Closing In On **Confined Spaces**

A primer on hazards and personal protective equipment

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Because every life has a ***purpose...***

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For official standards and information on confined space procedures, refer directly to Department of Labor document Permit-Required Confined Spaces, Final Rule; OSHA, 29 CFR Part 1910.146; Federal Register (1998, December 1).

Worker Protection in Confined Spaces

Confined spaces represent major health and safety risks for many workers. Recognizing and planning appropriately for confined space work can mean the difference between a job well done and disaster.

This primer presents basic information to be used as a guideline to develop confined space work programs, with particular emphasis on appropriate monitoring and personal protective equipment selection. This publication is not a technical instruction manual, nor is it all-inclusive in content or scope.

The primer is structured to help identify what constitutes confined space, what hazards can be found in confined spaces, how those hazards can impact workers, and what should be done to protect workers functioning in confined space. Also discussed are confined space application equipment ranging from environmental surveillance and monitoring equipment to respiratory protection equipment, protective clothing and lowering and retrieval systems.

United States: OSHA Standards and Directives for Work within Confined Spaces

For full compliance with the Occupational Safety and Health Administration (OSHA) standard governing confined spaces, 29 CFR 1910.146, it is necessary to rely upon the expertise of safety and health professionals such as industrial hygienists. MSA, with over 100 years of mining and industrial safety experience, can assist in this effort by providing equipment, training and services suited for the special conditions found within confined spaces. For more complete information, refer to the following publications:

- Permit-Required Confined Spaces, Final Rule; OSHA, 29 CFR Part 1910.146; Federal Register, 63:66018-66036 (1998-Amended)
- Confined Spaces in Construction – OSHA, 29 CFR 1926.12, Subpart AA (Released May 4, 2015, Effective August 3, 2015)
- Confined and Enclosed Spaces and Other Dangerous Atmospheres in Shipyard Employment, 29 CFR 1915, Subpart B – 1994 (Amended)
- A Guide to Safety in Confined Spaces, (NIOSH Publication Number 87-113), July 1987
- Working in Confined Spaces, (NIOSH Publication Number 80-106), December 1979
- Assistance in Preventing Occupational Fatalities in Confined Spaces: NIOSH Alert, (NIOSH Publication Number 86-110), January 1986
- Standard Practice for Confined Area Entry, ASTM D4276-02 (2007)

Confined space is defined as an area that:

- Is large enough for an employee to bodily enter and perform work.
- Has limited or restricted means of entry or exit.
- Is not designed for continuous human occupancy.

A permit-required confined space is defined as a confined space that has one or more of the following criteria:

- Contains, or has a known potential to contain, a hazardous atmosphere.
- Contains material with engulfment potential.
- Has an internal configuration such that entrants could be trapped or asphyxiated by inwardly converging walls, or a floor which slopes and tapers to a smaller cross-section.
- Contains any other recognized serious safety or health hazard.

Confined spaces exist in many sizes and shapes and are found in heavy industry, food, chemical, and petroleum processing, utility and communications installations, and construction sites, to name just a few. These spaces often are deceiving in appearance; for example, an open-topped water tower's interior is defined as confined space, even though the top is open to the outdoor environment. As a general rule, the following areas are typically classified as confined spaces and should be treated with caution:

- Storage tanks
- Pump wet wells
- Degreasers
- Sewers and septic tanks
- Pipelines
- Pits
- Furnaces
- Manholes
- Tunnels
- Underground vaults
- Boilers
- Silos
- Vessels
- Grain elevators
- Mixers
- Open-topped water tanks
- Water towers
- Bottom-access enclosures
- Railcar tanks
- Slaughterhouse blood pits

In most cases, these confined spaces are fairly easy to spot. When areas are encountered that have confined space characteristics but are not included in the listing above, it is always best to treat unknown areas and their interior environments as confined spaces and to take all necessary safety precautions.

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Canada: CSA Z1006-10 Management of Work in Confined Spaces

CSA Z1006 Management of Work in Confined Spaces specifies requirements and guidelines for managing work in confined spaces and coordinating rescues.

The CSA Z1006 standard is a national Standard of Canada; previous standards and regulations varied across jurisdictions. Some regions have general occupational health and safety or sector regulations addressing various minimum requirements relating to their jurisdictions. The new standard considered these jurisdictional differences and embraced applicable legislation to address the need for a comprehensive national standard. The standard was developed specifically to ensure that it does not conflict with existing regulations but rather works in combination with them to help ensure high safety levels.

The development of this confined spaces standard was funded in part by various federal, provincial and territorial occupational health and safety governmental agencies. The standard's content was developed by a volunteer technical committee comprised of stakeholders from industry, producers, regulators, labor, and general interest representatives. Technical committee key industry experts provided input from various sectors, including steel, telecommunications, energy, manufacturing, chemical, petrochemical, emergency services, pulp and paper, mining, and railway.

The standard provides detailed guidance as to roles required for safe entry, entry and rescue team training requirements and training provider qualification requirements. The standard also addresses competency for individuals to work within confined spaces related to their ability to perform specific roles.

One of the main issues concerning confined space hazard assessment is failure to recognize a work area as confined space. The new standard provides a broad definition of confined space to allow organizations to properly and effectively identify a confined space and implement risk mitigation.

A confined space is defined as a workspace that is fully or partially enclosed, is not designed or intended for continuous human occupancy, has limited or restricted access, and has exiting or internal configurations that can complicate first aid provisions, evacuation, rescue, or other emergency response services. Every confined space is considered to be hazardous unless deemed to be not so by a competent person through hazard identification and risk assessment.

The definition of a confined space according to the CSA Z1006 Management of Work in Confined Spaces standard focuses on space characteristics and worker or rescuer ability to enter and exit the space without injury, illness or death.

Confined space workers can be at risk of serious injury or death resulting from asphyxiation, engulfment, electric shock, falls, and heat, fire, explosion, or long-term illness.

Hazard identification and risk assessment by a trained worker are required to determine appropriate controls to address the specific space hazards, including those that can cause acute or chronic harm to workers.

Why Confined Spaces May Be Hazardous

- Petroleum products, chemical by-products and other substances stored within confined spaces can often absorb or retain material. When spaces are emptied for maintenance, cleaning or other purposes, this absorbed material can leach out of walls, changing the composition of confined space environments.

- Accidental leaks or spills of such substances as ammonia, acetylene, acids or even plain water can create confined space hazards, as these substances can give off vapors or cause reactions that can create sudden, major changes in confined space environments. These hazards may also contribute to an increased likelihood of "slip, trip and fall" accidents.

- Chemical reactions within confined spaces may be caused by many circumstances.
  - Manufacturing processes can generate by-products that react with confined space atmospheres, producing hazardous conditions.
  - Cleaning activities using acids or solvents can give off vapors and fumes that may become serious health hazards.
  - Drying paint can create toxic vapors that can pose serious health threats or react violently with confined space atmospheres.

- Oxidation processes, such as rusting metals, decomposition and fermentation of organic materials can deplete confined space area oxygen levels. Special care should be taken in such atmospheres, because human respiration combined with oxidation can quickly reduce confined space oxygen levels to below acceptable limits.

