TECHNICAL GUIDE FOR SOLUTIONS OF SODIUM HYDROSULFIDE

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Overview

Sodium Hydrosulfide, chemical formula NaHS, is a highly alkaline salt solution with a pH of 11.5 to 12.5. The solution is typically yellow to dark green and has a rotten-egg odor due to the Hydrogen Sulfide (H_2S). The product strength typically ranges from 20% to 45% by weight and weighs 9 to 11 pounds per gallon (specific gravity from 1.13 to 1.30 g/cm^3). Solutions of NaHS are considered stable in normal transportation.

The vapor space over NaHS solutions contains highly toxic Hydrogen Sulfide gas. The Hydrogen Sulfide gas is colorless and it is heavier than air. It will remain close to the ground and collect in low lying areas. The amount of Hydrogen Sulfide gas evolved from NaHS solutions is noticeably increased when the pH of the solution is below the pH of 10.2. This happens when the solution comes into contact with acidic materials or other materials that have a pH lower than 10.2. Dilution of the material will also create a minimal amount of Hydrogen Sulfide gas due to the lower pH of water coming in contact with the solution. The evolution of Hydrogen Sulfide gas can also be increased when the solution is heated above 120 °F [49 °C]; limit exposure to heat to that which is required to maintain a working temperature between 80 - 100 °F (27 - 38 °C).

NaHS solutions are stored in mild steel, stainless steel or lined mild steel tanks. Transfers of NaHS solutions may be done utilizing a closed loop vapor return/recovery system minimizing personnel exposure to product vapor. The closed loop system ties the vapor space in a tank truck or railcar to the vapor space of the tank that is being discharged to. As the liquid displaces the vapor space in the storage tank, the vapor space in the carrier increases and there is no vapor exhausted to the atmosphere.

Personnel handling NaHS solutions should wear the recommended personal protective equipment (PPE) as noted in the SDS, which is hard hat, face shield, chemical goggles, chemical resistant jacket and pants, rubber boots and rubber gloves, to avoid exposure to the eyes and skin. NaHS poses a risk of exposure to Hydrogen Sulfide in a tank's vapor space above the liquid level or in the event of a spill. Personnel should wear SCBA when working in a confined space or near openings associated with NaHS. Hydrogen Sulfide may exist near these openings. Personal and stationary monitors for Hydrogen Sulfide gas should be utilized to alert personnel of the presence of that gas.

For more information please see the appropriate sections of the handbook. This information should be used as a guide when working with NaHS solution. We hope that the information provided will be useful to the safe and productive use of NaHS solution. Review the Safety Data Sheet as it contains the most definitive information regarding NaHS solution.

Health Hazards

NaHS is corrosive and is considered an oral poison. Additionally, a toxic H_2S gas can be released and present a hazard to individuals. Therefore employees should become familiar with the SDS sheet and understand its provisions for the personal protective equipment that is recommended for the safe handling of NaHS solutions. Personnel should also know the signs/symptoms of accidental exposure and know what actions to take

First Aid:

- Contact with the eyes will cause eye irritation and possibly corneal damage. NaHS solution is highly alkaline; pH 11.5-12.5.
    - Immediately flush with large amounts of water for a minimum of 15 minutes. While flushing the eyes, hold eyelids apart to ensure that the entire surface of the eye has been fully irrigated.
    - Seek immediate medical attention; chemical burns may not be evident for 48-72 hours after exposure.

      Note: Safety eye washes and showers should be located within 10 seconds of areas where NaHS is offloaded/loaded to be in compliance with ANSI Z358.1-2004 and OSHA requirements.

- Contact with the skin will cause irritation or burning sensation.
    - Flush with large amounts of water for a minimum of 15 minutes while removing contaminated clothing and footwear.
    - Affected clothing should be washed before it is reused.
    - Leather footwear cannot be cleaned and should be discarded.
- Ingestion of Liquid NaHS will result in severe burning and corrosion of the mouth, throat and stomach.
    - DO NOT induce vomiting.
    - Do not attempt to administer fluids to an unconscious victim.
    - Upon reaching the stomach, the NaHS mixed with stomach acid will evolve H_2S gas which can cause the symptoms of H_2S exposure.
- Inhalation of NaHS vapors which contain H_2S gas can cause headaches, nausea, dizziness and vomiting. Continued exposure to H_2S gas deadens the odor detecting nerves in the nose. Prolonged exposure can lead to loss of consciousness and death. (See Appendix B)
    - In the event of discomfort due to H_2S exposure, leave the area and report the event for medical observation.
    - If breathing becomes labored, oxygen may be administered.
    - If a person is overcome due to H_2S exposure, don respiratory protection and remove the person from the contaminated area.
    - Over-exposure to H_2S can cause cessation of breathing and circulation within minutes at concentrations as low as 300-400 ppm.
    - H_2S may be present in the clothing of a victim in concentrations of 500 ppm and may present exposure hazard to first responders.
    - If breathing has ceased, start artificial respiration with the aide of a pocket mask equipped with a one way valve.
    - If the heart stops beating, CPR should be administered.
    - Medical treatment should be sought immediately.

Flammability and Fire Response

Solutions of NaHS are not flammable; however, the H_2S gas in the vapor space has a wide flammable range from 4% to 44% by volume in air. The H_2S gas is heavier than air and may travel a significant distance to ignition sources and then flash back to the source of the gas. Combustion of H_2S yields sulfur dioxide which creates a severe respiratory hazard.

If H_2S is burning above NaHS solutions all efforts should be made to eliminate the sources of ignition prior to attempts to extinguish the H_2S fire. Otherwise the ignition source could cause another flash back to the gas source. To extinguish the H_2S fire suppressant foam applied to the surface of the liquid will limit the release of H_2S gas to the atmosphere. While the vapor space is burning, water application to the solution will cause the release of even more H_2S gas.

