

## CHAPTER 9: OCCUPATIONAL HEALTH HAZARDS AND SAFETY MEASURES

### 9.1 INTRODUCTION

The sanitation workers, engaged in O&M of sewerage system or septic tanks, are exposed to different types of occupational hazards like injuries caused by physical actions, chemicals contacts, infections caused by pathogenic organisms, and dangers inherent with oxygen deficiency, hydrogen sulphide, and combustible gases.

The Parliament of India is considering “Sanitation Workers (Regulation of employment and conditions of service) Bill, 2012”. This bill will be helpful in eliminating these risks to the health and ensure safety of sanitation workers.

As defined in the said bill, the employers are obligated to provide their employees with safety equipment or protective gears (See 9.3.1.2 for details) as well as cleaning devices and ensure observance of safety precautions appropriate for each hazardous condition to reduce the employees’ risks to health and safety. Moreover, to guard against human error and carelessness, proper safety training and adequate effective supervision by safety personnel are most essential.

The GOI enacted the “Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act, 1993,” which declared the employment of scavengers or the construction of dry latrines to be an offence, considering the foregoing, another bill titled “The Prohibition of Employment as Manual Scavengers and their Rehabilitation Bill, 2013” was introduced in the Parliament in September 2013 and has since been passed. The Bill aims to eliminate manual scavenging and insanitary latrines, and provides for proper rehabilitation of manual scavengers in alternative occupations so that they are able to lead a life of dignity.

In addition to the Acts mentioned above, employees shall follow “Contract Labour Regulation and Abolition Act, 1970” for secure operational health and safety at their sites.

O&M of sewerage facilities, which should not be discontinued at any moment, requires health and safety consciousness equal to or greater than one that is needed for construction projects.

In India, “health and safety policy” is defined in construction project management by Bureau of Indian Standard (BIS) (Refer to Appendix B.9.1).

Therefore, the same health and safety policy for construction projects may also be adopted for O&M of sewerage facilities.

STPs and SPSs are subject to safety audits, which confirm the status of safety and health organizational setup, education / training, provision / inspection of personal protection, and records of safety, to ensure occupational safety and health at the work sites. The plant engineer should rectify failures immediately, if any.

The audit shall be implemented as per IS: 14489 “Code of Practice on Occupational Safety and Health Audit.” Standard safety audit procedures of the inspectorate of factories shall be at a frequency of a month and compliance reported to that agency.

## 9.2 OCCUPATIONAL HAZARDS

Occupational hazards are classified into Diseases and Accidents and are described below.

### 9.2.1 Diseases

Workers for sewerage and on-site systems face the risk of various health problems by virtue of their occupation since they are exposed to a wide variety of chemicals, micro-organisms and decaying organic matters that are present in sewage. Table 9.1 shows the types of diseases and its causes.

Table 9.1 Types of diseases and their causes

Diseases	Causes
<b>Infections</b> - Leptospirosis - Hepatitis - Helicobacter pylori - Tetanus - Diphtheria	Pathogen present in sewers or sewage
<b>Dermatitis</b>	Chemicals, mineral oil and tar
<b>Respiratory symptoms</b>	Endotoxins, Bio-aerosols

Source: Rajnarayan Tiwari, 2008

### 9.2.2 Accidents

Workers for sewerage systems and on-site systems are exposed to the risk of accidents during work. This chapter deals with oxygen deficiency, hydrogen sulphide poisoning, and dangers of combustible gas as confined space hazards.

Confined spaces are locations in sewers, SPS and STPs where fatal accidents frequently occur. A confined space is defined as a space with:

- (1) Cramped entry and exit;
- (2) Absence of broad daylight and ventilation;
- (3) Access is meant for very limited persons such as one or two persons. The possible hazards that are considered to be common are

- Confined space hazards
- Oxygen deficiency / Hydrogen sulphide poisoning / Combustible gas
- Chlorine poisoning
- Fall
- Slip
- Electric shock
- Fire

The workplaces are categorized into the following five locations and Table 9.2 lists the possible hazards for each of the following location

- On-site
- Sewer system
- SPS
- STP
- Water and sewage testing laboratory

Table 9.2 Possible Hazards by locations

Locations \ Hazards	Confined space			CGP	Fall	Slip	ES	Fire
	OD	HSP	CG					
<b>On-site</b>								
Septic tanks	✓	✓						
Anaerobic filters	✓	✓						
Closed drains	✓	✓						
<b>Sewers</b>								
Sewers	✓	✓	✓			✓		
Manholes	✓	✓	✓		✓			
Closed drains	✓	✓	✓					
<b>Pumping station and STP</b>								
Wet / dry wells	✓	✓			✓	✓		
Settling tanks	✓	✓			✓	✓		
Biological reactor	✓	✓			✓	✓		
UASB reactors	✓	✓			✓	✓		
Anaerobic lagoons	✓	✓			✓	✓		
Sludge thickeners	✓	✓			✓	✓		
Sludge digesters	✓	✓	✓		✓	✓		✓
Sludge dewatering	✓	✓				✓		
Sludge drying beds	✓	✓				✓		
Disinfection devices				✓				
Electrical equipment							✓	✓
Electric room							✓	✓

Note: OD = Oxygen Deficiency, HSP = Hydrogen Sulphide Poisoning,  
CG = Combustible Gas, CGP = Chlorine gas poisoning, ES = Electric Shock

The possible hazards at sewage testing laboratory include toxic substances, alkalis /acids, glass appliances, and are described herein.

### 9.2.2.1 Confined Space Hazards

Possible hazards in confined space include oxygen deficiency, hydrogen sulphide poisoning, and danger of combustible gases.

#### 9.2.2.1.1 Risk of Oxygen Deficiency

Table 9.3 shows the change in symptoms of anoxia due to drop in oxygen concentration.

Table 9.3 Relationship between reduction in oxygen concentration and symptoms of anoxia

(%) Oxygen Concentration	Symptoms of anoxia
19.5	Human begin to suffer adverse health effects when the oxygen level of their breathing air drops below 19.5%.
16 to 19.5	Workers engaged in any form of exertion can rapidly become symptomatic as their tissues fail to obtain the oxygen necessary to function properly.  Increased breathing rates, accelerated heartbeat, and impaired thinking or coordination occur more quickly in an oxygen-deficient environment.  Even a momentary loss of coordination may be devastating to a worker if it occurs while the worker is performing a potentially dangerous activity, such as climbing a ladder.
12 to 16	Concentration of 12 to 16 % oxygen causes increased breathing rate, accelerated heartbeat, and impaired attention, thinking and coordination, even in people who are resting.
10 to 14	At oxygen conc of 10 to 14 %, faulty judgement, intermittent respiration, & exhaustion can be expected with minimal exertion.
6 to 10	Breathing air containing 6 to 10% oxygen results in nausea, vomiting, lethargic movements, and perhaps unconsciousness.
Below 6	Breathing air containing less than 6% oxygen produces convulsions, then cessation of breathing, followed by cardiac arrest. These symptoms occur immediately.  Even if a worker survives the oxygen deficiency, organs may show evidence of oxygen-deficiency damage, which may be irreversible.

Source: OSHA, 2008

### 9.2.2.1.2 Risk of Hydrogen Sulphide Poisoning in Confined Space

Hydrogen sulphide is extremely toxic. Sometimes it may be generated in high concentration in a STP, also which causes immediate death.

- Hydrogen sulphide enters the body through eyes or mucous membrane of breathing organs.
- Blood seeps out from the capillaries in cavities of the lungs, causes pulmonary oedema, leading to breathing difficulties and death by suffocation.
- In sewer facilities, it is generated in rising mains with no oxygen supply and in inverted siphons, etc., where sludge is likely to accumulate easily.
- It is generated in grit chamber, pumping well, sedimentation basin and sludge thickening tank in sewage treatment plants.
- Hydrogen sulphide generated in sewage and settled sludge is sealed within the static condition, so it does not disperse into the atmosphere easily. However, when agitated, it disperses all at once to the atmosphere.

The relationship between concentration of hydrogen sulphide gas and its toxic effect is shown in Table 9.4. overleaf.

### 9.2.2.1.3 Risk of Combustible Gas in Confined Space

- Combustible gas includes methane, gasoline, volatalised thinner and so on.
- These become a mix of explosive gases in sewers.
- The minimum concentration for explosion is 5% for methane and 1.3% for gasoline.
- Combustible substances like gasoline and thinner float on the surface of water, volatilise at room temperature and are dangerous.
- If large quantity of gasoline flows into a sewer, there is a possibility of large explosion to occur.
- At locations where sewage is likely to accumulate such as in sewers, toxic or explosive gases or vapours may be generated.

