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A Look Inside: Improving Safety within Permit Spaces Utilizing a Centralized Confined Space Monitoring System

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Many workplaces in various industries perform routine operations, such as maintenance and/or periodic inspection and repair, in areas considered to be “confined spaces.” To protect employees working within these spaces, the Occupational Health and Safety Administration (OSHA) developed labor-safety regulations (29 CFR 1910.146), described later, which define the requirements for a confined space and govern employers and employees’ responsibilities when entry into a confined space is undertaken.

OSHA identifies two different types of confined spaces: a non-permit required confined space and a permit-required confined space (or “permit space”) as elaborated by the regulation. Many working areas may technically be considered non-permit required confined spaces by the following criteria:

- Has limited or restricted means of entry or exit, and
- Is large enough for a worker to enter to perform required tasks, and
- Is not designed for continuous occupancy.

The key factor in designation of a permit-required confined space, in addition to the above criteria, is further classification that the confined space may pose a health or safety hazard either by the intrinsic nature of the space or by the nature of the work being performed inside the space; that is, the confined space should not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

These classifications may broadly be categorized as entrapment, engulfment, and hazardous atmospheric conditions, which may either be present at the time of entry into the confined space or facilitated/generated by on-going work efforts within the confined space.

Permit-required confined spaces present workers with the dangerous and potentially life-threatening task of performing duties inside. Employees entering permit spaces face increased risk due to limited means of entry and egress and the potential for significant hazards to be present within the space. These risks are compounded by numerous factors that may be associated with a specific permit space, in addition to the fact that the workers’ mere presence in the confined space may place them closer to potential hazards than in a normal working environment.

While there are some additional opportunities to increase worker safety in permit-required confined spaces, the focus of this white paper investigation will be on atmospheric monitoring of the permit space, visual monitoring of the worker(s), communication to and from the worker(s) within the space, and how those procedures, combined with advanced technology, can increase safety within the hazardous atmosphere.

The Problem

According to the National Institute of Occupational Safety and Health (NIOSH), “workers who enter and work in confined spaces are confronted with many potentially hazardous conditions. The hazards can range from an oxygen deficient atmosphere or liberation from a toxic agent, to mechanical equipment accidentally energized. The hazardous atmospheres that can be encountered in a confined space are; flammable, toxic, irritant and/or corrosive, and asphyxiation,” (*Criteria for a Recommended Standard 38*).

Permit-required confined spaces have three types of entry: as part of the industrial activity, unauthorized entry, and emergency rescue (NIOSH, *Criteria for a Recommended Standard 20*), but even authorized entrants can encounter near misses, injuries, or fatalities, if the proper precautions and procedures are not installed and implemented.

A major downfall within the industrial work environment is that, even with required safety training, access to proper personal protective equipment, barricades, warning signs, and more, there are still needless injuries and fatalities that occur as a result of the hazardous atmospheres with permit-required confined spaces—and not because only proper procedures are not being put into place. Incidents have occurred where the proper procedures were in place, yet there was disregard for those procedures.

In fact, NIOSH investigations suggest "that workers usually do not recognize that they are working in a confined space and that they may encounter unforeseen hazards. Testing and evaluation of the atmosphere are typically not initiated prior to entry and monitoring is not performed during the confined space work procedures. Rescue is seldom planned and usually consists of spontaneous reaction in an emergency situation," (*Alert 7*).

Though the company might have proper programs and policies in place, the procedures must be understood and carried out by all employees and contractors, especially in regards to rescue procedures. The Chemical Safety Board (CSB) noted in *Hazards of Nitrogen Asphyxiation,* "One of the most difficult issues concerning hazardous atmosphere emergencies is the human instinct to aid someone in distress," (USCSB, 10).

NIOSH states:

> It is essential that well planned rescue procedures and the proper use of personal protective equipment be followed. The literature and data reviewed have shown a very poor record in successful rescue efforts. Spontaneous reaction instead of well planned and executed rescue procedures has led to multiple fatalities in confined spaces. In 19 of the 25 cases in which rescue was attempted, the rescuers were injured or killed. These cases resulted in 13 deaths and 30 injuries to rescuers, even though only 5 victims were successfully saved. One particular case resulted in injury to 15 rescuers; however, they were successful in saving 3 lives *(Criteria for a Recommended Standard 42*).

But why should it even get to a reactive point of rescue? With all of the knowledge that exists around confined spaces and the associated hazards, it seems that the injury and fatality rates would decrease, but not so.

> During revision of the 2003 version of the [ANSI/ASSE Z117.1] standard the Z117 committee reviewed accident data for confined space incidents. A subsequent review of 200 confined space fatality cases reported by US Federal OSHA occurring between 1993 and 2004 showed that the causes of fatalities had not appreciably changed. Nearly two-thirds of fatal accidents in confined spaces were attributed to atmospheric contamination. Another ten percent were caused by engulfment (MSA, 1).[1]

Beyond the incidents mentioned above, a recent five-year U.S. Department of Labor study shows that an average of 92 deaths per year is associated with confined space accidents (NIOSH, *"Confined Spaces"*). Most fatalities are the result of personnel entering without a work permit, poor ventilation, lack of proper atmospheric monitoring, or an attempt to rescue a downed person inside the confined space, which can be attributed to a lack of qualifications and proper training of the safety attendant.

Though meeting the requirement of OSHA, the safety attendant role is staffed, at times, with a worker who has little experience or little training in confined spaces. Some employers and contractors might assume that anyone can be the attendant. However, this assumption can be a catalyst in a series of unsafe acts or even the contributing factor for the aforementioned causes that lead to an incident or fatality.

1. The remaining causes are related to many factors, including falls from heights, electrocution, and being struck by a moving object.

Even with government regulations, worker training, and significant emphasis on confined space hazards, unnecessary accidents and preventable fatalities occur all too often. NIOSH continues to track and document numerous accidents resulting in injury and fatalities associated with work performed in and around confined space environments. These serious incidents may be the result of worker/employer failure to implement regulatory guidance, but it may also be the result of lack of oversight, simple human error, inattention to detail, and/or other preventable factors that contribute to the chain of events leading up to these incidents.

What should be determined is how does industry balance its challenges of completing projects on-time and under budget with critical personnel safely? With every opening of closed systems, every worker that reports for duty, and every complexity of the project that arises, industry is faced with greater incident risk or, even worse, a fatality. Is a well-trained and qualified attendant the single control that delivers safe confined space work? Might the industry place too much responsibility on a single person standing outside the space?

One can deduce that increased oversight, combined with technological solutions, should improve worker safety and minimize hazards during confined space operations. The Centralized Confined Space Monitoring System evaluated in this paper attempts to reduce risk through observation and alleviation of preventable factors, while supplementing existing protocols.

