

Prevention of Gas Poisoning in Drainage Work



Occupational Safety and Health Branch
Labour Department

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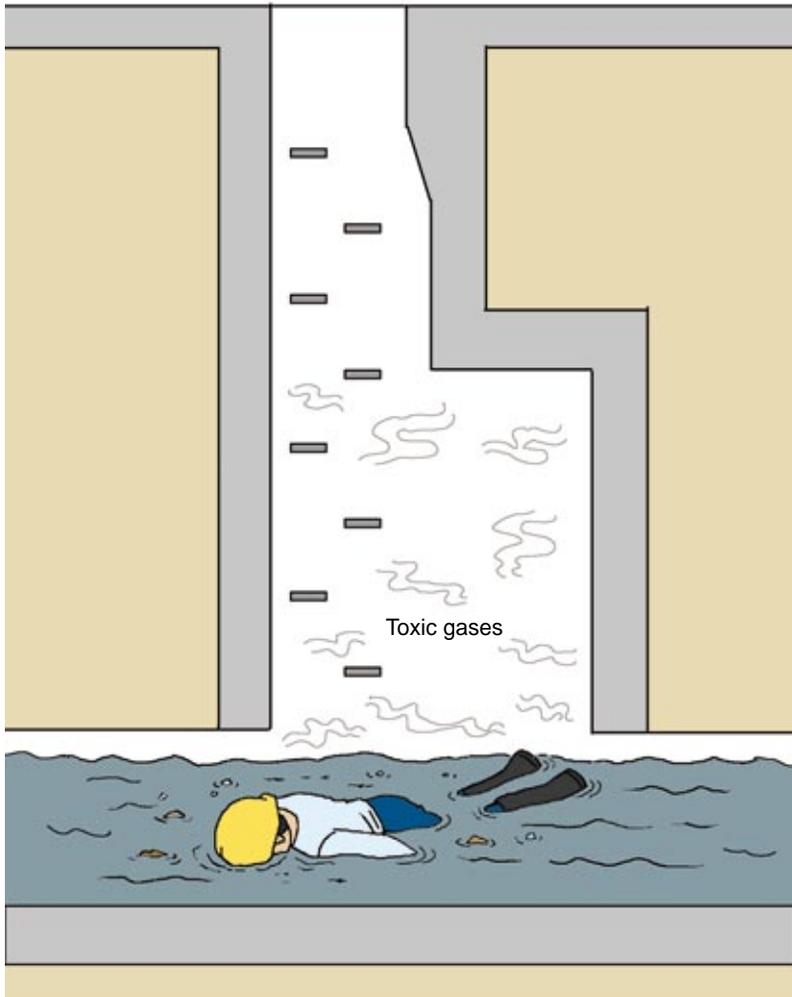
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1. Introduction

This publication describes the common gas poisoning risks in drainage work and the ways by which the risks can be either eliminated or reduced. It aims to help proprietors, contractors and workers to prevent gas poisoning in drainage work. For detailed legal requirements and practical guidance for drainage work or other work in confined spaces, please refer to the Factories and Industrial Undertakings (Confined Spaces) Regulation and the Code of Practice for Safety and Health at Work in Confined Spaces.



2. Common mistakes leading to gas poisoning incidents in drainage work

Most gas poisoning incidents in drainage work occur as a result of improperly identifying the dangers of atmospheric hazards in the workspace or ignoring safety procedures so as to get the jobs done more quickly.

2.1 Lack of safety awareness



Rush for tight schedule and inadequate assessment of risks associated.

1



Save the bother of adopting control measures and using personal protective equipment.

2



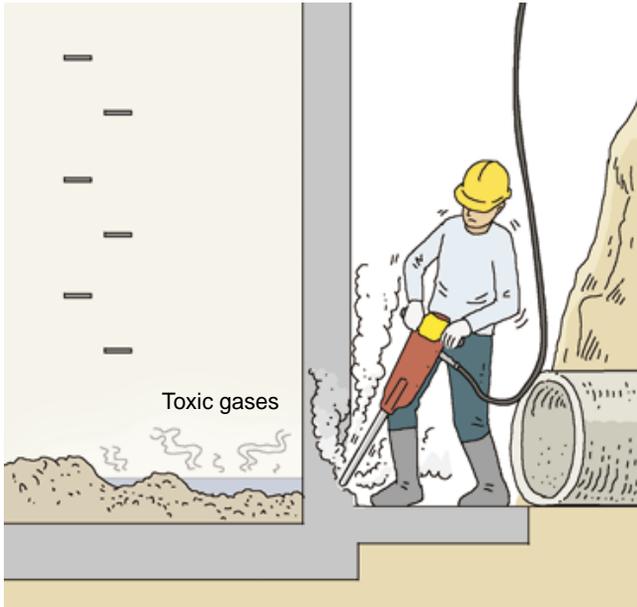
Not aware of the risk of sudden ingress of toxic gases.