### 9.2.2.2 Risk of Chlorine

- At a concentration of 2 to 5 ppm the symptoms are tear, cough, sneeze and running nose.
- At a concentration of 5 to 30 ppm, breathing becomes difficult and eyes cannot be opened. There is a crisis of life in 30 minutes to 1 hour.
- At a concentration of 30 to 60 ppm, difficulty in breathing and loss of consciousness are caused. If exposed with this concentration level for 30 minutes to 1 hour, it results in death.
- At a concentration of 1000 ppm, it results in death.
- Chlorine gas has specific weight that is 2.49 times heavier than air.
- It is a yellowish green gas and is a strong irritant.
- Although its disinfecting effect is high, its toxicity is also high.

Table 9.4 Relationship between concentration of hydrogen sulphide and its toxic effects

Conc. (ppm)	Effects and reaction by organ		
0.025	<u>Sense of odour</u> Sensitive persons can sense the odour (limit of sense of odour)		
0.3	Anybody can sense the odour		
3 to 5	Foul unpleasant odour of medium strength		
10		Permissible concentration (lower limit for irritation of the mucous membrane of the eye)	
20 to 30	Although bearable, after getting accustomed to the odour (olfactory fatigue), any higher concentration cannot be sensed.	<u>Breathing organs</u> Lowest limit for irritating the lungs	
50			<u>Eyes</u>
100 to 300	Olfactory nerve paralysis for 2 to 15 minutes; feels like unpleasant odour has reduced.	If exposed continuously for 8 to 48 hours, bronchitis, pneumonia, and death by suffocation due to pulmonary oedema	Conjunctivitis, itchiness, pain in the eyes, feeling of sand in the eye, glare, bloodshot eyes and swelling, turbidity of cornea, corneal damage and separation, bending and haziness of field of vision, increase in pain due to light
170 to 300		Scorching pain in the mucous membrane of respiratory tract; if exposure is less than 1 hour (limit), serious symptoms may not occur	
350 to 400		Exposure for 1 hour or more may lead to loss of life	
600		Exposure for 30 minutes may lead to loss of life	
700	<u>Cerebral nerves</u> After excessive respiration for a short period, respiratory paralysis occurs immediately thereafter		
800 to 900	Loss of consciousness, respiratory arrest, death		
1,000	Swoon, respiratory arrest, death		
5,000	Instantaneous death		

Source: JSWA, 2003

### **9.2.2.3 Fall**

- Accidents frequently occur while climbing/descending ladders.
- Accident often occurs while working at high elevations.

### **9.2.2.4 Slip**

Slippery surfaces are often encountered when working in an STP and sewers.

### **9.2.2.5 Electrical Shock**

Electric shocks occur because of the following:

- Exposure of live parts and defects such as damage to insulating sheath.
- Absence of insulated protective gear,
- Getting in contact with live parts by mistake.
- Adequate care shall be taken against these and relatable issues.

### **9.2.2.6 Fire**

Burns can be very serious and can cause painful injuries. The structural damage cause due to fires can be very costly.

The three essential ingredients of all ordinary fires are:

- Fuel, paper, wood, oil, solvents and gas
- Heat- the degree necessary to vaporise fuel according to its nature
- Oxygen-normally at least 15 % of oxygen in the air is necessary to sustain a fire. The greater the concentration of oxygen, the brighter the blaze and more rapid the combustion.

### **9.2.2.7 Risks in a Sewage Testing Laboratory**

#### **9.2.2.7.1 Toxic Substances**

Persons working in the sewage testing laboratory use various chemicals including toxic substances. Inhalation of excessive steam, gas or dust, etc., in the course of their work, is harmful to health. Hence, adequate precautions must be observed. Typical toxic substances used in a sewage testing laboratory and their toxicity are given in Table 9.5 overleaf.

#### **9.2.2.7.2 Alkali / Acid**

Acids and alkalis used in the sewage testing laboratory include:

- Hydrochloric acid
- Sulphuric acid
- Nitric acid
- Sodium hydroxide etc.

Table 9.5 Toxicity of chemical used in water quality laboratory

Type	Symptoms and poisons
Chemical asphyxia	Hydrogen cyanide, cyanogen compounds <ul style="list-style-type: none"> <li>Inactivation of haemoglobin in blood and oxygen associated with breathing leads to asphyxia.</li> <li>Likely to occur easily during a reaction; permissible quantity is very small so care is required.</li> </ul>
Caustic action	Arsenic compounds <ul style="list-style-type: none"> <li>Irritates mucous membrane of breathing organs, and at high concentration, breathing is arrested.</li> </ul>
Systemic poisoning	<p>Arsenic</p> <ul style="list-style-type: none"> <li>Absorbed from alimentary canal, skin, &amp; respiratory organs</li> <li>Diarrhoea, vomiting, and shock in 30 minutes in serious cases (Arsenious anhydride)</li> </ul> <p>Inorganic mercury</p> <ul style="list-style-type: none"> <li>Sharp pain in the stomach or the abdominal region, vomiting, and bloody urine</li> </ul> <p>Metal mercury</p> <ul style="list-style-type: none"> <li>Easily evaporated and inhaled.</li> <li>Trembling of hand and foot, and consciousness disorder</li> </ul> <p>Organic phosphorus</p> <ul style="list-style-type: none"> <li>Absorbed from the skin, alimentary canal &amp; respiratory organs</li> <li>Diarrhoea, vomiting, spasm and consciousness disorder.</li> </ul>

Source: JSWA, 2003

### 9.2.2.7.3 Glass Appliances

Glass appliances, if not handled carefully, may break and result in injury.

### 9.2.3 Instances of Accidents

An instance of accident related to anoxia (due to oxygen deficiency) is described below.

- Type of work: Sewerage work
- Number of casualties: 2 dead, 1 employee in serious condition
- This casualty occurred when lifting the drain pump from the manhole during sewerage work.
- On the day of the occurrence, storm water pipes were being replaced.
- worker (A) and worker (B) opened the manhole cover to perform work in the manhole, and entered the manhole.
- After a while, when worker (C) looked into the manhole, he found the workers (A) and (B) have collapsed.
- He notified the other workers. worker (C) rushed into the manhole for rescue and called out but there was no response.



- Soon after, worker (C) also collapsed on the spot.
- Later, workers (A), (B) and (C) were rescued by the rescue team and taken to the hospital.
- Workers (A) and (B) lost their lives, while the rescued worker (C) was admitted to the hospital with hypoxic encephalopathy (brain damage from lack of oxygen).
- Workers (A) and (B) were diagnosed with anoxia.

The probable causes of the accident were as follows:

- Was not aware that the location had the risk of oxygen deficiency.
- Did not measure the oxygen concentration and did not ventilate the manhole before entering it.
- Did not impart education and implement rescue drills related to work at dangerous locations of oxygen deficiency.
- No safety guard was stationed.

### 9.3 SAFETY ASPECTS AND MEASURES

Measures to protect workers from accidents are mentioned in 9.3.1 Preventive measures are taken to prevent accidents, and 9.3.2 Corrective measures are adopted when accidents occur. Preventive measures and corrective measures against accidents are described below.

#### 9.3.1 Preventive Measures

##### 9.3.1.1 Hazard-specific Preventive Measures

##### 9.3.1.1.1 Confined Space Hazards

The potential for build-up of toxic or combustible gas mixture and/or oxygen deficiency exists in all confined spaces. Characteristics of common gases causing hazards are shown in Appendix B.9.2. Table 9.2 lists the possible confined spaces related to sewerage works. Follow the “Confined space entry procedure” shown in Figure 9.1 and Appendix B.9.3.

