**BASF Chemical Emergency Medical Guidelines**

# Hydrogen sulfide ($H_2S$) B 1

## Information and recommendations for paramedics and doctors at the site

- **Before approaching the patient, the paramedics and doctors at the site must make sure that they do not risk exposing themselves to hydrogen sulfide.**
- **Patients exposed only to hydrogen sulfide gas do not pose a significant risk of secondary contamination. Patients whose clothing or skin is contaminated with liquid hydrogen sulfide (boiling point –60°C, -76°F, respectively) can secondarily contaminate rescue and medical personnel by direct contact or through off-gassing hydrogen sulfide.**
- **Hydrogen sulfide gas is irritating when it comes in contact with moist tissue such as the eyes, skin, and upper respiratory tract and causes headache, nausea, vertigo, dizziness, weakness, hypotension, and disorientation. Laryngospasm, signs of pulmonary edema (shortness of breath, cyanosis, expectoration, cough), unconsciousness, and apnea may occur. Rapid onset of unconsciousness, "knock-down", of severely exposed individuals is characteristic.**
- **In case of suspected hydrogen sulfide poisoning, immediate ventilation and oxygenation is crucial. Use of cyanide antidotes may be effective in severe cases when given immediately after exposure but may be hazardous after onset of pulmonary edema.**

### 1. Substance information

Hydrogen sulfide ($H_2S$), CAS 7783-06-4
Synonyms: dihydrogen monosulfide, sewer gas
Hydrogen sulfide is, at room temperature, a colorless, flammable gas with a rotten-egg odor. Under pressure or at temperatures below –60°C (-76°F), it is a clear, colorless liquid. It is moderately water-soluble. Hydrogen sulfide is used or encountered in farming (usually as agricultural disinfectant), brewing, tanning, glue making, rubber vulcanizing, metal recovery processes, mineral oil and gas exploration and processing, in rayon or artificial silk manufacture, lithography and photoengraving, fur-dressing and felt-making plants, fertilizer cookers, beet sugar factories, analytical chemistry, and dye production.

### 2. Routes of exposure

*Inhalation*

**Most exposures occur by inhalation**. Hydrogen sulfide's odor and irritant properties may be well perceived; however, they do not provide warning of hazardous concentrations. Moderate levels of exposure result in olfactory loss. Hydrogen sulfide is heavier than air and may cause asphyxiation in poorly ventilated, low-lying, or enclosed spaces.

*Skin/eye contact*

Direct contact with liquid hydrogen sulfide or gas on wet or moist skin or mucous membranes of the eyes causes irritation.

*Ingestion*

Ingestion of hydrogen sulfide is unlikely because it is a gas at room temperature.

### 3. Acute health effects

*Respiratory*

**Hydrogen sulfide exposure usually causes headache, nausea, vertigo, dizziness, weakness, disorientation, hypotension, and respiratory irritation.** Pulmonary injury may progress over several hours. Severe hydrogen sulfide poisoning may cause unconsciousness, respiratory and cardiovascular failure.

**Rapid onset of unconsciousness followed by immediate recovery, "knock-down", of severely exposed individuals is characteristic. Reawakening patients may experience an acute brain syndrome with agitation and confusion.**

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| *Dermal* | If the skin is wet or moist, contact with hydrogen sulfide gas can cause irritation. Contact with liquid hydrogen sulfide under pressure can result in frostbite. |
| *Ocular* | Exposure to low concentrations of hydrogen sulfide gas causes burning discomfort, spasmodic blinking or involuntary closing of the eyelids, and redness and tearing. Corneal opacities may occur at high concentrations or repetitive exposure. |
| *Estimation of exposure* | If monitoring data or other measurements are available, inhalation exposure can be estimated. |
| *Dose-effect relationships* | Dose-effect relationships are as follows: |

| Hydrogen sulfide concentration | | Effect |
|---|---|---|
| 0.02-0.2 ppm | - | Odor detection (some tolerance develops) |
| 50-150 ppm | - | Eye and respiratory irritation, olfactory paralysis |
| 200-500 ppm | - | Bronchitis, headache, dizziness, staggering |
| 500-1000 ppm | - | Pulmonary edema, respiratory depression, unconsciousness |
| 1000-1500 ppm | - | Rapid collapse, respiratory paralysis, fatal within a few minutes |
| 1800-5000 ppm | - | Immediately fatal |