3

4



Lack of a standby worker stationing outside the manhole for communication and emergency response.



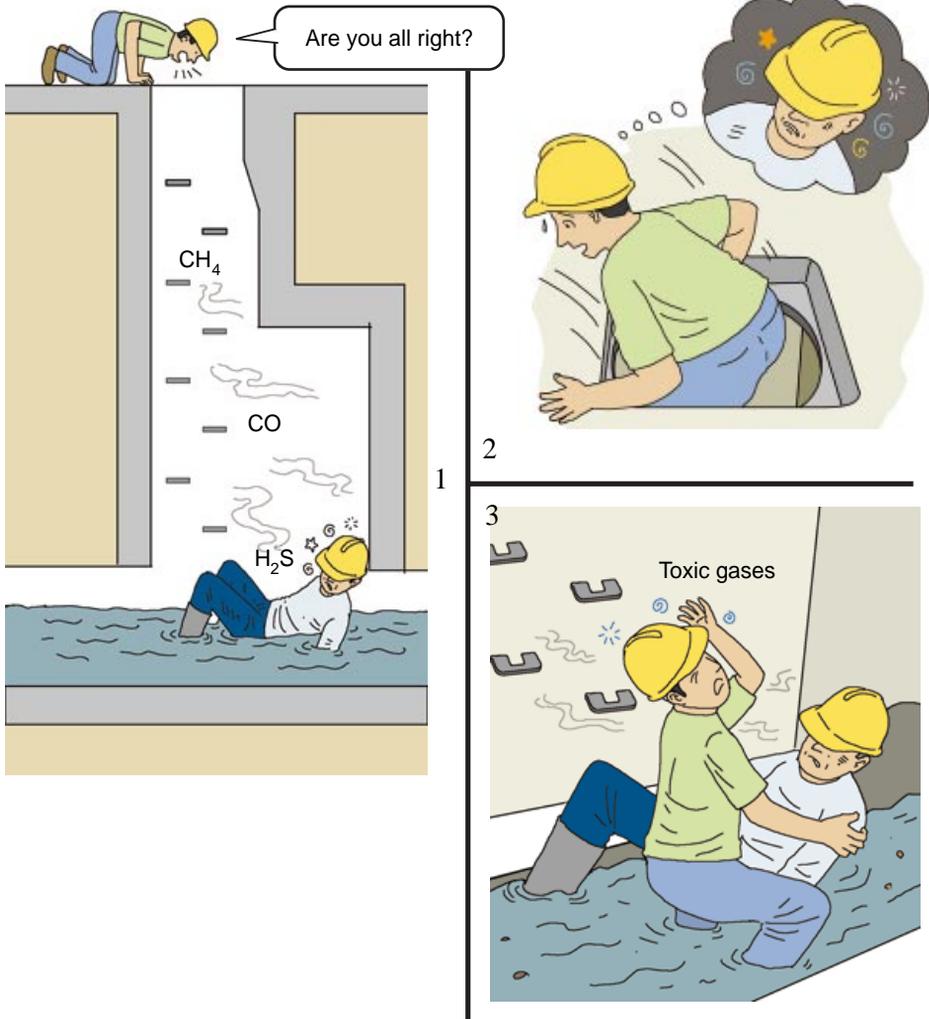
Disregard the risk of sudden ingress of toxic gases as a result of the engineering work.



Ignore the risks of conducting drainage work in a poorly ventilated environment.

2.2 Poor emergency preparedness

Incidents of gas poisoning in drainage work often result in multiple deaths because in such incidents, co-workers often instinctively enter the drainage immediately in an effort to help the collapsed victim and thus also succumb to the gas poisoning. Rescue should only be performed by trained personnel with appropriate equipment and support from other rescuers.



Standby person must not enter the manhole to rescue others without appropriate rescue equipment and support.

3. Atmospheric hazards in drainage work

Drainage workers may be exposed to hazardous gases, fumes and vapours, resulting in serious poisoning. A good understanding of the related atmospheric hazards is essential for the prevention of gas poisoning.