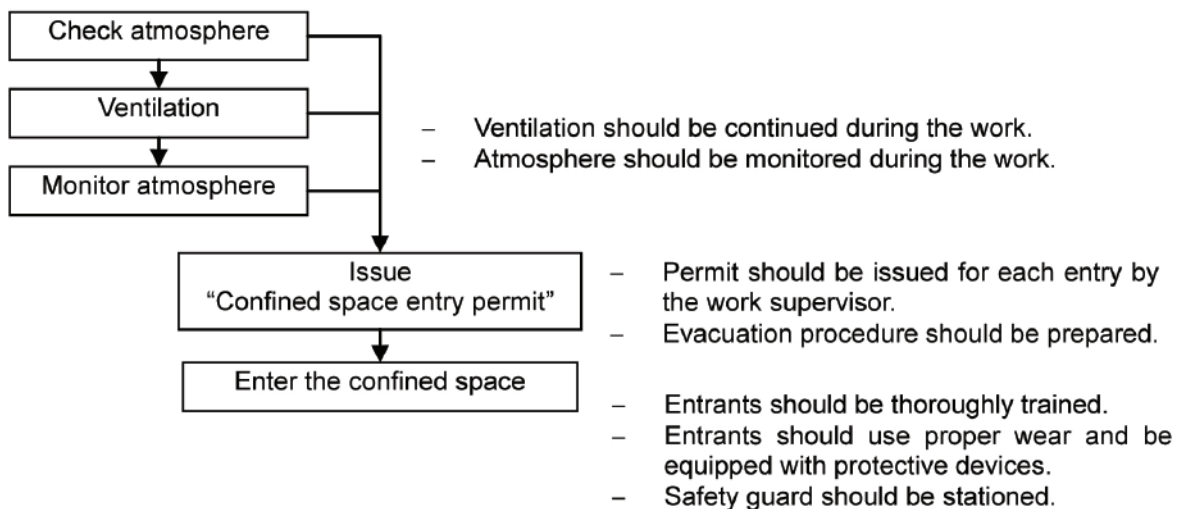


Figure 9.1 Confined space entry procedure

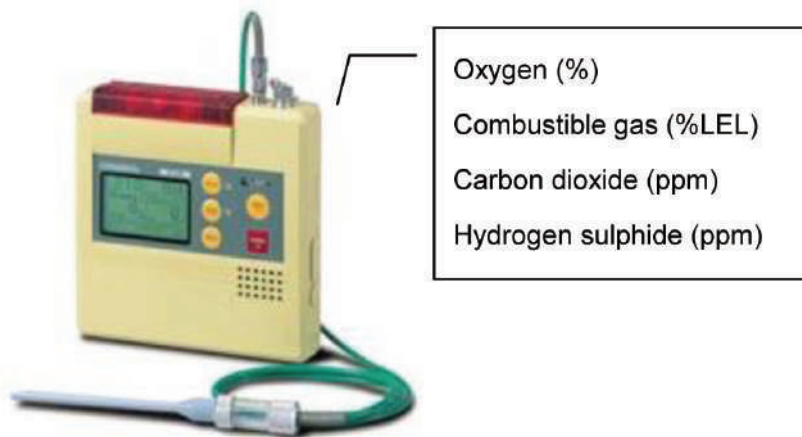
The entry into confined space should not be permitted until it is ensured to be safe as in Table 9.6.

Table 9.6 Acceptable entry condition

Substance	Concentration
Oxygen	19.5% and more
Hydrogen sulphide	Less than 10 ppm
Combustible gases	Less than 10%

#### A. Measurement Method

An example of a portable toxic gas detector that can measure oxygen, combustible gas, carbon dioxide and hydrogen sulphide simultaneously is shown in Figure 9.2.



Source: PRISM GAS DETECTION PVT. LTD.

Figure 9.2 Portable toxic gas detector

- Before measuring the confined space atmosphere, perform zero error correction of the instrument at a location where there is fresh air (no gas in the vicinity).
  - Measure the atmosphere within the space to confirm if any hazard exists as given below.
  - Oxygen : Less than 19.5 %
  - Hydrogen sulphide : 10 ppm or more
  - Combustible gases : 10 % LEL (lower explosive limit) or more
- Measurement should be done at three locations – top, middle and bottom of the confined space – since the oxygen concentration differs according to the position.
- Record the measured results on “Confined space pre-entry checklist” (Appendix B.9.4)

## B. Ventilation Method

If the measured results indicate one or more of the following hazards, be sure to ventilate the location before starting work.

- Oxygen : Less than 19.5 %
- Hydrogen sulphide : 10 ppm or more
- Combustible gases : 10 % LEL or more

To ensure the atmosphere is safe during the work, operate the ventilation equipment continuously.

Bring the blower outlet end close to the workplace and continue to blow air at the rate of 10 m<sup>3</sup>/minute per person or greater.

## C. Provisions for Evacuation

The work supervisor should make the following arrangements:

- Keep ready breathing apparatus, ladder, rope, safety belt and other equipment for use in evacuating or rescuing workers in the event of an emergency.
- Inspect protective gear before start of work and ensure that they are ready for use at all times. Repair or replace gear and equipment that are defective.
- Bear in mind that gas protection mask or dust protection mask is ineffective against anoxia.
- Non-spark tools should be used in confined spaces.

## D. Stationing of Safety Guard

The work supervisor should station a safety guard to detect abnormality at an early stage and to take immediate and appropriate action.

- The safety guard should be stationed outside the opening if the situation inside the confined space can be monitored from the outside.
- The safety guard should check access to the workplace of the workers engaged in the work.

### 9.3.1.1.2 Chlorine Poisoning

- The chlorine containers should be stored in a cool and dry place, away from direct sunlight or from heating units.
- Wear a face shield when changing chlorine containers.
- As chlorine is approximately two and half times heavier than air, vents should be provided at floor level.

### 9.3.1.1.3 Fall

The work supervisor and worker should take the following precautions to prevent persons from falling into manholes, etc.:

- Ensure that nobody falls from ladders (including metal rungs) and that tools are not dropped from ground level.
- Wear uniform suitable for the work and wear the necessary protective gear.
- Check that the ladder to the manhole is not corroded or worn out.

### 9.3.1.1.4 Slip

- Special anti-skid shoes with metal cladding over the “toe” should be provided by the employer for the workers. These shoes should be used by the workers only within the STP.
- Construct anti-skid floors and keep them free from oil and grease.

### 9.3.1.1.5 Electric Shock

Electric shocks occur because of the following:

- Exposure of live parts and defects such as damage to insulating sheath
- Inappropriate work such as absence of using insulated protective gear, touching live parts.

Measures to prevent electric shock are as follows:

- Methods for safe handling of electric equipment should be drilled into the workers and inspection and maintenance methods for electric equipment should be established.
- Special precautions should be taken to prevent electric shocks at locations where sewage is likely to accumulate (grit chamber, pumping room and in pipe gallery). Rubber-soled sports shoes may be used to prevent electric shocks.

#### A. Electric Room

Access to the electric room should be prohibited to all except authorized personnel. Signs should be put up indicating danger when current is flowing into the room. The electric room should be managed by the procedure below:

- Do not place combustible items near exposed wiring and electric equipment.
- Install fire extinguishers at easily visible locations such that they can be used immediately in the event of a fire.
- If there is excessive lightning, do not approach equipment wiring or lightning arrester.
- Periodically inspect and store disconnecting switches, operating rods, insulating plates, etc., at their specified positions.

- Store electric torch at its specified position such that it can be used immediately during an emergency such as power failure.
- Place insulating mat on the floor in front of the MCC panels.

## B. Equipment Repair

Before repairs of equipment or wiring, permission should be taken from the plant engineer (Refer to 9.5.2) and the work supervisor should hold a meeting and decide the work procedure. Repair work on electrical equipment should be prohibited to all except authorized personnel.

- Cut off circuits of equipment to be repaired before repairs.
- Put up sign indicating not to switch on power, assign a person to monitor the power switch, and strictly enforce power ON/OFF controls.
- Before starting the repair, always detect the voltage using a voltage detector and tester.
- Electric shock due to fault in cable run may also be considered and always ground the equipment before performing work.
- Operate switches such that you do not receive an electric shock.
- If a power capacitor exists, thoroughly discharge the remaining charge before starting work.
- If equipment breaks down at night, and if there is no emergency generator at the workplace, the worker should perform repairs during daytime when there is daylight and not during night time.

### 9.3.1.1.6 Fire

Every facility should develop a fire prevention plan with input from the local fire officers, fire chief and insurance company.

The plan may be very simple or very complex, depending on the specific facility needs. Some items, which may be included in any plan are:

- Regulate the use, storage and disposal of all combustible materials/substances.
- Provide periodic clean-up of weeds or other vegetation in and around the plant.
- Develop written response procedures for reacting to a fire situation to include evacuation.
- Provide required service on all fire detection and response equipment (inspection, service, hydrostatic testing).
- Routinely inspect fire doors to ensure proper operation and free access.
- Immediately repair, remove or replace any defective wiring.
- Restrict the use of any equipment, which may provide a source of ignition in areas where combustible gases may exist.
- Maintain clear access to fire prevention equipment at all times.

### **9.3.1.2 Personal Protection and Protective Devices**

#### **9.3.1.2.1 Head Protection**

- All personnel working in any areas where there may be danger from falling, flying tools or other objects must wear approved hard hats. Such hats should be according to the relevant BIS. Specially insulated hard hats must be worn when working around high voltage to protect the personnel from electrical shock.
- It is advisable to have detachable cradle and sweat bands for two reasons (1) to permit easy replacement of cradles and sweat bands and (2) to make possible assignment of one helmet to several workers each with its own cradle and sweat band for sanitary reasons.
- Once broken, the crown of a hard hat cannot be effectively repaired. It must be replaced.

#### **9.3.1.2.2 Face and Eye Protection**

Impact goggles must be worn mandatorily to protect against flying objects. They can be spectacle or cup goggles.

Spectacle goggles must have rigid frame to hold lenses in proper position before the eyes. Frames must be corrosion resistant and simple in design for cleaning and disinfection.

Cup goggles should have cups large enough to protect the eye socket and to distribute impact over a wide area of facial bones.