The Basic Solution

In an effort to protect the vital occupational health and safety of workers within industry, OSHA created a standard for confined spaces, 29 CFR 1910.146, that contains the requirements for practices and procedures to protect employees in general industry from the hazards of entering permit spaces.[2]

The law requires the employer to evaluate the workplace to determine if any spaces are permit-required confined spaces[3] (OSHA, 29 CFR 1910.146[c][1]). Once permit spaces are established, the employer shall inform potentially exposed employees of the location's existence and the danger posed by the permit space by posting danger signs or any other equally effective means (OSHA, 29 CFR 1910.146[c][2]).

2. Twenty-five states, Puerto Rico and the Virgin Islands have OSHA-approved State Plans and have adopted their own standards and enforcement policies. For the most part, these States adopt standards that are identical to Federal OSHA. However, some States have adopted different standards applicable to this topic or may have different enforcement policies.

3. For the purposes of *Criteria for a Recommended Standard: Working in Confined Spaces,* NIOSH defines confined spaces with the following classifications: Class A - Immediately Dangerous to Life/Health (IDLH); Class B - dangerous, but not IDLH; and Class C - potentially hazardous (1).

In addition, when working in and exiting confined spaces, a Checklist of Considerations for Entry is required (Table 1).

Table 1—Checklist of Consideration for Entry

	Item	Class A	Class B	Class C
1.	Permit	X	X	X
2.	Atmospheric testing	X	X	X
3.	Monitoring	X	O	O
4.	Medical surveillance	X	X	O
5.	Training of personnel	X	X	X
6.	Labeling and posting	X	X	X
7.	Preparation			
	Isolate/lockout/tag	X	X	O
	Purge and ventilate	X	X	O
	Cleaning processes	O	O	O
	Requirements for special	X	X	O
8.	Procedures			
	Initial plan	X	X	X
	Standby	X	X	O
	Communications/observation	X	X	X
	Rescue	X	X	X
	Work	X	X	X
9.	Safety equipment and clothing			
	Head protection	O	O	O
	Hearing protection	O	O	O
	Hand protection	O	O	O
	Foot protection	O	O	O
	Body protection	O	O	O
	Respiratory protection	O	O	
	Safety belts	X	X	X
	Life lines, harness	X	O	
10.	Rescue equipment	X	X	X
11.	Recordkeeping/exposure	X	X	

X – indicates requirement; O – indicates determination by the qualified person
NIOSH, *Criteria for a Recommended Standard* 5

For clarity purposes within this discussion, atmospheric testing, monitoring, communications/ observation, and rescue procedures are required for all three classifications of confined spaces, and that standby procedures and recordkeeping/exposure are required for Class A and B confined spaces.

Atmospheric Testing

OSHA requires that, 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 (OSHA, 29 CFR 1910.146[c][5][ii][C]). It is important to test in that order as "there may not be enough oxygen inside the confined space to support life, or the air could be so oxygen-rich that it is likely to increase the chance of fire or explosion if a source of ignition is present," (Pettit, 2).

Furthermore, the supervisor of a qualified[4] person shall be responsible for securing the permit and both shall sign off when the following have been reviewed and confirmed:

- Atmospheric test readings (of Class A, B, and C) for oxygen level, flammability and/or explosion levels and toxic substance levels
- Atmospheric monitoring while work is being performed (Class A on a continuous basis and Class B as determined by the Qualified Person) (NIOSH, *Criteria for a Recommended Standard 7*)

By requiring atmospheric testing, as well as having both the qualified person and the supervisor of the qualified person sign off on the permit, it should ensure that both parties are aware of the potential hazards and the safety procedures that combat those hazards.

In addition, "when atmospheric testing indicates the presence of a toxic substance, records shall be maintained in accordance with the existing Federal regulation(s). These records shall include the dates and times of measurements; duties and location of the employees within the confined space; sampling and analytical methods used; number, duration, and results of the samples taken; PEL concentrations estimated from these samples; type of personal protective equipment used, if any; and employees' names. These records shall be made available to the designated representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of employee or former employee," (NIOSH, *Criteria for a Recommended Standard 17*). By maintaining records, the employer, the employee, and the government can aid in "the prevention of deaths and injuries which occur during entry into such spaces," (OSHA, *Paperwork Reduction Act*).

Monitoring

Another requirement when working in a permit-required confined space is that the atmosphere within the space shall be periodically tested as necessary to ensure that the continuous forced air ventilation is preventing the accumulation of a hazardous atmosphere (OSHA, 29 CFR 1910.146[c][5][ii][F]). In addition, "if the work practice involved in the confined space has the potential to increase existing hazards or generate additional ones, it shall be necessary to frequently evaluate the space to determine if a classification change is warranted," (NIOSH, *Criteria for a Recommended Standard* 6). By frequently monitoring the permit space, worker safety increases within the space by ensuring that their work space is stable.

Additionally, "equipment for continuous monitoring of gases and vapors shall be explosion proof and equipped with an audible alarm or danger signaling device that will alert employees when hazardous condition develops," (NIOSH, *Criteria for a Recommended Standard* 9).

4. NIOSH's *Criteria for a Recommended Standard: Working in Confined Spaces* states that a "qualified person" is "a person designated by the employer, in writing, as capable (by education and/or specialized training) of anticipating, recognizing, and evaluating employee exposure to hazardous substances or other unsafe conditions in a confined space. This person shall be capable of specifying necessary control and/or protective action to insure worker safety," (2).

Communications/Observation

Vital in case of emergency, communications equipment "should be considered when the entry plan is formulated," (NIOSH, *Criteria for a Recommended Standard* 13). There are two main factors to consider when formulating the entry plan: communications between the attendant and the worker(s) and the communications between the attendant and the facility.

"Additional duties of the standby person[5] are to maintain unobstructed life lines and communications to all workers within the confined space, and to summon rescue personnel if necessary," (NIOSH, *Criteria for a Recommended Standard* 6). Sometimes difficult to facilitate, communication between the worker(s) and the attendant are imperative to safety not only of the worker(s) inside the permit space, but also those within the facility. The worker should communicate with the attendant as necessary to monitor entrant status and to alert entrants of the need to evacuate the space as required (OSHA, 29 CFR 1910.146[h][3]).

Additionally, "in a Class A entry, an audible warning device shall be installed in all equipment to signal when there is a ventilation failure," and gas monitoring equipment should "be equipped with an audible alarm or danger signaling device that will alert employees when a hazardous condition develops," (NIOSH, *Criteria for a Recommended Standard* 13, 9).

Recordkeeping/Exposure

By law, operators are required to "list all personnel working inside the barricaded area using a controlled area entry log," (USCSB, 12). It is the responsibility of the attendant to continuously maintain an accurate count of authorized entrants in the permit space and ensure that the means used to identify authorized entrants accurately identifies who is in the permit space (OSHA, 29 CFR 1910.146[i][3]). By logging who is inside and outside of the permit space, one can, at a moment's notice, identify potentially missing persons in emergency situations involving evacuation of the permit space or the facility.

