AgriLIFE EXTENSION
Texas A&M System

CONFINED SPACE SAFETY

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August 31, 1992. A 56-year-old male mill worker died of suffocation after becoming engulfed in soybean hulls in a grain mill storage bin. The victim and two coworkers were unloading the soybean hulls from an open-topped indoor storage bin compartment when the material became lodged in the compartment. The victim positioned himself on the upper level of the multilevel feed mill building to attempt to dislodge the material with a flexible sewer tape. After load out operations had been completed, the coworkers could not locate the victim. He was later found dead inside the bin compartment, engulfed in the soybean hulls. The victim either entered or fell into the open-topped storage compartment and was engulfed when the bridged material collapsed during load out operations. *Source: FACE 92-34.*

WHAT IS A CONFINED SPACE?

According to the Occupational Safety and Health Administration (OSHA), a confined space is defined by three conditions:

1. It has limited openings for entry and exit.
2. It has unfavorable natural ventilation which could contain or produce dangerous air contaminants.
3. It is not intended for continuous employee occupancy.

Confined spaces exist in many different industries and work environments including building construction, water and wastewater treatment and delivery, and agriculture. Confined spaces include, but are not limited to, storage tanks, pits, wells, vats, manholes, tunnels, underground utility vaults, sewers, and grain silos.

CONFINED SPACE HAZARDS

Approximately 100 people per year die from exposure to a confined space hazard. More than half of confined space fatalities include those attempting to rescue the primary victim(s).

Common hazards associated with confined spaces are generally categorized as either atmospheric or physical and include:

- Lack of natural ventilation
- Oxygen-deficient atmosphere
- Flammable/explosive atmosphere
- Unexpected release of hazardous energy
- Limited entry and exit
- Dangerous concentrations of air contaminants
- Physical barriers or limitation to movement
- Engulfment in contained material
- Instability of stored product

ATMOSPHERIC HAZARDS

The ambient, or normal, atmosphere contains approximately 21 percent oxygen, 78 percent nitrogen, and 1 percent argon with trace amounts of other gases. Within confined spaces, the concentration of gases may change considerably depending on the material being stored or used, by the process taking place inside the space, and by the effects of the external environment. Oxygen may become deficient or displaced by other gases and can become flammable or toxic.

Oxygen Deficiency

Oxygen levels may drop in confined spaces due to chemical or biological reactions that displace or consume oxygen. Since fires consume oxygen, activities such as welding, cutting, and brazing in confined spaces can create an oxygen-deficient

atmosphere unless fresh air is supplied through ventilation.
Oxygen is also used during bacterial actions in excavations and manholes near garbage dumps, landfills, or swamps. Even the formation of rust on the surface of metal pipes and storage tanks consumes oxygen.

Physiological Effects of Oxygen on the Human Body

Oxygen Content	Physiological Effects
21%	None
Below 17%	Deterioration of night vision Increased breathing volume Accelerated heartbeat
14% to 16%	Increased breathing volume Accelerated heartbeat Poor muscular coordination Rapid fatigue Intermittent respiration
6% to 10%	Nausea Vomiting Inability to perform Unconsciousness
Less than 6%	Rapid loss of consciousness Death in minutes

In some situations, gases such as nitrogen are used to inert (or displace oxygen in) a confined space. If a worker enters the confined space before it is properly ventilated, he or she is subject to immediate unconsciousness and death.

Flammable Atmospheres

A flammable atmosphere can occur from vaporization of flammable liquids, by-products of a chemical reaction, enriched oxygen atmospheres, and concentrations of combustible dusts.

Three components are needed to cause an explosion: fuel, oxygen, and an ignition source. Potentially explosive fuel vapor-oxygen mixtures vary depending on the fuel source. For example, methane becomes potentially explosive in air between 5 percent and 15 percent concentrations. Methane concentrations below 5 percent will not support combustion. Methane concentrations above 15 percent are too rich.

