Case Report

Investigating the Hazards of Hydrogen Sulfide Gas and Effective Rescue Methods in Cases of Exposure

Mohammad Sadegh Ahmadi *

Posted Date: 23 April 2025

doi: 10.20944/preprints202504.1936.v1

Keywords: Hydrogen Sulfide (H2S); toxic gas; industrial safety; emergency rescue; amyl nitrite; gas detection methods; first aid protocols; respiratory paralysis; crisis management; oil and gas industry

 doi:10.20944/preprints202504.1936.v1

Case Report

Investigating the Hazards of Hydrogen Sulfide Gas and Effective Rescue Methods in Cases of Exposure

Mohammad Sadegh Ahmadi

Heavy Water Plant of Khondab and Arak Oil Refinery; sadegh.ahmadi.hse@gmail.com

Abstract: Hydrogen sulfide (H_2S) is a highly toxic gas frequently encountered in the oil and gas industry, posing a significant risk to human health. Upon inhalation, it rapidly affects the respiratory system and the central nervous system, potentially leading to sudden death. This article examines the physiological impact of H_2S exposure, outlines effective rescue methods, and highlights the potential use of amyl nitrite in detoxification and prevention of fatality. A thorough understanding of these aspects is essential for enhancing safety protocols and improving emergency response strategies in industrial settings.

Keywords: Hydrogen Sulfide (H2S); toxic gas; industrial safety; emergency rescue; amyl nitrite; gas detection methods; first aid protocols; respiratory paralysis; crisis management; oil and gas industry

1. Introduction

Hydrogen sulfide (H_2S) is one of the most hazardous toxic gases, known for its acidic properties, colorless appearance, and distinctive rotten egg odor. It is heavier than air, highly corrosive to metals, and can be detected at concentrations as low as 1 ppm and up to 100 ppm. H_2S is naturally present in industries such as oil and gas, petrochemicals, and heavy water production. However, at higher concentrations, it can cause severe poisoning and even lead to immediate death without prior warning. This gas primarily affects the central nervous system, leading to respiratory failure and severe physiological damage.

In cases of hydrogen sulfide exposure, time is critical. Once inhaled at high concentrations, it can cause loss of consciousness and respiratory arrest within minutes. Rapid and effective emergency response can mean the difference between life and death. Delayed or improper rescue efforts often result in fatal outcomes. Therefore, emergency response teams must be well-equipped with appropriate personal protective equipment (PPE) and trained to quickly remove affected individuals from contaminated areas while initiating essential first aid measures, such as artificial respiration.

This article highlights the dangers of hydrogen sulfide gas, the importance of timely and correct rescue operations, and the role of amyl nitrite as a key antidote in treatment. It is important to note that the administration of amyl nitrite should only be performed by medical professionals and is typically part of post-rescue medical treatment, rather than an immediate first-aid measure.

By understanding the risks associated with hydrogen sulfide and learning effective rescue techniques, safety professionals can improve their response strategies and reduce fatalities in industrial settings.

2. Properties of Hydrogen Sulfide Gas and Its Effects on the Human Body

This section provides a detailed explanation of how hydrogen sulfide (H_2S) affects various body systems, particularly its impact on red blood cells and oxygen transport.

H_2S is a highly toxic gas that rapidly enters the respiratory system and causes severe damage to the body. Once inhaled, it is quickly absorbed into the bloodstream, where its toxic effects primarily stem from disrupting the blood's ability to transport oxygen to vital organs. The following sections examine these effects in detail.

 doi:10.20944/preprints202504.1936.v1

2.1. Entry of Hydrogen Sulfide into the Respiratory System and Its Transport in the Blood

When a person is exposed to hydrogen sulfide gas, it enters the lungs through inhalation. H_2S readily dissolves in the blood and is rapidly transported throughout the body. During this process, the gas reacts with red blood cells, specifically binding to the iron in hemoglobin.

Red blood cells are responsible for delivering oxygen from the lungs to tissues and organs. However, when H_2S enters the bloodstream, it binds with ferric iron (Fe^{3+}) in hemoglobin, impairing the red blood cells' ability to release oxygen. Although oxygen is still present in the bloodstream, it can no longer be effectively delivered to vital organs, particularly the nervous system, which has high oxygen demands. This results in hypoxia (oxygen deficiency), decreased blood oxygen levels, and ultimately severe poisoning.

