

## CHAPTER 9

### SAFETY

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## INTRODUCTION

The user should not assume that all safety measures are indicated in this manual or that other measures may not be required. The safety guidelines presented in this chapter are minimum standards only. Before commencing actual work the latest safety standards and laws should be checked and followed. It is the responsibility of each agency to follow current and comprehensive safety standards and laws at all times.

The contents of this chapter are not intended to be and should not be construed to be a standard of the Metropolitan Sanitary District of Greater Chicago or Metcalf & Eddy, Inc. No reference made in this chapter to any specific safety method, product, process, or service constitutes or implies an endorsement, recommendation or warranty thereof by the Metropolitan Sanitary District of Greater Chicago, or Metcalf & Eddy, Inc. The Metropolitan Sanitary District of Greater Chicago, and Metcalf & Eddy, Inc. make no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, or suitability of any information, apparatus, product, or process discussed in this chapter, and assume no liability therefore. Anyone utilizing this information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

Worker's safety should be the responsibility of everyone involved in the operation and maintenance of a collection system. Good safety procedures are a result of proper planning. Proper planning ensures that tasks can be achieved in a safe working manner and that difficulties are reported and action taken by a designated person or persons. This ensures that slackness does not develop. Safety hazards which may be encountered during routine collection system operation and maintenance are addressed in this chapter. The National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) are two governmental organizations which offer booklets and guidelines for worker safety procedures. The National Association of Sewer Service Companies (NASSCO) offers safety training on request.

The best working conditions for operation and maintenance personnel of sewage collections systems includes provision and correct use of safety equipment, proper job instruction, frequent review of safety practices, adequate and competent supervision, and proper planning of a job through to completion. A high injury rate is not only undesirable

for the obvious reason of human health care, but it also leads to a decrease in operating efficiency and an increase in operating costs.

## **SAFETY RESPONSIBILITIES**

### Agency

The agency under which the sewage collection system operates has the responsibility to develop safe working practices based on current and comprehensive safety standards for all jobs as well as to encourage and promote the implementation of these practices. The agency also has the responsibility of providing an organization which includes professional advisors, who recognize legal safety requirements and proper equipment and tools.

### Management

Adequate training and education of employees is the responsibility of the management, who must communicate safety information to workers through safety meetings, in-service training classes and safety instruction booklets which are published by OSHA, NIOSH and other safety organizations. Management also has the responsibility of investigating hazardous work conditions, seeing that workers are fit to perform the work assigned, and maintaining accurate records of accidents and injuries.

Supervisors and foremen provide a link between management and workers. They must have a thorough knowledge of the safety program and see that it is followed by workers. Foremen should review their work for compliance with established safety regulations. They should also inspect the equipment and methods used for any problems which could lead to safety hazards.

### Staff

All employees have a responsibility to themselves, their families, and their jobs to do everything they can to prevent personal injuries and accidents. This can be done by following established safety regulations, using the proper safety equipment required by any job, and keeping up to date with all current safety practices. In these ways, human error, the most significant cause of accidents, can be kept to a minimum.

In case an accident does occur, all employees should be familiar with the various routes to the nearest hospital. These routes can be marked on a map that is stored in each maintenance vehicle.

## **HAZARDS**

There are six major categories of hazards that may be encountered when performing maintenance operations in a wastewater collection system. These hazards are discussed in order of frequency of accidents and deaths attributable to each. They are: atmospheric, physical injury (due to slips, falls, falling objects, sharp objects, bumps, and structural failures), infection and disease, insects, toxic exposure and drowning.

## Atmospheric Hazards

Atmospheric hazards are of three major types: explosive or flammable, toxic, and oxygen deficient. These conditions are commonly found in confined spaces. The National Institute for Occupational Safety and Health (NIOSH) defines a confined space as a space which is characterized by any of the following:

- 1) Limited openings for entry and exit.
- 2) Unfavorable natural ventilation.
- 3) Not designed for continuous worker occupancy.

A confined space should NEVER be entered before the atmosphere is tested with the proper equipment for hazardous conditions. Table 9-1 summarizes common gases encountered in sewers and at sewage treatment plants.

Explosive or Flammable Atmospheres. Explosive or flammable atmospheres can develop at any time in the collection system. Flammable gases or vapors may enter a sewer system or manhole from a variety of legal, illegal or accidental sources. The principle causes of explosion are methane, gasoline, propane, other explosive fuel gases and grease solvents. Explosions can occur due to sparks from cars, tools, open flames, and cigarettes. Meters are available that measure the concentration of combustible gases. Check for combustible gases before lifting the manhole cover or before entering a manhole or sewer. Continue to meter for combustible gases for as long as workers are in the manhole or sewer.

Methane gas is one of the products of waste decomposition. This gas can be produced almost anywhere in the collection system. Methane is also the major flammable gas in the natural gas piped under streets by utility companies. Leaks in these pipes will saturate the soil around a sewer pipe, leading to seepage of the gas into the collection system. Since methane and other natural gases are lighter than air, some gas will diffuse or escape from a manhole if there is natural ventilation.

Explosive fuel gases, such as propane, gasoline, and grease solvents may be as much as four times heavier than air. This results in the accumulation of gases in deep manholes, underground structures, and sewers where ventilation is limited by venturi meters or sections flowing full.

Toxic Atmospheres. Toxic atmospheres (poisonous air) in wastewater collection systems are most often caused by sulfide, a gas produced by the decomposition of certain materials containing sulfur. Hydrogen sulfide mixes quickly with air and goes wherever the air goes. If there is no ventilation or air movement, hydrogen sulfide accumulates in the lower sections of the collection system. Hydrogen sulfide can also undergo a chemical reaction which results in the formation of sulfuric acid, a highly corrosive acid. Hydrogen sulfide can be identified by the smell of rotten eggs. However, the actual measurement of the hazard should be left to instruments that measure its concentration, because the human nose is unreliable. Other toxic gases that may be encountered include chlorine, carbon monoxide, and ammonia.

