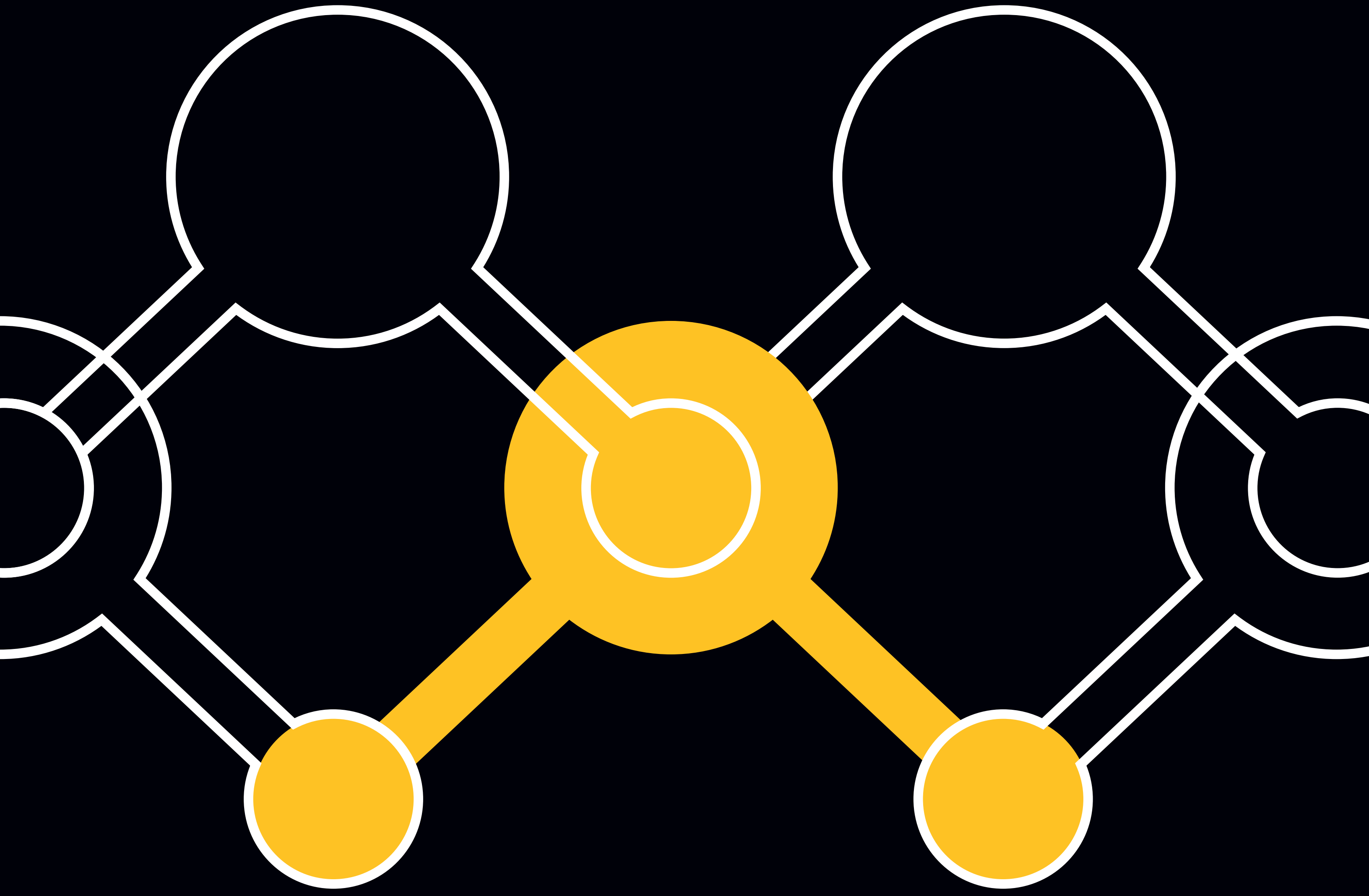
H_2S ALIVE®



Participant Manual
Version 24.1

ENERGY
SAFETY
CANADA

Acknowledgments

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Safety Doesn't Clock In and Punch Out. It's 24/7.

ENERGY SAFETY CANADA

ESC lives and breathes safety so Canada's energy industry can live and work safely.

With roots dating back to 1949, ESC was created by industry for industry with a single purpose to improve safety throughout Canada's energy industry. ESC is a not-for-profit and registered charity and this status allows the organization to reinvest any revenues back into health and safety programs and resources dedicated to advance safety in Canada's energy industry.

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- Make safety training easier to get
- Reduce redundancy of duplicate training
- Have easily accessible training certifications
- Standardize safety measures across multiple sites

For companies, we:

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- Provide leading-edge data and customized support
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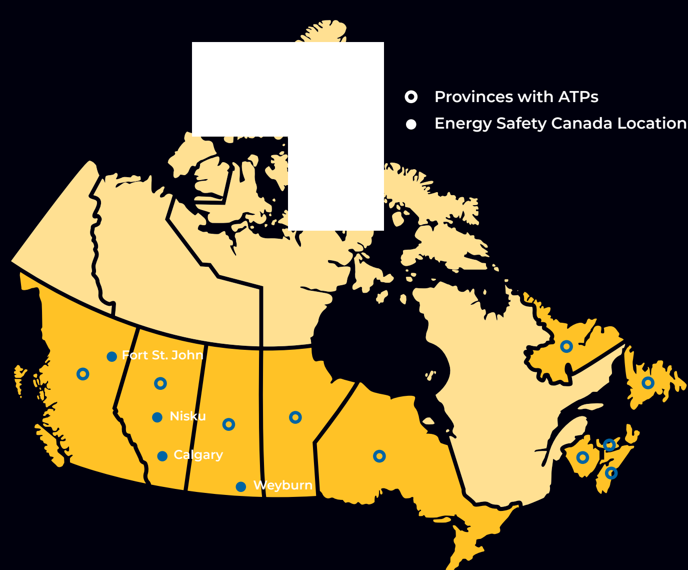

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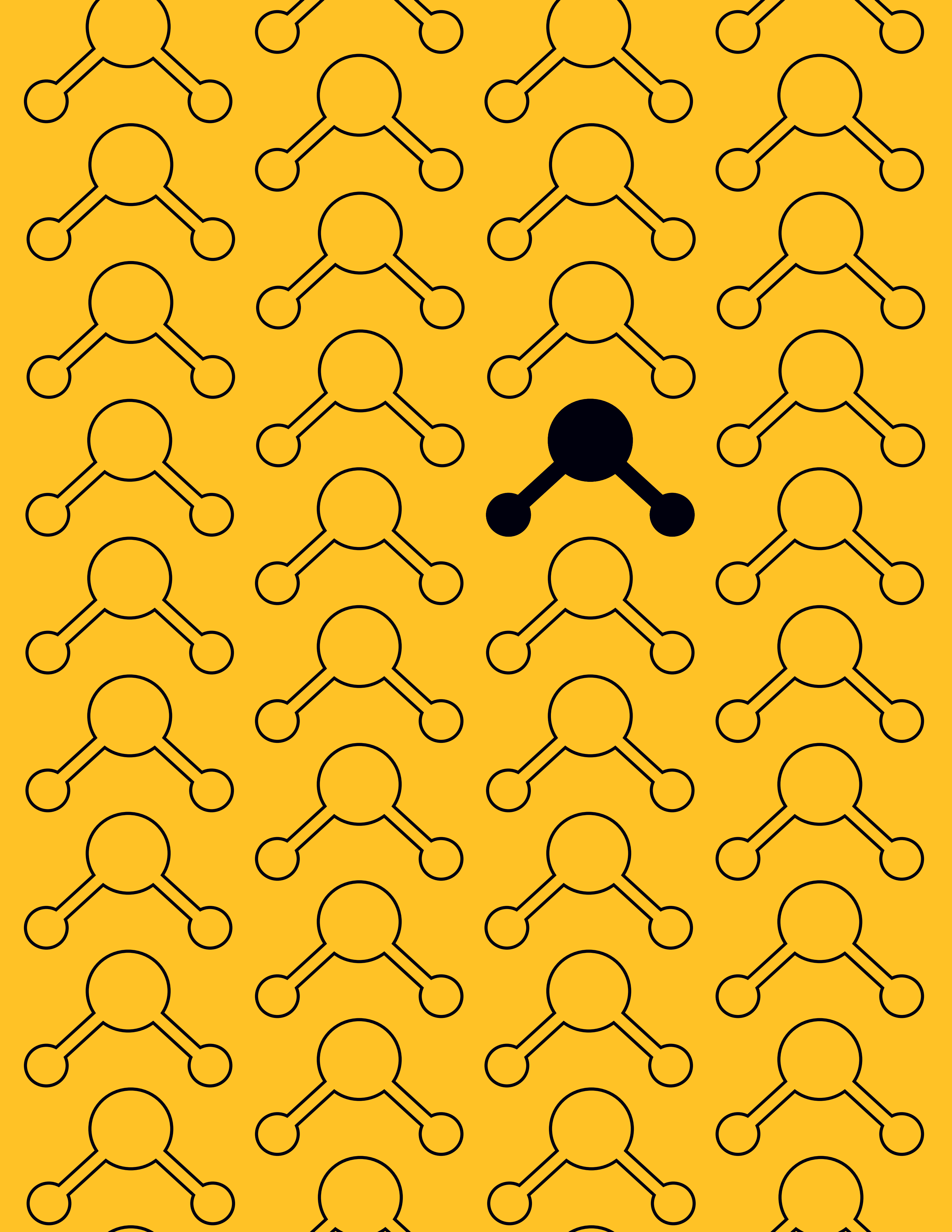

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Chapter 1:

H_2S Properties, Health Hazards and Locations

Outcome

Identify properties, health hazards and locations of H_2S in various industries.

Objectives

Upon completion of this chapter, you should be able to:

1. Describe the six properties of H_2S gas in particular conditions.
2. Identify the health hazards associated with various concentrations of H_2S gas.
3. Recognize probable locations for leaks and accumulation of H_2S gas in the various industries based on H_2S properties.

Introduction

Hydrogen Sulphide, or H_2S, is a naturally occurring gas. It is often referred to as sour gas, acid gas, stink damp or sulphureted hydrogen. H_2S is colourless, heavier than air in its pure state and extremely toxic. In low concentrations, it has a rotten egg smell and causes eye and throat irritation. H_2S can deaden your sense of smell and at higher concentrations, it can cause death. For these reasons, training in how to protect yourself is crucial.

This is an awareness-level course. Competency in these skills is developed through further on-the-job training and experience.

Activity 1.1

Actual H_2S Fatalities and Near Miss Incidents

Read the incidents descriptions below and be prepared to discuss how each incident could have been prevented.

Incident 1

A worker at a plant was repairing a pump. He opened a valve to relieve pressure on a pipe known to contain H_2S and was exposed to the gas. He lost consciousness after removing himself from the building and rolled down four to five steps to the ground. The worker was treated on site, then flown to a hospital for further treatment before being released.

Incident 2

A truck driver climbed onto a trailer containing sour product to gauge the load. When he loosened one of the hatch covers, built-up pressure in the trailer blew the hatch cover wide open. The driver, who was not masked up, was exposed to H_2S from within the trailer. He was overcome, fell from the trailer to the ground and sustained fatal head injuries.

Incident 3

Two workers were refilling a wastewater treatment tank following a shutdown at a pulp mill. After manually opening a valve to initiate the flow of effluent into the tank, the workers were exposed to H_2S gas that was released through a grated opening above the tank. Both workers experienced headaches and disorientation.

Preventing Incidents

The responsibility for preventing incidents like the ones described is shared by everyone at the worksite. Your employer is responsible for ensuring, within reason, a safe workplace. You must cooperate with your employer and do your part in protecting yourself and your co-workers.

Do not be a casualty! Many people have died over the years from exposure to H_2S. Many more have been injured.

You can help control these hazards through:

- Pre-job planning
- Hazard assessment, control and reporting
- Emergency response planning
- Suitable training
- On-the-job skills practice, drills and simulations
- Following safe work procedures and using available control measures including the use of breathing apparatuses and detection equipment
- Ensuring competency

This course is designed with your safety in mind. To ensure you know what to do when you suspect that H_2S may have been released, you must regularly practice the skills you learn in this course.

Activity 1.2

Identifying Potential H_2S Exposures at Your Worksite

Participate in a class discussion by answering the following questions. This will help you assess your current knowledge of potential H_2S exposures at your worksite.

1. Where can you find specific information about products containing H_2S at your worksite?
2. What are the main health risks of H_2S exposure?
3. What are potential locations of H_2S exposure at your worksite?

Properties

Knowing the properties of H_2S will help you protect yourself from exposure to this deadly gas. Refer to Table 1.1 to learn about the properties of H_2S.

Safety Data Sheet

H_2S is a controlled product under the Workplace Hazardous Materials Information System. As such, products that contain H_2S in significant quantities or concentrations must be properly labelled.

Safety Data Sheets (SDS) for the products must be provided and employers must ensure workers are suitably trained. This training should include H_2S properties, handling procedures and what to do in the event of a release.

A generic example of a SDS for H_2S is included at the end of this manual for reference purposes. However, this generic example is not meant to provide specific guidance. For that information, you must check the SDS available at your worksite.

Table 1.1: Properties of H_2S

Properties	Description	Properties	Description
Physical State	Normally encountered as a gas	**Vapour Density**	Slightly heavier than air (1.19 compared to 1.0 for air): » In gas mixtures, H_2S will be present whenever the gas mixture is found » Gas mixtures may be heavier or lighter than air, depending upon their vapour density and temperature compared to the ambient atmosphere (i.e. usually air) » In its pure state, or as a high proportion of gas mixture, H_2S may flow to settle into low-lying areas, such as pits, trenches and natural depressions
Colour	Colourless » No visible sign of H_2S to warn you of its presence		
Odour	Smells like rotten eggs (in low concentrations) » Impairs your sense of smell as concentrations increase		
Flammability	Flammable (4% LEL and 46% UEL)* » Burns with a blue flame and gives off Sulphur Dioxide (SO_2 gas) » Explosive when mixed with air, depending upon the proportions » SO_2 is also hazardous and irritates the eyes and the respiratory system	**Solubility**	Mixes in most fluids such as water, oil, sludge, emulsions, well fluids and molten sulphur » H_2S can be released when liquids are agitated, depressurized or heated

*The lowest amount of gas in the air that will burn is the lower explosive limit (LEL), also called the lower flammable limit (LFL). The highest amount of gas in the air that will burn is the upper explosive limit (UEL), also referred to as the upper flammable limit (UFL).
* Refer to Section 9 of the SDS form in the appendices.

H_2S Health Hazards

If you are exposed to H_2S gas over the Occupational Exposure Limit (OEL), seek medical attention immediately.

This means you must be extremely cautious when working in an area where H_2S gas may be present. Ask yourself, how will exposure to this gas affect my health? Will it harm me or kill me?

Without the answers to these questions, you cannot tell which exposure levels are harmful or fatal.

H_2S enters the body through:

- Inhalation
- Contact with the eyes

When inhaled, it dissolves readily in one's blood and is carried by the bloodstream throughout the body. It affects breathing by causing the respiratory control centre in the brain to shut down. Without messages from the brain, respiration stops. As a result, the oxygen in the blood is quickly used up, causing the heart to stop which leads to death if not treated promptly.

H_2S contact with the eye can cause redness, swelling, pain, tearing and blurred or hazy vision. The pain can quickly subside, but permanent eye damage or blindness could result.

You should also be aware that H_2S is often mixed with or found alongside other hydrocarbon products, wastes, gases or liquids. You must be prepared to deal with any other hazards posed by these substances.

Measurement of H_2S

Two scales are commonly used to measure H_2S concentrations: percentage (%) and parts per million (ppm). Most of us are already familiar with the percentage scale. It divides the total into 100 parts and enables us to indicate the concentration of H_2S in percent.

To provide guidelines for the potential effects of H_2S on the human body, we need a measurement scale that divides the total into much smaller units. For this purpose, the ppm scale is used. It divides the total into 1,000,000 parts and enables us to indicate the concentration of H_2S in parts per million. Using this scale, the smallest whole unit we can measure is 1 part per million or 0.0001%.

For every 1% of H_2S gas, there are 10,000 ppm of H_2S gas.

