Gas Chlorine Stations

What is in this lesson?

- The purpose of each of the following items found in a gas chlorination station: Scales, auxiliary pump, pump pressure gauges, injector, cylinders, chlorinator, yoke, pigtail, header, life line, auxiliary valve, gas pressure reducer, chlorinator vent, and “Y” strainer
- The most common types of booster pumps used in gas chlorine stations
- The direction to open the door in a gas chlorine station
- The proper location and type of electrical equipment in a gas chlorine station
- The location and air exchange rate of the exhaust fan in a chlorine station
- Two types of scales used in chlorine stations
- The proper temperature of a gas chlorine station
- The impact of the Uniform Building Code Article 80 on the design of chlorine stations
- The frequency of weighing gas cylinders
- The function of a diffuser
- The process of reliquifaction of gas chlorine
- The components of a properly designed chlorine station
- The problems associated with placing electrical panels and motors in gas chlorination stations
- The frequency of replacement for pigtails, auxiliary valves, and headers

Key Words

- IDLH
- Venturi
- Monel

Gas Chlorine Stations

Introduction

Application

This lesson is focused on gas chlorine stations that are commonly found in water systems, wastewater treatment plants, and swimming pool facilities. The descriptions are restricted to gas systems using 100 pound and 150 pound cylinders, ton containers, and tank cars.

Regulations

Introduction

The descriptions and recommendations provided here are based on the recommendations from the Chlorine Institute, OSHA, and Article 80 of the Uniform Building Code, as well as standard industry practices.

Compliance with Regulations

Every attempt has been made to assure these recommendations are in compliance with existing safety practices and recommendations. However, it is highly recommended that before any consideration is made to change an existing chlorine station to make it comply with these recommendations, the changes and existing conditions be reviewed by the local, state, or federal safety compliance agency.

OSHA Regulation

Federal OSHA has very few regulations that speak directly to the handling and use of chlorine. However, they can review facilities based on other organizations' existing standards and practices, such as the Chlorine Institute recommendations. It is important to remember that the OSHA, EPA, and DOT classifications have changed for chlorine gas from a compressed gas to a Poison and Inhalation Hazard Zone B. This change alone brings with it the application of regulations that have not been used in the past. The past is not a key to the future.

OSHA & DOT Regulations

OSHA regulation 29 CFR 1910.120 applies to the handling of hazardous material. It is also recommended to review the DOT regulations 49 CFR Part 100 through 180, the NIOSH regulation of 1979 ANSIZ-177.1 as updated in 1989, and the Process Safety Management regulation 29 CFR 1910.119.

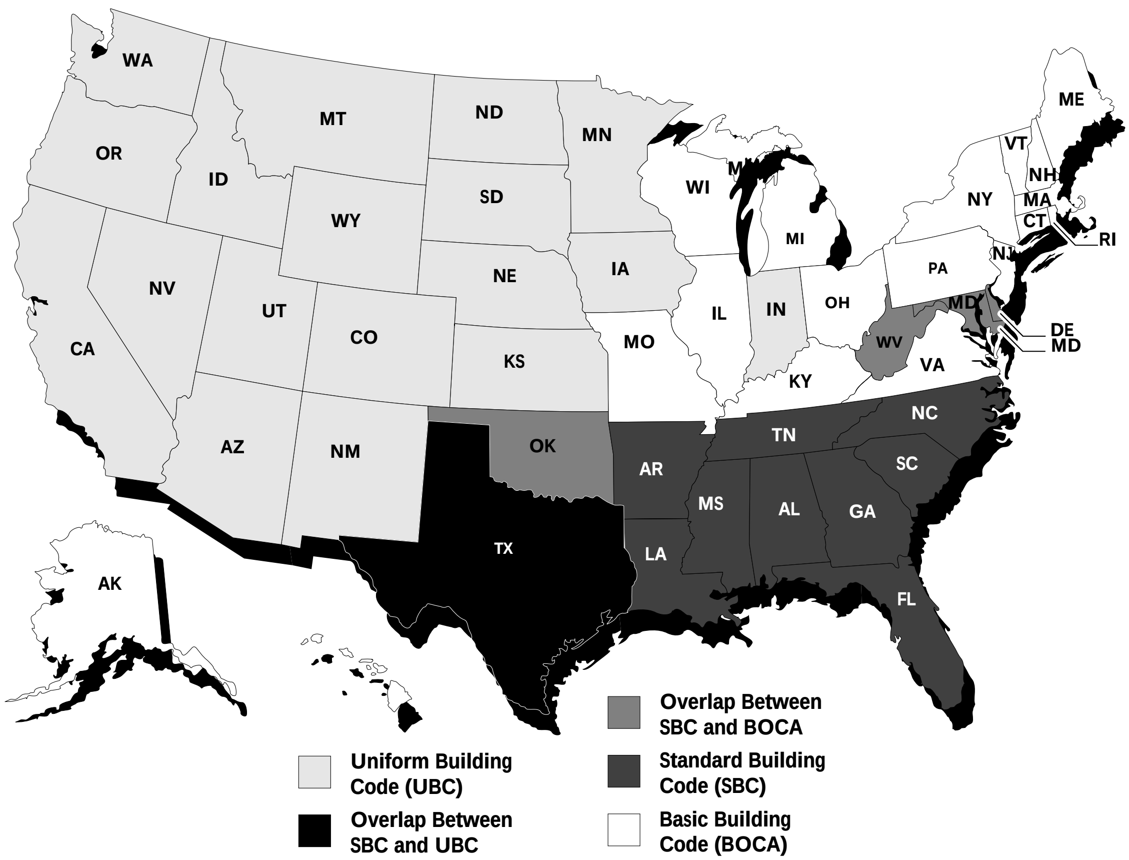
Clean Air Regulations

At the writing of this lesson, the new clean air regulations had not been completed. However, it appears most likely that a chlorine gas release into the atmosphere will be a violation of the clean-air act and as such the violator would be required to change the exhaust practices or face stiff fines.