- Mechanical operations within confined spaces such as welding, painting, cleaning, scraping, or sandblasting can generate confined space hazards. Sudden changes in temperature combined with petrochemical fumes or methane gas release can create unstable environments that may produce volatile reactions.

- Special care should be taken in confined spaces such as telephone vaults, basements and tunnels that contain rechargeable batteries. Recharging operations can produce significant levels of explosive or toxic gases that can displace oxygen within confined spaces.

- Inerting activities using non-flammable products such as carbon dioxide (CO_2), helium (He) and nitrogen (N_2) may displace oxygen within confined spaces. These products may also combine with other materials in the space to create hazardous substances.

Hazards Found in Confined Spaces

Hazards found in confined spaces appear in one of six groups:

- Atmospheric
- Physical
- Engulfment
- Corrosive
- Biological
- Other hazards

As a result, careful planning and preparation of all personnel involved in confined space entry should occur before anyone enters work areas.

Atmospheric hazards

Atmospheric hazards are some of the most dangerous, yet frequently unnoticeable hazards found in confined spaces. Hazardous atmospheres are those which expose workers to risk of death, incapacitation, injury, or acute illness from one or more of the following causes:

- Atmospheric oxygen concentration below 19.5% (oxygen deficiency). OSHA defines an oxygen-enriched atmosphere as that containing more than 23.5% oxygen by volume.
- Atmospheric concentration of any toxic contaminant above OSHA's permissible exposure limit (PEL).
- Airborne combustible dust at a concentration that obscures vision at a distance of five feet or less.
- Immediately dangerous to life or health (IDLH) atmosphere which poses immediate threat of loss of life, may result in irreversible or immediate, severe health effects, and may result in eye damage, irritation or other conditions which could impair escape. While airborne dust or particle concentrations may be easy to spot with the naked eye, oxygen deficiency or enrichment conditions, as well as hazardous vapor and gas concentrations must be detected with reliable instrumentation.

Oxygen

Oxygen deficiency occurs when oxygen levels in confined spaces dip below 19.5% of the total atmosphere. Normal ambient air contains oxygen concentration of 20.8% by volume. In oxygen-deficient atmospheres, life-supporting oxygen may be displaced by other gases such as carbon dioxide, resulting in potentially hazardous or fatal atmospheres when inhaled.

Oxygen deficiency may also be caused by rust, corrosion, fermentation, or other forms of oxidation. As materials decompose, oxygen is drawn from atmospheres to fuel oxidation. Oxygen deficiency's impact can be gradual or sudden, depending upon overall oxygen concentration, entrants' activity levels within confined space and other atmospheric gas concentration. Progressively decreasing levels of atmospheric oxygen can result in physiological symptoms of increasing severity, including accelerated heart beat, impaired judgment, nausea and vomiting, convulsions, and death.

Oxygen-enriched atmospheres contain oxygen concentration above 23.5% by volume; the atmosphere is considered to be oxygen-enriched and is prone to instability. As a result of higher oxygen levels, the likelihood and severity of flash fire or explosion significantly increases.

Combustion

For many years the concept of fire was symbolized by the **fire triangle** or **triangle of combustion** and represented fuel, heat and oxygen. For combustion to take place, three basic conditions must be met:

- Fuel source such as methane or gasoline vapors
- Enough oxygen to oxidize or burn the fuel
- Heat source to start the process

However, recent research determined that a fourth element, a chemical chain reaction, is a necessary ignition component. The fire triangle became the fire tetrahedron to reflect this fourth element (*see Figure 2*).

The percentage of combustible gas in air is also important. For example, a manhole filled with fresh air is gradually filled by a leaking combustible gas such as methane (natural gas) mixing with fresh air. As the gas-to-air ratio changes, the sample passes through three ranges: lean, explosive and rich (*see Figure 1*). Within the lean range, there isn't enough gas in the air to burn. The rich range has too much gas and not enough air to burn. However, the explosive range has the correct gas/air combination to form an explosive mixture. Care must be taken when a mixture is too rich, because fresh air dilution can bring the mixture into the flammable or explosive range. Explosive limits at both low-end and high-end gas concentrations where combustion can occur are known as the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL).

An analogy is an automobile that won't start on a cold morning (a lean atmosphere because the liquid gasoline has not vaporized sufficiently), but can be flooded with too much gasoline (a rich atmosphere with too much vaporization). Eventually, when the right mixture of gas and air finally exists (explosive), the car starts.

Incident: Pennsylvania

Two orchard workers arrived at their cold storage facility to find another worker lying unconscious inside. Believing that the downed worker had had a heart attack, they called 911 and stayed with him. First responders prepared to treat cardiac arrest entered the cold storage area, only to hear their carbon monoxide detectors sound an alarm. Within seconds, first responders evacuated the cold storage room, secured the unsafe building and called the fire department. Firefighters wearing SCBA and equipped with portable gas detectors ventilated the storage area to eliminate the very high CO concentration. The first responders agree that portable gas detectors saved many lives that day, and also allowed EMTs to quickly determine that the patient had been overcome by hazardous gas rather than by cardiac arrest.

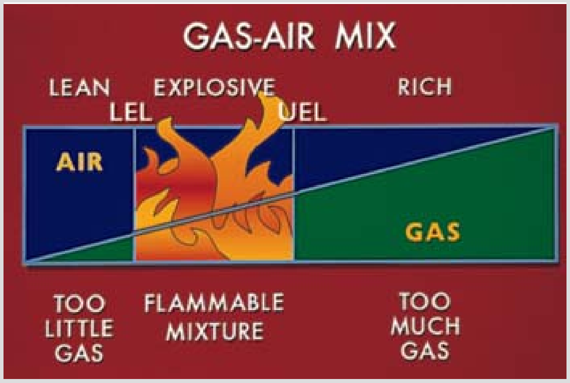


Figure 1

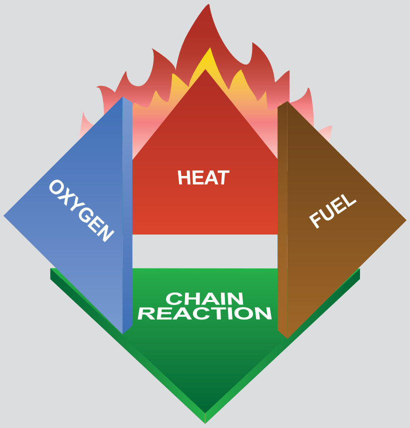


Figure 2

Toxic Gases

The physiological effects of toxic gases will vary according to the health or activity of exposed individuals.

Hydrogen sulfide (H_2S) is colorless and smells like rotten eggs; however the odor cannot be taken as warning, as smell sensitivity disappears quickly after breathing only a small quantity of H_2S. This gas is often found in sewers, sewage treatment facilities and in petrochemical operations. In addition, H_2S is flammable and explosive in high concentrations. Sudden poisoning may cause unconsciousness and respiratory arrest. In less-sudden poisoning, symptoms are nausea, stomach distress, eye irritation, belching, coughing, headache, lip blistering, and paralyzed olfactory nerves.

Carbon monoxide (CO) is a colorless, odorless gas generated by combustion of common fuels with insufficient air supply or where combustion is incomplete. CO is often released by accident, through improper maintenance or adjustment of confined space burners or flues and by internal combustion engines. Called the silent killer, CO poisoning may occur suddenly. Depending upon concentration, CO exposure can lead to headache, dizziness, nausea and death.