If vessels containing H_2S solutions are involved in a fire, responding fire fighting personnel should be equipped with self contained breathing apparatus (SCBA) due to the potential for exposure to H_2S and sulfur dioxide gases. If exposure to NaHS solution is anticipated personal protective equipment to prevent contact with the solution should also be worn. Extinguishing media appropriate for the combustible materials involved in the fire should be used (Class A for normal combustible materials, Class B for flammable liquids, Class C for electrical fires and class D for metals). Any approach to the fire should be from upwind and uphill.

Storage tanks and tank cars of NaHS in close proximity to a fire should be cooled with water spray to help reduce the evolution of H_2S gas and the subsequent increased in pressure within. Be aware that pressurized containers exposed to high heat may rupture. If you hear a hissing sound or see discoloration of the tank you should leave the area immediately.

Storage

For the bulk storage of NaHS solution, special care should be taken to assure that the storage tanks are placed in open and well ventilated areas. The storage facilities should be located away from combustible materials and sources of heat. Storage for NaHS should be located separate from acids to prevent the materials from commingling in the event of release. Common drainage from acid and NaHS containment areas should be avoided, since mixing with acids will cause the release of significant quantities of H_2S gas. Containment areas should be of adequate capacity to hold 110% of the volume of the largest tank in the containment area.
Storage tanks may be closed to the atmosphere by a vapor recovery system and can be vented through a caustic (Sodium Hydroxide) scrubber or other H2S sequestration system.

Small containers, such as totes and drums, should be stored in cool, dry and well ventilated areas that are out of direct sunlight. Containers should be left with a minimum of 2% head space for product expansion. Small containers can develop high H_2S pressure if left exposed to direct sunlight. The exposure to sunlight and the resulting H_2S pressure can compromise the containers integrity. Due to the H_2S toxicity, workers are at risk of injury in the event of a release. The risk of exposure from H_2S gas is increased for any personnel that may open the container. All storage tanks and containers should be grounded during product transfers such as loading and unloading.

The freezing point of NaHS solution is fairly high. 45% solution of NaHS may freeze at even 65 °F (18°C). Where lower temperatures may be encountered, tanks may be insulated and equipped with a temperature control.

When cleaning bulk storage tanks it is recommended that as much solution as possible is pumped out. The tank is then rinsed with water from the top to the bottom. Care must be exercised when cleaning the tank, protective equipment must be used to prevent contact exposure with the skin and eyes. SCBA or in-line supplied air respirators with 5-minute escape pack are to be utilized anytime personnel are in a confined space where H_2S gas may be present. Even if the tank tests clear of H_2S gas, heating the solids and the residual solution that remain on the floor of the tank can release H_2S back into the space again. The slurry of tank bottoms and wash solution that is removed from the tank is put into a dewatering box to allow the solids to separate from the liquids. The solids collected are tested for disposal while the liquids can be pumped to tank trucks for removal. Once the tank is cleared of the solution and residual solids, a solution of salt remover, can be applied to the walls and floors if the tank is to be lined or put into another service. Excess material is vacuumed out and the tank can be checked for residual salts.

Handling

When handling solutions of NaHS two criteria should be kept in mind. One, avoid any solution contact with the eyes and skin. Two, minimize personal exposure to the product vapors which contain H_2S gas. H_2S gas is evolved at a higher concentration when NaHS solution is exposed to heat or is mixed with acids or acidic materials which lowers the pH of the NaHS solution.

Personal Protective Equipment (PPE)

Engineering controls and work practices with procedures that reduce or eliminate exposure are the best defense against chemical exposure. Defense against exposure beyond controls and procedures is the proper use of PPE. When handling quantities of NaHS where there is likelihood for splash or release of product under pressure such as: opening pipelines, connecting and disconnecting hoses, maintenance or tank clean-out, the following is the recommended PPE to be worn for handling solutions of NaHS.

- Hard hat for some measure of protection of the head, face and neck.
- Face shield for additional face protection when performing loading and unloading operations or where splashing could occur.
- Wear chemical goggles in addition to the face shield for eye protection. These goggles should be close fitting with ventilation to prevent fogging but stop the entry of liquids. Note: Face shields and safety glasses alone are not adequate eye protection for liquid chemical, because they do not seal around the face.
- Wear chemical resistant impregnated vinyl or rubber slicker jacket and trousers.

- Wear rubber gloves or gloves that are coated with PVC or other plastic for hand protection. The cuff of the glove should be long enough to come above the wrist and the sleeve of the protective jacket should come down to cover the wrist.
- Wear rubber boots with the trouser leg of the suit to the outside of the boot. Do not tuck the trouser leg inside the boot.
- If exposure to Hydrogen Sulfide is anticipated a supplied fresh air respirator should be utilized for protection from exposure to H_2S gas.
- When working with NaHS the use of personal H_2S monitors is necessary.
  Areas where there is potential for exposure to NaHS solution, such as loading and unloading stations, must be equipped with safety showers and emergency eyewash stations in accordance with ANSI Z358.1.2004.

Transfers

For bulk shipments of NaHS the use of a vapor recovery/return system reduces the risk of expose to the vapors of NaHS. The vapor recovery system connects the vapor space of a container, such as a truck/trailer or railcar, to the vapor space of the tank into which the load is being discharged to. As the vapor space in the tank is displaced, it equalizes with the vapor space in the truck trailer or railcar. As H_2S gas may be flammable, all trucks, railcars and tanks are to be grounded prior to any transfer taking place. Transfer personnel must carefully inspect all connections including hoses that use a seal, gasket, or packing to make certain that they are in good condition and replace defective units prior to any transfer.

Equipment Recommendations

The following materials and equipment are recommended to store and handle NaHS solutions.