3.1 Sources of hazardous gases, fumes or vapours

Hazardous gases may be present naturally in a drainage system. However, some may arise from the work being carried out. The enclosed nature of the workspace may increase the danger, as hazardous gases can accumulate in the work area and their concentrations in air can rise rapidly. Typical sources of hazardous gases present in drainage work include the following:

- Decomposition of organic matters in sewers, manholes and pits of the drainage system will generate methane and/or hydrogen sulphide. Hydrogen sulphide, being very soluble in water, often dissolves in sewage and can be trapped within sediment and sludge in sewers as gas pockets. Disturbing the sewage, sediment or sludge can release the trapped or dissolved gas.
- Leaks from underground fuel tanks, gas utility pipes, connected sewer systems or contaminated land, such as landfills, may enter the work area.
- Use of generators and fuel-driven tools in poorly ventilated areas may use up oxygen and generate carbon monoxide.

Apart from gases, hazardous fumes or vapours can be generated from the work, e.g. welding or the use of adhesives, paints, volatile or flammable solvents, etc.

3.2 Characteristics of common hazardous gases

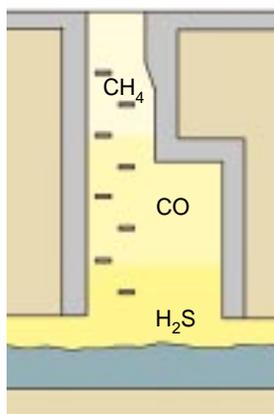
A number of hazardous gases, such as carbon monoxide, are colourless and odourless. On the other hand, some hazardous gases like hydrogen sulphide may have an unpleasant smell at low concentrations but such smell disappears at higher concentrations due to olfactory fatigue. It can be very dangerous if drainage workers think they can easily recognise the presence of toxic gases by smell.

Hydrogen sulphide, carbon monoxide and methane are the most common hazardous gases found in drainage worksites. In addition, oxygen deficiency is another major cause of illnesses and fatalities. The characteristics of these hazardous gases are listed below:

Hazardous gas	OEL (ppm)	IDLH (ppm)	Relative density (Air = 1.0)	LEL / UEL	Remarks
Hydrogen Sulphide (H ₂ S)	10	100	1.2	4.3% / 45.5%	Rotten egg smell
Carbon Monoxide (CO)	25	1,200	1.0	12.5% / 75%	Colourless and odourless
Methane (CH ₄)	---	---	0.6	5.3% / 15%	Displace air causing asphyxiation

Notes:

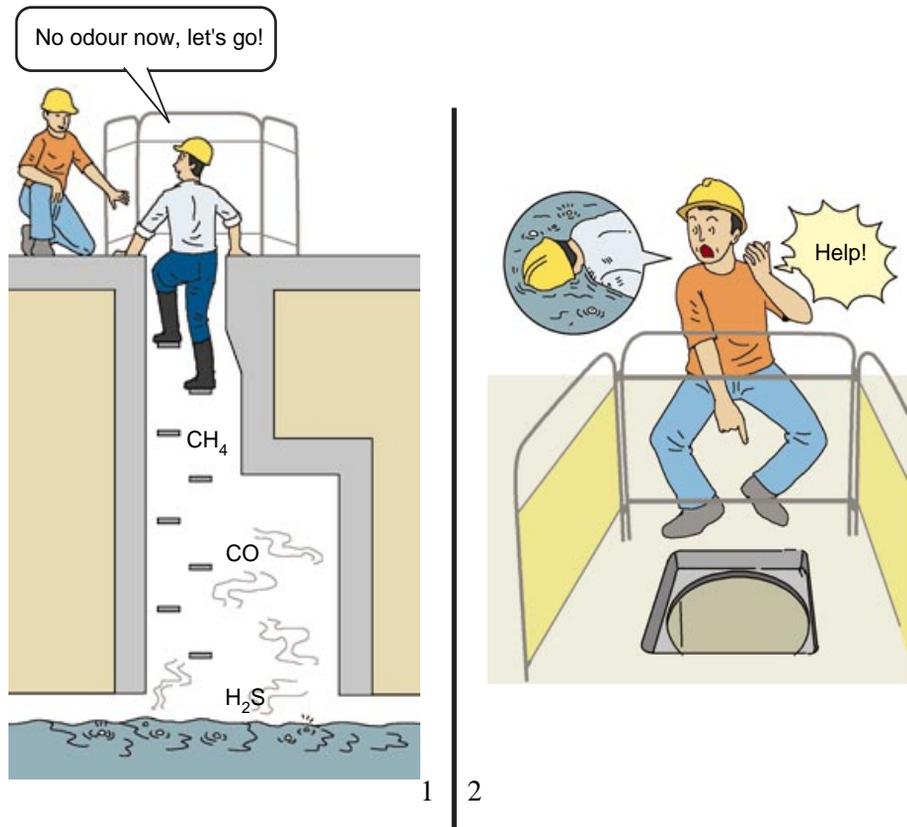
- ppm - Parts per Million
- OEL - Occupational Exposure Limit - Time-Weighted Average
- IDLH - Immediately Dangerous to Life or Health Concentration
- Relative density - < 1.0 means lighter than air; > 1.0 means heavier than air
- LEL/UEL - Lower Explosive Limit / Upper Explosive Limit



