Confined spaces: the devil's snare.

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On March 8, 1984, two workers entered a 66-in.-dia sewer line that was under construction. Their mission: to refuel a gasoline-engine-powered pump, which was being used to remove water from the line. The pump was about a half mile from where the workers had entered. One of the workers died from carbon monoxide poisoning; the coworker escaped. But a state inspector who entered from another point along the sewer line died in a rescue attempt.

Sadly, this sort of event happens too often. And the vast majority of such events within the water and wastewater fields occur among companies having fewer than 100 people. It painfully demonstrates a lack of regard within small to moderate-sized utilities for one or more of the following cardinal rules for averting the death and mishaps that lurk in confined spaces:

> *Sadly, [small-water-utility-worker death in confined spaces] happens too often...[and] painfully demonstrates a lack of regard...for one or more...cardinal rules*

- Identify confined spaces for what they are.
- Never enter a confined space without being authorized, suitably trained, and equipped.
- Never, ever, attempt to rescue someone from a confined space without suitable backup.

Recognizing confined spaces

There is no standard definition of a confined space. But, by consensus, a confined space is one that is not intended for continuous employee occupancy and that presents one or more of the following hazards:

- The potential for contaminated air
- Difficult egress or ingress
- The risk of engulfment
- The risk of entrapment

Confined spaces include manholes and storage tanks—even tanks without covers. A space is deemed "confined" because the person(s) who enters loses (at least some) ability to respond to or avoid or escape danger. The primary danger in a confined space is asphyxiation, but mechanical hazards and the potential for explosion are others.

Taking notice

Only a fool underestimates the kill potential of a confined space. Consider: (according to data gathered in the late '70s and early '80s) 65 percent of those who die in confined spaces have no concept of the danger they face. More than half who die in confined spaces are would-be rescuers; more than one-third of confined-space fatalities occur after the space has tested safe for entry.

No one entering or having entered a confined space should forget the precariousness of the situation. There's no room for horseplay, chance taking, or "overstaying your welcome."

The U.S. Occupational Safety and Health Administration (OSHA) in its proposed confined-space standard of 1989 identifies two types of confined spaces: high- and low- hazard permit spaces. The difference between the two is that low-hazard spaces present little danger from asphyxiation, combustion, or engulfment.

OSHA's confined space regs would have employers inventory their workplaces, and (except for those that are construction areas) identify "permit spaces." These spaces would then be permanently blocked or posted with signs that warn the employee from entering. Before asking any employee to enter, employers would have to develop a written program for identifying the hazards in that permit space, restricting access only to authorized personnel, and controlling the hazards. In addition, for high-hazard spaces, the employer would be required to provide an attendant to monitor workers while they are entering, occupying, and leaving the space.

> *A present danger for the person entering a confined space is an inadequately tested space*

Dealing with confined spaces

The safest way of dealing with a confined space is not to enter it. Certainly, employees with no business in confined spaces should never enter one, and education, permitting procedures, signs, and electric lockouts can reduce unauthorized, inadvertent, or foolhardy entry.

There are, however, times when entering a confined space is unavoidable. For these situations, the most that can (and should) be done is to maximumly reduce the danger through procedures and rigorous training.

Conditions should be made as favorable as possible for the employee before the employee attempts to enter. No employee in poor health should be authorized for entry. No employee without the proper training should be authorized for entry. All employees authorized for entry should have received suitable vaccinations (against tetanus, hepatitis, rabies, and other diseases that one might contract from the confined space). All employees authorized for entry should be suitably equipped for entry, including proper protective clothing, safety gear, functional (and functioning) gas detectors, and communications equipment. The space should hold fail-safe warning devices (to, for example, audibly warn of ventilation failure). The area around the confined space should be cleared of any objects that conceivably could topple into the space. Trenches should be suitably shored. The space should be electrically secured to ensure against sparked-caused fire or explosion.

Entry into a confined space should be by permit only. The permit should specify the type of work and where it is to be done, list known and suspected hazards and remedies or countermeasures, and be signed by a qualified supervisor.