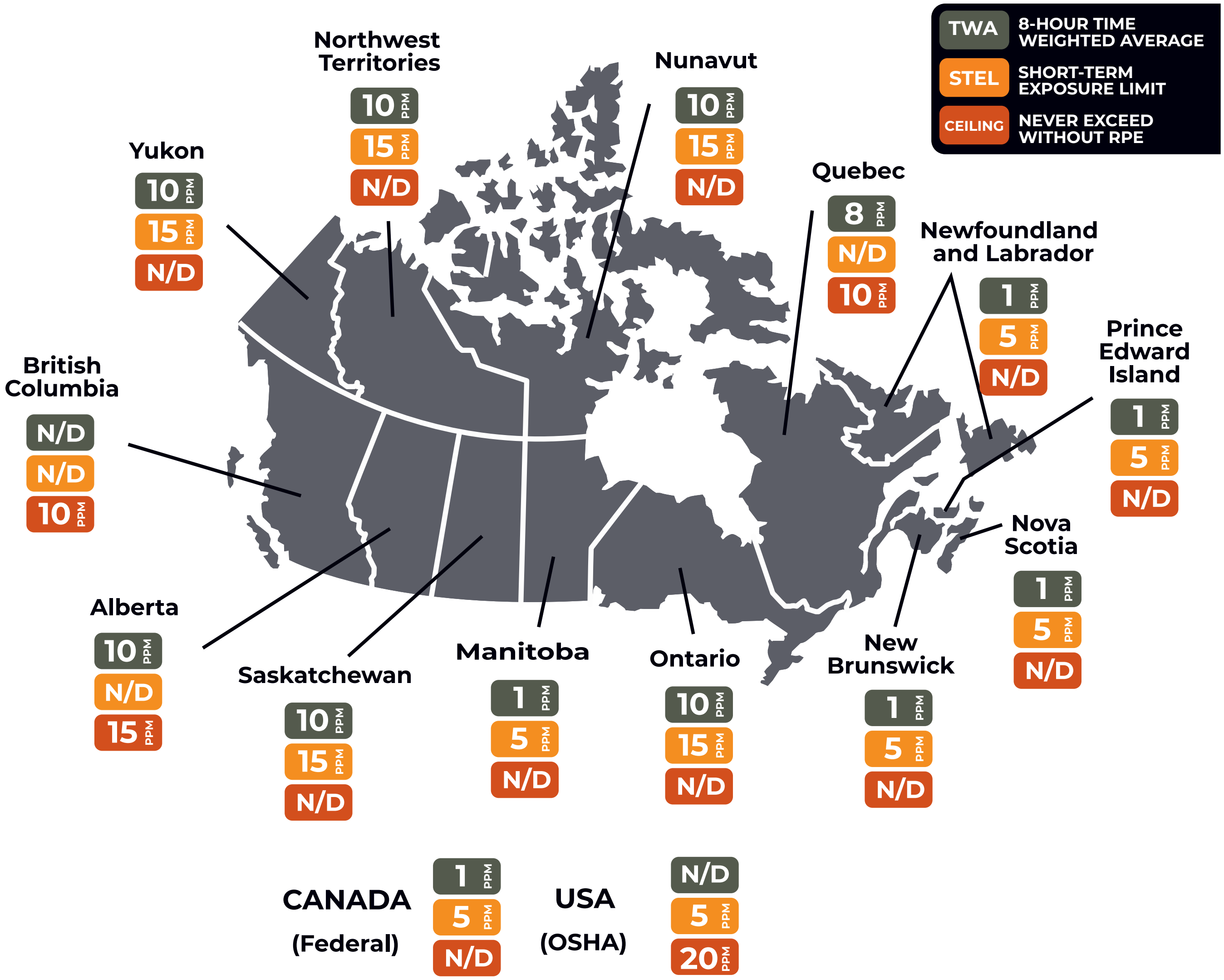
Worker Exposure Limits

Government agencies set limits for worker exposure to toxic substances. These levels are there for your safety and must not be ignored! Not all jurisdictions specify the same limits. Ultimately, the goal should be zero exposure.

The following infographic lists the exposure limits for a variety of jurisdictions:

- **8-Hour Time-Weighted Average (TWA)** is the average H_2S concentration that a person can be exposed to for 8 hours without risking health effects. Extended shifts (days and/or hours) increase worker exposure to hazards and reduce our bodies' time to process toxins. Special calculations (Daily Reduction Factors – DRF) are used, when appropriate, to determine reduced exposure levels in these circumstances.
- **Short-Term Exposure Limit (STEL)** is the average H_2S concentration that a person can be exposed to for 15 minutes without risking health effects.
- **Ceiling** is the maximum H_2S concentration that a person should ever be exposed to without respiratory protection.

If your jurisdiction is not included, ask your instructor for assistance.



N/D = Not Defined. Workers should not be exposed to the maximum allowable concentration without proper protection.

Figure 1.1 Worker Exposure Limits for H_2S

Activity 1.3

Identifying Worker Exposure Limits at Your Worksite

What are the worker exposure limits at your worksite? Be prepared to discuss your response.

	TWA	STEL	CEILING
Your Site			

Determining Toxicity Levels

If you are new to the hazards of H_2S, the following questions may have crossed your mind:

- How much H_2S does it take to make me sick or kill me?
- At what level can I smell it?
- When do I lose my sense of smell?
- At what concentration will I pass out?

Acute Health Effects

While immediate health effects are referred to as acute, long-term health problems are referred to as chronic. Table 1.2 identifies potential acute health effects associated with H_2S exposure.

Immediately Dangerous to Life and Health (IDLH)

IDLH values for H_2S were established to ensure that workers can escape from a given contaminated environment in the event of failure of the most effective respiratory protective equipment. In the event that the equipment fails, every effort must be made to exit the area immediately.

An H_2S concentration of 100 ppm or greater is considered to be IDLH.

Chronic Health Effects

A direct link between exposures to low H_2S concentrations and long-term health effects has not been established. However, some research suggests that the chronic effects of H_2S exposure could include:

- Reduced lung function
- Neurological effects such as headaches, nausea, depression and personality changes
- Irritation to the eyes and mucous membranes
- Damage to the cardiovascular system

Table 1.2: H_2S Exposure Health Effects

H_2S Exposure		Possible Health Effects
	LESS THAN 1 PPM	» No known health effects but you can smell it
1 PPM	10-20 PPM	» No known adverse health effects for most people
20 PPM	20-50 PPM	» Eye, nose, throat and lung irritation
50 PPM; 100 PPM → IDLH	50-150 PPM	» The point where serious complications may result » Severe eye, nose, throat and lung irritation » Loss of smell » Exposure duration of 8 hours or more may be fatal
150 PPM	200-300 PPM	» Headaches and drowsiness » Prolonged exposure of several hours may cause lungs to fill with fluid
300 PPM	300-500 PPM	» May cause unconsciousness or death within 1 to 4 hours
500 PPM	500-700 PPM	» Knock-down, may be fatal within 1 hour at this level of exposure
700 PPM	GREATER THAN 700 PPM	» Knock-down, may be immediately fatal

Hazards From Other Gases and Liquids

H_2S is often mixed with or found alongside a variety of hydrocarbons and other gases or liquids. These products may pose other hazards, in addition to those caused by H_2S. These hazards include:

- Hydrocarbon fire and explosion
- Hydrocarbon narcosis and oxygen deficiency
- Exposure to cancer-causing aromatic hydrocarbons
- Line blockage and over-pressurization caused by hydrate formations (ice plugs)
- Exposure to Naturally Occurring Radioactive Material (NORM)
- Spontaneous combustion of Iron Sulphide

Hydrocarbon Fire and Explosion

All hydrocarbon vapours and gases will ignite when mixed with air within a certain range of proportions. This range is called the flammable (or explosive) range. The flammable range for mixtures of crude oil vapours, natural gas and other hydrocarbon products is variable, depending upon the proportions of hydrocarbon and other components in the mixture.

Serious and potentially fatal burns may occur as a result of exposure to the uncontrolled ignition of hydrocarbon products.

Hydrocarbon Narcosis and Oxygen Deficiency

Recent research suggests that light hydrocarbon gases, such as methane and propane, may produce narcotic effects and cause oxygen deficiency. Both hydrocarbon narcosis and oxygen deficiency can incapacitate a worker.

Aromatic Hydrocarbons

Benzene, a known cancer-causing agent, is an aromatic hydrocarbon found in some liquid and gas streams. Other aromatics include toluene and xylene. (See Table 1.3)

Hydrate Formations

Hydrates are complex mixtures of water and gas that crystallize to form “ice plugs” under certain temperature and pressure conditions. Hydrates can totally block lines, resulting in over-pressurized conditions that can rupture piping and vessels with explosive force.

Naturally Occurring Radioactive Material (NORM)

NORM is found as radium in some produced liquids and as radon in some produced gases. The main hazard is inhalation or ingestion of dusts containing these products. The hazardous elements found in NORM are known to cause cancer and other abnormalities.

Iron Sulphide

Iron Sulphide is a by-product of crude oil and gas production. It is a grey paste-like material when it is dry, and it is commonly found in treaters, production tanks and piping systems. It is pyrophoric, meaning it is spontaneously combustible upon contact with air.

Other Materials

A variety of other hazardous materials may be introduced during drilling, well servicing and production operations. These materials include drilling fluids, workover fluids, corrosion inhibitors, descalers, sweetening agents and thiols (mercaptans).

Your employer is responsible for providing you with appropriate information and training if any of these hazards exist. If in doubt, ask your supervisor for more information or check the SDS for the product.

Note: Many other gases can displace oxygen which may cause health effects.

Table 1.3 : Aromatic Hydrocarbons Exposure Limits (Alberta)

Aromatic Hydrocarbon	TWA (8-Hour Time-Weighted Average)	STEL (Short-Term Exposure Limit)	CEILING (Never Exceed Without Respiratory Protection)
Benzene	0.5 ppm	2.5 ppm	N/D
Toluene	50 ppm	N/D	N/D
Xylene	100 ppm	150 ppm	N/D

N/D = Not Defined

Locations

H_2S can be found in a variety of geological formations and is produced naturally from decaying organic matter. It can be released from sewage sludge, liquid manure, sulfur hot springs and with natural gas. It is also used and is a by-product in many industrial processes such as:

- Petroleum production and refining
- Sewer and wastewater treatment
- Agricultural silos and pits
- Textile manufacturing
- Pulp and paper processing
- Food processing
- Hot asphalt paving
- Mining
- Utilities

Many workers are at risk for exposure to H_2S, especially when working in confined spaces. For example:

- Sanitation workers can be exposed when cleaning or maintaining municipal sewers and septic tanks.
- Farm workers can be exposed when cleaning manure storage tanks or working in manure pits.

In general, working in the following areas and conditions increases a worker's risk of overexposure to H_2S:

- Windless or low-lying areas that increase the potential for pockets of H_2S to form.
- Marshy landscapes where bacteria break down organic matter to form H_2S.
- Hot weather that speeds up rotting of manure and other organic materials and increases the H_2S vapour pressure.
- Confined spaces (for example: pits, manholes, tunnels, wells) where H_2S can build up to dangerous levels.

H_2S in the Energy Industry

The largest industrial source of H_2S is related to the energy industry. Workers in oil and natural gas drilling and refining may be exposed because H_2S may be present in oil and gas deposits and is a by-product of the desulfurization process of these fuels.

The first step in reducing your likelihood of exposure is knowing where H_2S is usually found. Talk to your supervisor or an experienced co-worker if you are not sure where you might be at risk of exposure to this deadly gas.

General locations linked to H_2S occurrence in the energy industry include:

- Trucking operations
- Drilling operations
- Well stimulation operations
- Well servicing operations
- Field production operations
- Plant production facilities
- Off-shore operations and facilities
- Pipeline operations
- Petrochemical and refining facilities
- Heavy oil operations
- Repairing equipment

Specific locations where you can expect to find H_2S in the energy industry include:

- Wellheads or wellbores
- Production facilities
- Vessels
- Tanks
- Piping systems
- Pipelines
- Bermed or diked areas
- Pits and low spots
- Sour spills
- Shacks or buildings
- Other confined or enclosed spaces
- Fluids (mud tank, shakers, produced water, waste streams)

When you enter a confined space, always consider the possibility that H_2S and other contaminants may be present. The main things to watch out for are liquids, sludge and scale. If you agitate liquids or sludge in a tank, they may release H_2S. Removing scale by steam, chemicals or grinding may cause the release of any H_2S in the scale. Blisters on the inside or outside of tanks may contain H_2S.

Be sure to follow confined space entry procedures applicable to your jurisdiction.

The most common areas where H_2S leaks occur are:

- Seals
- Fittings
- Flanges
- Drains
- Sample valves
- Relief valves
- Vent lines

Tasks associated with potential H_2S exposure include, but are not limited to:

- Maintaining wells
- Pigging
- Maintaining equipment
- Changing filters
- Entering compressor basements
- Responding to H_2S alarms
- Sampling with open or closed containers
- Gauging tanks
- Maintaining purged equipment
- Entering dikes or firewalls
- General trucking of sour fluids
- Uncoupling vent lines

Do not forget, H_2S may be found anywhere throughout worksite environments. Whenever there is a probability of H_2S in the air, respiratory protective equipment should be used.

Depending on the jurisdiction where you work, there may be a regulatory requirement to display a sign at locations where H_2S concentrations exceed the regulated exposure limit. For example, Figure 1.2 shows a warning sign required by the Alberta Energy Regulator.

Figure 1.2 Alberta Energy Regulator (AER) Category II (H_2S) Warning Sign

Evacuation

H_2S can be found in different places. Being heavier than air, it can collect in low-lying area or be trapped by buildings, natural barriers and other confined spaces.

However, as a component of a mixed gas stream that is lighter than air, the gas may rise, not fall. If released from pressurized containment, it may be wherever the gas stream is directed. If significantly warmer than the ambient air, H_2S mixtures may rise. For example, in winter, ambient temperatures are often much lower and H_2S mixtures are apt to rise.

If you are near a facility with potential H_2S presence, check the wind direction by looking at windsocks, flare stacks, weathervanes, tapes or trees. If H_2S is present, it will move downwind. Staying upwind of a facility in the event of a leak should help keep you out of danger.

In the event of a leak, move upwind if the release is downwind of you.

Figure 1.3 Wind Direction

Move crosswind if the release is upwind of you.

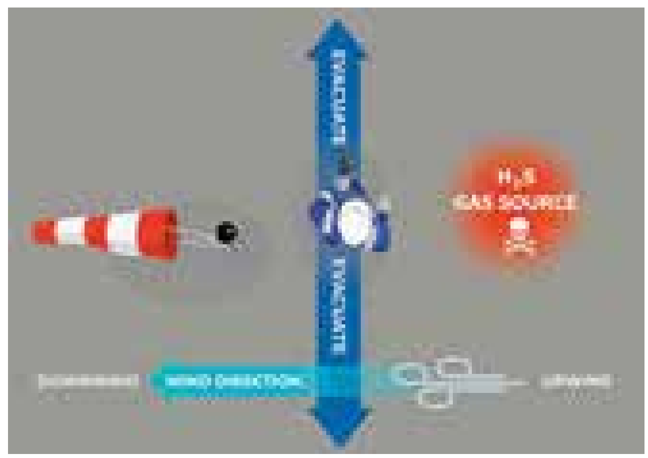


Figure 1.4

Go to higher ground if possible.

Figure 1.5

H_2S Evacuation Game

Check your knowledge of evacuation direction in the event of an H_2S release. Scan the QR code to play.

Scan the QR Code or use the link below
h2s-game.energysafetycanada.com

Exercise

1. What colour is H_2S gas?

____

2. What does H_2S gas smell like?

____

3. True or False: In its pure state, H_2S is heavier than air.

____

4. In what ways can H_2S enter the body?

____

5. What is the federal short-term exposure limit (STEL) in Canada?

____

6. What is the likely outcome of a worker exposed to H_2S levels beyond 700 ppm?

____

____

7. Based on H_2S properties, what are some common locations for leaks and accumulation of H_2S gas in the energy industry?

____

____

Discussion

- What are some other ways in which you can protect yourself and other workers from H_2S exposure?
- When is H_2S heavier than air?
- When is it lighter than air?
- What impact does the weight of gas have on its release?
- What are some potential locations for H_2S exposure at your worksite?
- Where can you find the SDSs and signage on your worksite?

Notes

Chapter 2:

Hazard Assessment and Control

Outcome

Identify hazards and apply control measures to reduce the risk of exposure to H_2S.

Objectives

Upon completion of this chapter, you should be able to:

1. Explain what a hazard assessment is and when it is used on a worksite.
2. Identify hazards at a worksite.
3. List the controls for the hazards identified.

Introduction

Hazard assessments help to prevent injury, illness, death and property loss. They help people identify worksite hazards and keep everyone safe. It is your responsibility to take reasonable care to protect your own health and safety, and the health and safety of other people at the worksite.

The energy industry has a social and moral responsibility as well as a regulatory and reputational commitment to:

- Clients
- Employers
- Workers and their families
- Regulators
- The public

Each person must understand their rights and responsibilities as they relate to workplace hazards, working alone and refusing unsafe work.

Hazard Assessments

A hazard is any situation, condition or object that has the potential to cause injury, illness, death or property loss. In other words, a hazard is an accident waiting to happen.

Accidents, injuries and property loss can happen to any worker, new or seasoned. New workers may not recognize hazards because they lack experience. Seasoned workers may not recognize hazards because they have come to think of them as a normal part of the job.

A hazard assessment is the process used to identify hazards and evaluate risk in the workplace. Control measures can then be put in place to mitigate that risk.

Why are Hazard Assessments Important?

The purpose of a hazard assessment is to prevent incidents by identifying and controlling hazards.

Who is Responsible for Hazard Assessments?

