



# Sulfur Dioxide Handling Manual

## Sulfur Dioxide Handling Manual

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## Warning

- Sulfur dioxide is a hazardous chemical that can cause injury and death if not handled properly. This manual contains only general information on the physical properties, storage, and handling of sulfur dioxide containers and relevant equipment. It is not intended to replace or limit safety procedures in your facility.
- Safety procedures in an industrial setting must be designed in accordance with all governmental regulations and national safety codes, after giving full consideration to the specific needs of the industrial facility involved. Under no circumstances should the information in this manual be construed as substituting or superseding any local, state, or federal laws and regulations.
- Hydro Instruments cannot anticipate the specific safety procedures required at every industrial facility. Accordingly, Hydro Instruments does not guarantee that safety procedures designed in accordance with this manual will completely eliminate hazards and thus assumes no liability for accidents that may occur in your facility.
- Read this entire manual and be fully familiar with your equipment and your entire industrial system so that the safety procedures you establish will meet the needs of the employees in your facility. Reading only part of the manual will not help you analyze the needs of your facility. Contact your sulfur dioxide suppliers, and other similar organizations to obtain any MSDS and/or more information.
- All information in this manual was current at time of printing. Please note the date of printing and possible obsolescence of material as a result of scientific and medical developments after the date of publication. This applies to all materials you review in the course of developing safety procedures for use at your facility.

## When working with sulfur dioxide

- Ensure that approved, self-contained breathing apparatuses are always available and personnel are properly trained for its use.
- Safety equipment should be inspected and maintained in accordance with the manufacturer's instructions.
- Ensure that all warning signs and placards are in their appropriate place and can clearly be displayed.
- In the event of a leak, use proper safety equipment and trained personnel to respond to the leak immediately. Evacuate all personnel in a dangerous area to a safe space. If breathing has stopped perform respiration immediately. If heart has stopped perform CPR.
- Knowledgeable design personnel should oversee and approve equipment installation and suitability of the system for which it is intended. Qualified personnel should also perform routine equipment checks and maintenance in accordance with manufacturer's recommendations and instructions.



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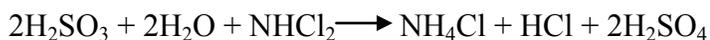
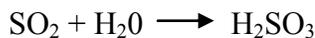
## I. INTRODUCTION

**Warning:** Sulfur dioxide is a hazardous and dangerous chemical. Take extreme care when handling and follow all pertinent safety rules and regulations.

This manual was designed for the reader to understand the proper handling, storage, service and delivery of sulfur dioxide. This manual should be read fully and understood before handling any containers or equipment. It is also suggested that the reader read all relevant material safety data sheets and contact your chemical supplier for more information.

## II. SULFUR DIOXIDE USES AND PROPERTIES

Sulfur dioxide has a wide variety of uses, but one of its primary uses for readers of this pamphlet is for de-chlorination in the water and wastewater industry (reaction see below). However, it can also be used for removal of dissolved oxygen and/or hydrogen sulfide, treatment of chromium wastes, sulfuric acid production, and as a preservative in both food and wine/beer making due to its antimicrobial properties.



Sulfur dioxide gas is normally stored as liquefied gas under pressure and is a gas at room temperature and pressure. As a gas it is colorless but will have a strong pungent odor at high enough concentrations. As a liquid it is also colorless, or clear in appearance. In the absence of moisture and at stable room temperatures, sulfur dioxide is generally considered non-corrosive; however even in the presence of a little moisture (such as atmospheric) it becomes extremely corrosive due to the generation of sulfurous acid. Sulfur dioxide gas and liquid can be lethal to human life above certain concentrations (see section III) by attacking the eyes, the lungs, and the skin. Extreme caution should be used when dealing with sulfur dioxide. Sulfur dioxide is considered non-flammable. Other important properties can be found in table 1.

**Table 1. Chemical Properties of Gaseous and Liquid Sulfur Dioxide**

Property	English Units	SI Units
<b>Sulfur Dioxide, gas</b>		
Density	0.19 lb./ft <sup>3</sup> (15 psia; 14 °F)	2.77 kg/m <sup>3</sup> (1.013 bar; 15 °C)
Compressibility factor	0.9802 (15 psia; 60 °F)	0.9802 (1.013 bar; 15 °C)
Heat capacity (C <sub>p</sub> )	0.148 Btu/(lb. F) (15 psia; 77 °F)	0.039 kJ/(mol K) (1 bar; 25 °C)
Thermal conductivity	.005 Btu/(hr. ft. F) (15 psia ; 32 °F)	8.58 mW/(m K) (1 bar; 0 °C)
<b>Sulfur Dioxide, liquid</b>		
Density	91.02 lb./ft <sup>3</sup> (15 psia; 14 °F)	1458 kg/m <sup>3</sup> (1.013 bar; -10.1 °C)
Liquid/gas equivalent	1:535 vol/vol (15 psia; 60 °F)	1:535 vol/vol (1.013 bar; 15 °C)
Latent Heat of Vaporization	167 Btu/lb. (15 psia; 14 °F)	389.37 kJ/kg (1.013 bar; -10.1 °C)

