

CGA G-12 — 2023

6TH EDITION

HYDROGEN SULFIDE

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Work Item 22-17
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NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendix A (Informative) is for information only.

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Contents	Page
1 Introduction.....	1
2 Scope	1
3 Definitions.....	1
4 Manufacture, properties, and uses.....	1
4.1 Manufacture.....	1
4.2 Properties	2
4.3 Commercial applications	5
5 Hazards and safety	5
5.1 Introduction.....	5
5.2 Flammability	5
5.3 Toxicity	5
5.4 Low temperature hazards.....	9
5.5 Corrosion hazards	9
5.6 General rules for using hydrogen sulfide gas safely.....	9
5.7 Handling of emergencies.....	10
6 General regulations	11
6.1 Jurisdiction of regulatory authority.....	11
6.2 Classification of hydrogen sulfide	12
7 Cylinders	12
7.1 Description.....	12
7.2 Valves.....	12
7.3 Pressure relief devices	12
7.4 Marking and labeling	12
7.5 Charging	13
7.6 Shipping and handling	13
7.7 Withdrawing contents	13
7.8 Storage.....	13
8 Cargo trailers.....	14
8.1 Description.....	14
8.2 Fabrication.....	14
8.3 Charging	14
8.4 Shipping and receiving regulations.....	14
8.5 Handling and unloading.....	15
8.6 Preparing cargo tank for return.....	15
9 Single-unit tank cars.....	15
9.1 Description.....	15
9.2 Fabrication details	15
9.3 Charging	15
9.4 Shipping and receiving regulations.....	15
9.5 Handling and unloading.....	16
9.6 Preparing tank cars for return.....	16
10 Unloading methods and systems for highway and single-unit tank cars.....	16
10.1 General.....	16
10.2 Methods.....	16
10.3 Other required or recommended equipment	18
10.4 Unloading procedures	18

11	Multi-unit tank car and truck shipments	19
11.1	Description.....	19
11.2	Fabrication.....	20
11.3	Marking, labeling, and placarding.....	20
11.4	Charging—filling density.....	21
11.5	Shipping.....	21
11.6	Handling	21
11.7	Storage.....	21
12	Piping and equipment.....	22
12.1	Introduction.....	22
12.2	Piping.....	22
13	References	22
14	Additional references.....	23
Tables		
Table 1—Physical properties of hydrogen sulfide		4
Table 2—Toxicity of hydrogen sulfide to humans		6
Table 3—Effects of hydrogen sulfide inhalation on humans		7
Table 4—Physiological effects of human exposure to hydrogen sulfide		8
Figure		
Figure 1—Vapor pressure of hydrogen sulfide		3
Appendix		
Appendix A—Additional toxicology information for hydrogen sulfide (Informative).....		24

1 Introduction

This publication is one of a series compiled by the Compressed Gas Association, Inc. (CGA) in response to demand for information relating to the properties, transportation, storage, and handling of compressed gases.

2 Scope

This publication provides information regarding the properties, manufacture, shipping, storage, handling, and use of hydrogen sulfide. It also describes many of the related regulatory requirements and safe practices in the United States and Canada. This information is intended to complement but not supplant national, state, provincial, territorial, municipal, and insurance company codes and requirements.

The information in this publication is intended for use by hydrogen sulfide shippers, carriers, distributors, repackagers, consumers, equipment designers or installers, safety administrators, and others desiring an introductory knowledge to the subject. Anyone requiring more detailed or specialized information should consult their hydrogen sulfide supplier. Also, see the references listed in Sections 13 and 14.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

4 Manufacture, properties, and uses

4.1 Manufacture

Hydrogen sulfide is widespread in nature, occurring to some extent in most petroleum and gas deposits, geysers and hot springs, and in some mines. Generally, it is associated with the anaerobic decay of dead organisms and is released from sewers, swamps, and lake bottoms in considerable amounts. Hydrogen sulfide does not remain in the atmosphere long because it is a part of the natural sulfur cycle and is quickly oxidized to sulfate and returned to the soil and water.