Article 80

Introduction

Article 80 of the Uniform Building Code is a part of the Uniform Fire Code in all states where the Uniform Building Code has been adopted. Article 80 relates specifically to the storage and use of hazardous materials. There are two types of hazards described in the code: physical hazards and health hazards.



Physical Hazards

Physical hazards (80.202) are listed as:

- Explosive and Blasting Agents
- Compressed Gases
- Flammable and Combustible Liquids
- Flammable Solids
- Organic Peroxides
- Oxidizers
- Pyrophoric Materials
- Unstable (Reactive) Materials
- Water Reactive Materials
- Cryogenic Fluids

Health Hazards

Health hazards (80.202) include:

- Highly Toxic or Toxic Material
- Radioactive Materials
- Corrosives
- Other Health Hazards (irritants, suffocants, etc.)

Chlorine Hazards

Article 80 only applies to those materials that fit one or more of the above categories. Chlorine fits the following:

Physical hazards

- Compressed Gas
- Oxidizer

Health hazards

- Highly Toxic or Toxic Material
- Corrosives
- Other Health Hazards (irritant, poison, and inhalation hazard)

Retroactive Application

Because this code is in the fire code section of Article 80, it can be made retroactive to any facility. In most locations the enforcement of this portion of the code is up to the local fire chief, fire marshal, or building code enforcement department.

Recommendations

Rather than detail the components of Article 80, the requirements have been incorporated into the recommendations described below. However, Article 80 should be reviewed along with the recommendations from the Chlorine Institute and the appropriate OSHA and state safety regulations prior to making any changes in the chlorine storage and handling system.

Stations

Types of Stations

Five Types

There are five common gas station configurations used by water, wastewater systems, and swimming pools:

- Floor or wall mounted chlorinators using pressure regulators and/or automatic switchover devices mounted on the cylinders. (W & T V-800 or V-75, Capital Control and Fisher and Porter are typical examples.)
- Floor or wall mounted chlorinators using remote vacuum regulators and/or automatic switchover devices mounted on the cylinders. (W & T V-75, V-100, V-500 or V-800 are typical examples.) This type of system is often called the remote vacuum system.
- Cylinder mounted chlorinators. (Typical examples are Capital Controls Model 200, Regal and W & T Sonix 100.)
- System using liquid chlorine, an evaporator, and a floor mounted chlorinator.
- Tank car systems feeding liquid chlorine to an evaporator and floor mounted chlorinator.

What is Different?

While the basic gas chlorine station is the same for all five of these types of systems, there are some unique differences. The differences will be noted when appropriate.

Building

Reference

See section 7 of the Chlorine Institute - Chlorine Manual and Article 80 of the UBC for more details on building requirements.

Location

The chlorine room and cylinder storage must be at ground level.

Structure

Materials

The building should be constructed so as to contain a chlorine leak. That is, the leak should not penetrate the walls. Concrete or sealed concrete block is best. If not concrete or concrete block, the walls and joints should be sealed. The floors must be level with a minimum amount of slope.

Door

The door must open out, preferably to the outside, and have a crash bar. To prevent the room from being classified as a permit-entry confined space, there must be more than one access into the room. All doors must open out.

Windows

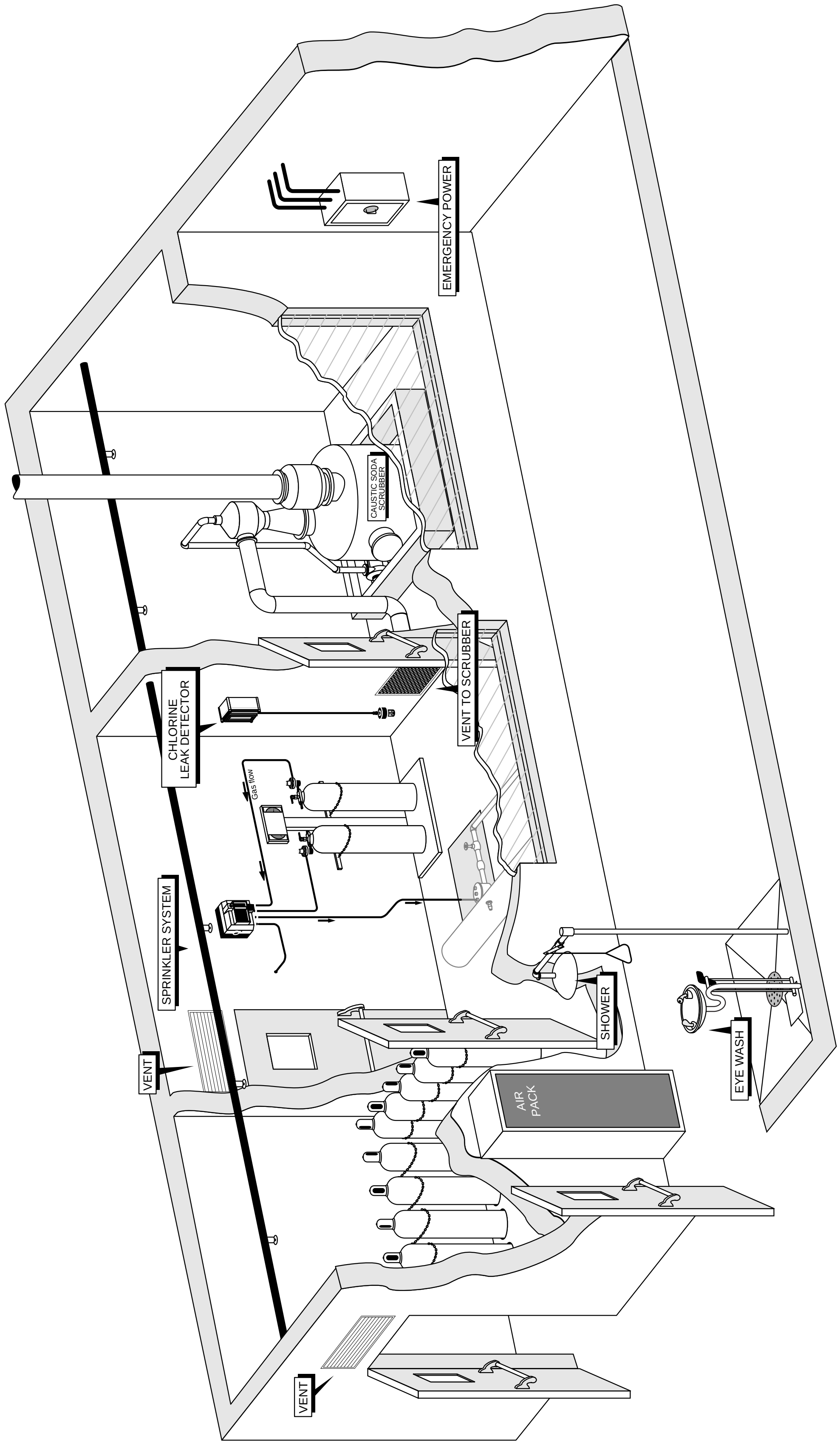
To reduce the need to enter the room, there should be a window between the chlorine room and some other portion of the mechanical area. This will allow the operator to observe the chlorinator and read the scales without entry into the room.