**Figure 1. Vapor Pressure Curve of Sulfur Dioxide Gas**

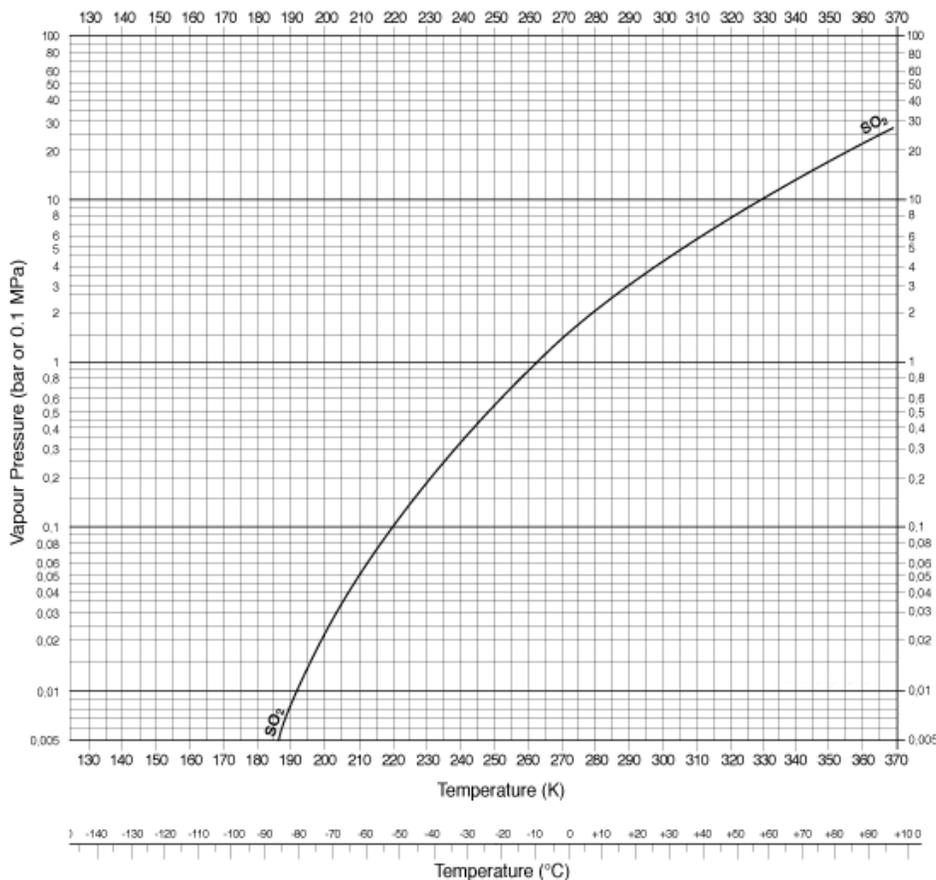


Image from: [encyclopedia.airliquide.com](http://encyclopedia.airliquide.com). Air liquide



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## III. SAFETY INFORMATION

### 1. General Health Hazards, Emergency Equipment & Emergency Action Plans:

Sulfur dioxide's primary health concern is that it will attack the lungs, mucous membranes and the eyes, and the skin leading to severe injury or death. Sulfur dioxide's odor is strong enough that it can be detected at levels around 3-5 ppm but some symptoms have been reported to occur around levels of 1 ppm. Symptoms of sulfur dioxide gas inhalation include: eye irritation, coughing, throat irritation, vomiting, and labored and difficulty breathing. Contact with liquid sulfur dioxide can also cause burns, irritation and frostbite. If any of these symptoms exist leave the area immediately. **Sulfur dioxide gas sensors should be installed everywhere appropriate.** If conditions exist, notify the appropriate personnel. If breathing has stopped then qualified personnel should perform respiratory measures until a medical team arrives. If heart stops, perform CPR.

