



From the trenches

Creating a safety frame of mind

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For a well-rounded, versatile engineer, technical and regulatory expertise must always remain a core competency. However, understanding and appreciating elements of human nature, team building, safe workplace practices, undocumented tribal knowledge, and unconventional diagnostic methods are just as important. These elements can't be learned from books or most undergraduate courses. They will come from a blend of first-hand experience and memorable advice collected along the way.

In this series, some seasoned (and battle-scarred) professionals will try to ease the learning curve in collection system operations and maintenance for younger professionals by offering advice and insight based on real-life experiences.

It is very appropriate that safety is our first discussion topic for this new series. Many organizations begin meetings with a safety briefing. The speaker may review emergency exits and fire extinguisher locations, and even share handy facts and personal stories about near misses that may resonate with you and make a lasting impression for the better.

When you start a new job as an engineer, your employer will do the same – provide safety training. But, ultimately, you are responsible for your own safety while in the field. You are your own best safety advocate. You are the one who can make thoughtful planning and preparation for sewer system field work a lifelong habit, preventing your own injuries, someone else's injuries, or even worse tragedies.

Someone who has attained a professional position – be it in planning, engineering, construction, operations, or maintenance – should already possess a good measure of common sense and know when it should be exercised. But common sense is not enough when it comes to safety.

Safety regulations affecting the wastewater sector are extensive, expansive, and layered. Your employer should have an individual, department, or outside contractor with the responsibility and expertise to provide the safety training necessary for you to perform your job.

If you plan to work in the sewers, the training topics your employer should include are hazard communication, bloodborne pathogens, proper lifting, lockout–tagout, trenching and excavation, fall protection, respiratory protection, personal protective equipment (PPE), heat and/or noise exposure, and confined space entry. That last one, confined space entry (CSE), is the heart of sewer system investigation and evaluation work. Most of the time, it applies to manhole entry, where line-of-sight

is maintained over a very short distance. For those of us with larger collection systems, it can involve chambers, shafts, large diameter interceptors, and tunnels.

Taking proper precautions

We mentioned before that when it comes to safety training, personal stories may resonate with you. Here is an example.

Fifteen years ago, a 32-year-old engineer was preparing to replace a battery in a flowmeter temporarily mounted inside a manhole. The flowmeter strap had slipped off a retrieval wire and fallen down the manhole.

The manhole was newer, looked clean, had good rungs, and was only 2.23 m deep. As such, the engineer entered it briefly to get the meter. He complained about an odor, lost consciousness, and collapsed. His assistant immediately called 911 for help while an intern flagged down nearby responders. Emergency rescue crews were onsite within 4 minutes of the call. However, it took another 16 minutes before they could assess the situation, deploy their entry gear, don their PPE, and enter the manhole for rescue. By then it was too late. Instead, they performed a body retrieval.

It can happen just that quickly and without much warning. A routine task that any of us might have to perform can turn deadly in minutes.

Reading this story, here's a question to ask yourself: Can you look into a vault or manhole and determine whether it is Immediately Dangerous to Life or Health? The answer: No, you can't. Normal ambient oxygen content is 20.8%. Multigas monitors will alarm at 19.5%, as per U.S. Occupational Safety and Health Administration requirements, but serious judgment impairment starts at about 14% ambient oxygen content, with unconsciousness following at 10% or so.

The engineer's rescuers measured an oxygen content in the accident manhole of 2.1%, with methane levels above 60% of the lower explosive limit. His reported cause of death was asphyxia with methane gas. Asphyxiation remains the leading cause of CSE fatalities.

As tragic as this was, it could have been worse. An accident with a single causality can blossom into multiple causalities when would-be rescuers rush in to try to save a friend. Rescue attempts account for about 10% of fatalities.

Imagine yourself in a suddenly stressful and frightening situation, the kind where time slows down because you cannot think or react fast enough. Confirmation bias may start to take over your reasoning, where you focus on factors favoring the course of action you want to take, deemphasizing the contradictory factors that would constitute a slower, logical decision-making process. If several people are witnessing the event, groupthink may reinforce these individual tendencies.

