Hydrogen Sulfide Safety Training

Understanding the Hazards of Hydrogen Sulfide

References

- OSHA 1910 Subpart Z – Toxic & Hazardous Substances
- OSHA 1910 134 – Respiratory Protection
- Center for Disease Control & Prevention
- National Institute for Occupational Safety & Health

Objectives

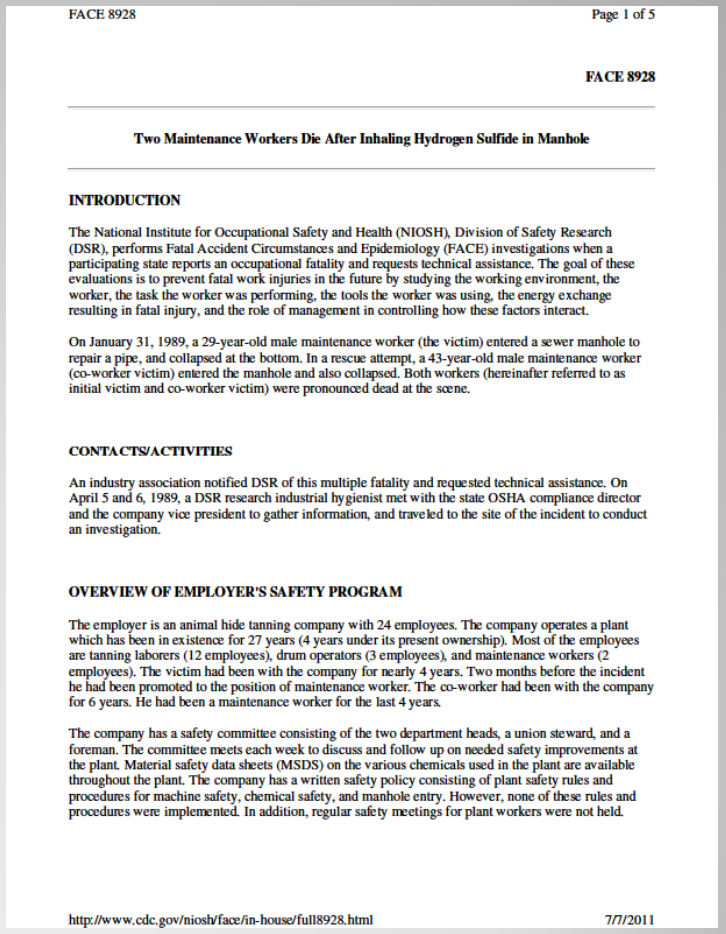
- To understand why Hydrogen Sulfide safety is important.
- To understand basic hydrogen sulfide safety precautions.
- To understand the sources of potential hydrogen sulfide exposure.
- To understand basic personal protective equipment required for hydrogen sulfide.

Part I

Introduction

Hydrogen Sulfide Is Deadly

- On January 31st, 1989, a 29 year old worker entered a sewer manhole to repair a pipe.
- The man collapsed immediately.
- His co-worker entered the space to rescue him, and also collapsed.
- They both died from hydrogen sulfide exposure.



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FACE 8928

Two Maintenance Workers Die After Inhaling Hydrogen Sulfide in Manhole

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR), performs Fatal Accident Circumstances and Epidemiology (FACE) investigations when a participating state reports an occupational fatality and requests technical assistance. The goal of these evaluations is to prevent fatal work injuries in the future by studying the working environment, the worker, the task the worker was performing, the tools the worker was using, the energy exchange resulting in fatal injury, and the role of management in controlling how these factors interact.

On January 31, 1989, a 29-year-old male maintenance worker (the victim) entered a sewer manhole to repair a pipe, and collapsed at the bottom. In a rescue attempt, a 43-year-old male maintenance worker (co-worker victim) entered the manhole and also collapsed. Both workers (hereinafter referred to as initial victim and co-worker victim) were pronounced dead at the scene.

CONTACTS/ACTIVITIES

An industry association notified DSR of this multiple fatality and requested technical assistance. On April 5 and 6, 1989, a DSR research industrial hygienist met with the state OSHA compliance director and the company vice president to gather information, and traveled to the site of the incident to conduct an investigation.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is an animal hide tanning company with 24 employees. The company operates a plant which has been in existence for 27 years (4 years under its present ownership). Most of the employees are tanning laborers (12 employees), drum operators (3 employees), and maintenance workers (2 employees). The victim had been with the company for nearly 4 years. Two months before the incident he had been promoted to the position of maintenance worker. The co-worker had been with the company for 6 years. He had been a maintenance worker for the last 4 years.

