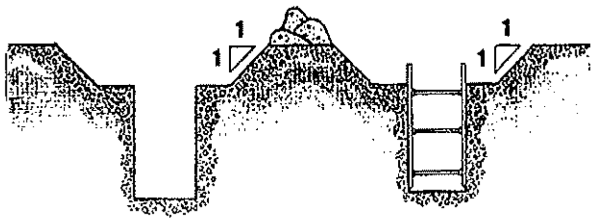


Figure 31-13: Sloping Soil Above Trench Box

Trench Boxes

Trench boxes are not usually intended to shore up or otherwise support trench walls. They are meant to protect workers in case of a cave-in.

Design drawings and specifications for trench boxes must be signed and sealed by the professional engineer who designed the system and must be kept on site by the constructor.

Boxes are normally placed in an excavated but unshored trench and used to protect personnel. A properly designed trench box is capable of withstanding the maximum lateral load expected at a given depth in a particular soil condition. Trenches near utilities, streets, and buildings may require a shoring system.

As long as workers are in the trench, they should remain inside the box. Workers must not be inside the trench or the box when the box is being moved. A ladder must be set up in the trench box at all times.

Excavation should be done so that the space between the trench box and the excavation is minimized (Figure 31-14).

The two reasons for this are

1) Allowing closer access to the top of the box
2) Limiting soil movement in case of a cave-in.

Check the drawings and specifications for the trench box to see if the space between the box and the trench wall needs to be backfilled and the soil compacted.

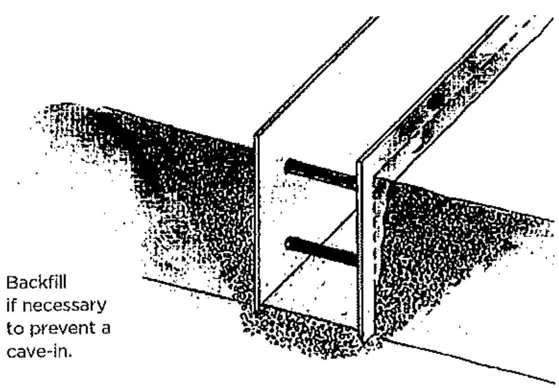


Figure 31-14: Keep Space Tight Between Trench Box and Excavation

2. Shoring

Shoring is a system that "shores" up or supports trench walls to prevent movement of soil, underground utilities, roadways, and foundations.

Shoring should not be confused with trench boxes. A trench box provides worker safety but gives little or no support to trench walls or existing structures such as foundations and manholes.

The two types of shoring most commonly used are timber and hydraulic. Both consist of posts, wales, struts, and sheathing.

Figures 31-15 and 31-16 identify components, dimensions, and other requirements for timber shoring in some typical trenches. **Note: The dimensions are only included as an example.**

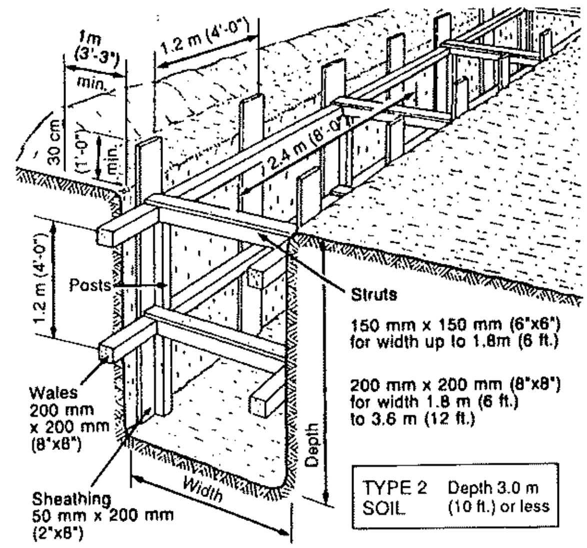


Figure 31-15: Typical Shoring for Trench in Type 2 Soil

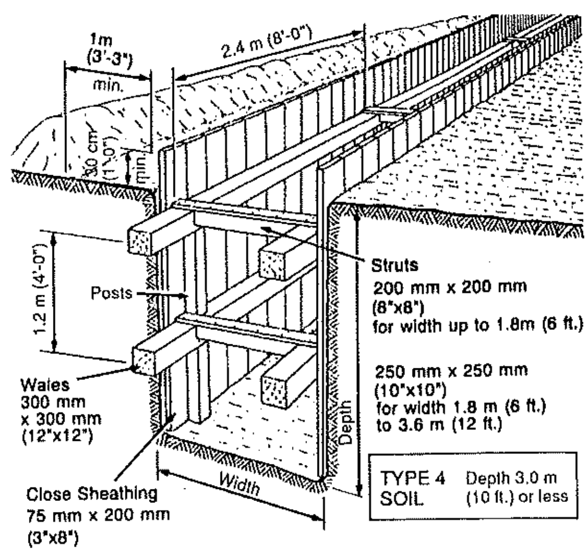


Figure 31-16: Typical Shoring for Trench in Type 4 Soil

"Hydraulic shoring" refers to prefabricated strut and/or wale systems in aluminum or steel. Strictly speaking, these may not operate hydraulically. Some are air-operated or manually jacked. Design drawings and specifications for prefabricated shoring systems must be kept on site.

One major advantage of hydraulic shoring over some applications of timber shoring is safety during installation. Workers do not have to enter the trench to install the system. Installation can be done from the top of the trench.

Most hydraulic systems are

- Light enough to be installed by one worker
- Gauge-regulated to ensure even distribution of pressure along the trench line
- Able to "pre-load" trench walls, thereby using the soil's natural cohesion to prevent movement.
- Easily adapted to suit various trench depths and widths.

Wherever possible, shoring should be installed as excavation proceeds. If there is a delay between digging and shoring, no one must be allowed to enter the unprotected trench. All shoring should be installed from the top down and removed from the bottom up.

REMEMBER: Never enter a trench more than 1.2 metres (4 feet) deep unless it is sloped, shored, or protected by a trench box.

Access/Egress

Whether protected by sloping, boxes, or shoring, trenches must be provided with ladders so that workers can enter and exit safely (Figure 31-17).

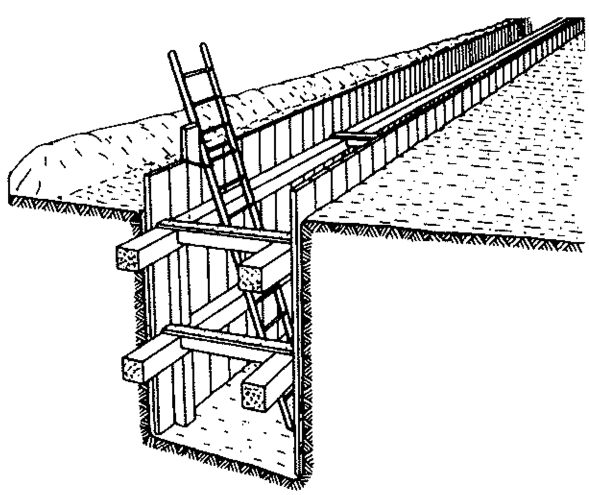


Figure 31-17: Ladders Must Be Provided for Entering and Exiting

Ladders must

- Be placed within the area protected by the shoring or trench box
- Be securely tied off at the top
- Extend above the shoring or box by at least 1 m (3 ft)
- Be inspected regularly for damage.

Ladders should be placed as close as possible to the area where personnel are working and never more than 7.5 m (25 ft) away.

Anyone climbing up or down must always face the ladder and maintain three-point contact. This means that two hands and one foot or two feet and one hand must be on the ladder at all times.

Maintaining three-point contact also means that hands must be free for climbing. Tools and materials should not be carried up or down ladders. Pumps, small compactors, and other equipment should be lifted and lowered by methods that prevent injury from overexertion and falling objects.

Inspection

Inspection is everyone's responsibility. Whatever the protective system, it should be inspected regularly to make sure that it remains sound and reliable.

Check hydraulic shoring for leaks in hoses and cylinders, bent bases, broken or cracked nipples, and other damaged or defective parts (Figure 31-18).

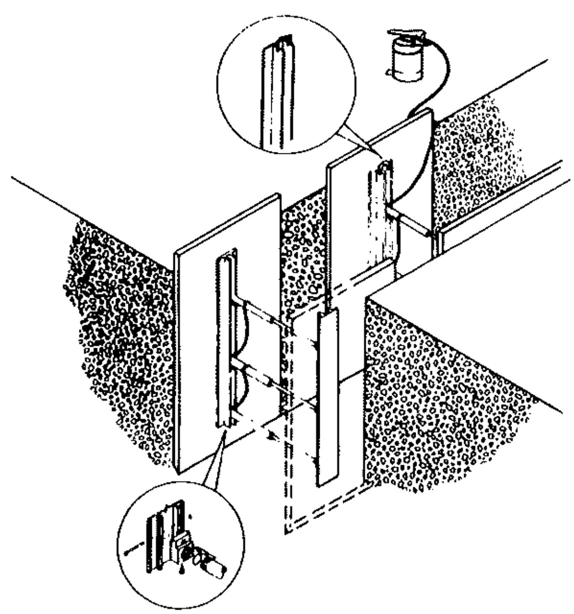


Figure 31-18: Check Hydraulic Shoring for Leaks

Check timber shoring before installation. Discard damaged or defective lumber. After installation, inspect wales for signs of crushing. Crushing indicates structural inadequacy and calls for more struts (Figure 31-19).

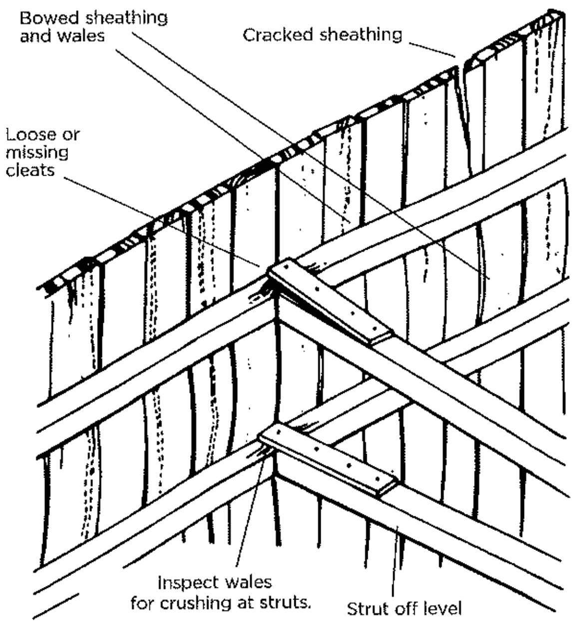


Figure 31-19: Check Timber Shoring for Damage

Inspect trench boxes for structural damage, cracks in welds, and other defects (Figure 31-20). During use, check the box regularly and often to make sure that it is not shifting or settling much more on one side than the other. If it is, leave the trench and ask the supervisor to check for stability.

