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Confined Spaces: Managing Unseen Hazards

By Dave Kuiawa

What lurks in the confined areas that your workers enter everyday?

They can be tight with little room to operate; they can be wide open. They can be damp; they can be dry. They can be oppressively hot; they can be extremely cold; or they even can be climate controlled. They can be well lit; they can be dark. They can be filled with liquid or they can be energized. They can be virtually any size, shape, or configuration and can contain any number of physical and gas hazards.

These statements describe the classic confined space, and while most individuals can recognize the dangers of moving parts, live electrical circuits, rising liquid levels, and temperature concerns, often the unseen hazards go unchecked and pose the greatest danger.

Definition of a Confined Space

In 29 CFR Part 1910.146, OSHA describes a confined space as an area that has limited openings for entry or exit, is not designed for continuous worker occupancy, has poor natural ventilation, or has the potential to contain a hazardous atmosphere. The last one is the "catch all." A hazardous atmosphere can manifest itself in many ways. The most dangerous are hazards that occur as a result of gases in the atmosphere. Gas hazards are often unseen and have no scent, so they are undetected, sometimes with disastrous consequences.

Confined Space Hazards

According to OSHA statistics, asphyxiation is the number one cause of death in a confined space. In an effort to protect against deaths and injuries in confined spaces, OSHA mandates that all confined spaces be evaluated prior to and continuously during entries with a calibrated, direct reading gas monitor containing the following sensors; oxygen, combustible gas, and any applicable toxic gas. Gases must be evaluated in four-foot intervals in every direction of travel.

Continuous Monitoring

Once the space is determined "safe" for entry, it must be monitored continuously during occupancy to protect workers against changes in the atmosphere. Often, the work itself can liberate gas hazards that were not detected during the initial assessment of the confined space. Some examples of this can be power washing, cutting, welding, grinding and opening of process lines.

In reviewing OSHA's definition of a calibrated, direct reading gas monitor, it is apparent that the words were chosen carefully to leave little room for error. By calibrating a gas monitor prior to entry, the worker ensures that the instrument is capable of accurately monitoring the target gases of concern.

Calibration

Calibration is accomplished by introducing a certified, known concentration of bottled or generated gas, at a fixed flow, for a fixed duration. The instrument is then adjusted so that the display mirrors the gas concentration. This can be accomplished either manually or through an automated calibration system. Records for each gas monitor calibration need to be documented and retained for reference as evidence of compliance with the standard.

Photo courtesy of Industrial Scientific Corp., Oakdale, Pa.

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Monitoring for Oxygen

OSHA further stipulates that confined spaces be monitored for oxygen content, combustible gases and applicable toxic gases. Initially, oxygen is the target gas, because all living creatures need oxygen to breathe. Oxygen is measured in percent by volume, and normal atmospheric air contains approximately 20.9 percent of oxygen by volume.

If the oxygen concentration changes significantly by increasing or decreasing, the results can be catastrophic. On the reduction side, the effects are obvious. If oxygen decreases, we have less to breathe and therefore cannot function. OSHA has set the minimum acceptable level of oxygen at 19.5 percent by volume. While most gas monitors have adjustable alarms, they need to be set to 19.5 percent on the low side so workers are alerted when the atmosphere is unsafe to breathe. With oxygen below 19.5 percent, a worker's breathing becomes labored; he or she can become light headed, impaired, and at extremely low levels, even die.

If too little oxygen is a bad thing, then an excess of oxygen would be good, wouldn't it? This is a common misconception about confined spaces. OSHA further establishes an upper limit for oxygen at 22.5 percent by volume. The main reason for the upper limit is that excess oxygen enhances combustion.

While not combustible itself, excess oxygen can propagate a flame. One common example of this is the oxy/acetylene torch. When the acetylene line is ignited, the flame is feathery and not intense. Once the oxygen is turned on and the mixture burns, the flame is much more intense and cutting can take place. The same scenario can happen in the atmosphere. Materials that normally do not burn in the presence of excess oxygen will go up like a tinderbox.