Of course, none of this discussion is meant to dismiss taking action and making a change for the better. That is an admirable quality and more of it is needed in this world. The difference here comes down to analytical risk management: the development of procedures and protocols for dealing with situations riskier than sitting at your desk. It also requires realistic training to embed the procedures sufficiently so that they don't fly out the window when things start to go sideways.

To repeat, common sense is not enough.

Luckily, this accident was not a multiple causality because the engineer's assistant and intern resisted the urge to enter the obviously dangerous manhole themselves. Instead, they immediately called for the properly trained and equipped rescuers.

Given that the tragedy cannot be undone, we can best honor the memory of our fallen colleague by remembering the lesson of his loss and applying what we have learned from it to prevent a reoccurrence.

Bringing proper equipment

To illustrate another point about safety, here's another true story, this time about a junior utility engineer preparing to enter a 10-m-deep rock shaft to document groundwater infiltration. When all his entry PPE was in place and he verified the shaft safe for entry, the assisting crew leader started to connect the engineer's harness ring to the service truck's electric winch. It would provide fall protection. The crew leader was about to connect the engineer with a non-lockable snap ring from a hardware store with a stamped warning "Not for loads greater than 150 lb" (or 60 kg).

Remember who your best safety advocate is? The engineer remembered it, too. He questioned the crew leader about the snap ring he was going to use. Of course, the entry activity stopped until the crew found a properly rated, lockable carabiner. There was an unused one onsite with a rating of 27 kN (6070 lb). But imagine if the engineer hadn't spoken up.

The crew leader was not a bad person nor did he have bad intentions. He simply used what he had handy to get on with the job. If nothing else went wrong, it probably would not have mattered. If the entrant slipped, though, and his full weight shifted to the harness, ring, cable, and winch system, the ring would have become the weak link that could have failed.

The dangers of dangling

Confined space entry training teaches the importance of all the associated equipment including the harness, attachments, lowering mechanism, and fall protection mechanism. All the aforementioned equipment exists to protect you if you slip off manhole rungs, a ladder, a bosun chair, or some other means by which you are descending belowground. If a slip occurs, you'll need to regain your footing or seating and either continue onward or terminate the entry.

The harness exists for fall protection; it is not intended as a primary means of entry. Hanging in a harness for even less than 30 minutes can lead to orthostatic shock or suspension trauma. This isn't simply discomfort; it's a medical disorder which, if untreated or improperly treated, can kill a person. The progression can look like this:

- Constriction of the femoral arteries will lead to lack of blood circulation in the legs, or venous pooling.
- Blood pooling reduces the volume of blood in circulation. The body increases the heart rate to try to maintain circulation to the brain; blood pressure consequently drops.
- Onset symptoms can include dizziness, nausea, sweating, and greying vision.
- Oxygen becomes depleted in the pooled areas, leading to toxin accumulation. Blood that is circulating will have deficient oxygen levels.
- Unconsciousness, organ damage, organ failure, and death can result if uncorrected.

Hanging for 20 to 30 minutes may seem like an unreasonably long time without getting back on the ladder or being cranked back up to the surface by the entry support crew – that is, assuming nothing else goes wrong. But if a ladder wasn't used and the entrant was lowered by harness on a cable through a restrictive opening, a jam or a failure of the winch could produce such a



Dressing for success (and safety)

Some of the manholes requiring our attention are on open land or off in the margin. Most often, though, they are in or very close to paved roadways. What else shares those roadways? Two-ton projectiles (cars and other vehicles) with an often-unreliable biological control mechanism (also known as the average driver). High visibility outerwear (vests, jackets, hoodies, etc.) aren't a fashion statement so much as a means of being seen and lessening the chances of a collision and injury. Situational awareness applies not just to your work at hand, but also to all elements of the environment in which you are working.