Sulfur dioxide (SO_2) Sulfur combustion or compounds containing sulfur produce this pungent, irritating gas. Severe exposures may result from loading and unloading tank cars, cylinders, lines either rupturing or leaking, and fumigation aboard ships. Depending upon the concentration, an SO_2 exposure can result in irritation of the nose, throat and eyes, edema of the lungs, and death.

Nitrogen dioxide (NO_2) forms when fossil fuels such as coal, oil, gas or diesel are burned at high temperatures. NO_2 also mixes in the outdoor air to form particle pollution and ozone. Overexposure may irritate the nose, throat and lungs, and can cause headaches and irregular respiration, choking, dizziness, pulmonary edema, and death.

Ammonia (NH_3) is a strong irritant that can produce sudden death from bronchial spasms. Small concentrations that do not produce severe irritation are rapidly passed through the respiratory tract and metabolized so that they no longer act as ammonia. A whiff of household cleaning solution can take one's breath away and is just a hint of potential severe reactions brought on by high industrial exposure. Ammonia can be explosive if tank or refrigeration system contents are released into open flame.

Chlorine (Cl_2) is used in making plastics, solvents for dry cleaning and metal degreasing, textiles, agrochemicals and pharmaceuticals, insecticides, dyestuffs, household cleaning products, etc. It is a respiratory irritant, and exposure to Cl_2 can result in coughing, vomiting, lung damage and death depending upon concentration.

Hydrogen cyanide (HCN) is an extremely rapid poison that interferes with respiratory system cells, causing chemical asphyxia. Liquid HCN is an eye and skin irritant.

Chlorine dioxide (ClO_2) is primarily used for bleaching wood pulp and disinfecting municipal drinking water. Exposure to ClO_2 can result in irritation of the eyes, nose and throat, coughing, shortness of breath, headache, pulmonary edema and death.

Hazardous Gas Detection Instruments

Portable gas detection instruments are battery-powered, direct-reading units used to conduct confined space atmosphere spot and pre-entry checks. Portable gas detection instruments are classified into two groups: single-gas instruments and multigas instruments. These monitoring devices typically monitor one or a combination of the following atmospheric conditions:

- Oxygen deficiency or enrichment.
- Presence of combustible gas.
- Presence of certain toxic gases.

Depending upon instrument capability, hazardous gas monitoring can be conducted simultaneously for different combinations of oxygen, combustible gases and toxic gases. Instruments that perform this type of monitoring are commonly referred to as multigas detectors. Regardless of which instrument type is used to check environmental gas concentrations, continuous monitoring should be performed during all confined space operations. A contaminant's combustibility or toxicity level might increase even if it initially appears to be low or nonexistent. In addition, oxygen deficiency can occur unexpectedly.

Atmospheric composition should be determined within confined space atmospheres prior to entry. Reliable instruments should be used to draw air samples through a weep hole or other small confined space entry port. If possible, do not open confined space entry portals prior to completing this step. Sudden changes in confined space atmospheric composition could cause violent reactions or dilute contaminants within, giving a false low initial gas concentration reading.

When testing permit spaces for acceptable entry conditions, always test in the following order:
- Oxygen content.
- Flammable gases and vapors.
- Potential toxic air contaminants.

Comprehensive testing should be conducted in various work area locations. Some gases are heavier than air and tend to collect at the bottom of confined spaces. Others are lighter than air and are usually found in higher concentrations near the top of confined spaces. Still others are the same molecular weight as air and can be found in varying concentrations throughout confined spaces. Test samples should be drawn at the top, middle and bottom of confined spaces to pinpoint varying concentrations of gases or vapors (*see Figure 3*).

Atmospheric testing results will directly impact personal protective equipment selection necessary for confined space tasks. Testing may also dictate worker exposure duration to the space's environment, or whether entry will be made at all. Substance-specific detectors should be used whenever actual contaminants have been identified. Assume that every confined space has an unknown, hazardous atmosphere. Under no circumstances should anyone enter or even stick his/her head into confined space for quick looks; such action constitutes confined space entry and can expose entrants to hazardous and possibly deadly atmospheres.

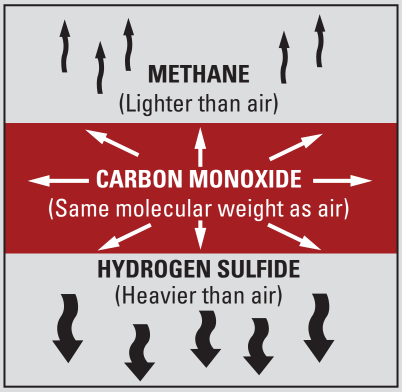


Figure 3

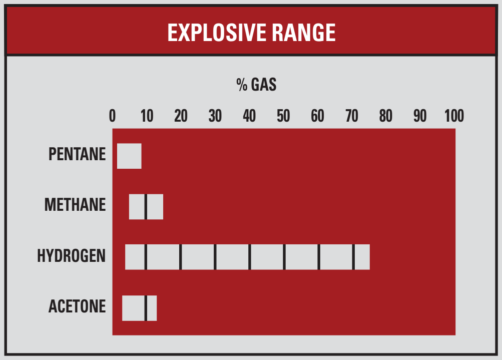


Figure 4

Combustible gas monitors work on the premise that when certain combustible vapor proportions mix with air and an ignition source is present, combustion can occur. The range of concentrations over which this reaction can occur is known as the explosive or flammable range. This range includes all concentrations in which a flash will occur or a flame will travel if the mixture is ignited. The lowest percentage at which this can happen is 100% of the LEL (Lower Explosive Limit); the highest percentage is the UEL (Upper Explosive Limit) (*see Figure 1*).

Combustible gas monitors are generally calibrated on pentane or methane and are designed for hydrocarbon vapor general-purpose monitoring. Such instruments operate through the catalytic action of a heated platinum filament in contact with combustible gas. The filament is heated to operating temperature by electric current. When the gas sample contacts the heated filament, surface combustion raises the temperature in proportion to the quantity of combustibles within the sample. A Wheatstone Bridge circuit, incorporating the filament as one arm, measures electrical resistance change due to increased temperature. This change indicates combustible gas percentage present within the sample.

Most combustible instruments display gas concentrations in LEL percent. For example, 100% of the LEL of methane (the major component in natural gas) is 5% by volume; the UEL is 15% by volume. If a room fills slowly with methane and the concentration reaches 2.5% by volume, it is actually at 50% of the LEL (2.5/5.0 x 100%). Between 5 and 15% by volume, a spark could set off an explosion. In short, for methane, 5% by volume=100% LEL.

Different gases need different percent-by-volume concentrations to reach 100% of the LEL (*see Figure 4*). Pentane, for example, has an LEL of 1.4%. Instruments that measure in LEL percent are easy to use regardless of the gas in question, as users are most concerned with how close the gas concentration is to its LEL. Some portable instruments provide combustible gas readouts that display in both LEL percent and in percent of combustible gas by volume, that is, the total amount of combustible gas present.

Single-gas monitors for oxygen deficiency measure atmospheric oxygen concentrations. Concentrations are generally measured over a range of 0 to 25% oxygen in air, with readings displayed via digital readout. Oxygen indicators are calibrated with uncontaminated fresh air containing 20.8% oxygen. With some models, alarm levels are set to alert users of both oxygen deficiency and oxygen enrichment.