The American Conference of Governmental Industrial Hygienists (ACGIH) has established a threshold limit of exposure to sulfur dioxide gas to 0.25 ppm for a 8 hour a day, 40 hour work week (the threshold limit will change based on the amount of time spent in the environment). Once sulfur dioxide levels reach 50 ppm, the concentration is considered immediately dangerous to life and health and the room should be vacated immediately and not be entered unless wearing proper respiratory and other personal protective equipment (PPE) and should only be entered by appropriately trained personnel using the buddy system (a system in which two people are accountable for the welfare of each other). The best respirators for dealing with leaks can depend on the size of the leak, but they should meet the NIOSH safety requirements for dealing with sulfur dioxide. Escape type respirators should also be available for any personnel in rooms where leaks may occur. All safety equipment should be located outside of the sulfur dioxide feed room and be easily accessed by all personnel. **Do not lock up equipment.**

Emergency kits are available that can seal off most leaking areas of sulfur dioxide containers. Only trained personnel familiar with this equipment should use these kits. If a ton container is leaking it is good practice to orient the container so that only gas is escaping.

Emergency action plans should be determined before setting up the sulfur dioxide system and reviewed by the chemical supplier and the agency in your area responsible for handling chemical disposal. For assistance developing an emergency action plan or providing respiratory and personal protective equipment, contact your chemical supplier, or OSHA. In the event of an emergency, you may also use CHEMTREC (United States). This is a 24/7 emergency response line, their number is 1-800-424-9300. Those who call this number should be able to provide the operator the name of the facility, the address, the phone number, contact information for other personnel, the type of leak, the action already taken, weather conditions, injuries, and directions.



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It is always good to practice emergency action plans and provide proper and routine maintenance to the equipment in order to prevent and quickly respond to leaks. Be sure to always replace gaskets and check piping. **Sulfur dioxide leaks never get better, they should be responded to immediately.**

If the container is stored in the area of a fire, it should be removed to a safe area; if this is not possible then water should be sprayed on the container to keep it cool. Although sulfur dioxide is not flammable, a pressure build up can occur resulting in an explosion

**Warning:** Never use water on a leaking sulfur dioxide container; this can cause rapid corrosion of the metals making the leak worse.

*If sulfur dioxide is in contact with skin or clothes* move to the nearest, safe emergency shower and use immediately. Clothing should be removed while showering and skin should be washed with large amounts of water for at least 15 minutes. Do not attempt chemical neutralization on skin unless recommended by an appropriate physician.

*If sulfur dioxide is in contact with the eyes* move to the nearest, safe eye wash or sink (if no eye wash is available) flush eyes with large amounts of warm, low flow water. Do not attempt chemical neutralization on the eyes unless recommended by an appropriate physician.

Material safety data sheets, as well as other important sulfur dioxide documentation should be on site for operator and emergency personnel reference.

## 2. Sulfur Dioxide Storage Facilities:

Buildings used to hold sulfur dioxide containers and equipment should comply with all local building and fire codes. If the storage facility is to have any flammable materials inside then a fire wall must be built to segregate the two areas. Non-combustible building material is recommended and sulfur dioxide gas monitors should be installed in the facility. Sulfur dioxide gas is heavier than air so gas monitors should be mounted approximately two feet from the floor for quick and accurate detection. All facilities should be designed with at least two outward opening exits. Ventilation should be installed in accordance with local building codes. The facility should not have any heavy objects placed above the containers, nor should the containers be placed near elevators or other quick leak paths. Sulfur dioxide storage facilities should be maintained at 60-70 °F (15-20 °C) to facilitate safe and consistent discharge rates of sulfur dioxide. **Never apply heat directly to a sulfur dioxide container** as the fusible plugs will melt at 165 °F (74 °C) resulting in a leak. Take special care to avoid restrictive spaces in working areas.



## IV. SULFUR DIOXIDE CONTAINERS

### 1. Sulfur Dioxide Cylinders

There are many different sizes of sulfur dioxide cylinders ranging from 1 to 150 pounds. However, the 100 and 150 pound cylinders generally dominate the market. All cylinders as well as other containers must conform to appropriate DOT standard to be certified for use. Common sizes and weights can be seen table 2.

Moving sulfur dioxide cylinders should be done with the utmost care and with a hand truck which has restraint chains to secure the cylinder. Never move a cylinder with a sling or magnetic devices or lift by the neck ring. If lifting is absolutely necessary, then there are specially designed slings that can be purchased. **Always handle cylinders with extreme care and avoid contact between cylinders.** Once the cylinders are in place, they should each be individually chained to the wall to prevent the cylinders from falling.