Storage tanks:

- Product solutions of NaHS may be stored in mild steel and lined mild steel tanks and drums.
- NaHS is mildly corrosive to mild carbon steel under normal circumstances, however carbon steel tanks, have lasted in excess of ten years if designed with the proper thickness.
- High density polypropylene is suitable for tank service. PVC and polypropylene fittings are also appropriate as long as the maximum allowable temperature for these materials is not exceeded. The manufacturer should be contacted to determine limitations of the material in question for your particular application.
- To limit iron contamination or extend the service life of a carbon tank a lining may be applied, consult with your coatings specialist/vendor as to particular specification for service with NaHS solutions.
- To greatly reduce corrosion and minimize iron contamination of NaHS solution, stainless steel tanks may be used.
- Consider keeping product suction at least 4 inches above the bottom of the tank.
- Install a sump at the lowest point in the tank and run a drain line with a connection outside the tank help drain the tank for cleaning.
- Where air temperatures may fall below 65°F (18°C) heating may be required and insulation may be utilized for heat preservation.

Common Gasket Applications for NaHS

Material selection, flange mating surfaces and types of fasters selected are critical in creating a non-leaking union. The information enclosed is to be use as a guide in conjunction with other plant/site-approved procedures to ensure a successful gasket installation.

- **Rail cars**
  - Material- EPDM, Teflon.
  - Type-Garlock, Durlon 9000/9000N series, Durlon 8, Cycletight RCM-6.
- **Chemical Tankers**
  - Material- EPDM, Teflon.
  - Type-Garlock, Durlon 9000/9000N series.
- **Pumps, Seals, Hoses/Camlock**
  - Material- Teflon, EPDM.
  - Type- Garlock, Gaylon 3510.
- **Flanges— Manways, Valves and Pipe Connections**
  - Material- Teflon, EPDM.
  - Type- Garlock, Gaylon 3510, Spiral-wound 316L stainless steel.

Successfully sealing a connection using a gasket whether it is a hose, manway/dome or flange connection is dependent upon all of the components of a well-designed system working together to make a seal.

The integrity of a safe seal depends upon three factors:

- Selection of the correct gasket material and components appropriate for the application.
- Careful preparation, cleaning, installation and assembly.
- Correct tightening (bolt, studs or camlock) flanges and loading.

Since gasket materials vary in hardness or resistance to flow, selection of the proper gasket material is important with regard to the flange finish and application one should always check with the manufacture to ensure gasket/material compatibility

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Failures at the Gasket

- Failure due to the fastener:
  - Fasteners which are insufficiently tight provide the most common cause of joint failure, which may result from:
    - Incorrect assembly.
    - Fastener failure.
    - Self-loosening.
    - Fatigue/relaxation over time.
  - A fastener that is too tight at the joint may fail because the excessive load has:
    - Crushed the gasket.
    - Encouraged stress corrosion cracking.
    - Increased fatigue.

- Fastener failure occurs when the applied load exceeds the ultimate strength of the fastener or threads, and for a variety of reasons, typically:
    - Fasteners do not meet design specifications.
    - Over-tightened during assembly.
    - Corrosion.
    - Stress corrosion cracking.
    - Fatigue.

- Failure due to the gasket:
    - Gasket failure resulting from:
        - Flange surfaces damaged.
        - Flanges warped.
        - Flanges not parallel.
        - Corrosion.
        - Flanges not clean on assembly.
        - Selection of incorrect gasket for the application or conditions.
        - Selection of incorrect gasket thickness, predominantly for soft gaskets.
        - Excursions outside normal operating parameters.
        - Gasket damaged in storage, handling or on installation.
        - Gasket crushed by excessive load during assembly.
        - Deterioration over time.
        - Gasket reused.
        - Re-tightening after exposure to service (elevated) temperature.

Gasket Selection

Generally, the selection of materials will be decided by the designer in the first instance and thereafter by the site operations group for replacement. Hence, one should always replace an existing gasket with the exact same type; despite the similarity of many materials, the properties of the seal and performance achieved by the gasket will vary from one manufacturer to another. Always consult the manufacturer for detailed guidance on specific products.

- Primarily, selection must be based upon:
    - Compatibility with the manufactured product.
    - Operating temperature and pressure.
    - Variations of operating conditions or parameters.
    - The type of joint involved.
- Storage:
    - Gaskets should not be subjected to extreme heat or humidity - store in a cool, dry place, away from direct sunlight, water, oil and chemicals.
    - Store sheet materials flat.
    - Avoid hanging gaskets - they may distort. Store soft gaskets flat. Large diameter spiral wound gaskets should be retained on their mounting board.
    - Gaskets should be kept clean and free from mechanical damage and store in sealed plastic bags for protection.

Install gasket-General

- Ensure gasket is the specified size and material.
- Examine the gasket to ensure it is free of defects.
- Carefully insert the gasket between the flanges.
- Make sure the gasket is centered between the flanges.
- Do not use jointing compounds or release agents on the gasket or seating surfaces unless specified by the gasket manufacturer.
- Bring flanges together, ensuring the gasket isn't pinched or damaged.

Tools required

- Specific tools are required for cleaning and tensioning the fasteners. Additionally, always use standard safety equipment and follow good safety practices.
  - Calibrated torque wrench, hydraulic or other tensioner.
  - Wire brush--brass if possible.
  - Safety goggles/Face shield.
  - Hardhat.
  - Gloves.
  - Lubricant.
  - Other plant/site-specified equipment.

Clean:

- Remove all foreign material and debris from:
  - Seating surfaces.
  - Fasteners --bolts or studs, nuts and washers.

Examine

- Visually inspect:
  - Fasteners (bolts or studs), nuts and washers for defects such as burrs or cracks.
  - Flange surfaces for warping, radial scores, heavy tool marks, or anything prohibiting proper gasket seating.
  - Replace components if found to be defective. If in doubt, seek advice.

Align flanges

- Align flange faces and bolt holes without using excessive force.
- Report any misalignment.