- Chemical goggles and acid hoods should be used for protection against splashes of corrosive chemicals. A hood treated with chemical-resistance material having a glass or plastic window gives good protection. There should be a secure joint between the window (glass or plastic) and hood material.
- Face shields can be used against light impact. Plastic shields should be non-inflammable and free from scratches or other flaws, which introduce distortions.
- Welding masks must be used for protection from splashes and radiation produced by welding.
- Protective creams are used to protect the skin from contamination and penetration by oils, greases, paints, dust etc.

#### **9.3.1.2.3 Hands and Lower Arms**

- Protective sleeves, gloves and finger pads are used for different types of hazards and jobs.
- Rubber and asbestos gloves should be long enough to come well above the wrist, leaving no gap between the glove and coat or shirtsleeve.
- Gloves or mittens having metal parts should never be used around electrical equipment.
- Linemen and electricians working on energized or high voltage electrical equipment require specially made and tested rubber gloves.

#### 9.3.1.2.4 Body Protection

- A good quality diver suit should be provided to the diver whose services are very necessary while plugging the sewer line or removal of some hard blockage due to stone etc. at the mouth of the pipe in the manholes. Depending upon the site condition, the suit should have a provision to connect to an air-line with compressor or oxygen cylinder.
- Always use rubber aprons when working with chemicals.

#### 9.3.1.2.5 Legs and Feet

- Leggings are provided where leg protection is necessary and are in the same category as coats, frocks and aprons. Kneepads made of cloth, padding, rubber, cork are used on jobs where kneeling is required.
- Ordinary work shoes are acceptable. They should have non-skid soles to prevent slips.
- Safety shoes are required where there is danger of dropping tools or materials on the feet. Toe guards have been designed for the men to wear when operating machines like air hammers, concrete breakers etc.
- For working on electrical equipment suitable safety shoes must be used.

#### 9.3.1.2.6 Mask

##### A. Gas Mask

General purpose gas masks are used for respiratory protection from low and moderately high concentrations of all types of toxic gases and vapours present in the atmosphere in which there is sufficient oxygen to support life. Figure 9.3 shows a picture of a gas mask.



Source: JICA, 2011

Figure 9.3 Gas mask

The masks afford necessary respiratory protection under many circumstances but it is most important to know the limitations of the various types available and to be familiar with their use. Even when masks are used properly, other precautions such as never using open flames or creating sparks in the presence of inflammable gases must be taken.

The general purpose gas masks afford protection against organic vapours, acid gases, carbon monoxide up to 2 % concentration, toxic dusts, fumes and smoke. The gas mask consists of a face piece, a canister containing purifying chemicals, a timer for showing duration of service and a harness for support. Protection against specific contaminants can be achieved by the selection of appropriate canisters.

Persons using gas masks should practice regularly with them in order to become proficient in putting them on quickly and breathing through them. Gas masks should not be used in oxygen deficient atmospheres, in unventilated locations or areas where large concentrations of poisonous gases may exist.

#### F. Dust Protection Mask

This mask consists of a fine particle filter due to which suspended fine particles in the air are not allowed to enter into the respiratory system of the user. This protects the user from inhaling toxic fine particles laden ambient air and hence, protects the health of workers using this mask.

#### G. Respiratory Equipment

In all dusty areas, effective filter masks should be used to guard against specific hazards. Hose mask should be used by men entering tanks or pits where there may be dangerous concentrations of dust, vapour, gases or insufficient oxygen. Hose mask with blower and the airline respirator are used where the hazard is immediate, that is, hasty escape would be impossible or cannot be made without serious injury if there is failure of the equipment.

Oxygen or air breathing apparatus, that is, self-contained oxygen breathing equipment using cylinders or bottles of compressed oxygen or air is used where required. This is a must when the length of the hose pipe in on-line supply of oxygen exceeds more than 45 m.

Gas masks: Canisters consist of a face piece connected by a tube to a canister. Chemicals in the canister purify contaminated air. No single chemical has been found to remove all gaseous contaminants. It does not supply oxygen and can be used where there is sufficient oxygen.

Various types of respirators and their suitability are as follows:

- Self-contained breathing apparatus

This apparatus is equipped with a cylinder containing compressed oxygen or air, which can be strapped on to the body of the user or with a canister, which produces oxygen chemically when a reaction is triggered. This type of equipment is suitable for an oxygen deficient atmosphere. It is also suitable for spaces having high concentration of chlorine. The self-contained breathing apparatus is shown in Figure 9.4 overleaf.

- Air-line respirator: Air-line length 90 m (maximum)

It is suitable in any atmosphere, regardless of the degree of contamination or oxygen deficiency, provided that clean, breathable air can be reached. This device is suitable for high concentrations of chlorine, provided conditions permit safe escape if the air supply fails.





Source: Stylex Fire Protection Systems  
Figure 9.4 Self breathing apparatus

#### 9.3.1.2.7 Ear Protection

Where noise levels are high and exceed specified limits, effective ear-pads or earplugs to be used.

#### 9.3.1.2.8 Safety Belt

When you work on ladders or scaffolding, use extreme caution to prevent falls. Safety belt should be used to prevent falls.

#### 9.3.1.2.9 Portable Lighting Equipment

The equipment normally used is portable electric hand lamps of permissible types, electric cap lamps and explosion-proof flashlights.

#### 9.3.1.2.10 Portable Blowers / Ventilating Fan

Replace the air in oxygen deficient and hazardous spaces with fresh air using exhaust fan and exhaust ducts. Figure 9.5 shows the portable blower.



Source: GVT Engineering  
Figure 9.5 Portable blower (ducting blower)

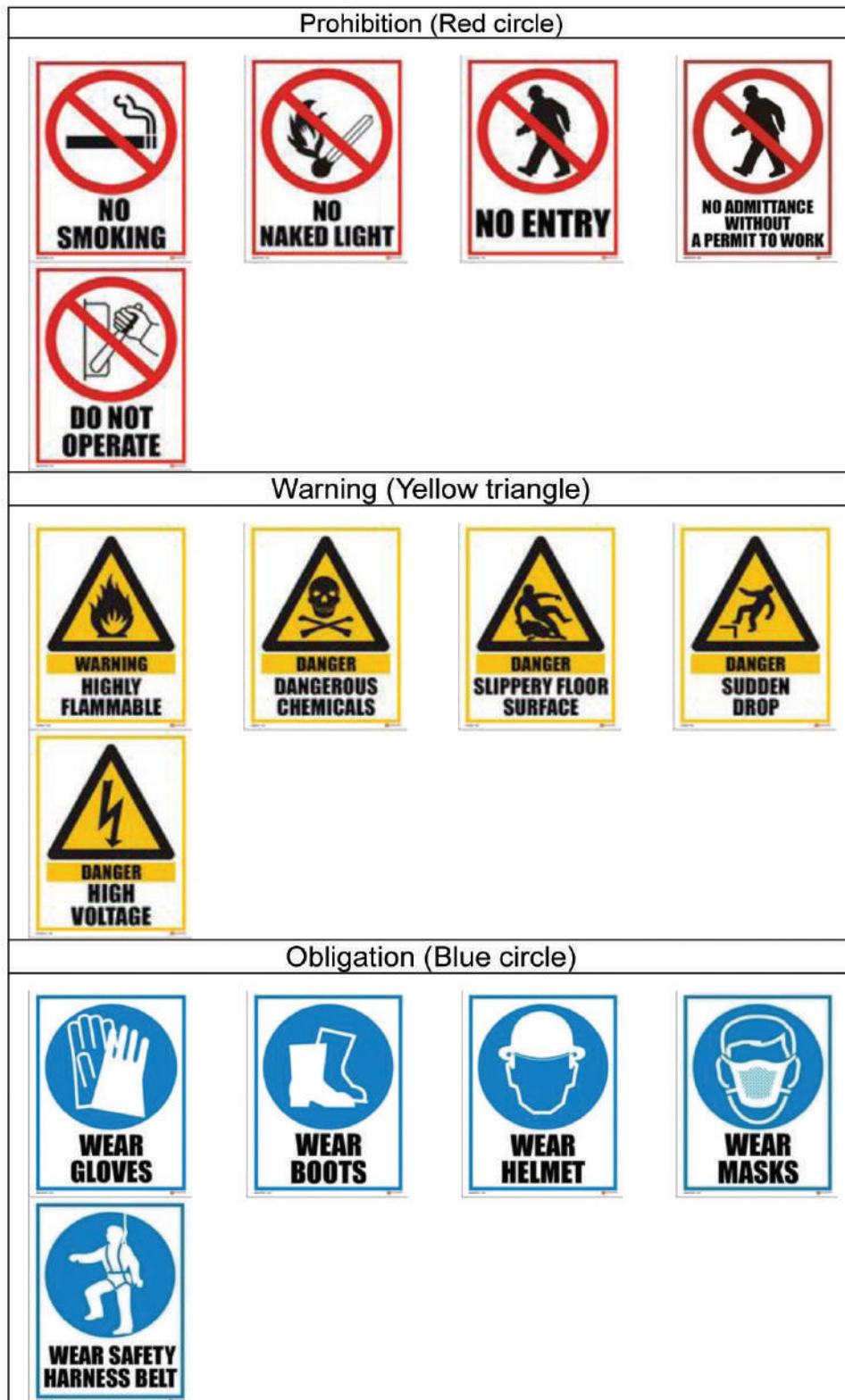
Ventilation also includes exhausting the air, but generally blowing in air is more effective.