Electrical	All lights, plugs, motors, and other electrical fixtures inside of the chlorine room should be corrosion proof (NEMA Code 4X). This is to prevent the deterioration of the electrical equipment from the occasional release of chlorine.
Exterior Switches	The interior lights and ventilation fan must have a switch outside the entry door. The standard practice would be to turn on these devices three to four minutes before entry into the room. Some chlorine rooms are designed with these devices operated from a switch activated by the door. Normally this switch deteriorates quickly and it is difficult to shut off the fan during troubleshooting, making this design undesirable.
Motors and Control Panel	No electric motors or electrical control panels should be placed in the chlorine room that are not directly related to the chlorination system. Occasional releases of chlorine gas will quickly deteriorate the motors and control panels.
Heat	The room should be maintained at a standard 68° to 70° F. The heating system must be designed so that there is no direct heat applied to the chlorine cylinders. Steel will ignite at 483°F in the presence of chlorine.

Ventilation System

Vent	The room must be equipped with continuous exhaust ventilation system. The intake to this ventilation system must be near the floor. (Chlorine as a gas is 2.5 times heavier than air.)
Exhaust Rate	The exhaust system must be able to exchange the air in the room every three to four minutes. According to Article 80, the minimum exhaust rate is 1 cfm per square foot of storage area.
Vent Exhaust	Under Article 80 of the Uniform Building Code, the exhaust air must be treated to 50% of the IDLH[1] level. For chlorine this would be 15 ppm. However, this level may exceed the anticipated new Clean Air Standards.The exhaust concentration is related to the concentration of the chlorine in the room and the air temperature. At 70°F most scrubbers are capable of producing an exhaust air below the 15 ppm level. An alternate design is to recirculate the air back through the chlorine room. Entry would be denied to the room until the chlorine concentration was below 1 ppm.
Air-Treatment System	The most common air-treatment system is a caustic soda scrubber. Article 80 indicates this scrubber must be designed to treat the entire contents of the largest single tank being used. However, it would seem wise to design the system to handle the contents of all tanks that are in an “ON” position. This would be

[1] **IDHL** - Immediately Dangerous to Health and Life.



Chlorine room designed to meet OSHA and Article 80 requirements

especially true if a pressure header system was being used with more than one tank in the "ON" position.

Containment of Scrubber

When the scrubber system contains caustic soda, a secondary containment system, usually concrete, must be built to contain a spill of the total volume of the caustic soda.

Inlet of Fresh Air

The total ventilation system must be designed to allow fresh air to enter the room near the ceiling.

Negative Pressure

The exhaust and fresh air entry system must be designed so that a slightly negative pressure is maintained in the room any time the exhaust ventilation system is on.

Ventilation Without Treatment

If the system is not designed to meet the requirements of Article 80 for treatment, all other facets of the ventilation system other than treatment must be maintained. In addition the exhaust of air from the chlorine room must be placed so that no harm can be caused to workers or the public in the immediate area. This is a special concern for swimming pools. A roof vent is not considered a good idea. Chlorine is 2.5 times heavier than air and concentrated chlorine could be dumped from the roof onto anyone entering or exiting the building.

Other Considerations

Eye Wash & Shower

An emergency eye wash and emergency shower must be provided. The eye wash must be rinsed daily. If considering a new design, a tepid (warm) water design is recommended.

Floor Drains

The floor drains must be isolated so that a release of chlorine in the room cannot enter into another room. If an air treatment system is available, the floor drain should be connected to this system.

Sprinkler System

The chlorine room and any secondary chlorine cylinder storage area must have an overhead fire sprinkler system. The system must be designed to produce maximum flow for at least 20 minutes (Article 80).

Secondary Containment

A secondary containment system, usually made of concrete, must be designed to contain a spill of the maximum amount of chlorine that could be available from all cylinders that are connected and on line, plus the water from the overhead sprinkler system. As an alternate, the secondary containment can be avoided if a treatment system is installed to treat all the chlorine release plus the water to a safe level.

Emergency Power

Emergency power must be available to handle the exhaust system, scrubber, and if necessary, the fire sprinkler system.

Leak Detector

The chlorine room and storage area must be equipped with a chlorine leak detector. This detector must be set to sound an alarm any time the chlorine level in the room goes above 1 ppm. In most cases, the leak detector is wired into the scrubber system. When there is a leak, the scrubber will automatically come on and an alarm signal will be sent.

Vandals

All attempts must be made to make the chlorine storage and use area vandal resistant. This includes proper locks and signs. The standard Poison placard must be clearly visible on all doors.

DOT & UN ID

The interior and exterior doors should clearly indicate that the room contains chlorine. The DOT number for chlorine gas is 2.3 and the UN number is 1017.