Single-gas monitors for toxic gases are used to measure levels of hydrogen sulfide (H2S), carbon monoxide (CO), or other toxic gases, depending upon the model selected. Most toxic gas monitors use electrochemical sensor cells. If the gas of interest enters the cell, the resulting reaction produces a current output proportional to the amount of gas in the sample.

Audible, vibration and visible alarms activate if gas concentrations exceed preset levels. These devices are well-suited for confined space areas containing motors or engines that can generate large quantities of CO, as well as in sewers, waste treatment plants and oil refineries which tend to have hazardous volumes of H_2S and SO_2 present. In recent years, infrared sensors have been integrated within portable instruments, typically for carbon dioxide (CO_2) and hydrocarbon detection.

ALTAIR®, ALTAIR Pro, and ALTAIR 2X Single and Two-Tox Monitors offer several sensor options including carbon monoxide, hydrogen sulfide and oxygen. Other features include superior dust and water protection, high resistance to RFI, one-button operation, and triple-alarm system.

Incident: Quebec

Two cosmetics factory workers who tried to rescue another died themselves from breathing large quantities of argon gas. A subcontractor died on the scene after using argon gas to weld inside a large metal tank at the facility. The two would-be rescuers died the next day after being taken to a local hospital. One was overcome by fumes after trying to rescue his colleague. The other fell unconscious after entering the tank. According to a spokesperson for the Quebec workplace safety board, the welders were not properly equipped to work within a confined space.

Multigas monitors are available for simultaneous monitoring of oxygen, combustible and toxic gases. Toxic gases and vapors that can be inhaled or absorbed through the skin are frequently found within confined spaces. Sometimes these atmospheric hazards displace oxygen and may make the body incapable of maintaining respiration. Some toxic gases and vapors can also cause long-term physical damage to the body in cases of repeated exposure.

Whereas most single-gas monitors operate in diffusion mode, some hand-held multigas instruments use built-in pumps to draw samples from the immediate area, or from outside the confined space work area when used with sampling lines. The user views sensor readout on the instrument's digital display. Regardless of the number of sensors used, all sensors monitor and display readout continuously. Diffusion-type instruments are available for simultaneously measuring combustible gas LEL, oxygen and toxic levels in parts per million (ppm) of H_2S, CO and other toxic gases. Remote sampling pump adapters are sometimes offered to convert diffusion instruments into pumped instruments.

Photoionization detectors (PID) for toxic gas and vapors use ultraviolet light to ionize molecules of chemical substances in a gaseous or vaporous state. Real-time digital readout allows users to immediately determine gas and vapor concentrations. Depending upon calibration input, gas and vapors are measured over a 0.1 to 10,000 ppm scale. Some PID designs are less sensitive to humidity than are others.

Calibration is the manual or automatic process of adjusting instrument readings to match actual calibration gas values. To help ensure accurate monitoring and detection equipment, calibration checks should be performed frequently on all instruments used within confined space applications. Depending upon a particular instrument's capabilities, calibration kits containing known gas concentrations should be used daily to check instrument response, a procedure commonly known as a bump test.

MSA recommends performing a bump test before each day's use to verify proper instrument operation. If the instrument fails a daily bump test, that instrument must not be used until it passes a full calibration test. For further information, visit osha.gov for Verification Of Calibration for Direct-Reading Portable Gas Monitors.

Incident

Confined spaces can be unknowingly created, resulting in hazardous environments. On a late December day with below-freezing temperatures, a small construction crew poured a 50,000 square foot concrete floor inside of a building. Heat was provided by propane-fired heaters and kerosene jet heaters with blowers. The concrete was soon ready to be finished. To maintain temperatures, the crew had walled off the bay from the rest of the building with plastic, unwittingly creating a confined space. One worker entered the self-made confined space and began to float the concrete. When his co-workers returned, they entered the plastic enclosure and found their co-worker lying face down in the concrete. Although he was rushed to the hospital, the man now suffers from involuntary motor functions loss, attributed to increased CO level as well as oxygen deficiency. As with so many other instances, the crew had followed this practice before without incident, believing gas detection equipment to be too expensive, too complicated and unnecessary.

The MSA ALTAIR® 4X Multigas Detector with XCell® Sensor Technology offers many performance advantages: faster response time, four-year sensor life, increased stability, and less than 60-second calibration time. This instrument measures combustible (LEL), O_2, H_2S, and CO gas concentrations, and also provides exclusive optional MotionAlert™ and InstantAlert™ features. This rugged, durable detector withstands a 20-ft drop and is IP67-rated. Other features include greater signal stability and repeatability, 24-hour run time and sensor response and clear times in less than 15 seconds. Glow-in-the-dark housing is a great tool to create visibility within dark confined spaces. Two-tox CO/H_2S sensor has virtually no cross-channel interference. Sensor digital output results in greatly reduced RF interference susceptibility. Users typically save more than 50% on calibration gas, replacement sensors and maintenance.

The rugged, multi-featured ALTAIR 5X Gas Detector is capable of measuring up to 6 gases simultaneously and is now available with integrated PID sensor for VOC detection. Exclusive end-of-sensor warning cautions users when unit's sensor nears end-of-life. Featuring large easy-to-use buttons, the rugged overmolded polycarbonate housing provides unsurpassed durability, including ability to survive 10-ft. (3m) drop and is IP65-certified. Two exclusive features especially useful in confined space situations include MotionAlert that tells others if the user has become immobile, and the InstantAlert feature provides manual alarm to alert others as to a potentially hazardous situation. Bluetooth is a standard feature, and after downloading the free MSA ALTAIR Connect App from Google Play, any compatible Android device becomes an enhanced safety and productivity tool when paired with the ALTAIR 5X Detector.

Incident: Louisiana

A routine inspection of a pipe at a Louisiana chemical plant turned deadly when two workers were overcome due to nitrogen asphyxiation. One worker was killed and another seriously injured when nitrogen gas was trapped and failed to vent safely. Workers were performing an inspection at an open (for maintenance) end of a wide horizontal pipe. The open pipe end was wrapped with plastic sheeting to keep out debris. Nitrogen was injected into process equipment to protect reactors from exposure to moisture. While working inside the sheet, two workers were apparently overcome by nitrogen. One worker was found unconscious with his head lying inside the pipe. The other was found lying beside the pipe opening, dazed. No warning sign was posted on the pipe opening identifying it as a confined space or warning that the pipe contained potentially hazardous nitrogen.

Hazards

Physical hazards within the work area should be identified after atmospheric hazards of a confined space have been identified. Physical hazards, such as grinding equipment, agitators, steam or steam fittings, mulching equipment, drive shafts, gears, and other moving parts can pose a danger within confined spaces, in that they can burn, maim or crush confined space entrants. Hazards such as pipe fittings and uneven or wet surfaces may also pose slip, trip and fall hazards.

Engulfment hazards frequently exist within areas where loose materials such as grains, crushed stone or sawdust are stored. Often housed within silos or other containment equipment, these materials harbor air pockets that can collapse under a worker's weight. Engulfment hazards either block the worker's airways or compress his/her upper body to the point of suffocation. Engulfment also includes liquids or flowing solid substance that can be aspirated to cause death.