#### 9.3.1.2.11 Safety Fences

Visitors including adults and children visit the STP as part of social studies. For this reason, the safety management officer should install fences in the facility and ensure a proper route for visitors to prevent any accident.

9.3.1.2.12 Safety Signs

To warn of danger to workers, visitors, and other construction workers in an STP, safety signs such as shown in Figure 9.6 should be displayed in the STP.



Source: <http://www.safetysignindia.com>

Figure 9.6 Safety signs

### 9.3.1.3 Workplace-specific Preventive Measures

Good design and the use of safety equipment will not prevent physical injuries in sewerage works unless safety practices are understood by the entire crew and are enforced. These measures specific for the workplace are described here.

#### 9.3.1.3.1 On-site

- Before entering the pit or tank, follow all the procedures required for work in confined spaces defined in 9.3.1.1.1.
- When oxygen concentration is less than 19.5 % and hydrogen sulphide concentration is more than 10 ppm, use forced ventilation to ventilate the tank before entering it.
- Wear rubber gloves to prevent wounds from infection.

#### 9.3.1.3.2 Sewer System

##### A. Traffic Hazards

- Before starting any job in a street or other traffic area, study the work area and plan your work.
- Traffic may be warned by high-level signs well ahead of the job site.
- Traffic cones, signs or barricades to be arranged around the work, and signboards to direct the traffic.
- Whenever possible place your work vehicle between the working site and the oncoming traffic.
- Use fluorescent jacket while working along roads. Figure 9.7 shows a fluorescent jacket



Source: Vibgyor Industries  
Figure 9.7 Fluorescent jacket

##### B. Manhole

- Before entering the manhole follow safety entry procedure as shown in Figure 9.8 overleaf. (Refer to Sec. 2.11.1.2 “Safety measures to be taken before any manhole entry”)



Source: JICA, 2011

Figure 9.8 Photo showing typical confined space entry

- Before entering the manhole, follow all the procedures required for work in confined spaces defined in 9.3.1.1.1.
- When oxygen concentration is less than 19.5 % and hydrogen sulphide concentration is more than 10 ppm, use forced ventilation to ventilate the tank before entering it.
- Manhole work usually requires job site protection by barricades and warning devices.
- Never use your fingers or hands to remove a manhole lid. Always use a tool specifically designed for this purpose.
- Be alert for loose or corroded steps.
- Wear a properly fitted pair of rubber gloves and boots, or an approved substitute that will provide protection from infection.
- Tools and equipment should be lowered into a manhole by means of a bucket or a basket.

#### 9.3.1.3.3 Pumping Station

- Before entering the well, follow all of the procedures required for work in confined spaces defined in 9.3.1.1.1.
- When oxygen concentration is less than 19.5 % and hydrogen sulphide concentration is more than 10 ppm, use forced ventilation to ventilate the tank before entering it.
- Do not work on electrical systems or controls unless you are qualified and authorized to do so.
- Guards over couplings and shafts should be provided and should be in place at all times.
- If stairs are installed in a pumping station, they should have handrails and non-slip treads.
- Fire extinguishers should be provided in the station, and should be properly located and maintained. The use of liquid-type fire extinguishers should be avoided.

- All-purpose A-B-C chemical-type fire extinguishers are recommended.
- Good housekeeping is a necessity in a pumping station to prevent slip and fall accidents.
- Properly secure and lock up an unattended pumping station when you leave, s to prevent injury to a neighbourhood child and possible vandalism to the station.

#### 9.3.1.3.4 Sewage Treatment Plant

##### A. Head Works

- Bar screens or racks
  - Remove all slime, rags, grease, etc., to prevent slip and fall accidents. Never leave rake or other tools on the floor.
  - Never lean against safety chains.
  - Always turn off, lock out and tag the main circuit breaker before you begin repairs.
  - The time and date the unit was turned off should be noted on the tag, as well as the reason it was turned off. No one should turn on the main breaker and start the unit until the tag and lock have been removed by the person who placed them.
- Pump rooms
  - If the room is below ground level and provided with only forced-air ventilation, be certain the exhaust fan is working before entering the area.
  - Guards should be installed around all rotating shaft couplings, belt drives, or other moving parts normally accessible.
  - Remove all oil and grease, and clean up spills immediately.
  - Be sure to provide barricades or posts with safety chains around the opening to prevent falls.
  - Until the area has been checked for an explosive atmosphere, no open flames (such as a welding torch), smoking or other sources of ignition should not be allowed.
  - Do not work on electrical systems or controls unless you are qualified and authorized to do so.
- Wet pits or sumps
  - Before entering the pits or sumps, follow all of the procedures required for work in confined spaces such as defined in 9.3.1.1.1.
  - When oxygen concentration is less than 19.5 % and hydrogen sulphide concentration is more than 10 ppm, use forced ventilation to ventilate the tank before entering it.
  - For access ladders to pit areas, the application of a non-slip coating on ladder rungs is helpful.
  - Watch your footing on the floor of pits and sumps as the floor may be very slippery.

- Tools and equipment should be lowered into a manhole by means of a bucket or a basket.
- Only explosion-proof lights and equipment should be used in these areas.
- Grit channels
  - Keep walking surfaces free of grit grease, oil, slime or other material to prevent accidents due to slip and fall.
  - Before working on mechanical or electrical equipment, be certain that it is locked out and properly tagged.
  - Install and maintain guards on gears, sprockets, chains, or other moving parts that are normally accessible.
  - Before entering the channel, pit or tank, follow all of the procedures required for work in confined spaces such as defined in 9.3.1.1.1.
  - When oxygen concentration is less than 19.5 % and hydrogen sulphide concentration is more than 10 ppm, use forced ventilation to ventilate the tank before entering it.
  - Rubber boots with steel safety toes and a non-skid cleat-type sole should be worn.

#### B. Clarifiers or Sedimentation Basins

- Always turn off, lock out and tag the circuit breaker before working on the drive unit.
- Maintain a good non-skid surface on all stairs, ladders and catwalks to prevent slipping.
- When it is necessary to actually climb down into the launder, always wear a harness with a safety line to prevent a fall accident and have someone to accompany you.
- Watch your footing on the floor of pits and sumps as the floor may be very slippery.
- Guards should be installed over or around all gears, chains, sprockets, belts, or other moving parts. Keep these in place whenever the unit is in operation.

#### C. Digesters and Digestion Equipment

- Methane gas produced by anaerobic conditions is explosive when mixed with air.
- Smoking and open flames should not be allowed in the vicinity of digesters, in digestion control buildings, or in any other areas or structures used in the sludge digestion system.
- All these areas should be posted with signs in a conspicuous place, which forbid smoking and open flames.
- All enclosed rooms or galleries in this system should be well ventilated with forced air ventilation. Never enter any enclosed area or pit which is not ventilated.
- Before entering the digester for cleaning or inspection, follow all of the procedures required for work in confined spaces such as defined in 9.3.1.1.1.

- When oxygen concentration is less than 19.5% and hydrogen sulphide concentration is more than 10 ppm, use forced ventilation to ventilate the tank before entering it.
- Explosion-proof lights and non-sparking tools and shoes must always be used when working around, on top of, or inside a digester.
- When working on equipment such as draft tube mixers, compressors and diffusers, ensure that equipment is properly isolated in function by closing valves locked out and appropriately tagged, to prevent the gas from leaking.
- If a heated digester is installed, read and obey the manufacturer's instructions before working on the boiler or heat exchanger because there is a risk of explosion.
- Sludge pump rooms should be well ventilated to remove any gases that might accumulate from leakage, spillage or from a normal pump cleaning.
- Good maintenance of flame arresters will ensure that they will be able to perform their job of preventing a back flash of the flame.

#### D. Aerators

- An operator should never go alone into unguarded areas.
- Approved life buoys with permanently attached hand-lines should be accessible at strategic locations around the aeration tank.
- Operators should wear a safety harness with a lifeline when servicing aerator spray nozzles and other items around an aerator.
- Lower yourself into the aeration tank only with a truck hoist if one is available or use a crane.
- Be extremely careful when using fixed ladders as they become very slippery.
- Watch your footing on the floor of the aerators: the floor may be very slippery.