The simple answer to that question is you. Everyone should assess for hazards while at work.

Employers are responsible for:

- Identifying hazards and explaining how hazards are controlled
- Ensuring workers have the necessary qualifications, instruction and training to perform their roles safely
- Ensuring workers are equipped with the required personal protective equipment (PPE)
- Investigating injuries and near misses

Workers are responsible for:

- Following all job-related health and safety procedures
- Asking for training if they do not know how to do something safely
- Using all required PPE
- Immediately reporting unsafe conditions
- Informing their supervisor if they have a physical, mental or emotional issue that could affect their ability to work safely
- Refusing work that is unsafe to perform

When is a Hazard Assessment Required?

Hazard assessments are necessary in the following situations:

- Before starting work
- At practicable intervals during work
- When there is a change to the work process or worksite
- When a new work process is introduced

Conducting a Hazard Assessment

Hazard assessments consist of four steps:

1. Identify the hazards.
2. Evaluate the risk of exposure to the hazards.
3. Apply control measures to reduce the risk of exposure.
4. Monitor the effectiveness of the control measures.

We will focus on hazard identification and control measures.

Identifying Hazards

Hazard Sources

Hazards can impact health (disease from exposure) or safety (injury or fatality).

There are four sources of hazards:

1. People:

People's actions may create a hazard.

Their actions may be due to a lack of training, poor communication or other factors.

2. Equipment:

All of the tools, machines and systems that people come into contact with at a worksite. Examples range from hand tools and PPE to mud pumps and flare systems.

Some equipment is inherently hazardous. Other equipment may become hazardous over time due to contamination or inadequate maintenance, storage or disposal.

3. Materials:

All types of cargo or any chemical substance you may come into contact with.

4. Environment:

The environment you work in may also present hazards due to layout, ventilation, lighting, temperature, walking surfaces and similar concerns. The environment may cause hazardous gases to be released, present dangerous conditions due to severe weather or be infused with biological hazards such as moulds and fungi.

Energy Wheel

The Energy Wheel is a tool that can be used to increase hazard recognition. This tool is based on the idea that most hazards are directly related to an energy source.

For example, vehicle hazards are based on motion energy sources, while welding hazards involve temperature energy sources.

It is important to note that the Energy Wheel is not the only approach that can be used to enhance your hazard identification capabilities, but it is certainly a great tool to consider.

Scan the QR code for a short video elaborating on the Energy Wheel

https://youtu.be/BInj9tZdjZw?si=CmAqSBAliMwqyuwf

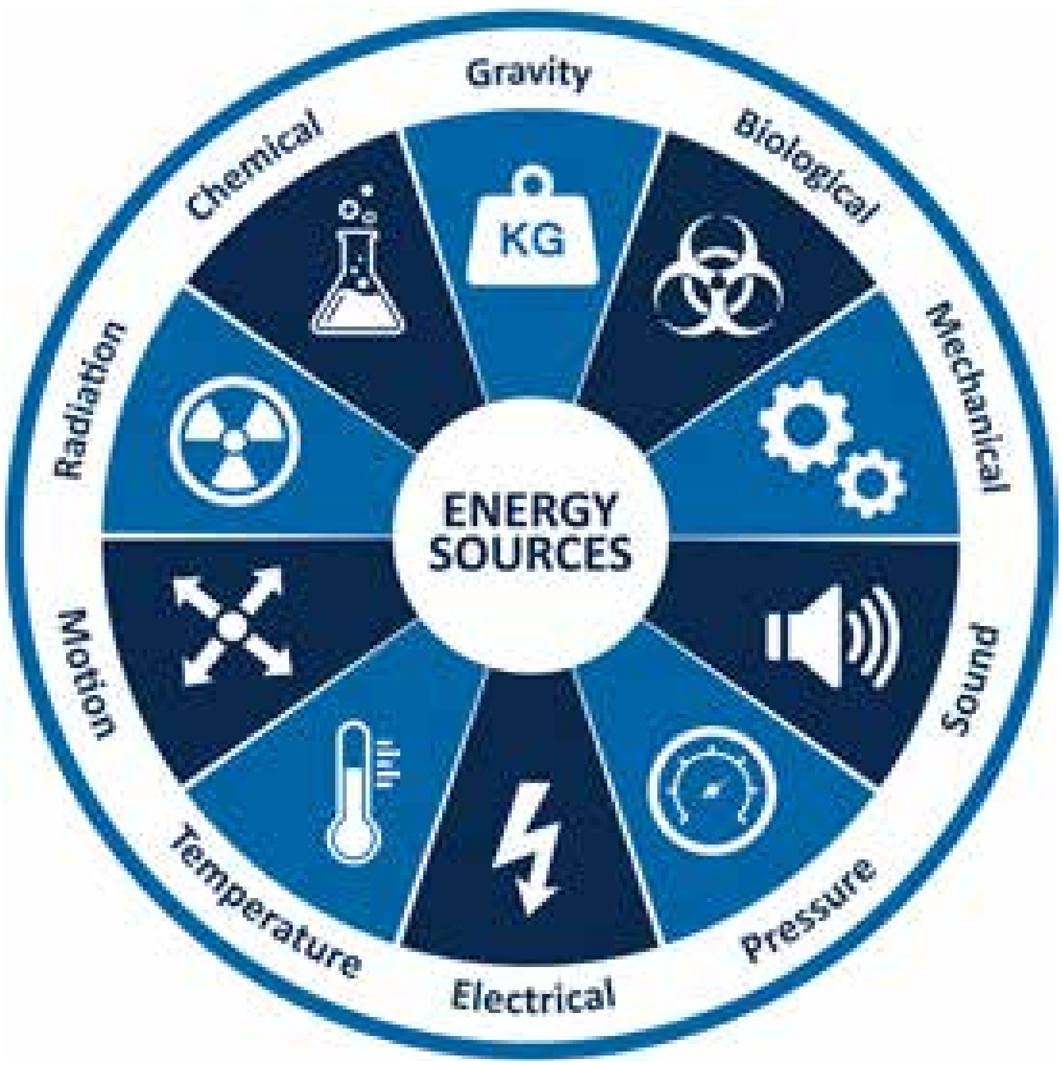


Figure 2.1: Energy Wheel

Activity 2.1

Identifying Hazards By Their Source

Examine the following scenario and identify the hazards according to their source.

Scenario

Contract workers are hired to perform routine maintenance on a gas line blocked by an ice plug. One of the contractor workers is experienced and the other worker is new.

During the pre-job safety meeting, they are not informed that the line might contain 300 ppm of trapped H_2S. They wear gas monitors that were bump tested at the shop. Although there is an air trailer, they do not use the SABAs to perform the job. At the lease entrance, the wind direction is northeast. The outside temperature is -29°C.

Hazard Source	Hazards
People	
Equipment	
Materials	
Environment	

Evaluate Risk

Obviously, all hazards are not created equal. Your employer will have a method of quantifying the risk associated with each hazard. This is done to help prioritize the risk and the response and to ensure that more serious hazards are not overlooked or underestimated.

Typically, a matrix that combines severity (how bad could this be) with probability (how likely is this to occur) is utilized for charting severity against probability to determine what controls would be appropriate to manage the risk based on that analysis.

Categories of risk are diverse and specific to work environments, industries and employers. Risk often includes evaluations of:

- Injury potential
- Property damage
- Environmental impact
- Reputational damage
- Business interruption

More sophisticated risk analyses compare risk before and after controls are applied to monitor and evaluate effectiveness.

Apply Control Measures

The closer controls are to the source, the more effective they are, which is why understanding the source is important.

The method of control selected should be based on the following hierarchy:

- Elimination
- Substitution
- Engineering controls
- Administrative controls
- Personal protective equipment (PPE)

If the hazard cannot be adequately controlled by a single method, a combination of methods may be required.

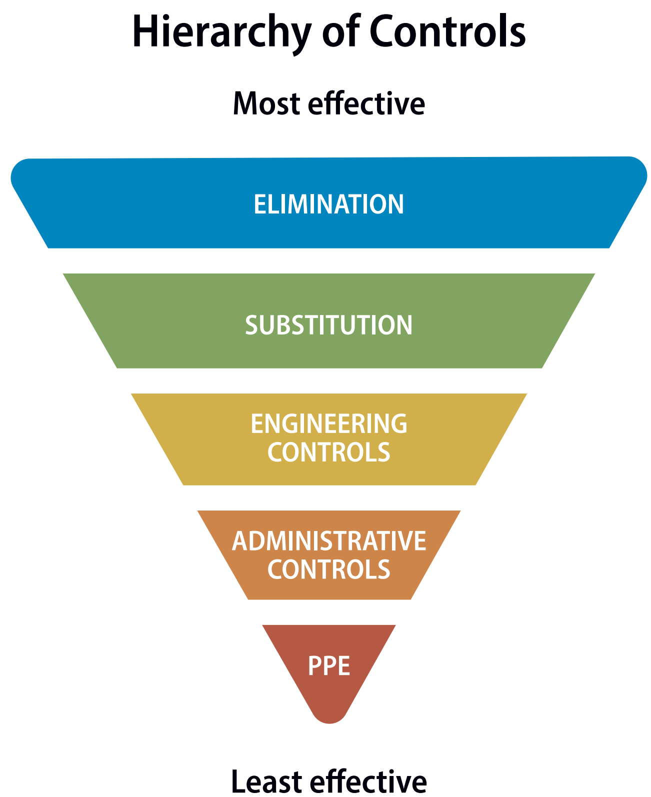


Figure 2.2 Hierarchy of Controls

Elimination

Hazards may be eliminated through changes in the process or by modifying a single step in a complex task. They may also be removed by hiring experts in a field to conduct the work on your behalf with specialized knowledge and equipment.

The assessment team should ask itself whether the activity that results in the hazard is truly necessary. If not, the team should remove it.

For example:

- Automating a process to reduce the need for people to be present
- Lowering equipment to the ground to avoid the risk of falls.

Substitution

The core idea of substitution is to use less toxic or less harmful products or materials to achieve the same results.

Examples include:

- Switching from a toxic to a non-toxic chemical
- Using more modern equipment with built-in safety features rather than older models.

Engineering Controls

Engineering controls are controls that do not rely on human action or decision.

If it is not possible to eliminate or substitute the hazard with a safer alternative, engineering controls should be considered.

This involves installing or modifying facilities and equipment to control the hazard at its source. This is typically done during the design of a worksite or process. Although workers may not be directly involved in engineering controls, it is important they understand them.

As a worker you may not create the engineering solution, but you are responsible for ensuring the engineering controls are working properly and reporting any concerns to your supervisor.

Examples of engineering controls include:

- Guards on tools and equipment
- Pressure regulators
- Closed handling systems
- Mechanical ventilation systems
- Backup equipment for high-risk processes
- Systems that automatically lock out or disable equipment

Administrative Controls

Administrative controls focus on the work process and the worker. They control the hazard by managing how the work is performed and are often used in conjunction with other types of controls.

Administrative controls include the following:

- Company policies
- Safe work processes
- Gas detectors and alarms
- Training
- Work rotation
- Signage

Administrative controls require training for them to work effectively.

Personal Protective Equipment (PPE)

PPE is the last line of defence. It is used when other controls are not possible or additional protection is needed. It is important to remember that PPE does not remove the hazard; it only inserts a barrier between the worker and the hazard. Workers must be trained in the proper usage, maintenance, and storage of their PPE. They must also use the right type of PPE for the task and environment, make sure the PPE fits properly, and be comfortable using the PPE under working conditions. PPE is the least effective because it only protects a worker who is actually exposed to the hazard!

Examples of PPE include:

- Safety glasses
- Respiratory Protection Equipment (RPE)
- Hard hat
- Safety footwear
- Gloves

Monitor the Effectiveness of the Control Measures

The fourth step of the hazard assessment process involves monitoring the effectiveness of the control measures implemented in step three. This step is critical to ensure that the controls put in place are effective in reducing or eliminating the risk of exposure to the identified hazards.

If any new hazards or unexpected outcomes are identified, appropriate actions should be taken to address them. This may involve modifying the existing control measures or implementing additional measures to address the new hazards or unintended consequences.

Furthermore, it is crucial to communicate any changes to the control measures or new hazards to employees, especially those who work across shifts or for different employers. This communication can include training sessions, written documentation, or regular safety meetings to ensure that all workers are aware of any changes and can take appropriate precautions.

Activity 2.2 Identifying Hazards at Your Worksite

Scenario 1: In the Deep Snow

Working in pairs or small groups, complete the following tasks:

1. **Read the scenario carefully or scan the QR code to watch the video.**
2. **Using the Hazard Sources or the Energy Wheel, identify hazards, including H_2S.**
3. **Using the Hierarchy of Controls, determine the most suitable control for each of the identified hazards.**

www.energysafetycanada.com/Training/Courses/H2S-Alive-Videos

Scenario

On a cold winter day in mid-January, John, a surveyor, is tasked with conducting a survey at a drilling site.

The survey is being conducted in a 2,500 m^2, 50x50 m area situated 45 kms outside the city. The site is enclosed by a chain-link fence and is located within a forest.

The weather is overcast, with a temperature of -15°C and a wind chill of -25°C. The wind is coming from the northwest at a speed of 15 km/h, causing snow to drift across the site.

The survey includes measuring dimensions and elevations among different points in the site area inside the fence.

John and his assistant, Peter, drive to the site and park their pick-up truck outside the site on the lease road. In the back of the truck, they have surveying equipment, including a prism and their SCBAs. The truck is equipped with a radio connection to the company headquarters.

John and Peter leave the cab of the truck wearing their personal monitors and their handheld radios clipped to their coveralls.

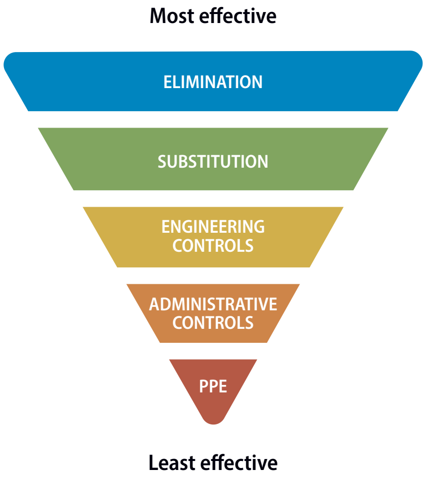
John, the surveyor, sets up the surveying instrument near the site entrance. Peter assists John by moving the prism to different points around the site so that measurements can be taken and recorded.

Scenario 1: In the Deep Snow

Hazard Sources

Energy Wheel

Hierarchy of Controls



Hazard Assessment and Control (Partial Template)

Tasks	**Hazards** (List both health and safety hazards and consider people, equipment, materials and environment, or energy sources if you are using the Energy Wheel)	**Plans to eliminate/control** (List the controls for each hazard: Elimination, Substitution, Engineering, Administrative, PPE)
Drive to and park truck at entrance		
Conduct the survey		
Pick up all tools and materials		

Scenario 2: In the Laboratory

Working in pairs or small groups, complete the following tasks:

1. **Read the scenario carefully or scan the QR code to watch the video.**
2. **Using the Hazard Sources or the Energy Wheel, identify hazards, including H_2S.**
3. **Using the Hierarchy of Controls, determine the most suitable control for each of the identified hazards.**

www.energysafetycanada.com/Training/Courses/H2S-Alive-Videos

Scenario

You were tasked to conduct a hazard assessment in a laboratory situated on the second floor of a two-storey research facility.

The lab has two entrances, both with double doors and air curtains. One is dedicated to shipping and receiving samples and the other is the main lab entrance.

The lab has a robust ventilation system, including an emergency exhaust ventilation system that is triggered when the alarm is activated.

The lab has three benches equipped with scientific equipment, in addition to three fume hoods.

The lab also has a fixed gas-detection system, with detectors positioned at various heights throughout the lab.

In the corner, there is a first-aid station that includes a spill kit, eyewash, a safety shower and a safety data sheet binder.

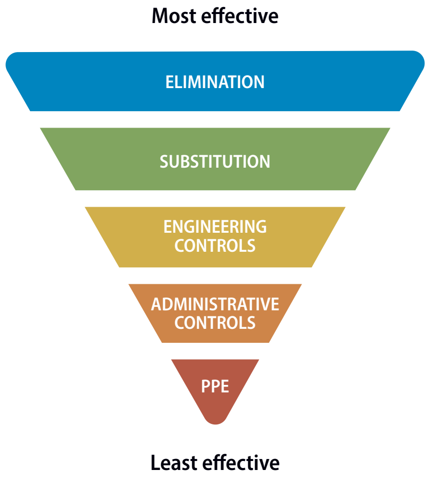
Three technicians work in the lab, where they receive, unpack and test samples, according to the service form.