Other Sources. The combination of certain industrial wastes in the sewer system can result in the release of gases. Knowledge of the industrial discharges is important. Industrial wastes discharged within the collection system can constitute a major concern to worker health and safety. Further, due to the effects of undesirable discharge, either singularly or combined, major physical damage to the collection system, pumping and lifting stations, receiving treatment facility, and receiving waters can result.

**TABLE 9-1. COMMON DANGEROUS GASES ENCOUNTERED IN SEWERS AND AT SEWAGE TREATMENT PLANTS\***

Name of Gas	Chemical Formulae	Specific Gravity of Vapor Density** (Air=1)	Explosive Range (% by Vol. in air)		Common Properties (Percentages below percent in air by volume)	Physiological Effects (Percentages below are percent in air by volume)	Most Common Sources in Sewers	Simplest and Cheapest Safe Method of Testing
			Lower Limit	Upper Limit				
Oxygen (in air)	O <sub>2</sub>	1.1	Not flammable		Colorless, odorless, tasteless, non-poisonous gas. Supports combustion.	Normal air contains 20.93% of O <sub>2</sub> . Man tolerates down to 12%. Below 5% to 7% likely to be fatal.	Oxygen depletion from poor ventilation and absorption or chemical consumption of available O <sub>2</sub> .	Oxygen deficiency indicator.
Gasoline	C <sub>3</sub> H <sub>12</sub> to C <sub>3</sub> H <sub>26</sub>	3.0 to 4.0	1.3	7.0	Colorless, odor noticeable in 0.03% Flammable. Explosive.	Anesthetic effects when inhaled. 2.43% rapidly fatal. 1.1% to 2.2% dangerous for even short exposure.	Leaking storage tanks, discharges from garages and commercial or home dry-cleaning operations	1. Combustible gas indicator. 2. Oxygen deficiency indicator for concentration CO ampoules.
Carbon monoxide	CO	0.97	12.5	74.2	Colorless, odorless, non-irritating. Tasteless, flammable. Explosive.	Hemoglobin of blood has strong affinity for gas causing oxygen starvation. 0.2% to 0.25% causes unconsciousness in 30 minutes.	Manufactured fuel gas.	
Hydrogen	H <sub>2</sub>	0.07	4.0	74.2	Colorless, odorless, tasteless, non-poisonous, flammable. Explosive. Propagates flame, very dangerous.	Acts mechanically to deprive tissues of oxygen. Does not support life. A simple asphyxiant.	Manufactured fuel gas.	Combustible gas indicator.
Methane	CH <sub>4</sub>	0.55	5.0	15.0	Colorless, tasteless, odorless, non-poisonous, flammable, explosive.	See hydrogen.	Natural gas, marsh gas, mfg. fuel gas, sewer gas.	Combustible gas indicator.

\*From Water and Sewage Works - Van Kleeck - August 1953.

\*\*Gases with a specific gravity less than 1.0 are lighter than air, those more than 1.0 are heavier than air.

TABLE 9-1. (Cont.) COMMON DANGEROUS GASES ENCOUNTERED IN SEWERS AND AT SEWAGE TREATMENT PLANTS\*

Name of Gas	Chemical Formulae	Specific Gravity of Vapor Density** (Air=1)	Explosive Range (% by Vol. in air) Lower Limit Upper Limit	Common Properties (Percentages below percent in air by volume)	Physiological Effects (Percentages below percent in air by volume)	Most Common Sources in Sewers	Simplest and Cheapest Safe Method of Testing
Chlorine fumes.	$Cl_2$	2.5	Not Flammable Not explosive	Greenish yellow gas, or amber color liquid under pressure.  Highly irritating and penetrating odor. Highly corrosive in presence of moisture.	Respiratory irritant, irritating to eyes 30 ppm causes coughing. 40-60 ppm dangerous in 30 minutes. 1000 ppm apt to be fatal in few breaths.	Leaking pipe connections. Overdosage.	Odor, strong ammonia on swab gives off white
Hydrogen Sulfide	$H_2S$	1.19	4.3 46.0	Rotten egg odor in small concentrations but sense of smell rapidly impaired. Odor not evident at high concentrations. Colorless. Flammable. Explosive. Poisonous.	Death in few minutes at 0.2%. Paralyzes respiratory center.	Petroleum fumes, sewer gas.	1. $H_2S$ ampoules. 2. 5% by wt. lead acetate solution.
Carbon Dioxide	$CO_2$	1.53	Not flammable	Colorless, odorless, non-flammable. Not generally present in dangerous amounts unless there is already a deficiency of oxygen.	10% cannot be endured for more than a few minutes. Acts on respiratory nerves.	Issues from carbonaceous strata. Sewer gas.	Oxygen deficiency indicator.
Nitrogen	$N_2$	0.97	Not flammable	Colorless, tasteless, odorless. Non-poisonous. Principle constituent of air (about 79%).	See Hydrogen.	Issues from some rock strata. Sewer gas.	Oxygen deficiency indicator.
Ethane	$C_2H_4$	1.05	3.1 15.0	Colorless, tasteless, odorless, non-poisonous. Flammable. Explosive.	See Hydrogen.	Natural gas.	Combustible gas indicator.

\*From Water and Sewage Works - Van Kleeck - August 1953.

\*\*Gases with a specific gravity less than 1.0 are lighter than air, those more than 1.0 are heavier than air.

Due to the relative exposure it is critical to catalog, define, and develop appropriate safety job instructions and work measures to safely conduct required work within these areas.

Knowledge of industrial discharges should be obtained from such sources as; the local board of health, local right-to-know co-ordinator, local industrial waste officer, and regulatory agency personnel.

Oxygen Deficient Atmospheres. The amount of breathable oxygen present in a manhole or sewer can be decreased or eliminated by having the air mixed with or replaced by the entry of another gas. Meters are available that measure the concentration of oxygen in the atmosphere. It is extremely important to ventilate the manhole during occupancy. A manhole or other confined space where the atmosphere contains less than 19.5 percent or more than 21 percent oxygen is unsafe to work in. In this case, ventilation should be increased and the use of appropriate respiratory protection considered.

