Chlorine Handling Manual

The information contained in this manual was accurate at the time of printing. The most current versions of all Hydro Instruments' manuals can be found on our website www.hydroinstruments.com.

TABLE OF CONTENTS

WARNING

- Chlorine 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 chlorine 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 you facility. Reading only part of the manual will not help you analyze the needs of your facility. Contact your chlorine supplier, the Chlorine Institute, 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 Chlorine

- 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 places and are clearly visible.
- In the event of a leak, use trained personnel with the proper safety equipment to respond to the leak immediately. Evacuate all personnel from dangerous areas 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 manufacturers recommendations and instructions.

I. INTRODUCTION

WARNING: Chlorine 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 chlorine. This manual should be read fully and understood before handling any containers or equipment. It is also suggested that the reader read the following documents for further understanding.

The Chlorine Manual. Sixth ed. Washington: The Chlorine Institute, INC., 2000.

Pamphlet 1: Chlorine Basics. Seventh ed. Washington: The Chlorine Institute, INC,2008.

Pamphlet 155: Water and Wastewater Operators Chlorine Handbook. Second ed. Washington:The Chlorine Institute, INC, 2008.

II. CHLORINE USES AND PROPERTIES

Chlorine has a wide variety of uses, but one of its primary uses is in the disinfection of water and wastewater. Since the early 1900's chlorine has been the primary form of disinfection for water utilities and it is estimated that approximately 98% of all modern drinking water systems in the United States use chlorine chemistry for disinfection purposes. Generally used as a gas, chlorine has many applications in the fields of: Food and beverage processing, pharmaceuticals, electronics manufacturing, rubber processing, aluminum fluxing, and many others.

Chlorine gas is normally stored as liquefied gas under pressure and is a gas at room temperature and pressure. As a gas it has a greenish yellow color and as a liquid it appears brown. In the absence of moisture, chlorine is generally considered non-corrosive; however even in the presence of a little moisture (such as atmospheric) it becomes a strong oxidizing agent and becomes extremely corrosive. Chlorine gas and liquid can be lethal to human life above certain concentrations (see Section III) by attacking mucous membranes in the eyes, throat and lungs. Extreme caution should be used when working with chlorine. Other important properties can be found in Table 1.

Table 1. Chemical Properties of Gaseous and Liquid Chlorine

Property	English Units	SI Units
Chlorine, gas		
Density	0.19 lb./ft^3 (15 psia; 60 ˚F)	3.04 kg/m^3 (1.013 bar; 15 ˚C)
Compressibility factor	0.9867 (15 psia; 70 ˚F)	0.9867 (1.013 bar; 21 ˚C)
Heat capacity (C_p)	0.1139 Btu/(lb. F) (15 psia; 68 ˚F)	0.033 kJ/(mol K) (1 bar; 25 ˚C)
Thermal conductivity	.0048 Btu/(hr. ft. F) (15 psia ; 32 ˚F)	7.91 mW/(m K) (1 bar; 0 ˚C)
Chlorine, Liquid		
Density	91.67 lb./ft^3 (53 psia; 32 ˚F)	1562.5 kg/m^3(1.013 bar; -34.1 ˚C)
Liquid/gas equivalent	1:521 vol/vol (15 psia; 60 ˚F)	1:521 vol/vol (1.013 bar; 15 ˚C)
Latent Heat of Vaporization	111 Btu/lb. (85 psia; 60 ˚F)	287.79 kJ/kg (1.013 bar; -34.1 ˚C)