Lubricate load-bearing surfaces

- Liberally apply lubricant uniformly to all thread, nut and washer load-bearing surfaces Ensure lubricant doesn't contaminate either flange or gasket face.
  - Lubricate fastener threads and all bearing surfaces -underside of bolt heads, nuts, washers. Apply the lubricant in a consistent manner as a thin, uniform coating making sure the lubricant does not contaminate either flange or gasket faces.

  - Before installation, make certain that the flange components are correctly assembled and the flange mating surfaces are parallel. Insert the new gasket carefully between the flanges to prevent damage to the gasket surfaces.
  - Large diameter spiral wound gaskets--seat the gasket in its mounting on the flange, remove securing straps, then slide the gasket from its mounting onto the flange using an suitable number of persons to avoid damage to the gasket ensure the gasket is central in the flange do not use tape to secure the gasket to the flange. If it is necessary to secure the gasket to the flange, use a light spraying of multi-purpose spray adhesive. Do not use jointing compounds or release agents.
  - Line up the joint components, including the flanges and the gasket--inspect them to guarantee that an acceptable fit has been obtained, be careful when bringing the flanges together, to ensure that the gasket is not pinched or otherwise damaged.

Install and tighten fasteners

- Always use proper tools:
  - Calibrated torque wrench or other controlled tensioning device.
  - Consult your gasket manufacturer for guidance on torque specifications.
  - Always torque in a cross bolt tightening pattern.

Tighten the nuts in multiple steps

One of the most difficult jobs in replacing a gasket is to produce the correct assembly pressure on the gasket, low enough to avoid damaging the gasket, but high enough to prevent a leak in the seal. Consequently, when tightening a fasteners on a flange with any gasket type not incorporating a metal stop (such as a sheet gasket), never use an impact tool or cheater bar It is vitally important to control accurately the amount of force applied to any particular flange arrangement:

- Always use a torque wrench or other controlled-tensioning device-recently calibrated.
- The sequence in which bolts or studs are tightened has a substantial bearing upon the distribution of the assembly pressure on the gasket. Improper bolting could move the flange out of parallel. A gasket is able to compensate for a small amount of distortion of this type.

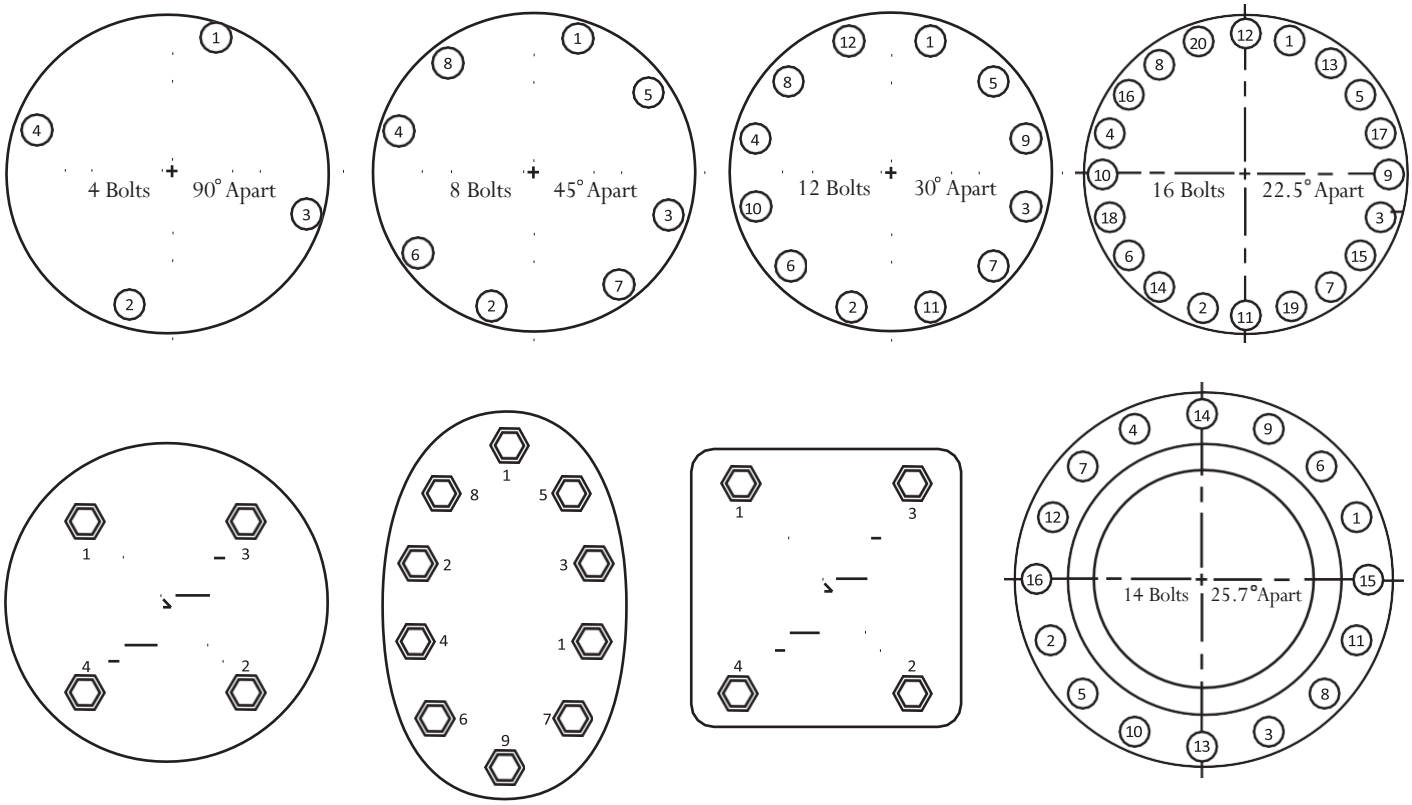
Therefore:

- Always torque nuts in a cross bolt tightening pattern.
- Always run the nuts or bolts down by hand. This gives an indication that the threads are satisfactory. If the nuts will not run down by hand, then there is probably some thread defect - check again and, if necessary, replace defective parts. Now torque the joint using a minimum of 5 torqueing passes, using a cross-bolting sequence for each pass, as shown.