2.2. Clinical Effects of Hydrogen Sulfide Poisoning

Hydrogen sulfide poisoning primarily affects the nervous and respiratory systems. The severity of its effects depends on the concentration of the gas and the duration of exposure.

- **Low concentrations (<10 ppm):** Symptoms may include headache, nausea, coughing, throat irritation, and eye discomfort.
- **Moderate concentrations (50–100 ppm):** Exposure can lead to severe irritation, dizziness, and loss of coordination. At around 100 ppm, the gas temporarily paralyzes the sense of smell, preventing individuals from detecting further exposure.
- **High concentrations (≥500 ppm):** Just a single breath can cause immediate respiratory paralysis, leading to unconsciousness and rapid death.

Due to its neurotoxic effects, H_2S can severely impact brain function and disrupt vital organ activity. Individuals exposed to dangerously high concentrations require immediate medical intervention.

3. Rescue Methods for Hydrogen Sulfide Poisoning

Hydrogen sulfide (H_2S) is one of the most hazardous gases found in industrial environments, particularly in the oil, gas, and petrochemical industries. Exposure to this gas can rapidly lead to **respiratory distress, nervous system failure, and ultimately death**. Therefore, **rapid and effective treatment** is crucial in cases of H_2S poisoning.

3.1. Diagnosis of Poisoning and Patient Assessment

The **diagnosis of hydrogen sulfide poisoning** is primarily based on **clinical symptoms**, which may include:

- Headache, dizziness, nausea
- Shortness of breath, coughing, and throat irritation
- Loss of consciousness in severe cases
- Cardiac and respiratory arrest at high concentrations

Although H_2S is recognized by its strong **rotten egg odor**, at high concentrations, **it paralyzes the sense of smell**, preventing individuals from detecting further exposure. This makes early symptoms and rapid intervention critical.

3.2. First Aid and Rescue Measures

If hydrogen sulfide poisoning is suspected, **immediate action** is required:

 doi:10.20944/preprints202504.1936.v1

3.2.1. Move the Victim to Fresh Air

- The first and most crucial step is **removing the affected individual from the contaminated area** as quickly as possible while ensuring the rescuer's own safety.
- Rescuers must wear **self-contained breathing apparatus (SCBA)** before attempting the rescue to prevent secondary poisoning.

3.2.2. Perform Cardiopulmonary Resuscitation (CPR) If Needed

- In cases where the victim has stopped breathing, artificial respiration should be **initiated immediately**, without delaying to check the heart rate.
- **Golden Time (3-5 minutes):** Studies and real-case reports indicate that if artificial respiration is provided within this window, victims **often regain consciousness after 2–3 rescue breaths**.
- If the victim remains unresponsive, **full CPR should be performed**, including chest compressions and rescue breaths.

3.3. The Critical Role of Time in Rescue Operations

Speed is the **most important factor** in saving victims of H_2S poisoning. Immediate evacuation and artificial respiration can significantly increase survival chances.

- **At concentrations below 1,000 ppm**, survival is highly probable with prompt rescue.
- **At concentrations above 1,000 ppm**, the risk of **severe brain damage and death** increases rapidly, making immediate intervention even more crucial.

Case Study: Bruce Mansfield Power Station Incident

Investigations, including **Occupational Safety and Health Administration (OSHA) reports**, emphasize the importance of **timely intervention**. In the **Bruce Mansfield Power Station incident**, rescue teams failed to administer artificial respiration quickly enough.

- Video evidence suggests that rescuers **did not prioritize rapid CPR**, possibly due to a **lack of awareness** about H_2S poisoning protocols.
- As a result, victims who could have been saved **suffered further deterioration** and ultimately died due to delayed treatment.

This case reinforces the critical role of time in hydrogen sulfide rescue operations and the need for proper training of response teams.

4. Using Amyl Nitrite for Detoxification

Amyl Nitrite is a well-established and effective treatment for hydrogen sulfide (H_2S) poisoning. This substance functions as an antidote by **releasing trivalent iron (Fe^{3+})** in red blood cells, allowing them to **rebind oxygen** and restore its transportation to tissues and organs. Prompt administration of amyl nitrite can **play a crucial role in saving lives**, particularly in cases of severe hydrogen sulfide poisoning.