Corrosive hazards such as acids, solvents and cleaning solutions can pose additional confined space hazards. Contact between these substances and skin, mucous membranes or eyes can cause serious irritation or burns. Vapors released by these materials can also irritate the respiratory system and can cause gastrointestinal distress.

Biological hazards such as molds, mildews and spores frequently found in dark, damp spaces can irritate the respiratory system. Bacteria and viruses found in applications such as sewage treatment plants, can also threaten the body with a variety of diseases. In addition, bird and animal feces can present serious human health hazards.

Other hazards such as poor visibility, inadequate lighting, electrical wiring installations that are not up to code, and insecure footing can cause significant confined space safety hazards to exist. Confined spaces may also harbor rodents, snakes, spiders, or insects, which may be hazardous to confined space entrants. Finally, sudden changes in wind or weather can contribute to unexpected variations within confined space environments.

MSA's GALAXY® GX2 Automated Test System offers ease of use, reduced cost of ownership and proactive safety management. Integrated system provides simple and intelligent testing and calibration of MSA ALTAIR® product family.

Incident: West Virginia and Kentucky

Coal mining has always been an inherently dangerous occupation but in 2006, there were 19 coal mine-related fatalities in Appalachia. Two miners were killed during a belt fire in the Aracoma Alma 1 mine in Logan County, WVA, and 5 men died in a methane explosion at the Darby mine in Harlan County, KY. The Sago mine explosion on January 2, 2006 in Sago, WVA trapped 13 miners for nearly two days with only one survivor. Sago was the worst mining disaster in the U.S. since a 2001 disaster in Alabama killed 13, and the worst in West Virginia since a 1968 disaster that claimed 78 miners.

Procedures for Entering Confined Space

Confined space entry procedures are critical; before any worker enters a permit-required confined space, a system of procedures and precautions must be followed. It is essential that supervisors, attendants and entrants all know the confined space specifics. Correct equipment must also on hand to help ensure worker safety. The following procedures must be followed:

Completion of an entry permit by supervisory personnel is required prior to anyone entering a confined space. Specifically, the permit must clearly identify:

- Location of the confined space.
- Purpose of entry into the area.
- Date of entry and authorized duration of occupancy in the space.
- List of authorized entrants
- List of attendants
- List of necessary tools and equipment
- Signature of individual authorizing entry
- List of hazards and acceptable entry conditions
- Results of initial and periodic tests
- Measures to isolate the space and eliminate or control hazards before entry
- List of rescue and emergency services
- Communications procedures
- Additional permits (hot work) issued

A permit may be valid for a period not to exceed that necessary to complete the task or job for which the permit was obtained.

On February 1, 1999, the final OSHA Standard on Permit-Required Confined Spaces, 29 CFR Part 1910.146, became effective. This standard was originally published in the Federal Register on December 1, 1998. According to the U.S. Department of Labor, 1.6 million workers enter confined spaces annually in manufacturing, trade, service, and utility sectors including tanks, vats, pits, electric, gas, and sanitary services. Confined spaces are also found in oil and gas extraction, food product manufacturing, agricultural services, machinery areas, and fire service applications.*

This regulation requires employers to use a calibrated, direct-reading instrument to help ensure confined space safe entry. The rights of workers who enter potentially life-threatening confined space are more clearly defined; authorized entrants have the right to observe confined space testing and have written certification to help ensure proper testing, that respirators and other personal protective equipment being worn are appropriate and that entrants understand the nature of confined space hazards.

Section (C): "Before an employee enters the space, the internal atmosphere shall be tested, with a calibrated direct-reading instrument, for oxygen content, for flammable gases and vapors, and for potential toxic air contaminants, in that order. Any employee who enters the space, or that employee's authorized representative, shall be provided an opportunity to observe the pre-entry testing required by this paragraph. The employee whose life could be endangered by inadequate completion of preliminary safeguards has the strongest incentive to see that they are performed properly." More information is available from OSHA at http://www.osha.gov.

**Source: DOL, OSHA, 29 CFR Part 1910 [Docket No. S-019A], RIN 1218-AA51, Permit-Required Confined Spaces, final rule*

Incident: Pennsylvania

A plumbing firm employee sustained a shoulder injury while installing a new sewer line when the side of a five-foot trench collapsed, trapping the 30-year-old man. A co-worker alerted a passing ambulance to the situation. A trench rescue team from Pittsburgh Emergency Medical Services worked for more than 90 minutes to shore up the trench before freeing the victim. The U.S. Occupational Safety and Health Administration's Pittsburgh office learned of the collapse from a television news report and immediately dispatched an inspector, as federal safety and health regulations dictate that trenches five feet or deeper must be protected from cave-ins. A shallower trench can also require the same protection if the soil is deemed to be unstable.

Before any confined space entry, authorizing individuals must sign entry permits. Upon completion of confined space area work, permits are canceled by entry supervisors but retained for at least one year for ease of program review. Any problems must be noted on permits. For situations requiring hot work such as welding, a notation should be added to confined space entry permits, or separate hot work permits attached. This additional information should detail both scope and duration of hot work.

To accurately complete entry permits, and to inform entrants of confined space work area hazards, a comprehensive hazard assessment, listing all hazards that could be encountered by entrants during confined space occupation, must be conducted before entry. Persons entering confined spaces and those acting as attendants must also know the signs and symptoms of hazard exposure. The assessment should then be followed by a document describing the formal method of operation for all confined space occupants. This document should explain in detail all cleaning, purging and ventilating practices as well as safe work practices, and should be reviewed by all confined space entry participants.

A formal safety procedure should also be documented to cover critical safety concerns such as first-aid, showering and decontamination and obtaining necessary rescue and medical equipment. To help ensure the understanding of responsibilities and hazards found within particular confined spaces, pre-entry sessions for all participants should be scheduled shortly before entry. At this time, each hazard should be discussed with all authorized entrants and attendants, as well as the consequences of each hazard exposure.

Ventilation OSHA has determined that a complete permit entry program may not be needed for entries into permit spaces that contain only atmospheric hazards that can be controlled by ventilation alone. These spaces can be made safe for entry if employers:

1. Demonstrate that the only hazard posed by the permit space is an actual or potentially hazardous atmosphere.
2. Demonstrate that forced air ventilation alone will maintain permit spaces as safe for entry.
3. Develop monitoring and inspection data to support 1 and 2 (above), and make supporting data available to workers.
3. Perform initial entry to obtain data and subsequent entries in compliance with OSHA 1910.146, paragraph (c)(5)(ii), that includes requirements for periodic testing to assure that ventilation is preventing accumulation of a hazardous atmosphere.

According to OSHA, spaces with all hazards eliminated can be reclassified as non-permit spaces as long as the hazards remain eliminated. As a general rule, confined spaces should not be ventilated with pure oxygen, as oxygen can react violently with other materials in confined space atmospheres.

Lockout and tag-out procedures. In preparation for entry into confined space work areas, utilities and mechanical equipment serving confined spaces should be isolated and disconnected. Lockout procedures must be performed only by authorized employees. Pipes and steam lines should be blind-flanged in the OFF position and locked-out with padlocks. Main breakers to electrical service within the confined space should be thrown to the OFF position and locked out at the breaker panel. To help ensure that equipment power supply has been interrupted, all ON and OFF switches should be tested. Hydraulic lines serving confined spaces should also be blocked and bled to prevent unanticipated equipment movement.