  Step 1 - Tighten all nuts initially by hand--larger bolts may require a small hand wrench.
  Step 2 - Torque each nut to -30% of full torque.
  Step 3 - Torque each nut to -60% of full torque.
  Step 4 - Torque each nut to full torque, again still using the cross. Bolt tightening pattern--larger diameter flanges may require additional tightening passes.
  Step 5 - Apply at least one final full torque to all nuts in a clockwise direction until all torque is uniform--larger diameter flanges may require additional passes.

- Consult your gasket manufacturer and/or engineering department for guidance and recommendations on retightening.
- Do not re-torque elastomer based gaskets after they have been exposed to elevated temperatures unless otherwise specified. Re-torque fasteners exposed to aggressive thermal cycling.
- All re-tightening of flanges/gaskets should be performed at ambient temperature and atmospheric pressure.

Typical Bolt Pattern Tightening Sequence



Gasket Materials:

- Spiral-wound 316L stainless steel
  - Depends upon the mechanical characteristics of a formed metal spiral strip, rather than the compressive virtues of traditional gasket materials. This makes it particularly suitable for low or fluctuating bolt loads.
  - Relatively inexpensive.
  - Fairly easy to install.
- Polytetrafluoroethylene (PTFE) or "Teflon"
  - Principally used as a gasket material because of its capability to remain unaffected by the majority of chemicals used in industry
  - Virgin – cheapest and perhaps most widely used in general application.
  - Filled – a virgin based material with a filler added during manufacture to improve the gaskets sealing characteristics. The filler is usually glass, graphite or ceramics.
  - Expanded – PTFE is specially manufactured so as not to have a "grain", the molecules from which PTFE is made do not arrange themselves into set patterns. The material possesses no structural weakness and expands and contracts equally in all directions. No additives are required so expanded PTFE possesses the same chemical resistance as virgin PTFE.
- Ethylene propylene diene monomer (EPDM)
  - Cost effective gasket material
  - Resistant to weathering, ozone and ultraviolet light exposure.
  - Non-oil resistant.
  - Working temperature up to 200^{o}F (93^{o}C).
  - Working pressure up to 150 psi.

Piping:

- Carbon steel piping is cost effective for most applications. Stress relieved schedule 80 piping is preferred for lines in continuous service.
- Welded and flanged connections are preferred over threaded connections.
- For minimum amount of corrosion and maintenance 304L or 316L stainless steel is recommended especially for temperatures above 180°F (82°C).
- Outdoor pipes should be insulated and, heat traced if air temperatures may fall below 65°F (18°C).
- Pipe lines should slope so as to be self-draining.
- New piping installations should always be hydro-tested for leaks prior to product being introduced into the piping.
- 2-inch diameter process piping at a minimum is recommended which permits greater flow-through and minimizes the possibility of plugging or freezing.

Transfer Hose:

- Truck to tank: 2 – 4 inch diameter chemical transfer hose use UHMWPE with abrasion resistant covering of EPDM and reinforcements of multiple layered high tensile strength textiles and wire.
- Barge to shore tank: 4 – 8 inch diameter polypropylene hoses with inner reinforcement of polypropylene coated carbon steel or T316 stainless steel wire.
- Assure that hoses and connections are rated for appropriate maximum working temperature and pressure.
- Be sure to check hose, cam-locks, gaskets and ears for serviceability prior to each use.
    - Check cam-locks and ears for wear, word ears will not seal the cam-lock with the gasket as tightly as needed to prevent a leak at the connection.
    - Check cam-lock for presence of a gasket and assure that the gasket is not cracked, worn out or twisted.
    - Assure that the hose and the cam-lock fitting are secured to each other.
    - Check the hose for bulging, splitting, or punctures.
    - Review your specific hose requirements with your supplier.

Valves:

- 316 stainless steel construction with 316L Stainless steel plugs, seats and stems are preferred for good long term service.
- Plug valves and ball valves with Teflon seats are recommended.
- Valves made with a PTFE sleeve and seals are also acceptable.

Pumps:

- 316L Stainless steel construction (casing, impeller, shaft and shaft sleeve).
- Single mechanical seals; AFLAS o-rings have been used with success.
- Flush the seal with product or low pressure steam.
- A base plate of carbon steel construction is recommended.

Material Incompatibility:

- Due to the corrosiveness of NaHS, you must avoid products that are made with:
    - Copper (brass, bronze)
    - Zinc (galvanized materials)
    - Aluminum
    - Any combination of the alloys of the above materials

Shipping

The Department of Transportation (DOT) has classified Sodium Hydrosulfide as a corrosive (primary) and toxic (secondary) liquid for commercial shipments. The proper shipping description for all shipments is: UN2922, Corrosive liquids, toxic, n.o.s., 8 (6.1), PG II (Sodium Hydrosulfide solution), RQ.

For international shipments over water, proper bulk shipping description is: UN2922, CORROSIVE LIQUIDS, TOXIC, N.O.S. (SODIUM HYDROSULFIDE SOLUTION), CLASS 8 (6.1), PGII, RQ, SODIUM HYDROSULFIDE SOLUTION (45% OR LESS)

The Environmental Protection Agency (EPA) has designated Sodium Hydrosulfide as a "Hazardous Substance" (40 CFR 302) with a 5,000 pound "Reportable Quantity" (RQ). All shipments whose individual containers have a quantity of 5,000 pounds or greater (100% basis) of Sodium Hydrosulfide must add the designation "RQ" to the shipping description on all shipping papers.