As previously mentioned, the employer is required to maintain additional records "when atmospheric testing indicates the presence of a toxic substance," (NIOSH, *Criteria for a Recommended Standard* 17). These records are useful during incident investigations by allowing investigators to analyze the data to find leading indicators or at-risk behaviors that can help prevent future incidents and fatalities.

The Basic Solution's Deficiencies

One of the most common deficiencies regarding the Basic Solution is the difficulty to control, let alone monitor, unauthorized entry into the permit space. As NIOSH notes, "one of the most difficult entries to control is that of unauthorized entry, especially when there are large numbers of workers and trades involved, such as welders, painters, electricians, and safety monitors," (*Criteria for a Recommended Standard* 21). It is difficult enough to keep workers safe within the hazardous conditions of a confined space when the person(s) is authorized; let alone one who is not authorized. Unauthorized entry, by far, increases the injury and fatality rate of not only the entrant, but the rescuers as well.

One cannot underestimate the critical nature of this failure, according to NIOSH:

> A final and most important reason for entry would be emergency rescue. This, and all other reasons for entry, must be very well planned before initial entry is made and the hazards must be thoroughly reviewed. The standby person and all rescue personnel should be aware of the structural design of the space, emergency exit procedures, and life support systems required," (*Criteria for a Recommended Standard* 21).

5. NIOSH's *Criteria for a Recommended Standard: Working in Confined Spaces* states that a "standby person" is "a person trained in emergency rescue procedures and assigned to remain on the outside of the confined space and to be in communication with the worker inside," (3).

Incident after incident, case after case, it is found that even if the requirements are met and procedures are in place, there are still near misses, injuries, and fatalities to workers due to deficiencies of the Basic Solution: human nature and human instinct cannot be controlled.

Atmospheric Testing

According to NIOSH, one important "area of research [that is] needed is development of more adequate methods for preventing and detecting gas leaks into confined spaces. Many accidents have occurred because the atmosphere in a confined space, which was presumed to be safe by the nature of the contents or obvious safe history of the confined space, had suddenly become lethal," (*Criteria for a Recommended Standard* 46).

Table 2 shows the number of events, injuries, and fatalities obtained for each of the 15 basic accident and illness types that appear in Appendix A of this white paper. "A total of 276 confined space related events were identified, which resulted in a total of 234 injuries and 193 fatalities. The table shows that the most hazardous conditions in a confined space are a result of the atmospheric related events," (NIOSH, *Criteria for a Recommended Standard* 31).

Table 2—Events, Injuries and Fatalities per Accident and Illness Type

Ref.	Accident and Illness Type	Events	Injuries	Fatalities
1	Atmospheric Conditions in Confined Space	80	72	78
2	Explosion or Fire in Confined Space	15	49	15
3	Explosion or Fire at Point-of-Entry to	23	20	32
4	Electrocution or Electrical Shock	11	2	9
5	Caught in/Crushing of Confined Space	10	3	10
6	Trapped in Unstable Materials in Confined	16	0	16
7	Struck by Falling Objects in Confined Space	15	1	14
8	Falls (while in Confined Space; not into	27	26	1
9	Ingress/Egress of Confined Space	33	30	3
10	Insufficient Maneuverability in Confined	15	15	0
11	Eye Injury in Confined Space	10	10	0
12	Contact with Temperature Extreme in	7	4	3
13	Noise in Confined Space	1	1	0
14	Vibration in Confined Space	1	1	0
15	Stress from Excess Exertion in Confined	12	0	12
	Totals	**276**	**234**	**193**

NIOSH, *Criteria for a Recommended Standard* 33

Though there are a variety of equipment and resources available to test and monitor the atmosphere within the permit space and both the qualified person and the supervisor of the qualified person signing off on the permit, there is a deficiency with the Basic Solution as the leading cause of events, injuries, and fatalities in a confined space is a direct result of the atmospheric conditions within that space. The existing standard does not define the frequency of which the space should be tested—only that it should be monitored when the potential for a hazard exists or as conditions change. By failing to require continuous monitoring of the atmosphere, the standard leaves room for human error.

Monitoring

Despite the requirement to periodically test the atmosphere being in place, especially if the environment within the permit space has the potential to increase existing hazards or generate additional ones, events, injuries, and fatalities are highest as a result of atmospheric conditions; however, events, injuries, and fatalities due to explosions or fire within the confined space or at the point-of-entry of the confined space are also high.

NIOSH states that, based on its review, "the potential for explosion is greatly increased when explosion proof equipped tools and equipment are not used or improperly maintained," (*Criteria for a Recommended Standard* 41). While based upon the texts reviewed, there is no mention that events, injuries, or fatalities in the aforementioned table were a direct cause of the tools or equipment used, these events were a result of a spark generated by the activity of one or more workers within the confined space. Further information regarding the basic accident and illness types can be found in Appendix A of this paper.

In addition to the deficiency of the Basic Solution regarding atmospheric testing, there is also a great insufficiency regarding intrinsic safety. Directly related to this insufficiency, the intrinsic safety of the permit space could be identified if the atmosphere was monitored and tested properly and frequently.

Communications/Observation

Effective communication is perhaps the most difficult requirement to facilitate, but real-time communication between trained safety personnel and the worker(s) inside the permit space greatly increases worker safety within the space, as well as throughout the facility.

> Communication between the worker inside and the standby person outside is of the utmost importance. If the worker should suddenly feel distressed and not be able to summon help, an injury could become a fatality. Frequently, the body positions that are assumed in a confined space make it difficult for the standby person to detect an unconscious worker. When visual monitoring of the worker is not possible because of the design of the confined space or location of the entry hatch, a voice or alarm- activated explosion proof type of communication system will be necessary (NIOSH, *Criteria for a Recommended Standard* 29).

The nature of the space and the work can inhibit the communication between the attendant and the worker(s) and not just verbally: some estimate that non-verbal communication or "body-language" accounts for anywhere between sixty-five to ninety percent of communication, and confined spaces are rarely conducive to visual monitoring of the worker(s) within the space. Clearly, a way to improve visual contact would also improve safety.

In addition, "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," (NIOSH, *Criteria for a Recommended Standard* 30).

Recordkeeping/Exposure

The naiveté of why exposures, events, injuries, and fatalities occur within permit spaces can [also] be attributed to the insufficiency of available and accurate, even real-time, records. NIOSH warns that "recordkeeping systems must be changed to identify areas where accidents occur, so that underlying causes can be determined," (*Criteria for a Recommended Standard* 42). Currently, there is not an efficient way of tracking incidents and fatalities resulting from confined spaces, making it difficult to prove the deficiency that is there.