Old placard - Could not be used after Oct. 1994

Approved placard with DOT identification

Approved placard Need additional 1017 placard

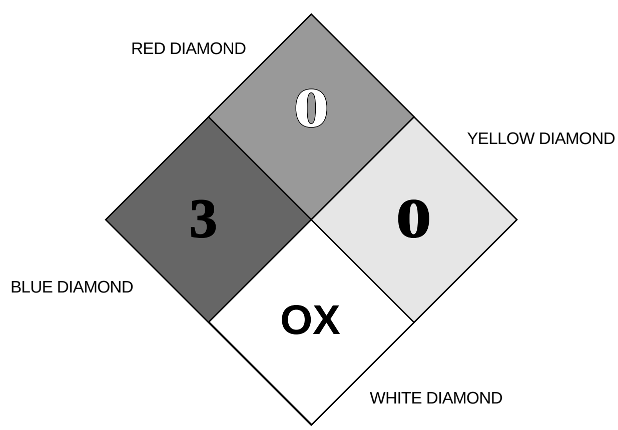
NFR Placard

The NFR (National Fire Rating) system placard showing a Health rating of 3, a Flammability rating of 0, a Reactive rating of 0, and a special notice of OX should be plainly visible.

Chemical Storage

No other chemicals or hydrocarbon based products (gas, diesel or oil) should be stored with chlorine cylinders. Chlorine gas will react violently with light hydrocarbons.

Blue = Health
Red = Flammability
Yellow = Reactive
White = Special notice



Scrubber System Operation

Components

A scrubber system consists of a tank, venturi, pump, and packed tower.

Caustic Soda Flow

When the scrubber is operating, caustic soda is pumped from the tank and down through a Venturi[2]. The Venturi produces a vacuum that is used to draw air from the room into the scrubber. Air from the chlorine room is mixed with caustic soda in the Venturi.

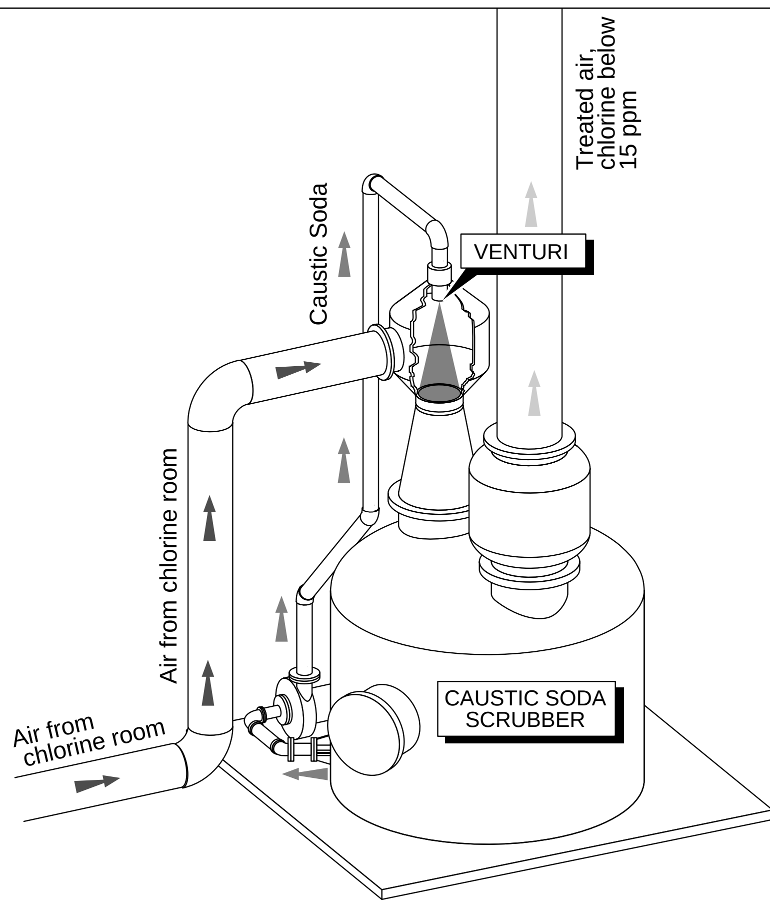
Air Flow

Air passes through the Venturi, into the tank,and out through the packed tower. Depending on the design, the air either passes up through the tower and back into the room where it is recycled, or it is exhausted into the atmosphere.

Treatment

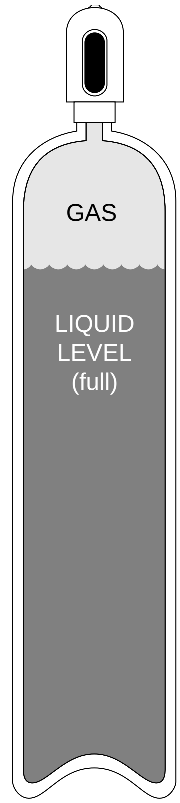
Approximately 85-90% of the chlorine is neutralized with each pass through the scrubber. It would require approximately one to two hours for a scrubber to reduce the chlorine level in the air from 100% to 1ppm. When the air is exhausted into the atmosphere, a packed tower must be used in order to provide adequate treatment time.

Scrubber System



[2] **Venturi** - A device used to create a vacuum. The vacuum is created by transferring pressure head to velocity head. This transfer is the result of a reduction in cross sectional area of the device while maintaining the flow. Named after G. B. Venturi (1746 - 1822).