Ignition sources may include an electric motor spark, busted light bulb, and fire or heat from welding, cutting, or brazing. Confined spaces should be monitored for explosive atmospheres before and during any work where potential ignition sources will be used.

July 10, 1986. Two employees died after exposure to an oxygen-deficient atmosphere. A three-man work crew was boring under a street and hit a 24-inch water line causing water to gush from the pipe. The work crew was instructed to close valves at three different locations to shut off the supply of water. After closing one valve, one crew member entered the second valve pit and immediately called out for help. A second crew member entered the pit and was overcome. The third crew member started down the pit, but realized he was in trouble and exited immediately to call for help. Within minutes, fire department and rescue personnel removed the two victims where they were transported to a hospital. The two victims died a short time later. Oxygen levels in the pit measured 17 and 18 percent. *Source: FACE 86-37.*

Toxic Atmospheres

Numerous toxic gases are known to cause death in workers in confined spaces. These include carbon monoxide, hydrogen cyanide, hydrogen sulfide, arsine, chlorine, oxides of nitrogen, and ammonia.

Presence of toxic gases in confined spaces may result from leaks in piping that vent toxic by-products of a manufacturing process, biological or chemical process from material stored within a confined space, or from toxic gases expelled during a maintenance operation (such as welding) in the confined space.

Without the use of specialized gas meters, some toxic gases may not be detectable until damage is done. For example, high concentrations of hydrogen sulfide can cause paralysis of the olfactory system. The victim is unable to smell the gas, and may become disoriented, experience respiratory failure, lose consciousness, and die.

PHYSICAL HAZARDS

Confined spaces may contain a range of physical hazards depending on the specific design, equipment, and function of the space. These include engulfment in stored material, electrocution, contact with mechanical parts,

exposure to stored energy in pressurized systems, and falls.

Engulfment in stored materials is one of the most common physical causes of death in confined spaces, especially among agricultural operations. Workers entering grain silos and wagons for the purpose of breaking through layers of crusted or bridged material risk becoming entrapped when grain flow resumes. Workers should never stand inside storage containers where grain, sand, gravel, concrete, or other loose material is being pumped or transferred from the container.

Electrical components and machinery may become energized in a confined space causing injury and death to workers. All electrical circuits that may pose a risk should be de-energized and locked out before entering the confined space.

Additional hazards that may cause injury in confined spaces include:

- Release of pressurized liquids, steam, and gases
- Falling objects through topside entrances
- Extremely cold or hot temperatures
- Wet or slick working surfaces
- Amplified noise levels that inhibit communication
- Snakes, spiders, scorpions, bees, etc.

September 21, 1990. A 52-year-old maintenance worker for a furniture manufacturing company fell headfirst into a sawdust storage silo and suffocated. The silo is 17 feet in diameter, 36 feet high, and has a 24-inch diameter manhole on top near the edge. Although there were no eyewitnesses, evidence suggests that the victim did the following: 1) climbed to the top of the silo to check the sawdust level inside, 2) removed the manhole cover, 3) stuck his head inside the manhole and noted that the silo was nearly full of sawdust, 4) reached inside the manhole with a hoe-like tool to "rake down" the sawdust pile, 5) slipped from this position, and 6) fell headfirst into the sawdust seven feet below. The upper half of the victim's torso became submerged in the sawdust and the victim suffocated in an upside down position. *Source: FACE 91-04.*

CONTRIBUTING FACTORS TO CONFINED SPACE INJURIES AND FATALITIES

An examination of confined space fatality cases reveals several common factors or circumstances that contributed to these tragic incidents. These include:

- Lack of proper worker training
- Supervisor not qualified to direct confined space entry
- No confined space entry procedures
- No recognition of potential hazards
- Protective equipment not provided or not worn
- Access portal too small for protective equipment to fit through
- Lack of air quality monitoring equipment
- Electrical service to energized equipment not locked out
- Failure to ventilate toxic atmospheres
- Failure to monitor air quality during ventilation process
- No communication between workers inside a confined space and outside standby personnel
- No rescue plan or equipment available
- No standby personnel available
- Lack of emergency rescue plan/training