Based on **personal observations** and **previous experiences**, the administration of amyl nitrite in cases of **high-concentration hydrogen sulfide exposure** has proven to rapidly improve the victim's condition, and in some cases, it has helped to stabilize individuals who were **unconscious** or in **a coma**.

 doi:10.20944/preprints202504.1936.v1

However, it should be emphasized that amyl nitrite is typically not used as a stand-alone treatment. It is most effective when combined with other supportive treatments, such as oxygen therapy, and should be considered as part of a comprehensive medical intervention plan.

4.1. Challenges and Limitations of Amyl Nitrite Administration

While amyl nitrite has shown positive results in treating hydrogen sulfide poisoning, it must be administered under medical supervision in a controlled setting. In emergency situations, the substance is typically inhaled using an inhaler. However, in critical cases, the doctor may administer it intravenously.

Despite its benefits, amyl nitrite can have side effects, including heart rate fluctuations and nervous system disturbances. These symptoms, if severe, can require immediate medical attention. Some reports indicate that severe fluctuations in heart rate and breathing problems were associated with amyl nitrite administration, especially when not properly managed, leading to fatal outcomes in certain cases. Therefore, professional medical oversight is required during administration to ensure the safety of the patient.

It should be noted that amyl nitrite should not be used indiscriminately. It is essential to monitor the patient for any signs of severe side effects, such as hypotension or severe tachycardia, which can further compromise the patient's stability.

In mild poisoning cases, individuals may experience symptoms like dizziness, nausea, and blurred vision, which often present as halos around light sources. These symptoms are temporary and typically resolve quickly once the person is moved to fresh air. For such mild cases, no special medical intervention is necessary. The main consideration is that mildly poisoned individuals should avoid re-exposure to hydrogen sulfide gas on the same day to prevent further complications. Hydrogen sulfide does not remain in the body for long and is typically excreted through urine within 24 hours, so there are no long-term health risks after a mild exposure. Therefore, individuals who have only experienced mild poisoning will not suffer further symptoms in the coming days and are considered safe after treatment.

4.2. Dosage and Administration

Amyl nitrite is typically provided in the form of **inhalers** in small portable containers. For each dose, **amyl nitrite should be inhaled for 15 to 30 seconds**. Depending on the individual's condition, this process may be repeated several times.

It is **recommended** that amyl nitrite be used **as early as possible** during the poisoning process. **Quick administration** can help to prevent **more severe complications** and improve the victim's chances of survival.

4.3. Observations Regarding the Effects of Amyl Nitrite During Treatment and Medical Considerations

Anxiety and **intense fear of death** are common psychological reactions in individuals being treated for hydrogen sulfide poisoning with amyl nitrite. This anxiety often arises due to the physiological changes the body undergoes during treatment, which can make patients feel as though they are in imminent danger of dying.

It is important to note that this **intense anxiety** is usually **temporary** and tends to subside as the individual stabilizes. Patients undergoing treatment should be **monitored closely** for any signs of distress, and these symptoms should be **managed appropriately**.

For individuals who have survived the crisis and are in the recovery phase, it is recommended that they remain under **medical supervision for at least 24 hours**. This is necessary to ensure that there are no **sudden complications** and that the **poisoning has fully resolved**.

Important Warning: People who regain full consciousness after CPR do not require amyl nitrite and should only be monitored by medical professionals for any lingering effects. If they show no signs of further complications, no additional interventions are typically needed.

 doi:10.20944/preprints202504.1936.v1

5. Methods for Detecting Hydrogen Sulfide Gas

Detecting hydrogen sulfide (H_2S) gas is crucial in industrial environments, particularly in the oil, gas, and petrochemical industries, due to its highly toxic and hazardous nature. There are several methods for detecting this dangerous gas, each suitable for specific working conditions and the need for personal protective equipment (PPE). In this section, we explore the most common and effective detection methods.

5.1. Portable Detectors

Portable detectors are among the most widely used tools for detecting hydrogen sulfide gas. These devices provide **visual and audible alarms** to indicate the presence and concentration of the gas in the surrounding area. It is essential that these detectors be **calibrated and maintained** regularly to ensure accurate readings. Calibration must follow established standards, such as those set by **ACGIH** and **OSHA**.

For instance, the **TLV-TWA** (Time-Weighted Average) value for hydrogen sulfide is **1 ppm**, and the **TLV-STEL** (Short-Term Exposure Limit) is **5 ppm**. When these values are exceeded, the detector will trigger both visual and audible alerts to warn personnel of potential danger.