Cylinders



Sizes

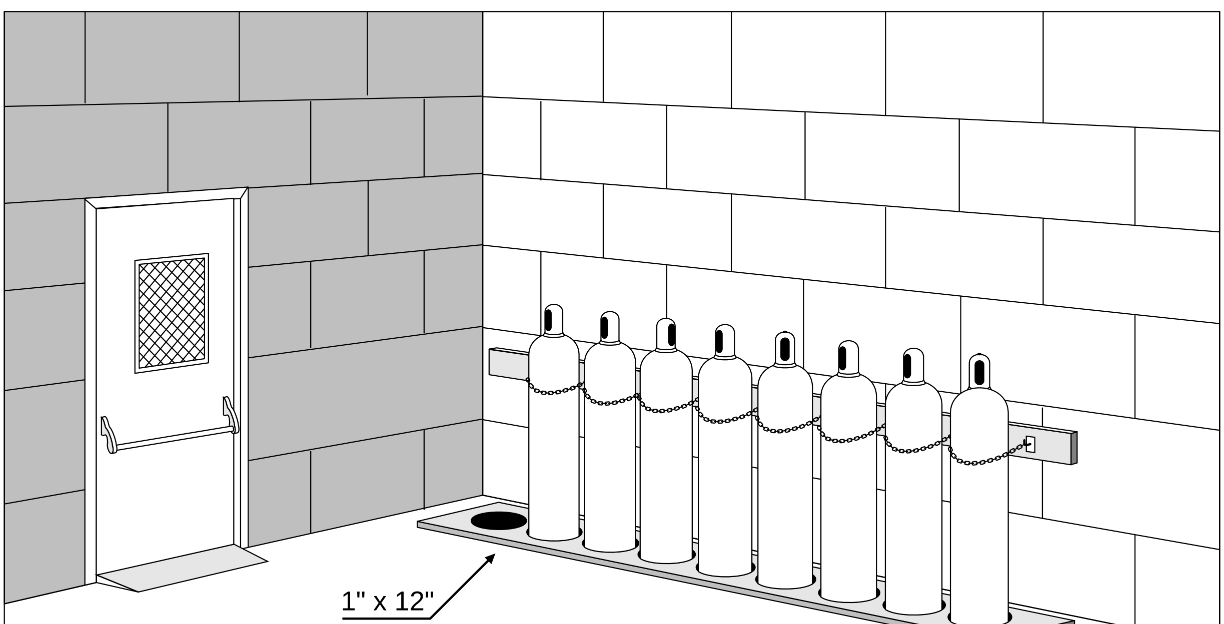
Gas chlorine is supplied in 100 and 150 pound cylinders, 1 ton containers, tank cars, and barges.

Cylinder Temperature

Chlorine cylinders are filled to 88% of their volume with liquid chlorine at 70° F. In order to obtain gas from a cylinder, the liquid must boil. This happens at -29°F. The pressure and the amount of gas that can be extracted from a cylinder is directly associated with the temperature of the liquid.

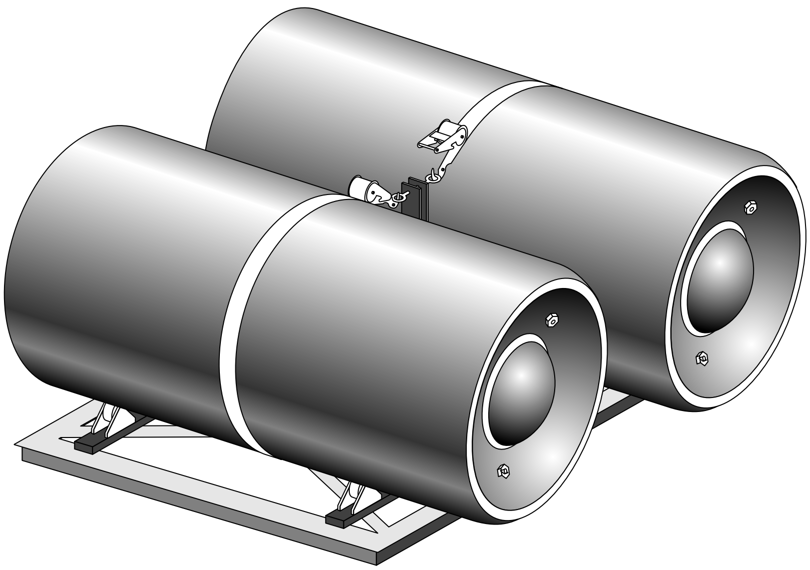
Secured

One hundred and 150 pound chlorine cylinders must be secured from falling by being restained by chains placed 2/3 up from the bottom. In an earthquake zone, a second containment strap or shoe should be placed on the bottom of the cylinder. The chain must be strong enough to hold the weight of the cylinder when full. While it is not necessary to contain each cylinder individually, it is desirable. One ton containers should be placed in trunnions or double chocked. Tank cars should be secured with the brake in a locked position, the wheels should be chocked and derails installed.



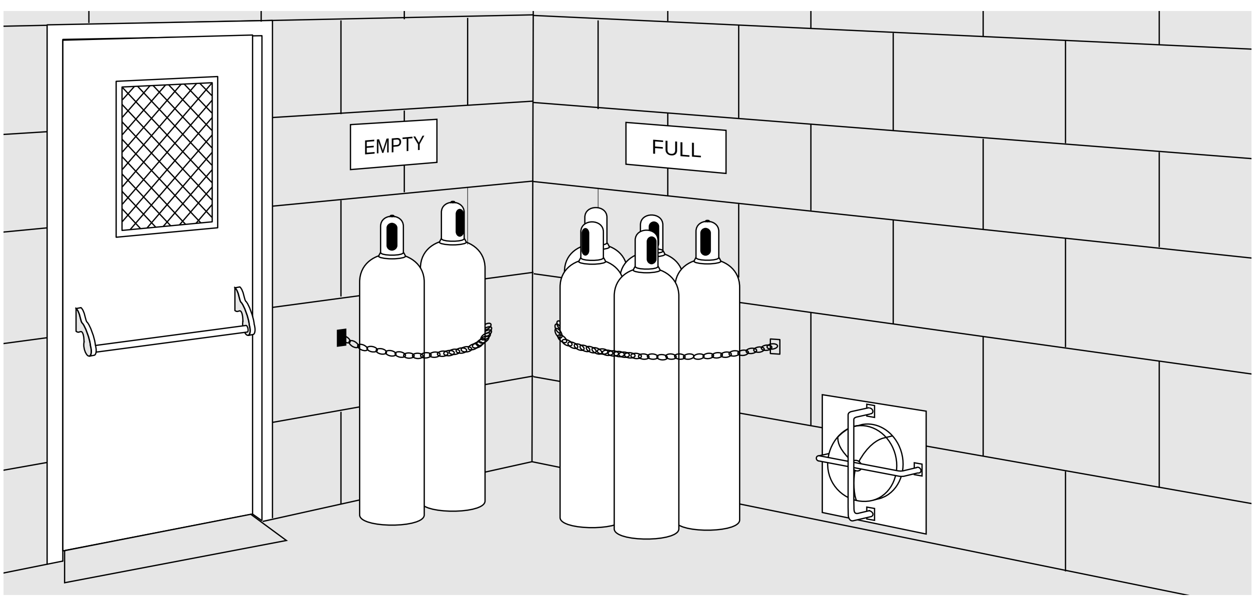
Method of securing 100 and 150 pound chlorine cylinders in an earthquake zone.