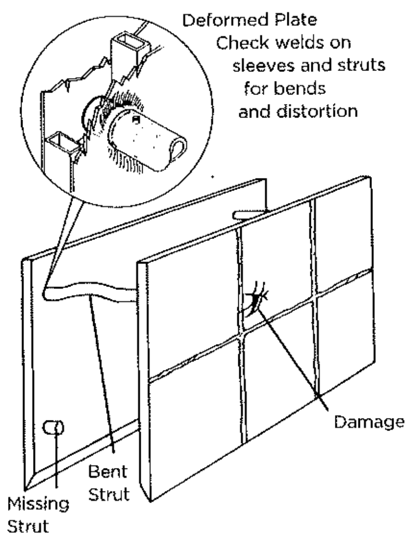


Figure 31-20: Inspect Trench Boxes for Structural Damage and Defects

Check ground surface for tension cracks which may develop parallel to the trench at a distance one-half to three-quarters of the trench depth (Figure 31-21). If cracks are detected, alert the crew and check all protective systems carefully.

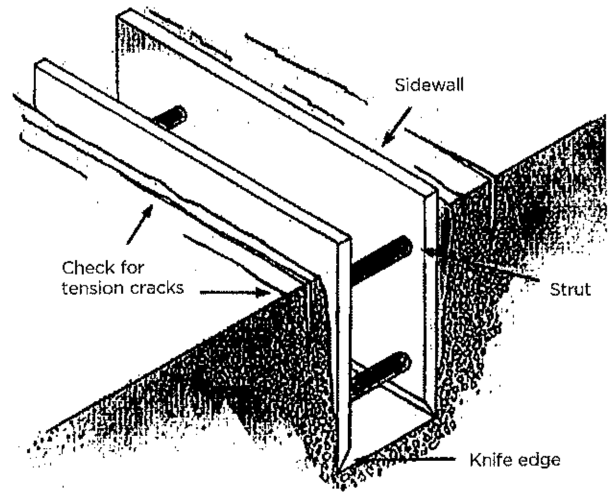


Figure 31-21: Check Ground Surface for Tension Cracks

Check areas adjacent to shoring where water may have entered the trench. A combination of water flow and granular soils can lead to undermining of the trench wall. Such conditions have caused fatalities.

Finally, make sure that tools, equipment, material, and spoil are kept at least 1 m (3 ft) back from the edge of the trench to prevent falling objects from striking workers.

Other Trenching Hazards

The risk of a cave-in is not the only hazard in trenching. Injuries and deaths are also related to other major areas:

- Struck-by injuries
- Utilities underground
- Overhead powerlines
- Materials handling
- Housekeeping
- Heavy equipment
- Traffic control
- Confined spaces.

Struck-By Injuries

Injuries from falling and flying objects can be reduced by wearing personal protective equipment (PPE) such as hard hats, safety boots, and eye protection.

It is mandatory for everyone on a construction project to wear head protection in the form of a hard hat that complies with the current Construction Regulation. Eye protection is strongly recommended to prevent injuries from construction operations such as chipping and drilling and site conditions such as dust.

Everyone on a construction project must wear Grade 1 safety boots certified by the Canadian Standards Association (CSA) as indicated by the CSA logo on a green triangular patch. Under the wet, muddy conditions often encountered in trenching, you may also require rubber safety boots displaying the same CSA logo on a green triangular patch. (See Chapter 19: Personal Protection Equipment for more information.)

Underground Utilities

Locates—Services such as gas, electrical, telephone, and water lines must be located by the utility before excavation begins (Figure 31-22).

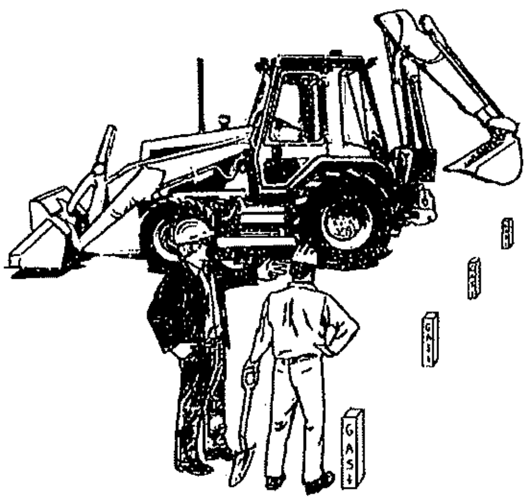


Figure 31-22: Locate Existing Utilities Before Excavating

Request locates for all the underground utilities in the area where excavation will be taking place. The contractor responsible for the work must contact the owners of any underground utilities that may be in that location or phone Ontario One Call (1-800-400-2255). Some utilities are not part of the Ontario One Call system. Contact those utilities separately for locate requests.

The service locate provided by the utility owner should indicate—using labelled stakes, flags, and/or paint marks—the centre line of the underground utility in the vicinity of the proposed excavation.

The excavator should not work outside of the area covered by the locate stakeout information without obtaining an additional stakeout.

Locate stakeout accuracy should be considered to be 1 metre on either side of the surface centre line locate unless the locate instructions specifically indicate other boundary limits.

Where the underground utility cannot be located within the locate stakeout limits, the utility owner should be contacted to assist with the locate. Excavators can refer to the Ontario Regional Common Ground Alliance's (ORGCA) Best Practices Version 6.0 for more detailed information.

Mechanical excavation equipment should not be used within the boundary limits of the locate without first digging a hole or holes using the procedure below to determine the underground utility's exact centre line and elevation.

Test holes should, in general, be excavated by one of the following methods:

(a) machine excavation immediately outside the boundary limits and then hand digging laterally until the underground utility is found

(b) hand excavation perpendicular to the centre line of the locate in cuts of at least 1 foot in depth. Mechanical equipment can then be used carefully to widen the hand-dug trench to within one foot of the depth of the hand-dug excavation. Repeat these steps until the utility is located (Figure 31-23).

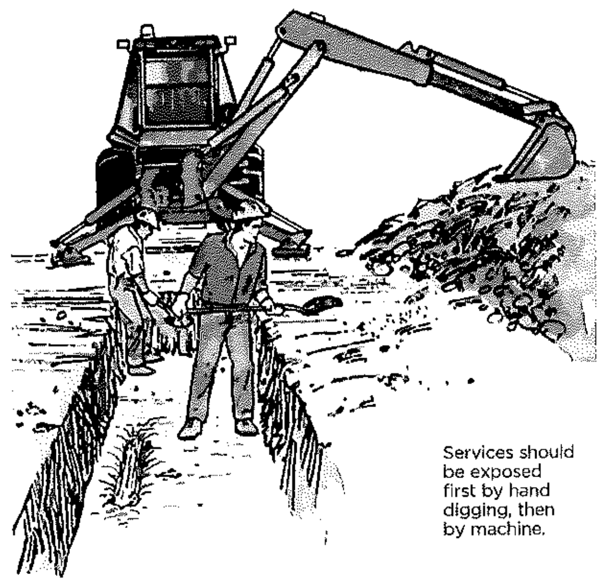


Figure 31-23: Hand Dig to Expose Utilities Before Using Machinery

(c) a hydro-excavation system that is acceptable to the owner of the utility and that uses high-pressure water to break up the cover material and a vacuum system to remove it can be used to locate the underground utility. (See the next section for more information about hydro excavation.)

Centre line locates should be provided and test holes dug where a representative of the utility identifies

(a) alignment changes

(b) changes in elevation.

Where an underground utility may need support or where it may shift because of disturbance of surrounding soil due to excavation, guidelines for excavation and support should be obtained from the owner of the utility.

Hydro Excavation

Precautions:

- Before starting work, use barricades and signs to inform unauthorized personnel to keep out.
- Employers must ensure that workers are properly trained on the machine they are using.
- When exposing underground power utilities, the operators should use bonding mats.
- Use a fall-protection system when required.
- Keep clear of the vacuum. It is powerful and can cause serious injury or even death if you are caught in the tube.
- Some utility owners set limits for the water pressure that can be used near their buried plan. Check with the utility owner before excavating.
- Excavators can refer to the following for further information:
  - TSSA/ESA's Guideline for Excavation in the Vicinity of Utility Lines www.tssa.org/regulated/fuels/productsForSale.aspx
  - ORCGA's Best Practices www.orcga.com/Publications/Best-Practices
  - IHSA's Safe Practice Guide: Excavating with Hydrovacs (SPG4)
  - IHSA's Call Before You Dig (IHSA051)

Safety tips for workers using or in the vicinity of hydro excavation:

- Keep away from the operation if you are not directly involved in the work.
- Wear hearing protection if working in vicinity of the hydrovac truck.
- Be aware of the hazards, such as slips from the runoff water and ice during the winter.
- Wear appropriate eye and face protection such as safety glasses and faceshields. They will protect you from getting any airborne debris (caused by splashing) in your eyes.
- Keep clear of the vacuum. It is powerful and can cause serious injury or even death if you are caught in the tube.

Breaks—Breaks in electrical, gas, and water services can cause serious injuries, even deaths. Hitting an underground electrical line can result in electrocution, while hitting a gas line can cause an explosion. A broken waterline can release a sudden rush of water, washing out support systems and causing a cave-in.

Cutting telephone lines can create a serious problem if emergency calls for police, fire, or ambulance are required.

In the event of gas line contact, call the gas company immediately. The company will check the line and close down the supply if necessary.

If a leak is suspected, people in the immediate area should be told to evacuate. Where service to a building or home has been struck, people inside should be advised to leave doors and windows open; shut off appliances, furnaces, and other sources of ignition; and vacate the premises until the gas company declares it safe to return.

Construction personnel should take two precautions.

1) Put out smoking materials and shut off other sources of ignition such as engines and equipment.
2) Leave the trench immediately. Gas can collect there.

Overhead Powerlines

When equipment operates within reach of (and could therefore encroach on) the minimum permitted distance from a live overhead powerline (Table 31-1), the constructor must have written procedures in place to prevent the equipment from encroaching on the minimum distance.

Table 31-1: Minimum Distances to Overhead Powerlines

Voltage Rating of Powerline	Minimum Distance
750 or more volts, but not more than 150,000 volts	3 m (10 ft)
more than 150,000 but not more than 250,000 volts	4.5 m (15 ft)
more than 250,000 volts	6 m (20 ft)

If equipment touches a high-voltage line, the operator should take the following precautions.

1) Stay on the machine. Don't touch equipment and ground at same time. Touching anything in contact with the ground could be fatal.
2) Keep others away. Warn them not to touch the load, load lines, boom, bucket, or any other part of the equipment (Figure 31-24).