Figure 1. Vapor Pressure Curve of Chlorine Gas

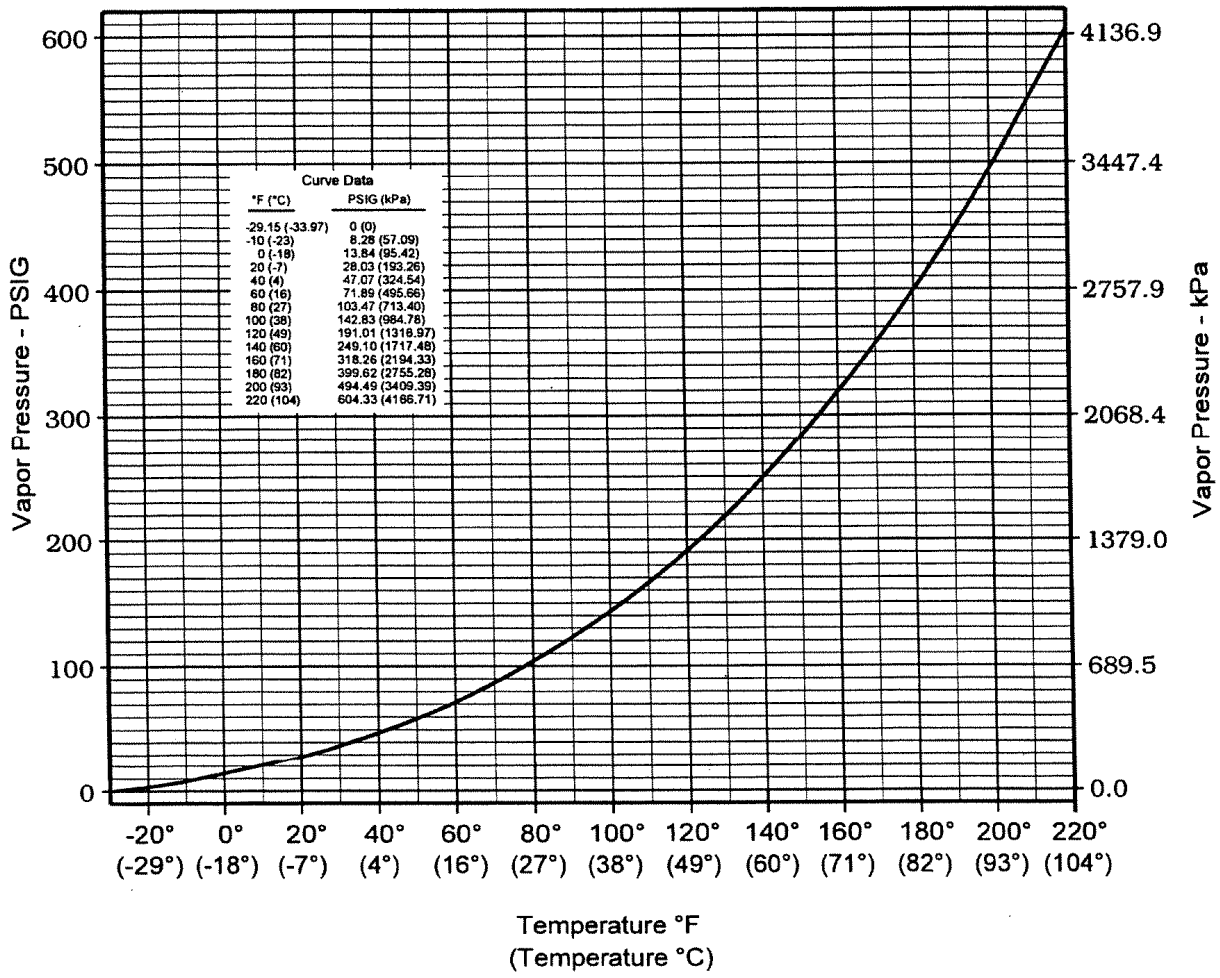


Image from: The Chlorine Manual. Sixth ed. Washington: The Chlorine Institute, INC., 2000.

III.SAFETY INFORMATION

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

Chlorine's primary health concern is that it is an extreme oxidizer and will attack the mucous membranes of the lungs, eyes and throat leading to severe injury or death. Chlorine's odor is strong enough that it can be detected at levels around 1 ppm. Symptoms of chlorine gas inhalation include: eye irritation, coughing, throat irritation, vomiting, and labored breathing. Contact with liquid chlorine can also cause burns and irritation. If any of these symptoms exist leave the area immediately. **Chlorine gas sensors should be installed everywhere appropriate**. If symptoms 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 chlorine gas to 0.5 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 chlorine levels reach 10 ppm, the concentration is considered immediately dangerous to life and health and the area should be vacated immediately. Above 10 ppm, the area must not be entered unless wearing proper respiratory and other personal protective equipment (PPE). The area 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 are the air tank type pressure demand masks. This equipment should also meet the NIOSH safety requirements. Escape type respirators should also be available for any personnel in rooms where leaks may occur (see Chlorine Institute INC's pamphlet 65 and 75). All safety equipment should be located outside of the chlorine room and be easily accessed by all personnel. **Do not lock up safety equipment.**

Emergency kits are available that can seal off most leaking areas of chlorine 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 chlorination system and reviewed by the chlorine 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, see the Chlorine Institute INC's pamphlets 64 and 65 respectively. 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.