**4. Actions**

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| *Rescuer self-protection* | **In response situations that involve exposure to potentially unsafe levels of hydrogen sulfide (see below), pressure-demand, self-contained breathing apparatus and chemical-protective clothing shall be worn**.<br>Patients exposed only to hydrogen sulfide gas do not pose a significant risk of secondary contamination. Patients whose clothing or skin is contaminated with liquid hydrogen sulfide can secondarily contaminate other people by direct contact or through off-gassing hydrogen sulfide. |
| *Patient recovery* | Patients should be removed from the contaminated zone immediately. Patients who are unable to walk may be removed on backboards or stretchers; if these are not available, carefully remove/transport patients with appropriate action to a safe zone, taking into account your self-protection.<br>Immediate priorities must follow the "**A, B, C's**" (Airway, Breathing, Circulation) of resuscitation. |
| *„CRASH"-Decontamination* | a) Rescue with hydrogen sulfide contaminated, unconscious patients or patients who are unable to move (critically ill/injured patients according to the ABCDE approach) from the danger zone immediately. The use of appropriate personal protective equipment and self- protection have top priority<br>b) Start Basic Life Support if necessary (e.g. bleeding control with Tourniquet, cardiac massage etc.)<br>c) In a safe zone: fast and complete removal of clothing using a rescue knife or trauma shears (approx. 1 minute)<br>d) Short rinsing off with plenty of water (approx. 1 minute)<br>e) Place patient on a clean rescue sheet. Consider heat preservation. Transport the patient to the handover area to emergency medical services (approx. 1 minute) |
| *Decontamination* | Patients exposed only to hydrogen sulfide gas who have no evidence of skin or eye irritation do not need decontamination. All others require decontamination.<br>Patients who are able and cooperative may assist with their own decontamination. If the exposure involved liquid hydrogen sulfide and if clothing is contaminated, remove and double-bag the clothing.<br>**Assure that exposed or irritated eyes have been irrigated with plain water or saline for at least 20 minutes**. If not, continue eye irrigation during other basic care and transport. |

Remove contact lenses if present and easily removable without additional trauma to the eye.
**Assure that exposed skin and hair have been flushed with plain water for at least 15 minutes**. If not, continue flushing during other basic care and transport. Protect eyes during flushing of skin and hair.

*Initial treatment*

**In cases of suspected hydrogen sulfide poisoning, immediate ventilation and administration of humidified 100% oxygen is crucial**. For all unconscious patients immediate endotracheal intubation (if necessary under sedation with benzodiazepine and morphine derivatives) is recommended. Mechanical ventilation with a $FiO_2$ of 1.0 (100 % of oxygen) should be started, regardless of the blood gas analysis. Very high $PaO_2$ such as at 200 mmHg can be tolerated for several hours. The administration of oxygen can be considered as antidotal treatment. Immediate and very early administration of cyanide antidotes (but NOT sodium thiosulfate) may be beneficial in preventing severe hypoxia, but may be hazardous after onset of pulmonary edema because oxygen transport is decreased in methemoglobinemia (see *Antidotes* below).
**The following measures are recommended if exposure is 50-150 ppm (depending on time exposed), if symptoms, e. g. eye irritation or pulmonary symptoms have developed, or if the exposure concentration can not be estimated but exposure has possibly occurred:**

- **Administration of oxygen**
- **Administration of 8 puffs of beclomethasone (800 µg beclomethasone dipropionate) from a metered dose inhaler.**

**Patients with severe clinical respiratory symptoms (e.g. bronchospasms, stridor) should be treated as follows:**
a) Nebulization of adrenaline (epinephrine): 2 mg adrenaline (2 ml) with 3 ml NaCl 0.9% and inhale through a nebulizer mask.

b) Administration of a ß2-selective adrenoceptor agonist, e.g., four strokes of terbutaline or salbutamol or fenoterol (one stroke usually contains 0.25 mg of terbutaline sulfate; or 0.1 mg of salbutamol; or 0.2 mg of fenoterol); this may be repeated once after 10 minutes. Alternatively, 2.5 mg salbutamol and 0.5 mg atrovent may be administered by nebulizer mask.
If inhalation is not possible, administration of terbutaline sulfate (0.25 mg to 0.5 mg) subcutaneously or salbutamol (0.2 mg to 0.4 mg over 15 minutes) intravenously.

c) Intravenous administration of 250 mg methylprednisolone (or equivalent steroid dose).