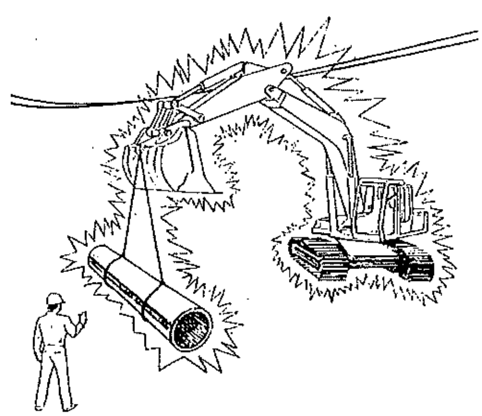


Figure 31-24: Stay Clear of Machine During a Powerline Contact

3) Anyone operating accessory equipment should also remain on that equipment. They should also avoid making contact with the ground and the equipment at the same time.
4) Get someone to call the local utility to shut off power.
5) If possible, the operator (while remaining on the machine) can try to break contact by moving the machine clear of the wires.
6) If the operator can't break contact by moving the machine—while remaining on it—do not move the machine until the utility shuts down the line and confirms that power is off.
7) If an emergency such as fire forces you to leave the machine, jump clear (Figure 31-25). Never step down. If part of your body contacts the ground while another part touches the machine, current will travel through you.

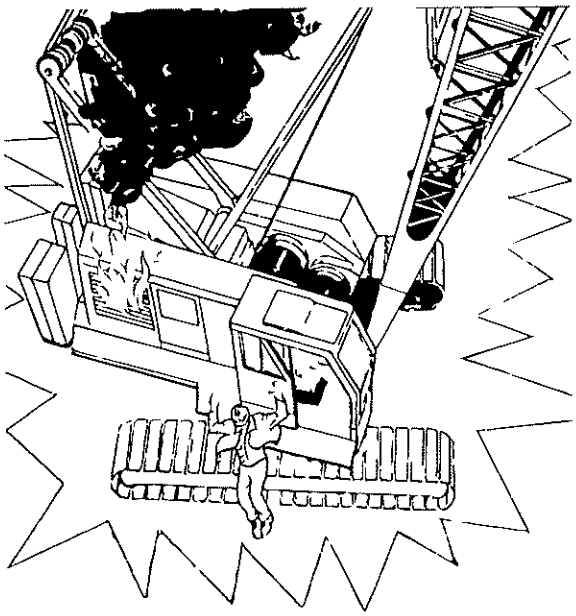


Figure 31-25: Jump Clear of Machinery—Do Not Step Down

8) Jump with feet together and shuffle away in small steps. Don't take big steps. With voltage differential across the ground, one foot may be in a higher voltage area than the other. The difference can kill you (Figure 31-26).

WARNING: Beware of time relays. Even after breakers are tripped by line damage, relays may be triggered to restore power.

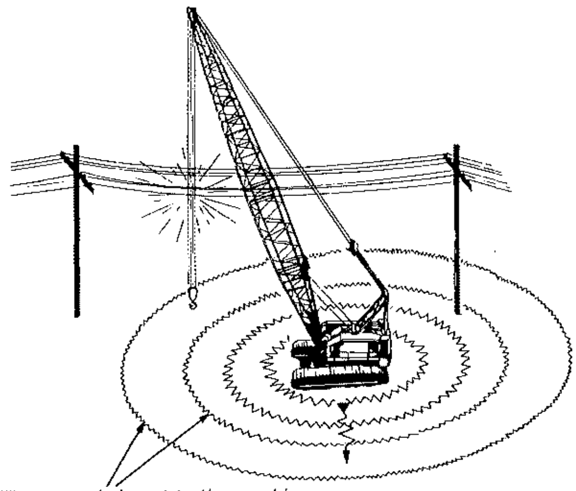


Figure 31-26: Voltage Differential Across the Ground Can Kill You

Special precautions are required for casualties in contact with live powerlines or equipment.

1) Never touch the casualty or anything in contact with the casualty.
2) If possible, break contact. Use a dry board, rubber hose, or dry polypropylene rope to move either the casualty or the line. An object can sometimes be thrown to separate the casualty from the wire.

Warning : Touching the casualty, even with dry wood or rubber, can be dangerous. With high voltage lines, objects that are normally insulators can become conductors.

3) Call emergency services—in most cases ambulance, fire department, and utility.
4) Provide first aid once the casualty is free of contact. If the casualty is not breathing, begin artificial respiration immediately (mouth-to-mouth is most efficient) or CPR. Apply cold water to burns and cover with clean dressing.

Materials Handling

Many lost-time injuries in trenching involve materials handling. Moving rock and soil, lifting pipe and manhole sections, laying down bedding material, or lowering pumps and compactors into the trench can all be hazardous.

Pipe—Trucks should always be on level ground when pipe is unloaded. Pipe should be chocked or staked before tie-downs are released. These measures will reduce the risk of sections rolling off the truck.

Plastic and small diameter pipe is often banded with metal straps. Be careful cutting the straps. They are under tension and can fly back and hit you.

Personnel often injure fingers and hands when laying and joining sections of pipe. While sections are suspended from hoisting equipment, keep hands away from slings or chokers in tension. When guiding and pushing sections together by hand, never curl fingers around ends or flanges.

As pipe is placed along the trench, each section should be blocked or set so that it cannot roll and cause injury.

Back injuries can occur when small-diameter pipe is being homed into position (Figure 31-27). The worker pushing the bar should place his feet directly in front of the pipe with one foot ahead of the other. Large-diameter pipe should be placed with pipe pullers (Figure 31-28).

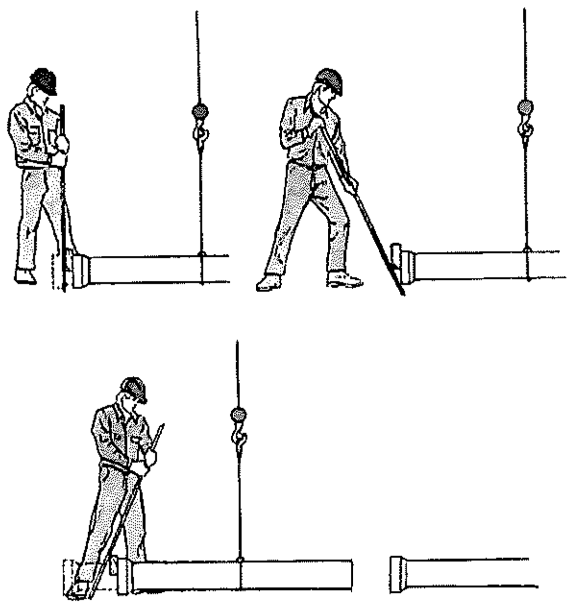


Figure 31-27: For Balance, Keep One Foot Ahead of the Other

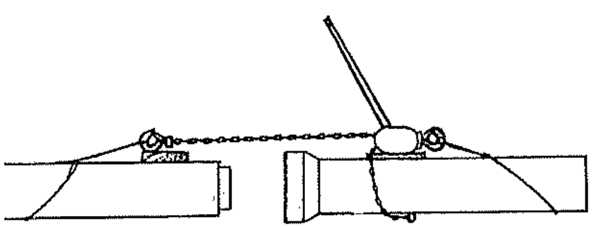


Figure 31-28: Use Pipe Pullers When Positioning Large Pipes

Bedding material—Personnel shovelling bedding material in the trench are usually working in a confined area where footing is muddy and uneven.

The result can be overexertion or slips and falls leading to back and other injuries. Mechanical equipment can significantly reduce this hazard. For instance, bedding material can be put in the excavator bucket with a front-end loader, then spread evenly along the trench bottom.

Rigging—Rigging is essential to safe, efficient materials handling since pipe, manhole sections, and equipment are lowered into the trench by cranes or other hoisting devices. Rigging these loads properly can prevent injury. Inspect slings and rigging hardware regularly and replace any damaged or worn devices.

With **nylon web slings,** damage is usually easy to spot: cuts, holes, tears, worn or distorted fittings, frayed material, broken stitching, or heat burns. Damaged web slings should be replaced.

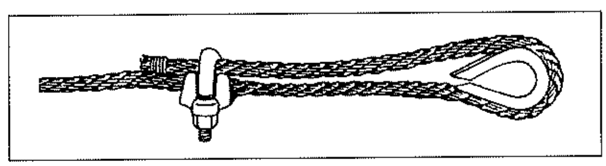
When using **wire rope slings,** inspect for broken wires, worn or cracked fittings, loose seizings and splices, flatening, and corrosion. Knots or kinks indicate that wire rope slings are permanently damaged and should not be used.

Damage most often occurs around thimbles and fittings. Don't leave wire rope lying on the ground for any length of time in damp or wet conditions.

Follow the steps below when installing wire rope clips. At least three clips are required for wire rope up to 5/8" diameter, and four are required for wire rope greater than 5/8" up to and including 7/8" diameter.

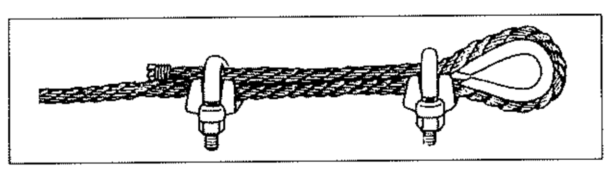
Step 1: Apply First Clip

- Apply first clip one base width from dead end of wire rope.
- Clip over dead end.
- Live end rests in clip saddle.
- Tighten nuts evenly to recommended torque.



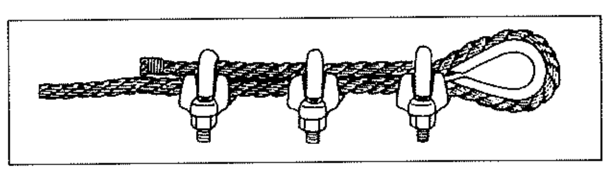
Step 2: Apply Second Clip

- Apply second clip as close to loop as possible.
- Clip over dead end.
- Turn nuts firmly. DO NOT TIGHTEN.



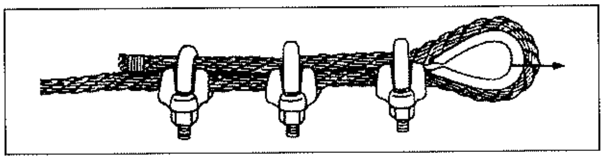
Step 3: Apply All Other Clips

- Apply all other clips spaced evenly between the first and second clip.



Step 4: Apply Tension

- Apply tension and tighten all nuts to recommended torque.
- Check nut torque after rope has been in operation.



Avoid binding the eye section of wire rope slings around corners. The bend will weaken the splice or swaging.

When using choker hitches, do not force the eye down towards the load once tension is applied.

When using **chain slings,** inspect for elongated links. A badly stretched link tends to close up (Figure 31-29).