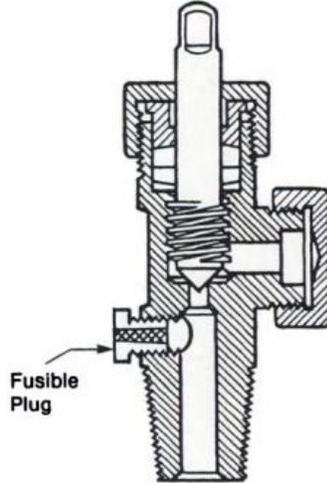
**Table 2. Sizes and Dimension of Sulfur Dioxide Containers**

Type of Container	Net Weight	Tare Weight	Gross Weight	Outside Diameter	Length
Cylinder	150 lbs.	85-140 lbs.	235-290 lbs.	10 1/4" - 10 3/4"	4'5" - 4'8"
Ton Container	2000 lbs.	1300-1650 lbs.	3300-3650 lbs.	2'6"	6'7 3/4" - 6'10 1/2"
Tank Car	55 tons 90 tons	N/A	N/A	14'3" - 15'1" 14'11" - 15'1"	29'9" - 43'0" 45'8" - 47'2"

Sulfur dioxide cylinders also contain a fusible plug which is designed to melt and release gas in a relatively safe manner should the sulfur dioxide gas temperature in the container reach 165 °F (74 °C).

Sulfur dioxide cylinders are only designed for gas withdrawal and have one header valve which most commonly CGA 660 which threads into a 3/4" NGT thread located at the top of the cylinder. The fusible plug is also located on the header valve of a sulfur dioxide cylinder (see figure 2). Using a specially designed wrench, gas will be allowed to flow from the valve by turning the top valve open 1/4 turn.

**Figure 2. Sulfur Dioxide Header Valve**

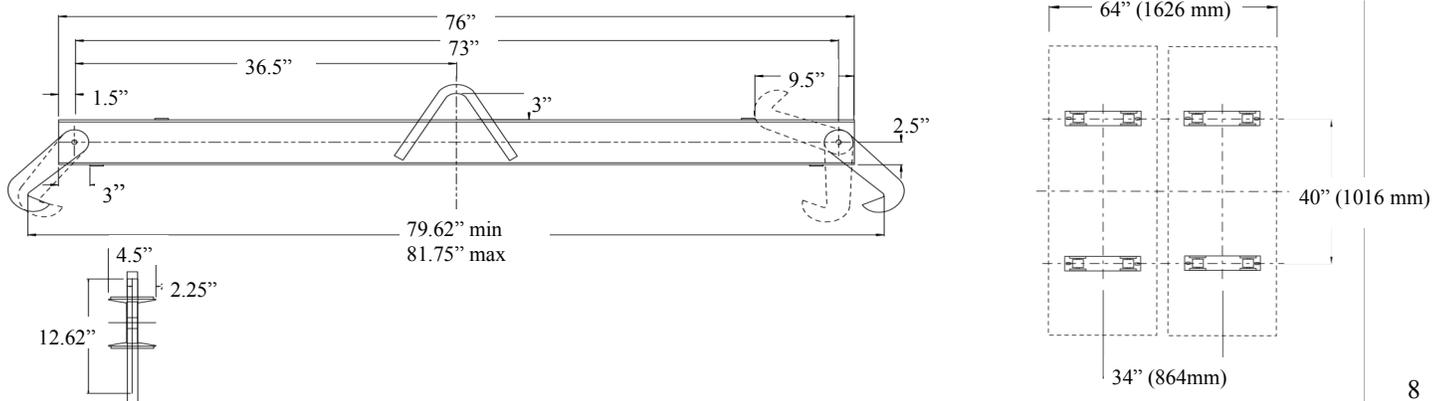


*Image from: Handbook of Compressed Gases 4<sup>th</sup> edition. Compressed Gas Association.*

## 2. Ton Containers

Ton containers are much larger than sulfur dioxide cylinders and are usually used in larger feed applications when the use of manifolded cylinders is impractical. Ton containers carry 2000 lbs. (910 kg.) of sulfur dioxide. Ton containers are of welded construction, and must be certified by the appropriate department of transportation (DOT). Due to their considerable size and weight, special considerations should be given to the use of lifting bars and roller trunnions for the placement and storage of ton containers (see figure 3). Other common methods have been through fork lifts, or conveyors. Operators, especially in earthquake prone areas, may want to secure ton containers to the ground by strapping them to the floor. In the event of an earthquake, unrestrained ton containers can move off their trunnions resulting in a major leak. **Always handle ton containers with extreme care and avoid contact between containers.**