- Placards & Labeling
  - Bulk shipments of Sodium Hydrosulfide will be placarded CORROSIVE. Non-bulk shipments will be labeled as CORROSIVE and TOXIC.
- Containers
  - The proper shipping containers which should be used for bulk shipments of NaHS, such as MC307 or DOT412 tank trailers, are listed in 49 CFR 173.243
  - The proper shipping containers which should be used for non-bulk shipments of NaHS, such as a 4G fiberboard outer packaging and a glass or earthenware inner receptacle or a 1H1 or 1H2 plastic drum single packaging, are listed in 49 CFR 173.202.

Releases

Personnel responding to a release of NaHS must be trained in accordance with OSHA's 29 CRF 1910.120(q), "Hazardous Waste Operations and Emergency Response".

NaHS is a corrosive liquid and evolves toxic H_2S in dangerous concentrations. Restrict access to release area. Keep unprotected personnel upwind of release. Wear the proper personal protective equipment to avoid skin and eye contact with the liquid and inhalation of H_2S vapors. Monitor the area for H_2S concentration. At H_2S concentrations greater than 10 ppm personnel should be removed from the area or wear air-supplied respirators with 5-minute escape pack.

In the event of a release non-essential personnel should be evacuated from the area.

Spills/Leaks

- Check for wind direction and move upwind and uphill from spill.
- Wear proper personal protective equipment: rubber boots, rubber gloves, chemical resistant suit, goggles, hard hat and face shield.
- Isolate for 50 meters (150 feet).
- Containment is a priority. Dike spill to prevent run-off into sewers, drains or surface waterways. Absorb with sand earth or other inert dry absorbent.
- Recover as much of the solution as possible. Material should be pumped to a sump or a 55 gallon drum for potential disposal.
- Apply a weak (3-5%) Hydrogen Peroxide or bleach solution to the affected/contaminated area to stop the release of toxic Hydrogen Sulfide gas and neutralize the effects of the NaHS.
- Remove contaminated soil and dispose of in accordance with all Governmental Regulations after adequate testing has been completed.

Notification

- An immediate telephone notification to the National Response Center (NRC),(800) 424-8802, is required by 40 CFR 302 if the quantity released equals or exceeds the Reportable Quantity (RQ) for Hydrogen Sulfide or NaHS.
- The RQ for Sodium Hydrosulfide is 5,000 pounds (100% basis).
- Telephone notification is also required by Superfund Amendments & Reauthorization Act (SARA), Title III, Section 304, to the affected State Emergency Response Commission and Local Emergency Planning Committee.

Disposal Considerations

- NaHS solutions released to the environment exhibit two characteristics which may cause it and materials it contaminates to be classified as a hazardous waste in accordance with 40 CFR 261.
    - The normal pH of NaHS solution is 11.5 to 12.5.
    - If the solution exceeds a pH of 12.5 it and any material it contaminates should be classified as an EPA D002, Waste Corrosive.
    - Examination should be made to determine if reactive sulfide levels are sufficient to characterize the materials as an EPA D003, Waste Reactive.

Appendix A
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Appendix B

H_2S Monitors

HYDROGEN SULFIDE (H_2S) MONITORS

The primary health hazards associated with Sodium Hydrosulfide (NaHS) are the inhalation of highly toxic Hydrogen Sulfide (H_2S) gas vapors and the corrosiveness of the solution in contact with human tissue. In every container of NaHS, whether drums, tank trucks, railroad tank cars, or storage tanks, H_2S is present in vapor spaces. Hydrogen Sulfide is a colorless gas with a rotten egg odor. The gas has an odor threshold near 0.13 ppm, an OSHA PEL of 10 ppm, and an OSHA STEL of 15 ppm for 15 minutes. Some exposure concentrations to be aware of:

0.13 ppm..... Minimal odor.

4.60 ppm..... Easily detectable.

10 ppm..... Beginning eye irritation – PEL.

100 ppm..... Coughing, eye irritation loss of sense of smell - IDLH.

300 ppm..... Respiratory tract irritation after one hour.

500-700….....Loss of consciousness and possibly death in 30 minutes to one hour exposure.

1000 ppm..... Rapid unconsciousness stopping of breathing, death.

Eliminate hazards with air monitoring. In environments that may pose a risk of H_2S exposure monitoring the air can ensure worker safety. Choices include stationary monitors, personal monitors, and portable monitors.

STATIONARY MONITORS

Fixed, stationary monitors provide coverage for indoor and outdoor areas such as work areas, storage areas, sewers, or confined spaces.

Features:

- Ease of installation
- Continuous monitoring
- Comprehensive real time readings and data management
- Weather durable and explosion proof
- Audio and visual alarms
- Remote sensor connected to a central control station
- Flexible power sources

Examples:

- Honeywell’s Sieger Model 705 sensor with Sieger Digi-Chem transmitters
- General Monitors Model S24000 0-00 monitor with remote sensor Model 50448-1
- Gas Point from BW Technologies

PERSONAL MONITORS

Personal monitors are worn by workers in areas where H_2S may be present. The monitors should be worn by the individual in a way that will monitor the air breathed.

Features:

- Single operational for H_2S gas or multi-operational for more than one gas
- Reliable, durable, and easy to operate
- Continuous monitoring
- Comprehensive real time recording and data storage
- A visual, audible, and vibration alarm
- LCD display for battery life remaining, gas level when detected, calibration settings, alarm settings
- Water resistant
- Lifetime of 2 years or more

Examples:

- GasAlert Extreme from BW Technologies – single gas detector
- Gas Alert Quattro from BW Technologies – multi-gas detector
- Honeywell's Lumidor Minimax XT

PORTABLE GAS DETECTORS

Portable monitors can be used for checking confined spaces as well as open areas or storage areas.