Physical hazards

The physical hazards in confined spaces include falling, bumping, drowning, touching hot or otherwise dangerous objects (such as moving equipment), and getting hit by falling objects. The use of suitable gear (hoists and harnesses) and the wearing of suitable garments (hard hats, steel-lined boots, protective eyewear, earmuffs, gloves, and other gear as the situation warrants) can go a long way to reducing punctures, scrapes, and contusions. Awareness and prudent care (in following safe work practices) can help minimize other physical injury. This includes standing clear when tools are being lowered (in a bucket) into the confined space. The employee entering a confined space via its ladder should look for handrails and be alert for loose, deteriorated, or missing rungs or possible clutter on any rung. If the employee is to be lowered into the confined space, all parts of the safety harness should be checked for integrity and functionality. The worker's lifeline should be able take the tension applied to it during the rapid evacuation of the worker turned victim.

Atmospheric danger

Only the senseless trust to their own senses. Confined-space-atmosphere dangers are far from obvious. Where they are, reaction time may be insufficient. Noses can't substitute for gas detectors. (Most gases that water or wastewater employees are likely to encounter are odorless; and the nose quickly desensitizes to those gases that do have odor.)

The greatest danger facing the person entering a confined space is a lack of oxygen. Several breaths of an atmosphere holding less than 6 percent oxygen can disable in seconds and can kill in minutes. Either the volume percent of oxygen can be too little (less than 19.5) or other gases (such as carbon monoxide) in the confined space may interfere with the body's uptake of an otherwise sufficient supply. Oxygen deficiency can also debilitate sensors: Thus a space with very low oxygen levels can't be tested for combustible gases since standard instruments for this purpose require oxygen to function. (The sensor actually attempts to ignite a sample of the atmosphere and can't do so when the fuel/oxygen ratio is too high.)

A present danger for the person entering a confined space is an inadequately tested space: Gases may drift from the area where one would expect them to be. Heavier-than-air gases, which settle, may elude detection until they are agitated and dispersed by someone in the space. The tester may give less time than needed (which often may be more than a minute) to draw samples from the space and into the detector. The gas detector may be inadequate because it is wrong (antiquated or mismatched) for the job, improperly calibrated or used, undercharged, or too "numbed" by the cold or radio interference. (Use of instruments with plastic cases is ill-advised where radio waves abound. Mixing tubes and pumps from manufacturers of different tube-type detectors can skew readings. And contrary to conventional wisdom, keeping detectors on near-constant trickle charge for long periods can hobble performance.)

Gas detectors that serve to give a running account of confined-space air quality should provide continual readings of oxygen content, lower explosive limit (LEL), carbon monoxide, and one other gas (depending on the other gas likely to be present). Instruments that test for one or two contaminants are passé. An acceptable instrument should offer fail-safe readings, be rugged and simple, and be cost effective.

The importance of order

It's important to establish the safety of a confined-space atmosphere in a deliberate, routinized way. The first gas to check for is oxygen; it should constitute 19.5 to 23 percent of the atmosphere, by volume. A bit too little oxygen can affect a worker's ability to concentrate. Too little can cause dysfunction. Much too little can cause death— in seconds. On the other hand, too much oxygen can create an overly flammable situation.

The only safe assumption about a confined space is that Murphy's law prevails. (Whatever can go wrong will.)

Where the oxygen level is less than the acceptable lower bound, ventilate. Where ventilation doesn't do the job, provide workers with a separate source of clean, safe air.

Next, check for combustible gases. Most gases are combustible; however, many, such as carbon monoxide and hydrogen sulfide are toxic at levels well below those required for combustion.

Next, check for carbon monoxide or hydrogen sulfide if either is likely to be in the space.

Last, test for other suspected gases or vapors that may be associated with the space.

During all gas testing, samples should be taken at all levels of the confined space and at all areas within it for a time that is sufficient to ensure accurate sampling.

Testing of the atmosphere cannot be a once-a-day or once-a-shift practice. More than a third of all worker confined-space deaths has been caused by toxic gas, despite the atmosphere's having been certified safe prior to entry into the confined space at the start of the work shift.

911

Something's amiss when 60 percent of confined-space fatalities occur during rescue missions. Mostly this statistic suggests that rescue is a knee-jerk, desperate reaction to an emergency situation when it should be a well-conceived, cooly executed exercise undertaken only by experienced professionals.

Rescue procedures should be established before entry and should be specific for each type of confined space. No procedure can be written to contend with every contingency, so although procedures should be thorough, they should leave room for best-judgment calls by the rescue crew chief. However, no rescue should ever be attempted by anyone who is not authorized, trained, and well-drilled in the rescue procedures; who is not properly equipped for the task (lifeline, self-contained breathing apparatus, etc); or who is not suitably backed by others remaining outside the space.