Scenario 2: In the Laboratory

Hazard Sources

Energy Wheel

Hierarchy of Controls



Hazard Assessment and Control (Partial Template)

Tasks	**Hazards** (List both health and safety hazards and consider people, equipment, materials and environment, or energy sources if you are using the Energy Wheel)	**Plans to eliminate/control** (List the controls for each hazard: Elimination, Substitution, Engineering, Administrative, PPE)
Receive samples and store on the shelves		
Test samples		
Dispose of samples		

Scenario 3: Waste Disposal Facility

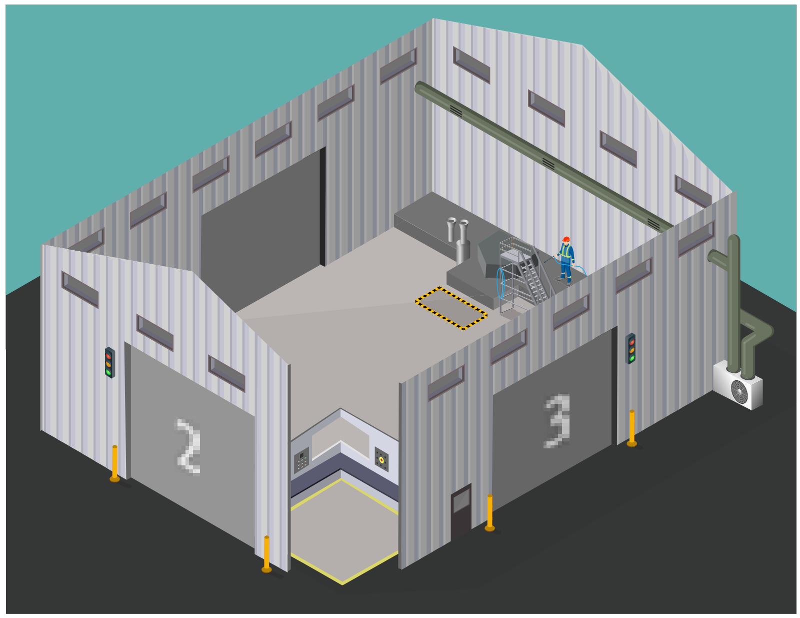
Working in pairs or small groups, complete the following tasks:

1. **Read the scenario carefully or scan the QR code to watch the video.**
2. **Using the Hazard Sources or the Energy Wheel, identify hazards, including H_2S.**
3. **Using the Hierarchy of Controls, determine the most suitable control for each of the identified hazards.**

www.energysafetycanada.com/Training/Courses/H2S-Alive-Videos

Scenario

A food waste collection service has implemented a temporary storage system for food waste on the company's premises, aiming to store the waste until it can be transported more efficiently to the biogas plant.

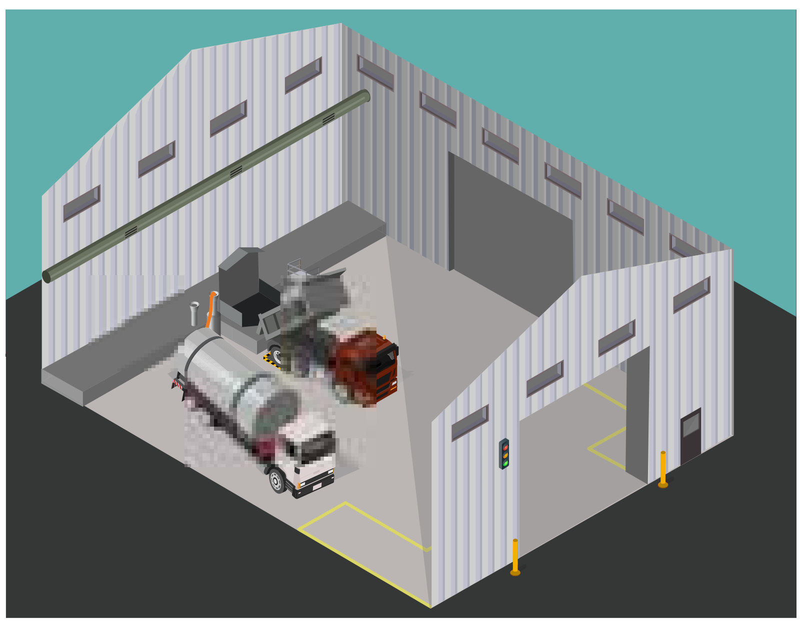


The feedstock pit dedicated for temporary collection is located inside a building with a general exhaust ventilation system.

The building has three overhead doors for trucks to access the facility, each with a man door immediately next to it.

Dump trucks use overhead door number 2 to back up into the building, where food waste is unloaded into the feedstock pit.

The pit has an actuated lid and continuous local exhaust ventilation. Road tankers use overhead door number 1 for entry into the building to unload manure into the feedstock pit, via the chutes. The storage facility can accommodate one dump truck and one road tanker at the same time.



The supervisor, Mike, is responsible for controlling the delivery trucks' access to the storage building. He is also responsible for hosing down the area around the feedstock pit with pressurized water to clean the area after each delivery.

The feedstock door, the overhead doors, access signage, the emergency shutdown and the alarm system are all controlled from the panels in the monitoring station.

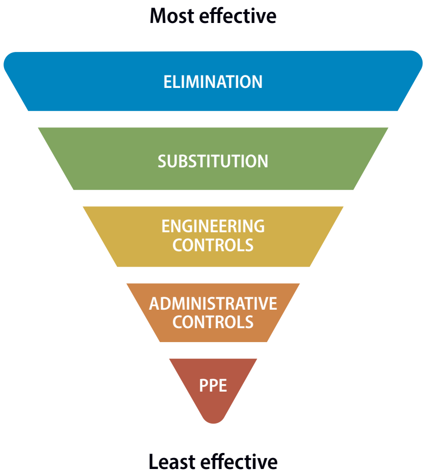
Mike stays in the monitoring station during the unloading and interacts with the drivers using the text screen mounted over the monitoring station or the access lights outside of the building.

Scenario 3: Waste Disposal Facility

Hazard Sources

Energy Wheel

Hierarchy of Controls



Hazard Assessment and Control (Partial Template)

Tasks	**Hazards** (List both health and safety hazards and consider people, equipment, materials and environment, or energy sources if you are using the Energy Wheel)	**Plans to eliminate/control** (List the controls for each hazard: Elimination, Substitution, Engineering, Administrative, PPE)
Accessing the facility		
Unloading		
Leaving the facility		

Exercise

1. What are the four potential sources of hazards?

____

____

____

____

2. When is a hazard assessment required?

____

____

3. Which is the least effective method of hazard control?

   a) PPE
   b) Engineering controls
   c) Administrative controls

4. Who is responsible for hazard assessments?

____

____

Discussion

- Describe an H_2S hazard at your worksite and how that hazard is controlled .
- How are hazard assessments initiated at your worksite?
- What methods of risk analysis have you seen in the workplace?

Notes

Chapter 3:

Respiratory Protective Equipment

Outcome

Inspect and use respiratory protective equipment (RPE) in the proper manner.

Objectives

Upon completion of this chapter, you should be able to:

1. Identify the major components of a Self-Contained Breathing Apparatus (SCBA).
2. Identify the major components of a Supplied-Air Breathing Apparatus (SABA).
3. Demonstrate use of SCBA including pre-use inspection, donning, doffing and post-use inspection.
4. Describe use of SABA including pre-use inspection, donning, doffing and post-use inspection.

Introduction

H_2S may be present just about everywhere you work in many industries. There may be situations when you have to work where H_2S is present. To do this without placing yourself at risk, you must plan your job and have a source of quality breathing air. The accepted industry practice is to wear respiratory protective equipment (RPE) any time a risk of exposure exists. Failure to wear RPE is a leading cause of injuries and death from H_2S exposure.

All government jurisdictions have legislation about the use of RPE. Standards such as those developed by the Canadian Standards Association (CSA) also guide the use of RPE. Make sure you know what regulations and standards apply in your areas. Good work practices should aim for zero exposure to H_2S.

Approved Respiratory Protective Equipment (RPE)

The only approved type of RPE for protection from H_2S in the energy industry is the type that maintains positive air pressure in the facepiece. This type of RPE provides the user with a supply of safe, breathable air.

The primary difference between the two kinds of approved RPE used for H_2S protection is how the air is supplied. While a SCBA has its own air cylinder, a SABA is linked to a remote air supply by manifold and air line assembly.

Self-Contained Breathing Apparatus (SCBA)

Major Components

Before you can use a SCBA safely, you must be able to identify its major components. Many makes and models of SCBA are used in the energy industry. However, all of them have the same four basic components :

1. **Air supply**
2. **Regulator assembly**
3. **Facepiece assembly**
4. **Harness assembly**

Figure 3.1 SCBA

Air Supply

The air supply is made up of three components:

1. Air cylinder
2. Cylinder valve
3. Cylinder pressure gauge

Figure 3.2 Air Supply

At a minimum, the air cylinder must be rated for 30 minutes of breathable air. Some cylinders are rated for 45 or 60 minutes. The quality of breathing air in the cylinder must meet the current standards stipulated in the Compressed Breathing Air and Systems document issued by the CSA.

The cylinder valve must be fully opened to allow a full and continuous flow of air from the cylinder. When not in use, the valve must be fully closed to prevent the loss of air from the cylinder.

The cylinder pressure gauge indicates how much air there is in the cylinder.

How quickly your air supply is used depends upon:

- Your training, experience and comfort
- The condition of the equipment
- The amount of air in the cylinder
- Your emotional and mental state
- The physical effort needed to do your job
- Your size and physical condition

Regulator Assembly

The regulator assembly controls the flow of air and consists of:

1. High-pressure system
2. Facepiece regulators
3. Bypass/purge valve
4. Regulator pressure gauge
5. Low-air alarm

Air from the cylinder flows through the high-pressure system to the regulator. When you are wearing the apparatus, the regulator pressure gauge tells you how much air is left in the cylinder.

The pressure regulator reduces the cylinder air pressure and provides positive air pressure in your facepiece.

The bypass/purge valve enables you to purge the facepiece or bypass the air if the regulator fails.

The regulator pressure gauge indicates the amount of pressure currently in the air cylinder.

When the air supply is getting low, a warning alarm will be activated. The alarm may be a sound that you hear or a vibration that you can feel. This warning could save your life! It tells you there is 20% to 25% of your air supply left in the cylinder, giving you enough time to get to a safe area.

Always be aware that in a noisy work environment it may be difficult to hear an audible alarm. If you hear or feel the alarm go off, move to a safe area immediately.

The slight positive pressure maintained by the regulator helps to prevent H_2S from entering your facepiece.

Figure 3.3 Regulator Assembly

Facepiece Assembly

The facepiece assembly is made up of:

1. Head harness
2. Lens
3. Nose cup
4. Speech diaphragm
5. Exhalation valve

Figure 3.4 Facepiece Assembly

The most important aspect of the facepiece is the seal it forms around your face. The seal between the facepiece and your face must be complete to keep your air supply in and H_2S out. You must be clean-shaven where the facepiece and your face meet to ensure a proper seal. Regular eyeglasses with temple pieces prevent a proper seal. Special eyeglass kits are available that fasten inside the facepiece, allowing for a proper seal.

The low-pressure hose delivers air from the regulator to the facepiece. Some regulators connect directly to the facepiece.

The nose cup channels exhaled air to the exhalation valve, reduces the volume of stale air and prevents the facepiece from fogging up during use .

The exhalation valve vents your breath from the facepiece to the atmosphere and prevents toxic gases from entering the facepiece.

The head harness is adjustable to ensure a proper seal between your face and the facepiece.

It is your employer's responsibility to maintain a program to ensure the proper selection, maintenance and use of RPE. Part of this program includes monitoring breathing air quality, inspecting and maintaining air cylinders, and fit testing to ensure the facepiece provides a proper seal. CSA requires a quantitative fit test when using SCBA or SABA. Refer to the current CSA document CAN/CSA-Z94.4 for the Selection, Use and Care of Respirators.

Harness Assembly

The harness assembly consists of a backpack-style adjustable harness. The harness holds the air cylinder in place, which allows you to carry the cylinder and go about your work with minimum effort.

Figure 3.5 Harness Assembly

Using a Self-Contained Breathing Apparatus

Using a SCBA consists of four main tasks:

1. Pre-use inspection
2. Donning
3. Doffing
4. Post-use inspection

One of the most important things to remember when using a SCBA is to breathe normally. A normal breathing pattern uses your air supply at a slower rate than if you breathe quickly.

All RPE must be used, maintained, inspected and stored according to company-specific procedures and manufacturer's specifications.

Pre-Use Inspection of a Self-Contained Breathing Apparatus

To operate a SCBA safely, you must be able to tell if it is in good repair and working properly. This is done by conducting a pre-use inspection. Because your life may depend upon the operation of your RPE, it is important for you to master these simple checks.

You are not expected to do technical repairs or maintenance on these units by yourself.

At the beginning of every work shift, workers must ensure that all SCBA units intended for emergency use undergo a complete pre-use inspection.

Regular checks ensure that your equipment will work for you when you need it. Check all components before use. Never use a damaged RPE. Report all defective equipment to your supervisor. Only a qualified technician should service and repair equipment that is not working properly.

Table 3.1: Pre-Use Inspection Checklist for a Self-Contained Breathing Apparatus

These are generic guidelines. You should always check and follow manufacturer's instructions and company-specific procedures.

General

☐ Are all required components available? These include the air cylinder, regulator assembly, facepiece assembly and harness assembly.

Facepiece Assembly

☐ Is the facepiece clean and dust-free?

☐ Is the lens clear and free of scratches?

☐ Is the nose cup installed correctly?

☐ Is the exhalation valve intact, clean and functioning properly?

☐ Is the head harness intact and are the straps fully extended?

Harness Assembly

☐ Are all harness straps clean, in good repair and fully extended?

☐ Is the framework in good condition?

Air Supply and Regulator Assembly

☐ Is the air cylinder at full pressure?

☐ Are there any gouges or dents on the air cylinder?

☐ Is the composite wrapping damaged?

☐ Is the high-pressure hose intact?

☐ Is the low-pressure hose intact?

☐ Is the hose connector tight?

☐ Close the bypass/purge valve and engage the standby button. Fully open the cylinder valve. Does the regulator pressure gauge indicate the same pressure as the cylinder gauge?

☐ Does the bypass/purge valve work? When you turn the bypass/purge valve, air should flow freely into the facepiece.

☐ Does the low-air alarm work properly? Close the cylinder valve and slowly open the bypass/purge valve. The low-air alarm should sound at 20% to 25%. Slowly bleed pressure from the system and close the regulator control valves unless the manufacturer recommends otherwise.

If the answer to any of the above questions is No, the SCBA must be removed from service and sent for repairs. Never use a SCBA that fails the pre-use inspection.

Finishing Step

☐ Return the SCBA to the storage case. Now the SCBA is ready for immediate use.

Activity 3.1

Pre-Use Inspection of Self-Contained Breathing Apparatus

Working in groups, conduct a pre-use inspection using the checklist from the previous page. Give one another feedback. Ask the instructor for help if you have any questions or concerns.

Donning and Doffing a Self-Contained Breathing Apparatus

Up to this point, you have learned about the major components of SCBA, how they work and the pre-use inspection procedures.

You must also be familiar with the operating instructions for the specific type of apparatus you are going to use at your worksite. Remember to always follow the manufacturer's instructions and/or company-specific procedures for donning and doffing a SCBA. Table 3.2 outlines the generic instructions for donning a SCBA. Doffing consists of the same steps, but in reverse order.

To become competent in SCBA use, you must practice using a SCBA at your worksite. You must also be familiar with the operating instructions for the specific type of apparatus you are going to use. Remember to always follow the manufacturer's instructions and/or company-specific procedures for donning and doffing a SCBA. In the event of an emergency, you should don a SCBA as quickly as possible so that you can avoid inhaling any released product.

Figure 3.6 SCBA

Table 3.2: Generic Instructions for Donning a Self-Contained Breathing Apparatus

Don the cylinder

- Put on harness assembly.
- Adjust and tighten harness straps.

Don the facepiece

- Place chin in chin cup first.
- Pull head harness over back of head.
- Start with chin straps. Then temple straps.
- If there is a top-of-head strap, tighten it last.
- Be sure to tighten each strap by pulling towards back of head. Do not pull straps out to side.
- Ensure no hair is caught in seal.

Perform a negative pressure test

- Block facepiece opening with your hand or facepiece regulator. Be careful not to create a false seal by pushing the mask against your face.
- Breathe in to check face seal. If facepiece does not seal, make sure it is centred on your face, straps are not twisted and face seal is not rolled over. Then re-check. If facepiece still does not seal, do not use the SCBA.
- Exhale to check exhalation valve.

Connect the air

- Connect regulator if not already connected.
- Fully open cylinder valve.
- Check regulator pressure gauge.
- Take a deep breath.

Activity 3.2

Donning And Doffing A Self-Contained Breathing Apparatus

Your instructor will divide you into small groups or pairs. Using the instructions on the previous page, take turns putting on and taking off a SCBA. Give each other feedback. Ask the instructor for help if you have any questions or concerns.

Post-Use Inspection of a SCBA

When you are finished using a SCBA, it is very important that you conduct a post-use inspection to ensure the next person to use the apparatus will find it in good repair.