Earthquake zone storage for 1 ton containers



Storage Space

While full, empty, or in operation, cylinders and containers do not have to be stored in separately, but full and empty cylinders must be separated and clearly marked. An emergency responder must be able to identify which containers are full during a response to an emergency. The preferred method of marking is to place a sign on the wall behind the cylinders indicating which are full and which are empty.



Impact of Temperature

Chlorine cylinders should be stored at a temperature equal to or greater than the chlorinator temperature. If the chlorine in the container being used exceeds the temperature of the chlorinator, a process called reliquifaction will take place. In the process gas chlorine is reliquefied. In the liquid state chlorine will quickly destroy a chlorinator. The following example explains this process.

Automatic Shutdown

Tied to Leak Detector

To reduce the possibility of a chlorine leak at the connection to the cylinder an electric valve operator can be installed on the cylinder valve. This operator is electrically tied to the leak detector. When a leak is identified the detector sends a signal to the valve operator shutting down the cylinder.

Reliquifaction

System Prone to Reliquifaction

Reliquifaction is not a concern with cylinder mounted or remote vacuum chlorinators. It is a primary concern with pressure feed systems. That is, systems where chlorine under pressure is transported from the container to the chlorinator through a metal pigtail and header system.

Temperature Difference

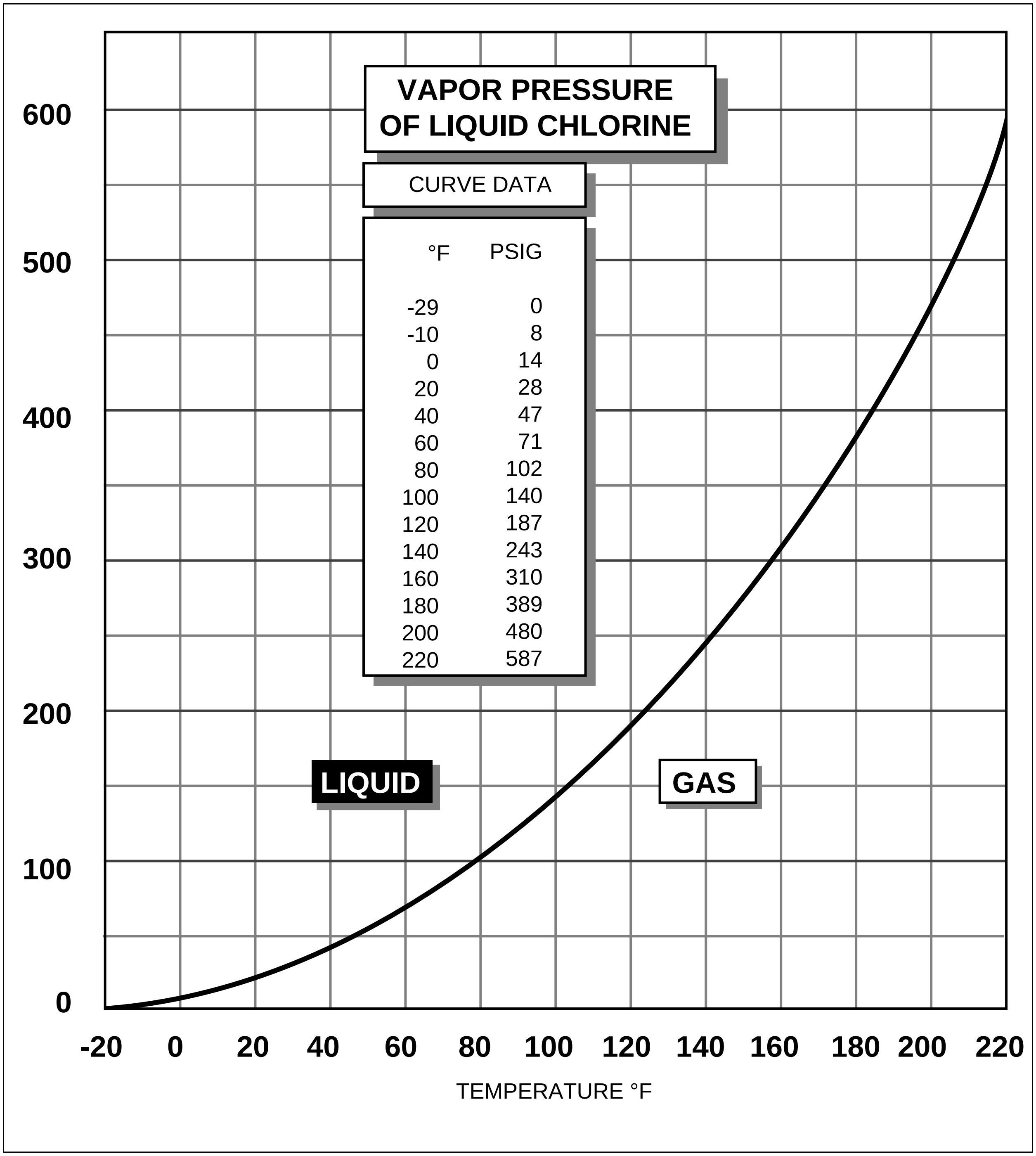
View the graph titled “Vapor Pressure of Liquid Chlorine” on the next page. Note that on the left side of the graph is the word “Liquid” and on the right is the word “Gas”. In the example, the cylinder is outside, exposed to the sun. The liquid in the cylinder warms to 60 °F. Notice from the graph and the table that this represents a discharge pressure from the cylinder of 71 psi. The chlorine moves from the cylinder into the chlorine room. The temperature in the room is 58° F.