OSHA would limit rescue efforts to teams who have been briefed with regard to the potential dangers in the space and who are properly trained and suitably equipped for the task. In addition, those supervising the entry into confined spaces must be trained to distinguish between acceptable and unacceptable conditions and recognize conditions for which occupancy should be terminated.

Remember

Only the naive assume conditions regarding a confined space. The only safe assumption about a confined space is that Murphy's law prevails. (Whatever can go wrong will.) Workers should never assume that the space that has tested safe will remain safe. Nor should they assume the reliability or worthiness of their safety equipment. Workers who lack an understanding of their equipment's operation and effectiveness are gravely disadvantaged. Without proper selection, strict maintenance, attention, and proper use, gas detectors can give false or deceptive readings; breathing apparatus can perform below rated capacity; and safety harnesses can become deadly shackles. Confined spaces deserve respect.

Standard operating procedures for working in confined spaces

Although only part of a total program for protecting workers in confined spaces, standard operating procedures (SOPs) help ensure worker safety. A checklist of SOPs to follow when preparing for, entering, and working in confined spaces should be developed for each confined space and should

- Identify the hazards of the confined space, listing all that are known or are conceivable—such as: "the floor is very slippery," or "air-quality conditions change rapidly due to flows that cannot be secured."
- Explain each step needed to isolate the confined space from: flows, moving machinery, potential gas sources, etc.
- List all: (1) valves that are to be locked out and chained; (2) breakers that need to be locked out and tagged; (3) any other devices that must be secured.
- Cover each step required to flush, ventilate, or otherwise ensure that all proper precautions have been taken for safe entry into, and for safe work in, the confined space.
- Identify all equipment and the methods used to test and monitor conditions before and during entry into and while working in the confined space.
- List the emergency or support services to be called, explaining how the communications are made and maintained with a third party.
- List all safety equipment required at the work site— and at the plant site, if needed.
- Identify the minimum safety equipment that each worker in the confined space and the top-side attendant must wear.
- Explain how the worker in the confined space and the attendant(s) will maintain effective communications—whether by visual means, by radio, or by other methods.
- Provide any other information whose inclusion is necessary to ensure employee safety. Examples are: time of day or week during which entry is permitted, mechanical-ventilation requirements, who-needs-to-know information, etc.

As earlier stated, the development of SOPs that take workers through the step-by-step process of securing their safety in confined spaces is only one of several key elements needed to address a comprehensive confined-space plan. Others include a common understanding by management and labor of the definition of terms; the writing of a manifest that identifies each confined space and any associate concerns that each may create; the development of an entry permit; and the training of employees with regard to handling standard and emergency situations.

These procedures were taken from the 1991 Pacific Northwest Pollution Control Assn meeting presentation, "Confined Space Management Plan," by Owen Boe of EOS, Vancouver, WA.

For All Your Gas Detection Needs

ENMET Corporation was founded in 1970 by Dr. Verne R. Brown to develop solid state electronic devices for health and safety applications. Today ENMET is a leading manufacturer of a variety of innovative hazardous gas and vapor detection instruments. In addition to the wide array of equipment offered, we also provide expert technical assistance ranging from problem assessment and product selection to advice on equipment installation and training. The ENMET product line includes toxic/combustible and oxygen level detectors, portable and continuous models, respiratory airline CO monitors, multi-channel systems, toxic gas detector tubes, and instructional video tapes. ENMET gas detectors are sold through a network of fully trained, service oriented safety equipment distributors located in all major industrial areas throughout the United States and Canada. ENMET products are also available worldwide.

ENMET Analytical Instrument Division supplies versatile and reliable state-of-the-art gas monitoring systems for detecting a wide range of toxic gases. Utilizing various types of electrochemical sensors, the instrumentation is available as single or multi-channel systems. These systems can be designed for a variety of unique applications and requirements. Over 50 gases can be detected, including, for example, chlorine, ozone, hydrogen fluoride, arsine, phosphine, nitrogen trifluoride, and many others.

Confined Space Safety

Dr. Verne R. Brown, founder and president of ENMET Corporation, is a frequent lecturer on confined space entry to safety and health groups throughout North America. Dr. Brown's popular confined space safety seminar is available for purchase on video cassette. The confined space safety seminar video package includes valuable reference material and covers a variety of confined space safety topics such as atmospheric hazards, safety standards, gas detection instruments and confined space safety program development.

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