> Accidents in confined spaces, like all others, are required by Federal regulations to be reported only if medical attention or loss of time from work, or death is involved. Some states and workers' compensation carriers have slightly more stringent requirements, but none require the reporting of incidents which can be considered near misses. The report by Safety Sciences prepared under contract for NIOSH tended to show that fatalities occurred more frequently in confined spaces. For example, death by asphyxiation would be reported; however, if an employee experiences shortness of breath or dizziness, but managed to escape the confined space, and was not treated by a physician, this would probably not be a reported case (NIOSH, *Criteria for a Recommended Standard* 31).
>
> NIOSH is aware that a number of deaths occur each year when workers must enter and work in a confined space, and it recognizes that due to current data collection methods, an estimate of the injuries and deaths which do occur will be inaccurate. Also, since there is no specific Standard Industrial Classification [SIC] where these injuries and deaths are recorded for confined spaces, they are recorded in several different categories, thereby giving the appearance of a limited exposure to the hazard (*Criteria for a Recommended Standard* 18).
>
> Based on the total working population of selected specific SIC codes, and a rough estimate of the percentage of each category who may work in confined spaces at some time, NIOSH estimates that millions of workers may be exposed to hazards in confined spaces each year (NIOSH, *Criteria for a Recommended Standard 1*9).
>
> An estimation of the number of workers potentially exposed to confined spaces would be difficult to produce. A report prepared under contract for NIOSH shows that the rate of confined space related injuries in the shipbuilding and repair industry is 4.8%. Projected on a national level, 2,448 accidents per year may be attributed to the hazards of working in confined spaces in this single industry (NIOSH, *Criteria for a Recommended Standard* 19).
>
> The limited statistical data available on accidents and injuries directly related to confined spaces indicate a very high mortality level. This disproportionately high mortality level for the number of reported accidents and injuries could be the result of inadequate reporting methods, as not reporting a near miss with death, or data collection systems failing to list a confined space as a causative or other factor in traumatic accidents (NIOSH, *Criteria for a Recommended Standard* 38).

How can one solve a problem if the problem does not "officially" exist? Better track of workers and the near misses and incidents that occur within confined spaces is the only sure way the industry can improve worker safety. Leading indicators help to determine the at-risk behaviors, but if one has no data to determine the leading indicators, industrial leaders face repeating the very mistakes that are injuring countless workers each year.

Another "area of research is the need to define and evaluate the stresses on employees who are required to work in confined spaces," (NIOSH, *Criteria for a Recommended Standard* 46). Industry is aware of the external factors that affect the safety of workers who work in confined spaces, like atmosphere, personal protective equipment, and explosion-proof tools, but little is known about the psychological and emotional stresses that workers incur, consciously or subconsciously, while working in confined spaces. Again, proper records will need to be kept to determine the indirect factors that may increase the rate of events, injuries, and fatalities in permit spaces.

Total Safety's Solution

Though basic requirements may be met, and proper procedures may be in place, Total Safety's mission is resolute: "to ensure the safe Wellbeing of Workers Worldwide (W^3)."That means going above and beyond basic requirements and standards; the company often puts enhanced procedures in place that have proven to reduce incidents and increase safety. To combat hazards within confined spaces, Total Safety utilizes a patented-pending Centralized Confined Space Monitoring System that acts as a supplement to existing confined space entry procedures. The system, already successfully deployed on over one hundred projects in Europe, is ready for the North American market.

Total Safety's Centralized Confined Space Monitoring System combines the requirements of trained personnel with the advancement of technological equipment to deliver a solution that serves to fill some of the deficiencies described earlier within permit-required confined space programs and the basic solutions available today.

This third generation, state-of-the-art system, balanced with trained safety personnel, is available to continuously monitor confined space work. This advanced technology includes a risk control process that provides user flexibility to deploy the appropriate equipment combined with the associated staffing. The modular system not only meets, but exceeds all the attendant duty responsibilities of the OSHA confined space regulation, while solving many of the confined space issues that have been attributed to previous incidents.

The system centralizes all functions to one control center that maintains real-time status of the confined space using five types of technology: badge/ID reader technology, closed-circuit cameras, push-to-talk communications, fixed gas monitoring, and audible and visual alarms (Table 3). With this technology, the control center continually identifies workers within the confined space, maintains a visual and a clear line of communication, continuously monitors the atmosphere for toxic or dangerous gases, and sounds appropriate alarms if an incident occurs. By both supplementing and centralizing the responsibility, one can expect increased safety as a result of continuous atmospheric monitoring, more reliable communications, and more consistent records.

Table 3—Standard Configuration per Confined Space

Access control	Active badging system: 1 inside confined space, 1 outside confined space
Gas detection	4 sensors + 1 optional input[6] O, LEL, H S, CO
Camera monitoring	1 internal camera, 1 external camera
Antennas	Standard wireless communications from the confined space(s) to the control center
Communications and alarming	1 full duplex intercom inside, 1 full duplex intercom outside 2 automatic audible alarms with flashing

For a more in-depth list of the Centralized Confined Space Monitoring System components, see Appendix B.

6. Oxygen, lower explosive limit, hydrogen sulfide and carbon monoxide

The continuous monitoring strategy adds value and an additional layer of control through the placement of fixed gas detection, access control readers, cameras, visual and audible alarms, and instant communications at each confined space entry point. The system provides the following direct and indirect benefits:

- Centralized control via inside control room and outside field technicians
- Monitoring by competent technicians
- State-of-the-art fixed gas detection instrumentation
- Observation of real-time behaviors via cameras
- Correct unsafe behaviors and practices immediately
- Roll call and headcount information available in real-time in case of an emergency
- Communications on the inside and outside of the confined space
- Quicker response time to summon rescue or emergency assistance
- Support to the rescue team with live feed of the confined space
- 24/7 monitoring, even if there is no entry personnel present
- Extra set of eyes and ears, monitoring confined space work that can activate communications and appropriate alarms, if needed
- Reduce permitting time after 30-minute or longer breaks of inactivity
- Reliable reporting of data
- Real-time monitoring of atmospheric conditions with ad hoc reports and trend analysis
- Documented video surveillance and gas detection readings available for incident investigation use
- Facilitate improved safety performance and less incidents, which save direct and indirect costs associated with workers compensation, days off, liabilities, and productivity
- Provide badge readers at designated unit evacuation/muster points to keep accurate headcount and names

Atmospheric Testing

"Prior to entry into a confined space, workers should know the space's potential hazards," (NIOSH, *Criteria for a Recommended Standard* 38), and with the Centralized Confined Space Monitoring System, workers can. The control room completes checklists to verify atmospheric hazards, as well as applicable work permits and required personal protective equipment. With continuous monitoring of the atmosphere, the control room eliminates the "presumption" that the atmosphere is considered safe.

Monitoring

> Continuous and/or frequent monitoring becomes necessary in cases where the work being performed within the confined space has the potential of generating toxic agents. Data collected for NIOSH by Safety Sciences shows that in 28 out of 80 accident events, the toxic gas or oxygen deficiency was not in the confined space at the time of entry, but was either generated by the work occurring in the space, or by the gas being unexpectedly admitted into the confined space after the worker had entered. In these cases, only continuous and/or frequent monitoring would be a possible countermeasure (NIOSH, *Criteria for a Recommended Standard* 39).