The company has a safety committee consisting of the two department heads, a union steward, and a foreman. The committee meets each week to discuss and follow up on needed safety improvements at the plant. Material safety data sheets (MSDS) on the various chemicals used in the plant are available throughout the plant. The company has a written safety policy consisting of plant safety rules and procedures for machine safety, chemical safety, and manhole entry. However, none of these rules and procedures were implemented. In addition, regular safety meetings for plant workers were not held.

http://www.cdc.gov/niosh/face/in-house/full8928.html 7/7/2011

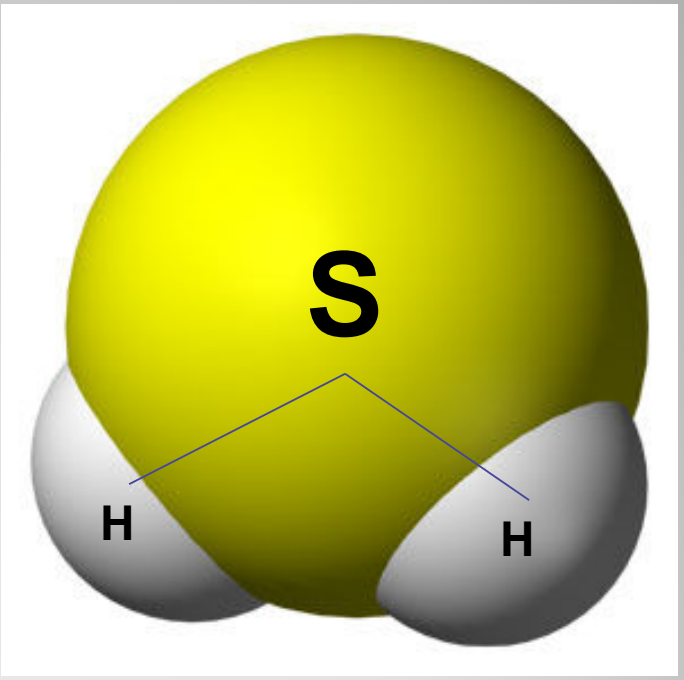
Hydrogen Sulfide Is Deadly

- After investigation, it was determined that:
  - The employer did not have an established safety program.
  - They employer did not have any confined space entry procedures.
  - The employer did not have an effective respirator program.
- This lack of basic safety procedures caused the death of two employees.

Hydrogen sulfide exposure results in roughly twelve deaths a year in the United States.

What is Hydrogen Sulfide?

- Hydrogen sulfide (H_2S) is an extremely hazardous gas.
- It is colorless and flammable.
- At low concentrations, it has a "rotten eggs" smell.
- It is also known as:
  - Swamp gas.
  - Sewer gas.
  - Stink damp.
  - Manure gas.



Warning – At higher concentrations H_2S will immediately kill your sense of smell, so do not rely on the "rotten eggs" smell to detect it.

The Source of H_2S

- Hydrogen sulfide occurs naturally in crude petroleum, natural gas, and hot springs.
- It is also produced by bacterial breakdown of organic materials, human waste, and animal waste.
- It is very common in industrial activities such as:
  - Drilling.
  - Waste water treatment.
  - Coke ovens.
  - Tanneries.
  - Paper mills.
  - Sewer maintenance.

Entering sewers through manholes is a very common place to be exposed to H_2S.

Health Effects of H_2S Exposure

- H_2S is both an irritant and an asphyxiate.
- At low concentrations, it will cause:
  - Burning and tearing of the eyes.
  - Coughing and chest pains.
  - Shortness of breath.
- At medium concentrations, it will cause:
  - Severe eye and respiratory irritation.
  - Headaches, dizziness, nausea and vomiting.

Concentration	Effect
>10 PPM	Eye irritation.
50 PPM – 100 PPM	Respiratory tract irritation.
100 PPM – 500 PPM	Coughing, eye irritation, loss of sense of smell. Several hours of exposure may result in death within 48 hours.

Health Effects of H_2S Exposure

- At high concentrations it will cause:
  - Shock.
  - Convulsions.
  - Inability to breathe.
  - Coma.
  - Death.
- Long term, low level exposure can have chronic health effects such as:
  - Headaches
  - Irritability.
  - Insomnia and fatigue.
  - Stomach problems and weight loss.

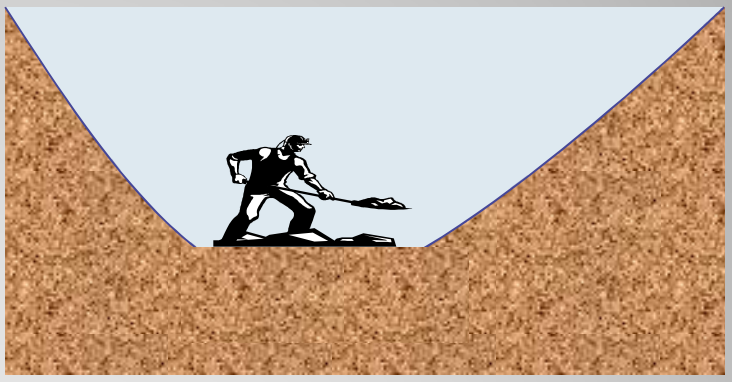
Concentration	Effect
500 PPM – 700 PPM	Loss of consciousness and possibly death within 30 minutes of exposure.
700 PPM – 1,000 PPM	Rapid unconsciousness and death
> 1,000 PPM	Immediate unconsciousness and death.

In liquid form, H_2S is extremely cold and will cause frostbite on contact.

Movement and Collection of H_2S

- H_2S is heavier than air, and may travel along the ground.
- It collects in low, poorly ventilated areas.

