaces.

Attendant/rescuers **will not** enter the permit space to attempt a rescue of entrants. At no time will the site be left without an attendant.

Rescue equipment will be provided for attendant/rescuers to use without entering the space. Attendant/rescuers will be trained in the proper use of such equipment and demonstrate ability to use that equipment prior to being designated an attendant/rescuer. Attendant/rescuers will also be trained to perform the required 'bump test' calibration prior to each use of the gas meter.

TRAINING AND DUTIES OF THE INDIVIDUAL AUTHORIZING OR IN CHARGE OF THE ENTRY

Prior to being eligible to authorize an entry, the designated authorizer will obtain training in the following areas and perform the following duties:

1. Authorizers will be trained in the same procedures as attendant/rescuers and entrants. In addition authorizers will be trained to perform the required monthly 'full' calibration of the gas meter.
2. All authorizers will use only the authorized permits and determine that all pertinent information is noted on the permit. They will determine that the necessary procedures, practices and equipment for safe entry are in effect before allowing entry.
3. Authorizers will determine at appropriate intervals that the entry operations remain consistent with the terms of the entry permit and that acceptable entry conditions are present.
4. Authorizers will cancel the entry authorization and terminate entry whenever acceptable entry conditions are not present. Authorizers will take the necessary measures for concluding an entry operation, such as closing off a permit space and canceling the permit, once the work authorized by the permit has been completed.
5. The authorizer may enter the permit space during the term of the permit that he/she authorized. If an attendant/rescuer is required, the attendant/rescuer will be informed of that entry and assure that the authorizer's name is on the permit.

6. In the event of an ordered evacuation, the authorizer will be required to respond to the space immediately.

RESCUE TEAM

For ABC Company's purposes, the rescue team for making entry rescue into a confined space will be the local fire department or rescue team having jurisdiction over that job site. The general contractor/job site controlling agency shall inform ABC Company of who that rescue team is and how to contact them (usually by dialing 911). Rescue team members will be trained in personal protective equipment, including appropriate respirator protection and equipment necessary for making rescues.

WORK OTHER CONTRACTORS (Multi-Employer Job Sites)

When another contractor is expected to perform work in a permitted space, ABC Company will inform that contractor that the space is considered a permit-required space. The contractor will be advised of the elements, which make the space a permit space and the associated hazards. The contractor will also be advised of any safety provisions that may be in place, including that project's specific written program. The contractor will be required to contact an authorizer at the completion of the entry to debrief with an authorizer on any hazards confronted or created during the entry.

In spaces where an attendant/rescuer is not required, the general contractor or job site controlling agency may allow contractors to review sites for possible work (e.g., pre-bid) or to enter a space with an authorized entrant under their permit. An explanation of the specific hazards in that area will be explained to the contractors prior to the entry. In all other cases, the other contractor will be required to have their own program and enter under their own permit. Contractors working with ABC Company will be required to exchange copies of their Confined Space Program.

When both another contractor and ABC Company employee will be making a joint entry, the entry will be coordinated by the ABC Company authorizer.

Permit Required Confined Space Entry Rules

During all Confined Space Entries, the following Safety Rules must be strictly enforced:

1. Only Authorized and Trained Employees may enter a Confined Space or act as an attendant.
2. No Smoking is permitted in a Confined Space or near entrance/exit area.
3. During Confined Space Entries, an attendant must be present at all times.

4. Constant visual or voice communication will be maintained between the Attendant and Employees entering a Confined Space.
5. No bottom or side entry will be made or work conducted below the level any hanging material or material which could cause engulfment.
6. Air and Oxygen Monitoring is required before entering any Permit-Required Confined Space. Oxygen levels in a Confined Space must be between 19.5 and 23.5 percent. Levels above or below will require the use of an SCBA or other approved air supplied respirator. Additional ventilation and Oxygen Level Monitoring is required when welding is performed. The monitoring will check Oxygen Levels, Explosive Gas Levels and Carbon Monoxide Levels. Entry will not be permitted if explosive gas is detected above one-half the Lower Explosive Limit (LEL).
7. To prevent injuries to others, all openings to Confined Spaces will be protected by a barricade when covers are removed.