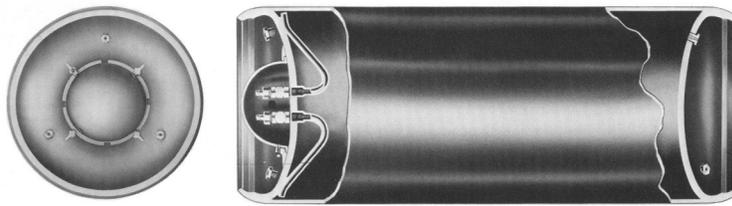
**Figure 3. Ton Container Lifting Bar and Roller Trunnion**



Ton containers have six fusible plugs which are located three at each end and separated 120 degrees apart from one another. This allows for the release of sulfur dioxide gas in a relatively safe manner should the temperature of the gas reach 165 °F (74 °C). They also have concave heads which are designed to expand due to a build-up in pressure; this is an additional safety feature that a gas cylinder does not have.

Ton containers most commonly have two outlet connections, the top one for gas withdrawal and the bottom one for liquid withdrawal (figure 4). Both of these outlets most commonly use CGA 660 valves but do not have a fusible plug on them. In some cases, ton containers may have four outlets. It is very important that the two valves be aligned vertically so that one valve may be used for gas and the other for liquid. The reason being that each valve is connected to a steel tube, commonly called an eduction pipe, that extends to the outer edge of the inside container (figure 4). This way, when they are in vertically alignment one can be used solely for gas, and the other one solely for liquid.

**Figure 4. Ton Container**

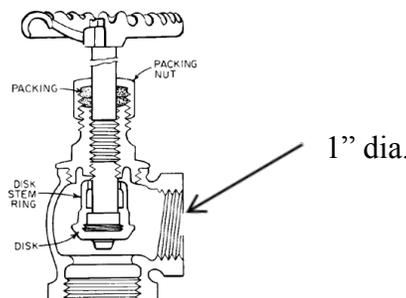


### 3. Tank Trucks/Rail Cars

Tank trucks that are used for choline service come in sizes ranging from 15-22 tons, with 17 tons being the most prevalent. These trucks must be certified by the appropriate standards of the department of transportation. Most operators will either unload the contents of the truck into a storage tank, or feed directly from the truck.

Gaseous or liquid feed is possible from tank trucks through the use of four slow-opening angle valves (2 liquid, 2 gas) and a pressure relief valve. As seen in figure 5, connections to tank trucks are made using 1” ANSI standard taper pipe threaded connections. Feed from rail cars have the same setup but are considerably larger in size; usually around 90 tons.

**Figure 5. Standard Slow-opening Angle Valve Tank Trucks and Rail Cars**





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## 4. Withdrawal Rates

In general, a dependable withdrawal rate from a 100/150 pound cylinder is around 3.5 lb./day/(°F-40). The dependable withdrawal rate for gas from a ton container is 6.0 lb./day/(°F-40). Both these rates assume a liquid sulfur dioxide temperature of 70 °F. Gas withdrawal rates can be increased for brief periods of time (usually at the start of feed) if necessary, but if prolonged will lead to pipe sweating and frost formation on the pipes. If a larger feed rate is required the best practice is to manifold containers together or use a vaporizer. **Never apply heat directly to a container**, in this case the gas temperature could get too hot and melt the fusible plugs resulting in a leak.

Liquid withdrawal from ton containers can reach feed rates considerably higher and have a maximum rating of 7200 PPD. Note however that a ton container only contains 2000 pounds of sulfur dioxide so the containers would have to be changed multiple times a day. Liquid withdrawal from tank trucks can be considerably higher depending on the type of vehicle. Contact your chemical supply for liquid withdrawal rates. **DO NOT manifold ton containers for simultaneous liquid withdrawal.** This can lead to over pressurization of the pipe, resulting in a leak.

The withdrawal rates are primarily based on the temperature of the liquid in the cylinder, and thus the pressure of the gas. For low withdrawal rates, heat will be able to be transferred from the surrounding air to the container in time so that there is no drop in temperature or pressure, resulting in a constant withdrawal rate. If the feed rates are large enough, the air will not be able to transfer the heat quickly enough and the temperature (and pressure) of the sulfur dioxide will drop, thus resulting in a lower feed rate. If high enough and prolonged enough, this can even result in ice formation around the outside of the container, further decreasing the withdrawal rate. The most effective way to increase withdrawal rate from a single container is to circulate the surrounding air with a fan. Again, never apply heat to the containers.

If the gas withdrawal rate from one container is not enough, then multiple containers can be manifolded together.