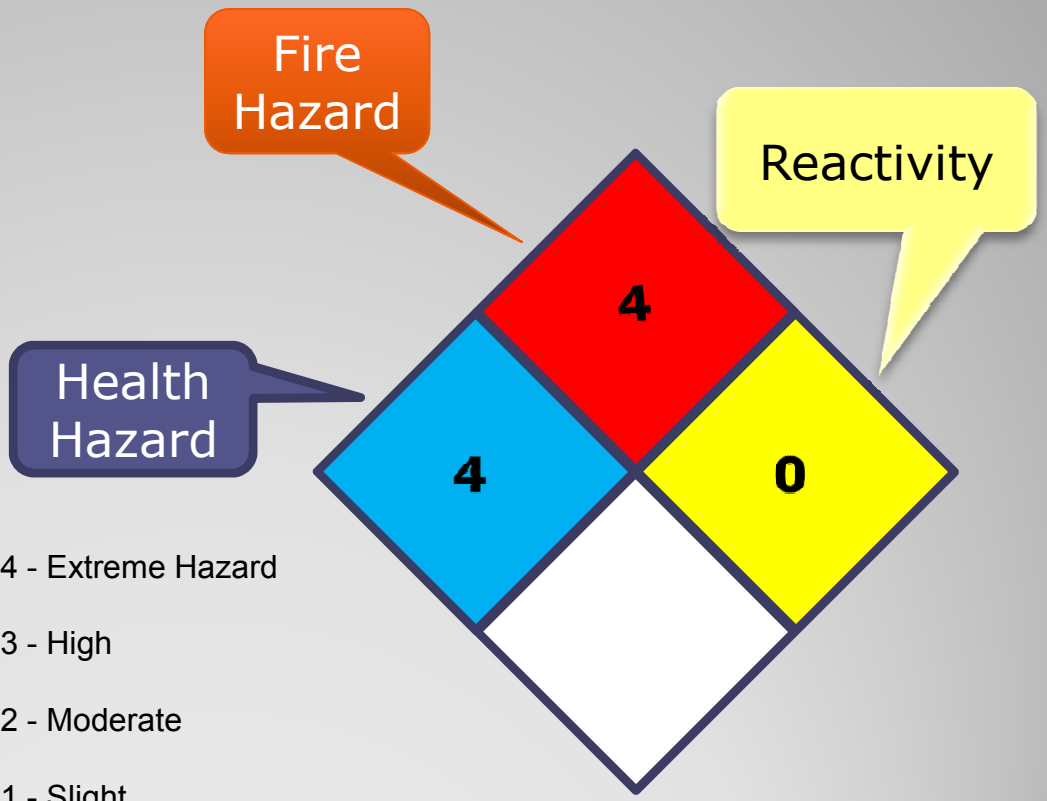
- H_2S may be found in areas such as:
  - Basements.
  - Manholes.
  - Sewer lines.
  - Underground telephone vaults.
  - Manure pits.
  - Confined spaces.
  - Sunken outdoor areas.



Hydrogen sulfide gas moves along the ground with the wind. It can enter low elevation work areas that were previously free of H_2S.

Properties of H_2S

- Aside from being an asphyxiate, H_2S is highly flammable.
- In certain gas/air mixtures it can be explosive.
- Burning H2S produces toxic vapors and gasses, such as sulfur dioxide.



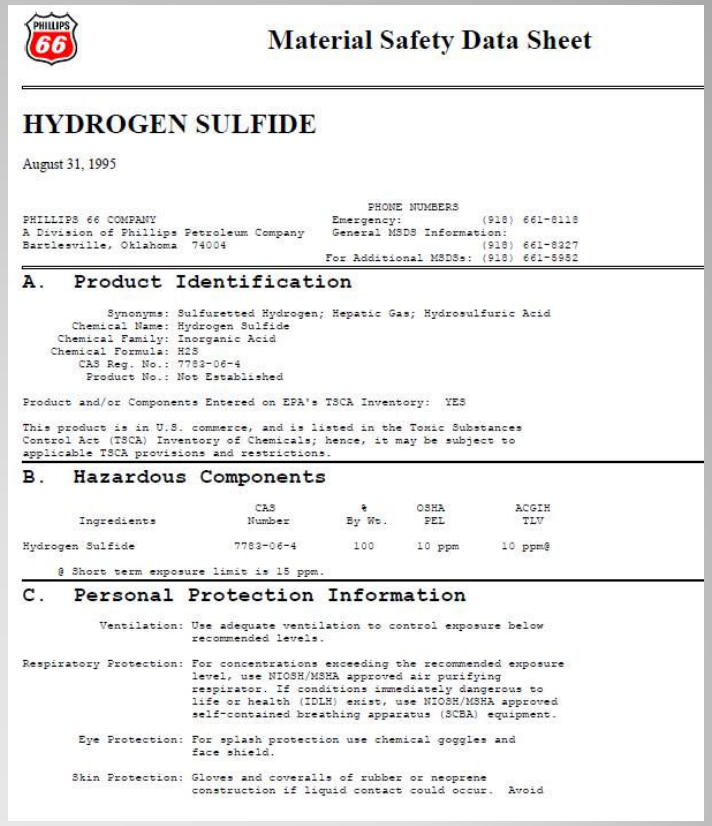
NFPA Hazard Warning

Part II

Hydrogen Sulfide In The Workplace

Material Safety Data Sheets

- A Material Safety Data Sheet (MSDS) is a document that provides information on chemicals.
- The MSDS covers the chemical description and properties, the potential hazards, and all the requirements for safe use.
- A MSDS must be available for each chemical used at the company.
- The company will make them readily available to employees.



