H_2S: Hazards and Safety Practices

STANLEY D. ATHERTON
Getty Oil Company

Hydrogen sulfide gas is encountered in various petroleum operations, from the drilling operation through to and including the refining process; therefore, we must be aware of its properties, its toxicity and how to circumvent employee exposure to the acidic gas.

Hydrogen sulfide (H_2S) is a colorless gas with a definite odor that is generally referred to as the smell of rotten eggs. The odor itself is not reliable as an indicator to warn that it is in dangerous concentrations because the higher concentrations have a paralyzing effect on the olfactory nerves. H_2S, even in low concentrations, irritates the eyes and respiratory tract. Also, inceased concentrations of H_2S become progressively more harmful. Inhalation of high concentrations of H_2S can cause death immediately.

H_2S is dangerously reactive with strong acids and oxidizing materials. Also, in concentrations of 4.3 to 46 percent by volume in air, it explodes upon ignition. A mixture of two volumes of hydrogen sulfide and three of oxygen explodes violently upon ignition. The H_2S vapor is like that of other flammable liquid vapors in that it is heavier than air and may travel a considerable distance to a source of ignition and flash back. These properties are listed in Table 1.

TABLE 1
PROPERTIES OF HYDROGEN SULFIDE

Chemical Name	Hydrogen Sulfide
Chemical Symbol	H_2S
Color	Colorless gas with odor of rotten eggs
Explosive Limits	4.3 to 46 percent by volume in air
Specific Gravity	1.54
Vapor Density	1.189 (Air = 1.0) at 15°C
Ignition Temperature	260°C (500°F.)
Threshold Limit Value (TLV)	10 ppm or 15 Mg/M^3

The generally accepted threshold limit value of 10 parts per million is the Maximum Allowable Concentration that a person may be exposed to without respiratory protection equipment for eight hours per working day. Concentrations as low as 150 ppm may cause severe irritation to the eyes and respiratory tract if exposure lasts through the working day. Exposures of 800 to 1000 ppm may be fatal in a few minutes.

A pre-employment physical examination should be made. Workers with eye and nervous diseases or those having any severe illness should not be employed in operations having potential H_2S exposure.

Those persons assigned to work in areas where sour crude is handled must be properly trained in the use of U.S. Bureau of Mines-approved breathing apparatus for the H_2S concentration involved. These concentrations may be determined with a hydrogen sulfide detector which is applicable for low concentration, or by the Tutwiler Test for concentrations above that which the hand-held instrument can read. Other test procedures similar to the Tutwiler Test are also suitable.

Personnel should be provided a handy conversion table for hydrogen sulfide (see Table 2).

Workers who are to work on jobs where hydrogen sulfide is used or otherwise involved, must be given clear instructions relative to the type of approved breathing apparatus to be worn for the H_2S concentration involved. U.S. Bureau of Mines-approved breathing apparatus for H_2S can be worn for the concentrations shown in Table 3.

Approved self-contained breathing apparatus or approved hoseline mask (positive displacement blower or positive supplied air) may be used in any H_2S atmosphere (less or greater than two percent) in which protection of the respiratory tract only is required. This would include oxygen-deficient atmosphere and confined spaces.

(The approved breathing apparatus provides protection of the respiratory tract only. It does not protect against absorption through the skin. Persons with a perforated ear drum should not be exposed to concentrations of H_2S with or without respiratory protection equipment.)

TABLE 2

CONVERSIONS FOR HYDROGEN SULFIDE

Grain*/ 100 cu ft of Air	Volume of H_2S in Air (percent)	Parts per Million (ppm)	Effect Upon Exposure
0.61	0.001	10	Maximum Allowable Concentration for eight-hour exposure.
3.03	0.005	50	Slight conjunctivitis and irritation of respiratory tract after one-hour exposure.
6.06	0.01	100	Coughing, eye irritation and loss of sense of smell after 2 to 15 minutes. Altered respiration, pain in eyes, and drowsiness after 15 to 30 minutes, followed by throat irritation after one hour. Prolonged exposure results in a gradual increase in the severity of these symptoms.
12.1-18.2	0.02-0.03	200-300	Marked conjunctivitis and respiratory tract irritation after one hour of exposure.
30.3-42.4	0.05-0.07	500-700	Loss of consciousness and possibly death in 1/2 hour.
42.4-54.5	0.07-0.09	700-900	Rapidly produces unconsciousness, cessation of respiration, and death.
60.6	0.1	1000	Unconsciousness at once with early cessation of respiration, and death in a few minutes. Death may occur even if individual is removed to fresh air at once. Higher concentrations are fatal.