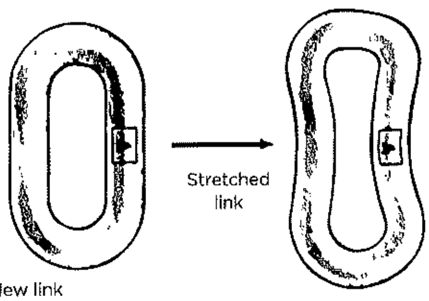


Figure 31-29: Inspect Links for Stretching

Look for bent, twisted, or damaged links that can result when chain has been used to lift a load with unprotected sharp edges.

Inspect for cracks. Although sometimes hard to detect, cracks always indicate that the chain should be removed from service. Also look for gouges, chips, cuts, dents, peen marks, and corrosive wear at points where links bear on each other.

Rigging Tips

- Wherever possible, lower loads on adequate blockage to prevent damage to slings.
- Keep hands away from pinch points when slack is being taken up.
- Stand clear while the load is being lifted and lowered or when slings are being pulled out from under it.
- Use tag lines to control swinging, swaying, or other unwanted movement of the load.

Housekeeping

Maintaining good housekeeping practices is important both at ground level and in the trench. At the top of the trench, sections of pipe, unused tools and timber, piles of spoil, and other material must be kept at least 1 m (3 ft) away from the edge.

The slips and falls common on excavation projects can be reduced by cleaning up scrap and debris. Trenches should also be kept as dry as possible. Pumps may be required.

Proper housekeeping is especially important around ladders. The base and foot of the ladder should be free of garbage and puddles. Ladders should be tied off at the top, placed in protected areas, and inspected regularly for damage (see Figure 31-17).

Heavy Equipment

Excavators, backhoes, and other heavy equipment can cause injuries and fatalities to operators and personnel on foot.

Operators—Improperly climbing on and off equipment has caused many injuries to equipment operators. The best prevention is to maintain three-point contact. Equipment should be fitted with steps, grabs, and rails that are repaired or replaced when damaged.

Operators have also suffered serious injuries when equipment upsets because of soil failure near excavations (Figure 31-30), improper loading on floats, or inadvertently backing into excavations.

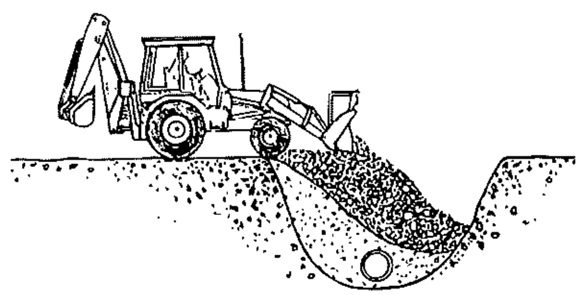
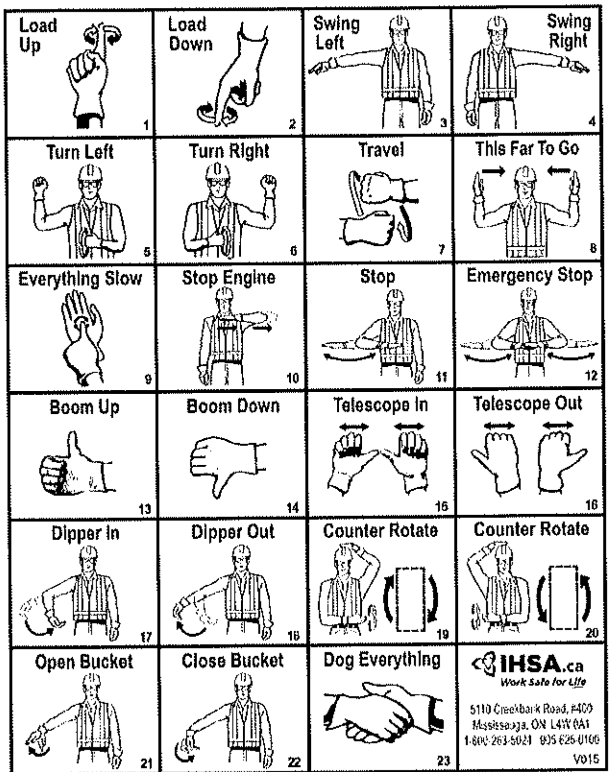


Figure 31-30: Pushing (Instead of Dumping) Backfill into Excavation

Excavator hand signals—Communicate clearly with your co-workers. Use the following hand signals (Figure 31-31). Pocket-sized cards containing these hand signals are available to order from the ihsa.ca website (see *Excavator Hand Signal Cards* (V015) in Products).



No response should be made to unclear signals!

Figure 31-31: Excavator Hand Signals

Moving equipment—Signallers are required by law

- If the operator's view of the intended path of travel is obstructed, or
- If a person could be endangered by the moving equipment or its load.

Back-up alarms are required on dump trucks and recommended for all moving equipment. Where vehicles have to operate in reverse, warning signs must be conspicuously posted.

Ground rules for truck drivers

- Understand and obey the signaller at all times.
- Remain in the cab where possible.
- Ensure that mirrors are clean, functional, and properly adjusted.
- Do a circle check after being away from the truck for any length of time. (Walk around the truck to ensure the area is clear before moving.)
- Stop immediately when a signaller, worker, or anyone else disappears from view.

Workers on foot—Personnel on foot are frequently stuck by machine attachments such as excavator buckets and bulldozer blades when they stand or work too close to operating equipment, especially during unloading and excavation.

Workers on foot are also injured and killed by equipment backing up.

Ground rules for workers on foot

- Beware of common operator blind spots. (See Chapter 28: Backing Up.)
- Stay alert to the location of equipment around you.
- Avoid entering or standing in blind spots.
- **Always remain visible to the operator. Make eye contact to ensure that you are seen.**
- Never stand behind a backing vehicle.
- Remember—the operator may be able to see you while you are standing but not when you kneel down or bend over.

Signallers—In heavily travelled or congested work areas, a signaller may be necessary to direct equipment and prevent injuries and deaths caused by vehicles backing up.

Ground rules for signallers

- Wear a fluorescent or bright orange safety vest. (Note: other colours listed in the CSA standard may be acceptable. See Chapter 17: High-Visibility Clothing.)
- Use standard hand signals (Figure 31-31).
- Stand where you can see and be seen.
- Stay in full view of the operator and the intended path of travel.
- Know where the operator's blind spots are.
- Warn other workers to stay clear of equipment.

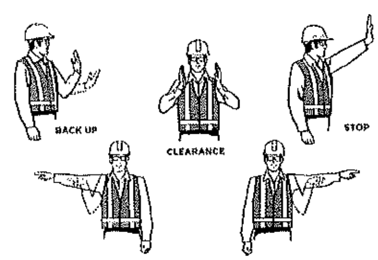


Figure 31-32: Traffic Control Handsignals (V006)

Traffic Control

On trenching projects along public roadways, the construction crew must be protected from traffic. Regulations specify the following methods for protecting personnel:

- Traffic control persons (TCPs) using signs (Figure 31-33)
- Warning signs
- Barriers
- Lane control devices
- Flashing lights or flares.

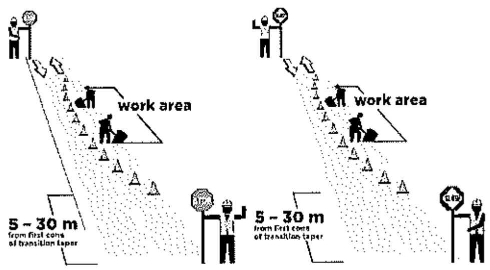


Figure 31-33: Typical Arrangement for Traffic Control Persons (TCPs)

Supervisors must ensure that TCPs have received adequate training. They must also instruct them on the hazards present on site and explain the nature of the project, where construction equipment will be operating, and how public traffic will flow. TCPs must wear a fluorescent or bright orange safety vest (see Chapter 17: High-Visibility Clothing).

Training must also include the proper use of the STOP/SLOW sign, where to stand, how to signal, and how to communicate with other TCPs. See Chapter 29: Traffic Control.

After presenting this information, the supervisors must give TCPs written instructions in a language they can understand.

Confined Spaces

A confined space is defined as a place

1) That is partially or fully enclosed
2) That is not both designed and constructed for continuous human occupancy, and
3) Where atmospheric hazards may occur because of its construction, location, or contents, or because of work that is done in it.

All three criteria have to be met before a space is defined as a confined space.

In the sewer and watermain industry, confined spaces can be locations such as excavations, manholes, valve chambers, pump stations, and catch basins. The atmosphere in these spaces may be

- Toxic
- Oxygen-deficient
- Oxygen-enriched
- Explosive.

Sewage not only smells bad but can create dangerous atmospheres. Decaying waste releases hazardous gases such as hydrogen sulfide and methane. The bacteria in sewage are not only a source of infection but can also consume oxygen and leave the atmosphere oxygen-deficient. PPE such as a supplied-air respirator may be required.

Other sources of contamination can include

- Fumes from welding or patching compounds
- Chemicals from waste disposal sites
- Engine exhaust
- Propane or other explosive gases that are heavier than air and collect in the bottom of the trench
- Leaks from underground storage tanks
- Decomposing material in landfill sites.

Protecting the health and safety of personnel starts with some basic steps.

- A competent worker must test a confined space to determine whether it is hazard-free before a worker enters, and continue testing to ensure that it remains hazard-free.
- Where tests indicate safe air quality, workers may be allowed to enter the confined space.
- Where tests indicate a hazardous level of fumes, vapours, gases, or oxygen, entry must not be allowed until the space has been adequately ventilated and subsequent tests indicate that the air is safe to breathe.
- Where possible, mechanical venting should be continued in any confined space containing hazardous levels of fumes, vapours, gases, or oxygen, even after venting has corrected the hazard. The space must also be continuously monitored while personnel are working there.
- In situations where ventilation has removed a hazard, workers entering the space should still wear rescue harnesses attached to individual lifelines. A worker should also be posted at the entrance and be prepared, equipped, and trained to provide rescue in an emergency. For rescue situations, workers entering the space should wear supplied-air respirators (Figure 31-34).

Figure 31-34: Self-Contained Breathing Apparatus (SCBA)

For more information on confined spaces and controls, see Chapter 33: Confined Spaces.

Hydrostatic Testing

Hydrostatic testing involves entry into a confined space such as a manhole or valve chamber, so the procedures listed above should be followed.

Testing new lines can be very hazardous if components break or plugs let go. For that reason, additional precautions are required.

- When testing watermains, ensure that all lines, elbows, and valves are supported and equipped with thrust blocks. Otherwise the line could come apart under test pressure.
- Arrange watermain testing so that lines are pressurized when no one is in the manhole or valve chamber.
- For sewer line testing, all requirements for entering confined spaces apply.
- Ensure that plugs are secure. No one should be in a manhole when the upstream line is being filled. Plugs that are not properly installed can let go, causing injury and letting a manhole fill quickly, depending on the size of the line.