In the laboratory, hydrogen sulfide is generated by the action of an acid on iron sulfide or by warming a solution of a thioacetamide.

Commercially, hydrogen sulfide is usually produced by one of the following methods:

- separation of the native compound from hydrocarbons in petroleum and natural gas processing;
- reaction of a sulfide or bisulfide with an inorganic acid; or
- union of sulfur and hydrogen at high temperature and pressure.

As an industrial by-product, hydrogen sulfide is formed in such processes as follow:

- coagulation of viscose rayon;
- production of synthetic rubber;
- manufacture of carbon disulfide;
- recovery of sulfite waste liquors in the pulp and paper industry;
- refining of sulfur by distillation;
- cracking and hydrogenation of oils in petroleum refining; and
- manufacturing of reactive petroleum coke.

4.2 Properties

4.2.1 Composition

4.2.1.1 Structure

Hydrogen sulfide is the compound designated by the formula H_2S and is formed by the combination of hydrogen and sulfur. By weight, the proportion of elements in the compound is 5.9% hydrogen and 94.1% sulfur.

4.2.1.2 Specifications

Hydrogen sulfide is commercially available in a chemically pure grade (minimum purity generally 99.0% by volume in the liquid phase).

4.2.2 Physical properties

At room temperature and atmospheric pressure, hydrogen sulfide is a colorless gas that in low concentrations has the offensive odor characteristic of rotten eggs. The familiar odor is initially perceptible by many persons at concentrations well below 1 parts per million (ppm), and most leaks are actually first detected by odor in practice. The perceived absence of odor should not be relied upon to confirm the absence of the gas by persons working in a leak situation, in confined spaces, or in any work areas where the gas is routinely present in the air. Prolonged exposure to low concentrations deadens the sense of smell so a person cannot detect the presence of the gas. Higher concentrations initially have a different sickening sweet odor and metallic taste and have a more rapidly paralyzing effect on the olfactory nerves. Important physical properties of hydrogen sulfide are given in Figure 1 and Table 1.

At temperatures less than 85 °F (29.4 °C), water and hydrogen sulfide can form solid hydrates under certain conditions.

Hydrogen sulfide is significantly soluble in water, alcohol, ketones, and hydrocarbon solvents. For more information on the solubility of hydrogen sulfide in water, see Table 1.

4.2.3 Chemical properties

Under normal conditions, hydrogen sulfide is a thermodynamically stable compound. At elevated temperatures, it decomposes into its constituents, hydrogen and sulfur.

Dry hydrogen sulfide in the liquid or gaseous phases is not acidic. However, in aqueous solutions hydrogen sulfide dissociates to some extent and is a very weak acid.

In acidic and alkaline solutions, hydrogen sulfide is a reducing agent. Under specific conditions, hydrogen sulfide reacts vigorously with oxidizing agents such as chlorine, nitric acid, sulfuric acid, and hydrogen peroxide.

Hydrogen sulfide reacts with alkali and alkaline carbonates.

In the presence of air and moisture, hydrogen sulfide attacks mercury, silver, lead, and most common metals of construction including iron, copper, and other metals, to form sulfides. The sulfides of iron are sometimes pyrophoric in air. Conversely, dry, oxygen-free hydrogen sulfide can be handled in most materials of construction.

With solutions of heavy metals, hydrogen sulfide reacts to form sulfides.

Hydrogen sulfide reacts with olefins at high temperature and pressure in the presence of a catalyst to form mercaptans.