#### E. Sewage Ponds

- Never go out on the pond for sampling or other purposes alone. Someone should be standing by on the bank in case of trouble.
- Always wear an approved life jacket when working from a boat or raft on the surface of the pond.

#### F. Disinfection Device

- Do not accept containers that have not been pressure tested within five years of the delivery date.
- Do not accept containers not meeting the standards. (Refer to IS 10553 Part I "Requirement for chlorination equipment")

The most common causes of accidents involving chlorine are leaking pipe connections and excessive dosage rates.

- Bottles or cylinders should be stored in a cool, dry place away from direct sunlight and heat.
- Bottles or cylinders should never be dropped or allowed to strike each other with force. Cylinders should be stored in an upright position and secured by a chain, wire rope, or clamp.
- One of the bottles or cylinders should be blocked so that they cannot roll.
- Always wear a face shield when changing chlorine containers.
- Connections to cylinders and tanks should be made only with approved clamp adaptors or unions. Always inspect all surfaces and threads of the connector before threading the connection. Check for leaks as soon as the connection is completed.

Never wait until you smell chlorine or sulphur dioxide. If you discover even the slightest leak, correct it immediately.

- Like accidents, leaks generally are caused by faulty procedure or carelessness.
- Obtain from your supplier and post in a conspicuous place (outside the chlorination and sulphonation room), the name and telephone number of the nearest emergency service in case of severe leak.
- Cylinder storage and equipment rooms should be provided with some means of ventilating the room. As chlorine is approximately two and a half times heavier than air, vents should be provided at floor level.
- Normally ventilation from chlorine storage room is discharged to the atmosphere, but when a chlorine leak occurs, the ventilated air containing the chlorine should be routed to a treatment system to remove the chlorine.
- A caustic scrubbing system can be used to treat the air containing chlorine from a leak. A caustic solution holding tank with full solution at all times should be at site so that a leaky chlorine tonner can be rolled and dropped into it if the chlorine leak cannot be stopped. There should be a suitable hoist for this purpose.
- Always enter enclosed chlorine cylinder storage or equipment rooms only after precaution. If you smell chlorine or sulphur dioxide when opening the door to the area, immediately close the door; leave ventilation on, and seek assistance.
- Never attempt to enter an atmosphere of chlorine when you are by yourself or without an approved air supply and protective clothing.

Remember to use the “dost system” (system in which two persons work as a single unit) when responding to a leak.



**9.3.1.3.5 Sewage Quality Test Laboratory**

A. Toxic substances should be handled with the following precautions:

- Store poisonous substances in containers with tight lids. Clearly indicate the contents of the containers; place them in a special cupboard with glass front for chemicals that can be locked and record the quantities of the substances used.
- Some substances may decompose when exposed to light and explode and store them in cool and dark location.
- Store gaseous substances in well-ventilated locations.
- Gaseous substances should generally be handled in well-ventilated locations. If this is not possible, safety masks should be worn, the location ventilated thoroughly, and after use, the persons handling the substances should gargle and wash their face.

B. Alkali / acid should be handled with the following precautions:

- Wear protective goggles, rubber gloves and protective clothing, if necessary.
- Handling hydrochloric acid
  - Since this acid is highly corrosive, always wash your hands after handling it.
  - Sometimes, pressure remains in sealed bottles in which this acid is stored. When opening the bottle, take care because the acid within the bottle may gush out unexpectedly.
- Handling nitric acid
  - Nitric acid vapours are strong respiratory toxins, so take care to ventilate the place thoroughly.
  - Take measures not to handle vapours.
  - When opening the container with nitric acid, ensure that the acid does not gush out when the container cap is removed.
- Handling sodium hydroxide
  - Take care that sodium hydroxide does not stick to the hand or other body parts because it has the action of decomposing proteins and skin.
  - Locations should be available for properly washing parts of the body, preferably where sodium hydroxide is used.
  - When dissolved in water, intense heat is generated and the solution may spray out. Take care to dissolve in small quantities to avoid risks.

C. Glass appliances should be handled with the following precautions:

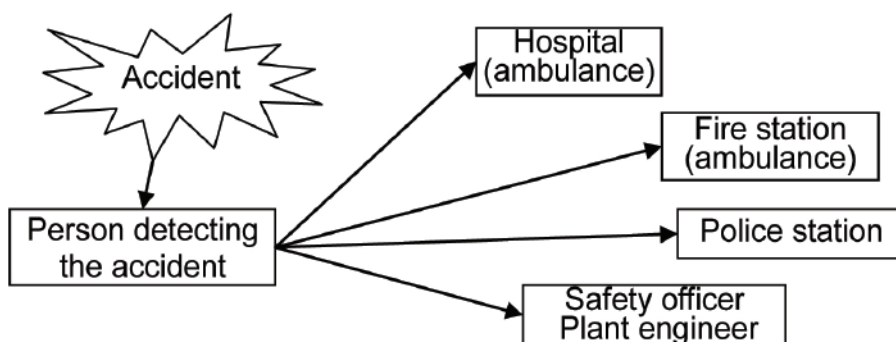
- Inspect thoroughly before use; do not use those with scratches or cracks.

- Handle beakers, flasks, test tubes that have small thickness very carefully, since these objects have less mechanical strength.
- Containers with reasonable thickness if heated suddenly may break; so take precautions.
- Do not use glass tubes with sharp corners.
- Use appropriate supporting stands when you handle large flasks.
- When you insert a glass tube or a thermometer into the hole of a rubber stopper or cork stopper, do carefully as it may break and lead to an injury.
- Take care not to touch heated glass with bare hands.
- Insert solids in a beaker or flask while tilting the container and slide in the solid gently so as not to break the bottom.

### 9.3.2 Corrective Measures

#### 9.3.2.1 Emergency Contact

The plant engineer should set up an emergency contact system to prepare for emergencies, and appropriately fix the scope of contacts and the persons responsible for contacting relevant personnel. The contact system should include records of medical organizations, and the names and telephone numbers of departments such as internal medicine, surgical department, ophthalmology and general hospital nearby. Figure 9.9 shows an example of emergency contacts.



Source: JSWA, 2003

Figure 9.9 Example of emergency contacts

#### 9.3.2.2 Emergency Measures

Workers frequently perform dangerous work or handle dangerous chemicals while working in sewerage systems and on-site systems. For this reason, emergency measures need to be thoroughly understood beforehand. Workers need to adopt appropriate action if such an unexpected situation arises. Information on emergency measures is as follows.

- The supervisor of the safety personnel (organization) should always inspect and maintain rescue appliances and clearly indicate their storage location.

- The supervisor of the safety personnel (organisation) should establish assistants for rescue action at each workplace and train them beforehand.
- Medical organisations to be contacted in an emergency should be decided beforehand (names and telephone numbers of hospitals with internal medicine, surgical department, ophthalmology and general hospital to be kept ready so they can be summoned immediately).
- Should be able to offer first-aid immediately.
- Subsequently, the doctor, and if necessary, the rescue organisation where the patient is being given treatment, should be notified the type and seriousness of the accident, the first aid given, the rescue appliances in hand, etc.
- The patient should be made to lie in a relaxed manner.
- Although it is good to rest the head and the body in a horizontal condition on a bed, if the face is flushed, the head should be raised slightly.
- If the colour of the face turns blue, the pillow should be removed from underneath and the head to be maintained at a low level to enable better blood circulation.
- If the patient has a vomiting sensation, the face should be kept sideways to allow vomiting.
- The patient's body temperature should be checked, and the patient should be encouraged, but should not be moved at random.
- Attention should be paid so as not to overlook any wound, burn, bone fracture, hip dislocation, etc.
- The status of the patient, the condition of the surroundings, environment and work method should be studied closely, a sketch should be made and photos should be taken.
- Samples of vomit, excrement and urine, bloodstain, etc., should be preserved as it is, so that they can be tested later.

Care and treatment for injured workers are described in Appendix B.9.5 separately for each wound or injury.

#### **9.3.2.2.1 First Aid Tools**

The plant engineer should make arrangements for quickly offering first aid measures.

The plant engineer should do the following to minimize injury during an accident or disaster:

- Provide necessary materials for offering first aid.
  - Artificial respirator
  - Stretcher as shown in Figure 9.10
  - First aid box as shown in Figure 9.11



Source: Hiren Industrial Corporation

Figure 9.10 Stretcher



Source: Hiren Industrial Corporation

Figure 9.11 First aid box

- Should ensure that a responsible person always manages the first aid tools.
- Drugs and equipment set aside in a first aid box are as given below. Unnecessary and out of date items should not be placed in the first aid box.
  - Waterproof casts
  - Adhesive plasters of assorted sizes
  - Eye protection pads
  - Disinfectant lotions
  - Safety pins of assorted sizes
  - Unused sealed twin blade razor

#### 9.3.2.2.2 Extinguisher

Fires are classed as A, B, C, or D type fires, according to what is burning.