## V. STORAGE AND USE OF CONTAINERS

Any type of sulfur dioxide container should be kept in a cool, dry, temperature and stable environment generally around 60-70 °F (15-50 °C). They should also be kept out of direct sunlight and securely mounted on either trunions (ton containers) or chained to a wall (cylinders). Operators, especially in earthquake prone areas, may want to secure ton containers to the ground by strapping them to the floor. The storage area should be well ventilated and free of flammable materials (see section III.2). If stored outdoors, the containers should be fenced off so that only proper personnel can reach them. Containers should not be stored below ground or in heavily trafficked areas. Anywhere sulfur dioxide is being stored or there is a possible chance for a leak a sulfur dioxide gas monitor must always be installed. Since the fusible plugs will



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melt and result in a sulfur dioxide leak at 165 °F (74 °C), measures must be taken to avoid the temperature getting this high. Heater malfunctions have caused such leaks so installations with heaters should install high air temperature alarms wired to shut off the heaters.

Full and empty containers should be stored separately. Cylinders should always be stored in an upright position and properly secured using chains. Avoid contact between cylinders or any situations where objects will contact cylinders.

In most cases, state and/or local regulations will limit the amount of sulfur dioxide that can be stored on site, be sure to check with all the regulations before purchasing.

Do not remove the protective cap from cylinders or ton containers unless they are ready to be used. It is good practice to use the containers that have been in storage the longest before using newer ones.

When in use, it is ideal to have a separate scale for each container tared to its specific weight so that you can monitor chemical supply. There are many different types of scales for cylinders, ton containers, and even tank cars. Scales should be kept as flat with the floor as possible to minimize lifting of the containers. The only exception is with ton containers as they are normally stored on trunnions which are lifted off the ground.

If moving the containers from a storage area to a feed area, an adequate amount of time should be allowed to let the temperature and pressure of the cylinder stabilize before beginning to feed. All containers that are manifolded together should be at the same elevation, temperature and pressure before feeding.

If feeding from ton containers make sure that two valves are in vertical alignment, and use the top valve for gas withdrawal and the bottom valve for liquid withdrawal.

## **VI. PRESSURE MANIFOLDING, PIPING AND OTHER SULFUR DIOXIDE LINE ACCESSORIES**

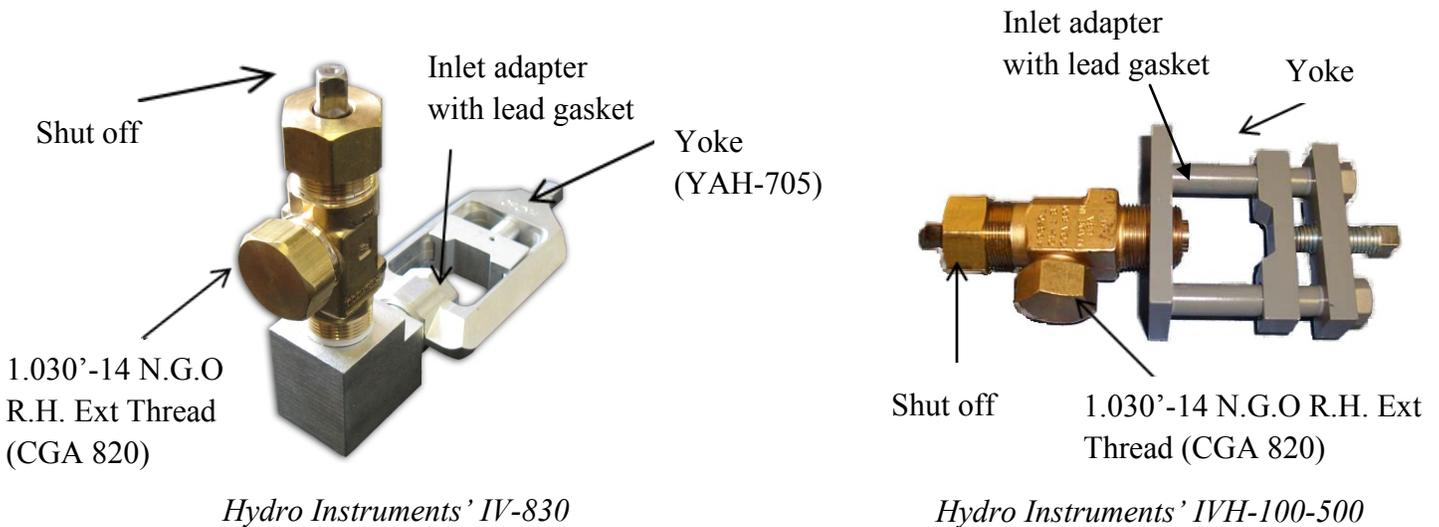
In some instances, sulfur dioxide vacuum regulators can be mounted directly onto the cylinder/container valve using a specially designed yoke included with the unit. For direct ton container mounting these yokes will also include a drip leg to vaporize any liquid that was trapped in the education pipe. It is important that the regulator be mounted to the top valve, and the top valve only. To mount the vacuum regulator onto the container valve, first place a lead gasket on the inlet assembly and then put the yoke around the container valve. Tighten the screw on the yoke with the specialty wrench until it is firmly sealed in place.