To conduct a post-use inspection:

1. Replace the air cylinder with a fully charged one.
2. Clean the facepiece according to the manufacturer’s instructions.
3. Inspect the harness.
4. Perform a pre-use inspection and log the results.
5. Store the apparatus in an appropriate place.

Supplied-Air Breathing Apparatus (SABA)

Major Components

SABA systems have a remote source of breathing air that can supply air to several workers. If you must use a SABA, it is important to be able to identify the major components of the system that are different from SCBA components, including the:

- Air supply
- Escape cylinder

Escape Cylinder

Your supplied air unit must always be equipped with an escape cylinder. A sling-type harness holds the escape cylinder in place. The cylinder must supply you with enough breathing air to exit the hazardous atmosphere if your air supply is interrupted. To provide for a safe exit, the escape cylinder must be rated for at least 5 minutes of air. Escape cylinders are also available in 10-minute and 15-minute sizes.

Figure 3.7 SABA Major Components

Figure 3.8 SABA Facepiece Assembly and Escape Cylinder

Air Supply

The quality of breathing air in your cylinder must meet the standards established by the CSA.

Air may be supplied from a compressor, cylinders "pig-tailed" together, an air trailer or a plant breathing air system. The air travels through a regulator to a manifold which supplies several hoses. Each hose has a mask assembly with an escape cylinder attached to it.

Always make sure your escape cylinder is full and that there are no kinks, knots or damage to the air hose. This will ensure you get the air you require from the system. Use the cylinder for escape purposes only. Always ensure a proper seal between the facepiece and your face. Also, be aware that some SABA systems do not have a low-air alarm.

Using a Supplied-Air Breathing Apparatus

Using a SABA consists of four main tasks:

1. Pre-use inspection
2. Donning
3. Doffing
4. Post-use inspection

Pre-Use Inspection of a Supplied-Air Breathing Apparatus

A pre-use inspection enables you to determine whether the SABA is in good repair and working properly. Remember, your life may depend upon the operation of the SABA. At the start of every shift, complete a pre-use inspection on all SABA that may be used in an emergency.

If you find defective equipment, report it to your supervisor. Only qualified technicians should service and repair equipment that is not working properly.

Table 3.3: Pre-Use Inspection Checklist for a Supplied-Air Breathing Apparatus

General ☐ Are all required components available? These include air supply, escape cylinder, regulator assembly, facepiece assembly and harness assembly.
Facepiece Assembly ☐ Is the facepiece clean and dust-free? ☐ Is the lens clear and free of scratches? ☐ Is the nose cup installed correctly? ☐ Is the exhalation valve intact, clean and functioning properly? ☐ Is the head harness intact and are the straps fully extended?
Harness Assembly ☐ Are all harness straps clean, in good repair and fully extended?
Air Supply ☐ Is the escape cylinder at full pressure? Does a tag indicate the date of the last refill? ☐ Is the low-pressure hose intact? ☐ Are the air supply line and manifold intact? ☐ Does the purge valve work? ***If the answer to any of the above questions is No, the SABA must be removed from service and sent for repairs. Never use a SABA that fails the pre-use inspection.***

Donning and Doffing a Supplied-Air Breathing Apparatus

Table 3.4 outlines the generic instructions for using a SABA. It only introduces you to the basic process. To become competent in SABA use, you must practice using the equipment at your worksite. In the event of an emergency, you should don the SABA as quickly as possible so that you can avoid inhaling any of the released gas.

The procedure for doffing a SABA is the same as for donning it, only in reverse.

Post-Use Inspection of a Supplied-Air Breathing Apparatus

When you are finished using a SABA, it is very important that you conduct a post-use inspection. This is to ensure the next person to use the apparatus will find it in good repair.

To conduct a post-use inspection of a SABA:

1. Replace or refill the escape cylinder if it has been used.
2. Clean the facepiece.
3. Inspect the harness.
4. Perform a pre-use inspection on the apparatus and log the results.
5. Store the apparatus in an appropriate place.

Table 3.4: Generic Instructions for Donning a Supplied-Air Breathing Apparatus

Don the cylinder

- Put on harness assembly.
- Adjust and tighten harness straps.

Don the facepiece

- Place chin in chin cup first.
- Pull head harness over back of head.
- Start with chin straps. Then temple straps.
- If there is a top-of-head strap, tighten it last.
- Be sure to tighten each strap by pulling towards back of head. Do not pull straps out to side.
- Ensure no hair is caught in seal.

Perform a negative pressure test

- Block facepiece opening with your hand or facepiece regulator. Be careful not to create a false seal by pushing mask against your face.
- Breathe in to check face seal. If facepiece does not seal, make sure it is centred on your face, straps are not twisted and face seal is not rolled over. Then re-check. If facepiece still does not seal, do not use SABA.
- Exhale to check exhalation valve.

Connect the air

- Ensure air supply is open (for example: air trailer valves).
- Connect remote supply hose.
- Take a deep breath.

Advantages and Disadvantages of Different Types of Breathing Apparatuses

Each type of RPE has its strengths and weaknesses, depending on the situation it's used for.

Type	Advantages	Disadvantages
SCBA Figure 3.9	» Unrestricted mobility. » Portable. » Excellent for safety watch and rescue operations. » Low-air alarm.	» Limited air supply. » Bulky and heavy.
SABA Figure 3.10	» Continuous air supply. » Lighter and less bulky.	» Limited mobility due to air line length. » Air line can tangle. » Must exit the area the same way you entered to avoid air line tangle. » No low-air alarm on some systems.

Figure 3.9

Figure 3.10

Exercise

1. What are the two kinds of approved RPE used to protect workers from H_2S exposure?

___

2. What are the major components of a SCBA?

___

3. Which SABA components differ from those of a SCBA?

___

4. When must workers complete a pre-use inspection of all RPE that may be used in an emergency?

___

5. List the advantages and disadvantages of SCBAs and SABAs in the table below.

Type	Advantages	Disadvantages
SCBA		
SABA		

6. How is positive pressure maintained in a facepiece?

___

7. What is the required minimum rating of breathable air for a SCBA air cylinder?

___

8. Why is it important to breathe normally when using RPE?

___

9. How can you ensure a proper seal of a facepiece?

___

Discussion

- Where is the RPE located at your worksite?
- How can you build and maintain your competency using SCBA and/or SABA at your worksite?

Notes

Chapter 4:

Detection of H_2S

Outcome

Properly use gas detectors and monitors at your worksite.

Objectives

Upon completion of this chapter, you should be able to:

1. Describe the common types, functions and limitations of electronic monitors and detector tube devices.
2. Describe the pre-use inspection and operation of electronic monitors.
3. Describe the pre-use inspection and operation of detector tube devices.

Introduction

To protect yourself and everyone else at your worksite, you need to be able to identify both the acts and the conditions that put people at risk. While hazard assessments enable you to identify hazardous acts, H_2S detection devices enable you to identify hazardous conditions.

Electronic monitors and detector tube devices are specifically designed to detect the presence and concentration of H_2S. Learning how to use these devices properly will reduce the risk of being exposed to hazardous levels of H_2S. It may even save your life!

Your employer is responsible for providing on-going training on the proper use and limitations of electronic monitors and detector tube devices. However, it is also your responsibility to learn how to use the specific equipment available at your worksite and to maintain your competency.

Gas Detection Devices

There are two main types of H_2S detection devices:

- Electronic monitors
- Detector tube devices

These devices can be used in a variety of applications such as:

- Hazardous waste sites
- Clean-up of spills
- Protecting workers from toxic vapours
- Well sites
- Refineries
- Leak detection for compliance
- Pulp and paper plants
- Hazardous materials response

Electronic Monitors

Electronic monitors use sophisticated electronics to measure the concentration of H_2S and other hazardous gases. They provide very accurate readings, if functioning properly. The purpose of these devices is to protect your safety by warning of the presence of a hazardous gas and some can also be used for atmospheric testing based on the sampling method and technology being used. Be sure to check the log book of the monitor you are going to use for any repairs completed, last calibration date and next calibration due date.

Be careful as some electronic monitors cannot measure H_2S concentrations above 200 ppm. If the H_2S concentration exceeds what can be measured, the electronic monitor will give a reading of “OL” for over limit. If there is any chance that you could encounter levels beyond the capability of your monitor, use a detector tube device. Accuracy and monitor run time can also be affected by extreme temperatures. To determine more accurate readings, check the owner’s manual or manufacturer’s specifications for the unit.

Major Components

The basic components of electronic monitors are:

- Power source
- Sensor(s)
- Visual display (for example: a flashing light and/or LED read-out)
- Audible and vibrating alarm

Principle of Operation

Electronic monitors contain a sensor that detects H_2S. When the sensor detects H_2S gas, a low or high alarm will sound. A low alarm will typically sound at 10 ppm. A high alarm will sound at the ceiling — the concentration that should never be exceeded during the workday. The specific concentration for the alarm settings depends on the jurisdiction you are working in.

When your monitor alarm sounds, you must evacuate the area.

Bump testing is the best way to make sure your gas detector actually works before you use it.

A bump test is a simple test carried out to make sure the gas detector will respond to gas exposure and will sound its alarm. During the test, the installed sensors are briefly exposed to an expected concentration of calibration gas that is greater than the low alarm set point.

A bump test does not tell you anything about the accuracy of the gas detector’s performance, but it does give you confidence that it is working and is therefore suitable for use. Best practice for a bump test is daily, prior to use.

Check the owner's manual for specific manufacturer's requirements.

Types of Electronic Monitors

Electronic monitors function in a variety of ways:

- Portable personal monitors are worn by the worker.
- Portable placed monitors are set up between the worker and the atmosphere being detected.
- Fixed monitors are installed at the worksite.

Table 4.1 summarizes the functions and limitations of portable electronic monitors.

Table 4.1: Types of Portable Electronic Monitors

Type	Functions	Limitations
Portable Personal Figure 4.1	» Worn by worker in a breathing zone* » Commonly have more than one sensor to detect multiple gases » Issues a personal warning » Used for particular atmospheric testing	» Some monitors can only measure H_2S concentrations below 200 ppm » May only detect a specific gas » Worker may be exposed to H_2S while attempting to detect it
Portable Placed Figure 4.2	» Placed between the worker and the atmosphere being detected » Usually tests for multiple gases » Issues a warning to people in the general area	» Some monitors can only measure H_2S concentrations below 200 ppm » Must be placed correctly

*Breathing Zone Definition: Conventionally, the "breathing zone" is defined as the zone within a 0.3 m (or 10 in.) radius of a worker's nose and mouth. That would indicate that an instrument used primarily for personal protection from toxic hazards such as H_2S should be worn on the collar, lapel, breast pocket or somewhere within a 10-inch radius of your nose and mouth.

Figure 4.1 Portable Personal Electronic Monitors

Figure 4.2 Portable Placed Electronic Monitor

Operation of Portable Electronic Monitors

Your portable electronic monitor can save your life, but only if it is in proper working condition. To ensure that your monitor is safe for use, you must perform a pre-use inspection at the start of every work shift.

In addition, you should perform a pre-use inspection whenever the unit has been:

- Dropped
- Exposed to a high or over-the-range concentration of a gas for that type of equipment
- Submerged in water
- Exposed to mechanical shock

A pre-use inspection is critical to confirm proper operation. Always consult the manufacturer's instructions to verify you are following the correct pre-use inspection routine. In most cases, as part of a pre-use inspection, gas monitors are function tested to confirm:

- The unit powers on
- Alarms function properly
- The unit displays gas concentrations correctly

This is typically done through a simple bump test that involves exposing the monitor to a small amount of gas from a test cylinder. If the unit does not respond correctly in a pre-use inspection, it should be removed from service and repaired by a qualified technician.

Some portable electronic detectors are equipped with a docking station that performs these tests automatically. However, even if that is the case at your worksite, it is important that you understand the procedures for performing these tests.

Gas Detector Bump Test

There are two methods for performing a bump test; one uses a docking station, the other is done manually. The following are general guides only. You should always follow the specific manufacturer's instructions.

Manual Bump Test Procedure (Generic)

1. Connect tubing to both the cylinder and adaptor.
2. Turn on the monitor and allow it to stabilize in a "clean air" environment.
3. Attach the adaptor to the monitor and apply gas.
4. Verify that the monitor responds to the target gas and activates the visual, audible and vibrating alarms. If so, the monitor is ready for use.
5. Remove the adaptor.

Bump Test Procedure Using a Docking Station (Generic)

1. Turn on the gas monitor.
2. Allow the instrument to stabilize.
3. Turn on the calibration dock and install the gas monitor in the appropriate location following the manufacturer's instructions (the docking station should acknowledge the gas monitor and display its serial number once in place).
4. With the monitor installed on the docking station, press the bump button. When the test is complete, the result will be acknowledged on the bump station display.
5. Once the gas monitor has passed the bump test, it can be returned into service.

Figure 4.3 Bump Test Docking Station

Gas Detector Calibration

The gas detector calibration process involves testing the gas detector's sensors against a known calibration standard (for example the contents of your bottle of calibration gas) and adjusting the gas detector to correct for any inaccuracies.

A gas detector calibration is therefore a much more thorough process than a simple bump test. A successfully calibrated gas detector gives you confidence in the accuracy with which it will detect its target gases.

Calibration frequencies differ between gas detectors and the manufacturer's recommendations should be carefully followed.

Calibration gas can sometimes be used as a bump gas, but bump gases cannot be used as calibration gases.

Fixed Electronic Monitors

Fixed electronic monitors are permanently installed. They are commonly used in gas plants and oil batteries. This is the most sophisticated type of electronic monitor.

The fixed electronic monitor system consists of:

- Central control unit
- Remote display(s)
- Remote sensor(s)
- Alarm(s)

The central control unit is usually installed in the control room or a central building. Sensors are positioned throughout the job site or plant area. In some cases, a number of systems are linked together to form a network. Remote sensors send signals by wire or radio waves to the central unit.

Like the other types of electronic monitors, fixed monitors work on a continuous basis and will alarm at a pre-set level of H_2S. This level is usually 10 ppm.

Fixed electronic monitors, however, do have some limitations. For example:

- Some monitors can only measure H_2S concentrations below 500 ppm.
- The area covered depends on the number and location of sensors.
- They require an independent reliable power source.
- They can be costly.

Operation of Fixed Electronic Monitors

Figure 4.4 Typical Fixed Electronic Monitor System

As part of installing the system, trained technicians calibrate and test fixed electronic monitors as required by the manufacturer's specifications.

Detector Tube Devices

Detector tube devices are portable, measure the presence of gas and identify approximate concentrations. They test an atmosphere at a specific point in time, but do not give a continuous reading.

Some electronic monitors cannot measure the concentration of H_2S at levels above 200 ppm. You must use a detector tube device if there is any chance that you could encounter levels beyond the capability of your electronic monitor.

Therefore, even if you typically rely on an electronic monitor for your daily tasks, you must be fully competent in using the detector tube devices provided at your worksite.

Principle of Operation

Detector tube devices work by drawing a sample through a tube filled with a chemical that reacts to the presence of H_2S by changing colour.

Lead acetate is the chemical used to detect H_2S. A pump creates a vacuum, which draws air through the tube.

The average length of stain gives you a reading of the concentration of H_2S gas. If the stain is at an angle, the reading must be averaged. There are a variety of detector tube units including the "piston-type" and "bellows-type" units.

Piston-Type Unit

The piston-type unit is a pump operated by the action of a piston to create a vacuum (see Figure 4.5).

The unit consists of:

- Cylinder
- Piston with handle
- Inlet
- Vacuum indicator
- Tip breaker
- Valves and seals

Figure 4.5 Piston-Type Detector Tube Pump

Bellows-Type Unit

In this unit, a bellows pump is used to create the vacuum necessary to take a sample.

Figure 4.6 shows typical bellows-type units.

A bellows-type unit consists of:

- Spring-loaded bellows (with hand grip)
- Inlet
- Vacuum indicator
- Stroke counter
- Valve and seals

Figure 4.6 Bellows-Type Detector Tube Pumps

Detector Tubes

Various types of tubes are used to detect a variety of gases as well as their concentration levels. The ones we are concerned with detect H_2S. The concentration readings on the tube can be in either ppm or percent. Make sure you carefully follow the instructions for the number of pump strokes and wait the required amount of time between strokes.

Remember, 1% is equal to 10,000 ppm.

Tubes from different manufacturers are not interchangeable! Always ensure you have the correct tube for your detector unit and the gas to be tested.

Accuracy

The accuracy of detector tubes can vary up to ±25% of the true gas concentration, depending upon the make and type of the tube. Elements that further affect the accuracy of a detector tube reading include:

- Condition of the pump (air tightness)
- Age of the tube (check expiry date on box)
- Temperature
- Operating procedures
- Storage conditions
- Interferences from other airborne contaminants

Always store detector tubes in a cool dark place, and always follow the manufacturer's instructions.

Figure 4.7 Detector

Remember, before testing an unknown atmosphere for H_2S, you must first protect yourself by wearing a SCBA or SABA.