Different hazardous gases accumulate at different levels of a manhole.

3.2.1 Hydrogen sulphide (H₂S)

Hydrogen sulphide is a deadly gas with a distinctive "rotten egg" odour that can be detected at very low concentrations. At concentrations above 100 ppm, hydrogen sulphide has a paralysing effect on the sense of smell. Even at lower concentrations, hydrogen sulphide can affect the olfactory nerve and workers cannot detect the changes in concentrations. Therefore, it is very dangerous to rely on the smell to detect the presence of hydrogen sulphide. A more reliable method for detecting hydrogen sulphide is by using a calibrated gas detector. An airborne concentration of hydrogen sulphide above 100 ppm is immediately dangerous to life or health and concentrations over 1,000 ppm could cause immediate collapse. As sewage is very often present in a drainage system, workers overcome by hydrogen sulphide could be easily killed by drowning.



Do not rely on the smell to detect the presence of hydrogen sulphide or other toxic gases.

3.2.2 Carbon monoxide (CO)

The lethal colourless and odourless gas – carbon monoxide, is given off when charcoal is burnt in poorly ventilated areas. Similarly, it is produced when gasoline/diesel generators or other fuel-driven tools are used in inadequately ventilated workplaces. Exposure to carbon monoxide at concentrations over 350 ppm can cause confusion, fainting on exertion and collapse. An airborne concentration of carbon monoxide above 1,200 ppm is immediately dangerous to life or health.

3.2.3 Methane (CH₄)

Methane is commonly generated when organic matter is decomposed by a variety of bacterial processes. It is a colourless, extremely flammable and explosive gas that can cause fire and explosion. The accumulation of methane in a poorly ventilated area will displace normal air and result in an oxygen-deficient environment.

4. Safety measures for prevention of gas poisoning in drainage work

4.1 Assessing the atmospheric hazards

A high risk of atmospheric hazards is inherent in drainage work, particularly underground pipework. Working inside the drainage should be avoided as far as possible. If it is not reasonably practicable to carry out the work without entering the drainage, a competent person should be engaged to carry out a risk assessment to identify the hazards likely to be present in the drainage and to take the necessary safety precautions to eliminate or reduce the safety and health risks.

The person responsible for the workplace should verify that the risk assessment so conducted has covered all the potential safety and health hazards.

4.1.1 Collect all information relevant to the drainage work



The competent person should consider all relevant information carefully including the work methods, the surrounding environment and the potential atmospheric hazards.

The risk assessment should be conducted by a competent person before the work starts. The competent person should:

- understand the work methods to be employed, the plant and materials to be used, and the physical layout and surrounding environment of the drainage worksite. This can be done by conducting an on-site survey and studying the layout plans, drawings and work plans.
- identify and assess all the potential atmospheric hazards that may exist before the work begins as well as those that may emerge in the course of the work. Even if toxic gases, fumes and vapours may not be present initially, they may be released while the work is in progress inside the drainage. For example, if sludge or waste water containing hydrogen sulphide is disturbed, the hydrogen sulphide gas will be released quickly and accumulate in the confined space to hazardous levels. Also, sudden ingress of hazardous gases to newly built drainage from existing sewers is not uncommon.

4.1.2 Air monitoring

Air monitoring should be conducted by a person with appropriate training and experience. It includes pre-entry atmospheric testing and atmospheric monitoring during the work.



The competent person should recommend continuous air monitoring if the risk assessment shows that there could be adverse changes of atmospheric conditions.



The competent person should state in the recommendation whether the use of approved breathing apparatus is necessary and the period within which workers may safely remain in the confined space.