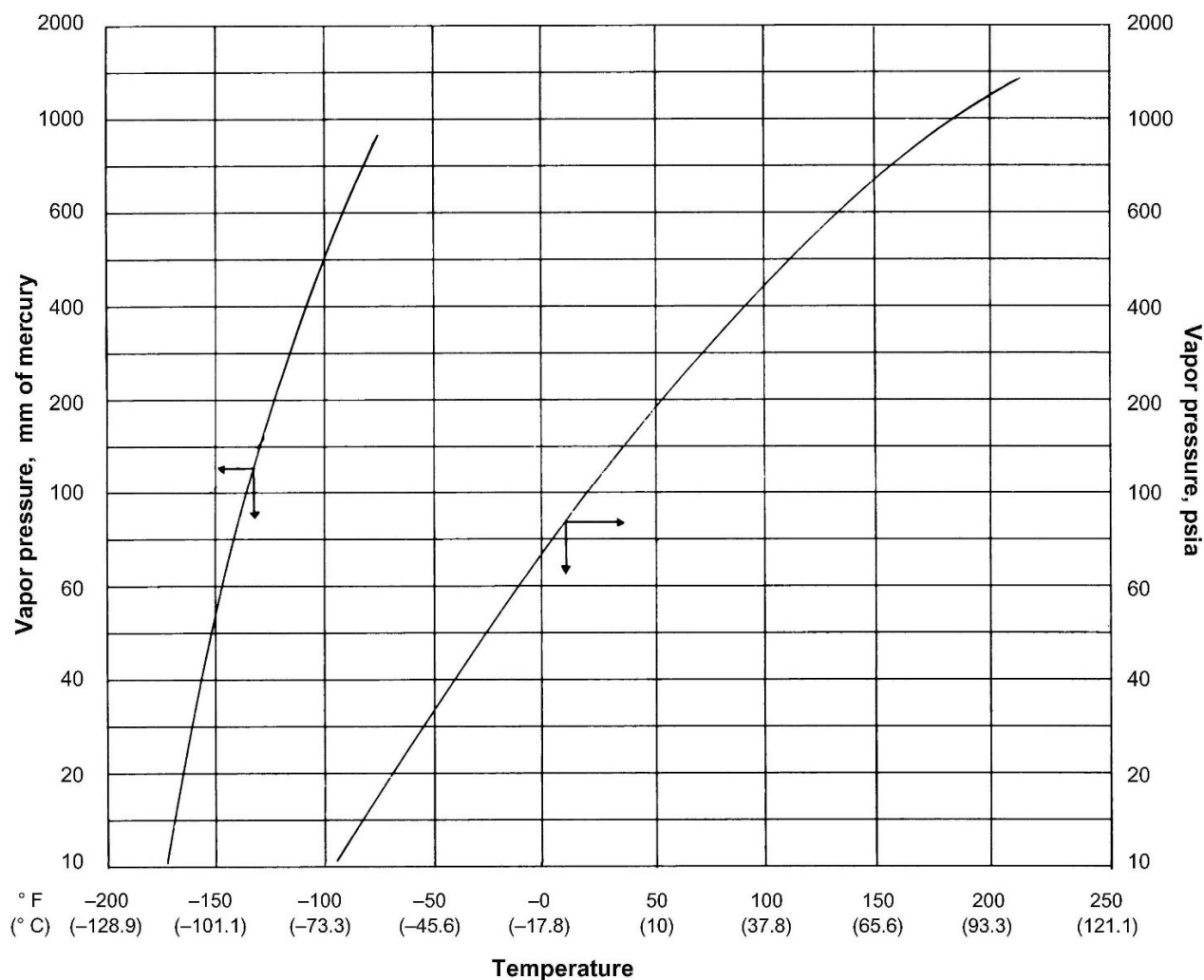


Figure 1—Vapor pressure of hydrogen sulfide

Table 1—Physical properties of hydrogen sulfide ^{1, 2}

	U.S. Customary Units	SI Units
Molecular symbol	H ₂ S	
Molecular weight	34.08	
Boiling point at 1 atm	−76.6 °F	−60.3 °C
Melting point at 1 atm	−117.2 °F	−82.9 °C
Triple point		
temperature	−122.0 °F	−85.6 °C
pressure	3.36 psia	23.2 kPa, abs
Critical temperature	212.9 °F	100.5 °C
Critical pressure	1306.5 psia	9008 kPa, abs
Critical density	21.8 lb/ft ³	349 kg/m ³
Density of gas at 1 atm and		
32 °F (0 °C)	0.0961 lb/ft ³	1.539 kg/m ³
59 °F (15 °C)	0.0910 lb/ft ³	1.457 kg/m ³
70 °F (21.1 °C)	0.0890 lb/ft ³	1.426 kg/m ³
Density of liquid at 1 atm and −76.6 °F (−60.3 °C)	57.1 lb/ft ³	915.3 kg/m ³
Specific gravity of gas at 1 atm and 59 °F (15 °C) (air = 1)	1.189	
Specific volume of gas at 1 atm and		
32 °F (0 °C)	10.41 ft ³ /lb	0.650 m ³ /kg
70 °F (21.1 °C)	11.24 ft ³ /lb	0.701 m ³ /kg
Specific gravity of liquid at 59 °F (15 °C) compared with		
water at 59 °F (15 °C)	0.789	0.789
gas at atm and 70 °F (21.1 °C)	11.24 ft ³ /lb	0.702 m ³ /kg
Latent heat of vaporization at 1 atm and −76.6 °F (−60.3 °C)	236.3 Btu/lb	549.3 kJ/kg
Latent heat of fusion at 1 atm and −117.2 °F (−82.9 °C)	29.99 Btu/lb	69.7 kJ/kg
Vapor pressure of saturated gas at		
59 °F (15 °C)	211.2 psi	1456 kPa
70 °F (21.1 °C)	249.8 psi	1722 kPa
Solubility of gas in water at 1 atm and 104 °F (40 °C)	Range of 1.8 cm ³ H ₂ S/cm ³ water to 3 cm ³ H ₂ S/cm ³ water	
Flammability limits in air	4.0% to 44%	
Autoignition temperature	500 °F	260 °C
NOTE—1 atm = 760 mm of mercury or 14.696 psi (101.325 kPa)		

¹ psi, bar, and kPa shall indicate gauge pressure unless otherwise noted as (psia; bar, abs; and kPa, abs) for absolute pressure or (psid; bar, dif; and kPa, dif) for differential pressure. All kPa values are rounded off per CGA P-11, *Guideline for Metric Practice in the Compressed Gas Industry* [1].