Operation of Detector Tube Devices

Your detector tube devices can save your life, but only if they are used correctly and are in proper working condition. For each device, you should know how to:

- Perform a pre-use inspection (see Table 4.2)
- Operate the detector unit (see Table 4.3)
- Take a tube reading (see Table 4.3)

When you return to your worksite, make sure that you check the specific instructions for the types of detector tube devices being used and practise using them. Always follow the manufacturer's instructions for the operation of any detector tube device. Your safety depends on your ability to accurately detect H_2S.

For the most part, detector tubes are best used when a quick test will suffice. Examples are:

- Testing around piping components where a leak is suspected and it is known what compound would be leaking.
- Cursory evaluation of hazardous material spill situations, especially when more appropriate instruments are not available.
- Cursory evaluation of nuisance odour complaints, especially if there is a suspect compound.

Table 4.2: Generic Pre-Use Inspection of Detector Tube Devices

Steps	Bellows-Type Units	Piston-Type Units
1. Check the condition of the unit	» Check the condition of the bellows, top and bottom caps, chain (if so equipped) and pump head stopper.	» Check the tightness of the nut on the inlet opening. » Pump body for damage.
2. Plug the inlet opening	» Squeeze the bellows fully. » Insert an unbroken tube into the inlet.	» Insert an unbroken tube into the inlet.
3. Conduct a leak test	» Release the bellows. » Wait for the time period set out in the manufacturer's specifications.	» Line up the indicators on the pump shaft and body for a 100 ml sample. » Pull the shaft out to the lock position. » Wait for the time period set out in the pump specifications.
4. Decide whether to use or repair the detector tube device	» If the bellows are not fully expanded, the unit may be used. » If the bellows are fully expanded, have the unit serviced before using it.	» Refer to the manufacturer's instructions for the criteria to determine if the pump is fit for use.

Table 4.3 Generic Operating Instructions for Detector Tube Devices

Steps	Bellows-Type Units	Piston-Type Units
1. Select the correct tube	» Ensure that you have the correct tube. Check the expiry date, scale units and range. » Read the tube instructions for the number and length of pump strokes and the waiting time after (or between) strokes.	
2. Prepare the detector pump.	» Check the pump condition. » Ensure that the pump bellows are fully extended. » On pumps with a chain, check that the chain is taut (not slack).	» Check the pump condition. » Ensure that the pump handle is fully retracted. » Line up the alignment indicators on the pump body and handle.
3. Put on a RPE	» Put on a RPE before preparing the tube. » There should be minimal time lapse between preparing the tube and testing the atmosphere.	
4. Prepare the detector tube	» At the location to be tested, break both ends of the tube using the tube breaker on the pump body or the manufacturer's tube opener. » Insert the tube into the pump inlet with the arrow pointing toward the pump.	
5. Test the atmosphere	» Put the open end of the tube into the atmosphere to be tested.	
	» Squeeze the handle to compress the bellows fully. Then, release the bellows.	» Pull the handle out until it locks at the correct stroke volume indicator (usually at 100 ml stop).
6. Wait the required time	» Consult the instrument operation manual and allow appropriate time for the instrument to respond completely before recording the reading. » Some pumps have a stroke completion indicator. » If additional strokes are required, repeat steps 5 and 6.	
7. Read the gas concentration	» Read the tube scale at the end of the discoloration. » If the discoloration is uneven, take a reading at the average or middle point of the uneven portion of discoloration.	

Activity 4.1

Electronic Monitors Versus Detector Tube Devices

1. List as many disadvantages as you can for electronic monitors.
2. List as many advantages as you can for detector tube devices.

Type	Advantages	Disadvantages
Electronic Monitors	» Provides continuous monitoring » May test for more than one hazardous gas » Fixed monitors have automatic response capabilities » A variety of sensors are available » Backlit for night-time operations » Docking stations make bump tests and span calibrations easy	» Some portable monitors can only measure concentrations below 200 ppm » Worker may be exposed to a hazardous atmosphere (unless remote sampling is used) » Requires a bump test to ensure monitor is functional » Accuracy and run time can be affected by extreme temperatures » ____________________ ____________________ » ____________________ ____________________ » ____________________ ____________________ » ____________________ ____________________ » Limited sensor life
Detector Tube Devices	» Can measure concentrations above 200 ppm » ____________________ ____________________ » ____________________ ____________________ » ____________________ ____________________ » ____________________ ____________________ » Some devices can be operated with one free hand » Easily stored » Inexpensive to purchase and repair	» Worker may be exposed to a hazardous atmosphere » Only provides intermittent detection » Readings may be affected by cross-contaminants » Requires a leak test as part of pre-use inspection (time consuming) » Requires proper disposal of used tubes » Readings requires interpretation on the scale

Do not use personal electronic monitors for sampling unless the manufacturer specifies that it is properly equipped or designed for sampling!

Exercise

1. What are the two main types of H_2S detection devices?

____

2. Portable ______________________ electronic monitors are worn by workers.

3. Portable ________________ electronic monitors are set up between the worker and the atmosphere being detected.

4. ______________________ electronic monitors are installed at the worksite.

5. Which detection device should you use if you encounter gas levels beyond the capability of your monitor?

____

6. Which H_2S detection device provides continuous readings?

____

7. Which H_2S detection device only tests an atmosphere at a specific point in time?

____

Discussion

- What types of H_2S detection devices are used at your worksite?
- What should you do if your monitor goes into alarm?
- How can you build and maintain your competency using electronic monitors and detector tube devices at your worksite?

Notes

Chapter 5:

Initial Response Strategy

Outcome

Apply the initial response strategy to an incident involving an H_2S release.

Objectives

Upon completion of this chapter, you should be able to:

1. List and explain each step of the initial response strategy used in an H_2S incident.
2. Demonstrate rescue techniques.

Introduction

This chapter brings together all the knowledge and skills you have developed in the previous chapters. It gives you an opportunity to start applying what you have learned to emergency scenarios. But the information provided in this manual is only the beginning.

To ensure your safety and the safety of others, you must be prepared to enact the specific Emergency Response Plan for your worksite. Do not wait until an emergency to learn the procedures detailed in this plan.

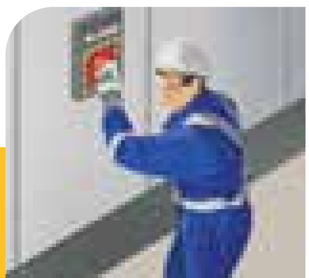
Seven-Step Initial Response Strategy

When responding to an H_2S release, you must also follow the Emergency Response Plan for your worksite. Learn the details of the plan before an emergency occurs.

1 Evacuate

Get to a safe area immediately. Move upwind if the release is downwind of you. Move crosswind if the release is upwind of you. Move to higher ground if possible.

2 Alarm

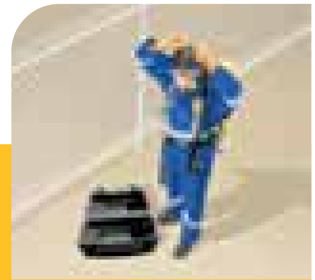


Call for help. Activate the alarm system by sounding a bell, horn or whistle. If necessary, call by radio.

3 Assess

Take a head count. Locate any casualties. Consider all of the hazards.

4 Protect



Put on a breathing apparatus before attempting rescues.

5 Rescue

Remove any casualties to a safe area.

6 First Aid

Follow the standard first aid protocol at the worksite.

7 Medical Aid

Arrange transport of casualties to medical care. Provide information to Emergency Medical Services (EMS).

Offshore Oil and Gas Facilities

In addition to the equipment already described in this program, the offshore oil and gas industry has some unique challenges to address especially around evacuation and abandonment. Most offshore facilities that are working in known sour gas fields will be equipped with a positively pressurized accommodation block where personnel will muster in the event of an H_2S emergency. Personnel need to be protected while making their way from outside work areas to the muster station or, in the case of a major emergency, to the lifeboat abandonment station.

Emergency Escape Breathing Apparatus

In an offshore work environment, you may be issued an Emergency Escape Breathing Apparatus (EEBA) as part of your personal safety equipment. These come in many different configurations and air supply durations.

- Some have masks requiring users to be fit tested.
- Some are one-size-fits-all hoods.
- All are designed for quick donning and escape only.

In the event of an H_2S or other toxic gas leak, it is deployed to provide the user with enough fresh air to escape to their designated safe muster area or to the lifeboats for abandonment to sea.

EEBAs are available with either air-supplying or air-filtering technologies. However, safety standards prohibit the use of air-filtering EEBAs in an IDLH environment. Therefore, if dispersion modelling or other calculations suggest that H_2S levels may exceed 100 ppm, EEBAs must rely solely on air-supplying technology.

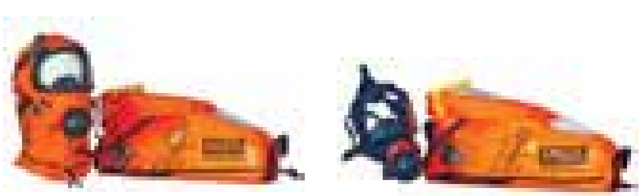


Figure 5.1 Emergency Escape Breathing Apparatus

Lifeboats and Supplied-Air Systems

Lifeboats and their associated muster areas are commonly equipped with supplied-air systems. These air systems provide personnel with supplemental air while waiting their turn to board the lifeboats. Additionally, the lifeboat itself has an independent positive pressure air system that will prevent toxic gases and smoke from entering the capsule during and after launching to the sea.

Abandonment

In a worst-case scenario, offshore personnel may be directed to abandon the facility by the Offshore Installation Manager (OIM). Unlike land-based evacuations, those done at sea present unique challenges and dangers.

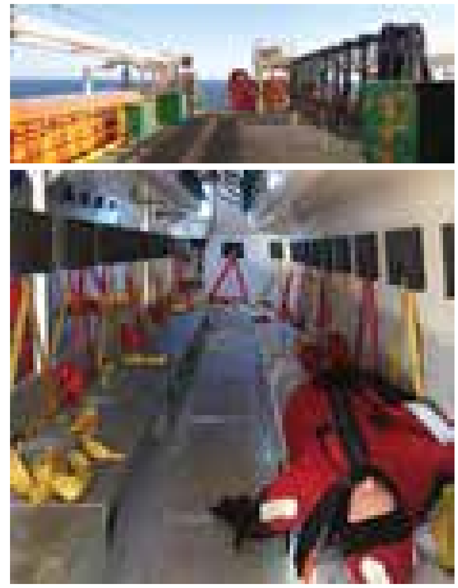
NOTE: The primary difference between an abandonment and an evacuation is that personnel who abandon the facility still need to be rescued.

Activity 5.1

Responding to an Offshore H_2S Emergency

As a group, discuss how the following unique considerations could affect your response to an offshore H_2S emergency and how they would be/are handled at your facility.

- Extreme weather and sea conditions are present.
- Personnel may have to don specialized survival equipment in addition to escape RPE.
- The time it takes to board all the crew into a lifeboat may exceed the duration of the emergency escape RPE.
- Some personnel may need to abandon into lifeboats or directly into the sea.



Onshore IRS* Step	Offshore ERP* Equivalent	Comments for Offshore ERP Steps
Evacuate	**Muster**	Personnel are trained to go to their designated primary muster station which is usually inside the accommodation block. A secondary muster station is used if the primary muster is compromised by gas or smoke conditions.
Alarm	**Alarm**	Alarms will be followed by a PA announcement. Listen for specific instructions that may impact your response to the emergency.
Assess	**Assess**	Assessment is typically conducted by the Offshore Installation Manager (OIM).
Protect	**Protect**	In addition to the considerations already discussed in this chapter, personnel working offshore must protect themselves against H_2S while abandoning to sea. This includes aviation and sea survival suits, personal GPS locators, life vests, etc.
Rescue	**Rescue**	Offshore emergency response teams are given specialized training and equipment to deal with emergencies. Fire Teams are comprised of designated personnel who, under the direction of the Offshore Installation Manager (OIM), will attempt rescue activities.
First aid	**First aid**	Most personnel can perform emergency first aid, but in the isolation of the offshore environment, a trained paramedic or occupational nurse is usually part of the crew. Their job is to provide advanced first aid and life support until transportation to medical care can be arranged.
Medical aid	**Medical aid**	Transportation to medical care is primarily done by helicopter. A medical evacuation team will be onboard to provide medical care enroute to the closest healthcare facility.
	Abandonment may be required at any stage of the seven-step initial response strategy.	At the direction of the Offshore Installation Manager (OIM), an abandonment of the offshore facility may be ordered. All workers in Canada's offshore receive specialized training in how to safely perform an abandonment to the sea.

*IRS – Initial Response Strategy | *ERP – Emergency Response Procedure

1 Evacuate

The first priority when responding to an H_2S release is to evacuate to a safe area. To do this, you must determine the wind direction and ensure that you evacuate to a location where the H_2S will not travel. Wind socks, flare stacks, flags, exhaust steam and trees can help you determine the wind direction.

Move to higher ground if possible. If the release is downwind of you, move upwind. If the release is upwind of you, move crosswind (Refer to Figure 1.3 Wind Direction on page 14).

2 Alarm

Call out to all people in the immediate area, “Danger! Get out!”. The common practice is to repeat the alarm three times, such as “GAS! GAS! GAS!”

Then activate the alarm, if necessary. Depending on the worksite, this may entail sounding a bell, horn or whistle, or making a radio call.

Follow the Emergency Response Plan for the worksite, including instructions for contacting emergency response services such as STARS or 911.

3 Assess

Once you have evacuated to a safe location and activated the alarm, stop and think before considering rescue. Assess the situation carefully before you react. You need to identify the hazards, control the risks and determine the resources available for responding to the incident.

When assessing the situation prior to commencing a rescue, you must consider:

- Concentration of released H_2S
- Critical hazards, such as fire or explosion
- Number of rescuers available
- Availability of rescue equipment
- Number of workers on site
- Location of casualties
- Any injuries to casualties

These concerns will have a bearing on which rescue technique you use. You may need to modify the rescue technique to suit the situation.

Do not forget to consider hazards other than H_2S exposure, such as wildlife and ice conditions. Take measures to control all types of hazards that could impact the emergency response.

H_2S Hazards

Consider the likely behaviour and location of the H_2S. Where H_2S is likely to be found depends on a number of factors. Remember, H_2S is heavier than air. H_2S gas may collect in low-lying areas or be trapped by buildings, natural barriers or other confined spaces.

However, as a component of a mixed gas stream that is lighter than air, the gas may rise, not fall. If released from pressurized containment, it may be wherever the gas stream is directed. If significantly warmer than the ambient air, H_2S mixtures may rise. For example, in winter, ambient temperatures are often much lower and H_2S mixtures are apt to rise.

Rescue Hazards

It is also important to evaluate the risks placed on rescuers. Rescuer safety must come first. Rescues should only be performed by workers who are competent in RPE use and rescue techniques. The number of workers involved in a rescue should be kept to a minimum. Every reasonable effort should be made to control any hazards while the rescue is being performed.

In addition to rescue concerns, you need to assess first aid capabilities:

- How many on-site workers are qualified to perform first aid?
- What equipment is available to them in the first aid kits?
- Where will first aid be performed?

Refer to the First Aid Plan and the Emergency Response Plan developed for your worksite.

4 Protect

Never attempt to perform a rescue without proper respiratory protection. Rescuer safety is paramount. Protect yourself first. Make sure that you take action to control all the hazards you identified during step 3. Put on your RPE. Wear a hard hat, steel-toed boots, gloves and flame-resistant coveralls. You should also be equipped with an H_2S electronic monitor. Depending on the circumstances, fall protection may be required.

5 Rescue

Company management is responsible for setting the maximum H_2S exposure at which personnel equipped with RPE will be allowed to enter an area to perform a rescue. This information should be included in the Emergency Response Plan for the worksite.

Some techniques for moving an unconscious casualty to a safe area are:

- Collar drag
- Two-arm drag
- One-arm drag
- Two-rescuer drag
- Two-rescuer carry

Be sure to use proper body positioning when doing carries or drags.

Activity 5.2

Demonstrating Rescue Techniques

You will be required to demonstrate each of the rescue techniques that you learn. These demonstrations will be done later in class with your instructor who is monitoring the activity.

Collar Drag

This technique is used in one-on-one rescue situations. It is particularly good for casualties on flat and even surfaces.

To perform the collar drag:

1. Place the casualty on their back.
2. Unzip the casualty's coveralls and parka approximately 15 to 20 cm.
3. Roll up the collar of the casualty's coveralls. Grip the collar firmly.
4. Lift the casualty to a semi-sitting position, if possible.
5. Support the casualty's head on your forearms.
6. Drag the casualty to safety, head first.

Two-Arm Drag

This technique is used in one-on-one situations. If necessary, it can be used on uneven surfaces.

To perform a two-arm drag:

1. Place the casualty on their back.
2. Squat behind the casualty.
3. Lift the casualty to a semi-sitting position, while supporting the head and neck on your forearms.
4. Use your thigh or knee to support the casualty's back.
5. Put your arms under the casualty's armpits.
6. Cross the casualty's arms and get a firm hold on their wrists. Ensure that their arms are in contact with their chest.
7. Lift the casualty up against your chest as you stand. Use your legs to lift, not your back.
8. Drag the casualty to safety.