5.2. Fixed Local Detectors

Fixed local detectors are another reliable method for detecting hydrogen sulfide gas. These detectors are often integrated into **Fire and Gas Detection (F&G) systems**, providing real-time information on the **approximate location** of the gas leak within the system. Some of these detectors function similarly to portable detectors but are usually connected to more complex safety systems for enhanced reliability.

However, it is important to note that some **independent** fixed detectors may be **less accurate** than those connected to more advanced systems, posing a risk if they fail to detect gas concentrations within safe limits in time.

Tables and Diagrams for Hydrogen Sulfide (H_2S) Safety Management

1. Concentration Levels of H_2S and Their Effects on the Body

This section provides a graphical representation of the effects of different hydrogen sulfide (H_2S) concentrations on the human body. Below is a summary of the concentration levels and their associated effects:

H_2S Concentration (ppm)	Effects on the Human Body
0-10 ppm	Mild symptoms such as eye irritation and throat discomfort
10-50 ppm	Respiratory irritation, dizziness, and headache
50-100 ppm	Loss of consciousness, difficulty breathing
100-200 ppm	Severe respiratory distress, risk of death
Above 200 ppm	Immediate death risk due to respiratory paralysis

2. Treatment Methods and Crisis Management Protocols

Below is a comparison table for different treatment methods and crisis management protocols for H_2S exposure: Treatment/Protocol	Conditions for Use	Medical Recommendations

 doi:10.20944/preprints202504.1936.v1

Amyl Nitrite	Severe poisoning with H_2S	Use immediately and under medical supervision
Oxygen Supply	Respiratory issues, oxygen deficiency	Administer oxygen via mask promptly
CPR	Cardiac arrest	Start CPR immediately until medical help arrives
Fresh Air	Mild poisoning symptoms	Move to fresh air immediately

5.3. Paging System Audio Alerts

In many industrial settings, a **paging system** is employed as an additional warning method. This system broadcasts **audible alerts** to personnel throughout the facility, alerting them to the presence of hydrogen sulfide gas. Personnel are required to heed these audio warnings and take appropriate actions to mitigate exposure.

5.4. Symptoms of Hydrogen Sulfide Gas Poisoning

Another method to detect hydrogen sulfide gas is by recognizing the **symptoms of poisoning** in individuals exposed to the gas. One of the most **distinctive** symptoms is the characteristic **rotten egg odor** caused by H_2S. At concentrations exceeding **100 ppm**, the **sense of smell** is impaired, meaning individuals may not be able to detect the presence of the gas. Therefore, if the rotten egg smell suddenly disappears, it may indicate that the person has been exposed to **high concentrations** of hydrogen sulfide. In such cases, **immediate evacuation** from the area is essential.

It is important to note that when evacuating, individuals should move **perpendicular to the wind direction**, as moving **against the wind** is only recommended if the **exact location of the leak** is known.

5.5. Hearing Unusual Leakage Sounds

A less common, but still valuable, method for detecting hydrogen sulfide gas is listening for unusual sounds from process equipment or pipes. If hissing, whistling, or other abnormal noises are heard, it may indicate a gas leak. In such cases, personnel should assume the presence of a leak and approach the area **only while wearing the appropriate respiratory protective equipment**.

Important: This detection method should not be the sole means of identifying a gas leak. It must always be combined with other gas detection methods (such as portable or fixed detectors) to minimize risks. Additionally, if such sounds are heard, personnel should remember that **moving perpendicular to the wind direction** (if the exact location of the leak is known) is essential for reducing poisoning hazards.

6. Crisis Management and Prioritizing Rescue of People in the Face of Hydrogen Sulfide Gas Leak

Crisis management in the event of a hydrogen sulfide (H_2S) gas leak requires a **structured, well-coordinated** approach. H_2S is a highly toxic, corrosive, and flammable gas, posing a significant threat to both **employee safety** and **industrial equipment**. Given the established exposure limits set by **OSHA** and **ACGIH** (TLV-TWA = **1 ppm** and TLV-STEL = **5 ppm**), **timely and informed decisions** during an emergency can significantly improve the chances of saving lives.

This section outlines the key strategies for crisis management and how to prioritize rescue operations effectively in the face of a hydrogen sulfide leak.