*1 grain equals 16.51 ppm.

The health and safety of workers are of prime importance, especially when they are working in an area wherein exposure to H_2S is possible. Although training and retraining of employees in the hazards involved with H_2S is essential, it is also necessary to post health and safety notices to remind workers of that hazard. It may be appropriate to review such a health and safety notice with workers at the job site before starting a work assignment involving H_2S. Table 4 is a simplified notice that points out essential information for such a quick, ready review and reference.

TABLE 3

USBM DATA ON H_2S BREATHING APPARATUS

Grain/ 100 cu ft of Air	Volume of H_2S in Air (percent)	Parts per Million (ppm)	Remarks
0.61	0 to 0.001	0 to 10	Respiratory protection equipment not required for H_2S concentrations of 10 ppm or less.
	above 0.001 to 2	above 10 to 20,000	USBM-approved H_2S canister gas mask can be worn in H_2S concentrations at or below 20,000 ppm. (2 percent H_2S); however, it cannot be worn in oxygen deficient atmospheres. NOTE: Use of approved H_2S canister mask in H_2S concentrations greater than 2 percent may be fatal.
	Any volume	Any concentration	Self-contained breathing apparatus or approved hose-line mask (USBM-approved) can be worn, in atmospheres including those that are oxygen deficient, and in confined spaces.

TABLE 4

HYDROGEN SULFIDE GAS-HEALTH AND SAFETY

WHAT IS HYDROGEN SULFIDE?—Hydrogen Sulfide (H_2S) is a ***very poisonous gas,*** heavier than air, with an odor somewhat like rotten eggs. Hazards are poisoning by inhalation and the formation of ignitible mixture with air—caution, ***Highly Flammable.*** The gas is colorless and can be detected safely and accurately only by a gas test, and momentarily by the odor. Its toxic effects are noncumulative and a person will fully recover from irritation if he proceeds to fresh air promptly on detection of the gas. Inhalation of concentrations exceeding 10 ppm with air may cause death, based on concentration involved. ***Respiratory protection is required above 10 ppm. Approved Canister Gas Masks*** can be used in concentrations of 2 percent (20,000 ppm) or less. ***Self-contained breathing apparatus,*** air line mask or like approved equipment, is to be worn where concentrations are 2 percent or greather.

PRECAUTIONS — 1. Know exactly what H_2S concentrations exist by location under normal operation and what concentrations to expect under abnormal operation conditions.

2. Prevent the escape of gas into work places. Report and record all leaks, breaks or other malfunction of equipment. Records are important to develop preventive measures. ***Use approved respiratory equipment when repairing, cleaning-up, sampling and gauging.***

3. Always maintain best ventilation possible, work on upwind side of vapor release with approved respiratory equipment.

4. If the odor of hydrogen sulfide is very noticeable, it constitutes a definite warning—H_2S rapidly DEADENS THE SENSE OF SMELL, so don't rely on your nose. Warn others of hazard and blockade work area until area is properly checked and found to be free of poisonous gas.

5. If caught in a pocket of H_2S gas, proceed crosswise to the direction of the wind. Remain to the windward side until approved respiratory equipment is donned, then control release, check area for gas-free condition.

FIRST AID—The symptoms of H_2S are irritation of eyes and throat, dull oppressed headache, followed by panting respiration, pallor, cramps and paralysis of the pupils and limbs. The following things should be immediately done

in the order named:

1. Put on approved respiratory equipment and remove victim at once to fresh air. Attempting rescue without approved respiratory equipment can be fatal.
2. If victim has stopped breathing, apply mouth-to-mouth resuscitation or other approved artificial respiration immediately upon reaching fresh air.
3. Seek medical assistance as quickly as possible.