Air monitoring does not end with the pre-entry test. Since atmospheric conditions within a drainage workspace can change rapidly, it is necessary to perform air monitoring continuously to ensure that the air quality remains acceptable throughout the work. A 're-entry' test should be conducted if the workers have temporarily left the space. In fact, re-entry testing and pre-entry testing should be performed in exactly the same manner and should be considered as equally important. In case the alarm of the air monitoring equipment is activated or any other indication of danger is observed, workers should leave the work space immediately according to emergency procedures.

Some important points on the use of air monitoring instruments:

- Only properly maintained and calibrated equipment should be used for atmospheric testing. Unscientific methods such as throwing a flame down the manhole, and observing the presence of living organisms or the colour of manhole are unreliable.

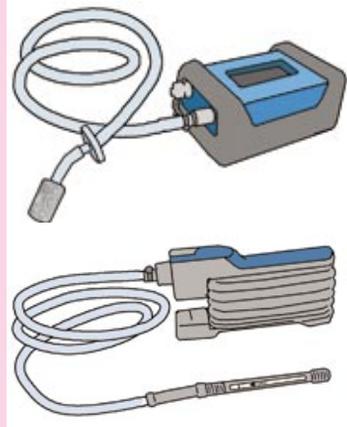
Never rely on unscientific methods.

The air can be checked this way!



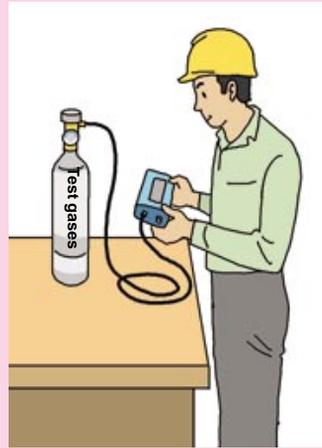
- The most common configuration for a multiple-sensor gas monitor is one that can read levels of oxygen, combustible gases, hydrogen sulphide and carbon monoxide. Never assume that the hazardous gases present are limited to these gases. Different or additional air monitoring instruments are required for other hazardous gases that may be present in the drainage.

Various air monitoring instruments may be required for assessing the potential atmospheric hazards in drainage work.



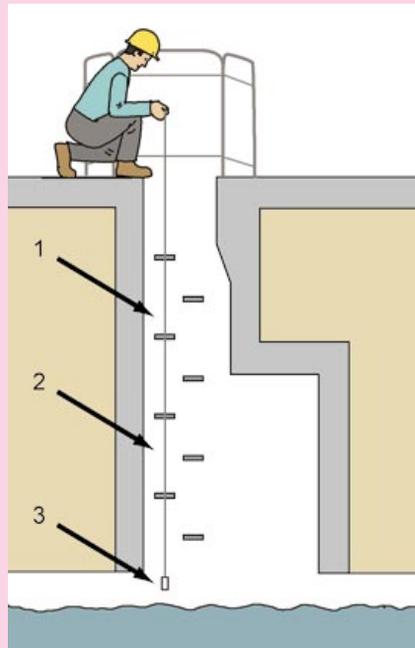
- The proper functioning of the air monitoring equipment should be tested before use according to the manufacturer's instructions, i.e. functional or bump test.

Conduct bump test according to the manufacturer's instructions.



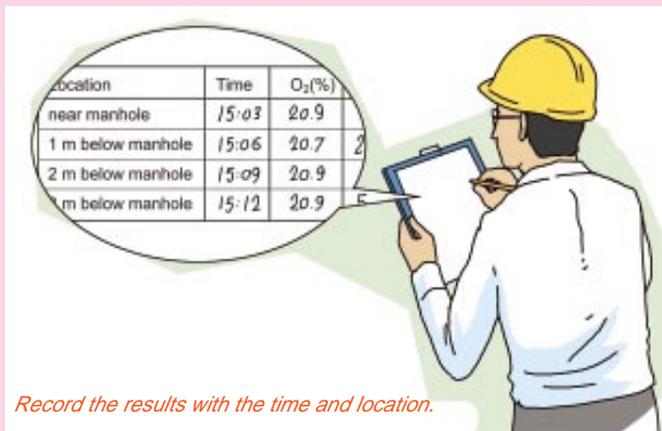
- The atmosphere in the drainage should, as far as practicable, be tested by using remote probes and sampling lines connected to direct-reading instruments placed outside the drainage.
- The atmosphere around the working position of the person carrying out the air monitoring should be tested first to ensure his safety and health during the air monitoring.
- In general, testing for oxygen should be performed first because some gas sensors are oxygen dependent and could give unreliable readings in oxygen deficient situations. Even though it may still be sufficient for survival, any depletion of oxygen should be further investigated.