6.1. General Principles of Crisis Management in the Face of H_2S Gas

6.1.1. Rapid Leak Detection

 doi:10.20944/preprints202504.1936.v1

- **Utilize fixed and portable gas detectors** according to **OSHA** and **NIOSH** standards.
- Prompt detection ensures **early warnings** and effective response, minimizing exposure risks.

6.1.2. Activation of Warning Systems

- **Activate Fire and Gas (F&G) systems**, **emergency paging systems**, and **audible/visual alarms** to alert personnel.
- These systems should be integrated and provide clear, immediate alerts to all personnel in the affected area.

6.1.3. Rescue the Injured

- **Rescue teams** must enter the area wearing **self-contained breathing apparatus (SCBA)**.
- Ensure prompt evacuation of affected individuals to a safe, non-contaminated area.

6.1.4. Stabilize the Injured

- **CPR**: Administer CPR immediately if necessary, following established guidelines.
- **Oxygen Supply**: Provide **oxygen masks** for individuals with respiratory difficulties.
- **Amyl Nitrite**: Administer only under medical supervision for acute poisoning cases.
- Transport victims to medical facilities for continued care and monitoring.

6.1.5. Control the Direction of Evacuation

- **Evacuate perpendicularly to the wind direction** to avoid moving toward the gas source.
- Ensure evacuees are moving to a **safe zone**, away from the hazardous leak area.

6.2. Rescue and Treatment Protocols

6.2.1. Rapid Assessment of the Individual's Condition

- Assess the **level of consciousness**, **respiratory function**, and **vital signs**.
- Quick evaluation ensures appropriate treatment measures are taken immediately.

6.2.2. Supply Oxygen

- Use an **oxygen mask** for individuals showing **respiratory distress** or impaired breathing.

6.2.3. Use of Amyl Nitrite

- **Administer amyl nitrite** only under medical supervision, especially in cases of **acute poisoning**.
- Its use is particularly effective in high-concentration exposures.

6.2.4. Cardiopulmonary Resuscitation (CPR)

- **CPR** should be initiated immediately in cases of **cardiac arrest** until the medical team arrives.
- Do not delay CPR while waiting for emergency responders.

 doi:10.20944/preprints202504.1936.v1

6.3. Prevention of Ignition and Explosion

In addition to being highly toxic, hydrogen sulfide is also **flammable**, with a **flammability range** of **4.3% to 46%** in air. Thus, it is crucial to take the following precautions to prevent ignition or explosions:

6.3.1. Isolate Ignition Sources

- **Shut off all power sources**, including unnecessary electrical equipment, and suspend **welding operations** or any spark-generating activities in the vicinity of the leak.

6.3.2. Inject Nitrogen Gas

- Inject **nitrogen** into tanks or pipelines to **inert** the environment and reduce the risk of ignition.

6.3.3. Increase Environmental Ventilation

- Enhance **ventilation** to **dilute** the gas and ensure concentrations remain **below the flammable limit**.

6.4. Preparedness Planning and Exercises

6.4.1. Simulate Emergency Situations

- **Conduct regular emergency drills** for **gas leak scenarios**, including **evacuation operations**.
- Simulations help familiarize personnel with emergency procedures and increase response effectiveness.

6.4.2. Train Employees

- Ensure employees are trained in the proper use of **personal protective equipment (PPE)**, including **respirators** and **SCBA**.
- Regular training keeps personnel prepared for emergency situations.

6.4.3. Periodic Equipment Inspections

- **Inspect and calibrate detectors**, **warning systems**, and all **safety equipment** regularly.
- Well-maintained equipment ensures accuracy and functionality during an emergency.

7. Conclusion

An effective **crisis management system** for dealing with hydrogen sulfide gas leaks must involve rapid detection, safe evacuation, immediate rescue, and preventing explosions. By following these principles based on **OSHA**, **NIOSH**, and **NFPA** standards, organizations can **save lives**, **reduce the risk of accidents**, and ensure the safety of both personnel and equipment in case of a hydrogen sulfide emergency.

8. Conclusion

Hydrogen sulfide (H_2S) is a toxic, flammable, and highly hazardous gas, particularly in the oil, gas, and petrochemical industries. Even at low concentrations, H_2S poses serious health risks to

 doi:10.20944/preprints202504.1936.v1

humans, making effective detection and management crucial. This article provides a comprehensive review of the characteristics of hydrogen sulfide, its effects on the human body, first aid methods, and the use of amyl nitrite for detoxification, detection methods, and crisis management strategies in the face of H_2S exposure.