OCCUPATIONAL STANDARDS

OSHA has developed permit-required confined spaces standards for the general industry businesses that employ 11 or more employees [29 CFR 1910.146]. These standards do not apply to agriculture, to construction, or to shipyard employment. Construction and maritime industries have their own confined space standards, 29 CFR 1926.21 and 29 CFR 1915 Subpart B, respectively. There are no confined space OSHA standards for the agriculture industry.

Elements of OSHA standard 29 CFR 1910.146 include the following:

- Decision aid for classifying a confined space as "permit" or "non-permit"
- Signage, guards, railings and other barriers to restrict unauthorized entrance
- Atmospheric testing and monitoring procedures
- Personal protective equipment
- Ventilation procedures

- Pre-entry employee permit and certification requirements
- Working with contractors who must work in permit-required confined spaces
- Components of a written permit-required confined space program (confined space program)
- Elements of a confined space "permit" document
- Employee training requirements
- Duties of authorized entrants, attendants, and entry supervisors
- Rescue and emergency services and training

OSHA Definitions

Attendant – An individual stationed outside one or more permit spaces who monitors the authorized entrants and who performs all attendant's duties assigned in the employer's permit space program.

Authorized entrant – An employee who is authorized by the employer to enter a permit space.

Entry supervisor – The person responsible for determining if acceptable entry conditions are present at a permit space where entry is planned, for authorizing entry and overseeing entry operations, and for terminating entry as necessary.

Permit-required confined space - a confined space that has one or more of the following characteristics:

1. Contains or has a potential to contain a hazardous atmosphere
2. Contains a material that has the potential for engulfing an entrant
3. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section
4. Contains any other recognized serious safety or health hazard

Non-permit confined space - fits the definition of a confined space, but does not contain or have the potential to contain any atmospheric hazard capable of causing death or serious physical harm.

OSHA Hits Employer with $1.6 Million Fine after Confined Space Fatalities, Injuries

An employer faces a $1.6 million fine following a federal job safety investigation into complaints that it continued to expose painters to hazards while working in an enclosed rail tank car even though several employees have died doing similar work since 1993. Four workers have died and at least six have been hospitalized from confined space hazards over the last five years at this rail car repair facility, but the employer allegedly continued to allow painters to enter tank cars without ensuring that the workers had retrieval systems for use in an emergency. *OSHA December 1998.*

GENERAL SAFETY PRECAUTIONS

Although most confined spaces such as valve pits, vaults, water wells, and storage containers seem harmless, they can be extremely hazardous for workers who are unaware of the potential atmospheric and physical hazards that linger inside. These same risks extend to rescue workers and bystanders who attempt to remove victims, thereby placing themselves and subsequent rescue workers to danger. Take the following safety precautions to avoid becoming another statistic:

- Never enter a confined space without evaluating the potential atmospheric and physical risks
- Never enter a permit-required confined space without proper certification and supervision
- Never enter a confined space without someone outside equipped with rescue equipment.
- Use gas monitoring equipment to test confined spaces that could potentially harbor oxygen-deficient, flammable, or toxic atmospheres before entering
- Always wear the proper personal protective equipment before entering oxygen deficient, flammable, or toxic atmospheres
- Leave a confined space immediately at the first sign of trouble, such as difficulty breathing
- Always establish communication with someone standing outside the confined space
- Make sure all potential physical hazards are minimized (such as energized machinery and electrical systems)
- Establish and periodically practice a confined space rescue plan tailored to your work environment
- Make sure everyone that will be working inside, standing outside, or supervising confined space work is properly trained on hazard assessment, atmospheric monitoring and emergency rescue.