Confined Space Entry Procedures

Each ABC Company employee who enters or is involved in the entry must:

1. Understand the procedures for confined Space Entry
2. Know the Hazards of the specific space
3. Review the specific procedures for each entry
4. Understand how to use entry and rescue equipment

Confined Space Entry Permits

Confined Space Entry Permits must be completed before any ABC Company employee enters a Permit-Required Confined Space. The Permit must be completed and signed by an entry supervisor before entry.

1. Permits will expire before the completion of the shift or if any pre-entry conditions change. Permits will be maintained on file for 12 months.

Confined Space Hazards

Flammable Atmospheres

A flammable atmosphere generally arises from enriched oxygen atmospheres, vaporization of flammable liquids, byproducts of work, chemical reactions, concentrations of combustible dusts, and absorption of chemical 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 for combustion to occur. Combustible gases or vapors will accumulate when there is inadequate ventilation in areas such as a confined space. Flammable gases such as acetylene, butane, propane, hydrogen, methane, natural or manufactured gases or vapors from liquid hydrocarbons can be trapped in confined spaces, and since many gases are heavier than air, they will seek lower levels as in pits, sewers, and various types of storage tanks and vessels. In a closed top tank, it should also be noted that lighter than air gases may rise and develop a flammable concentration if trapped above the opening.

The byproducts of work procedures can generate flammable or explosive conditions within a confined space. Specific kinds of work such as spray painting can result in the release of explosive gases or vapors. Welding in a confined space is a major cause of explosions in areas that contain combustible gas.

Chemical reactions forming flammable atmospheres occur when surfaces are initially exposed to the atmosphere, or when chemicals combine to form flammable gases. This condition arises when dilute sulfuric acid reacts with iron to form hydrogen or when calcium carbide makes contact with water to form acetylene. Other examples of spontaneous chemical reactions that may produce explosions from small amounts of unstable compounds are 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 will spontaneously ignite upon exposure to air.

Combustible dust concentrations are usually found during the process of loading, unloading, and conveying grain products, nitrated fertilizers, finely ground chemical products, and any other combustible material. High charges of static electricity, which rapidly accumulate during periods of relatively low humidity (below 50%), can cause certain substances to accumulate electrostatic charges of 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.

Toxic Atmospheres

The substances to be regarded as toxic in a confined space can cover the entire spectrum of gases, vapors, and finely-divided airborne dust in industry. The sources of toxic atmospheres encountered may arise from the following:

1. The manufacturing process (for example, in producing polyvinyl chloride, hydrogen chloride is used as well as vinyl chloride monomer, which is carcinogenic).

2. The product stored [removing decomposed organic material from a tank can liberate toxic substances, such as hydrogen sulfide (H₂S)].
3. The operation performed in the confined space (for example, welding or brazing with metals capable of producing toxic fumes).

During loading, unloading, formulation, and production, mechanical and/or human error may also produce toxic gases which are not part of the planned operation.

Carbon monoxide (CO) is a hazardous gas that may build up in a confined space. This odorless, colorless gas that has approximately the same density as air is formed from incomplete combustion of organic materials such as wood, coal, gas, oil, and gasoline; it can be formed from microbial decomposition of organic matter in sewers, silos, and fermentation tanks. Carbon monoxide is an insidious toxic gas because of its poor warning properties. Early stages of CO intoxication are nausea and headache. Carbon monoxide may be fatal at 1000 ppm in air, and is considered dangerous at 200 ppm, because it forms carboxyhemoglobin in the blood, which prevents the distribution of oxygen in the body.