By centralizing the control room that continuously monitors the confined space(s) for potential atmospheric hazards, any generation or unexpected admittance of toxic gases or oxygen deficiency will be immediately identified (Figure 1.1). At that point, the trained control room operator will notify appropriate personnel and sound any alarms, if necessary, relieving the attendant of having to juggle such duties.

The Centralized Confined Space Monitoring System includes fixed gas detection with a standard configuration (O2, LEL, H2S and CO) with up to forty different gases possible upon request. Optional sensors are available for photoionization detection, dust, temperature, and humidity. Additionally, the CE-approved[7] system features a sample draw gas detection system, continuous flow control in sampling system (2 LPM[8]), and full event logging.

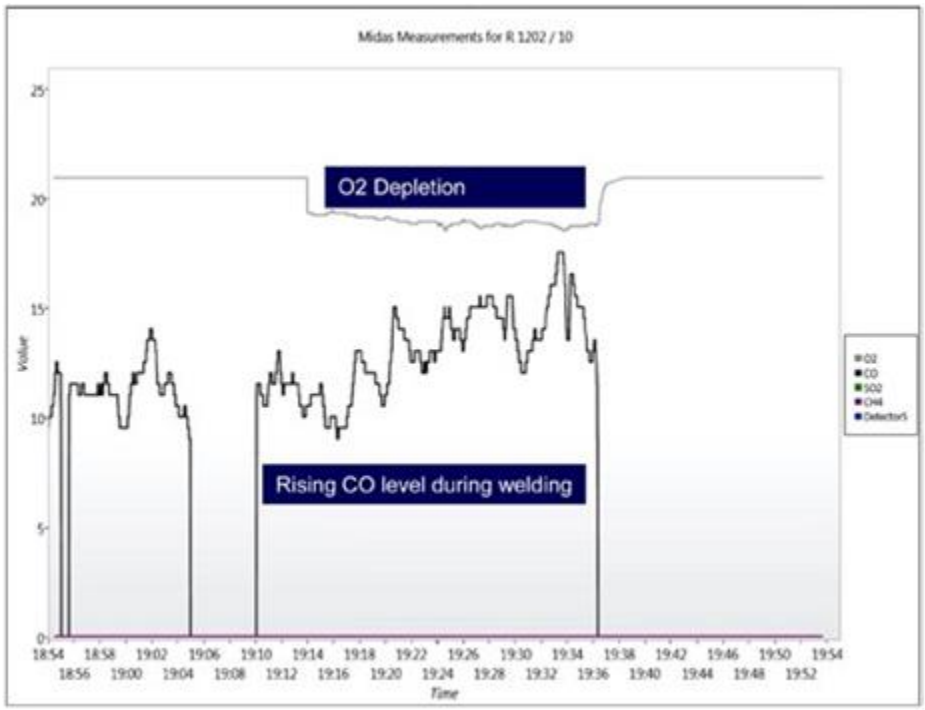


Figure 1.1—The Centralized Confined Space Monitoring System allows for real-time, continuous atmospheric monitoring, allowing the operator to be aware of any potential hazards at any given moment.

7. The system meets or exceeds all requirements and standards for CSA- and UL-Approval. The units manufactured in the United States meet the same standards as UL-Approval, and a formal application process is underway.
8. Liters per minute
9. Up to 3 mega-pixels
10. Since infrared radiation is emitted by all objects above absolute zero, according to the black body radiation law (which states that as long as the temperature of an object is greater than absolute zero [on the Kelvin scale], the object's atoms have thermal energy and can radiate), thermography makes it possible to see one's environment with or without visible illumination.

Communications/Observation

The Centralized Confined Space System technology allows for constant visual monitoring of the worker(s) inside the permit space, as the cameras can be easily moved as the workers move within the space, increasing visibility of potential distress or injury that a traditional attendant might not—and rarely can—see (Figure 1.2). One or more dual-lens, high-resolution[9] cameras can be set-up within the confined space, as well as one outside the confined space to monitor the entrance. In addition, the camera offers day-and night-vision through infrared (IR) imaging[10], full event- and datalogging and storage intervals configurable to the customer's specifications. The control room utilizes visualization software to centralize, analyze, and report all incoming data through one video wall and two system servers.

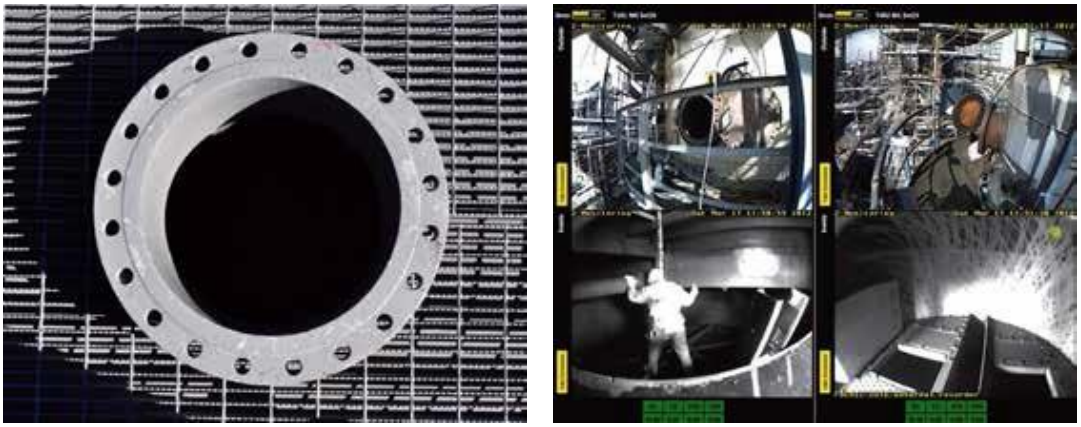


Figure 1.2 - The image on the left shows what the traditional safety attendant sees when looking inside the confined space, making it difficult to observe the worker(s) within the space. By comparison, the image on the right shows what the operator of the Centralized Confined Space Monitoring System sees—real-time video inside the confined space.