Material Safety Data Sheet

HYDROGEN SULFIDE

August 31, 1995

PHILLIPS 66 COMPANY
A Division of Phillips Petroleum Company
Bartlesville, Oklahoma 74004

PHONE NUMBERS
Emergency: (918) 661-8118
General MSDS Information: (918) 661-8927
For Additional MSDSs: (918) 661-5952

A. Product Identification

Synonyms: Sulfuretted Hydrogen; Hepatic Gas; Hydrosulfuric Acid
Chemical Name: Hydrogen Sulfide
Chemical Family: Inorganic Acid
Chemical Formula: H2S
CAS Reg. No.: 7783-06-4
Product No.: Not Established

Product and/or Components Entered on EPA's TSCA Inventory: YES

This product is in U.S. commerce, and is listed in the Toxic Substances Control Act (TSCA) Inventory of Chemicals; hence, it may be subject to applicable TSCA provisions and restrictions.

B. Hazardous Components

Ingredients	CAS Number	% By Wt.	OSHA PEL	ACGIH TLV
Hydrogen Sulfide	7783-06-4	100	10 ppm	10 ppm@

@ Short term exposure limit is 15 ppm.

C. Personal Protection Information

Ventilation: Use adequate ventilation to control exposure below recommended levels.

Respiratory Protection: For concentrations exceeding the recommended exposure level, use NIOSH/MSHA approved air purifying respirator. If conditions immediately dangerous to life or health (IDLH) exist, use NIOSH/MSHA approved self-contained breathing apparatus (SCBA) equipment.

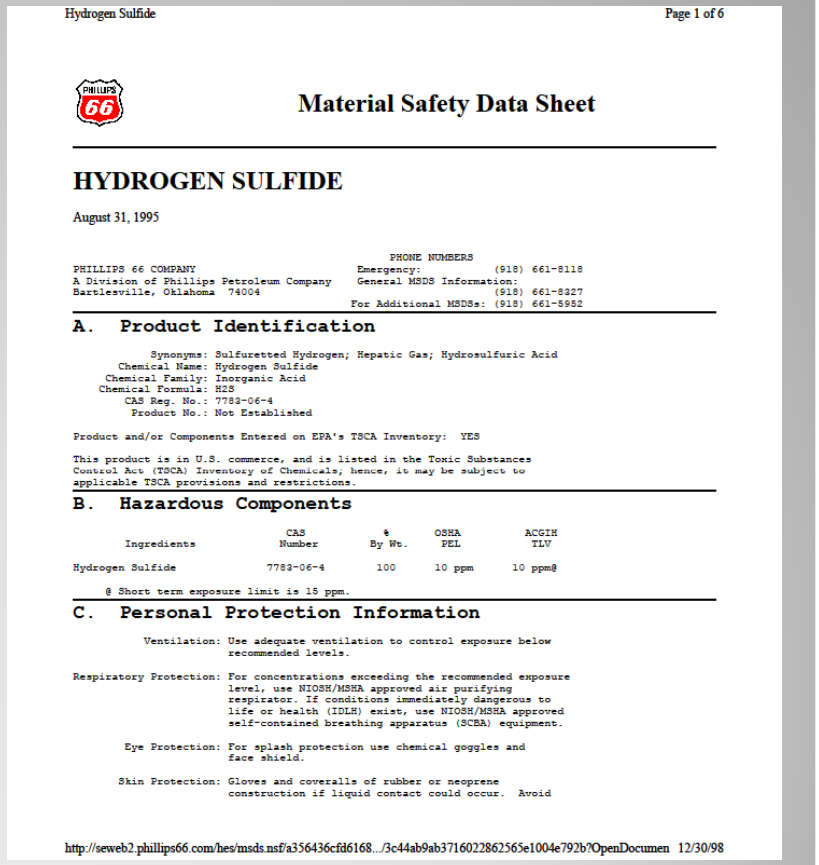
Eye Protection: For splash protection use chemical goggles and face shield.

Skin Protection: Gloves and coveralls of rubber or neoprene construction if liquid contact could occur. Avoid

Employees must review the MSDS before working with a chemical.

Material Safety Data Sheet For H_2S

- The Hydrogen Sulfide Material Safety Data Sheet must be reviewed by every employee.
- The H2S MSDS information includes:
  - Product ID.
  - Hazardous Components.
  - Required PPE.
  - Health Hazard Data.
  - Spill Control Procedures.
  - First Aid Requirements.



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Where is the H_2S MSDS stored at your facility?

Hydrogen Sulfide Storage

- H_2S must be stored in accordance with the requirements of the MSDS.
- Must be kept in an area designated for compressed gas storage.
- Store away from heat, sparks, or flames.
- Make sure the containers are fixed securely to prevent damage.
- H_2S should only be used in closed systems.

Unless H_2S is frequently used for operations, do not store large quantities on site.

Hydrogen Sulfide Storage

- Cylinders must be stored in a way to protect them from damage.
- Containers may not be subjected to temperatures above **125 F**.
- Never heat cylinders to affect the discharge rate.
- Check valves must be used to prevent backflow into the cylinders.
- All nearby electrical equipment should be non-sparking or explosion proof.