### Physical Injury

Physical injuries during manhole work can occur from several causes. Working in manholes is often awkward due to the narrow space and uneven footing. This results in poor balance and decreased coordination which could lead to strained muscles, bruises, scrapes and cuts. Injuries can also occur due to slipping on ladder rungs and manhole benches. Care must also be taken in removing manhole covers. The cover should be removed with a hook or crowbar and dragged from the manhole frame. All loose debris and dirt should be cleaned from around the manhole opening to prevent the falling of such debris upon a worker below.

Corroded and otherwise unsafe manhole steps are also a potential source of injury. It is sometimes best to enter a manhole with the use of a portable window washer ladder. The use of heavy ladders should be avoided. Workers should not be in the manhole when ladders or other heavy objects are being moved. Access is impossible with standard ladders.

Dropping tools to workers in a manhole, and tossing them back out, have caused many injuries. A worker should avoid looking up and out of the manhole while inside it. This will decrease the chance for dust and debris to get in the eyes and for possible eye infection if the worker should wipe his eyes with a hand or glove that has been exposed to the wastewater environment. Tools should be lowered into and pulled out of manholes in a canvas bag or sling. Often, truck winches are used to lower a worker or tools into the manholes.

Protective eyewear must be used at all times. The use of spectacles or safety goggles in a manhole may be difficult because of their tendency to fog. These glasses can also become smeared by moisture in a manhole environment, resulting in decreased vision capacity by the wearer. Proper ventilation will reduce fogging problems. If a chipping gun or other tool is used to chip concrete or pipe, protection for the eyes must be worn. A helmet and clear face shield may be a better choice than safety goggles.

When working in a manhole, beware of sharp objects that can cut or penetrate your skin and cause a serious infection. Typical objects to look for include razor blades, pins, hypodermic needles, and pieces of broken glass and metal.

## Infections and Disease

Workers who come in contact with wastewater are exposed to a number of viruses such as Hepatitis A, Polio and Reovirus. Exposure to the AIDS virus is also possible. However, the AIDS virus cannot survive outside the human body for more than a few seconds. Therefore, it is highly unlikely that the AIDS virus can be contracted from wastewater.

When working on the sewer system, protective clothing such as rubber surgical gloves, coveralls, and rubber boots become very important in reducing exposure to disease. Personal hygiene is also extremely important in reducing workers exposure to disease. Immunizations and inoculations for Typhoid, Paratyphoid, Polio, and Tetanus should be obtained by all workers. Specific state and local immunization requirements can be obtained from the Center for Disease Control, Atlanta, GA, NIOSH, Morgantown, W. VA, and state and local health officials.

## Pests

Insects, rodents, and other pests, while less severe a danger to workers than infections and diseases, can be a source of danger. Many insect bites are associated with diseases. For example, mosquito bites can cause malaria. Always inspect a manhole for pests before entering. The following pests are found in manholes and should be avoided:

- Stinging insects such as wasps, daubers, and bees.
- Ticks.
- Fleas.
- Lice.
- Mosquitoes.
- Houseflies.
- Blowflies.
- Rats.
- Snakes.
- Roaches.

To remove pests and clean the manhole before entry, flush it with a water jet.

## Toxic Exposure

Toxic acid, bases, and other hazardous liquid or solid chemicals can be discharged into the wastewater collection system either accidentally in spills or deliberately by industry or the public. This is always a potential health hazard. Proper boots and gloves are examples of protection against toxicants.

## Drowning

With the trend toward larger regional wastewater treatment plants, intercepting sewers are being constructed that convey large flows. These large diameter sewers and flows increase the chance of a worker drowning from an accidental slip or fall into the flowing wastewater. Step carefully at all times, especially when working in or near large flows, to avoid drowning. Always wear a lifeline connected to the safety harness. Wear a life jacket if necessary. Make sure barricades, warning devices and signs are used.



## **SAFETY PRACTICES**

All sewer system personnel should be aware of and use safety practices when working in or around the sanitary sewer system. Some of the more important safety practices are listed below.

To minimize the chance of injury due to asphyxiation or explosion the following safety practices must be used:

1. When entering a manhole where an atmospheric hazard is suspected to exist, there should be no smoking or open flames, workers should guard against sparks by using non-sparking tools and explosion-proof equipment. The atmosphere must be tested for hazards, including combustible gases, oxygen deficiency and hydrogen sulfide. If any hazard is detected, the sewer or manhole must be ventilated by natural or artificial means. Testing of the atmosphere must be repeated before entering the manhole.
2. Adequate ventilation must be maintained during work and tests must be conducted frequently.
3. Appropriate respiratory protection must be worn if adequate ventilation is not possible or practical.
4. Fire and explosion prevention is practiced through care in avoiding making sparks from shoes, tools, open flames, and even from the removal of manhole covers.
5. Appropriate personal protection and safety equipment must be used.

To minimize physical injuries, simple good housekeeping is very effective.

1. Tools should not be left near an open manhole and should be put away immediately after use.
2. Manhole covers should be replaced promptly after work is completed to guard against injury to workers and the public.
3. Sufficient help should be available whenever manhole entry is required. This calls for at least a three worker crew.

Some other very important, rules of safety are as follows:

1. Rubber gloves should be worn when handling wastewater or similar materials. Special precautions should be taken to prevent wastewater from coming in contact with open cuts or other injuries. Rubber boots or rubber shoe coverings should also be worn. Rinse any contaminated skin areas with hydrogen peroxide.
2. Emergency first aid must be given to all minor cuts or injuries. A doctor should treat all but the minor injuries. Instruction for first aid treatment is available from several sources including state health departments, the National Safety Council, and the American Red Cross.