Carbon monoxide is a relatively abundant colorless, odorless gas, therefore, any untested atmosphere must be suspect. It must also be noted that a safe reading on a combustible gas indicator does not ensure that CO is not present. Carbon monoxide must be tested for specifically. The formation of CO may result from chemical reactions or work activities, therefore fatalities due to CO poisoning are not confined to any particular industry. There have been fatal accidents in sewage treatment plants due to decomposition products and lack of ventilation in confined spaces. Another area where CO results as a product of decomposition is in the formation of silo gas in grain storage elevators. In another area, the paint industry, varnish is manufactured by introducing the various ingredients into a kettle, and heating them in an inert atmosphere, usually town gas, which is a mixture of carbon dioxide and nitrogen.

In welding operations, oxides of nitrogen and ozone are gases of major toxicologic importance, and incomplete oxidation may occur and carbon monoxide can form as a byproduct.

Another poor work practice, which has led to fatalities, is the recirculation of diesel exhaust emissions. Increased CO levels can be prevented by strict control of the ventilation and the use of catalytic convertors.

Irritant (Corrosive) Atmospheres

Irritant or corrosive atmospheres can be divided into primary and secondary groups. The primary irritants exert no systemic toxic effects (effects on the entire body). 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 chloropropene.

Irritant gases vary widely among 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 at irritant or corrosive concentrations in a confined space may produce little or no evidence of irritation. This may result in a general weakening of the defense reflexes from changes in sensitivity. The danger in this situation is that the worker is usually not aware of any increase in his/her exposure to toxic substances.

Asphyxiating Atmospheres

The normal atmosphere is composed approximately of 20.9% oxygen and 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 (iron oxide). The number of people working in a confined space and the amount of their physical activity 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. The use of nitrogen to inert a confined space has claimed more lives than carbon dioxide. The total displacement of oxygen by nitrogen will cause immediate collapse and death. Carbon dioxide and argon, with specific gravities greater than air, may 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 to 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% physiologic effects are increased breathing volume, accelerated heartbeat, very poor muscular coordination, rapid fatigue, and intermittent respiration. Between 6-10% the effects are nausea, vomiting, inability to perform, and unconsciousness. Less than 6%, spasmodic breathing, convulsive movements, and death in minutes.

Mechanical Hazards

If activation of electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated to prevent inadvertent activation before workers enter or while they work in a confined space. 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 which must be taken.

To prevent vapor leaks, flashbacks, and other hazards, workers should completely isolate the space. To completely isolate a confined space, the closing of valves is not sufficient. All pipes must be physically disconnected or isolation blanks bolted in place. Other special precautions must be taken in cases where flammable liquids or vapors may re-contaminate the confined space. The pipes blanked or disconnected should be inspected and tested for leakage 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.

Thermal Effects

Four factors influence the interchange of heat between people and their environment. They are: (1) air temperature, (2) air velocity, (3) moisture contained in the air, and (4) 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, workers will continue to function until the body temperature reaches approximately 102°F. When this body temperature is exceeded, the workers 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 conditions 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 worker and must be considered in allowing for movement in the confined space and exit time. Therefore, air temperature of the environment

becomes an important consideration when evaluating working conditions in confined spaces.

Noise

Noise problems are usually intensified in confined spaces because the interior tends to cause sound to reverberate and thus expose the worker to higher sound levels than those found in an open environment. This intensified noise increases the risk of hearing damage to workers 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 confined space. If the workers inside are not able to hear commands or danger signals due to excessive noise, the probability of severe accidents can increase.

Vibration

Whole body vibration may affect multiple body parts and organs depending upon the vibration characteristics. Segmental vibration, unlike whole body vibration, appears to be more localized in creating injury to the fingers and hands of workers using tools, such as pneumatic hammers, rotary grinders or other hand tools which cause vibration.

Other Hazards

Some physical hazards cannot be eliminated because of the nature of the confined 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 workers or materials falling, improper use of guard rails, and lack of maintenance to insure worker 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, workers must review and enforce safety precautions to assure safety.

Addendum A

Addendum B