H_2S storage and use is covered by the company compressed gas safety program.

H_2S Exposure Limits

- OSHA Permissible Exposure Limit for H_2S is **20 ppm**.
- If no other exposure occurs during an 8 hour work shift, exposure may exceed 20 ppm, but not more than **50 ppm**, for up to 10 minutes.

TABLE Z-2

Substance	8-hour time weighted average	Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift	
			Concentration	Maximum duration
Benzene[a] (Z37.40-1969)	10 ppm	25 ppm	50 ppm	10 minutes.
Beryllium and beryllium compounds (Z37.29-1970)	2 ug/m(3)	5 ug/m(3)	25 ug/m(3)	30 minutes.
Cadmium fume[b] (Z37.5-1970)	0.1 mg/m (3)	0.3 mg/m(3)	.....	
Cadmium dust[b] (Z37.5-1970)	0.2 mg/m (3)	0.6 mg/m(3)		
Carbon disulfide (Z37.3-1968)	20 ppm	30 ppm	100 ppm	30 minutes.
Carbon tetrachloride (Z37.17-1967)	10 ppm	25 ppm	200 ppm	5 min. in any 3 hrs.
Chromic acid and chromates (Z37-7-1971)[c]	.....	1 mg/10 m(3)		
Ethylene dibromide (Z37.31-1970)	20 ppm	30 ppm	50 ppm	5 minutes.
Ethylene dichloride (Z37.21-1969)	50 ppm	100 ppm	200 ppm	5 min. in any 3 hrs.
Fluoride as dust (Z37.28-1969)	2.5 mg/m (3)	.....	.....	
Formaldehyde: see 1910.1048	.....	.....	.....	
Hydrogen fluoride (Z37.28-1969)	3 ppm	.....	.....	
Hydrogen sulfide (Z37.2-1966)	.....	20 ppm	50 ppm	10 mins. once only if no other meas. exp. occurs.
Mercury (Z37.8-1971)		1 mg/10m(3)		

Immediately Dangerous To Life and Health

- H_2S concentrations above **100** ppm are considered to be immediately dangerous to life and health. (IDLH)
- Unprotected entry into IDLH areas can result in immediate injury, illness, or death.
- Never enter an IDLH area unless absolutely necessary.

IDLH area entry requires special procedures and equipment.

Hydrogen Sulfide Monitoring

- H_2S monitoring must be performed by a qualified person using air monitoring equipment.
- The workplace should be checked to see if there is any H_2S exposure.
- The exact concentrations must be known so that appropriate procedures can be used and correct PPE selected.

Gas monitoring and testing should be done by someone specially trained for the task.

Hydrogen Sulfide Locations

- Employers must take steps to eliminate the hydrogen sulfide hazards.
- Work areas that have H_2S exposure hazards must be clearly marked.

What locations at your facility are known to have H_2S hazards?

Engineering Controls

- Before requiring employees to use PPE, the company will attempt to eliminate the hazard using engineering controls.

- This may include:
  - Eliminating the use of H_2S in the workplace.
  - Changing the materials that produce H_2S gas.
  - Adding or increasing ventilation to eliminate the hazard.
  - Moving work outside of H_2S hazard areas.

Elimination of the hazard is always the first priority. Good ventilation can eliminate an H_2S hazard.

Personal Protective Equipment

- If the hazard cannot be eliminated, the employer must provide PPE at no cost to the employees.
- H2S MSDS requires the following PPE:
  - Respiratory protection.
  - Eye and face protection.
  - Gloves and coveralls to protect the skin if liquid contact could occur.

What type of PPE is required at your facility?

Respiratory Protection

- Companies that require employees to wear respiratory protection must have:
  - A written respirator safety program.
  - Training on the use of respirators.
  - Fit testing.
  - Medical screenings for employees who use respirators.
  - A program for selecting and providing appropriate respirators.

Full face piece respirators will provide face and eye protection as well as respiratory protection.

Respirator Selection – Cartridge Types

- Air purifying respirators have different types of cartridges for different hazards.
- The proper cartridge must be selected in order to provide protection from the existing atmospheric hazards.
- Cartridges are colored by the types of contaminates they filter.
- If a respirator cartridge does not have an "end of life" indicator, a set cartridge change out schedule must be used.

Make sure the cartridge selected is designed to filter Hydrogen Sulfide.

Respirator Selection – Assigned Protection Factors

- Respirators are rated by their Assigned Protection Factor (APF).
- A respirator with an APF of 10 will reduce the airborne particulates by a factor of 10.
- If an air contaminant has a Permissible Exposure Limit of 10 ppm, and the respirator has an APF of 10, the maximum concentration that an employee can work in is 100 ppm.

Type of respirator[1, 2]	Quarter mask	Half mask	Full facepiece	Helmet/ hood	Loose-fitting facepiece
1. Air-Purifying Respirator	5	[3]10	50	.....	.....
2. Powered Air-Purifying Respirator (PAPR)	.....	50	1,000	[4]25/1,000	25
3. Supplied-Air Respirator (SAR) or Airline Respirator					
• Demand mode	.....	10	50	.....	.....
• Continuous flow mode	.....	50	1,000	[4]25/1,000	25
• Pressure-demand or other positive-pressure mode	.....	50	1,000	.....	.....
4. Self-Contained Breathing Apparatus (SCBA)					
• Demand mode	.....	10	50	50	.....
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	.....	.....	10,000	10,000	.....