Flooding is another reason why no one should be in a manhole without a rescue harness and a worker outside ready and prepared for an emergency.

Emergency Procedures

Emergency telephone numbers—ambulance, fire, police, local utilities, senior management, Ministry of Labour—should be posted in the field office for quick reference.

If someone is seriously injured, take the following steps.

1) Protect the area from hazards.
2) Prevent further injury to the casualty.
3) Administer first aid.
4) Call an ambulance or rescue unit.
5) Have someone direct the ambulance or rescue unit to the accident scene.

All projects must have a person qualified and certified to provide first aid.

Cave-ins

It is natural to try to rescue casualties caught or buried by a cave-in. But care must be taken to prevent injury and death to rescuers, whether from a further cave-in or other hazards.

The following procedures may be suitable, depending on conditions.

1) To get down to the casualty, use a tarpaulin, fencing, plywood, or similar material that can cover the ground and will ride up over any further cave-in.
2) Sometimes a further cave-in can be prevented by placing a backhoe bucket against the suspected area or excavating it.
3) Rescue workers should enter the trench with ropes and wear rescue harnesses if possible.
4) To prevent further injury, remove the casualty by stretcher whenever possible. Tarps or ladders can be used as a makeshift stretcher.
5) Stabilize the casualty.

Breathing—Ensure that the casualty is breathing. If not, open the airway and start artificial respiration immediately. Mouth-to-mouth is the most efficient method.

Bleeding—Control external bleeding by applying direct pressure, placing the casualty in a comfortable position, and elevating the injured part if possible.

Unconsciousness—This is a priority because it may lead to breathing problems. An unconscious person may suffocate when left lying face up. If injuries permit, unconscious persons who must be left unattended should be placed in the recovery position (Figure 31-35).

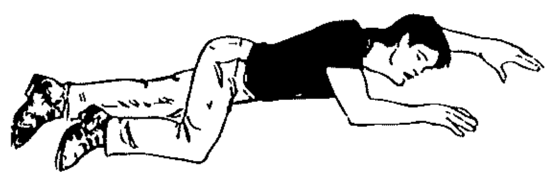
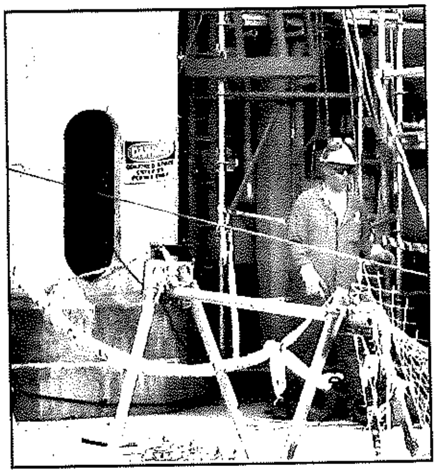


Figure 31-35: Recovery Position

CONFINED SPACES

33 CONFINED SPACES



A confined space is defined as a place

a) that is **partially or fully enclosed**

b) that is not both designed and constructed for **continuous human occupancy**, and

c) where **atmospheric hazards** may occur because of its construction, location, or contents, or because of work that is done in it.

All three criteria have to be met before a space is defined as a confined space. Here is more information on each of the criteria.

Partially or fully enclosed

Because air does not move in and out of a partially or fully enclosed space in sufficient quantities, there is a potential for a hazardous atmosphere to be generated inside. This is especially true for spaces such as vaults, tanks, pits, trenches, or manholes.

Not designed and constructed for continuous human occupancy

Confined spaces are not designed or constructed for people to work in them on an ongoing basis. They are usually designed and constructed to store material, transport products, or enclose a process. But occasionally, some work must be done inside the space.

Atmospheric hazards

A hazardous atmosphere is one that contains any of the following:

- An accumulation of flammable, combustible, or explosive agents
- Less than 19.5% or more than 23% oxygen, or
- An accumulation of atmospheric contaminants that could result in ***acute*** (short-term) health effects which
  - a) pose an immediate threat to life, or
  - b) interfere with a person's ability to escape unaided from a confined space.

Figure 33-1 shows some typical locations where confined spaces are found.

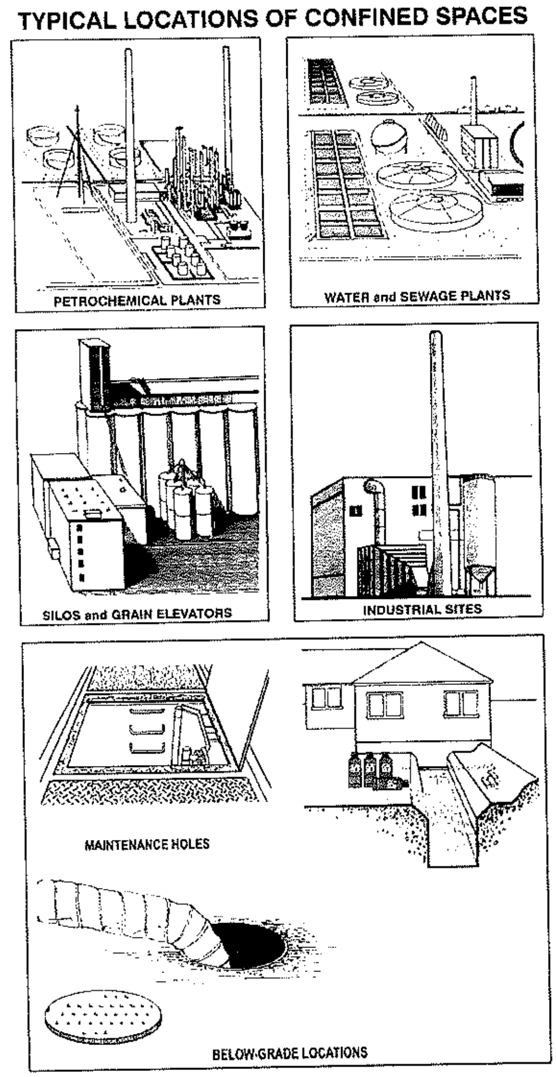


Figure 33-1: Typical Locations of Confined Spaces

Confined Space Program

Before letting a worker enter a confined space, the employer must develop a written confined space program meeting the requirements of Regulation 632-*Confined Spaces*. The employer must maintain the program.

Among the first requirements for employers developing a confined space program is the need to assess which workers will be entering the confined space and therefore which workers will need a copy of the confined space program.

Employers must provide a copy of the program to the constructor of a project. In turn, the constructor must provide a copy of the program to the project's joint health and safety committee or health and safety representative, if any. A copy must also be available to other employers to which the program relates and every worker if there is no project joint health and safety committee or health and safety representative.

If workers from more than one employer will be entering the confined space, the constructor must prepare a **confined space coordination program.** A copy of the confined space coordination document must be provided to each employer who is performing work in the confined space and to the project's joint health and safety committee or the health and safety representative.

The confined space program can apply to one or more confined spaces.

Program elements must include

- A method for recognizing each confined space
- A method for assessing and evaluating the hazards to which workers may be exposed
- A method for developing plans to control the hazards
- A method for training workers
- An entry permit system setting out measures and procedures to be followed when working in a confined space.

Coordination

When workers of more than one employer perform work in the same confined space, the constructor must prepare a coordination document to ensure that the various employers perform their duties in a way that protects the health and safety of all workers.

A copy of the coordination document must be provided to

- Each employer of workers who perform work in the same confined space
- The project's joint health and safety committee or health and safety representative.

Hazard Assessment

Before each time that a worker enters a confined space, a person with adequate knowledge, training and experience must perform a written hazard assessment. The name of the competent worker must appear on the assessment and the employer must keep a record of the competent worker's qualifications.

The hazard assessment must take into account

a) the hazards that may exist in the confined space

b) the hazards that may develop while work is performed inside the confined space

c) general safety hazards in the confined space.

The person with adequate knowledge, training and experience must sign and date the assessment and give it to the employer.

If requested, the employer must give copies of the assessment and the qualifications of the person with adequate knowledge, training and experience to

- The project's joint health and safety committee, or
- The health and safety representative, or
- Every worker involved in the confined space entry if the project has no joint health and safety committee or health and safety representative.

The employer must review the assessment as often as necessary to make sure that the plans remain adequate. For example, if the potential chemical hazard changes due to a change in process or equipment use, then the assessment must be changed.

An assessment is generally required for each confined space. But if there are two or more similar confined spaces containing the same hazards, then you need only a single assessment document.

To perform a hazard assessment, you need to anticipate potential hazards. Often, the hazards of working in confined spaces are not recognized until it's too late.

For example:

- A mixing tank was inadvertently started while a worker was inside.
- A worker was killed by carbon monoxide gas from a gasoline-powered pump used to drain a pit.

If control measures (such as continuous mechanical ventilation) are used to ensure that the concentrations of an atmospheric hazard are **controlled** or maintained at an appropriate level (but not eliminated), then the space would still be considered a confined space. If, however, measures are implemented to **eliminate** the possibility that any atmospheric hazards may occur in a space, then the confined space provisions no longer need to apply.

Eliminating the possibility that an atmospheric hazard will occur is different from controlling the hazard. If workers must enter the confined space to eliminate the hazards (by steam-cleaning or vacuuming, for example), then the confined spaces provisions apply.

EVERY CONFINED SPACE MUST BE THOROUGHLY ASSESSED AND EVALUATED BY A PERSON WITH ADEQUATE KNOWLEDGE, TRAINING AND EXPERIENCE TO DETERMINE WHETHER IT IS POSSIBLE TO ELIMINATE THE ATMOSPHERIC HAZARD COMPLETELY.

Even if a space is not defined as a confined space under the regulations, the employer must take every precaution reasonable in the circumstances to protect workers entering the space. This could involve using protective measures and procedures similar to those used in a confined space if the hazards require this type of worker protection.

Table 33-1: Common Hazards in Confined Spaces

Examples of confined spaces	Common hazards
Chemical and petrochemical projects Tanks, vessels, storage tanks, underground tanks, pipes, sumps, pits, any area where a worker cannot readily escape from a toxic or explosive atmosphere; any area where toxic, explosive, or oxygen deficient atmospheres may be encountered.	Toxic and explosive gases, vapours, and fumes; physical hazards of cramped entry and exit, narrow passages, and chemical spills. Difficulty in rescuing an incapacitated worker because of the configuration of the space and limited routes of access and egress.
Sewage-handling systems Settling tanks, sewers, manholes, pumping areas, septic tanks, digesters.	Toxic and/or explosive atmospheres such as hydrogen sulphide and methane; oxygen deficiencies.
Water treatment plants Settling tanks, holding tanks, equipment and wells below floor level.	Oxygen deficiency, chlorine gases, ozone; also possibly methane and hydrogen sulphide produced by decaying debris removed from lake and river water.
Heavy industrial projects Sumps, pits, roasters, digesters, mixers, bins, flues, ducts, conveyors, elevators, bag houses.	The hazards will depend on processes and materials involved but may include methane, hydrogen sulphide, oxygen deficiency, flammable agents, potential toxins, electrical hazards, moving parts, and engulfment due to free-flowing materials.
General construction Vaults, caissons.	Toxic materials such as carbon monoxide from temporary heaters in low-lying areas; refrigerants; high-voltage transmission equipment; physical hazards involving poor lighting, cramped working conditions, and the inrush of water.