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. **Chlorine 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.

WARNING: Never use water on a leaking chlorine container; this can cause rapid corrosion of the metals making the leak worse.

If chlorine 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 chlorine 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 chlorine manuals and documentation should be on site for operator and emergency personnel reference.

Chlorine gas is neither explosive nor flammable. However since it is an oxidizer, chlorine can support combustion, and is extremely corrosive to metals when in a moist environment.

2. Chlorine Storage Facilities:

Buildings used to hold chlorine 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 chlorine gas monitors should be installed in the facility. Chlorine 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. Chlorine storage facilities should be maintained at 60-120 ˚F (15-50 ˚C) to facilitate safe and consistent discharge rates of chlorine. **Never apply heat directly to a chlorine container** as fusible plugs will melt at temperatures between 158-165 ˚F (70-74 ˚C) resulting in a chlorine leak. Take special care to avoid restrictive spaces in working areas.

IV.CHLORINE CONTAINERS

1. Chlorine Cylinders

There are many different sizes of chlorine cylinders, but typically 100 and 150 pound cylinders dominate the market. All chlorine cylinders are made from one piece of seamless carbon steel construction and must conform to DOT3A480 or DOT3AA480 specifications. The DOT specification number, serial number, identifying symbol tare weight, inspectors mark and hydrostatic test date must be marked on the cylinder to be certified for use. Common sizes and weights can be seen Table 2.

Moving chlorine 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 cylinder is in place, it should be chained to the wall to prevent the cylinder from falling.

Table 2. Sizes and Dimension of Chlorine Containers

Data from: The Chlorine Manual. Sixth ed. Washington: The Chlorine Institute, INC., 2000.

Type of Container	Net Weight	Tare Weight	Gross Weight	Outside Diameter	Length
Cylinder	100 lbs. 150 lbs.	63-115 lbs. 85-140 lbs.	163-215 lbs. 235-290 lbs.	8 ¼”-10 ¾” 10 ¼”- 10 ¾”	3’3 ½”-4’11” 4’5”-4’8”
Ton Container	2000 lbs.	1300-1650 lbs.	3300-3650 lbs.	2’6”	6’7 ¾”-6’10 ½”
Tank Car	16 tons 30 tons 55 tons 85 tons 90 tons	N/A	N/A	10’5”-12’0” 12’4 ½”-13’7” 14’3”-15’1” 14’11”-15’1” 14’11”-15’1”	32’2”-33’3” 33’10”-35’11 ½” 29’9”-43’0” 43’7”-50’0” 45’8”-47’2”

Chlorine cylinders contain a fusible plug, located on the rear of the cylinder valve (Figure 2) which is designed to melt and release pressure in a relatively safe manner should the temperature reach 158-165 ˚F (70-74 ˚C).

Chlorine cylinders are only designed for gas withdrawal and have one CGA 820 header valve which threads into a ¾” NPT port at the top of the cylinder. Using a specially designed wrench, gas will be allowed to flow from the valve by turning the top valve open ¼ turn. It is recommended that this wrench be left on the container valve when open for quick closure in the event of a leak.