Finally, if possible, drive mechanisms, gears and belts to all mechanical equipment should be physically disconnected before confined space area entry. Printed tags are used to warn employees that the energy-isolating devices must stay in position and that tags must not be removed.

Equipping Personnel for Confined Space Entry

A wide range of protective equipment is available for protecting confined space work area entrants. It is essential that all entrants have correct equipment for specific environments and are versed in its safe and effective use. **Under no circumstances should an employee enter a confined space without the correct training and equipment.**

Tools and equipment required to complete confined space tasks must be collected before confined space entry. Lack of proper equipment can pose dangerous situations for workers and waste valuable work time. All equipment should be checked before use and should be in good working order. Protective measures should also be taken to protect people working outside the confined space area; barricades should be erected to protect passers-by from open manholes, hatch entrances, and other unmarked confined space area entrances. In addition, care should be taken to prevent accidental dropping of materials into confined space entrances. In the case of contractors and subcontractors, all confined space workers will adhere to entry permit requirements. Deviation from standards set on the permit necessitates immediate confined space evacuation.

Proper respiratory protection should be selected once confined space atmospheres have been analyzed and should be provided to all confined space entrants. Recommended confined space respirator types include SCBA (self-contained breathing apparatus), dual-purpose SCBA, combination air-line respirators with escape cylinder, air-purifying devices, and escape respirators.

Because these devices vary in design, application and protective capability, it is important to first assess work site contaminant levels. Equally important is up-to-date knowledge of respiratory protection device limitations to help ensure proper selection.

MSA's Quick-Fill® System allows workers to extend SCBA air supply by replenishing via a hose from a secondary air source, such as a cascade cylinder bank.

Self-Contained Breathing Apparatus (SCBA) provide the highest level of respiratory protection, as they are designed to protect workers within oxygen-deficient atmospheres and/or in IDLH atmospheres often found within confined space applications. SCBA are equipped with user-worn air cylinders that provide dependable, yet limited air supply without hoses or tethers to impede movement.

SCBA are useful for confined space applications with entrances large enough to accommodate an entrant wearing the apparatus and cylinder. Low-profile cylinders are available for tight confined space entrances. **Under no circumstances should the entrant enter a confined space that contains a hazardous or potentially hazardous atmosphere unprotected and wait to have SCBA equipment lowered to him or her.**

OSHA requires pressure-demand respirators for IDLH use. The advantage of pressure-demand apparatus is maintenance of slight positive pressure to the facepiece, which helps to prevent inward contaminant leakage. Major SCBA components include an air cylinder, low-pressure warning device, regulator, facepiece, and carrier and harness assembly. During operation, high-pressure cylinder air is reduced by the regulator and delivered to the wearer in response to his/her respiratory requirements. In general, SCBA are available in both low-pressure (either 2216 or 3000 psig) and high-pressure (4500 or 5500 psig) units. For a given cylinder size, high-pressure units have greater storage capacity, enabling longer service life. With high-pressure devices, SCBA users can select from 30-, 45- or 60-minute-rated cylinders. 30-minute-rated cylinders are used with low-pressure SCBA.

Recent SCBA technology includes a cylinder refilling system (MSA's Quick-Fill System) using a special adapter that allows for fast air cylinder refill while the unit is worn. This configuration also expands the range of uses for SCBA equipment as it eliminates the need to leave the confined space work area to access cascade-type refilling stations.

Combination-type dual-purpose SCBA merge air-line capabilities with those of an SCBA. Dual-purpose units differ from conventional SCBA in that they generally have a regulator with two inlet ports—one high-pressure port (2216, 3000 or 4500 psig) for standard air cylinder connection, and another low-pressure port (85 psig) for air-supply hose connection. The major advantage of these devices is that they offer SCBA-type mobility when air-lines are disconnected, and also offer extended air supply when air-line options are used.

These types of respirators are especially suited for confined space applications, as confined space entrants can connect to regulated, low-pressure air sources and have long-duration, uninterrupted air supply. However, users may opt to rely on 30-, 45- or 60-minute SCBA cylinders if they must move about or leave confined spaces.

Air-line respirators with escape cylinders combine supplied-air capabilities with those of an SCBA. These devices are equipped with cylinders offering 5-, 10- or 15-minute-rated cylinders that can be used for emergency escape purposes only. Combination air-line respirators with escape cylinders offer apparatus approved for entrance and exit from IDLH atmospheres except with the flexibility of lower-profile and lighter-weight options needed for confined spaces.

The unique dual-supply combination-type respirator is equipped with a five-minute-rated cylinder for emergency escape. The unit's regulator features two primary air inlets that permit workers to switch from one air source to another without interrupting air flow and without diminishing the escape cylinder's air supply. Using this device, workers can more easily enter confined spaces while transporting a personal air supply, usually a 30- or 60-minute-rated cylinder equipped with a carrying handle.

Workers first entering confined spaces breathe via supplied-air from a larger air source, such as a 300-cubic foot cylinder; this cylinder is located outside the confined space and is connected to one of two regulator inlets. After entering confined space, transportable air cylinders are lowered to workers using work winches. Workers then connect to the transportable air source. Employing a connection that shifts worker air source from an outside cylinder to a transportable cylinder, workers can rely upon smaller tanks as air sources while exploring confined space. As this technique allows workers to more easily fit through tight spaces, this option can become part of a company's confined space program.

The PremAire® Cadet Escape Respirator Combination Supplied-Air Respirator with Escape Cylinder offers a first-stage regulator and cylinder valve within one assembly. Low-profile escape cylinder can be worn on left or right hip.

Air-purifying respirators are designed for use only within atmospheres containing sufficient oxygen to sustain life (at least 19.5%) and containing known concentrations of gases, vapors, and particulates. With these devices, special filter/chemical cartridges are used to remove specific gases, vapors, dusts, mists, and fumes from ambient air. For respirators to be effective, levels of contaminants must be within concentration limitations of the specific respirator and filter. Generally, the useful life of air-purifying respirator cartridges depends not only upon contaminant concentration but also on users' breathing volume and the air-purifying medium's capacity.

Because of the increased likelihood of oxygen deficiency and due to the possibility of confined space contaminant concentrations suddenly changing or not being fully known, air-purifying respirators should not be used for confined space entry unless known conditions exist and can be maintained.

Escape respirators provide means of escape from IDLH atmospheres. These lightweight units generally are carried by workers and feature a 5- or 10-minute air cylinder that delivers respirable air to a hood. Hoods are typically made of flexible material such as urethane, and can be used in temperatures as low as 0° F. Optional hood models are available for use over hard hats. Escape respirators must never be used to enter confined space. As the name implies, they are intended for escape only.

Head, Eye, Face, and Hearing Protection

Head protection should be worn by all workers entering confined spaces. MSA offers two helmet types per ANSI/ISEA Z89.1-2009 and CSA Z94.1-2005: Type I helmets protect the wearer from top impact, while Type II helmets protect the wearer from top and lateral impact. The necessary protection should be determined by the employer based upon hazards within a specific work area. Workers should not be allowed to enter confined space areas without appropriate head protection.