Hazards

Because construction projects are not limited to new buildings, confined spaces may be encountered in a variety of places. Table 33-1 describes typical confined spaces and the most common hazards found there.

Hazards in confined spaces can be divided into two distinct categories:

1. Physical hazards
2. Atmospheric hazards.

Physical Hazards

Physical hazards often present a greater danger inside an enclosed space than they do outside. Examples of physical hazards include the following:

Noise and vibration

An enclosed environment can amplify noise. Excessive noise can damage hearing and prevent communication. It can affect workers' ability to hear alarms, warning shouts, or orders to evacuate.

Temperature extremes

Determine whether workers could encounter dangerous temperatures. For example, heat stress can be a hazard when working around boilers, hot pipes or tanks, or structures heated by the sun. Protective clothing can also add to heat stress.

Cramped work spaces

Cramped work spaces restrict movement and can make using tools and equipment difficult and dangerous.

Poor access or exit

Confined space openings are generally small and not well-located. This can make entry and exit difficult and can interfere with rescue.

Rotating or moving equipment

Before entry, identify any moving or rotating equipment (such as conveyors, mixers, augers, etc.) which could become activated by stored pressure, accidental contact, or gravity. Check with plant personnel on lockout and tagging procedures, and review drawings, plans, and specifications.

Electrical hazards

Any exposed conductors or energized equipment should be identified before entry. The presence of water in confined spaces may pose an additional electrocution hazard where electrical circuits, equipment, and tools are used.

Engulfment due to uncontrolled movement of liquids and solids

Liquids, sludge, fine solids, and other material may not be completely removed from confined spaces and may present an engulfment or drowning hazard. Use inspection ports and dipsticks, and check with knowledgeable personnel to evaluate such hazards.

Slick or wet surfaces

Workers can be severely injured from a slip or fall on icy, oily, wet, or moist surfaces.

Lighting

Confined spaces generally have poor lighting, which is why temporary lighting is often required. In potentially explosive atmospheres, use lighting designed for such situations.

Atmospheric Hazards

Confined spaces can present three kinds of atmospheric hazards:

1. Flammable, combustible, or explosive atmosphere
2. Oxygen-enriched or oxygen-deficient atmosphere
3. Toxic contaminants.

A hazardous atmosphere may be due to existing conditions (e.g., residue in a tank,) or it may be created by the work being done inside the confined space (e.g., welding or using solvents). In some cases, removing sludge or scale can release trapped pockets of gas or vapour and create a hazardous atmosphere. Moreover, dangerous atmospheres often exist together. For instance, flammable, combustible or explosive atmospheres may also be toxic or cause an oxygen deficiency.

Flammable, Combustible, or Explosive Atmospheres

Flammable atmospheres are generally caused by

1. Evaporation of flammable liquids (e.g., gasoline)
2. By-products of chemical reactions (e.g., decomposition of organic matter to form methane).

Explosive atmospheres are those in which a flammable gas or vapour is present in quantities between the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL). These limits define the "Explosive Range" which varies from one substance to another. (Refer to the Safety Data Sheet (SDS) of a hazardous material for fire- and explosion-related information.)

The LEL is the lowest and the UEL is the highest concentration of gas or vapour that will support combustion in an explosive reaction. For example, gasoline has an LEL of 1.4% and a UEL of 7.6%. Below 1.4% there is not enough fuel to burn, while above 7.6% there is too much fuel and not enough oxygen to burn (Figure 33-2). Explosions with the most destructive force occur mid-range between the LEL and UEL.

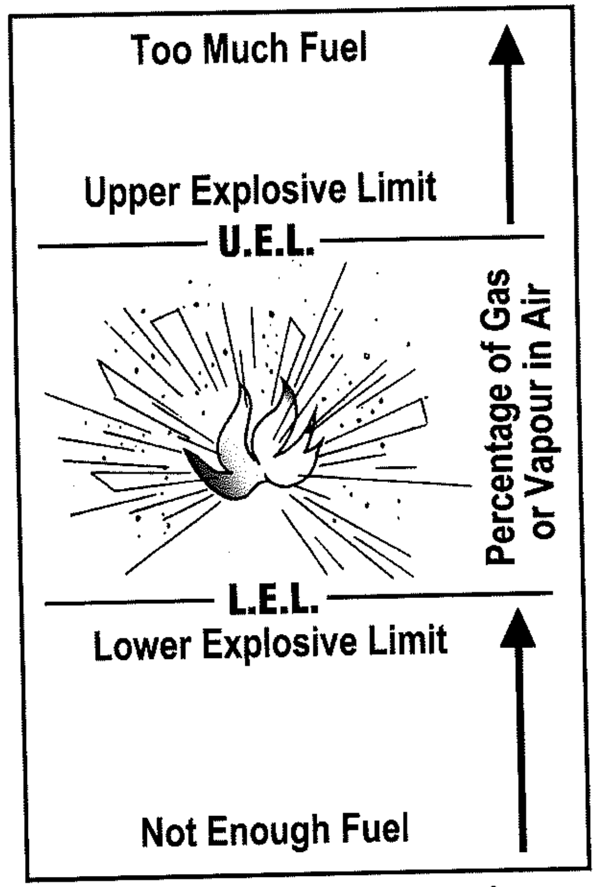


Figure 32-2: Explosive Range of a Flammable Atmosphere

The most common explosive gas likely to be encountered in sewers and other underground structures is methane or "natural gas" produced by decaying garbage and sewage.

Other explosive gases and vapours may be present in confined spaces depending on previous contents or accidental spills and leaks (e.g., leaking fuel-storage tanks near service stations).

Explosive ranges for common gases and vapours are listed in Table 33-2. These values must be considered when selecting and operating gas-testing equipment.

Combustible atmospheres can arise in grain elevators, feed mills, and some industrial settings such as bag houses, because of the large quantities of dust generated. The most common combustible dust is grain or flour dust—there is a history of severe explosions in grain elevators. This hazard needs to be addressed whenever people are working in these settings.

Table 33-2: Explosive Range for Common Gases and Vapours

Gas/vapour	Lower Explosive Limit (%)	Upper Explosive Limit (%)
Acetone	2.5	12.8
Ammonia	15.0	28.0
Benzene	1.2	7.8
Ethyl Alcohol	3.3	19.0
Gasoline	1.4	7.6
Hexane	1.1	7.5
Hydrogen Sulphide	4.0	46.0
Methane	5.0	15.0
Methyl Alcohol	6.0	36.0
Propane	2.1	9.5
Toluene	1.1	7.1
Xylene	0.9	6.7

Source: National Institute for Occupational Safety and Health (NIOSH)

Oxygen-Enriched and Oxygen-Deficient Atmospheres

Normal outside air contains about 21% oxygen. In some instances, air can become oxygen-enriched, which means that the concentration of oxygen exceeds 23%. The primary concern with oxygen-enriched atmospheres is the increased flammability of materials. Things that would only smoulder in normal air will burn vigorously in oxygen-enriched atmospheres (e.g., oil-soaked coveralls, which are difficult to burn in "normal" air, will burn vigorously in an oxygen-enriched environment).

Oxygen-enriched atmospheres are fairly rare in construction. They are usually associated with pure oxygen escaping from leaking or ruptured oxyacetylene hoses or—on projects in industrial plants—from an oxygen line in an industrial setting (e.g., hospital) or in a manufacturing process (e.g., welding).

Oxygen-deficient atmospheres, on the other hand, are fairly common. They may result from work being done (such as welding), bacterial action (which consumes oxygen), or from chemical reactions (such as rusting/oxidation). Oxygen may also be displaced by another gas or vapour (e.g., carbon dioxide or nitrogen used to purge tanks, pipe, and vessels). Table 33-3 lists the effects of oxygen deficiency.

Table 33-3: Effects of Oxygen Deficiency

Oxygen Concentration	Effect
19.5%	Minimum for safe entry
Less than 18%	Loss of judgment and coordination
Less than 15%	Loss of consciousness
Less than 12%	Sudden collapse and loss of consciousness

Never use pure oxygen to ventilate a confined space. Use clean air.

Atmospheric Contaminants

Because confined spaces are poorly ventilated, atmospheric contaminants can build up to hazardous levels very quickly. The types of airborne hazards that may be encountered on a jobsite will depend on the following factors:

- The products that are stored in the confined space
- The type of work tasks being performed in the confined space
- The type of work or processes being performed near the confined space.

The most common atmospheric contaminants in construction include hydrogen sulphide, carbon monoxide, sulphur dioxide, chlorine, and ammonia.

Hydrogen Sulphide (H_2S) is a gas generated by the decomposition of garbage and sewage. H_2S can be found in sewers, sewage treatment plants, refineries, and pulp mills. It is also found in many oil refineries since most crude oil in Canada has some H_2S dissolved in it. H_2S is very toxic. A single breath at a concentration of about 500–700 ppm (parts per million) can be instantly fatal. At very low concentrations, H_2S has the characteristic odour of rotten eggs. However, at about 100 ppm, it can deaden your sense of smell and create the false impression that no hazard exists.

Carbon Monoxide (CO) is a very common toxic gas. It has no odour or taste and is clear and colourless. Carbon monoxide poisoning can be very subtle and may cause drowsiness and collapse followed by death (See Table 33-4). A major source of CO in construction is the exhaust from an internal combustion engine used to power saws, scissor lifts, powered trowellers, generators, and forklift trucks. Even these relatively small engines produce high levels of CO.

NOTE: Adequate ventilation is absolutely essential when you cannot avoid using combustion engines in confined spaces.

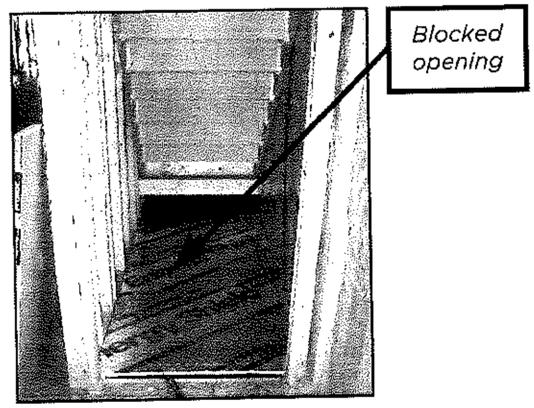
Heating in confined areas, particularly with propane, presents special hazards and requires special safeguards. Propane is heavier than air and can collect in low-lying areas such as trenches, basements, and shaft bottoms. Propane can also be absorbed into clothing. Workers must therefore use extreme caution in the event of leakage or flame-out.