Figure 2. USA Standard Chlorine Cylinder Header Valve

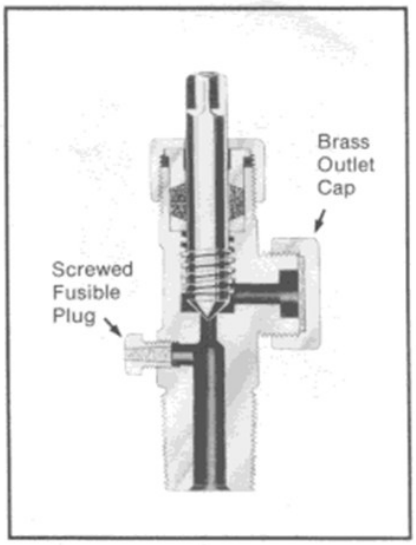
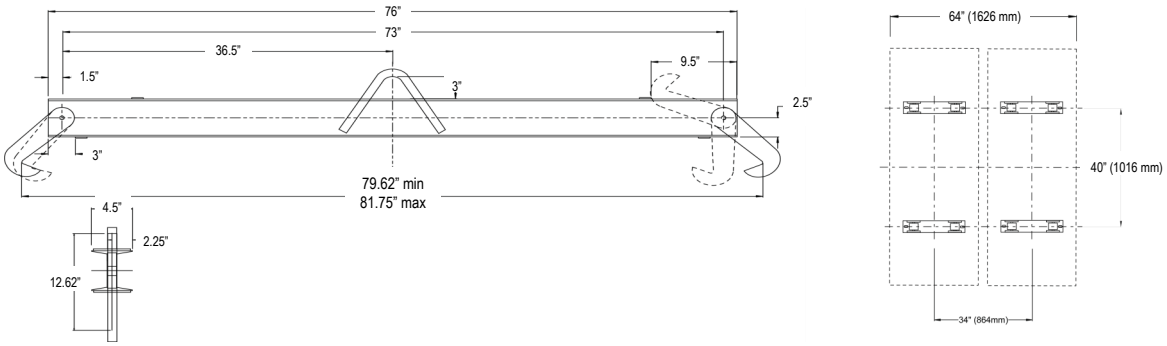


Image from: The Chlorine Manual. Sixth ed. Washington: The Chlorine Institute, INC., 2000.

2. Ton Containers

Ton containers are much larger than chlorine cylinders and are usually used in larger feed applications when the use of manifold cylinders is impractical. Ton containers carry 2000 lbs. (910 kg.) of chlorine. Ton containers are of welded construction, DOT106A500X certified and their dimensions can be seen in Table 2. The DOT specification number, serial number, identifying symbol tare weight, inspectors mark, hydrostatic test date and water capacity must be marked on the cylinder to be certified for use. Due to their considerable size and weight, special considerations should be given to the use of lifting bars and roller trunions for the placement and storage of ton containers (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.**

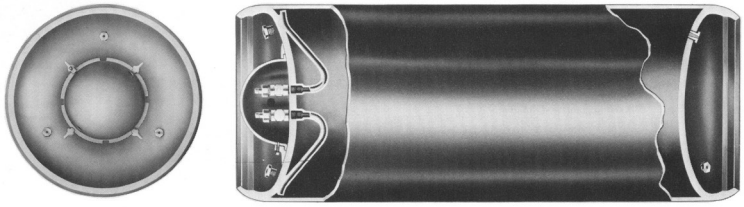
Figure 3. Ton Container Lifting Bar and Roller Trunnion



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 chlorine gas in a relatively safe manner should the temperature of the gas reach 158-165 ˚F (70-74 ˚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 use CGA 820 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

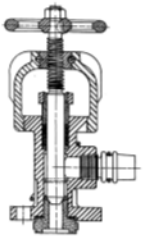


3. Rail Cars / Tank Cars

Rail cars that are used for choline service come in sizes ranging from 16 to 90 tons, with 55 and 90 tons being the most common. Most operations will unload the liquid contents of the rail car into a storage tank, or feed liquid chlorine directly from the rail car.

Chlorine is fed from the cars through the use of slow-opening angle valves (Figure 5). There are four angle valves arranged around a central pressure relief valve at the top of the car (Figure 6). The two angle valves on the lengthwise centerline of the rail car are for liquid withdraw—these valves have a drop pipe which extends down to the bottom of the tank. The other two go to the cars vapor space. Do not attempt to feed gaseous chlorine directly from rail cars, see the note on the next page regarding this point.

Figure 5. Slow-opening Angle Valve



Images from: The Chlorine Manual. Sixth ed. Washington: The Chlorine Institute, INC., 2000.

NOTE:

Chlorine Institute, Inc. Pamphlet 66, Recommended Practices for Handling Chlorine Tank Cars (section 2.3) discusses why NOT to withdraw chlorine from tank cars in the vapor phase, see excerpt below.