² References are shown by bracketed numbers and are listed in order of appearance in the reference section.

4.3 Commercial applications

Hydrogen sulfide can be used commercially as follows:

- to prepare metallic sulfides, with considerable quantities being used in the manufacture of sodium sulfide;
- to produce elemental sulfur in the recovered sulfur industry;
- to separate deuterium oxide from water for the nuclear energy industry;
- to prepare chemical fertilizer compounds;
- to prepare extreme pressure lubricants and cutting oils;
- to synthesize organic sulfur compounds such as thiophenes and mercaptans;
- to prepare phosphors as for television tubes, fluorescent tubes, etc.;
- in special pollution control applications for the destruction of toxic wastes; and
- as a precipitating agent:
 - for preparing metallic sulfides
 - in the separation of metals
 - in the removal of metallic impurities
 - in the regeneration of catalyst
 - in the production of pigments and dyestuffs.

5 Hazards and safety

5.1 Introduction

Hydrogen sulfide is a compressed, liquefied gas that is both poisonous and flammable. In the presence of oxygen and moisture, the gas can attack certain common materials and therefore design allowances shall be made for this contingency.

5.2 Flammability

Hydrogen sulfide is flammable, see 4.2.3. Precautions should be taken to prevent the unintentional ignition of the material. The Threshold Limit Value–Time-Weighted Average (TLV[®]–TWA) is significantly lower than the lower flammability limit (LFL) [2]. The same engineering/operational safeguards necessary to prevent toxic levels in the workplace can prevent flammable levels of hydrogen sulfide.

5.3 Toxicity

Summation of toxicity and physiological effects are addressed in Tables 2, 3, and 4. More detailed information is available in Appendix A.