Direct-fired heaters release combustion emissions directly into the air where people work. Although carbon monoxide (CO) is the main concern, carbon dioxide (CO_2) and nitrogen oxides may also be a problem.

Traditionally, explosive blasting has been used for demolition or breaking up rock. Blasting in a confined space can produce high levels of carbon monoxide. Use mechanical ventilation to clean the air and perform air tests before workers re-enter the blast area to ensure that the amount of carbon monoxide is within acceptable levels.

Table 33-4: Effects of Carbon Monoxide (CO)

CO in atmosphere (parts per million)	Signs and symptoms
10	No symptoms
25	TWA (Time-weighted average): The maximum average amount a worker is allowed to be continuously exposed to during an 8-hour work day or 40-hour work week.
70	Blood vessels widen, shortness of breath, tightness across the forehead
100	STEL (Short-term exposure limit): The maximum amount a worker is allowed to be exposed to for a 15-minute period.
120	Shortness of breath, headache with throbbing in temples
220	Headache, irritability, tiredness, impaired judgment, impaired vision, dizziness
350-520	Headache, confusion, fainting, collapse
800-1220	Unconsciousness, spasms, respiratory failure, death if exposure continues
More than 2000	Rapidly fatal (usually in less than 15 minutes)



Do not restrict ventilation by blocking openings

Sulphur Dioxide (SO_2) is a very irritating and corrosive gas with a strong sulphur-like odour which can be found in pulp-and-paper mills and oil refineries.

Chlorine (Cl_2) is another irritating and highly corrosive gas with a bleach-like odour used as a disinfectant in water and sewage treatment plants and a wide variety of other industrial settings.

Ammonia (NH_3) is a fairly common chemical used as a refrigerant and in making fertilizer, synthetic fibres, plastics, and dyes.

Hundreds of other toxic materials may be encountered in factories, chemical plants, and similar industrial settings. The best way to obtain information regarding the presence or absence of toxic materials is to discuss the proposed work with the client and ask for the information or consult a knowledgeable expert. Always refer to the safety data sheet (SDS) for any hazardous products you find.

Flammable Products

When using flammable materials in a confined space, take these precautions:

- Provide adequate ventilation.
- Control sparks (use non-sparking tools) and control other potential ignition sources.
- Extinguish all pilot lights.
- Use specially protected lighting that will not explode.
- Have fire extinguishers handy.

Contact cement is an example of a product with fire or explosion potential when used in a small area with poor ventilation. Workers have been killed from explosion and fire when they finished work and switched off the light in a room where solvent vapours from contact cement or adhesives had accumulated.

Accumulation of Contaminants

Trenches, manholes, and low-lying areas may become hazardous from leaking gases heavier than air, such as propane, or from gases such as carbon monoxide seeping through the soil and into the confined space.

Case study

A construction crew finished installing a 12-foot-deep manhole without incident. After the crew left the area, 265 pounds of nitroglycerin-based explosive in 20 boreholes, each 18 feet deep, were detonated 40–60 feet from the manhole. A worker who entered the manhole 45 minutes after the explosion collapsed within minutes, and two coworkers descended into the manhole to rescue him. One rescuer retrieved the unconscious worker before collapsing on the surface, and the other rescuer died in the manhole.

An investigation determined that carbon monoxide released from the explosion had migrated through the soil into the manhole. Carbon monoxide concentrations at the bottom of the manhole two days after the incident were 1,905 ppm (parts per million). This concentration was well above 1,200 ppm, the concentration classified as Immediately Dangerous to Life or Health (IDLH). Tests following ventilation of the manhole showed that high levels of carbon monoxide reappeared as a result of continued migration from the surrounding soil. Subsequent monitoring of the manhole showed a decline in carbon monoxide levels over the next 8 days.

Accumulation of Contaminants in Areas Not Classified as Confined Spaces

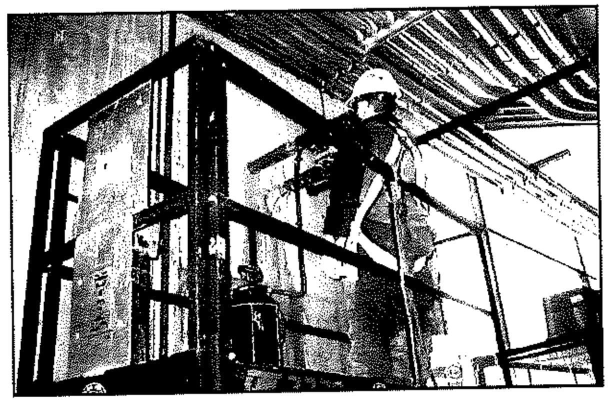
A variety of spaces can become hazardous because of the products being used or the work being done in them. These areas can be deadly even if they are not classified as confined spaces and even if the Confined Space Regulation does not apply.

Skylights, Domes, and Ceilings

Work is sometimes required within newly installed skylights where lighter-than-air gases and fumes may accumulate.

Workers should be aware of this hazard. At the first sign of discomfort or disorientation, they should leave the area until it has been ventilated.

Workers feeling light-headed or experiencing headaches may be inhaling these pollutants. Drowsiness or disorientation can lead to falls. Again, leave the area until it has been ventilated.

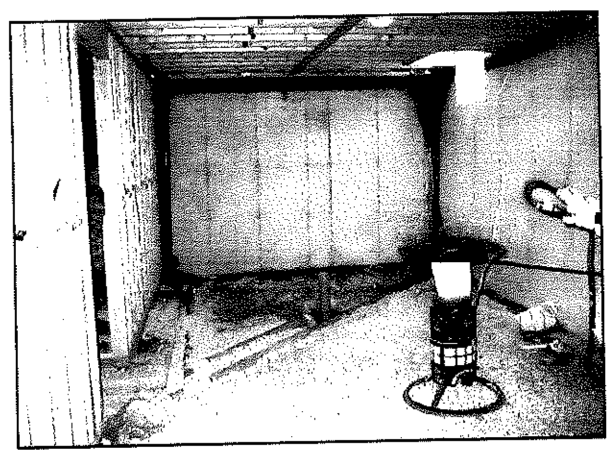


Underground Mines, Tunnels, and Shafts

These spaces are intended for people to carry out work in them (this work is covered by specific regulation). These spaces may present physical or atmospheric hazards. Many utilities are routed through tunnels or underground shafts where hazardous atmospheres may collect from containers or operations above, or be created by utility leaks (such as gas and oil).

Work in shafts must be carefully planned. Because the work may be of short duration and require only a temporary platform, these jobs are often not given proper attention.

In addition to the areas already described, beware of apparently harmless areas such as basements, halls, and small rooms that can become dangerous when a lack of ventilation and hazardous materials or operations combine to create atmospheric hazards.



If a worker can be injured by inhaling a hazardous gas, vapour, dust, or fume—or if there is an explosion hazard—then adequate ventilation must be provided (either by natural or mechanical means). If this is not possible, then respiratory protection equipment suitable for the hazard must be provided and workers must be trained in the proper use and limitations of this equipment.

Plan for Controlling Hazards

Once the hazards have been identified in the assessment, **a person with adequate training, knowledge and experience** must develop a **plan** to eliminate or control the hazards.

A person with adequate knowledge, training and experience can include a worker, a supervisor, a consultant, or anyone who has—in addition to the "academic" knowledge of the task at hand—a hands-on knowledge in safety performing the work, a knowledge of the associated hazards, possible controls and legal requirements needed in order to enact the necessary controls to protect the health and safety of the workers in and about the confined space.

The primary objective of the **plan** is to control or eliminate the hazard before entry. If this is not possible, then adequate controls, measures, and procedures must be put in place to ensure that workers are not in danger.

If confined spaces on multiple construction projects are similar and present the same hazards, a single plan can be used. Still, the individual confined spaces must be identified in both the hazard assessment and the plan.

The plan is the program element with the most regulatory requirements attached to it. The regulation outlines 11 mandatory requirements that must be contained in the plan:

1) Duties of workers
2) Co-ordination document (prepared by the constructor) if workers of more than one contractor enter the same confined space
3) On-site rescue procedures
4) Rescue equipment and methods of communication
5) Protective clothing and equipment
6) Isolation of energy and control of material movement
7) Attendants
8) Adequate means of entry and exit (access and egress)
9) Atmospheric testing (conducted by a competent worker)
10) Adequate procedures for working in the presence of explosive or flammable substances
11) Ventilation and purging.

Each of these 11 mandatory requirements are addressed in the following sections.

Duties of Workers

a) Do not enter or re-enter (if the confined space has been left unoccupied and unattended) the confined space unless atmospheric testing has been performed.
b) Know the hazards that may be faced upon entry. Know the routes of exposure (e.g., inhalation or skin absorption), signs and symptoms, and long-term effects of exposure.
c) Know how to use the equipment (including personal protective equipment and tools) properly.
d) Maintain communication with the attendant so that the attendant can monitor your safety and be able to alert workers to evacuate the confined space.
e) Alert the attendant whenever
   - you recognize any warning sign or symptom of exposure
   - you see a dangerous condition
   - an alarm is activated.
f) Get out of the permit space immediately whenever
   - a warning system indicating a ventilation failure is activated
   - the attendant gives an evacuation order
   - a worker recognizes any signs or symptoms of exposure
   - a person inside detects a dangerous condition
   - an evacuation alarm is activated.

Co-ordination Document

When workers of more than one employer perform work in the same confined space, the constructor must co-ordinate entry operations. The constructor must prepare a co-ordination document to ensure that the various employers perform their duties in a way that protects the health and safety of all workers entering the confined space.

A copy of the co-ordination document must be provided to each employer of workers who perform work in the confined space and the project's joint health and safety committee or health and safety representative.

Each employer is responsible for the health and safety of their own workers and for ensuring compliance with the regulation.

Rescue Procedures

The confined space plan must include written procedures for safe onsite rescue that can be implemented immediately in case of an emergency. An adequate number of people must be available to carry out the rescue procedures immediately.

Rescuers must be **trained** in

a) The onsite rescue procedures

b) First aid and cardio-pulmonary resuscitation (CPR)

c) How to use the rescue equipment necessary to carry out the rescue.

Dialing 911 is not a sufficient rescue response. A rescue plan and procedures must be developed. If a rescue is not completed within five minutes of an alarm, there is an increased chance of fatalities (i.e., a rescue operation can quickly become a "recòvery" operation).

Remember: Rescuers are no good to the victim if they also become victims. Rushing into a confined space to help your friend who is laying on the ground will likely result in your own death. Experts estimate that between 50 and 60% of all confined space fatalities involve would-be rescuers who entered the confined space without adequate knowledge and preparation to deal with the hazards they encountered.