3. Personnel must make a habit of frequently and thoroughly washing hands and face with antiseptic soap and hot water, especially before meals and smoking. Prior to leaving work, a shower and change of clothes is recommended to reduce the chance of transmitting infection to others. Leave work clothes in the yard. Nails should be kept short and clean to prevent the accumulation of any dirt or infectious materials. Dirty hands should be kept away from eyes and mouth.
4. In general, the highest injury rate is usually associated with workers that are very aggressive in their work habits. Workers should always, without exception, take the necessary time to:
  - a. Review and understand approved instructions.
  - b. Wear all of the necessary approved personal protective apparel.
  - c. Properly use all required safety tools, devices, and equipment.

## **SAFETY EQUIPMENT**

Using the proper safety equipment is critical for any sewer system operation and maintenance program. When entering confined spaces many vapors and gases which are toxic cannot be detected without the use of approved detection equipment. NEVER conduct entry into a confined space without the use of such devices. Several types of gas detection and oxygen deficiency indicators are available for analyzing the atmospheres of confined spaces. A portable oxygen/explosivity alarm unit should be the type that continuously withdraws a sample of the atmosphere from a manhole and tests it for the presence of explosive or flammable gases and the percentage of oxygen, or that is equipped with a sensor or probe that is lowered into the manhole. The device should have an audible and visible alarm that will warn when flammable gases (such as methane, etc.) exceed 20 percent of the lower explosive limit, or when the amount of oxygen drops below 19.5 percent. A device must also be available to test for hydrogen sulfide gas and other toxic gases that might be present. Battery operated units should also have an alarm to indicate low battery power before such power becomes inadequate to permit the equipment to function properly. These gas testing devices must be maintained and in proper operating conditions at all times. It is important that these devices receive regular preventive maintenance and calibration before and after entry inspections.

When ventilation is unable to provide a suitable atmosphere in a manhole or confined space, self-contained breathing apparatus (SCBA) are required to safely enter. This apparatus consists of a face mask respirator and hose to the air supply. Air may be supplied either from a tank on the worker's back, or from larger cylinders placed at a convenient location and not carried by the worker.

A ventilation blower is required to ventilate sewers and manholes. The blower must be on ten to fifteen minutes and the atmosphere tested before entry to the manhole. The blower hose outlet must be all the way down to the bottom of the manhole. A fan type blower should have between 750 and 850 cfm (cubic feet per minute) capacity for a standard manhole with a four foot diameter at the bottom. The standard unit will have a fifteen foot long hose, eight inches in diameter to conduct the blower air to the bottom of the manhole. Hose couplings and extensions must be available because some manholes are over twenty

feet deep. Gasoline engine powered blowers are less desirable due to the high noise factor, and the possibility of producing undesirable fumes and gasoline leaks. Whether the blower is powered by a gas engine or an electronic motor, it should be explosion-proof. One problem encountered in using blowers is that blowing air into a manhole can create a pocket of gas. Ventilation can be improved by removing the nearest upstream or downstream manhole cover. If the manhole is washed with a jet stream immediately before entry, the air current from the jet will further remove any gases.

Another method is to draw air from the bottom of the manhole. If the downstream pipe is not flowing full, there is an air space in it and air can be exhausted or drawn from the downstream manhole. In this way, the person in the manhole is breathing fresh air from the manhole entrance. This method is acceptable if the new air that flows into the bottom of the manhole is satisfactory for breathing and does not contain flammable or toxic gases. When airflow is stopped, hazardous atmospheric conditions may once again result. Therefore, ventilation and atmospheric testing should be continuous.

Safety harnesses should be worn by all workers entering the manhole to guard against several serious injuries including asphyxiation. The harness should be a parachute type which prevents a limp body from falling out of it. The lifeline connection should attach at the shoulders to suspend a body in the upright position. Tilting or doubling over of a body can prevent its rapid removal through the 24 inch manhole opening, or cause injury to a person while being removed in the doubled over or tilted position. Approved lifting devices should be used, whether they be portable or fixed. When fixed to vehicles, make sure the exhaust pipe has an extension hose and discharges fumes downwind of the entrance.

The harness and lifeline may be used to lower a worker into a confined space. Whenever a worker is underground, at least two persons of ample strength to pull the other worker out must be topside of the manhole holding the lifeline and observing the actions of the worker in the harness. Do not tie the above ground lifeline to any object that could be hit by a careless driver, which could result in injury to the worker in the harness.

Fire extinguishers should be available at all times to maintenance personnel. All personnel should be familiar with their use and location. The most convenient location for these extinguishers would be at a common location in each vehicle. For example, mounted to the left or right of the rear window over the driver's seat in division trucks. The extinguishers should be checked periodically for operability and charge.

Safety equipment needed to guard against physical injury includes traffic signs, cones, barricades, and high level flags when working in areas where vehicle traffic is present. Where traffic is very heavy or road conditions are dangerous, traffic police may be desired or required. A utility truck is an effective barricade. A manhole cage, proper lighting, and a safety harness and rope are necessities to guard against personal injury.

No person should be allowed to enter a manhole without adequate head protection. The full strength hard hat is recommended. The brim should be adequate to protect the face, or a clear face shield should be used. Chin straps are recommended for work in confined quarters.

As much of a person's skin as possible should be covered with clothing that will prevent scrapes and abrasions. This includes proper shoes, gloves, and long sleeves. Leather gloves protect best against cuts and scrapes. The use of disposable rubber surgical gloves, used in combination with outer gloves, can further reduce exposure.

Physical injuries in pumping stations should also be prevented. This can be done by enclosing ladders with hoop cages and supplying long ladders with intermediate landings and safety straps. Sufficient day and night lighting is required. Warning signs should be posted near dangerous machines. Carbon dioxide and dry chemical extinguishers should be supplied in every pumping station.

## **PRECAUTIONS FOR MANHOLE ENTRY**

**NOTE:** The safety guidelines presented here are minimum requirements only. It is the responsibility of each agency to follow current and comprehensive safety standards at all times.