If larger feed rates are required and direct mounting is not feasible then manifolding the containers is required. There is special equipment that goes along with the procedure and it will be described in the remainder of this section.

## 1. Auxiliary Valves

It is strongly recommended that auxiliary valves be used on all container header valves. This will greatly reduce the chances of sulfur dioxide leaks and increase the lifetime of the flexible connectors. Auxiliary valves can also be used to prevent air from entering the flexible connectors and manifold piping. Auxiliary valves come with a yoke for mounting onto the container valve with a lead gasket and an adapter to fit around the thread. This leads out into another CGA 820 header valve where the flexible connector can be attached. The auxiliary valve allows for gas to be shut off right at the container. See figure 6 for a detailed auxiliary valve drawing.

**Figure 6. Auxiliary Valve for Container Connection**



## 2. Flexible Connectors

Flexible connectors are available in various lengths, but the most common are 4', 6', 10', and 16'. Flexible connectors are constructed from 3/8" O.D. copper tubing and have a cadmium or nickel plating for superior corrosion resistance. Inlet and outlet connections are 1.030"-14 FNPT which are suitable for mating to CGA 820 and CGA 660 header valves. Adapters are also available to mate the CGA 820 connection to NPT or any other type of thread.

## 3. Manifold/Pressurized Piping

All piping that leads up to the vacuum regulator will be under pressure and must follow strict safety precautions and regulations. Pressurized piping lines should be kept as short as possible in order to minimize the chance of pressurized leaks. If constructing a manifold for ton container gas withdrawal the piping should also be equipped with a drip leg and heater to vaporize any liquid sulfur dioxide that may enter the



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line. Piping should consist of schedule 80 seamless carbon steel A-106, grade B and fittings should be 3000 psi rated carbon steel A-105. Teflon tape or litharge glue should be used on all joints, or they can be socket welded. The most common diameter piping is  $\frac{3}{4}$ " or 1" pipe.

## 4. Valves

There are many varieties of ball valves that can be used for pressurized sulfur dioxide service such as ball valves, line valves, angle valves etc. They must be compatible with pressurized sulfur dioxide which usually makes their material of construction a carbon steel body, with Monel or Hastelloy C internals although other compatible materials may be available. Ball valves must also come with a provision for venting the cavity in the closed position to the upstream side.

## 5. Pressure Gauges

Many types of pressure gauges can be used. However, due to the corrosive nature of sulfur dioxide they must be diaphragm protected by a material suitable for sulfur dioxide. The pressure gauge must remain connected to the diaphragm seal at all times or the gauge will not function accurately.

## 6. Expansion Chambers (for liquid service)

Expansion chambers are a necessary component of any liquid sulfur dioxide line. Due to sulfur dioxide's large coefficient of expansion, any liquid that is trapped in the pipeline could expand rapidly and burst the pipe should the temperature of the room increase. Expansion chambers provide pressure relief to avoid such a leak. They consist of a rupture disc and holder assembly, a pressure switch and an expansion chamber. The rupture disc is designed to burst should the pressure in the pipeline exceed safe limits, and then the gas will expand into the expansion chamber, thus relieving the pressure. The pressure switch is for indication that the disc has burst. The volume of the expansion chamber should cover at least 20% of the volume of pipeline it is to protect.

## 7. Pressure Reducing Valves:

Pressure reducing valves are used to help prevent liquefaction downstream of the valve, and to prevent inlet pressures into the regulator from being too high. Damage to regulators can occur at inlet pressures above 150 psig. To prevent liquefaction of sulfur dioxide gas, the pressure reducing valve should be set no higher than 15 psig. The pressure reducing valve must be of the self-actuating spring loaded type, or pneumatically, hydraulically or electrically actuated type.



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## 8. Vaporizers:

Most liquid feed applications call for the use of an evaporator to vaporize the incoming liquid into a gas rather than inject liquid sulfur dioxide. Most commercial vaporizers can vaporize up to 8,000-9,000 PPD of liquid sulfur dioxide. Vaporizers usually consist of an ASME certified Carbon Steel welded pressure vessel immersed in hot water or steam. Appropriate control features are also included to monitor vaporizer performance and operating conditions.