Eye protection in the form of protective spectacles or goggles helps to shield workers' eyes from flying debris. For additional face protection, faceshields are available for protection against splashes and debris. Made for use with helmet-mounted frames or protective headgear, MSA recommends that faceshields be worn over impacted-rated spectacles or goggles.

Hearing protection products provide auditory protection from noises commonly generated within confined spaces. By their nature, confined spaces tend to reverberate and amplify even small sounds, creating potentially serious auditory hazards for workers. Aural protectors frequently take two forms: flexible plugs that insert into workers' ear canals, or ear muffs that cover each ear.

Ear plugs or ear muffs should be worn within environments where cutting, grinding or other high levels of mechanical noise are present. If no head protection is worn, then muffs are worn with headbands. When head protection is worn, headbands fit under the chin or behind the head. Other models that snap into hard hat accessory slots are also available.

The TransAire® Escape Respirator provides a means of escape from IDLH atmospheres. Lightweight unit delivers a high flow rate of compressed air to the hood, supplied by a 5- or 10-minute-rated cylinder.

V-Gard® Helmets offer head protection while accommodating hearing protection, faceshields or welding helmets.

Sightgard® Protective Eyewear provides side- and front-impact protection along with style and comfort.

Connect-By-Cable Earmuffs provide comfortable hearing protection and communication in one.

Communication Equipment

Communication equipment is critical within confined space work areas. Reliable communication equipment allows workers to communicate amongst themselves as well as with work area attendants stationed outside. In the event of an emergency, communication equipment allows for help to be summoned quickly. When working in confined spaces, contact must be maintained between workers in confined spaces and attendants stationed outside. Battery-operated, voice-activated communication systems are frequently used, as they allow workers to move freely within confined spaces, eliminating the need to hand-operate communication devices.

Special care should be taken to ensure that all communication device batteries are in good working order, and that the range of the devices is sufficient for transmission from any part of confined space work areas. Lines of contact should also be established outside confined space areas to summon rescue personnel, should the need arise. Personal Alert Safety System (PASS) devices, frequently used by the fire service, are also useful in confined spaces where communication between workers and attendants is difficult. Designed to sound if users do not move during a specified period of time, the alarm alerts other workers and attendants that a worker is not moving and may have been overcome. Attendants can then clear the confined space and summon help.

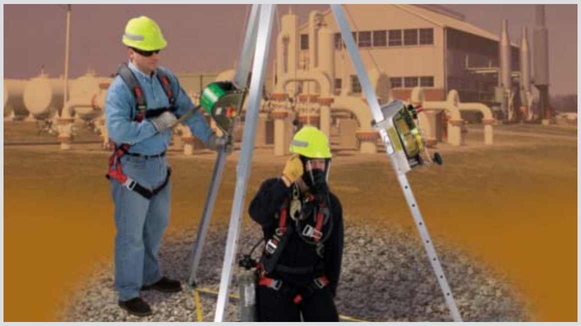
Some personal multigas detectors are also available with a similar alerting feature that can be activated manually in the event of a hazardous condition, or will activate automatically if no movement is detected after a set period of time—usually 30 seconds.

Incident: Pennsylvania

One man was killed and another injured when a seven-foot trench collapsed in Beaver County, PA. The men were digging a sewer line trench when they were trapped approximately four feet apart within the 30-foot long trench. One was buried up to his shoulders, the other up to his nose. Rescue workers attempted to dig the men out using a backhoe, but feared further collapse and resorted to digging with hand shovels. An investigator for the U.S. Occupational Safety and Health Administration Pittsburgh Office said that the trench was not reinforced as required by federal health and safety standards. A cube of soil measuring 1 ft. on a side weighs around 100 pounds. A cubic yard of soil contains 27 of these, or 2,700 pounds total, weighing about as much as a small automobile. A trench wall collapse might contain 3 to 5 cubic yards of soil, weighing from 8,000 to 14,000 pounds. A person buried under only a few feet of soil would experience enough chest area pressure to prevent lung expansion, resulting in suffocation within approximately three minutes. Even if the victim is rescued prior to suffocation, heavy soil loads are still likely to inflict serious internal injuries. A person buried in earth as high as his diaphragm would not be able to dig himself out and his survival chances are low. If the face is even partially covered, death is almost a certainty.

Confined space entry and retrieval equipment may be necessary to facilitate both entry into and exit from confined spaces. Proper retrieval systems for both workers and equipment consist of a full-body harness, heavy-duty lifeline, a tripod and a personnel /material hoist. Retrieval equipment is useful in lowering workers into confined spaces as it controls descent rate and prevents accidental falls into the work area. Additional work hoists are frequently used to raise and lower tools and equipment. Every entrant should always wear a full-body harness and have some sort of lifeline attached to the harness. Even in horizontal entry applications. If an entrant becomes non-responsive, the lifeline can be used to haul the worker out as a non-entry rescue.

If a worker must be quickly extracted from confined space without entrance of another worker into that confined space (non-entry rescue), lifting equipment employs concepts of physics to raise entrants out of work areas. Hoists typically have a mechanical advantage of 25:1. It is very difficult for an average person to pull someone out of a deep manhole without some mechanical advantage.



Hoists on lifting equipment should be outfitted with durable retrieval lines, and should be self-braking to prevent free falls and to hold personnel in place when raising or lowering have stopped. Tripods and davit arms should be equipped with two mechanical devices for confined space entry: a hoist for raising and lowering materials and personnel, and a self-retracting lanyard (SRL) with emergency rescue capability for back-up fall protection and emergency retrieval. The SRL with emergency rescuer remains connected to the confined space entrant. The SRL feature allows the entrant free movement within the confined space and doesn't require a topside attendant to constantly payout/retract the cable line on a hoist as the entrant moves around. If the entrant needs to be rescued, the top-side attendant activates the emergency rescue feature of the SRL and retrieves the entrant without entering the confined space.

Workman® Fall Protection Products

Provide quality, comfort and value, allowing your company to provide optimum quality, comfortable fall arrest systems.

- Workman Harness provides comfortable protection, due to its lightweight components and durable webbing.

- The Workman Winch & Rescuer provide methods of rescue/retrieval in confined space applications.

- Workman Tripod is easy to use, offering simple setup procedure
- Includes four attachment points

Before entry into confined space work areas, all equipment should be inspected carefully before each use. **Any equipment that shows any signs of wear or damage should not be used.**

A wide variety of harnesses are available for use with retrieval equipment. Shoulder, back or chest D-rings may be used as retrieval line attachment points. For confined space emergencies with extremely tight openings, wrist-type harnesses allow downed workers to be quickly extracted from work areas by pulling arms over the head and then raising workers with a tripod and hoist. This arrangement helps to protect injured workers' heads and reduces the possibility of catching downed workers' shoulders on confined space entry ports.

- MSA's EVOTECH® Full Body Harness offers user comfort, ease of use, durability, and user safety.

- The Manhole Guard with Integrated Mast barricades exposed entry points while providing the necessary strength needed for fall protection, entry, and retrieval applications.

- Manhole Collar systems are portable anchorage connectors used for vertical entry into confined spaces by providing an adapter base that fits within a manhole opening.