Features:

- Single operational for H_2S gas or multi-operational for more than one gas
- Reliable, durable, and easy to operate
- Continuous monitoring
- Comprehensive real time monitoring and data storage
- Visual, audible, and vibration alarms
- Independent power and radio signal transmission
- Flexible power sources
- Engineered and designed for portability and transporting

Examples:

- Rig Rat III from BW Technologies – wireless multi-point system
- Honeywell's Lumidor Impact and Impact Pro multi-gas monitors
- RKI Instrument's Gas Monitor
- UEI's CD100A

Appendix C

Toxicity Chart for Hydrogen Sulfide Gas

Toxicity Chart for Hydrogen Sulfide

PPM**	0 – 2 minutes	2 - 15 minutes	15 – 38 minutes	38 minutes - hours	1 – 4 hours	4 – 8 hours	8 - 48 hours
20-100				Mild conjunctivitis, respiratory tract irritation	Symptoms worsen, fatigue, headache	Symptoms worsen	
100-150		Coughing, irritation of eyes, loss of sense of smell	Disturbed respiration, pain in the eyes, sleepiness	Throat irritation	Salivation and mucous discharge, sharp pain in eyes, coughing	Increased symptoms	Death
150-200		Loss of sense of smell	Throat and eye irritation	Throat and eye irritation	Difficult, blurred vision, light shy	Death	
200-350	Irritation of eyes, loss of sense of smell	Irritation of eyes	Painful secretion of tears, weariness	Light shy, nasal catarrh, pain in eyes, difficult breathing	Suffocate, poison in blood, death		
350-450	Loss of sense of smell	Irritation of eyes, dizziness	Difficult breathing, coughing, eye irritation, fatigue, nausea	Death			
450-700	Respiratory disturbances, irritation of eyes, collapse, unconsciousness	Coughing, collapse, unconsciousness, death	Palpitation of the heart, death				
Over 700	Collapse, unconsciousness, death						

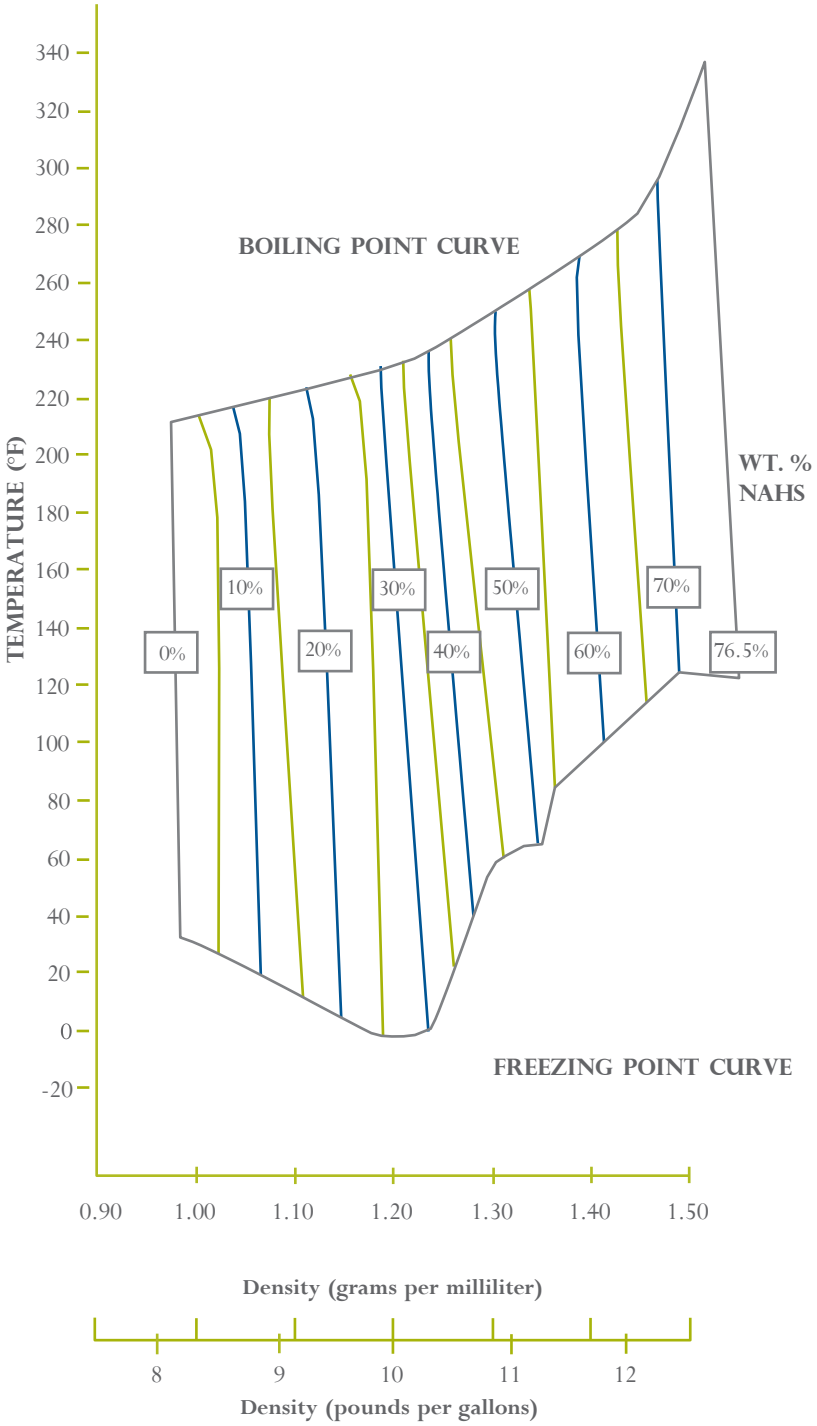
Toxicity Chart for Hydrogen Sulfide

*** ppm, parts per million by volume; different levels of exposure, and not regulatory values.*
Susceptibility varies between individuals