### Immunizations

Workers in a wastewater collection system should have current immunizations against illnesses and diseases which might be encountered in the collection system. Typhoid and tetanus shots with booster shots every five years is the policy for many agencies. Records on all employees should be kept indicating when more shots are required. Contact state and local health agencies to determine specific immunization and inoculation requirements.

### Health Conditions of Workers

All workers entering a manhole should conform to the following rules at the time of entry:

1. Be in good health. If a worker is recovering from a recent illness or surgery, manhole work should not be performed until fully recovered.
2. Do not have a hangover or be under the influence of alcohol or drugs as these impair physical and mental ability.
3. Be in sound physical condition.
4. Have no open sores, skin irritations (including such things as poison ivy or poison oak), fungus infections (such as athlete's foot), or serious sunburn.
5. Workers who do not require corrective eyeglasses for manhole tasks are recommended for such work.

Other workers on the manhole entry or maintenance crew should also follow the above rules to help make any operation as safe as possible for all involved.

### Confined Space Entry Permit

Every Agency should have a specific procedure that must be followed before a worker is allowed to enter a confined space. This will ensure that the workers are familiar with safety procedures associated with confined space entry. Part of this procedure may consist of an employee completing a Confined Space Entry Permit and Record form before being allowed to enter a confined space. Figure 9-1 shows an example Confined Space Entry Permit and Record form. Additionally a Safe Work Permit or a Safe Job Instructions Form could be filled out prior to performing potentially dangerous work. Figures 9-2 and 9-3 are example Safe Work Permit and Safe Job Instructions form respectively. These forms serve

LOCATION OF WORK: (Name of Plant, Name of Confined Space)

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DESCRIPTION OF WORK:

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EMPLOYEES ASSIGNED:

---

---

ENTRY DATE:

---

**ISOLATION CHECKLIST:**

- Blanking and/or Disconnecting Piping
- Electrical Lockout and Danger Tags
- Mechanical
- Other

**HAZARDOUS WORK TO BE DONE:**

- Burning
- Welding
- Brazing
- Open Flame, Sparks
- Cleaning (solvents, water blast, sandblast)
- Other

**HAZARDS EXPECTED:**

1. Restrictive Opening
2. Oxygen Deficiency, Enrichment
3. Flammable Materials
4. Toxic Materials
5. Corrosive Materials
6. Dusty Materials
7. Darkness (Inside, Outside)
8. Slippery Surfaces

9. Water (Standing, Flowing)
10. Inlet Drain Open
11. Bacteria, Vermin
12. Hot Surfaces
13. Low Headroom
14. Noise
15. Other

**PERSONAL SAFETY:**

1. Training (This Assignment)
2. Emergency Procedures (See Below)
3. Clothing
4. Head, Hand, Foot, Ear Protection
5. Respirators
6. Safety Line and Harness
7. Communications

8. Traffic Controls
9. Ventilation
10. Lighting
11. Ladder, Handlines
12. Personnel Hoist
13. Fire Extinguisher
14. Other

**FIGURE 9-1. EXAMPLE CONFINED SPACE ENTRY PERMIT AND RECORD**

ATMOSPHERIC TESTS (OXYGEN, FLAMMABLE, TOXIC)

TIME	TEST	READING	TIME	TEST	READING
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Tests Performed By: \_\_\_\_\_  
Signature

EMERGENCY PROCEDURES

Standby Person(s) \_\_\_\_\_

Telephone, Emergency Notification (To Whom? How?) \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Rescue Procedure (By? How?) \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

AUTHORIZATION:


Plant Manager \_\_\_\_\_  
Signature Date

FIGURE 9-1 (Cont.). EXAMPLE CONFINED SPACE ENTRY PERMIT AND RECORD

<b>HEADING</b>		
TYPE OF PERMIT:		VESSEL ENTRY <input type="checkbox"/> HOT WORK <input type="checkbox"/> OTHER <input type="checkbox"/> PERMIT NO. _____
GOOD ON THIS DATE ONLY:	FROM:	AM <input type="checkbox"/> PM <input type="checkbox"/> TO: AM <input type="checkbox"/> PM <input type="checkbox"/>
LOCATION: _____		
WORKERS AUTHORIZED ENTRY:	WORK MONITORS:	FIRE WATCH: (HOT WORK ONLY)
_____	_____	_____
_____	_____	_____
_____	_____	_____
DESCRIPTION OF JOB OR SPECIAL PROCEDURES: _____		
<b>EMPLOYEE TRAINING AND PRE-ENTRY BRIEFING</b>		
1. SAFE ENTRY AND RESCUE TRAINING CONDUCTED ON:		_____ (DATE)
2. MANDATORY PRE-ENTRY BRIEFING CONDUCTED ON:		_____ (DATE)
3. DOES THE JOB REQUIRE SPECIAL TRAINING? YES <input type="checkbox"/> NO <input type="checkbox"/>		
<b>CONTRACTOR NOTIFICATION</b>		
CONTRACTOR NOTIFIED OF:		PERMIT CONDITIONS <input type="checkbox"/> POTENTIAL HAZARDS <input type="checkbox"/> N/A <input type="checkbox"/>
<b>LIGHTING REQUIREMENTS</b>	<b>SPECIAL TOOLS/EQUIPMENT</b>	<b>COMMUNICATION DEVICES</b>
_____	_____	_____
_____	_____	_____
_____	_____	_____
1. ARE ALL ELECTRICAL DEVICES INTRINSICALLY SAFE?		YES <input type="checkbox"/> N/A <input type="checkbox"/>
2. HAVE ALL POWER CORDS AND TOOLS BEEN VISUALLY INSPECTED?		YES <input type="checkbox"/> N/A <input type="checkbox"/>
<b>PRE-ENTRY ATMOSPHERIC TESTING</b>		
	READING:	TIME: INITIALS:
1. TEST FOR OXYGEN CONTENT:	_____ %O <sub>2</sub>	_____
2. TEST FOR FLAMMABLE CONCENTRATION:	_____ %LEL	_____
3. TEST FOR TOXIC CONCENTRATION:	_____ PPM OF _____ (TLV= _____)	_____
4. TEST FOR HEAT STRESS HAZARD:	_____ °F <input type="checkbox"/> °C <input type="checkbox"/> WBGT	_____
<b>EMERGENCY/RESCUE PROCEDURES</b>		
1. LOCATION OF WRITTEN EMERGENCY RESCUE PLAN		_____
2. TYPE OF EMERGENCY RESCUE TEAM REQUIRED:		ON-SITE <input type="checkbox"/> OFF-SITE <input type="checkbox"/> PHONE NO. _____
<b>SAFETY EQUIPMENT</b>		
PERSONNEL PROTECTIVE EQUIPMENT REQUIRED:		AREA SAFETY EQUIPMENT REQUIRED:
_____		_____
_____		_____
_____		_____
1. SELF-CONTAINED BREATHING APPARATUS REQUIRED?		YES <input type="checkbox"/> NO <input type="checkbox"/> TYPE _____
2. PORTABLE ATMOSPHERIC MONITOR REQUIRED?		YES <input type="checkbox"/> NO <input type="checkbox"/> TYPE _____
<b>PERMIT AUTHORIZATION</b>		
I CERTIFY THAT I HAVE INSPECTED THE WORK AREA FOR SAFETY AND REVIEWED ALL SAFETY PRECAUTIONS RECORDED ON THIS PERMIT.		
PERMIT AUTHORIZED BY (SIGNATURE) _____		