"2.3 NITROGEN TRICHLORIDE - HAZARD AWARENESS

The presence of nitrogen trichloride in liquid chlorine is the suspected cause of explosions that have occurred, although infrequently, in chlorine systems including chlorine transportation containers. Nitrogen trichloride is formed from nitrogen that enters the system during the chlorine production process. Pamphlet 152 Safe Handling of Chlorine Containing Nitrogen Trichloride (Reference 13.1.9) provides methods for the detection, prevention and destruction of nitrogen trichloride. Bulk shipping containers (barge tanks, tank cars and cargo tanks) should not be unloaded in the gas phase. If present, nitrogen trichloride will concentrate in the liquid phase because of nitrogen trichloride's higher boiling point. Due to the relatively large amount of chlorine in the bulk container, the nitrogen trichloride in the liquid phase could concentrate to dangerous levels if only gases are removed." -The Chlorine Institute, Inc. (2009)*Pamphlet 66: Recommended Practices for Handling Chlorine Tank Cars, Fourth Edition –Revision 1* [PDF], Arlington, VA, The Chlorine Institute, Inc.

Additional information can be found in:

The Chlorine Institute, Inc. (2010) *Pamphlet 21: Nitrogen Trichloride—A Collection of Reports and Papers, Edition 6* [PDF], Arlington, VA, The Chlorine Institute, Inc.

The Chlorine Institute, Inc. (2011) *Pamphlet 152: Safe Handling of Chlorine Containing Nitrogen Trichloride, Edition 3* [PDF], Arlington, VA, The Chlorine Institute, Inc.

Figure 6. Angle Valve Arrangement

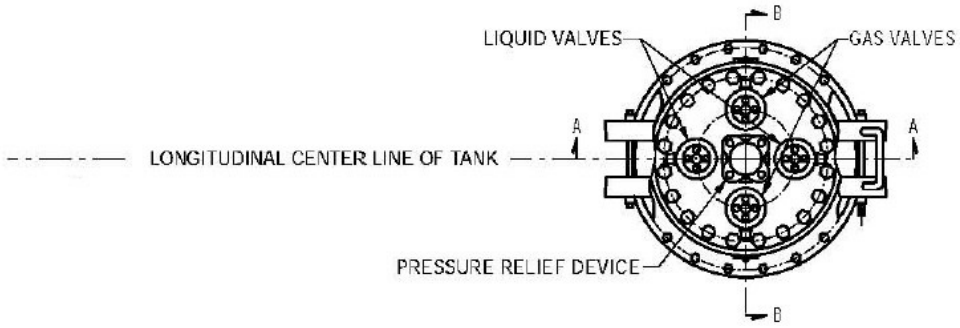


Image from: The Chlorine Institute, Inc. (2009)*Pamphlet 66: Recommended Practices for Handling Chlorine Tank Cars. Fourth Edition–Revision 1* [PDF], Arlington, VA, The Chlorine Institute, Inc.

4. Withdrawal Rates

In general, a dependable withdrawal rate from a 100/150 pound cylinder is around 1 lb./day/˚F. The dependable withdrawal rate for gas from a ton container is 8.0 lb./day/˚F. Both these rates assume a back pressure of at least 35 psig and a chlorine gas temperature of 60 ˚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 chlorine leak.

Liquid withdrawal from ton containers can reach feed rates considerably higher and have a maximum rating of 9600 PPD (180 kg/hr). Note however that a ton container only contains 2000 pounds (909 kg) of chlorine so the containers would have to be changed multiple times a day. Liquid withdrawal from tank trucks can reach up to 8,000 pounds per hour (3,636 kg/hr).

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 chlorine 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 withdrawal rate from one container is not enough, then multiple containers can be manifold together.

v. STORAGE AND USE OF CONTAINERS

Any type of chlorine container should be kept in a dry, temperature stable environment around 60-120 ˚F (15-50 ˚C). They must 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 (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 chlorine is being stored or there is a possible chance for a leak a chlorine gas monitor must always be installed. Since the fusible plugs will melt and result in a chlorine leak at 158-165 ˚F (70-74 ˚C) measures must be taken to avoid the temperature getting this high. Heater malfunctions have caused such leaks so installations with room heaters should install high air temperature sensors 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 chlorine that can be stored on site. Be sure to check with all the regulations before purchasing the chlorine.