**Patients with clinical signs of a toxic lung edema (e.g. foamy sputum, wet crackles) should be treated as follows:**
a) Start CPAP-therapy (Continuous Positive Airway Pressure Ventilation).
b) Intravenous administration of 1000 mg methylprednisolone (or an equivalent steroid dose) is recommended.

**Intubation of the trachea or an alternative airway management should be considered in cases of respiratory compromise. When the patient's condition precludes this, consider cricothyrotomy if equipped and trained to do so.**

Note: Efficacy of corticosteroid administration has not yet been proven in controlled clinical studies.

**Patients exposed to a concentration of 50-150 ppm or greater (depending on time exposed) and patients without available exposure measurements but suspected of being exposed to concentrations of 50-150 ppm or greater (depending on time exposed) should be transferred to a hospital/emergency department.**
If hydrogen sulfide gas has been in contact with moist skin, irritation may result; treat as thermal burns. If liquefied compressed gas is released and contacts the skin, frostbite may result.
**After eye exposure, irritation may result; treat as thermal burns. Consult an ophthalmologist.**
Note: Any facial exposure to liquid hydrogen sulfide should be considered as a serious exposure.

*Antidotal treatment*

**The following treatment with antidotes should be given under medical supervision to unconscious patients who have known or suspected hydrogen sulfide poisoning.** Immediate and very early administration of cyanide antidotes (but NOT sodium thiosulfate) may be beneficial in preventing severe hypoxia but may be hazardous after onset of pulmonary edema because oxygen transport is decreased in methemoglobinemia. The effectiveness is not proven by clinical trials. The availability of antidotes may vary due to statutory and regulatory differences among different countries.
Note: In some countries administration of 0.2-0.4 ml amyl nitrite via anesthesia bag is recommended before the following treatment. If amyl nitrite is to be used, one ampoule should be administered for 30 seconds every minute until intravenous access is established for further treatment; it should be omitted until good oxygenation is present and there are no signs of pulmonary disturbance.
**If 4-dimethylaminophenol (4-DMAP) is available, the following method of treatment may be considered: Administer immediately 4-DMAP intravenously, usually in a dose of 3 to 5 mg/kg body weight (i.e. 1 ampoule of 250 mg 4-DMAP in an adult).**
**If 4-DMAP is not available, infuse sodium nitrite intravenously as soon as possible. The usual adult dose is 10 to 20 ml of a 3% solution infused over four minutes.** Monitor blood pressure during sodium nitrite administration. Slow the rate of infusion if hypotension develops.
**CAUTION! Sodium thiosulfate must not be administered in case of hydrogen sulfide poisoning.**
Do not treat methemoglobinemia, unless 4-DMAP was overdosed or the initial diagnosis of hydrogen sulfide poisoning is revised.
Please note that conscious patients should neither receive 4-DMAP nor sodium nitrite.

*Patient release/ follow-up instructions*

**Asymptomatic patients** exposed to a concentration of **less than 50 ppm** (depending on the period of time exposed) **as well as patients who have a normal clinical examination and no signs or symptoms of toxicity may be discharged after an appropriate observation period in the following circumstances:**

a) The evaluating physician is experienced in the evaluation of individuals with hydrogen sulfide exposure.
b) Information and recommendations for patients with follow-up instructions are provided verbally and in writing. Patients are advised to seek medical care promptly if symptoms develop or recur.
c) The physician is comfortable that the patient understands the health effects of hydrogen sulfide and the provided follow-up instructions.
d) Site medical is notified, so that the patient may be contacted at regular intervals in the 24-hour period following release.
e) Heavy physical work should be precluded for 24 hours.
f) Exposure to cigarette smoke should be avoided for 72 hours; the smoke may worsen the condition of the lungs.

In this document BASF has made a diligent effort to ensure the accuracy and currency of the information presented but makes no claim that the document comprehensively addresses all possible situations related to this topic. This document is intended as an additional resource for paramedics and doctors at the site in assessing the condition and managing the treatment of patients exposed to hydrogen sulfide. It is not, however, a substitute for the professional judgement of a paramedic or a doctor and must be interpreted in the light of specific information regarding the patient available to such a paramedic or doctor and in conjunction with other sources of authority.

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