Confined Space/Head First Extraction System

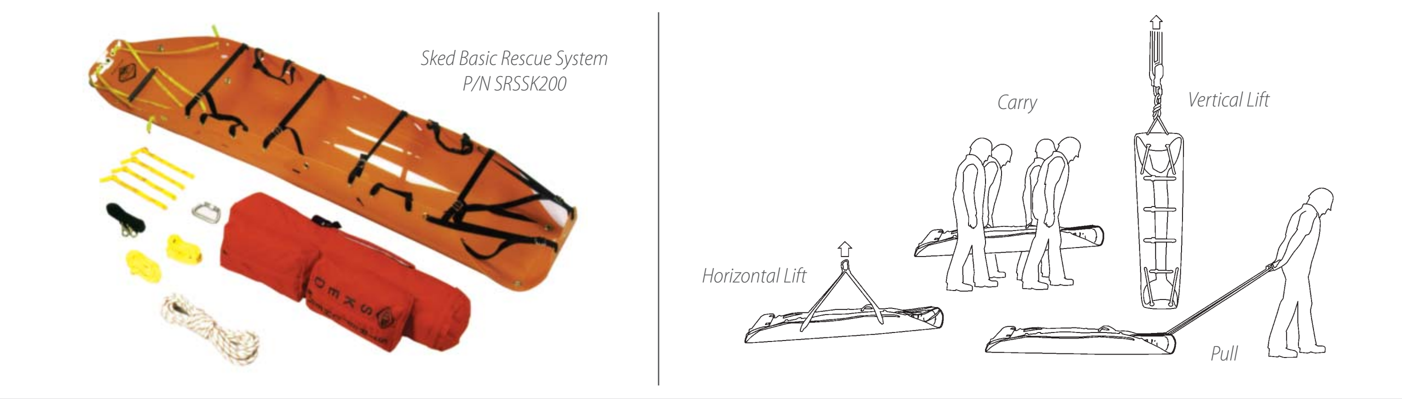
A specialized rescue product designed for extreme cases in which a rescuer needs to be lowered head-first into a confined space to perform a rescue. The Confined Space/Head First Extraction System (HFES) allows the rescuer to be lowered comfortably into a confined space head first, harness the victim, and raise both victim and rescuer out of a confined space. Consists of an adjustable lifting strap, an adjustable victim strap, one pair of ankle harnesses, two carabiners, and a storage bag. This small, compact system can be used with any confined space retrieval equipment such as tripods and davits.

- Leaves both hands free for the rescuer to assist in the retrieval of another person
- Small, compact system

Confined Space/Head First Extraction System
- Part No. SRS3100
- Strength: 5,000 lb (22 kN)
- Weight Approx: 2 lb (0.9 kg)

SKED Basic Rescue System

The best solution for confined space, high angle or technical rescue, and traditional land-based applications, the Sked stretcher is a revolutionary design which provides outstanding patient protection and security. The Sked stretcher comes equipped for horizontal hoisting by helicopter or vertical hoisting in caves or industrial confined spaces. When the patient is secured, the stretcher becomes rigid. The durable plastic provides protection for the patient while allowing extrication through the most demanding confined spaces. The stretcher is rolled for storage in a tough cordura backpack which is included in the system. The system ships at 19 lb (8.6 kg) and comes complete for most applications.



Sked Basic Rescue System
- Sked Stretcher
- Vertical lift sling
- Cordura backpack/towing harness
- Tow strap
- Horizontal lift slings
- Removable webbing handles

Training Entry Personnel and Attendants

All personnel involved in confined space entry, including supervisors, entrants, attendants, and rescue personnel should be well-trained.

Individuals authorizing confined space entry must have complete knowledge of the space's contents and hazards. All confined space workers must fully understand their duties prior to entry or if changes occur in assigned duties or confined space applications. Training must also be certified. Specifically, employers should ensure that confined space entrants are familiar with:

- **Hazard recognition**: employers must let entrants know that hazards that are contained within confined spaces and consequences of exposure to those hazards. In addition, employers must inform entrants of hazardous exposure signs and symptoms contained within confined spaces.
- **Communication**: employers must ensure that authorized entrants maintain contact with attendants stationed outside of confined space work areas.
- **Warnings**: attendants are alerted when entrants recognize exposure warning signs, symptoms or detect prohibited conditions.
- **Protective equipment**: employers must make sure that employees have all necessary personal protective equipment and instruments, including external barriers to protect entrants from external hazards. Workers must be instructed in protective equipment proper use and donning as well as proper operation of confined space instruments.

  Specifically, each worker needs to know of available equipment, where to get it and how to use it properly. Workers should also be trained in proper use of communication equipment so as to maintain contact with attendants and to notify co-workers of any hazardous situations or sudden changes within confined spaces.
- **Self-rescue**: employers must ensure safe entry and exit from confined space work areas.

Entrants should leave work areas when:

1. Attendants order evacuation.
2. Entrants recognize hazardous exposure warning signs or symptoms.
3. Entrants detect prohibited conditions.
4. Evacuation alarms are activated.

Employees must also become familiar with self-rescue procedures.

The attendant's role should be observed by all confined space workers. Attendants are located outside of confined space work areas and must remain on duty at all times during entry operations. Specifically, attendants must oversee:

- **Number of entrants**: it is the attendant's responsibility to maintain accurate confined space worker count.
- **Hazard recognition**: attendants must know and be able to recognize all confined space potential hazards. In addition, attendants must monitor all confined space work area conditions both inside and outside to determine if confined space occupation is safe.
- **Coordinate rescue**: if workers are overcome, attendants must order all workers from the confined space, summon help and coordinate all necessary rescue efforts. Help may come from in-house rescue, emergency services or community emergency response teams.
- **Communications**: attendants must maintain effective and continuous contact with all confined space entrants during entry. In addition, attendants must order all entrants out of the space when:
  - Conditions occur that are not allowed per entry permits.
  - Attendants notice behavioral changes in entrants.
  - Uncontrolled hazards within permit spaces occur.
  - Attendants notice conditions outside permit spaces that could endanger work area entrants.
  - An attendant must leave his/her post in the event that another confined space monitored by that attendant has an emergency.
- **Securing the area**: attendants are also charged with keeping unauthorized personnel from entering the area. If unauthorized personnel enter confined space area vicinity, attendants bear responsibility to instruct them to leave. If unauthorized personnel enter confined space work areas, attendants must notify entrants as well as supervisory personnel of their presence.

Attendants may perform non-entry rescues as specified by company rescue procedure. **Under no circumstances should attendants ever enter confined spaces. More than 60% of all confined space fatalities occur because attendants or unauthorized persons rush into hazardous environments without protective equipment.**

Some companies outfit attendants with proper personal protective equipment and instruments necessary for rescue. In this situation, attendants are on standby in the event that rescue is necessary. However, in these situations, rescue entry must not take place until back-up attendants for the original attendants arrive.

After confined space entry is complete and all personnel have left work areas, confined spaces should be secured and entry permits canceled.

Records and canceled entry permits, including notes of problems encountered, must be retained for at least one year. Annual review of permits is required and programs are to be revised as necessary. Comprehensive records documenting all training activities, safety drills, equipment inspections, atmospheric test results, and equipment maintenance should be kept for every entry into confined space areas. These records will help to ensure that proper procedures were followed and that confined space safety requirements have been properly addressed.

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