One-Arm Drag

If the casualty has an injured arm, the one-arm drag may be preferable.

Repeat steps for the two-arm drag but modify step 6 by leaving the injured arm free.

Two-Rescuer Drag

This technique requires two rescuers. It is probably the quickest way to remove a casualty from a danger zone and may be used on flat and even surfaces.

Working together, the two rescuers perform the drag as follows:

1. Place the casualty on their back and unzip their coveralls 15 to 20 cm.
2. Stand on opposite sides of the casualty. Face away from the casualty's feet.
3. With your closest hand, reach inside the casualty's collar until you grasp the shoulder of the coveralls. There will be one rescuer on each side of the casualty.
4. Get a firm hold of the coveralls and lift.
5. Drag the casualty to safety. Support the casualty's neck with the collar of their coveralls, as much as possible.

Two-Rescuer Carry

This technique requires two rescuers. Sometimes called a "lift", this technique can be used on uneven surfaces. The proper procedure for this rescue technique is as follows:

Rescuers 1 and 2

1. Place the casualty on their back.

Rescuer 1

2. Squatting at the casualty's head, support the casualty's head and neck on your forearms.

Rescuer 2

3. Squatting at the casualty's waist, grip the casualty's coveralls and slowly pull the casualty into a sitting position. If the casualty has a broken arm, only grip the wrist on the unbroken arm.

Rescuer 1

4. Reach under the armpits and grasp the casualty's wrist(s).

Rescuer 2

5. Cross the casualty's outside leg over the inside leg at the ankles.
6. Hold both legs of the casualty to one side with one hand, so that you have a hand free to open doors and move obstacles.

Rescuers 1 and 2

7. Lift the casualty evenly.
8. Facing forward, carry the casualty to safety.

6 First Aid

Any casualties knocked down by H_2S should be assisted by people who are properly qualified in first aid and cardiopulmonary resuscitation (CPR). All personnel who might work in an area where there could be H_2S should maintain current first aid and CPR certification. You could be putting yourself and the casualty at risk if you attempt a rescue when not properly trained in these first aid techniques.

General First Aid Measures

Once the casualty has been removed to a safe area, unzip their coveralls to remove trapped gas. Do not remove your RPE until the area is clear.

Provide comfort, warmth and rest. Be aware of possible accompanying injuries, such as a fall injury. Assess the casualty's condition and apply the following first aid measures, as appropriate:

- Inhalation: Remove the casualty to fresh air. If breathing has stopped, perform CPR.
- Eyes: If the casualty's eyes appear irritated, flush them with plenty of warm water for at least 15 minutes. Get medical attention as soon as possible.
- Skin: If the casualty's skin appears irritated, immediately flush the skin with warm water. Remove non-adherent contaminated clothing. However, if the clothing adheres to the casualty's skin, do not remove it.

Resuscitation

The brain can only survive for four to six minutes without a continuous supply of oxygen. That is why your goal is to get casualties to fresh air as quickly as possible. For this reason, as part of your pre-job safety meeting, you should discuss and practise a rescue plan designed to get casualties to fresh air and resuscitate them within three minutes.

Removing casualties from the area where H_2S knocked them down may not be enough to save their lives. If casualties are not breathing, you may have to use CPR.

CPR is a combination of artificial respiration, which provides oxygen to the lungs, and artificial circulation, which causes blood to flow through the body. CPR causes only enough oxygen and blood to flow to give the casualty a chance for survival. The purpose of CPR is to circulate oxygenated blood to the brain and other organs until the heart starts beating or medical help takes over.

If an Automated External Defibrillator (AED) is available and you or someone else is trained in its use, use it as soon as possible.

Breathing barrier devices and protective gloves are recommended when performing CPR.

7 Medical Aid

Depending on the location of the worksite, you may need to arrange transport by vehicle, helicopter or boat.

Be prepared to provide information to EMS personnel when they arrive. They may ask the following:

- How many casualties are there?
- Where are the casualties?
- What has been done to assist the casualties?

When responding to an H_2S release, you must also follow the emergency response plan for your worksite. Learn the details of the plan before an emergency occurs.

Activity 5.3

Scenario 1: In the Deep Snow

Working in groups, complete the following tasks:

1. **Read the scenario carefully or scan the QR code to watch the video.**
2. **Describe how you would respond to the following scenario.**

www.energysafetycanada.com/Training/Courses/H2S-Alive-Videos

Scenario

John is setting up his surveying instrument near the site entrance, 30 m from a recently drilled well. Peter is helping him by moving the prism to different points around the site, including near the well head. Based on John's instructions over the radio, Peter makes his way slowly through the deep snow towards the well.

Suddenly, Peter drops to his knees and appears to be struggling to get up. Concerned about Peter's well-being, John asks Peter over the radio if he is OK but receives no response.

Based on the information provided, explain how John should respond to this emergency using the seven-step initial response strategy.

Scenario 1: In the Deep Snow	
1. Evacuate	
2. Alarm	
3. Assess	
4. Protect	
5. Rescue	
6. First Aid	
7. Medical Aid	

Scenario 2: In the Laboratory

Working in groups, complete the following tasks:

1. **Read the scenario carefully or scan the QR code to watch the video.**
2. **Describe how you would respond to the following scenario.**

www.energysafetycanada.com/Training/Courses/H2S-Alive-Videos

Scenario

You are back at the same lab where you did your hazard assessment. Three lab technicians, Ron, Sam and Nataly, work on analyzing various gas samples, each focusing on their assigned tasks. The lab receives the sample containers in well-sealed shipping packages. At their work bench, the technicians unpack the sample containers from this protective packaging. They then move the exposed sample container to the work surface under the fumehood to start the gas analysis process, according to the details on the request form.

On this day, a unique sample is brought in for analysis. Ron removes the sample container from the shipping packaging. But as he picks it up, he notices a tiny crack in the sample container. Before he has a chance to place the sample under the fume hood, gas from the sample begins to escape and the laboratory fills with an odour of rotten eggs.

The technician's personal gas monitor and the fixed gas-monitoring system sound off alarms, telltale signs of the presence of toxic gas. Ron falls to the ground, still moving but seemingly confused.

The muster point is in the parking lot. Explain how Sam and Nataly should respond to this emergency, using the seven-step initial response strategy.

Scenario 2: In the Laboratory	
1. Evacuate	
2. Alarm	
3. Assess	
4. Protect	
5. Rescue	
6. First Aid	
7. Medical Aid	

Scenario 3: Waste Disposal Facility

Working in groups, complete the following tasks:

1. **Read the scenario carefully or scan the QR code to watch the video.**
2. **Describe how you would respond to the following scenario.**

www.energysafetycanada.com/Training/Courses/H2S-Alive-Videos

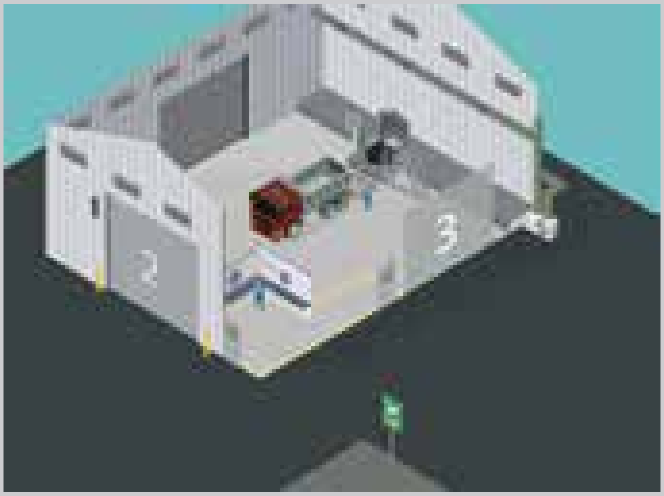
Scenario

It's a busy day in the storage building being used for food waste collection. Victor, a driver, arrives with his dump truck at the site. He gets the green light to proceed through overhead door number 2 from Mike who is sitting in the monitoring area.

Victor reverses his truck through overhead door number 2, preparing to unload into the feedstock pit. The lid of the feedstock pit opens automatically, and Victor begins to unload the waste from the truck into the pit.

After trying to move forward, the actuation step responsible for opening and closing the pit lid becomes stuck. Victor leaves his truck to check for the problem, getting closer to the pit and looking under the truck. As he crouches down, he loses consciousness and falls to the ground.

The muster point is outside the building in the parking lot. Explain how Mike should respond to this emergency using the seven-step initial response strategy.



Scenario 3: Waste Disposal Facility	
1. Evacuate	
2. Alarm	
3. Assess	
4. Protect	
5. Rescue	
6. First Aid	
7. Medical Aid	

Exercise

1. Number the seven steps of an initial response strategy in the correct order:

_______ Protect

_______ Assess

_______ Medical Aid

_______ Rescue

_______ Evacuate

_______ First Aid

_______ Alarm

2. What should you do if there is an H_2S release downwind of you?

____

3. Who should a worker protect first before attempting a rescue?

____

4. Which rescue technique is generally used in a one-on-one rescue situation and on a flat and even surface?

____

5. Which rescue technique can a rescue team use to quickly remove a casualty from a danger zone on a flat and even surface?

____

Discussion

» What are some things to consider when assessing a situation prior to commencing a rescue?

» How can you practice and maintain your rescue, first aid, CPR and other skills required to respond to an emergency safely?

Notes

Appendices

Energy Safety Canada

Safety Data Sheet

Hydrogen Sulphide (Canada)

Date: MM/DD/Year

Section 1: Identification

Product Name:	Hydrogen Sulphide (Canada)
SDS Number:	778987
Synonyms:	H_2S; Hydrosulfuric Acid; Sewer Gas; Sour Gas; Stink Damp; Sulfur Hydride; Dihydrogen Monosulphide; Dihydrogen Sulphide; Sulfureted Hydrogen; CASRN 7783-06-4.
Recommended Use:	Raw Product
Manufacturer:	Company Name Street Address City, Province/State Postal/Zip Code
Emergency Health and Safety Number:	123-456-7890
Customer Service:	123-555-1212

Section 2: Hazard(s) Identification

Classification

H220 -- Flammable gases -- Category 1
H280 -- Gases under pressure -- Compressed gas
H330 -- Acute toxicity, Inhalation -- Category 2
H335 -- Specific target organ toxicity (single exposure) -- Category 3
H400 -- Hazardous to the aquatic environment, acute toxicity -- Category 1

Hazards not Otherwise Classified

Contains poisonous Hydrogen Sulphide gas

Label Elements

DANGER

Extremely flammable gas. (H220)*
Contains gas under pressure. May explode if heated. (H280)*
Causes eye irritation. (H320)*
Contains poisonous Hydrogen Sulphide gas
Fatal if inhaled. (H330)*
May cause respiratory irritation. (H335)*
Very toxic to aquatic life. (H400)*

Precautionary Statement(s):
Keep away from heat/sparks/open flames/hot surfaces. - No smoking. (P210)*
Do not breathe dust/fume/gas/mist/vapours/spray. (P260)*
Use only outdoors or in a well-ventilated area. (P271)*
Avoid release to the environment. (P273)*
Wear respiratory protection. (P284)*
In case of inadequate ventilation wear respiratory protection. (P285)*
Leaking gas fire: Do not extinguish, unless leak can be stopped safely. (P377)*
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. (P305+P351+P338*) If eye irritation persists: Get medical advice/attention. (P313)*
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. (P340)*Immediately call a POISON CENTER or doctor/physician. (P310)*
Specific treatment is urgent: maintain adequate ventilation and consider administration of 100% oxygen. Sodium nitrite may be a useful antidote. (P320)*
Eliminate all ignition sources if safe to do so. (P381)*
Store in a well-ventilated place. Keep container tightly closed. (P403+P233)*
Store locked up. (P405)*
Dispose of contents/container to approved disposal facility. (P501)*

** (Applicable GHS hazard code.)*

Section 3: Composition / Information on Ingredients

Component	CASRN	Concentration[1]
Hydrogen Sulphide	7783-06-4	100

[1] All concentrations are percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.

Section 4: First Aid Measures

Eye Contact: For direct contact, remove contact lenses if present and easy to do. Immediately hold eyelids apart and flush the affected eye(s) with clean water for at least 15 minutes. Seek immediate medical attention.

Skin Contact: First aid is not normally required. However, it is good practice to wash any chemical from the skin.

Inhalation (Breathing): Immediately move victim away from exposure and into fresh air in a position comfortable for breathing. If respiratory symptoms or other symptoms of exposure develop, seek immediate medical attention. If victim is not breathing, clear airway and immediately begin artificial respiration. If breathing difficulties develop, oxygen should be administered by qualified personnel. Seek immediate medical attention.

Ingestion (Swallowing): This material is a gas under normal atmospheric conditions and ingestion is unlikely.

Most important symptoms and effects
Acute: Respiratory tract irritation.
Delayed: Pulmonary edema.

Notes to Physician: At high concentrations Hydrogen Sulphide may produce pulmonary edema, respiratory depression, and/or respiratory paralysis. The first priority in treatment should be the establishment of adequate ventilation and the administration of 100% oxygen. Animal studies suggest that nitrites are a useful antidote, however, documentation of the efficacy of nitrites in humans is lacking. If the diagnosis of Hydrogen Sulphide poisoning is confirmed and if the patient does not respond rapidly to supportive care, the use of nitrites may be an effective antidote if delivered within the first few minutes of exposure. For adults the dose is 10 mL of a 3% $NaNO2$ solution (0.5 gm $NaNO2$ in 15 mL water) I.V. over 2-4 minutes. The dosage should be adjusted in children or in the presence of anemia, and methemoglobin levels, arterial blood gases, and electrolytes should be monitored closely.

Other Comments: Before attempting rescue, first responders should be alert to the possible presence of Hydrogen Sulphide, a poisonous gas with the smell of rotten eggs, and should consider the need for respiratory protection (see Section 8). Remove casualty to fresh air as quickly as possible. Immediately begin artificial respiration if breathing has ceased. Consider whether oxygen administration is needed. Obtain medical advice for further treatment.

Section 5: Fire-Fighting Measures

NFPA 704 Hazard Class 

Health: 4 **Flammability:** 4 **Instability:** 0 (0-Minimal, 1-Slight, 2-Moderate, 3-Serious, 4-Severe)

Unusual Fire & Explosion Hazards: Extremely flammable. Contents under pressure. This material can be ignited by heat, sparks, flames, or other sources of ignition (e.g., static electricity, pilot lights, mechanical/electrical equipment, and electronic devices such as cell phones, computers, calculators, and pagers which have not been certified as intrinsically safe). Vapors may travel considerable distances to a source of ignition where they can ignite, flash back, or explode. May create vapor/air explosion hazard indoors, in confined spaces, outdoors, or in sewers. If container is not properly cooled, it can rupture in the heat of a fire. Hazardous combustion/decomposition products, including Hydrogen Sulphide, may be released by this material when exposed to heat or fire. Use caution and wear protective clothing, including respiratory protection.

Suitable Extinguishing Media: Dry chemical or carbon dioxide is recommended. Carbon dioxide can displace oxygen. Use caution when applying carbon dioxide in confined spaces.

Unsuitable Extinguishing Media: Not available.

Fire Fighting Instructions: For fires beyond the initial stage, emergency responders in the immediate hazard area should wear protective clothing. When the potential chemical hazard is unknown, in enclosed or confined spaces, a self-contained breathing apparatus should be worn. In addition, wear other appropriate protective equipment as conditions warrant (see Section 8).

Isolate immediate hazard area and keep unauthorized personnel out. Stop spill/release if it can be done safely. If this cannot be done, allow fire to burn. Move undamaged containers from immediate hazard area if it can be done safely. Stay away from ends of container. Water spray may be useful in minimizing or dispersing vapors and to protect personnel. Cool equipment exposed to fire with water, if it can be done safely.

Hazardous Combustion Products: Combustion may yield oxides of sulfur. (See Section 10)

See Section 9 for Flammable Properties including Flash Point and Flammable (Explosive) Limits

Section 6: Accidental Release Measures

Personal Precautions: Extremely flammable. Contains poisonous Hydrogen Sulphide gas. If the presence of dangerous amounts of H_2S around the spilled product is suspected, additional or special actions may be warranted, including access restrictions and use of protective equipment. Spillages of liquid product will create a fire hazard and may form an explosive atmosphere. Keep all sources of ignition and hot metal surfaces away from spill/release if safe to do so. The use of explosion-proof electrical equipment is recommended. Beware of accumulation of gas in low areas or contained areas, where explosive concentrations may occur. Prevent from entering drains or any place where accumulation may occur. Ventilate area and allow to evaporate. Stay upwind and away from spill/release. Avoid direct contact with material. For large spillages, notify persons down wind of the spill/release, isolate immediate hazard area and keep unauthorized personnel out. Wear appropriate protective equipment, including respiratory protection, as conditions warrant (see Section 8). See Sections 2 and 7 for additional information on hazards and precautionary measures.