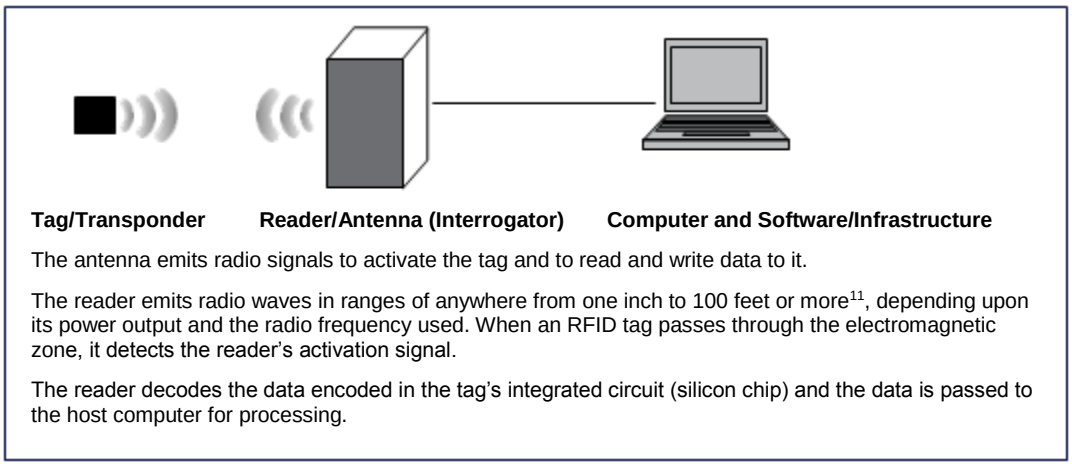
If a near miss or incident is seen or if the conditions of the space become hazardous, the control room notifies appropriate personnel, either inside or outside the confined space, for action to be taken. This is in addition to the rotating safety attendant nearby that can immediately be sent to the specific location. In the event that an alarm should be sounded, the control room will activate any applicable audible and visual alarms. In addition, the gas detection system can trigger an alarm, alerting appropriate workers.

The control room is also conducive to better communication between the worker(s) within the permit space and outside personnel. If noise is present, the push-to-talk intercom is available for more efficient communication. In addition, in the event of an alarm, audible and visual alarms are activated inside and outside the space to alert workers who might not be able to hear the alarm.

Recordkeeping

The Centralized Confined Space Monitoring System utilizes radio frequency identification (RFID) technology to maintain accurate real-time headcounts of workers who enter or exit the confined spaces(s) (Figure 1.3), making it ideal for situations involving evacuation or emergency response. RFID "is a generic term that is used to describe a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves… [and is] grouped under the broad category of automatic identification technologies," (Association of Automatic Identification and Mobility, "Radio Frequency Identification").

Figure 1.3—What is RFID Technology?



Association of Automatic Identification and Mobility, "RFID 101"

Each worker is given a personalized active RFID badge that has a standard maximum "reading" distance of 3 feet and an optional "long range" distance of 16 feet. The point-to-point (PTP) or point-to-multipoint (PTMP) data transmission between badge readers is ensured by a fully-secured and 128-bit-encrypted RS485/ETH network. This type of network can be used effectively over long distances and in electrically noisy environments, making it ideal for industrial environments and similar applications, and allows for the possibility of creating different zones, access levels and user profiles (up to 10,000 users). The ability to now store this data aptly and electronically takes future records to a whole new level.

Furthermore, the Centralized Confined Space Monitoring System allows for not only more accurate records, but more intelligent records. Through the use of video surveillance, the system can be designed to record the footage for later analysis, allowing for verification of occurred events, as well as review for potentially hazardous trends.

Safety Personnel

Though the Centralized Confined Space Monitoring System may not create a safe environment for workers, it does increase the likelihood that any hazardous conditions are recognized, as well as streamline the notification of emergency response, increasing the likelihood of survival.

Total Safety's Centralized Confined Space Monitoring System does not replace the human element—that would never be suggested—but instead supplements human capabilities in critical areas that humans are more prone to error or, in the case of direct visual contact, simply impossible. As discussed, alongside the technology, Total Safety provides trained operators that monitor the control center and rotate to the field to oversee and maintain the installed equipment: a more symbiotic relationship between man and technology.

11. Note that the Centralized Confined Space Monitoring System has the option to extend to 16 feet, though RFID technology will allow for greater distance.

Table 4 compares the required U.S. OSHA duties of the attendant with the features of the Centralized Confined Space Monitoring System. As noted below, in all cases, the requirements are met or exceeded.

Table 4—Traditional Attendant Duties Versus Centralized Confined Space Monitor Duties

Traditional Attendant Duties Required by OSHA	Centralized Confined Space Monitor Duties
Knows the hazards, including information on the mode, signs, symptoms, and consequences	Monitored by trained control room operators. Each person receives 32 hours of training.
Is aware of possible behavioral effects if authorized entrants are exposed to hazards	Monitored by trained control room operators
Continuously maintains an accurate count of authorized entrants and name identification	Monitored by access badge reader and printout of names on monitor screen
Remains outside the confined space until relieved by another attendant	Central control operator stays in contact (visually and orally) via inside and outside cameras and intercom
Communicates with authorized entrants to monitor entrant status and order entrants of need to evacuate	Central control operator stays in contact (visually and orally) via inside and outside cameras and intercom
Monitors activities inside and outside the space to determine if it is safe for entrants to remain in the space and orders the authorized entrants to evacuate immediately under any of the following: • If attendant detects a prohibited condition • If attendant detects the behavioral effects in an authorized attendant • If attendant detects a situation outside the space that could endanger the authorized entrants	• Continuously monitored • Continuously monitored via inside and outside cameras • Monitored by outside camera and outside operator
Summon rescue and other emergency services as soon as attendant determines that authorized entrants may need assistance to escape the hazards	Control room operator immediately calls fire/rescue teams
Takes the following actions when unauthorized persons approach or enter a space while entry is underway: • Warn the unauthorized persons that they must stay away from the space • Advise the unauthorized persons that they must exit immediately if they have entered the space • Inform the authorized entrants and entry supervisor if unauthorized persons have entered the space	Control room operator notifies via outside and inside intercom systems in all three situations. Outside technician will also intervene.
Performs non-entry rescues as specified by the rescue procedure	Outside technician will not enter the space for rescue; attendant will perform non-entry rescue efforts and control room operator will summon fire/ rescue teams
Performs no duties that might interfere with the attendant's primary duty to monitor and protect the authorized entrants	Control room operator continuously monitors entrant duties on TV monitors. Rotation every 2 hours to maintain alertness.

This technology does not replace traditional attendants. It serves to accompany technicians trained in its operations; however, by centralizing the “watch” aspects of the attendant, the number of needed attendants is decreased, thereby, decreasing the number of potential incidents as the number of workers present will be reduced.

Conclusion

Working in hazardous environments does not come without risks, yet it is evident that, even though a facility might meet Federal requirements, incidents, and fatalities are occurring to too many workers. In fact, “OSHA regulations like the Confined Spaces in General Industry rule are often aged and may not reflect the latest developments in occupational safety,” (MSA, 8).

Safety has to start at the top of the organization—with the company’s leaders, and if a company refuses to stand behind the safety of its workers, then industry will only continue to make the same mistakes and potentially risking the lives of more workers. If moral consequence is not enough to persuade, then the realization must be made that “in the current legal environment, liability can be assigned based on failure to follow the highest and best available protection regardless whether the knowledge is available from regulations or standards,” (MSA 8).

Much more research needs to be conducted to fully understand what at-risk behaviors occur within the permit space, and while the Centralized Confined Space Monitoring System will certainly not solve the mystery, it does allow experts and employers to examine a greatly unexplored topic. The system has been designed to play a critical role in the safety of those who work within confined spaces.