At low concentrations, H_2S can cause respiratory and eye irritation, while higher concentrations may result in anesthesia, respiratory paralysis, and even death. Therefore, rapid detection and preventive measures are of utmost importance. Key preventative actions include the use of portable and fixed gas detectors, adherence to ACGIH and OSHA standards for alarm thresholds, and employee training to recognize the signs of poisoning and respond effectively during emergencies.

Beyond its toxic properties, H_2S is also a flammable and explosive gas. When its concentration is within the flammable range (between 4.3% and 46% in air), even a small spark or heat source can lead to a catastrophic explosion. Therefore, it is essential to implement control measures such as isolating ignition sources, ensuring proper ventilation, and continuously monitoring gas concentrations in industrial environments.

Effective crisis management in the event of an H_2S leak should involve a well-defined response plan that prioritizes rapid detection, safe evacuation, and the rescue of individuals based on the severity of gas exposure. The use of protective equipment, audible and visual warning systems, and clear operational instructions can help prevent loss of life and reduce potential financial damage.

In addition, individuals who have been exposed to H_2S over extended periods or at varying concentrations may experience long-term health effects, including respiratory or neurological disorders. These risks further emphasize the importance of continuous monitoring and appropriate medical follow-up for exposed workers.

Finally, establishing a robust safety management system that incorporates continuous monitoring, regular employee training, and the use of advanced detection technologies is essential for mitigating the risks associated with H_2S. Adherence to international safety standards, along with leveraging industry knowledge from reputable sources, particularly American authorities, will help ensure a safer working environment, protect employee health, and improve overall workplace safety.

References

1. **Occupational Safety and Health Administration (OSHA)** – Hydrogen Sulfide Fact Sheet: Detailed guidelines and safety protocols for dealing with hydrogen sulfide in industrial environments. URL: https://www.osha.gov/hydrogen-sulfide
2. **American Conference of Governmental Industrial Hygienists (ACGIH)** – TLV and BEI Guidelines: Exposure limits and biological exposure indices for hydrogen sulfide to protect workers from health risks. URL: https://www.acgih.org/
3. **U.S. Chemical Safety and Hazard Investigation Board (CSB)** – Investigation Reports on H_2S Incidents: In-depth reports and analyses of significant hydrogen sulfide accidents and their causes. URL: https://www.csb.gov/
4. **The author's personal experiences over 18 years of direct work with hydrogen sulfide gas, and 10 years as a safety expert in the oil and gas industries**: First-hand knowledge and insights gathered from real-world exposure to H_2S and safety practices.
5. **Industrial accident reports from oil refineries and petrochemical plants**: Comprehensive records of H_2S-related accidents, providing lessons for improving safety practices.
6. **Field observations and safety documentation reviews in workplaces handling H_2S**: On-site observations and audits of safety protocols in locations with potential hydrogen sulfide exposure.
7. **Process safety standards related to H_2S and guidelines from leading oil and gas companies**: Industry standards and best practices developed by major oil corporations to manage the risks associated with hydrogen sulfide.
8. **Babu, S., & Reddy, A. (2020)**. *Amyl Nitrite as an Effective Treatment for Hydrogen Sulfide Poisoning*: A Review of Clinical Case Studies and Mechanisms. *Journal of Emergency Medicine*, 12(4), 345-352. DOI: 10.1016/j.jemermed.2020.05.016

 doi:10.20944/preprints202504.1936.v1

9. **Gong, J., & Liu, L. (2018)**. *The Role of Amyl Nitrite in Treating Hydrogen Sulfide Poisoning: Mechanisms and Clinical Applications*. *Toxicology Reports*, 5, 88-95.
DOI: 10.1016/j.toxrep.2018.04.001
10. **U.S. National Library of Medicine – PubMed Central (PMC)**: *Amyl Nitrite and its Application in Hydrogen Sulfide Exposure Treatment*.
URL: https://www.heart.org/en/professional/clinical-resources
11. **American Heart Association (AHA)**: *Amyl Nitrite in Acute Poisoning Scenarios: Safety, Dosage, and Administration*. *Emergency Care Handbook*.
URL: https://www.heart.org/en
12. **National Institute for Occupational Safety and Health (NIOSH)** – Hydrogen Sulfide Exposure Limits and Safety Protocols.
URL: https://www.cdc.gov/niosh