Environmental Precautions: Stop spill/release if it can be done safely. Water spray may be useful in minimizing or dispersing vapors. If spill occurs on water notify appropriate authorities and advise shipping of any hazard. If spill/release in excess of EPA reportable quantity (see Section 15) is made into the environment, immediately notify the National Response Center (phone number 800-424-8802).

Methods for Containment and Clean-Up: Notify relevant authorities in accordance with all applicable regulations.

Recommended measures are based on the most likely spillage scenarios for this material; however local conditions and regulations may influence or limit the choice of appropriate actions to be taken.

Section 7: Handling and Storage

Precautions for safe handling: Keep away from ignition sources such as heat/sparks/open flame – No smoking. Take precautionary measures against static discharge. May contain or release dangerous levels of Hydrogen Sulphide. Do not breathe gas. Use only outdoors or in well-ventilated area. Wear eye/face protection. Wear respiratory protection. Use good personal hygiene practices and wear appropriate personal protective equipment (see section 8).

Contents under pressure. The use of explosion-proof electrical equipment is recommended and may be required (see appropriate fire codes). Refer to NFPA-70 and/or API RP 2003 for specific bonding/grounding requirements. Electrostatic charge may accumulate and create a hazardous condition when handling or processing this material. To avoid fire or explosion, dissipate static electricity during transfer by grounding and bonding containers and equipment before transferring material. Do not enter confined spaces such as tanks or pits without following proper entry procedures such as ASTM D-4276 and 29CFR 1910.146. Cold burns may occur during filling operations. Containers and delivery lines may become cold enough to present cold burn hazard.

Conditions for safe storage: Keep container(s) tightly closed and properly labeled. This material may contain or release poisonous Hydrogen Sulphide gas. In a tank, barge, or other closed container, the vapor space above this material may accumulate hazardous concentrations of Hydrogen Sulphide. Check atmosphere for oxygen content, H_2S, and flammability prior to entry. Use and store this material in cool, dry, well-ventilated areas away from heat, direct sunlight, hot metal surfaces, and all sources of ignition. Store only in approved containers. Post area "No Smoking or Open Flame." Keep away from any incompatible material (see Section 10). Protect container(s) against physical damage. Outdoor or detached storage is preferred. Indoor storage should meet OSHA standards and appropriate fire codes.

"Empty" containers retain residue and may be dangerous. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose such containers to heat, flame, sparks, or other sources of ignition. They may explode and cause injury or death. Avoid exposing any part of a compressed-gas cylinder to temperatures above 125F(51.6C). Gas cylinders should be stored outdoors or in well ventilated storerooms at no lower than ground level and should be quickly removable in an emergency.

Section 8: Exposure Controls / Personal Protection

Component	ACGIH	OSHA	Other
Hydrogen Sulphide	STEL: 5 ppm TWA: 1 ppm	Ceiling: 20 ppm	TWA: 5 ppm 8hr TWA: 2.5 ppm 12hr STEL: 15 ppm

Note: State, local or other agencies or advisory groups may have established more stringent limits. Consult an industrial hygienist or similar professional, or your local agencies, for further information.

Engineering controls: If current ventilation practices are not adequate to maintain airborne concentrations below the established exposure limits, additional engineering controls may be required.

Eye/Face Protection: The use of gas/vapor tight eye protection that meets or exceeds ANSI Z.87.1 is recommended against potential eye contact, irritation, or injury. Depending on conditions of use, a full face respirator may be necessary.

Skin/Hand Protection: The use of skin protection is not normally required; however, good industrial hygiene practice suggests the use of gloves or other appropriate skin protection whenever working with chemicals. Wear thermal insulating gloves and face shield or eye protection when working with materials that present thermal hazards (hot or cold).

Respiratory Protection: A NIOSH approved, self-contained breathing apparatus (SCBA) or equivalent operated in a pressure demand or other positive pressure mode should be used in situations of oxygen deficiency (oxygen content less than 19.5 percent), unknown exposure concentrations, or situations that are immediately dangerous to life or health (IDLH).

A respiratory protection program that meets or is equivalent to OSHA 29 CFR 1910.134 and ANSI Z88.2 should be followed whenever workplace conditions warrant a respirator's use.

Other Protective Equipment: Eye wash and quick-drench shower facilities should be available in the work area. Thoroughly clean shoes and wash contaminated clothing before reuse.

Suggestions provided in this section for exposure control and specific types of protective equipment are based on readily available information. Users should consult with the specific manufacturer to confirm the performance of their protective equipment. Specific situations may require consultation with industrial hygiene, safety, or engineering professionals.

Section 9: Physical and Chemical Properties

Note: Unless otherwise stated, values are determined at 20°C (68°F) and 760 mm Hg (1 atm). Data represent typical values and are not intended to be specifications.

Appearance:	Colorless
Physical Form:	Compressed Gas
Odor:	Rotten egg / sulfurous
Odor Threshold:	0.00047 ppm
pH:	Not applicable
Vapor Pressure:	14000 mm Hg @ 68°F / 20°C
Vapor Density (air=1):	1.19
Initial Boiling Point/Range:	-76 °F / -60 °C
Melting/Freezing Point:	-122 °F / -86 °C
Solubility in Water:	Soluble
Partition Coefficient (n-octanol/water) (Kow):	No data
Specific Gravity (water=1):	1.54 (liquid under pressure)
Percent Volatile:	100%
Evaporation Rate (nBuAc=1):	>1
Flash Point:	< -76 °F / < -60 °C
Test Method:	(estimate)
Lower Explosive Limits (vol % in air):	4.3
Upper Explosive Limits (vol % in air):	46.0
Auto-ignition Temperature:	500 °F / 260 °C

Section 10: Stability and Reactivity

Stability: Stable under normal ambient and anticipated conditions of use.

Conditions to Avoid: Avoid all possible sources of ignition. Heat will increase pressure in the storage tank.

Materials to Avoid (Incompatible Materials): Avoid contact with acids and strong oxidizing agents.

Hazardous Decomposition Products: Not anticipated under normal conditions of use.

Hazardous Polymerization: Not known to occur.

Section 11: Toxicological Information

Information on Toxicological Effects of Substance/Mixture

Acute Toxicity	Hazard	Additional Information	LC50/LD50 Data
Inhalation	Fatal if inhaled	Contains poisonous Hydrogen Sulphide gas. See Signs and Symptoms	444 ppm (gas)
Skin Absorption	No information available		Not applicable
Ingestion (Swallowing)	Ingestion is not anticipated		Not applicable

Aspiration Hazard: Not applicable

Skin Corrosion/Irritation: Skin exposure is not anticipated.

Serious Eye Damage/Irritation: Causes eye irritation.

Signs and Symptoms: Hydrogen Sulphide is a poisonous gas with the smell of rotten eggs. The smell disappears rapidly because of olfactory fatigue so odor may not be a reliable indicator of exposure. Effects of overexposure include irritation of the eyes, nose, throat and respiratory tract, blurred vision, photophobia (sensitivity to light), and pulmonary edema (fluid accumulation in the lungs). Severe exposures can result in nausea, vomiting, muscle weakness or cramps, headache, disorientation and other signs of nervous system depression, irregular heartbeats, convulsions, respiratory failure, and death. Contains gas(es) which can cause asphyxiation at high concentrations by displacing oxygen. Symptoms of overexposure may include headache, fatigue, weakness, mental confusion, mood disturbances, and decreased coordination and judgment. Continued exposure can lead to hypoxia (inadequate oxygen), rapid breathing, impaired vision, ringing in the ears, cyanosis (bluish discoloration of skin), numbness of the extremities, unconsciousness and death.

Skin Sensitization: No information available.

Respiratory Sensitization: No information available.

Specific Target Organ Toxicity (Single Exposure): May cause respiratory irritation.

Specific Target Organ Toxicity (Repeated Exposure): Not expected to cause organ effects from repeated exposure.

Carcinogenicity: No information available. This substance is not listed as a carcinogen by IARC, NTP or OSHA.

Germ Cell Mutagenicity: Inadequate information available.

Reproductive Toxicity: Inadequate information available.

Other Comments: High concentrations may reduce the amount of oxygen available for breathing, especially in confined spaces. Hypoxia (inadequate oxygen) during pregnancy may have adverse effects on the developing fetus.

Section 12: Ecological Information

Ecotoxicity: 14.9 ug/L 96 hr. Fathead minnow (Pimephales promelas);
9730 ug/L 1.5 hr. Mediterranean mussel (Mytilus galloprovincialis)

Persistence / Degradability: Not available.

Bioaccumulation / Accumulation: Not available.

Mobility in Environment: Not available.

Other Adverse Effects: None anticipated. .

Section 13: Disposal Considerations

Disposal should be in accordance with applicable regional, national and local laws and regulations. Local regulations may be more stringent than regional or national requirements.

Section 14: Transport Information

Canadian (TDG)

Shipping Description: UN1053, Hydrogen Sulphide, 2.3, (2.1)

Small Means of Containment

Package Marking: Hydrogen Sulphide, UN1053

Package Labeling: Toxic gas and Flammable gas

Large Means of Containment

Package Placard/Marking: Toxic gas / 1053

ERAP Index: 500

Emergency Response Guide: 117

U.S. Department of Transportation (DOT)

Shipping Description: UN1053, Hydrogen Sulphide, 2.3,; , (2.1), Poison-Inhalation Hazard, Zone B RQ *

Non-Bulk Package Marking: Hydrogen Sulphide, UN1053

Non-Bulk Package Labeling: Poison gas and Flammable gas

Bulk Package/Placard Marking: Poison gas / 1053, Inhalation Hazard

Packaging - References: None; 49 CFR 173.304; 173.314 & .315
(Exceptions; Non-bulk; Bulk)

Hazardous Substance:	See Section 15 for RQ`s
Emergency Response Guide:	117
Note:	**** Omit "RQ" if the amount in a single packaging is less than the EPA Reportable Quantity amount shown in Section 15 for the hazardous substance. The following alternate shipping description order may be used until January 1, 2013:*** **Proper Shipping name, Hazard Class or Division, (Subsidiary Hazard if any), UN or NA number, Packing Group** ***Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code:*** *Not applicable* ***Other shipping description elements may be required for DOT compliance.***

International Maritime Dangerous Goods (IMDG)

Shipping Description:	UN1053, Hydrogen Sulphide, 2.3,; , (2.1)
Non-Bulk Package Marking:	Hydrogen Sulphide, UN1053
Labels:	Toxic gas , Flammable gas
Placards/Marking (Bulk):	Toxic gas / 1053 and Flammable gas
Packaging - Non-Bulk:	P200
EMS:	F-D, S-U
Note:	***U.S. DOT compliance requirements may apply. See 49 CFR 171.22, 23 & 25.***

International Civil Aviation Org. / International Air Transport Assoc. (ICAO/IATA)

UN/IDS #: **Forbidden**

	LTD. QTY	Passenger Aircraft	Cargo Aircraft Only
Packaging Instruction #:	---	---	---
Max. Net Qty. Per Package:	---	---	---

Section 15: Regulatory Information

CERCLA/SARA - Section 302 Extremely Hazardous Substances and TPQs (in pounds):

This material contains the following chemicals subject to the reporting requirements of SARA 302 and 40 CFR 372:

Component	TPQ	EPCRA RQ
Hydrogen Sulphide	500 lb	100 lb

CERCLA/SARA - Section 311/312 (Title III Hazard Categories)

Acute Health:	Yes
Chronic Health:	No
Fire Hazard:	Yes
Pressure Hazard:	Yes
Reactive Hazard:	No

CERCLA/SARA - Section 313 and 40 CFR 372:

This material does not contain any chemicals subject to the reporting requirements of SARA 313 and 40 CFR 372.

EPA (CERCLA) Reportable Quantity (in pounds):

This material contains the following chemicals subject to the reporting requirements of 40 CFR 302.4:

Component	RQ
Hydrogen Sulphide	100 lb

California Proposition 65:

This material does not contain any chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm at concentrations that trigger the warning requirements of California Proposition 65.

International Hazard Classification

Canada:

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the SDS contains all the information required by the Regulations.

WHMIS (2015) Hazard Class:

A - Compressed Gas
B1 - Flammable Gases
D1B
D2B

National Chemical Inventories

All components are either listed on the US TSCA Inventory, or are not regulated under TSCA
All components are either on the DSL, or are exempt from DSL listing requirements

U.S. Export Control Classification Number: EAR99

Section 16: Other Information

Date of Issue:	MM/DD/Year
Status:	FINAL
Previous Issue Date:	MM/DD/Year
Revised Sections or Basis for Revision:	Format change Identified Hazards (Section 2) Toxicological (Section 11)
SDS Number:	778987

Guide to Abbreviations:

ACGIH = American Conference of Governmental Industrial Hygienists; CASRN = Chemical Abstracts Service Registry Number; CEILING = Ceiling Limit (15 minutes); CERCLA = The Comprehensive Environmental Response, Compensation, and Liability Act; EPA = Environmental Protection Agency; GHS = Globally Harmonized System; IARC = International Agency for Research on Cancer; INSHT = National Institute for Health and Safety at Work; IOPC = International Oil Pollution Compensation; LEL = Lower Explosive Limit; NE = Not Established; NFPA = National Fire Protection Association; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration; PEL = Permissible Exposure Limit (OSHA); SARA = Superfund Amendments and Reauthorization Act; STEL = Short Term Exposure Limit (15 minutes); TLV = Threshold Limit Value (ACGIH); TWA = Time Weighted Average (8 hours); UEL = Upper Explosive Limit; WHMIS = Workplace Hazardous Materials Information System (Canada)

Disclaimer of Expressed and implied Warranties:

The information presented in this Material Safety Data Sheet is based on data believed to be accurate as of the date this Material Safety Data Sheet was prepared. HOWEVER, NO WARRANTY OF MERCHANTABILITY, FITNESS FOR ANY PARTICULAR PURPOSE, OR ANY OTHER WARRANTY IS EXPRESSED OR IS TO BE IMPLIED REGARDING THE ACCURACY OR COMPLETENESS OF THE INFORMATION PROVIDED ABOVE, THE RESULTS TO BE OBTAINED FROM THE USE OF THIS INFORMATION OR THE PRODUCT, THE SAFETY OF THIS PRODUCT, OR THE HAZARDS RELATED TO ITS USE. No responsibility is assumed for any damage or injury resulting from abnormal use or from any failure to adhere to recommended practices. The information provided above, and the product, are furnished on the condition that the person receiving them shall make their own determination as to the suitability of the product for their particular purpose and on the condition that they assume the risk of their use. In addition, no authorization is given nor implied to practice any patented invention without a license.

Notes

Notes

LIFE SAVING RULES

CONFINED SPACE

Obtain authorization before entering a confined space

- I confirm energy sources are isolated
- I confirm the atmosphere has been tested and is monitored
- I check and use my breathing apparatus when required
- I confirm there is an attendant standing by
- I confirm a rescue plan is in place
- I obtain authorization to enter

WORKING AT HEIGHT

Protect yourself against a fall when working at height

- I inspect my fall protection equipment before use
- I secure tools and work materials to prevent dropped objects
- I tie off 100% to approved anchor points while outside a protected area

WORK AUTHORIZATION

Work with a valid permit when required

- I have confirmed if a permit is required
- I am authorized to perform the work
- I understand the permit
- I have confirmed that hazards are controlled and it is safe to start
- I stop and reassess if conditions change

ENERGY ISOLATION

Verify isolation and zero energy before work begins

- I have identified all energy sources
- I confirm that hazardous energy sources have been isolated, locked, and tagged
- I have checked there is zero energy and tested for residual or stored energy

LINE OF FIRE

Keep yourself and others out of the line of fire

- I position myself to avoid:
  - Moving objects
  - Vehicles
  - Pressure releases
  - Dropped objects
- I establish and obey barriers and exclusion zones
- I take action to secure loose objects and report potential dropped objects

BYPASSING SAFETY CONTROLS

Obtain authorization before overriding or disabling safety controls

- I understand and use safety-critical equipment and procedures which apply to my task
- I obtain authorization before:
  - Disabling or overriding safety equipment
  - Deviating from procedures
  - Crossing a barrier

DRIVING

Follow safe driving rules

- I always wear a seatbelt
- I do not exceed the speed limit, and reduce my speed for road conditions
- I do not use phones or operate devices while driving
- I am fit, rested and fully alert while driving
- I follow journey management requirements

HOT WORK

Control flammables and ignition sources

- I identify and control ignition sources
- Before starting any hot work:
  - I confirm flammable material has been removed or isolated
  - I obtain authorization
- Before starting hot work in a hazardous area I confirm:
  - A gas test has been completed
  - Gas will be monitored continually

SAFE MECHANICAL LIFTING

Plan lifting operations and control the area

- I confirm that the equipment and load have been inspected and are fit for purpose
- I only operate equipment that I am qualified to use
- I establish and obey barriers and exclusion zones
- I never walk under a suspended load

FIT FOR DUTY

Be in a state to perform work safely

- I will be physically and mentally in a state to perform my assigned duties
- I commit to not being under the influence of alcohol or drugs
- I will inform a supervisor immediately if I or a co-worker may be unfit for work

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