What is the APF of the respirator that you use?

NIOSH APF Recommendations For H_2S

For Concentrations up to 100 PPM	
Respirator Type	**Recommended APF**
Powered, air purifying respirator.	25
Air purifying, full face piece respirator.	50
Supplied air respirator.	10
Self-contained breathing apparatus (SCBA) with full face piece.	50
Emergency Entry / Unknown Concentrations / IDLH	
SCBA with full face piece in a positive pressure mode.	10,000
Supplied air respirator in positive pressure mode.	10,000
Emergency Escape	
Appropriate escape respirator	50

Emergency Escape Respirators

- Respirators designated for emergency escape may not be used for any other purpose.
- NIOSH recommends an air purifying respirator with an APF of 50, or a self-contained breathing apparatus.

Locations of emergency escape respirators must be clearly marked.

H_2S Monitoring Equipment

- Areas with known H_2S hazards should have monitoring equipment that can alert workers when levels are unsafe.
- Workers may also use personal monitoring equipment.

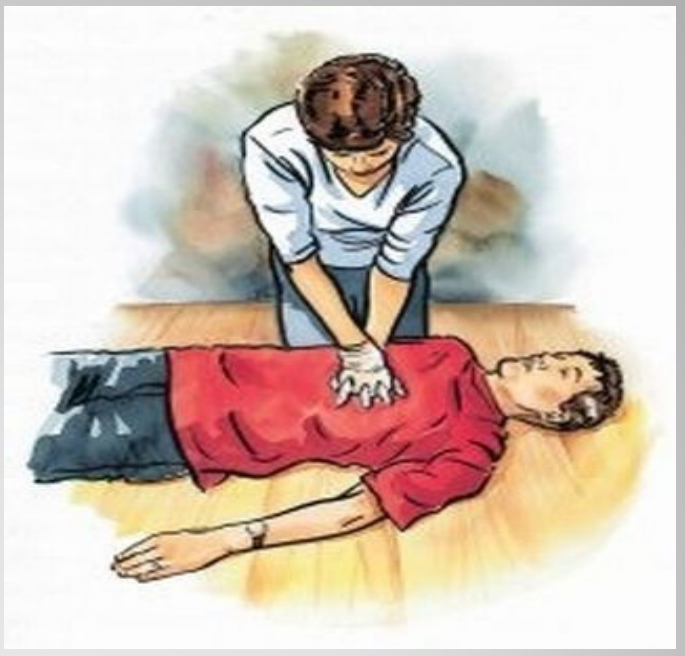
H_2S First Aid

- For eye contact:
  - Flush eyes with running water for at least 15 minutes.
- For skin contact:
  - Wash skin with soap and water for at least 15 minutes.

Flush eyes in an eye wash station. If illness or adverse symptoms develop, seek medical attention.

H_2S First Aid

- For inhalation of H_2S:
  - Immediately remove from exposure. If breathing is difficult, give oxygen. If breathing ceases, administer CPR.
- For ingestion:
  - Seek medical attention.



Prompt medical attention is required for all cases of overexposure.

Part III

Entering Spaces With H_2S Hazards

Is Entry Really Necessary?

- Before requiring workers to enter H_2S spaces, an evaluation should be done to see if entry is really necessary.
- Sometimes work can be done from outside the space.
- Systems can be redesigned to remove the equipment from the space, eliminating the need for entry.

What is a Confined Space?

- A Confined Space is one where:

1. It has a restricted opening making entry and exit difficult.
2. It is large enough for a whole person to enter.
3. It is not designed to be occupied.

Is a walk in freezer a confined space?

Yes **No**

Permit Required Confined Spaces

- A confined space requires an entry permit when it has **any one** of the following:

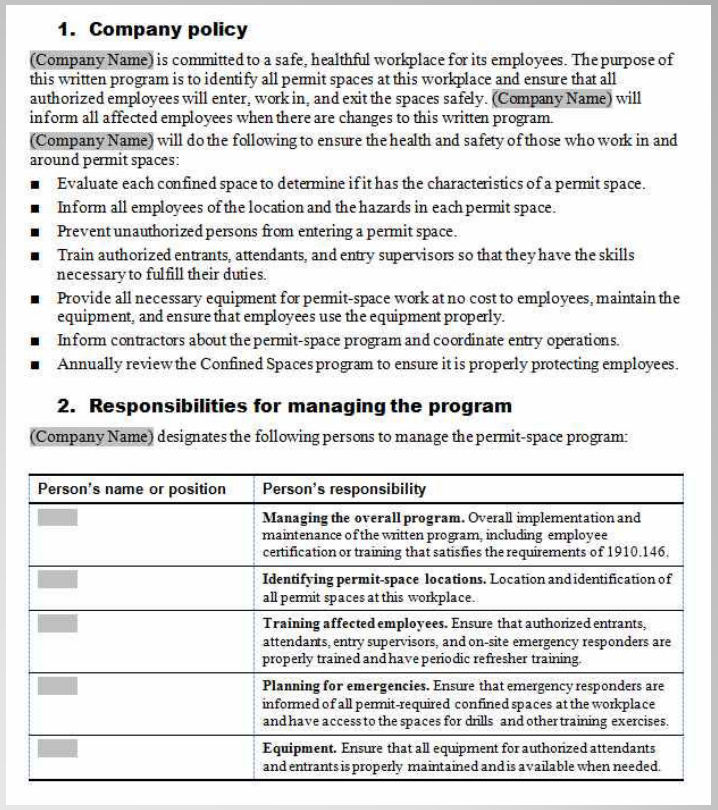
1. An atmospheric hazard. (Real or potential)
2. The potential for entrapment or engulfment.
3. It is in a hazardous configuration.
4. It contains any other serious safety or health hazard.

