YOUR SAFETY Department
SAFETY Solutions

Hydrogen Sulfide

Safety & Health Topics

Safety Solutions Made Simple

Hydrogen sulfide (also known as H_2S, sewer gas, swamp gas, stink damp, and sour damp) is a colorless gas known for its pungent "rotten egg" odor at low concentrations. It is extremely flammable and highly toxic.

Hydrogen sulfide is used or produced in a number of industries, such as:

- Oil and gas refining
- Mining
- Tanning
- Pulp and paper processing
- Rayon manufacturing

Hydrogen sulfide also occurs naturally in sewers, manure pits, well water, oil and gas wells, and volcanoes. Because it is heavier than air, hydrogen sulfide can collect in low-lying and enclosed spaces, such as manholes, sewers, and underground telephone vaults. Its presence makes work in confined spaces potentially very dangerous.

The health effects of hydrogen sulfide depend on how much H2S a worker breathes and for how long. However, many effects are seen even at low concentrations. Effects range from mild, headaches or eye irritation, to very serious, unconsciousness and death.

HIGHLIGHTS

HYDROGEN SULFIDE IS ONE OF THE LEADING CAUSES OF WORKPLACE GAS INHALATION DEATHS IN THE UNITED STATES. ACCORDING TO THE BUREAU OF LABOR STATISTICS (BLS), HYDROGEN SULFIDE CAUSED 60 WORKER DEATHS BETWEEN 2001 AND 2010.

Why is hydrogen sulfide so deadly?

- It is highly flammable and toxic, even at low concentrations.
- It is heavier than air and may travel along the ground.
- It can build up in low-lying areas, and in confined spaces (including enclosed, poorly ventilated areas, such as manure pits, sewers, manholes, and underground vaults).
- After a while at low or more quickly at high concentrations, you can no longer smell it to warn you it's there.
- It can quickly, almost immediately, overcome unprepared workers, including rescue workers.

Hazards

Health Hazards

Hydrogen sulfide gas causes a wide range of health effects. Workers are primarily exposed to hydrogen sulfide by breathing it. The effects depend on how much hydrogen sulfide you breathe and for how long.

Exposure to very high concentrations can quickly lead to death.

Short-term (also called acute) symptoms and effects are shown below:

Concentration (ppm)	Symptoms/Effects
0.00011-0.00033	Typical background concentrations
0.01-1.5	Odor threshold (when rotten egg smell is first noticeable to some). Odor becomes more offensive at 3-5 ppm. Above 30 ppm, odor described as sweet or sickeningly sweet.
2-5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Airway problems (bronchial constriction) in some asthma patients.
20	Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness.
50-100	Slight conjunctivitis ("gas eye") and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite.
100	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
100-150	Loss of smell (olfactory fatigue or paralysis).
200-300	Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure.
500-700	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1000	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.
1000-2000	Nearly instant death

Worker Exposure Limits
NIOSH REL (10-min. ceiling): 10 ppm
OSHA PELs: General Industry Ceiling Limit: 20 ppm General Industry Peak Limit: 50 ppm (up to 10 minutes if no other exposure during shift) Construction 8-hour Limit: 10 ppm

Shipyard 8-hour limit: 10 ppm
NIOSH IDLH: 100 ppm
IDLH: immediately dangerous to life and health (level that interferes with the ability to escape) (NIOSH) **PEL:** permissible exposure limit (enforceable) (OSHA) **ppm:** parts per million **REL:** recommended exposure limit (NIOSH)

What about longer term health effects?

Some people who breathed in levels of hydrogen sulfide high enough to become unconscious continue to have headaches and poor attention span, memory, and motor function after waking up.

Problems with the cardiovascular system have also been reported at exposures above permissible exposure limits. People who have asthma may be more sensitive to hydrogen sulfide exposure. That is,

EXPLOSIVE RANGE

THE EXPLOSIVE RANGE OF HYDROGEN SULFIDE IN AIR IS 4.5 TO 45.5 PERCENT. THIS RANGE IS MUCH HIGHER THAN THE PEL.

they may have difficulty breathing at levels lower than people without asthma.