N/A = NOT APPLICABLE TO PRESENT JOB

**FIGURE 9-2. EXAMPLE SAFE WORK PERMIT**  
9-15



TODAY'S DATE \_\_\_\_\_

DATE WORK WILL BE DONE \_\_\_\_\_

WORK TO DO	MAJOR HAZARDS EXPECTED	PRECAUTIONS TO CONTROL HAZARDS

**FIGURE 9-3. SAFE JOB INSTRUCTIONS SHEET**



to remind the workers of potential dangers and safety practices before entering a confined space.

### Equipment Test

Before leaving the maintenance yard at the start of each day, safety equipment must be carefully inspected and tested. Where functional capacities are doubtful, replacement equipment should be used while the defective or suspect equipment is repaired and further tested.

### Disinfectants

In cases where a manhole that must be entered is located reasonably close to the discharge of a hospital, venereal treatment center, clinical laboratory, surgical facility, or a veterinarian's office and hospital, a disinfectant may be required in the manhole and the upstream line, one or two hours ahead of scheduled entry. While this action may result in other problems and strong odors in the manhole, this may be the recommended procedure, rather than risk exposure of workers to the diseases which are possible in such manholes. Because disinfectants are poisons, it is important to not enter a manhole when the odor of a disinfectant is present.

Most state and local health departments have laws and regulations that prevent the discharge of infectious wastes into wastewater collection systems until after they have been disinfected (usually in an autoclave that disinfects by using steam). Contact the medical officer in charge of any medical facility immediately upstream from manholes and sewers in which you must work. This person should be able to explain the disinfection procedures used by the medical facility, indicate if the threat to your health is significant, and recommend any special precautions or disinfectants that may be necessary.

### Washdown

All manholes, but especially ones which are filthy, infested, contain slime or scum, or smell of hydrogen sulfide or insecticides, should be washed down with high velocity clearwater, preferably dosed with HTH, a disinfectant, before sending a worker down into the manhole. This wash is best done within an hour before entry.

### Pesticides

Where insects have been a problem, and where rats or other vermin may occupy a collection system, or where epidemics of insect borne diseases may be present, spraying a manhole with pesticide is suggested. The poison solution should be water soluble, and leave a toxic residue to be effective against the next hatch of any insects present and breeding in the collection system. Spraying should be conducted at the time of manhole entry if insects or other problems are observed. The manhole should be ventilated so that the pesticide will not be inhaled by workers.

### Tools, Materials, and Equipment

Prior to sending a worker into a manhole, a careful inventory and examination of the condition of all required tools, materials, and equipment needed for the work should be made. Exposure to injury is greatest while a worker is descending into, or climbing out of a manhole. Therefore, job organization and equipment requirements should be arranged to permit all work to be done with a single entry and exit of the manhole.

## MANHOLE ENTRY PROCEDURES

The minimum sized crew for work requiring manhole entry is three workers. One worker enters the manhole, another acts as lifeline attendant, and the third stands by and assists on the surface. Both of these topside workers must be physically able to lift the worker out of the manhole in an emergency. The safety and other equipment is generally the responsibility of the entire crew. However, a support crew may be needed to direct traffic and provide other needed assistance. The following is a step-by-step procedure which should be followed for any manhole entry operation, or before entering any confined space:

1. Always organize and plan the work to be done before entering the manhole. Avoid prolonged stays in manholes.
2. Place markers and safety cones around the work area, and park trucks and vehicles to protect the working area from traffic. If necessary, place a cage enclosure around the manhole. An open manhole should always be attended.
3. The portable explosivity/oxygen alarm must be calibrated BEFORE removing the manhole cover. Test for combustible gas before removing the cover because removing the cover may ignite a spark which could cause an explosion. Test the manhole from top to bottom for oxygen deficiency, explosive, and toxic gases. Also, it is helpful to know conditions in the manhole before any ventilation occurs.

If an explosive atmosphere is discovered in a manhole:

- a. Immediately notify the supervisor that an explosive condition has been discovered and provide as many details as possible, especially location of the hazard. Request notification of police and fire departments.
  - b. Do not remove manhole cover.
  - c. Turn off any running engines in the vicinity that could cause a spark.
  - d. Inspect upstream and downstream manholes for explosive conditions to determine the extent of the problem.
  - e. Route traffic off the street to reduce potential for explosion.
  - f. Notify industrial waste inspectors and wastewater treatment plant operators.
  - g. Attempt to locate the source of the problem and correct the situation.
  - h. Cautiously and continuously ventilate the system with a large blower to eliminate the explosive hazard. Try ventilating from a safe upstream or downstream manhole in order to keep workers and equipment away from explosive conditions.
4. Use proper tools to remove the manhole cover. Never use only your hands.