Use Graph

Looking at the graph, the chlorine remains at a pressure of 71 psi at the cylinder and in the room. When the temperature in the room drops and the pressure remains the same, move from the right side of the graph (the gas side) to the left on the graph (the liquid side). By crossing the curve, at the same pressure, the gas is returned to a liquid.

Prevention

Reliquifaction can be prevented by using the remote vacuum system or placing a pressure reducing valve in the chlorine pressure header system between the container and the chlorinator.


VAPOR PRESSURE
OF LIQUID CHLORINE
CURVE DATA
°F PSIG
-29 0
-10 8
0 14
20 28
40 47
60 71
80 102
100 140
120 187
140 243
160 310
180 389
200 480
220 587
LIQUID
GAS
600
500
400
300
200
100
0
-20
0
20
40
60
80
100
120
140
160
180
200
220
TEMPERATURE °F

Piping System

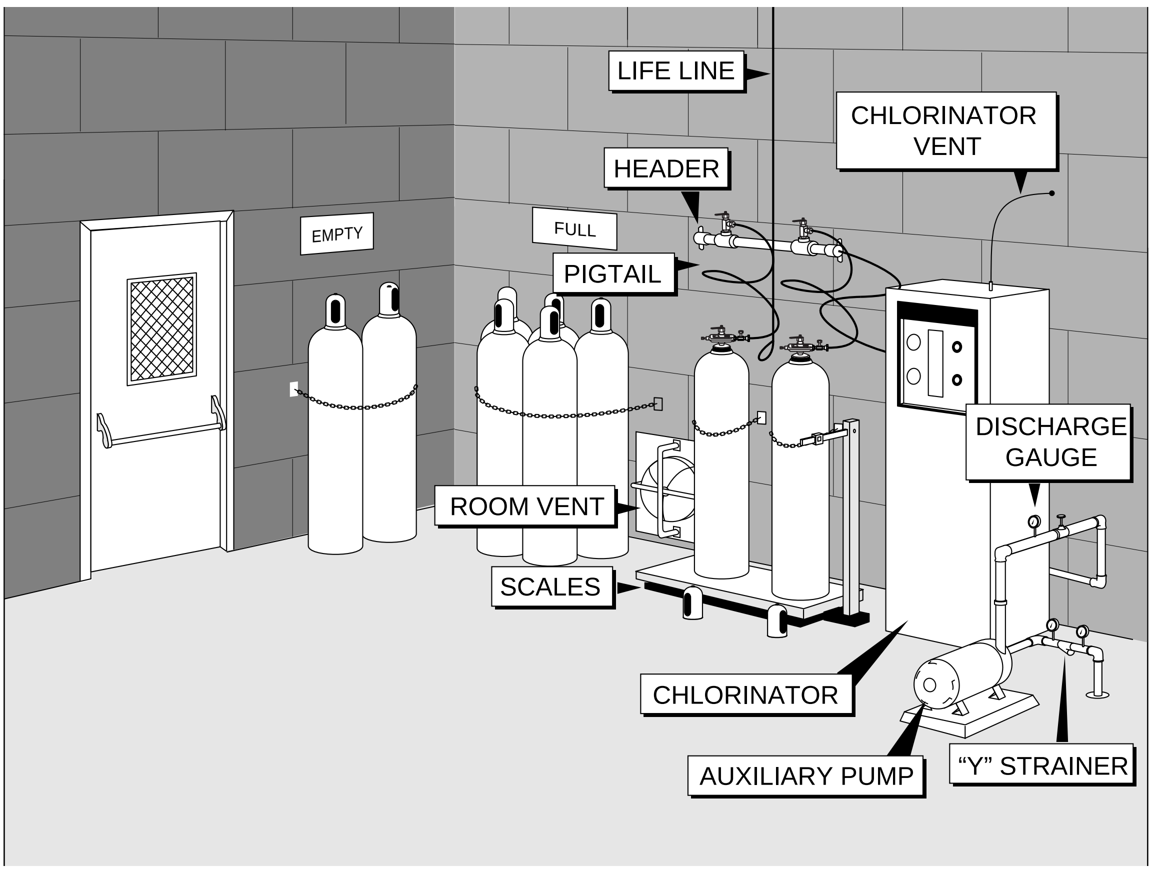
Based on Station Type

As discussed in the first part of this lesson, there are five basic stations. They are the floor or wall mounted chlorinators, remote vacuum stations, cylinder mounted stations, tank car stations, and liquid gas stations. The piping system for each is different and all are discussed below.

Pressure Station Piping

Pressure or Vacuum?