Once, a sewer flushing crew was cleaning a residential sewer when the truck's reel malfunctioned, leaving about 15 m of hose in the sewer. While the crew waited for a mechanic to arrive, they manually pulled the hose out and laid it on the pavement near the truck. Despite cones that were intended to prevent traffic from entering the work zone, a car drove through the area and snagged the loose hose. It was dragged just far enough to catch a worker's feet, pulling them out from under him. Fortunately, he only suffered bruises and other minor injuries.

But in this instance, what other precautions could have been taken? Many crews working out on the street have dedicated spotters, or have all members frequently scanning the area for potential intrusions into the active zone. The strategic placement of vehicles will afford much more protection than just cones and barricades. Better yet, use both.

situation. That's why it should not be done; never form a plan that becomes doomed by the failure of a single element.

Common sense would have you imagine the work ahead of time so that you can envision what can go wrong and what measures could provide protection from the consequences. CSE regulations and company safety policies will formalize the process in a comprehensive planning document like a Job Safety Analysis (JSA) or a Health and Safety Plan (HASP).

Avoiding hazards

Better and safer methods to collect sewer system data could avoid placing anyone in harm's way. Fortunately, there is technology that can make many, but not all entries, unnecessary. Closed-circuit television (CCTV) crawlers, extreme-zoom imaging with visible light and infrared capability, and acoustic pipe inspection are a few examples. It is now so much easier to research the capability of every new gizmo thanks to the Internet compared to the old days of canvassing bound catalogs and placing multiple calls to multiple vendors.

But we should note that not all dangers exist below ground. Just the act of removing a manhole cover can cause an injury. Actual cover and grate injuries in one municipality have included

- a cover puller (hook) slipping off a cover and swinging into a person's shin,
- a tilted cover slipping and falling on a steel-toed boot, and
- fingers getting crushed when they were caught between a frame and its grating that was being seated.

In another example from this municipality, an operating engineer was assisting a repair crew by removing a cover while they assembled their tools. Instead of laying it flat, he leaned it on edge against his loader bucket. As he was watching the crew do their work, the cover fell onto his boot, breaking foot bones between his ankle and the end of the steel toe protection. Another manhole cover removal led to a lumbar sprain that was first noticed when the engineer was getting into his car at the end of the day. After two months of physical therapy, the sprain became less noticeable, except when he did too much heavy lifting.

Thankfully, simple devices are now available that use a mechanical advantage to lift covers from a safer distance.

Professional pilots, and even the ones who fly occasionally for fun, use checklists for procedures they have followed hundreds or thousands of times. Think through your own lists of equipment and procedures (gloves, good footing, surveilling the area, tool selection, lifting with knees, coordinating help, etc.) to establish injury-free habits. Preparing a JSA or HASP makes you think through the possibilities for many work activities, not just the complex or riskier ones.

Proper hygiene: the last line of defense

So much time, effort, and expense go into planning and constructing a sewer collection system. After accomplishing this achievement, how do people treat it? They deposit the most disgusting things into it, expecting their problems to disappear like magic. Intended uses are bad enough, but prohibited discharges such as grease, automotive fluids, and interfering objects complicate maintenance activities and bring workers into closer contact with sewer contents than what ought to occur.

Customers' use of the collection system creates a microbial smorgasbord within it, and always will. The chances of HIV transmission are miniscule, but there are plenty of other microbes that exist in wastewater, searching for a comfortable host environment like yourself. Once introduced by inhalation, ingestion, or through a skin break, a wide variety of diseases can occur. The Centers for Disease Control and Prevention (CDC) recommends immunizations for tetanus, Hepatitis A, Hepatitis B, polio, and typhoid fever for workers exposed to sewage. The CDC website has other good guidance worth reading regarding PPE, training, and basic hygiene practices.

Routine hygiene is an effective preventive measure and will help you set a good example among workers who have gotten lax because they haven't been seriously ill for some time. That is just one way a person's experience will work against him or her. The next time you purchase a popular gel disinfectant for yourself, how about getting a dozen small samplers to pass around the jobsite too?

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Look for the next installment of From the Trenches in the January issue.