- Class A fires (general combustibles such as wood, cloth, paper or rubbish) are usually controlled by cooling. Water is used to cool the material.
- Class B fires (flammable liquids such as gasoline, oil, grease, or paint) are usually smothered by oxygen control - as by use of foam, carbon dioxide, or a dry chemical.
- Class C fires (electrical equipment) are usually smothered by oxygen control - use of carbon dioxide or dry chemical extinguishers - non-conductors of electricity.
- Class D fires occur in combustible metals, such as magnesium, lithium or sodium, and require special extinguishers and techniques.

Use carbon dioxide or halon compressed gas extinguishers to control fires around electrical contacts. Do not use soda-acid type extinguishers because the electric motor will have to be rewound and you could be electrocuted attempting to put out the fire. Also, remember that carbon dioxide can displace oxygen.

### **9.3.2.2.3 Emergency Lighting**

Emergency lighting is required for illuminating critical control areas and for allowing fast exit from an area if the normal lights go out. An emergency generator that starts automatically with a power failure is wired separately to turn on emergency lights in critical areas. Instead of an emergency generator, battery packs are often used for evacuation. Refer to clause 5.12.4 and 5.12.6 of Part-A manual.

### **9.3.2.3 Searching out Hazards**

The safety management officer should carry out the following safety examinations:

- Record the status of occurrence of accident (Appendix B.9.6). Study the status of occurrence and causes of accidents, and based on the studies pick out the conditions for occurrence of accidents (risk locations, risky work, risky actions, etc.).
- Examine which parts of the workers' bodies were affected by accidents from the records of accidents. Examine the necessity of protective gear.
- Check the status of work location, and study unsafe actions and inappropriate working methods of the workers.
- Study the status of use of workers' tools.
- The safety officer should consider the results and report them to the plant engineer.
- The safety officer should reflect the results of the examinations above in the education of the workers.

## **9.4 HEALTH ASPECTS AND MEASURES**

### **9.4.1 Preventive Measures**

#### **9.4.1.1 Personal Hygiene against Pathogen**

The worker should take precautions because a large number of coliform groups, various kinds of micro-organisms, and egg parasites exist in sewage.

The workers should strive to maintain good health by taking care of the following points:

- Wear clean uniform, work boots, etc.
- After work and before having a meal, always wash hands and disinfect them.
- After work, take a shower if possible.
- Do not enter the offices and lounges wearing dirty clothes.
- If necessary, take vaccinations against tetanus, leptospirosis fever and so on.

#### **9.4.1.2 Maintaining Cleanliness**

The worker should maintain each facility in a clean and neat condition.

- The floors of workrooms, stairs and corridors should be cleaned at the appropriate frequency to maintain them in a clean condition.
- Disinfection of relevant locations is to be carried out periodically.

#### **9.4.1.3 Health Check**

Workers should receive health check once a year to maintain their health, and prevent illnesses or detect them at an early stage.

The results of the health check should be maintained as records.

Recommended items to be inspected during the health check are as given below.

- Examine medical history.
- Examine subjective symptoms and other objective symptoms.
- Check height, weight, vision and hearing ability.
- Chest X-ray examination.
- Blood pressure measurement.
- Check for anaemia.
- Check for liver functions.
- Check for lipids in blood.
- Check blood sugar level.
- Urine analysis.
- Electrocardiogram analysis.

#### **9.4.2 Welfare Measures**

The Draft Sanitation Workers (Regulation of Employment and Conditions of Service) Act 2012 proposes constitution of a Sanitation Workers State Welfare Board to exercise powers conferred on it and to perform welfare functions such as the following for sanitation workers:

- Provide immediate assistance to a beneficiary in case of an accident
- Sanction of loan and advances
- Medical expenses for treatment of major ailments
- Financial assistance for education of children
- Payment of maternity benefit
- Make provision and improvement of welfare measures and facilities as may be prescribed.

### 9.4.3 Corrective Measures

When a worker has symptoms of an illness listed in Table 9.1, the plant engineer should ensure that the worker is checked-up by a specialist doctor and receives proper treatment and care and should take the following actions considering the content of work done by the worker:

- Change the workplace if necessary
- Change the content of the work
- Shorten the working hours
- Perform relevant measurements of the working environment
- Maintain the facility or equipment

## 9.5 SAFETY PERSONNEL (ORGANISATION)

The plant engineer is expected to establish an appropriate safety management organisation in order to avoid losses of workers, stoppage of operations, etc., due to accidents.

### 9.5.1 Institutional Arrangement

The number of workers assigned for O&M of an STP varies according to the scale of the facility, the treatment process used, and equipment installed.

If the scale of the facility increases, the following will also increase:

- Equipment installed
- Workers
- Quantity of work
- Injuries and accidents

Accordingly, the number of safety & health supervisors varies depending on the size of the facility.

Figure 9.12 shows the safety management organisations for large STP, medium STP, and small STP, respectively.

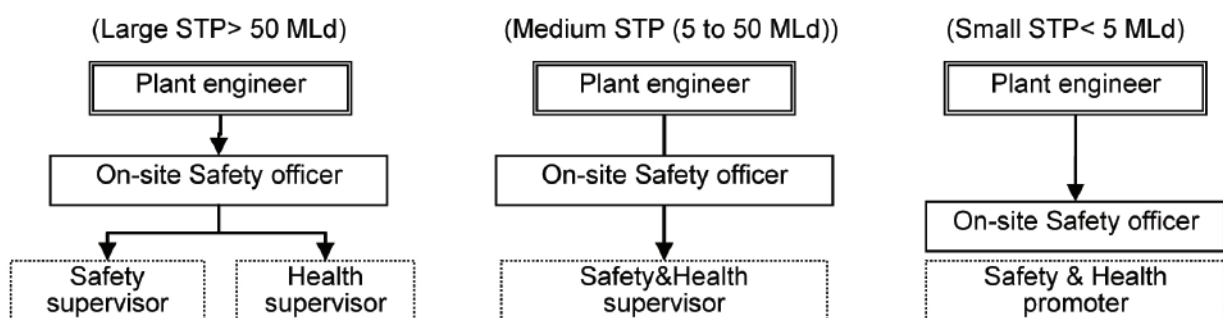


Figure 9.12 Safety Management Organisations for large, medium and small STP

### 9.5.2 Human Resources

Safety officer is to be assigned, and safety management to suit the number of workers in the workplace is required to be implemented.

The plant engineer should select and assign safety officer to ensure the safety and health at the workplace. The plant engineer should give permission for any required repair works on equipment / facilities in the STP.

The safety officer should carry out the following duties as full time service:

- Prevent risks or personal injury to workers and promote health checks and other improvements to health of the workers.
- Select a safety supervisor to manage worker's safety and select a health supervisor to manage workers' health.
- If an accident occurs, investigate its causes and take measures to prevent its recurrence.
- Perform tasks necessary to prevent accidents.

The safety supervisor is selected by the safety officer, and has the following duties:

- If there is a risk in the structure, equipment, work place or working method, adopt emergency measures or measures to prevent such risks.
- Periodically inspect equipment and tools such as safety equipment and protective gear, etc., to prevent risks.

The health supervisor is selected by the safety officer, and has the following duties:

- Study the working environment, working conditions and equipment in relation to how they affect the health of the workers.
- Inspect and maintain first-aid tools.
- Provide health education and look after matters necessary for maintaining good health.

The plant engineer should nominate a safety and health promoter at a site where a safety supervisor or a health supervisor is not selected.

The safety and health promoter is selected by the plant engineer and has the following duties:

- The safety and health promoter should inspect the facility and equipment, check their usage stage, and based on the results of these checks, should adopt relevant measures.
- The safety and health promoter should make efforts to maintain the health of the workers through health checks and impart safety and health education to workers.
- The safety and health promoter should examine the causes of work accidents and measures to prevent recurrence of the same.



- The safety and health promoter should collect information on workers' safety and health, prepare and maintain statistics of work accidents, diseases and absence from work.

In the absence of

- (a) safety management officer,
- (b) safety supervisor,
- (c) health supervisor,
- (d) safety & health promoter,

The plant engineer should manage all safety and health matters.

## **9.6 AWARENESS AND TRAINING**

Safety training should aim for improving awareness and techniques of persons engaged in work so that accidents during work are prevented. Safety training should consist of four courses to be imparted to Manager, Technical, Skilled and Unskilled grades of personnel.

- The Manager is a person who performs labour management and manages the work environment so as to ensure the safety of workers.
- A person in the Technical grade is an Assistant Engineer or Junior Engineer, who operates and repairs mechanical and electrical machinery and equipment by his own judgement.
- A person belonging to the skilled grade is one who uses machines and equipment, and performs work following the instructions of the superior using the Work Manual.
- A person belonging to the unskilled grade is one who performs manual work mainly in the plant under the instructions of the superior.