In addition, oxygen concentration is monitored because most catalytic combustible gas sensors are dependent upon it for proper operation. This is the main reason why combustible gas is always monitored in conjunction with an oxygen sensor. Catalytic combustible gas sensors actually burn the gas they are monitoring so without a minimum level of oxygen, usually 10 percent by volume, they will not function properly.

Combustible Gases

The reasons for monitoring for combustible gases are apparent. If combustible gases were to ignite, the harm to occupying workers would be extreme. Combustible gases are measured in a unit called percent of the lower explosive limit (LEL). This is a measure of the combustibility of the atmosphere. If an environment contains gases that are 100 percent of the LEL, an explosion could take place. As an example, a reading of 50 percent LEL would have half of the gas needed for an explosion.

Naturally, combustion cannot take place without the other elements of the fire triangle, an ignition source and oxygen. To protect workers from combustible gas hazards, OSHA has established a limit of 10 percent LEL. While this is a very conservative level, OSHA points out that if just 10 percent of the lower explosive limit is realized, then there is a gas source present and changes to the environment could occur abruptly.

Evaluating Specific Industries for Hazards

The industry-dependent portion of gas hazard monitoring is the toxic gas family. Because there are thousands of processes and operations in modern industry, these gases could be anything from ammonia to hydrogen cyanide to chlorine. Further understanding of the process in a specific industry is necessary to determine the sensor or sensors required to adequately protect workers in a specific environment.

General Industry

The two most toxic common gases for general industry are carbon monoxide and hydrogen sulfide. Because of the high toxicity of this family of gases, the unit of measurement is different and more precise. For toxic gases, OSHA stipulates monitoring in parts per million (ppm). This is literally defined as one part out of one million possible parts, obviously a very small level.

Carbon monoxide is a by-product of combustion and is the most common toxic gas. Carbon monoxide can be found in general industry as a result of cutting, grinding, generating, or burning, just to mention a few. The employee exposure level for carbon monoxide is just 35 parts per million and most gas monitors are manufactured with a default alarm setting at 35 ppm.

Carbon monoxide is termed a toxic asphyxiant because it enters the blood stream via the lungs and combines with hemoglobin robbing the body of oxygen (the asphyxiant) and replacing it with carbon monoxide (the toxic portion). In high doses, carbon monoxide can cause impairment, headache, nausea and even death.

Hydrogen sulfide is a bit different in that it is a neurotoxin, meaning it affects the central nervous system. When inhaled, hydrogen sulfide can cause paralysis of the lungs and other organs with catastrophic results. Hydrogen sulfide can be detected at low levels by its characteristic "rotten egg" odor. Unfortunately, when it is most dangerous, at higher concentrations, it is undetectable by smell.

A by-product of decomposition, hydrogen sulfide, is most commonly found in water and wastewater applications and in the oil and gas industry. Because of hydrogen sulfide's neurotoxic effects, OSHA has established an employee exposure level of just 10 parts per million.

Stratification of Gases

Understanding the gas hazards is one aspect of a safe confined space program. Understanding how these gases behave and stratify is the basis for OSHA's mandate to monitor gases in four-foot increments in every direction of travel. Stratification is a natural event that occurs because some gases are heavier than others. If left in a stagnant condition, gases will gravitate toward the top and/or bottom of a space. If you only monitor a single level within a confined space, determine it to be safe and then enter, you may ultimately "stir up" the gases that have stratified resulting in an unsafe condition.

Conclusion

When approaching a confined space, it is best practice to position yourself at a safe distance and utilize a mechanical sampling pump in conjunction with a rigid or flexible probe. Use the probe to thoroughly evaluate the space in four-foot increments, allowing ample time for the pump to deliver the sample and for the instrument to react.

Confined spaces can be unforgiving places to work, but unfortunately, periodic entry is necessary. A systematic approach to each and every entry will go a long way to ensuring workers are safe from entry to egress. Planning, preparation, and training are the keys to ensuring safe passage in these varied environments. **CM**

Dave Kuiawa is the sales manager, North/South America for Industrial Scientific Corp. Contact him at (800) 338-3287; dkuiawa@indsci.com.