## VII. PREPARING PIPING FOR USE

Often times in pressurized sulfur dioxide piping systems, oil, water and other chemicals can exist in the pipe before initial start-up. These dangerous components must be flushed out of the system before the sulfur dioxide is introduced or rapid pipe corrosion can occur and create a leak. All equipment for handling sulfur dioxide received in an oily condition should be cleaned before use. Passing hot steam through the lines is a generally accepted method of cleaning. Contact your chemical supplier for more cleaning information.

Drying of the pipe is the most essential step in preparation for sulfur dioxide use. This will eliminate any moisture buildup inside the pipe. Drying can be performed after cleaning by passing dry air or an inert gas, such as nitrogen, through the lines while the pipe is still hot until the dew point of the discharge gas is below -40 F. Certain provisions must be followed when drying the pipes, especially when dealing with the high pressures of nitrogen gas. Contact your chemical supplier for more information.

Sulfur dioxide piping systems should be pressure tested with an inert gas, such as nitrogen, before use and test pressures should be 1.5 times the maximum operating pressure. All components which could become damaged during the pressure test should be isolated.

Leak testing with sulfur dioxide should also be performed after pressure testing with nitrogen. For this hook up the piping to the sulfur dioxide **GAS** lines, as using liquid lines can result in a more serious leak due to its coefficient of expansion. Once the piping is connected to the gas line open the valve temporarily and shut once the pressure reaches a sufficient level. Check for leaks around the piping by using a 26 Baume solution of ammonia. Make sure only the gas is coming out of the bottom. Should there be a leak a puff of white smoke will appear. Take appropriate measures to fix the leak and retest.

## VIII. VACUUM PIPING AND OTHER SULFUR DIOXIDE LINE ACCESSORIES

Vacuum lines consist of piping from the vacuum regulator to the ejector. The most common material used is Polyethylene. Table 3 shows a guide for the appropriate selection of tubing based on feed rate and distance. Tubing under 3/4" is Polyethylene and larger is PVC.

Ball valves for vacuum piping can also be made from PVC but should also come with a provision for venting the cavity in the closed position to the upstream side.

**Table 3. Tube Diameter for Vacuum Feed**

Gas Feed Rate	100 ft.	200 ft.	300 ft.	500 ft.	1000 ft.	1500 ft.
50 PPD / 1 kg/h	3/8"	3/8"	1/2"	1/2"	1/2"	5/8"
100 PPD / 2 kg/h	3/8"	1/2"	5/8"	5/8"	3/4"	3/4"
250 PPD / 5 kg/h	1/2"	5/8"	3/4"	3/4"	1"	1"
500 PPD / 10 kg/h	5/8"	3/4"	1"	1"	1-1/2"	1-1/2"
1000 PPD / 20 kg/h	1"	1"	1-1/2"	1-1/2"	1-1/2"	1-1/2"
2000 PPD / 40 kg/h	1"	1-1/2"	1-1/2"	2"	2"	2"
4000 PPD / 80 kg/h	1-1/2"	1-1/2"	2"	2"	2"	3"
6000 PPD / 120 kg/h	1-1/2"	2"	2"	2"	3"	3"

**NOTES:**

1. In the above table:
  - a. 3/8", 1/2" and 5/8" refer to the OD (outer diameter) of flexible polyethylene plastic tubing.
  - b. 3/4", 1", 1-1/2", 2" and 3" refer to Schedule 80 PVC rigid piping.
2. The above recommendations are based on calculations limiting friction loss to 0.5" Hg or less.

## IX. SULFUR DIOXIDE ABSORPTION AND DISPOSAL

If a leak occurs at the facility, the best option if available would be to run the sulfur dioxide through the regular sulfur dioxide consuming/injection process, or run a temporary line to the consuming point. If the process cannot allow this, then a sulfur dioxide scrubber/absorption system should be considered.

A simple absorption system (scrubber) will consist of materials capable of holding a the materials and by-products present. Generally, this will hold a sodium hydroxide solution which is capable of neutralizing 1.25 pounds of sulfur dioxide per pounds. Other common absorption compounds are sodium carbonate, which can neutralize 0.5 pounds of sulfur dioxide per pound, or calcium hydroxide, which can neutralize 0.71 pounds of sulfur dioxide per pound. Sulfur dioxide scrubber systems can be very complex and should be installed only after given appropriate engineering consideration.