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 tare to its specific weight so that you can monitor chlorine 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 on the same manifold 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 CHLORINE LINE ACCESSORIES

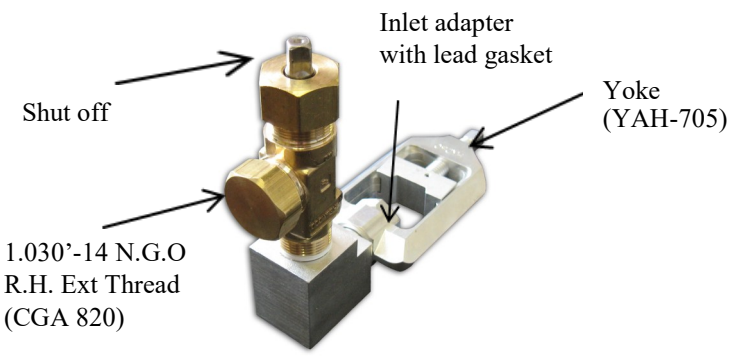
In some instances, chlorine vacuum regulators can be mounted directly onto the cylinder/ container using a specially designed yoke included with the unit. For direct ton container mounting these yoke assemblies will also include a drip leg to vaporize any liquid that was trapped in the eduction pipe. It is important that the regulator be mounted to the ton container 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. Then 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. It is important to ensure that all components installed in chlorine pressure manifolds must be rated to withstand the maximum possible pressure that could be experienced in the application of use. For gas withdrawal manifolds that is typically 400 PSI (28 bar) and for liquid withdrawal manifolds ratings should be at least 600 PSI (41 bar). Gauges and switches should be rated to 1,000 PSI (69 bar) on liquid manifolds.

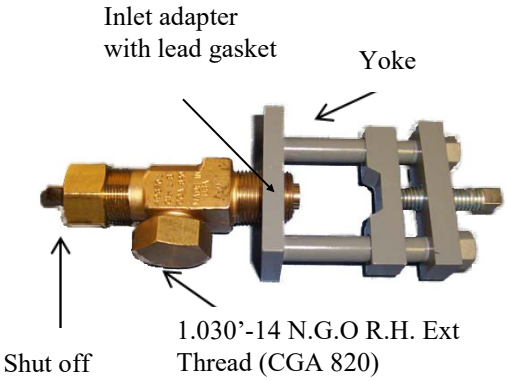
1. Isolation Valve Assemblies (Auxiliary Valves)

It is strongly recommended that isolation valve assemblies be used on all container connections. This will greatly reduce the chances of chlorine leaks and increase the lifetime of the flexible connectors. Isolation valves are also used to prevent air and moisture from entering the flexible connectors and manifold piping. If moisture is allowed to enter the manifold (usually during changing of containers) this can lead to serious corrosion inside the manifold which then causes equipment failures and additional maintenance. Isolation valves come with a yoke for mounting onto the chlorine container valve with a lead gasket and an adapter to fit around the CGA 820 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 7 for a detailed isolation valve assembly drawing.

Figure 7. Isolation Valve Assembly for Container Connection



Hydro Instruments' IV-830



Hydro Instruments' IVH-100-500

2. Flexible Connectors

Flexible connectors are available in various lengths (e.g. 4', 6', 10', and 16'). They are constructed from 3/8" O.D. copper tubing and have a cadmium or zinc plating for superior corrosion resistance. Inlet and outlet connections are 1.030"-14 FNPT which are suitable for mating to CGA 820 header valves.

Flexible connectors should be inspected regularly and during each ton container change out. The appearance of corrosion at the joints and/or a cracking sound when flexed indicates material corrosion and is cause for replacement. Usage and site conditions are a factor; a punch card is provided with each flexible connector as a helpful way to establish a trend / average number of ton container changes before replacement is necessary.

NOTE: The provided tag has 24 punches, but this is not a guarantee the flex connector will last for 24 uses. It is strongly recommended to replace the flexible connector after 24 uses.

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 set by the Chlorine Institute. 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 must also be equipped with one or more drip legs and heaters to vaporize any liquid chlorine that may enter the 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 joints, or they can be socket welded. The most common diameter piping is ¾" or 1" pipe. All pipe and fittings must be carefully cleaned before installation (Section VII below). For more details on piping guidelines see the Chlorine Institutes pamphlet 6, Hydro Instruments Vaporizer Piping Guide EVP-002-CL2 and Gas Ton Container Manifold Guide TCMGWS-DC.

4. Valves

There are many varieties of valves that can be used for pressurized chlorine service such as ball valves, line valves, angle vales etc. They must be compatible with pressurized chlorine which usually makes their materials of construction a carbon steel body, PTFE seals, and Monel or Hastelloy C-276 internals. Ball valves must also come with a provision for venting the cavity in the closed position to the upstream side.