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U.S. Chemical Safety and Hazard Investigation Board (USCSB). *Case Study: Confined Space Entry— Worker and Would-be Rescuer Asphyxiated, Valero Energy Corporation.* Report No. 2006-02-I-DE. 2006. Print.

Additional Resources

Safety and Health Topics—Confined Spaces

This section highlights OSHA standards, directives (instructions for compliance officers), standard interpretations (official letters of interpretation of the standards), and national consensus standards related to confined spaces.

http://www.osha.gov/SLTC/confinedspaces/index.html

Worker Deaths in Confined Spaces

NIOSH Publication No. 94-103 (January 1994)

This publication provides a summary of surveillance findings and the full text of 70 investigative case reports from 70 incidents in which 109 workers died. These incidents and investigations occurred between December 1983 and September 1993.

http://www.cdc.gov/niosh/docs/94-103/

Division of Occupational Safety and Health (DOSH)—Confined Space Emphasis Program

California Department of Industrial Relations. “Permit-Required Confined Spaces,”T8CCR §5157

http://www.dir.ca.gov/Title8/5157.html

Appendix A

Characteristics of Cases Included as "Confined Space Related"

As found in NIOSH's Criteria for a Recommended Standard: Working in Confined Spaces

Ref No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
1	Atmospheric Condition in Confined Space	Toxic levels in confined space of substances: • Contained in confined space • From decomposition of substances in confined space • From mixture of substances in confined space • Substances being used in confined space, e.g. cleaning solvents • Vapors left from left previously emptied confined spaces • Welding fumes Oxygen deficiency, due to: • Fermentation • Rust • Use of other gases, e.g., nitrogen to clear combustible gases • Welding is confined spaces Includes cases in which the employee was at the point of entry to the confined space (e.g., leaning into confined spaces to measure) and was overcome. Includes allergic reactions to substances inhaled. Note: all cases involving mining, tunneling are excluded. Includes falls and other accident types even if the employee was outside the confined space before he fell, if, and only if, they were the result of being overcome by atmospheric conditions. Examples: employee was sitting in top silo and was overcome by gas from fermenting corn and fell into silo; employee fell from ladder, when he was overcome by gas in confined space; employee drowned when he was overcome by gas and fell into 12-inch deep water in confined space.	Falls or other types which are not the result of hazardous atmospheric conditions, e.g. due to surface condition of confined spaces, are covered under other Accident Types such as Ref. No. 8.

2	Explosion or Fire in Confined Space	Only includes cases in which one or more victims were in the confined space at the time. May be able to identify a spark-generating activity that occurred in confined space, e.g., • Dip testing tank • Welding • Electrical tools • Light bulbs • Matches Usually the result of a combination of combustible gases in confined space and spark from activity of employee in confined space.	Cases in which a confined space exploded but no victim was inside. Cases in which the confined space exploded for "no apparent reason" or a reason not connected with the activities of those in the confined space.
3	Explosion or Fire at Point-of-Entry of Confined Space	Cases in which an employee was welding, using a power tool, or some other spark- generating activity at the entry point to the confined space. Driving an automobile near a confined space containing combustible materials.	Cases in which the confined space exploded for "no apparent reason" or for a reason unconnected with the activity of the employee near the confined space, e.g., "just walking by and it blew up." Cases in which the employee was welding (or performing some other spark-generating activity) on a confined space that was too small for, and would almost certainly never be used to contain an employee, e.g., 55-gallon oil drums. Welding drums contain flammable liquids or left over vapors in an extremely common cause of fatalities, and has causal factors similar to confined space-related cases were not typical of the problem NIOSH is addressing.
4	Electrocution or Electrical Shock	Must appear to be result, at least in part, of the confined space. Frequently the result of conductive walls of the confined space.	Cases in which an electrically "hot" source just happened to be in a confined space, e.g., "I picked up a cable with a frayed wire."

5	Caught in/Crushing of Confined Space	Cases in which an employee enters a machine and failed to "lock-out." A machine is activated and the employee is crushed inside the machine. The victim must be inside a machine which it was intended that he should enter and he must have entered deliberately. Elevator shafts, or cases in which the employee was on top of an elevator and crushed in the "confined space" when it was elevated. Examples of such machines include rock crushers.	Cases in which the machine is too small for the employee to ever place his entire body inside, e.g., caught in conveyor gears. Cases in which the employee was under (not in) a machine or machine part. In particular, being trapped under a vehicle, e.g., when the jack slips or under a falling bed of a dump truck are not included. Cases in which the employee is drawn into the machine. Elevator injuries if person is inside the elevator. Falls into machines.
6	Trapped in Unstable Materials in Confined Space	"Quicksand" effect of standing in silos containing fine grain or beans. Employee must have been in confined space before the surface gave way, e.g., unjamming blockage or intentionally stepped into confined space with unstable surface material.	Falls into confined space containing such the result of atmospheric conditions (Ref. No. 1).
7	Struck by Falling Objects in Confined Space	Employee is struck by objects falling from walls of confined space or through point of entry of confined space. Related in that employee is unable to maneuver to safety in confined space. Includes being suffocated when a confined space is accidentally filled while the employee is in it.	(Eye injuries are covered in Ref. No. 11) Does not include cave-ins of trenches as these have not been considered to be confined spaces.
8	Falls (While in Confined Space)	Only to employee in confined space due to surface condition, e.g., wet, oil; configuration, e.g., a rolling barrel; or other characteristics of the confined space. Falls through holes in or breaking part of confined space, e.g., employee goes through weak part of ventilation duct as he crawls through it. Falls over objects or tools, e.g., holes, on floor of confined space when it is not possible to locate elsewhere. Falls due to poor lighting in confined space. Falls due to uneven surface of confined space.	Falls in confined space, e.g., uncovered manhole. Atmospheric conditions of confined space. Falls into confined space where no characteristic of the confined space was involved. (Falls while leaving or entering the confined space are covered in Ref. No. 9.)

9	Ingress/Egress	Strains, bodily reactions, abrasions, or falls as the result of entering or leaving a cramped, sharp-edged, high-level, or otherwise hazardous point-of-entry to a confined space.	(Must be a bonafide confined space, e.g., ingress/egress of vehicle cabs, though subject to similar hazards, are not included because they are not a confined space.)
10	Insufficient Maneuver	Strains, bodily reactions, abrasions, contact with caustic substances, etc. when they are in part the result of attempting to maneuver in a confined space. Includes striking self or being struck by fellow employee as the result of a confined space. Low head room, e.g., striking head.	Cases of insufficient space when the employee is working under a machine (even though cramped), because these are not considered a confined space.
11	Eye injury in Confined Space	From dust falling from walls of confined space, generated by activity in confined space, or materials in confined space. Welding arc when unable to use face shield because of confined space.	
12	Contact with Temperature	Burns or scalds from hot steam discharged into confined space. Heat exhaustion of frost bite from temperature of confined space.	