Safety Hazards

- Hydrogen sulfide is a highly flammable, explosive gas, and can cause possible life-threatening situations if not properly handled. In addition, hydrogen sulfide gas burns and produces other toxic vapors and gases, such as sulfur dioxide.
- In addition to exposure to hydrogen sulfide in the air, exposure to liquid hydrogen sulfide can cause "blue skin" or frostbite. If clothing becomes wet, avoid ignition sources, remove the clothing and isolate it in a safe area to allow it to evaporate.
- The effect called knockdown (rapid unconsciousness) often results in falls that can seriously injure the worker.

Hydrogen Sulfide in Workplaces

Hydrogen sulfide is produced naturally from decaying organic matter. It can be released from sewage sludge, liquid manure, and sulfur hot springs, and with natural gas. It is also used or 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

Many workers are at risk for exposure to hydrogen sulfide, 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.
- Workers in oil and natural gas drilling and refining may be exposed because hydrogen sulfide may be present in oil and gas deposits and is a by-product of the desulfurization process of these fuels.

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

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

CONFINED SPACE ENTRY

FOLLOW OSHA REQUIREMENTS FOR CONFINED SPACE ENTRY. ENTER THE SPACE ONLY IF NECESSARY AND FOLLOW ESTABLISHED PROCEDURES:

- TEST (MONITOR) THE AIR IN THE SPACE FROM THE OUTSIDE BEFORE ENTERING.
- TEST (MONITOR) THE AIR IN THE SPACE CONTINUOUSLY DURING WORK OPERATION.
- DETERMINE IF ENTRY PERMIT IS REQUIRED.
- VENTILATE AREA CONTINUOUSLY TO REMOVE ACCUMULATED HYDROGEN SULFIDE.
- MAKE SURE THAT RESCUE PROCEDURES, PERSONNEL, AND EQUIPMENT (E.G.,

Evaluating and Controlling Exposure

To protect workers from harmful hydrogen sulfide exposures:

- Evaluate exposure to know whether H_2S gas is present and at what levels.
- Eliminate the source of hydrogen sulfide whenever possible.
- If the source cannot be eliminated, control exposures by:
  - Using engineering controls as the next best line of defense.
  - Developing administrative controls and safe work practices to reduce exposures to safe levels.
  - Use personal protective equipment if engineering controls and work practices alone cannot reduce hydrogen sulfide to safe levels.

Evaluate Exposure

- Identify processes that could release or produce hydrogen sulfide. This includes identifying known sources of hydrogen sulfide and evaluating possible fire and explosion hazards. Use a Process or Job Hazard Analysis for identifying and controlling hazards
- Test (monitor) the air for hydrogen sulfide. This must be done by a qualified person. Use the right test equipment, such as an electronic meter that detects hydrogen sulfide gas.
- Conduct air monitoring prior to and at regular times during any work activity where hydrogen sulfide exposure is possible. When working in confined spaces air monitoring must be conducted in accord with the applicable OSHA standards. Detector tubes, direct reading gas monitors, alarm only gas monitors, and explosion meters are examples of monitoring equipment that may be used to test permit space atmospheres.

DO NOT rely on your sense of smell to indicate the continuing presence of hydrogen sulfide or to warn of harmful levels. You can smell the "rotten egg" odor of hydrogen sulfide at low concentrations in air. But after a while, you lose the ability to smell the gas even though it is still present (olfactory fatigue). This loss of smell can happen very rapidly and at high concentrations and the ability to smell the gas can be lost instantly (olfactory paralysis).

Control Exposures

- Use exhaust and ventilation systems to reduce hydrogen sulfide levels. Make sure that the system is:
  - Non-sparking
  - Grounded
  - Corrosion-resistant
  - Separate from other exhaust ventilation systems
  - Explosion-proof

  These safety measures are important because hydrogen sulfide is flammable and can corrode materials if they are not properly protected. When working in confined spaces ventilation should operate continuously and must be conducted in accord with the applicable OSHA standards.
- Train and educate workers about hazards and controls. Training topics may include:

- Characteristics, sources and health hazards of hydrogen sulfide
- Symptoms of hydrogen sulfide exposure
- Types of hydrogen sulfide detection methods and applicable exposure limits
- Workplace practices and procedures to protect against hydrogen sulfide exposure
- Emergency plans, locations of safety equipment, rescue techniques, first-aid
- Confined space procedures

- Establish proper rescue procedures to safely rescue someone from a hydrogen sulfide exposure.