Spaces with H_2S have an atmospheric hazard, which makes it a **permit required confined space**.

These hazards must be dealt with prior to entry!

Confined Space Program

- Companies with confined spaces must have:
  - A written confined space entry plan.
  - Confined space training for workers.
  - Confined space permit program.



1. Company policy

(Company Name) is committed to a safe, healthful workplace for its employees. The purpose of this written program is to identify all permit spaces at this workplace and ensure that all authorized employees will enter, work in, and exit the spaces safely. (Company Name) will inform all affected employees when there are changes to this written program.

(Company Name) will do the following to ensure the health and safety of those who work in and around permit spaces:

- Evaluate each confined space to determine if it has the characteristics of a permit space.
- Inform all employees of the location and the hazards in each permit space.
- Prevent unauthorized persons from entering a permit space.
- Train authorized entrants, attendants, and entry supervisors so that they have the skills necessary to fulfill their duties.
- Provide all necessary equipment for permit-space work at no cost to employees, maintain the equipment, and ensure that employees use the equipment properly.
- Inform contractors about the permit-space program and coordinate entry operations.
- Annually review the Confined Spaces program to ensure it is properly protecting employees.

2. Responsibilities for managing the program

(Company Name) designates the following persons to manage the permit-space program:

Person's name or position	Person's responsibility
	Managing the overall program. Overall implementation and maintenance of the written program, including employee certification or training that satisfies the requirements of 1910.146.
	Identifying permit-space locations. Location and identification of all permit spaces at this workplace.
	Training affected employees. Ensure that authorized entrants, attendants, entry supervisors, and on-site emergency responders are properly trained and have periodic refresher training.
	Planning for emergencies. Ensure that emergency responders are informed of all permit-required confined spaces at the workplace and have access to the spaces for drills and other training exercises.
	Equipment. Ensure that all equipment for authorized attendants and entrants is properly maintained and is available when needed.

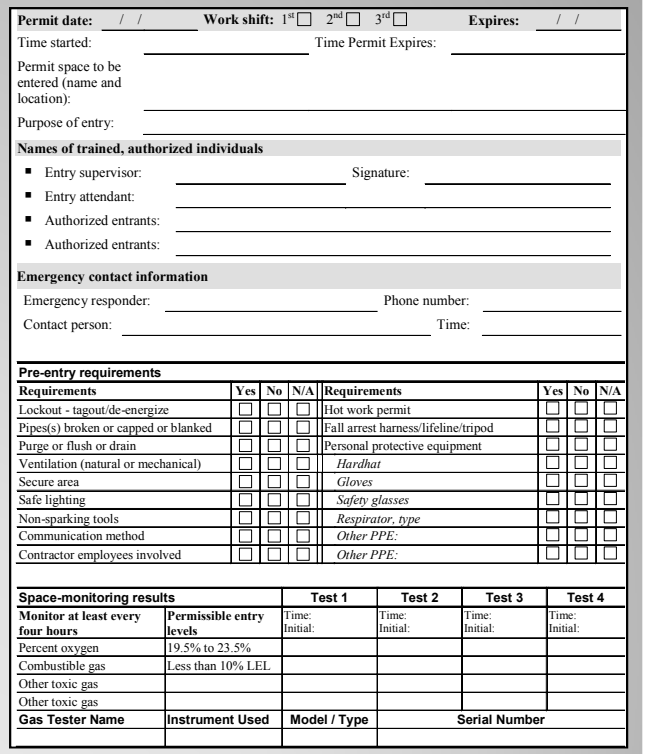
Workers who enter confined spaces must complete company confined space safety training.

Entry Permits

- All entry permits must contain:

1. Entry Purpose
2. Space to be entered
3. Date & duration
4. Authorized entrants
5. Attendants
6. Space Hazards
7. Isolation measures
8. Entry supervisor signature
9. Acceptable Entry Conditions
10. Test results with name of tester and the time
11. Rescue services available and how to contact
12. Communication Procedures
13. Necessary equipment for entry
14. Additional required permits
15. Other necessary information for a safe entry

Cancelled (Completed) permits must be retained at least one year .