5. Open manholes upstream and downstream from the work area to encourage natural ventilation of the sewer. Be sure all open manholes are properly barricaded and covered with grating.
6. Clean the area around the manhole opening, including the manhole ring and lid ledge, and remove all loose debris. Sweep the area before removing the manhole cover, and clean the ring ledge after the cover has been removed. Test for oxygen deficiency and toxics from top to bottom. Wash down manhole and rings with a water jet, preferably dosed with HTH.
7. Start the ventilation blower and purge the manhole atmosphere prior to entry. Locate the blower upwind of the manhole and at least ten feet from the manhole opening. If the blower has a gas driven engine the exhaust must be downwind from the manhole. Place the air intake to the blower from two to five feet above the ground surface, depending on conditions (higher for dusty ground surfaces). Some agencies prefer to exhaust or pull air from the downstream manhole if possible.
8. The person entering the manhole must put on all necessary personal protective apparel and use all necessary safety tools, devices, and equipment, including hard hat, safety harness with lifeline attached, gloves, etc. Another crew member or the foreman should inspect for proper fit and condition.
9. Before entry into the manhole, make sure the brickwork is sound and the steps are safe.
10. Continue to use the alarm system to test for the presence of an oxygen deficiency and explosive and toxic gases in the manhole atmosphere the entire time the worker is in the manhole.
11. Employees entering a manhole must not carry anything in their hands. Needed equipment must be lowered prior to entry by the employee when possible. Equipment should be lowered only when ordered and never dropped. Use a sling or material lift hoist.
12. Equipment and materials on the surface must be kept far enough away from the manhole so that they will not be accidentally kicked or dropped into the manhole.
13. The condition of employees in a manhole should be checked regularly by verbal communication.
14. Do not enter a confined space without a qualified stand-by assistant constantly stationed at the point of entry. **AT NO TIME SHALL AN EMPLOYEE IN A MANHOLE BE LEFT UNATTENDED.**
15. Before engaging in work in public rights-of-way, warning signs or traffic control devices must be placed in areas easily seen by approaching traffic, i.e. cones and flashing lights. Where further protection is needed, suitable barricades must be erected. When the nature of work and traffic requires it, a flagman must be stationed to warn traffic of the hazards.
16. When openings or obstructions are made in streets, side-walks, or on private property, danger signals, such as warning signs, cones and flags, must be

effectively displayed. At night warning lights must be prominently displayed. Excavations and openings must be enclosed with suitable barricades.

17. When working on private or public property, reasonable effort must be made to avoid creating hazards to persons or causing unnecessary property damage. Signs, barricades, tools, equipment and excess materials must be removed from the site when the job is completed.
18. When equipment or obstructions are left on a roadway overnight, the following precautions must be taken:
  - a. Do not obstruct fire hydrants or entrances to parks, playgrounds, churches, houses or schools unless absolutely necessary;
  - b. Lock, block or otherwise secure; and
  - c. Place approved warning devices where needed.
19. The manhole safety enclosure (cage support with a winch) must be placed around the manhole.
20. Rescue procedures will vary, however, some general guidelines are:
  - a. Call for help (oral, radio, and/or telephone).
  - b. Qualified rescuers must put on self-contained air units, life lines, harnesses, and other necessary equipment before entering the confined space.
  - c. Upon reaching the victim, assess the injury and the nature of the accident.
  - d. Administer first aid and prepare to move the victim.
  - e. Move the victim with care.
  - f. There must always be a top person even during rescue attempts.
21. Before using power tools in confined spaces, test the working atmosphere. Use personal protective equipment, and utilize continuous atmosphere monitoring.
22. Do not use fuel-powered tools in confined spaces.
23. Facial hair that would interfere with proper sealing of a respirator is not allowed.

## **PRECAUTIONS WHEN WORKING IN TRAFFIC**

When collection system maintenance work requires the disruption of traffic, safety precautions must be taken to ensure the safety of the workers, motorists, and pedestrians.

This is accomplished through proper planning, barricades, warning signs and flagmen, as appropriate.

When it is determined that traffic disruption will occur, the following procedure should be followed:

1. Determine if the road on which traffic will be disrupted is state, county, or locally owned.
2. Contact the proper state, county, or local authorities and indicate the date, location, and projected duration of the traffic disruption. A permit may be required so be sure to call in advance.
3. Determine proper safety and warning procedures for the specific job. This will depend on a number of factors such as:
  - a. Type of maintenance work.
  - b. Duration of maintenance work.
  - c. Type of road.
  - d. Speed limit on road.
  - e. Traffic patterns.
  - f. Location of work.

If excavation is required for the maintenance work, provisions for excavation equipment will be needed. Duration of maintenance work is very important for determining working procedures. Work completed in one day will not require night time warning systems such as electric lights.

The type of road can range from a residential street to a highway. The average traffic speed is a good indication of the potential hazard. Roads that have a high speed limit (35-55 mph) usually have more congested traffic patterns and, therefore, pose more potential hazards to workers due to the high speeds and heavy traffic. Roads with lower speed limits (up to 35 mph) tend to have less congested traffic patterns and pose less hazards to workers. Location of work is also important. Work in a traffic lane is more hazardous than shoulder work, and work in an easement beside the shoulder is even less hazardous.

Regardless of the degree of hazard involved with traffic disruption, safety precautions must be used. It is important that the traffic be warned of the work and that warning precautions are set up far enough in advance of the work site so that motorists have a chance to slow down, change lanes, and become alert to the situation. There are many types of warning devices, the ones most commonly used are listed below:

1. Barricades - should be reflectorized and stabilized (usually with sand bags).
2. Reflectors.
3. Reflectorized drums, usually 55 gallon size. The drums should not be weighted with sand or water to the point where they are a hazard to motorists. Weighting should be great enough so the barrel does not blow over, but not so great that it could cause a hazard in a collision.
4. Sandbags. If sandbags are used, they must be coated with reflectorized paint.
5. Cones. Cones should be bright orange.