  WARNING: First responders must be trained and properly protected before entering areas with elevated levels of hydrogen sulfide.

  Rescuer protection should include:

  - Positive-pressure, self-contained breathing apparatus (SCBA).
  - A safety line to allow for rapid exit if conditions become dangerous.

- Use respiratory and other personal protective equipment. If engineering and administrative controls cannot reduce hydrogen sulfide below OSHA's permissible exposure limit, employers must provide respiratory protection and other personal protective equipment (PPE), such as eye protection and possibly fire-resistant clothing. Employers must complete a PPE hazard assessment and equipment selection process in accord with the OSHA regulations before beginning any work activities. Respiratory protection should be at least:

  - For exposures at or above 10 ppm, use a full face pressure demand self-contained breathing apparatus (SCBA) with a minimum service life of thirty minutes or a combination full face pressure demand supplied-air respirator with an auxiliary self-contained air supply.

  - Exposures at or above 100 ppm are considered immediately dangerous to life and health (IDLH).

- Whenever respirators are used, the employer must have a respiratory protection program that meets the requirements of OSHA's Respiratory Protection standard (29 CFR 1910.134). This program must include proper respirator selection, fit testing, medical evaluations, and training.

Release of H_2S

All personnel working in an area where concentrations of Hydrogen Sulfide may exceed the 10 parts per million (ppm) should be provided with training before beginning work assignments.

Potential Hazard:

- H_2S exposure greater than the Permissible Exposure Limit (PEL).

Possible Solutions:

Implement an H_2S contingency plan (see API) including, but not limited to:

- Appropriate instruction in the use of hydrogen sulfide safety equipment to all personnel present at all hydrogen sulfide hazard areas.

- Gas detection where hydrogen sulfide may exist.

- Appropriate respiratory protection for normal and emergency use. [29 CFR 1910.134]

Comprehensive training should be provided for workers in H2S operations. Example topics include:

- Identification of the characteristics, sources, and hazards of Hydrogen Sulfide.

- Proper use of the Hydrogen Sulfide detection methods used on the site.

- Recognition of, and proper response to, Hydrogen Sulfide warnings at the workplace.

- Symptoms of Hydrogen Sulfide exposure.
- Proper rescue techniques and first-aid procedures to be used in a Hydrogen Sulfide exposure.
- Proper use and maintenance of personal protective equipment. Demonstrated proficiency in using PPE should be required.
- Worker awareness and understanding of workplace practices and maintenance procedures to protect personnel from exposure to hydrogen sulfide.
- Wind direction awareness and routes of egress.
- Confined space and enclosed facility entry procedures.
- Locations and use of safety equipment.
- Locations of safe briefing areas.
- Use and operation of all Hydrogen Sulfide monitoring systems.
- Emergency response procedures, corrective action, and shutdown procedures.
- Effects of Hydrogen Sulfide on the components of the Hydrogen Sulfide handling system.
- The importance of drilling fluid treating plans prior to encountering Hydrogen Sulfide.

Metal Fatigue

Metal fatigue, including hydrogen embrittlement or sulfide stress cracking, can result in a release of hydrogen sulfide gas.

Potential Hazard:

- Being exposed to Hydrogen Sulfide.
- Getting Injured due to equipment failure.

Possible Solutions:

- Select materials in accordance with the MR0175/ISO15156 criteria for H_2S service.
  - MR 0175C, Metals for Sulfide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments.
  - National Association of Corrosion Engineers (NACE), (2003, December) [Also ISO 15156, Petroleum and natural gas industries-Materials for use in H_2S containing environments in oil and gas production, International Standards Organization (ISO)].
- Treat drilling fluids to chemically reduce corrosion failures.

Accumulation of H_2S

It is possible for hydrogen sulfide gas to accumulate in any low or enclosed area, such as a gas venting system, mud system, cellars, pits, and tanks.

Potential Hazard:

- Being exposed to Hydrogen Sulfide.

Possible Solutions:

- Provide adequate ventilation for the removal of any accumulation of H_2S.
- Implement effective confined space entry program.