5. Pressure Gauges & Switches

Many types of pressure gauges and switches can be used. However, due to the corrosive nature of chlorine they must be diaphragm protected by a material suitable for chlorine service (usually Tantalum diaphragm, Hastelloy C-276 body, and Fluorolube fill). The pressure gauge or switch 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 chlorine line. Due to chlorine'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 Relief Valve Assemblies

Pressure relief valve assemblies are used on vaporizer systems to prevent exceeding the maximum working pressure of the vaporizer. Much like the expansion chambers mentioned in Section 6 above, pressure relief valve assemblies come with a rupture disc and pressure switch. The disc is designed to rupture at a safe pressure and vent out the relief valve to a safe outdoor or chlorine scrubber intake if the pressure exceeds set point of the relief valve. The pressure switch is used to indicate when the disc has ruptured and gas has reached the relief valve.

8. Pressure Reducing Valves:

Pressure reducing valves are used to help prevent liquefaction downstream of the valve, and to prevent inlet pressures into the vacuum regulator from being too high. Damage to vacuum regulators can occur at inlet pressures above 145 psig (10 bar). To prevent liquefaction of chlorine gas, the pressure reducing valve should be set no higher than 40 psig (2.75 bar). The pressure reducing valve must be of the self-actuating spring loaded type, or pneumatically, hydraulically or electrically actuated type.

9. Vaporizers (Evaporators):

Most liquid feed applications call for the use of a vaporizer to vaporize the incoming liquid into a gas rather than inject liquid chlorine. Most vaporizers on the market can vaporize up to 10,000 PPD (200 kg/hr) or more of liquid chlorine. 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 PRESSURE MANIFOLD PIPING FOR USE

Often times in pressurized chlorine piping systems, oil, water and other chemicals can exist in the pipe before initial start-up of chlorine feed. Such impurities must be thoroughly removed before installation. Otherwise rapid pipe corrosion can occur and cause leaks. All equipment for handling chlorine received in an oily condition must be cleaned thoroughly before use (see CI pamphlet 6 for appropriate cleaners).

Chlorine piping systems should be pressure tested with an inert gas, such as nitrogen, before use and testing should comply with the guidelines laid out in the Chlorine Institutes pamphlet 6. Also, refer to Hydro Instruments Nitrogen Purging bulletin. All components which could become damaged during the pressure test should be isolated.

Drying of the pipe is the most essential step in preparation for chlorine use. This will remove all moisture from the manifold. Drying can be performed by passing stream through the lines from the high end until the lines are heated. This will allow the condensate to be drained out. Afterwards, disconnect the steam line and pass 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 (-40 ˚C).

Finally, before start-up all pressure manifold piping systems should be painted to avoid corrosion of the external surfaces.

VIII. VACUUM PIPING AND ACCESSORIES

Vacuum lines consist of piping between the vacuum regulator to the ejector. The most common material used to Polyethylene tubing for small systems and Schedule 80 PVC for larger systems. Hydro Instruments Bulletin Vacuum Tubing & Piping Sizing Guide shows assists in selection of piping and tubing based on feed rate and distance.

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

IX. EJECTOR SOLUTION PIPING

Ejector solution lines contain highly concentrated chlorinated water solution that is generally under pressure. Only high quality Schedule 80 PVC/CPVC piping, fittings, and valves should be used for this piping. This piping must be protected from physical damage and direct sunlight. It should never be directly poured in concrete, but should be run in trenches with a grate cover or some other protective conduit. Injection of the chlorine solution into main water pipes must be done with appropriately selected injection quills or static mixers to avoid corrosion damage to the steel water piping at the point of injection.

X. CHLORINE ABSORPTION AND DISPOSAL

If a leak occurs at the facility, the best option would be to run the chlorine gas through the regular chlorine consuming/injection process, or run a temporary line to the consuming point.

For any installation with ton containers or rail cars, chlorine scrubber/absorption system should be considered. A simple absorption system (scrubber) will consist of materials capable of holding a large alkane solution. Generally, this will hold a sodium hydroxide solution which is capable of neutralizing 1 pound of chlorine per 1.4 pounds of sodium hydroxide.

Hydro Instruments also supplies the Vent Arrestor product line that can be used to absorb any chlorine gas emitted from vacuum regulator vent lines.

For more information on chlorine absorption and disposal please see the Chlorine Institute INC's pamphlet 89: Chlorine Scrubbing Systems.