

| | | | | | | | | | |
|--|--|---|-------------------------------------|--------------------------------------|----------------|------------------------------------|------------------|--|---|
| Agent Characteristics | <p>Agent Classification: Toxic Industrial Chemical: CAS: 7783-06-4; Formula: H₂S; Molecular Weight: 34.08 g/mol.</p> <p>Description: Hydrogen sulfide (H₂S) is a colorless gas with a strong smell of rotten eggs; however, the sense of smell becomes rapidly fatigued and can NOT be relied upon to warn of the continuous presence of H₂S. H₂S is shipped as a compressed gas. H₂S is produced by biological degradation of sulfur-containing products and as a by-product in many industrial processes. Therefore, H₂S may be present in unexpected locations. H₂S is reactive, extremely flammable and may decompose when heated, forming toxic sulfur oxide compounds. It is incompatible with strong oxidizers, metal oxides, peroxides and strong acids and bases.</p> <p>Persistence: H₂S is considered "non-persistent." Vapor: minutes to hours; liquid: rapidly evaporates at ambient temperatures and pressures. Persistence will depend upon amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted.</p> <p>Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m³ x 0.714; mg/m³ = ppm x 1.40. NA = not applicable.</p> | | | | | | | | |
| | Vapor Density | Vapor Pressure | Volatility | Boiling Point | Freezing Point | Flash Point / Explosive Range | Liquid Density | Aqueous Solubility | Non-aqueous Solubility |
| | 1.19 (air = 1) | 15,600 mm Hg (77°F/25°C) | very high, limited by mass transfer | -76°F/-60°C | -121°F/-85°C | Flammable gas / 4% LEL – 44% UEL | NA: vapor at STP | 5 g/L (68°F/20°C) | Common solvents, alcohols, gasoline, oils, fats |
| Release Scenarios | <p>AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.</p> <p>Open Areas: H₂S is a gas and the primary release/attack scenario is an airborne release. H₂S is heavier than air and can accumulate in lower terrains. An unreacted cloud of H₂S can migrate great distances to sources of ignition and flash back.</p> <p>Water/Water Systems: H₂S released into or over natural waters or into water systems can dissolve and then volatilize from water surfaces or react to form sulfur-containing compounds. These compounds may be malodorous and/or exert toxic effects if present in high concentrations. The half lives of both volatilization and reaction can be around 2 days. If a large cloud of H₂S is released, not all H₂S may dissolve or react before the H₂S cloud leaves the vicinity of the water. Water systems, plumbing, surfaces and equipment that have contacted contaminated water should be evaluated for sulfur-containing compounds along with the bulk water.</p> <p>Indoor Facility: Due to its volatility, H₂S could potentially be dispersed inside a building or facility; HVAC systems could be impacted. Explosive vapors can be formed by contact with strong oxidizers and some metallic oxides (i.e., rusty pipes, duct work). Toxic vapors (sulfur oxides) can be formed as H₂S decomposes in the presence of heat. H₂S is heavier than air and can accumulate in lower levels or utility corridors inside the buildings.</p> | | | | | | | | |
| | Onset | Onset of symptoms is dose and route dependent. Symptoms may occur rapidly following exposure. Prolonged exposure may lead to permanent or persistent systemic effects. | | | | | | | |
| Health Effects | Signs/Symptoms | <p>Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage.</p> <p>Mild to Moderate (less than 50 ppm): <i>Inhalation:</i> H₂S is primarily an irritant causing upper-airway irritation that initially causes cough and bronchospasms (20-50 ppm). Exposure can cause headache, nausea, vomiting, chest pain, shortness of breath, weakness, dizziness, disequilibrium, pharyngitis, pneumonitis, and/or lung irritation. <i>Skin:</i> May cause irritation, especially in moist areas. <i>Eye:</i> Corneal ulceration and rarely irreversible corneal scarring, inflammations of the cornea and conjunctiva.</p> <p>Severe (greater than 50 ppm): <i>Inhalation:</i> Causes central nervous system depression, seizures, coma, hemoptysis, myocardial ischemia, irregular heartbeat, acute lung injury, pulmonary edema, and/or death. Central nervous system depression is usually rapid and profound. While recovery may be complete in patients rapidly removed from exposure, permanent conditions (e.g., dementia, memory failure, delirium, ataxia, tremor, muscle rigidity) may result from prolonged hypoxia. <i>Skin:</i> Cyanosis may be noted following severe exposure. <i>Eye:</i> Permanent visual loss.</p> | | | | | | | |