- Different gases are stratified in a manhole basing on their densities relative to air. For example, methane is lighter than air and will be found near the top. On the other hand, hydrogen sulphide is heavier than air and will be found around the bottom, whereas carbon monoxide is slightly lighter than air and will stay in the vicinity of the release. So, testing of the atmosphere inside the drainage should be done from the top to the bottom of the space, preferably at about 1-metre intervals. Sampling for a few minutes at each location is required as there will be a time lag for the gas to be pumped from the sampling probe to the monitoring equipment.



Air monitoring should be conducted at different levels of a manhole.

- Record the results with the time and location of the atmospheric monitoring in the risk assessment.



Record the results with the time and location.

- Atmospheric monitoring must be conducted again when there is any potential change in the atmospheric conditions.

4.2 Control measures for prevention of gas poisoning

4.2.1 Avoid working inside drainage

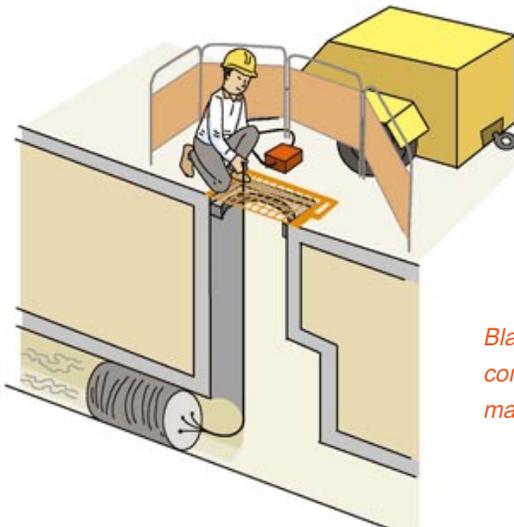
Working inside drainage should be avoided as far as possible. Where practicable, use other practical work methods without requiring workers to enter the drainage.



Avoid working inside drainage.

4.2.2 Isolation

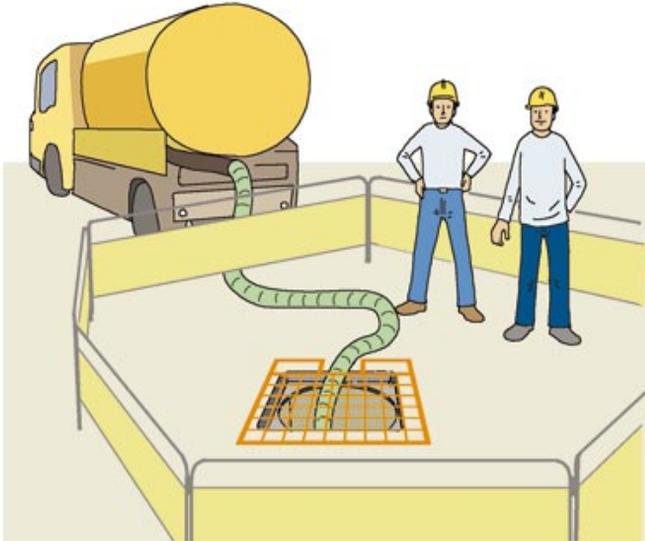
Blank off pipes or supply lines to prevent influx of hazardous materials.



*Blank off all pipelines
connected to the
manhole.*

4.2.3 Cleaning

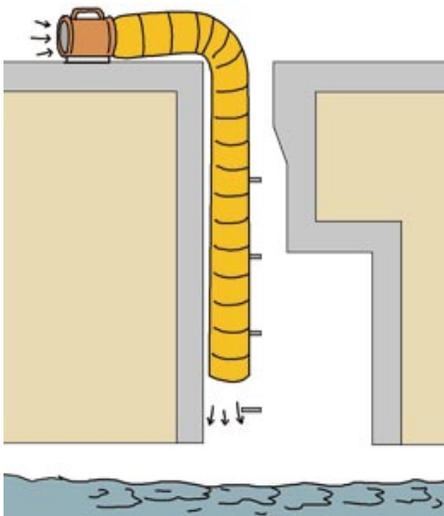
Use mechanical tools like vacuum/ jet cleaning instruments to remove the waste, such as grit, silt, sludge and sewage, from the drainage system to eliminate the sources of hazardous gases.



Remove sludge and sewage to eliminate the source of hazardous gases.

4.2.4 Ventilation

Mechanical ventilation should be used to dilute the air contaminants in the work environment and prevent accumulation of hazardous gases.



Fresh air should be supplied to the working location and the blower fan must be carefully located to avoid sucking in contaminated air.