Appendix B

Centralized Confined Space Monitoring System Components

Automatic Access Control

- Personalized active RFID tokens
- Maximum reader/tag distance:
- Standard – 3 feet
- Long range – up to 16 feet (upon request)
- Data transmission between badge readers on different levels is ensured by RS485/ETH network
- Headcount information available real-time in case of emergency
- Possibility to create different zones, access levels and user profiles up to 10,000 users

Fixed Gas Detection

- Standard configuration: O_2 , LEL, H_2S, CO
- Up to 40 different gases possible (upon request)
- 1 optional sensor possible: PID/dust/temperature/humidity
- Sample draw gas detection system
- Continuous flow control in sampling system (2 LPM)
- Full event logging
- CE and UL approved

Camera Monitoring

- 1 or more camera(s) inside the confined space
- 1 camera outside the confined space to monitor the entrance
- Dual lens, high-resolution cameras (up to 3 MP)
- Day and night operation via IR imaging
- Full event and data logging in camera
- PoE (Power over Ethernet) - no extra power cables needed
- Storage interval fully configurable to customer's specifications

Antennas

- Wireless data transmission (PTP or PTMP)
- Fully secured and 128-bit encrypted data transmission
- In accordance with RFI standards and, therefore, immune to in-plant data/control systems
- Uses 5.4 - 5.8 GHz band (16 channels)

Communications and Alarming

- Push-to-talk communications system
- Full duplex system
- Visual and audible alarm inside and outside the confined space
- Activated locally and automatically by the gas detection system or remotely by the operator
- First alarm level = flashing light
- Second alarm level = siren

Appendix C

Definitions of Terms Pertaining to Confined Spaces

As found in OSHA 29 CFR 1910.146(b)

Acceptable entry conditions means the conditions that must exist in a permit space to allow entry and to ensure that employees involved with a permit-required confined space entry can safely enter into and work within the space.

Attendant means 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 means an employee who is authorized by the employer to enter a permit space.

Blanking or blinding means the absolute closure of a pipe, line, or duct by the fastening of a solid plate (such as a spectacle blind or a skillet blind) that completely covers the bore and that is capable of withstanding the maximum pressure of the pipe, line, or duct with no leakage beyond the plate.

Confined space means a space that:

1. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
2. Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry.); and
3. Is not designed for continuous employee occupancy.

Double block and bleed means the closure of a line, duct, or pipe by closing and locking or tagging two in-line valves and by opening and locking or tagging a drain or vent valve in the line between the two closed valves.

Emergency means any occurrence (including any failure of hazard control or monitoring equipment) or event internal or external to the permit space that could endanger entrants.

Engulfment means the surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.

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

Entry permit (permit) means the written or printed document that is provided by the employer to allow and control entry into a permit space and that contains the information specified in paragraph (f) of [the standard].

Entry supervisor means the person (such as the employer, foreman, or crew chief) 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 required by this section.

NOTE: An entry supervisor also may serve as an attendant or as an authorized entrant, as long as that person is trained and equipped as required by this section for each role he or she fills.

Also, the duties of entry supervisor may be passed from one individual to another during the course of an entry operation.

Hazardous atmosphere means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:

1. Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL);
2. Airborne combustible dust at a concentration that meets or exceeds its LFL;
   NOTE: This concentration may be approximated as a condition in which the dust obscures vision at a distance of 5 feet (1.52 m) or less.
3. Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;
4. Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substances, of this Part and which could result in employee exposure in excess of its dose or permissible exposure limit;
   NOTE: An atmospheric concentration of any substance that is not capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision.
5. Any other atmospheric condition that is immediately dangerous to life or health.
   NOTE: For air contaminants for which OSHA has not determined a dose or permissible exposure limit, other sources of information, such as Material Safety Data Sheets that comply with the Hazard Communication Standard, section 1910.1200 of this Part, published information, and internal documents can provide guidance in establishing acceptable atmospheric conditions.

Hot work permit means the employer's written authorization to perform operations (for example, riveting, welding, cutting, burning, and heating) capable of providing a source of ignition.

Immediately dangerous to life or health (IDLH) means any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual's ability to escape unaided from a permit space.

NOTE: Some materials -- hydrogen fluoride gas and cadmium vapor, for example -- may produce immediate transient effects that, even if severe, may pass without medical attention, but are followed by sudden, possibly fatal collapse 12-72 hours after exposure. The victim "feels normal" from recovery from transient effects until collapse. Such materials in hazardous quantities are considered to be "immediately" dangerous to life or health.

Inerting means the displacement of the atmosphere in a permit space by a noncombustible gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible.

NOTE: This procedure produces an IDLH oxygen-deficient atmosphere.

Isolation means the process by which a permit space is removed from service and completely protected against the release of energy and material into the space by such means as: blanking or blinding; misaligning or removing sections of lines, pipes, or ducts; a double block and bleed system; lockout or tagout of all sources of energy; or blocking or disconnecting all mechanical linkages.

Line breaking means the intentional opening of a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic material, an inert gas, or any fluid at a volume, pressure, or temperature capable of causing injury.

Non-permit confined space means a confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

Oxygen deficient atmosphere means an atmosphere containing less than 19.5 percent oxygen by volume.

Oxygen enriched atmosphere means an atmosphere containing more than 23.5 percent oxygen by volume.

Permit-required confined space (permit space) means 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; or
4. Contains any other recognized serious safety or health hazard.

Permit-required confined space program (permit space program) means the employer's overall program for controlling, and, where appropriate, for protecting employees from, permit space hazards and for regulating employee entry into permit spaces.

Permit system means the employer's written procedure for preparing and issuing permits for entry and for returning the permit space to service following termination of entry.

Prohibited condition means any condition in a permit space that is not allowed by the permit during the period when entry is authorized.

Rescue service means the personnel designated to rescue employees from permit spaces.

Retrieval system means the equipment (including a retrieval line, chest or full-body harness, wristlets, if appropriate, and a lifting device or anchor) used for non-entry rescue of persons from permit spaces.

Testing means the process by which the hazards that may confront entrants of a permit space are identified and evaluated. Testing includes specifying the tests that are to be performed in the permit space.

NOTE: Testing enables employers both to devise and implement adequate control measures for the protection of authorized entrants and to determine if acceptable entry conditions are present immediately prior to, and during, entry.

Appendix D

Permit-required Confined Space Roles and Duties

As found in Steel Tank Institute's *Fact Sheet: Safety Tank Entry When Entering Aboveground Storage Tanks (in Service)*

Entry supervisor – the person (such as an employer, foreman, or crew chief) responsible for determining if acceptable entry conditions are present at a permit-required confined space where entry is planned, for authorizing entry and overseeing entry operation, and for terminating entry as required by 29 CFR 1910.146.

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

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

Rescue services – the personnel designated to rescue employees from a permit-required confined space.

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