| | Exposure Routes | <p>Inhalation: The primary route of H₂S exposure is in gaseous form. Inhalation of very small concentrations can produce adverse health effects.</p> <p>Skin: Contact with H₂S in gaseous form may cause irritation to moist skin. Contact with liquid H₂S can cause frostbite. Significant skin absorption is unlikely.</p> <p>Eyes: Contact with H₂S in gaseous form can cause inflammation and injury to the eyes. Contact with liquid H₂S can cause frostbite.</p> <p>Ingestion: H₂S is a gas at room temperature, making ingestion an unlikely exposure route.</p> <p>Other: Data suggest that ethanol consumption may potentiate the toxic effects of H₂S exposure.</p> | | | | | | | |
| Exposure Levels | <p>Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for H₂S (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Toxic Industrial Chemicals):</p> | | | | | | | | |
| | AEGL Level in ppm, at various exposure durations | | 10 min. | 30 min. | 1 hr. | 4 hr. | 8 hr. | | |
| AEGL 1: Threshold mild effects | | 0.75 | 0.60 | 0.51 | 0.36 | 0.33 | | | |
| AEGL 2: Potentially irreversible effects or impaired ability to escape | | 41 | 32 | 27 | 20 | 17 | | | |
| AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality | | 76 | 59 | 50 | 37 | 31 | | | |
| <p>Exposure Guidelines: IDLH = 100 ppm; STEL = 5 ppm; NIOSH REL = 10 ppm, 10-minute ceiling level (= 15 mg/m³); OSHA PEL = 20 ppm, 15-minute time-weighted average ceiling level; ACGIH TLV-TWA = 1 ppm; Inhalation Provisional Advisory Levels (PAL-1) for general public for 1, 30, and 90 days = 1.2, 0.85, and 0.85 ppm, respectively. Soil: None available. Regional Screening Level (RSL) for Drinking Water = 4.2 µg/L.</p> | | | | | | | | | |
| Personnel Safety | Note | <p>Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershd. We also recommend that responders check their own internal procedures (i.e., SOPs), if they have them.</p> | | | | | | | |
| | Medical | <p>Pre-incident: Annual physical and respiratory function exams. During Incident: Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.</p> | | | | | | | |
| | First Aid | <p>Immediately remove person from affected area and into fresh air, and remove contaminated clothing and articles. Provide respiratory support, if needed. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Compressed H₂S has cryogenic properties so frostbite may be a concern. Rinse eyes exposed to H₂S with potable water for 15 minutes. Antidote: THERE IS NO ANTIDOTE. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.</p> | | | | | | | |
| | PPE | <p>GENERAL INFORMATION: NIOSH-approved Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, and protective clothing should be used. Pre-incident training and exercises on the proper use of PPE are recommended. Per NIOSH guidance - LEVEL A: Recommended for the initial response to an H₂S incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), and eye protection when the contaminant identity or concentration is unknown. Select Level A when the H₂S concentration is unknown or above the IDLH or AEGL-2, and when there is a potential of ocular or dermal exposure. LEVEL B: Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the H₂S concentration is unknown or above the IDLH or AEGL-2 and dermal exposure is less of a risk. Level B differs from Level A in that it typically incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not vapor tight. LEVEL C: Select Level C when the contaminant identity and concentration are known and the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. LEVEL D: Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. Note: H₂S has odor fatigue properties; use APR/PAPR with caution. Downgrading PPE levels can be considered only when the identity and concentration of contaminant and risks of dermal exposure are known, and must be accompanied by on-site monitoring.</p> | | | | | | | |
| Field Detection | <p>Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges or levels for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations.</p> | | | | | | | | |