4.2.5 Personal protective equipment

Only certified workers wearing approved breathing apparatus should be allowed to enter a confined space, like a manhole, in view of the ever changing environment and the conditions are difficult to assess.

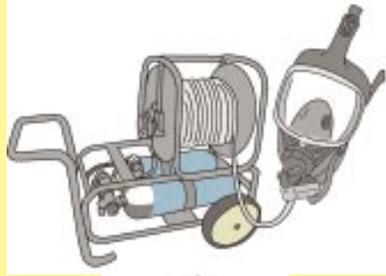
Where the use of approved breathing apparatus is recommended in the risk assessment report or a worker has to enter a confined space for underground pipework, the person responsible for the workplace shall ensure that any person entering or remaining in that confined space is properly wearing a suitable approved breathing apparatus with a suitable safety harness connected to a lifeline. The free end of the lifeline should be held by a standby worker outside the confined space.



Approved breathing apparatus should be worn in confined spaces where there are risks of the worker being overcome by hazardous gases.

The person using the breathing apparatus should have received appropriate training in the use of that particular type or model of equipment. Before each use, the equipment should be:

- connected to a cylinder, a pump or a compressor to provide breathable air. Care should be taken to ensure that the air compressor used for filling air cylinders or supplying air to airline type breathing apparatus is specially designed for providing breathable air, suitably maintained and properly located to avoid intake from contaminated air sources.
- inspected for any sign of physical damage on all parts and accessories.
- functionally checked according to the user manual. Tests include “high pressure leak test”, “positive pressure test”, “cylinder pressure test”, “whistle warning unit test”, etc.
- kept in clean and good conditions. Defective equipment should be clearly marked “defective” and removed from site for maintenance. Never use defective breathing apparatus.



Various types of approved breathing apparatus.



Check the proper functioning of the breathing apparatus before use.

4.2.6 Standby worker

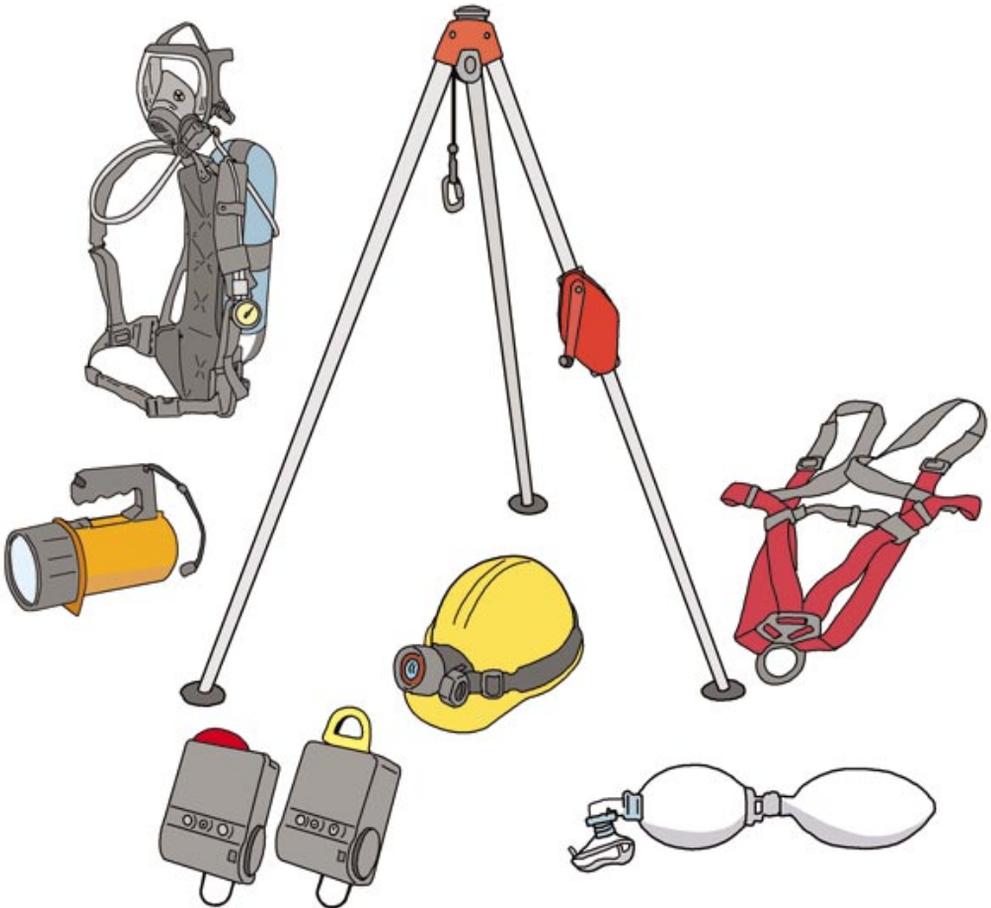
Standby workers should station outside the manhole to maintain communication with the certified worker inside. The worker working in the manhole must be constantly alerted to any change in the conditions within the space. In the event of an alarm from the monitoring equipment or any other indication of danger, the standby worker should assist the worker(s) inside the manhole to leave the space immediately in accordance with the emergency procedures.