Permit date: / / **Work shift:** 1st ☐ 2nd ☐ 3rd ☐ **Expires:** / /

Time started: Time Permit Expires:

Permit space to be entered (name and location):

Purpose of entry:

Names of trained, authorized individuals

- Entry supervisor: Signature:
- Entry attendant:
- Authorized entrants:
- Authorized entrants:

Emergency contact information

Emergency responder: Phone number:

Contact person: Time:

Pre-entry requirements

Requirements	Yes	No	N/A	Requirements	Yes	No	N/A
Lockout - tagout/de-energize	☐	☐	☐	Hot work permit	☐	☐	☐
Pipes(s) broken or capped or blanked	☐	☐	☐	Fall arrest harness/lifeline/tripod	☐	☐	☐
Purge or flush or drain	☐	☐	☐	Personal protective equipment	☐	☐	☐
Ventilation (natural or mechanical)	☐	☐	☐	*Hardhat*	☐	☐	☐
Secure area	☐	☐	☐	*Gloves*	☐	☐	☐
Safe lighting	☐	☐	☐	*Safety glasses*	☐	☐	☐
Non-sparking tools	☐	☐	☐	*Respirator, type*	☐	☐	☐
Communication method	☐	☐	☐	*Other PPE:*	☐	☐	☐
Contractor employees involved	☐	☐	☐	*Other PPE:*	☐	☐	☐

Space-monitoring results		Test 1	Test 2	Test 3	Test 4
Monitor at least every four hours	**Permissible entry levels**	Time: Initial:	Time: Initial:	Time: Initial:	Time: Initial:
Percent oxygen	19.5% to 23.5%				
Combustible gas	Less than 10% LEL				
Other toxic gas					
Other toxic gas					
Gas Tester Name	**Instrument Used**	**Model / Type**	**Serial Number**		

A Sample Confined Space Entry Permit

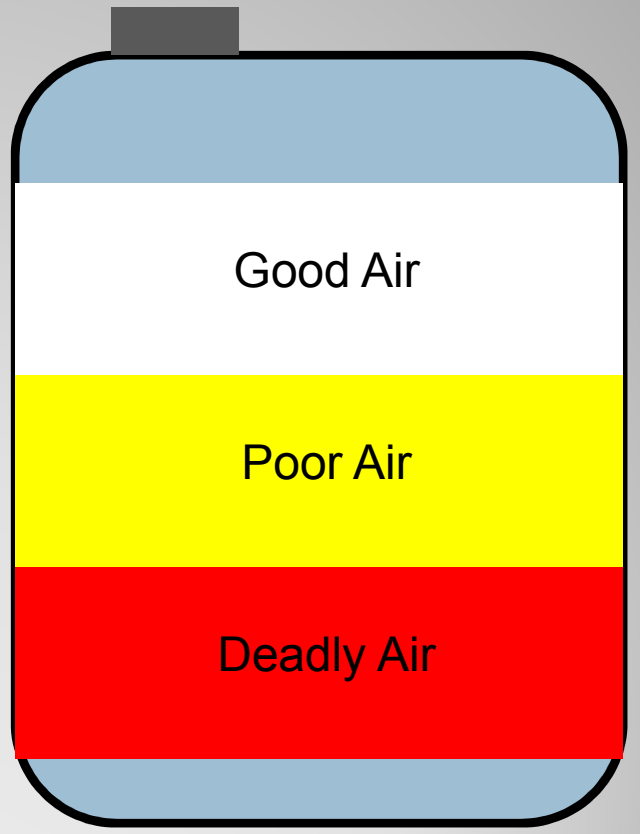
Testing A Space For H_2S

- Air must be tested for the presence and concentration of H_2S.
- Testing must be done by a qualified person using detector tubes or multi-gas meters.

Who at your facility is qualified to test spaces for H_2S?

Testing The Atmosphere

- Be sure to test the atmosphere at different levels in the space.
- Good air near the opening of the space does not mean that there is good air at the bottom.
- Remember that respirators will not protect employees from low oxygen environments.



Ventilating A Space

- If the gas is present, the space must be ventilated continuously to remove the gas.
- If the gas cannot be removed, the person entering the space must use appropriate respiratory protection and PPE.

Working In An H_2S Space

- When workers are exposed to H_2S, levels should be continuously monitored.
- Workers must be monitored for signs of overexposure.

An attendant must monitor workers for signs of exposure.

IDLH Atmospheres

- A level of H_2S has at or above 100 ppm is Immediately Dangerous to Life and Health.
- IDLH spaces can only be entered with one of the following:
  - A full face piece pressure demand self-contained breathing apparatus.
  - A combination full face piece pressure demand supplied-air respirator with an auxiliary self-contained air supply.

Never enter IDLH spaces unless absolutely necessary. Use special procedures developed by the employer.

Evacuating A Space

- Evacuate the space whenever:
  - A safety monitor tells you to evacuate.
  - When a gas monitoring alarm sounds.
  - Whenever there are signs that unsafe exposure has occurred.
- Evacuate to a designated safe area. If none is available, move to higher ground or upwind.

Are there designated safety areas at your facility? Where are they?

Rescue Plan

- A rescue plan must be in place for employees who work in H_2S hazard areas.
- It should include rescue procedures and a designated safe area.
- All affected employees must be trained on the rescue plan.

Never deviate from the rescue plan. Most H_2S fatalities occur when a worker enters a space to assist an injured person. Non-entry rescue is the preferred method.

Part IV

Summary

Summary

- Hydrogen sulfide is a deadly gas produced from the biological decay of organic matter, and is naturally present in petroleum and natural gas.
- Hydrogen sulfide smells like rotten eggs at low concentrations, and has no smell at higher concentrations.
- Employers should use engineering and administrative controls to eliminate H_2S hazards.
- Respirators must be worn to minimize hazard exposure.
- Never deviate from an established rescue plan.

Questions?