Rescue Equipment and Communications

The rescue equipment must be readily available, appropriate for the confined space, and inspected by a person with adequate knowledge, training and experience. This person must keep a written record of the inspection. Examples of rescue equipment include harnesses and lifelines, hoist/retrieval systems, tripods, respirators, and other personal protective equipment.

NOTE: Consider the size of the confined space's opening when choosing rescue equipment. There is no point planning for a rescuer to wear a SCBA (self-contained breathing apparatus) unit if it doesn't fit through the opening.

All too often, inadequate or incorrect emergency rescue response results in multiple fatalities. Here are two examples:

- A worker collapsed shortly after entering a degasser tank. His coworker went in after him and collapsed as well.
- A contractor went to test acid-tainted water and was discovered by a worker floating in a well of the above-ground pump house. The worker went to his rescue after calling 911 but was himself overcome. Two paramedics responding to the call were also struck down. All four victims died.

Even with the best planned and executed entry, there is a chance of a sudden change in conditions. The change could be due to factors recognized earlier but for which no "absolute" protection exists, such as the failure of a respirator, the introduction of a new hazard, or collapse from heart attack or illness. In such cases, you need a rescue plan that has been practiced and works.

Protective Clothing and Equipment

Protective clothing and equipment suitable for one situation may not be suitable for others. For example, polyvinyl chloride (PVC) plastic is resistant to most acids, but it can be softened or penetrated by many common solvents such as benzene, toluene, and xylene.

For this reason, a knowledgeable person should assess the protective clothing and equipment needed (e.g., gloves, boots, chemical suits, fire resistant coveralls—as well as hearing, respiratory, eye, and face protection). Don't forget that if workers need personal protective equipment, they must be trained in its use.

Respiratory protective equipment should be used where ventilation is impractical or inadequate. Certain basic rules apply to the equipment.

First of all, you need to select the proper type of respirator. Oxygen-deficient atmospheres require supplied-air respirators—either airline types with emergency reserves or SCBA (self-contained breathing apparatus). (See Figure 33-3.)

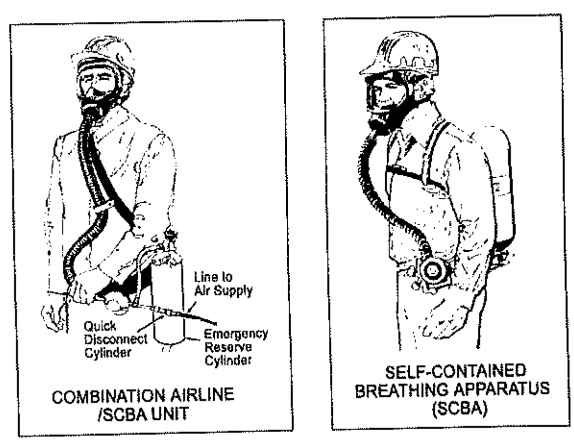


Figure 33-3: Supplied-Air Respirations

SCBA Note: Because the amount of air supply in standard SCBA cylinders is rated for a specific time period, it is very important to plan your tasks, especially rescue operations, accordingly. Heavy work and stress will increase breathing rates and workers will use up the air in less than the rated time. An alarm sounds when the air supply is low. If the alarm bell sounds and the exit or egress is far away, there must be a back-up plan to provide enough air for breathing to allow workers to reach the exit.

In toxic atmospheres, you must use supplied-air respirators if the concentration of the gas or vapour exceeds the level considered to be Immediately Dangerous to Life or Health (IDLH), or if the concentration is unknown.

When the level of toxic gas or vapour is above the exposure limit but below the IDLH level, air-purifying respirators approved by the National Institute of Occupational Safety and Health (NIOSH) may be used, provided the exposure conditions do not exceed the unit's limitations. Someone who is competent in respirator selection must determine the appropriate type of respirator.

Workers required to wear respirators must be instructed how to properly fit and maintain them. (For more information, refer to the chapter on "Respiratory Protection", or CAN/CSA-Z94.4: *Selection, Use, and Care of Respirators*.)

Workers must be supplied with NIOSH-approved respirators only. Single-strap dust masks and surgical masks provide little or no protection and are not approved. NIOSH-approved respirators have an approval number (starting with the letters TC).

Also, make sure your respirator has all the proper parts. Each manufacturer uses different designs, so parts are not interchangeable. Cartridges or air cylinders from another manufacturer will not fit correctly and will endanger the life of a worker or rescuer.

Isolation of Energy and Control of Material Movement

Equipment that moves in any way (even rotation) must be isolated by

- Disconnecting the equipment from its power source and de-energizing the equipment, or
- Lockout and tagging. Only workers trained in lockout and tagging should perform such operations. Lockout and tagging should be done even if you use the first option (disconnect and de-energize) to isolate the energy.

For pneumatic or hydraulic equipment, isolate the power source and depressurize the supply lines. Depressurize any components that may still be pressurized after the supply lines have been bled (e.g., hydraulic cylinders). You must disconnect and drain pipes carrying solids or liquids to or from a confined space, or insert blank flanges (Figure 33-4).

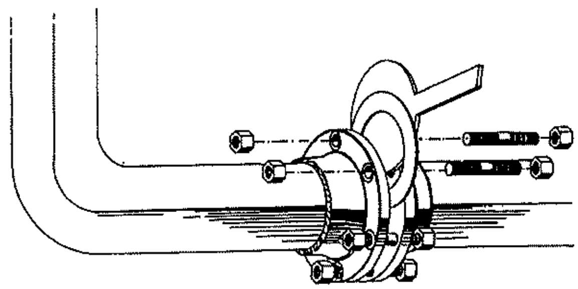


Figure 33-4: Disconnect or Blank Off Pipes

If the pipe cannot be blanked off or disconnected, the valve may be closed, chained, locked and tagged, provided that this type of control—and its importance—have been explained to all workers in the area (Figure 33-5). **Simply closing valves is not acceptable.**

Figure 33-5: Close, Chain, Lock, and Tag Pipe Valves

You may need blocking to prevent movement caused by gravity for some equipment (e.g., conveyors).

Electrical equipment in the space should be disconnected, tagged and locked out, and grounded when it's practical to do so (Figure 33-6).

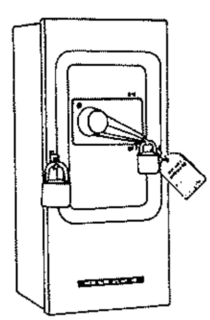


Figure 33-6: Disconnect, Lock, and Tag Electrical Equipment

In the case of live electrical work in a confined space, you need to pay special attention to standard procedures. A minor mistake in a manhole can lead to disaster.

Cramped working conditions can make accidental contact with an energized conductor more likely, so you may need non-conductive equipment.

You may need gloves, mats, and other insulating equipment depending upon the type of work. Capacitors or other components which can store a charge should be discharged and/or grounded.

Attendants

An attendant must be present whenever a worker enters a confined space. The attendant is not allowed to enter the confined space, unless he or she is replaced by another attendant in accordance with the plan.

Attendants must follow these requirements:

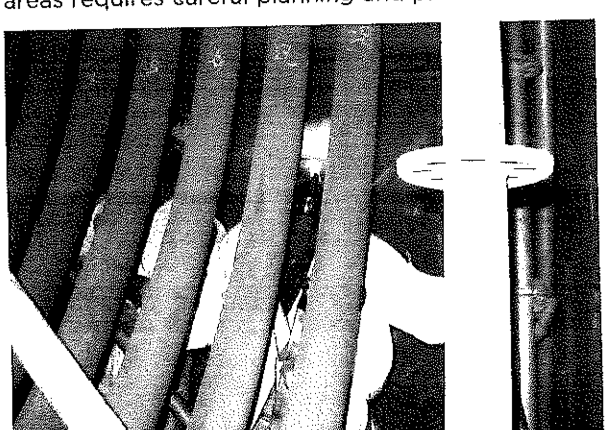
- Remain alert outside and near to the entrance.
- Be in constant communication (visual or speech) with all workers in the confined space.
- Monitor the safety of workers inside the confined space.
- Provide assistance as necessary (except rescue).
- Have a device for summoning help in case of emergency (device must be provided).
- Initiate an adequate rescue procedure in case of an emergency.

Entry and Exit (Access and Egress)

The means of entry and exit can be evaluated before entry by checking drawings, by prior knowledge, or simply by inspection from outside the space.

Confined space openings are generally small and not well located. These small openings must be considered in the rescue plan since they restrict the movement of workers and equipment in and out of confined spaces.

Entry and exit for top-side openings may require ladders. Ladders must be well secured. Performing an emergency rescue on workers trapped in such areas requires careful planning and practice.



Atmospheric Testing

If the hazard assessment determines that there is an atmospheric hazard in the confined space, you must perform atmospheric testing.

1) The employer must appoint a person with adequate training, knowledge and experience to perform adequate tests safely before and during the time a worker is in a confined space to ensure that acceptable atmospheric levels are maintained. The person who will perform the tests must receive training in the operation, calibration, and maintenance of the instruments. Most manufacturers can provide necessary training.
2) If the confined space has been left unoccupied and unattended, the testing must be performed again.
3) The person with adequate training, knowledge and experience performing the tests must use properly calibrated and maintained instruments appropriate for the hazards in the confined space.
4) Results of every sample of a test must be recorded on the entry permit. If continuous monitoring is performed, test results must be recorded at adequate intervals.

Gas Detection Instruments

Gas detection instruments can take many forms—"personal" or "area," single-gas or multiple-gas detectors, detectors with dedicated sensors, or those with interchangeable sensors (Figure 33-7).

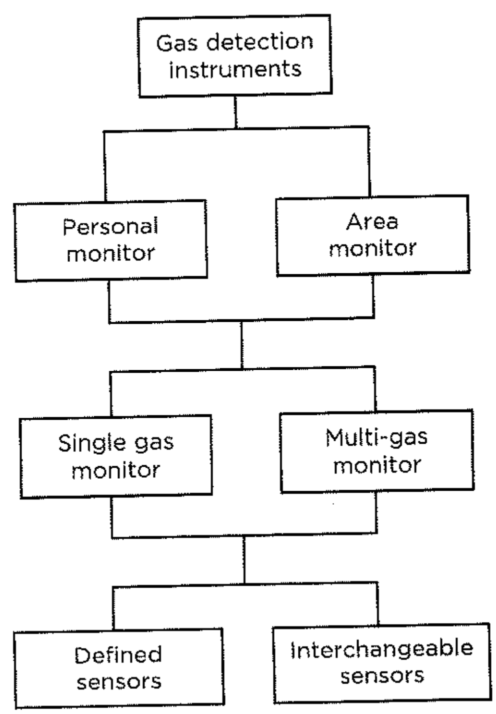


Figure 33-7: Gas Detection Instruments