Appendix D

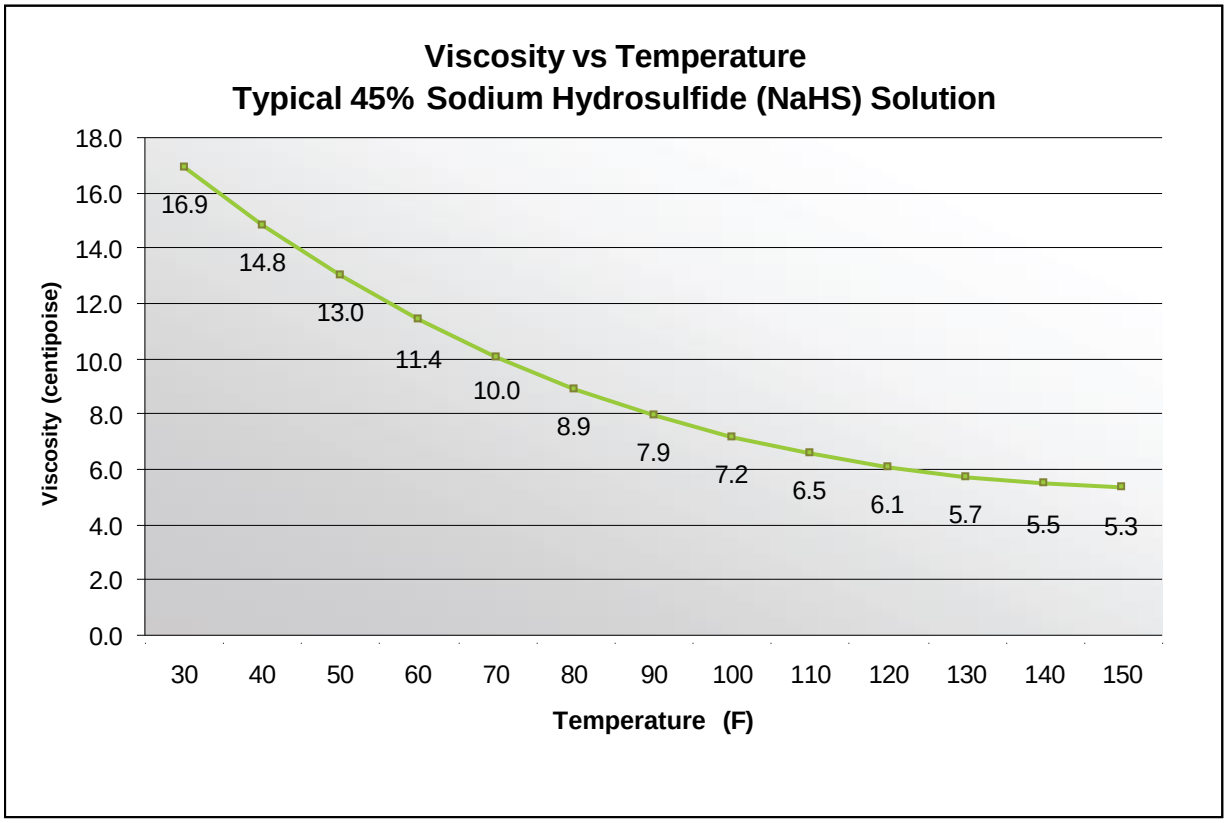
Graph of Density, Freezing and Boiling Points for Sodium Hydrosulfide in Water

Density, Freezing and Boiling Points of NaHS Solutions in Water



Appendix E

Graph of Viscosity
Typical 45% Sodium Hydrosulfide Solution


Viscosity vs Temperature
Typical 45% Sodium Hydrosulfide (NaHS) Solution
Viscosity (centipoise)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
16.9
14.8
13.0
11.4
10.0
8.9
7.9
7.2
6.5
6.1
5.7
5.5
5.3
30
40
50
60
70
80
90
100
110
120
130
140
150
Temperature (F)

Appendix F

Sodium Hydrosulfide Site Assessment Checklist

Sodium Hydrosulfide (NaHS) SITE ASSESSMENT CHECKLIST

General Information_____ Date: _____

Product

☐ Bulk Truck ☐ Tank Car
☐ Less than Truckloads ☐ NaHS ☐ Caustic

Customer_____

Contact Person:_____

☐ Mining
☐ Pulp and Paper
☐ Tanning
☐ Industrial ☐ Distributor

Phone Number_____

TDC Sales Contact: _____

☐ Other: _____

Facility Address: _____

City, State & Zip: _____

☐ Single Point Delivery

☐ Multiple Point Delivery

E-mail Address:_____

☐ Average quantity delivered to this location:_____ Average daily inventory: _____
Average Daily use _____

Facility Site Survey

	YES	NO	N/A
■ Does the facility have a written Emergency Response Plan?	☐	☐	☐
■ Is Safety Eyewash, Shower Station in the vicinity of Unloading Station?	☐	☐	☐
■ Is there a Grounding system at the Unloading Station?	☐	☐	☐
■ Is Containment separate for High and Low ph materials or common usage?	☐	☐	☐
■ Does the facility have written SOP's on unloading product?	☐	☐	☐
■ Is Proper Personnel Protective Equipment required and used in Unloading?	☐	☐	☐
Chemical Suit ☐ Rubber Boots ☐			
Face Shield ☐ Hard Hat ☐			
Chemical Goggles ☐			
■ Are gas sensors in unloading area—installed or personal?	☐	☐	☐
Stationary ☐ Personal ☐			
■ Are there remote activated shut off valves on or near tanks, unloading area?	☐	☐	☐
■ Are all Tanks and Transfer lines properly labeled or placarded?	☐	☐	☐
■ Is Company Personnel required to be present during offloading?	☐	☐	☐
■ Is the facility **HAZMAT** trained? Personnel Trained on safety issues of product?	☐	☐	☐
■ Can the Fire Department respond within 20 minutes to emergency and handle product?	☐	☐	☐
■ Is the facility located in an industrial area?	☐	☐	☐

COMMENTS:

_____

_____

Person completing form	Date