6. **Flags.** Flags are usually used in conjunction with barricades, barrels, sandbags, or cones.
7. **Caution, warning, and directional signs.**
8. **Warning lights.** These are usually attached to reflectorized barricades or drums and must be used during dark hours at excavations, obstructions, or other hazards. Flashing lights should be used when barricades are used singly and steady lights should be used when barricades are used in series.
9. **Flagmen.**

All workers must wear orange vests when working in traffic to optimize their visibility to motorists. Using common sense when working in traffic can also reduce the number of potential hazards. Instructions on proper use of warning devices can be obtained from the state department of transportation.

## **SAFETY RECORDS**

Unfortunately, accidents do happen in spite of the precautions taken. To prevent similar accidents from occurring, an accident report should be completed as soon as possible after the event. Complete accident reports also help if there is legal action. An example accident report is shown in Figure 9-4. When accidents do occur, emergency telephone numbers should be available and stored in a well known location. Emergency telephone numbers should be entered by each Agency into Table 9-2 for future reference.

Department: \_\_\_\_\_ Section: \_\_\_\_\_ Index No. \_\_\_\_\_  
 Name of Injured Employee: \_\_\_\_\_ Social Security No. \_\_\_\_\_  
 Home Address of Employee: \_\_\_\_\_ Phone: \_\_\_\_\_  
 Date of Birth: \_\_\_\_\_ Sex: M F Wage at Time of Accident: \_\_\_\_\_  
 No. of Hours Worked: Per Day: \_\_\_\_\_ Per Week: \_\_\_\_\_ No. of Days Per Week: \_\_\_\_\_  
 Classification: \_\_\_\_\_ Date of Hire: \_\_\_\_\_  
 Place of Accident: \_\_\_\_\_ City/Town: \_\_\_\_\_  
 Date of Accident: \_\_\_\_\_ Time: \_\_\_\_\_ Date Reported: \_\_\_\_\_ Time: \_\_\_\_\_  
 Did employee return to work on date of injury? \_\_\_\_\_ Lost Time: \_\_\_\_\_ Days/Hr.  
 Was employee off work beyond date of injury? \_\_\_\_\_  
 If so, last date worked: \_\_\_\_\_  
 Nature of injury (specify part of body injured?): \_\_\_\_\_  
 \_\_\_\_\_  
 Was employee acting in regular line of duty when injured? \_\_\_\_\_  
 If No, Explain: \_\_\_\_\_  
 \_\_\_\_\_  
 How did the accident occur? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 Was first aid given? \_\_\_\_\_ By whom? \_\_\_\_\_  
 Doctor: \_\_\_\_\_ Address: \_\_\_\_\_  
 Hospital (If Any): \_\_\_\_\_ Address: \_\_\_\_\_  
 What machine, tool substance, or object was most closely connected with the accident? \_\_\_\_\_  
 \_\_\_\_\_  
 Were mechanical guards or other safeguards provided? \_\_\_\_\_  
 Were mechanical guards or other safeguards used? \_\_\_\_\_  
 What, in your opinion, caused the accident? \_\_\_\_\_  
 \_\_\_\_\_  
 Describe Any Unsafe Act: \_\_\_\_\_  
 \_\_\_\_\_  
 Describe Any Unsafe Conditions: \_\_\_\_\_  
 \_\_\_\_\_  
 What has been done to prevent a similar accident? \_\_\_\_\_  
 \_\_\_\_\_  
 Witnesses: \_\_\_\_\_  
 Signed: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Phone: \_\_\_\_\_

For Further Particulars Please Use Reverse Side

**FIGURE 9-4. EXAMPLE SUPERVISOR'S REPORT OF ACCIDENT**

**TABLE 9-2. LIST OF EMERGENCY TELEPHONE NUMBERS**

	Office	Phone	Home
<b>1. PHYSICIANS/AMBULANCE/HOSPITAL</b>			
Dr. _____	_____	_____	_____
Dr. _____	_____	_____	_____
Ambulance _____	_____	_____	_____
Ambulance _____	_____	_____	_____
Hospital _____	_____	_____	_____
Hospital _____	_____	_____	_____
<b>2. FIRE</b>			
Department _____	_____	_____	_____
Department _____	_____	_____	_____
<b>3. POLICE</b>			
Town Police _____	_____	_____	_____
County Sheriff _____	_____	_____	_____
Deputy _____	_____	_____	_____
State Police _____	_____	_____	_____
Headquarters _____	_____	_____	_____
<b>4. POWER COMPANY</b>			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
<b>5. TELEPHONE COMPANY</b>			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
<b>6. GAS COMPANY</b>			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
<b>7. ELECTRICIANS</b>			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
Name _____	_____	_____	_____
<b>8. PLUMBERS</b>			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
<b>9. HEAVY EQUIPMENT OPERATORS</b>			
Name _____	_____	_____	_____
Type of Equipment Available _____	_____	_____	_____
Name _____	_____	_____	_____
Type of Equipment Available _____	_____	_____	_____



**TABLE 9-2 (Cont.). LIST OF EMERGENCY TELEPHONE NUMBERS**

	Office	Phone	Home
10. EXTRA LABOR			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
11. CONSULTING ENGINEER			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
12. TOWN OFFICIALS			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
Name _____	_____	_____	_____
Name _____	_____	_____	_____
13. COUNTY HEALTH DEPARTMENT			
Official _____	_____	_____	_____
Official _____	_____	_____	_____
14. ILLINOIS ENVIRONMENTAL PROTECTION AGENCY			
Name _____	_____	_____	_____
Name _____	_____	_____	_____
15. FEDERAL ENVIRONMENTAL PROTECTION AGENCY REGIONAL OFFICE			
Official _____	_____	_____	_____
Official _____	_____	_____	_____
16. AREA CIVIL DEFENSE			
Official _____	_____	_____	_____
Official _____	_____	_____	_____
17. OTHER			
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____