| | Minimum Screening Ranges for Air | TVA 1000B (PID) | Honeywell - SPM | Dräger – H ₂ S, 0.2a tube | MultiRAE | Minimum Screening Levels for Water | | HACH – Methylene Blue Method (as Total Sulfides) | |
| | ppm | 0.5 (as sulfur) | 0.001 | 0.2 | 0.10 | | | 5 (µg/L in water) | |
| | mg/m ³ | 0.7 (as sulfur) | 0.0014 | 0.3 | 0.14 | | | | |

| | |
|-------------------------|--|
| Sampling | <p>Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)</p> <p>Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. Because H₂S is reactive and volatile, field detection instead of laboratory analysis of samples for H₂S and/or sulfur-containing compounds may suffice and sometimes be necessary to achieve many goals of sampling. The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call the EPA/HQ-EOC at 202-564-3850.</p> |
| | <p>Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is an H₂S cloud that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because H₂S is reactive and generally not persistent, air sampling for a variety of sulfur-containing compounds along with H₂S to help to "clear areas" should be included in the sampling plan.</p> |
| | <p>Note: H₂S is highly volatile and reactive, forming a variety of sulfur-containing products including toxic sulfur oxides. Laboratory analysis may need to include these additional products. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Concurrent air monitoring for H₂S is recommended for all matrices.</p> <p>Types of Samples:</p> <p>Air (H₂S in gaseous form is heavier than air): On-site H₂S monitors may provide sufficiently accurate real-time results. For lab analysis, samples are collected using appropriate solid phase absorbent media (e.g., NIOSH 6013) at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces.</p> <p>Water: H₂S is soluble in aqueous solutions but can diffuse out of the bulk water phase or form sulfides and other sulfur-containing compounds. Total sulfides are easy to analyze in the field by colorimetric/litrimetric methods and can be used as a marker for H₂S contamination.</p> <p>Soil: For localized hot spot areas where soil deposition may occur, surface soil samples may be analyzed for H₂S and sulfur-containing breakdown and reaction products and should be taken from a non-vegetated area to a depth of less than one inch. Concurrent air monitoring is recommended. Sub-surface soil samples (e.g., for sulfur-containing breakdown and reaction products) may not be necessary unless a large amount of liquid was poured on the ground, or if an underlying aquifer is endangered.</p> <p>Surface Wipes: Although H₂S is very volatile, wipe samples are often desired to indicate the presence of sulfides, sulfur oxides, and sulfur-containing breakdown and reaction products, on non-porous surfaces. Concurrent air monitoring is recommended.</p> <p>Bulk: Although H₂S is very volatile, bulk samples of actual pieces or cores of contaminated surfaces may be collected at hot spot areas where high levels of H₂S deposition occurred on porous surfaces (e.g., concrete, asphalt), using appropriate tools (scabbling, coring or drills) and submitted for subsequent laboratory extraction analysis for H₂S, total sulfides, sulfur oxides, and any sulfur-containing breakdown and reaction products. Bulk samples of suspected sink materials may be recommended to rule out secondary vapor phase disposition or absorption of sulfur-containing breakdown and reaction products into these materials.</p> <p>Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.</p> |
| | <p>Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.</p> |
| Analy sis | <p>CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). H₂S and sulfur-containing compounds such as total sulfur may be accurately determined in the field using available meters and field kits. For access to the nearest ERLN laboratory specially trained and equipped for analysis of H₂S, total sulfides and other sulfur-containing breakdown and reaction products, contact the EPA/HQ-EOC at 202-564-3850.</p> |