The standby worker should station outside the manhole and maintain constant communication with the certified worker inside.

4.2.7 Emergency preparedness

An emergency plan should be formulated to deal with any serious and imminent danger to workers working inside the drainage system. All workers should familiarise themselves with the emergency procedures and should conduct drills periodically.



A set of emergency equipment and tools should be readily available on site.

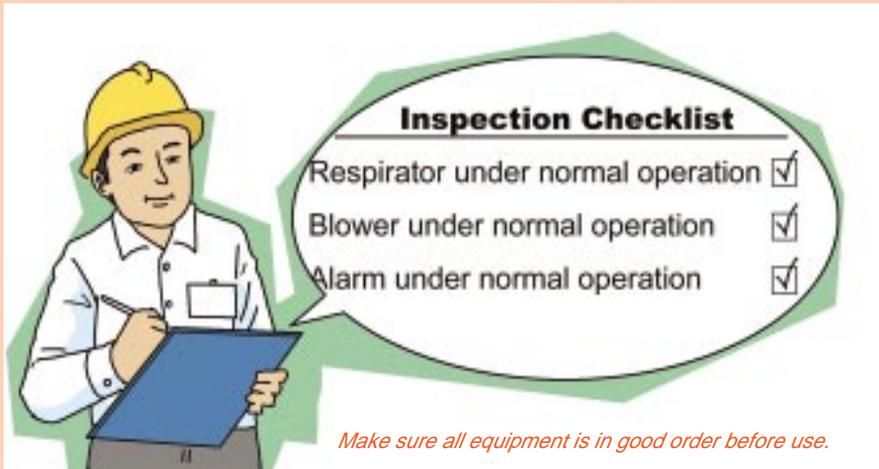
4.2.8 Permit-to-work system

A permit-to-work system is a useful means to ensure the safety and health of workers working in a drainage system. Workers should not be allowed to enter the drainage unless a permit-to-work certificate has been issued after all the necessary safety precautions as recommended in the risk assessment report have been carried out.



Entry into a manhole for work should be permitted only after the issue of a valid permit-to-work certificate.

5. Points to note



- Be aware of the characteristics and hazards of the hazardous gases likely to be present in the drainage system.
- Before work starts, ensure that all the necessary safety precautions recommended by the competent person have been properly implemented.
- Do not work alone if entry into a manhole or drainage system is required.
- Keep monitoring the workspace and surrounding areas and be alert to dangerous conditions.

- Immediately evacuate from the drainage system according to the emergency procedures if there are signs indicating that the safety and health of workers may come under threat.

- Assign a suitable standby person to station outside the manhole to maintain constant communication with the workers inside and provide necessary assistance.
- Call for emergency assistance immediately and implement the emergency plan in case of an accident.
- When an accident occurs, do not enter the manhole to rescue the collapsed victims without any rescue equipment and support from other rescuers.
- Keep close supervision of the drainage work at all times.



6. Further information

This booklet is issued free of charge and can be obtained from offices of the Occupational Safety and Health Branch of the Labour Department (LD) or downloaded from LD's website at http://www.labour.gov.hk/eng/public/content2_9.htm. If you wish to enquire about this booklet or require advice on occupational health and hygiene issues, please contact the Occupational Safety and Health Branch of the LD through:

Address : 15/F., Harbour Building, 38 Pier Road, Central, Hong Kong
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Fax : 2581 2049
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Information on the services offered by the LD and on major legislation can also be found by visiting our Home Page on the Internet at <http://www.labour.gov.hk>.

Information on the services provided by the Occupational Safety and Health Council can be obtained through its hotline 2739 9000.

Occupational Safety and Health complaint hotline:

If you have any complaint about unsafe workplaces and practices, please call the LD's Occupational Safety and Health complaint hotline at 2542 2172. All complaints will be treated in the strictest confidence.