Trainees should upgrade/acquire skills to perform their work safely through training. The overview of training for each grade of personnel is given below.

### **9.6.1 Manager**

Managerial training should be given to managers once-every five years on the topics below.

- Laws, regulations and latest information related to sewerage systems
- Labour and welfare matters related to workers
- Periodic performance assessment of subcontractors and vendors

### **9.6.2 Technical Staff**

The plant engineer should ensure that training in their respective fields is imparted to the technical staff once every three years in the mechanical and electrical sections (Technical Grade).

#### **9.6.2.1 Mechanical**

- O&M of mechanical machinery and equipment such as pumps and blowers

- Repairs to mechanical machinery and equipment such as pumps and blowers
- Methods of examining the causes of breakdown in mechanical machinery and equipment such as pumps and blowers
- Methods of operating machinery and equipment (welding equipment) used for repairs during breakdown of pumps, etc.
- Emergency response procedures

#### **9.6.2.2 Electrical**

- O&M of electric equipment such as motor controls center (MCC)
- Repairs to electric equipment such as MCC
- Methods for examining causes of breakdown in electric equipment
- Emergency response procedures

#### **9.6.3 Skilled Staff**

The plant engineer should ensure that training in their respective fields is imparted to the skilled staff once a year in the mechanical and electrical sections.

##### **9.6.3.1 Mechanical**

- Safe work
- Communication at the workplace including instructions from supervisors, communicating with subordinates, and communication during joint work
- Maintenance of mechanical machinery and equipment such as pumps and motors
- Repairs to mechanical machinery and equipment such as pumps and motors
- Hazardous work (oxygen deficiency, hydrogen sulphide poisoning)
- Measuring instrument (oxygen concentration meter, etc.)
- Method of usage of protective gear (safety belt, breathing apparatus)

##### **9.6.3.2 Electrical**

- Safe work
- Communication at the workplace including instructions from supervisors, communicating with subordinates and communication during joint work
- Maintenance of electric equipment such as breakers and switches

- Repairs to electric equipment such as breakers and switches
- Electric shocks
- Hazardous work (oxygen deficiency, hydrogen sulphide poisoning)
- Method of usage of measuring instruments (oxygen concentration meter, rpm gauge, insulation tester, etc.)
- Method of usage of protective gear (safety belt, breathing apparatus)

#### 9.6.4 Unskilled Staff

The plant engineer should give training to unskilled staff once a year.

- Safe work (what not to do)
- Communication at the workplace including instructions from supervisors, communicating with subordinates and communication during joint work
- Matters related to keeping things tidy and in order, cleanliness and neatness
- Names of tools and their usage (pliers, screwdrivers, etc.)
- Electric shocks
- Hazardous work (oxygen deficiency, hydrogen sulphide poisoning)
- Use of protective gear (gloves, protective goggles, etc.)

#### 9.6.5 Training Assessment

Persons who have received safety training should be assessed on the lessons learnt.

The results of the assessment should be recorded in the assessment table shown in Table 9.7.

Table 9.7 Record of training assessment

Job requirement	Trainee's current knowledge & skills				
	Excellent	Good	Fair	Poor	Nil
1					
2					
3					

Source: CPHEEO, 2005

The plant engineer should warn the trainees on items assessed as unsatisfactory, and improve their awareness to such items. The worker should receive safety training and should preferably not be transferred to a different workplace within one year. Otherwise, this would result in lowering the quality of work at the workplace and may lead to a drop in work efficiency. For this reason, work status at the workplace, stationing of personnel and training assessment should be considered during transfers.

## **9.7 EMERGENCIES**

### **9.7.1 What is an Emergency?**

An emergency is a situation developing before our eyes with full conscience and realization that soon the situation will turn to adversity and even fatal. We may not be equipped to deal with it. We cannot take control. This leaves us with no time to locate the source of help. We may not know where to get help for a given situation.

### **9.7.2 How to Think during Emergencies?**

The foremost requirement is not to jump to conclusions. Always think of what is most important and imperative at that moment. Let us consider some situations that can arise

#### **9.7.2.1 Situation 1**

You notice a colleague during working hours trying to repair a floodlight during broad daylight at a height of some 6 m by standing on a permanent secure ladder but he is not wearing safety gloves. You are afraid that he may get electrocuted and nobody could reach him at that height soon enough. This is a simple emergency situation. You have the options of (a) calling him on the cell phone to alert him about his not wearing gloves, (b) going up the ladder personally with a spare set of gloves, (c) quietly switching off the electrical circuit to that mast and (d) quietly slipping out of the scene unnoticed. Each solution will merit itself under certain situations. Solution (a) is apt when the electrical circuit is already found switched off. Solution (b) is apt when the electrical circuit is switched off and the fuse is in your pocket. Solution (c) is apt when you find that the circuitry is energized. Solution (d) is apt when you find the circuitry is already switched off and your colleague has recorded in the works register that he is taking the fuse with him, so that nobody can energize the circuit until he returns.

#### **9.7.2.2 Situation 2**

A colleague is sitting on the walkway of a clarifier and collecting a sample of the treated sewage overflowing the weir. You notice that a snake is slowly making its way towards him. If you move in speedily, the snake may be hustled and move away from you faster and move closer to your colleague. This is a very serious emergency. Now, what will you do? / what should you do? The first thing to do will be to call the colleague on cell phone and tell him not to move and sit still as reptiles are alerted only when there is movement ahead of them. The next thing to do will be to ask your colleague to jump into the clarifier and swim to the safety of the channel and launder only if he knows swimming.

Suppose he does not know swimming, ask him immediately to stand upright, so that if it bites, it may spare the body parts closer to the heart and he can be saved by tying up the limb above the bite with a rope or a torn piece of a shirt. Simultaneously, you can follow the reptile and try to push it into the water surface with whatever piece of extended tool that you may have.

### **9.7.2.3 Situation 3**

During a monsoon season, let us say there is a sudden cloudburst and torrential downpour and before the staff could realize, the entire site is flooded to about knee-height and the sludge pits are marooned. Electrical connections are shorted somewhere and there is total darkness. The staff are scattered at different locations in the STP area of over 25 hectares. There was no way of setting foot forward, as they cannot locate where the pump pit is. The fear of more floods is very much there. You can somehow make out the silhouette of the administrative building and slowly wade towards it by announcing yourself. When all the staff members reach the building, they do not hear the voices of two persons in that shift. Panic grips them. However, nothing could be done until next day morning when it is discovered that of the two missing persons, one was absent and the other had gone out on personal work without informing others. The lesson here is that in every shift, be punctual in reporting and ensure a mini assembly of handing over and taking over at the “meeting point”. This ensures mutual knowledge of presence or absence. Another lesson is to have solar powered lampposts with self-contained circuits insulated against rains and located adjacent to electrical lampposts so that when total electricity fails, these will come on at least for that interval of time.

### **9.7.2.4 Situation 4**

When two operators were moving a portable diesel pump on a trolley over a gravel roadway, the road caves in suddenly. They were pulled into a huge pit fortunately after the engine was pulled in. Later, it was found that the reason was the plant bypass concrete pipeline crossing the road had a corroded crown to such a degree that it could not take that load. There were no signs on the site showing that the pipeline is crossing the road there. It would have been catastrophic if the operators had fallen first and the engine after them. Hence, all pipe crossings of roads should be through culverts with sidewalls raised above the ground. Bypass pipelines flow rarely, and gases accumulate and corrode the pipe easily. Always provide bypass pipelines in non-corrodible pipe material. Always erect markers over the route of big buried pipes.

### **9.7.2.5 Situation 5**

A primary settling tank sludge-removal-arm is not rotating for sometime but the settling tank continues to be operated. After sometime, it is noticed that the accumulated sludge is becoming visible through the sewage liquid when seen from the top. The settling tank is stopped from service and the sludge is allowed to dry up. Manual labourers are employed to walk into the settling tank and scoop out the sludge and transport it as head loads. Suddenly, two of labourers are found to be “sinking” into the sludge. Fortunately, the other labourers throw a rope and the two are able to grab it and are pulled out. The lessons are simple. Wet grit dumps can behave like quicksand in such locations. Suppose the two were not noticed sinking, they would have been located only after death, while the sludge was being scooped. Removing such grit dumps should be as per regulations for confined spaces and all personnel should be watched and accounted for, by a supervisor.

## **9.8 THE NEED TO RESIST**

Sometimes, tasks required to be carried out by field staff may involve risks, ignoring safety and potential emergency. The employee must politely resist doing the same. If every staff member resists, only then the management will know and make amends.

## **9.9 SUMMARY**

Sanitation workers or STP operators are often forced to work under poor working conditions with high risk of operational diseases or accidents.

Each operator or worker should ensure operational safety by wearing designated personal protection or by using designated protection devices.

Above all, they should follow the working procedures thoroughly when working in confined spaces.