| Decontamination/Cleanup | <p>Use water spray to disperse H₂S cloud. Prevent wastewater from further contaminating the environment. Avoid use of oxidizers (e.g., peroxides, chlorine) in presence of gaseous or liquid H₂S. Liquid H₂S will quickly evaporate. As a gas, H₂S will dissipate or be consumed by reactions with surfaces/materials it encounters. H₂S rarely persists in the environment. Hence, most decontamination will not necessarily be for H₂S itself, but for decomposition products, such as metal sulfides. Separate, long-term decontamination strategies will need to be developed if those decomposition products are of concern in a particular situation. This decontamination section refers to H₂S itself.</p> <p>Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information.</p> <p>General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below).</p> <p>Disposal Option: The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be resistant to decontamination formulations, or may be cheaper to discard and replace than to decontaminate and restore.</p> <p>Monitored Natural Attenuation: H₂S dissipates via natural processes. Environmental monitoring must be maintained during decontamination and recovery phases. Monitored natural attenuation may require institutional controls (e.g., access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is non-destructive to materials.</p> <p>Fix-in-Place Option: H₂S dissipates rapidly via natural processes, as such a "Fix-in-Place Option" will not be required or feasible. Solid or liquid H₂S decomposition residues or wastes may require a separate decontamination evaluation process.</p> <p>Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas based on presence of: 1) liquid H₂S, 2) gaseous H₂S, or 3) aqueous solutions of H₂S.</p> <p>Strategy for Liquid H₂S: Prevent material from entering sewers or confined spaces. Stop or reduce leak if safe to do so. If not, allow liquid to vaporize. Actions that promote safe volatilization of liquid H₂S may be useful since H₂S in gaseous form can be allowed to dissipate; volatilization of liquid H₂S is a fast process but may depend on site conditions.</p> <p>Strategy for Gaseous H₂S: Aerate spaces where gaseous H₂S may be present. Forced Air ventilation methods are recommended for H₂S cloud contamination or low concentration of H₂S gas in large volumetric spaces or open areas. As a gas, H₂S is extremely flammable so Hot Air ventilation should be avoided. H₂S gas has corrosive properties and attacks some plastics and metals. Impact on materials should be assessed for mitigation efforts. Mechanical, electrolytic, or chemical cleaning of corroded products may be needed. H₂S gas may ignite if passed through rusty iron pipes.</p> <p>Strategy for Aqueous Solutions of H₂S: If H₂S is present in solution, contain liquid or transfer liquid to appropriate containers. Neutralize aqueous H₂S solutions with chlorine, bleach, or sodium bicarbonate (baking soda).</p> <p>Sensitive Equipment and Items: For difficult-to-clean equipment thought to be contaminated with small amounts of H₂S, options include aeration followed by flushing with water.</p> <p>CAUTION: Decontamination/neutralization products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use.</p> <p>Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.</p> |
| Waste Management | <p>CAUTION: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmqreqs.htm#hmp. These regulations differ from state-to-state. Detailed state regulations can be found at www.envcap.org. Current resources on packaging, labeling and shipping are available at www.phmsa.dot.gov/hazmat.</p> <p>Waste Management: Under the Resource Conservation and Recovery Act (RCRA), solid waste can be classified as hazardous (subtitle C) or non-hazardous (subtitle D). The RCRA regulations generally define a waste as hazardous if it is: (1) a listed waste (40 CFR§261.31, §261.32), (2) exhibits specific characteristics (40 CFR §261.21-261.24) or (3) is a discarded commercial chemical product, off-specification species, container residue, or spill residue thereof (40 CFR §261.33). H₂S is listed under RCRA, chemical code U135 for discarded commercial chemical products, and meets the ignitability characteristic as an ignitable compressed gas, chemical code D001. Sulfide waste can also be reactive hazardous waste, chemical code D003, if it generates toxic gases when exposed to pH conditions between 2 and 12.5. H₂S is also regulated under CERCLA with a reportable quantity threshold of 100 pounds. The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).</p> |