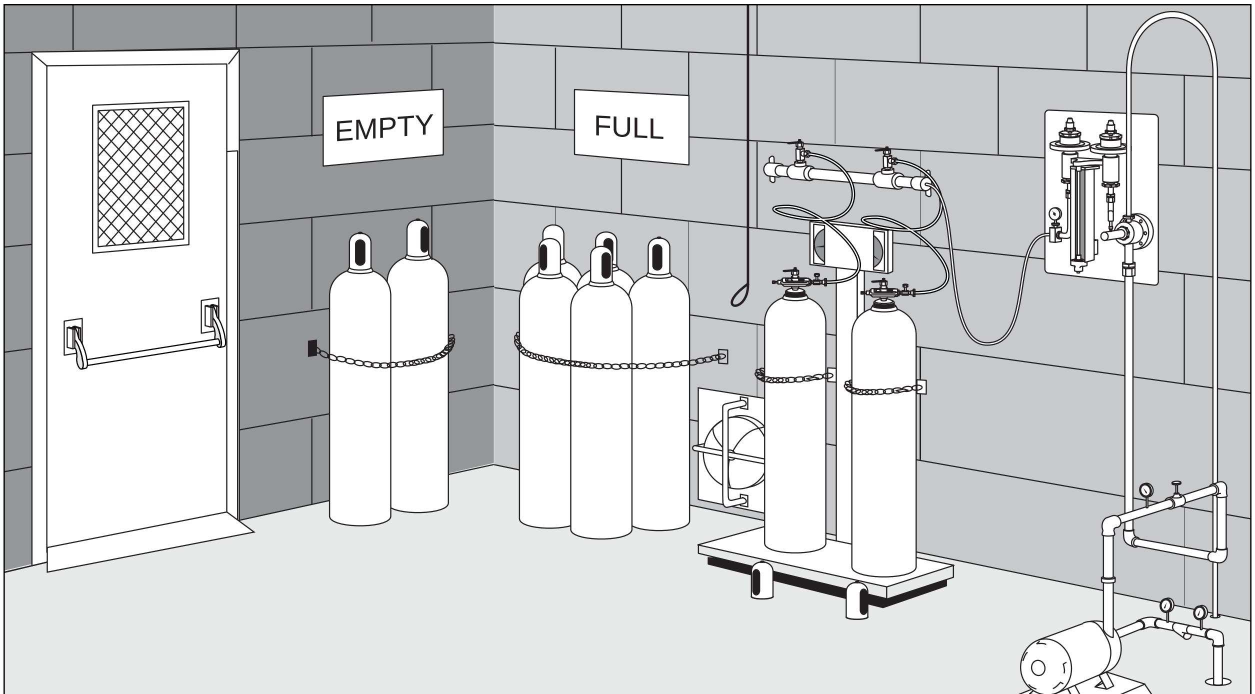
All gas chlorinators used today are vacuum operated. The system used to get the chlorine gas from the cylinder to the chlorinator is a pressure system. This system is an older design and commonly found with the W & T V-800 floor mounted chlorinators and V-75 wall mounted chlorinators.



Overview

Basic Components

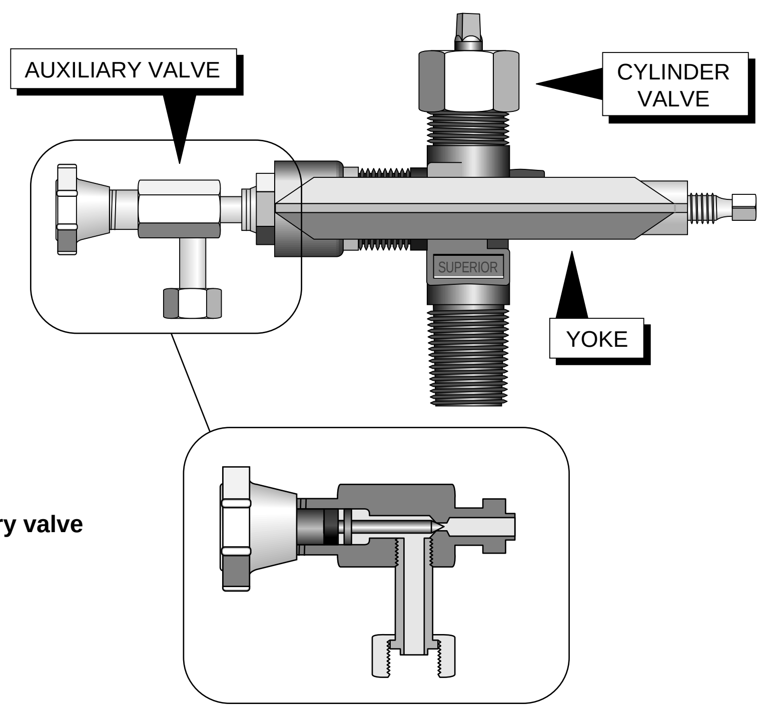
Gas flows from the cylinder through a cylinder valve. Connected to the cylinder valve should be an auxiliary valve. A pigtail is used to transport the chlorine from the auxiliary valve to the header or directly to the chlorinator. When there is a header, a second pigtail is used to transport the chlorine from the header to the chlorinator.



Wall Mounted - Pressure System

Cylinder & Auxiliary Valve

The primary safety valve in a chlorine system is the cylinder valve. Attached to the cylinder valve is a needle valve called an auxiliary valve. This auxiliary valve provides a second shut off and protects the pigtail from damage by preventing moist air from entering the pigtail when the cylinder is being changed. The auxiliary valve is attached to the cylinder valve with a yoke.

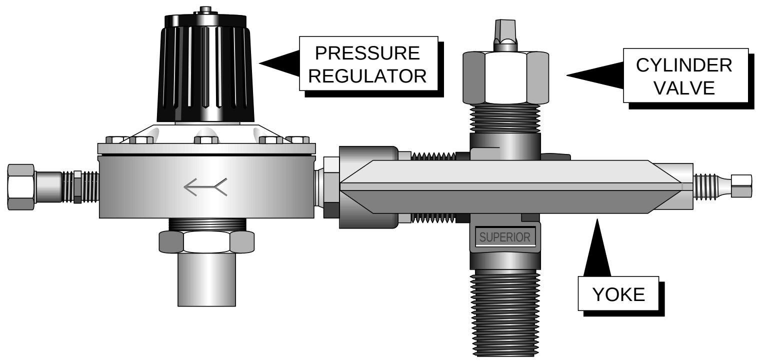


Cylinder valve, auxiliary valve, and yoke.

Cut-a-way of auxiliary valve

Automatic Switchover

One of the early advances in chlorine systems was the automatic switchover valve. This valve is installed on the cylinder in place of the auxiliary valve. The automatic switchover automatically switches to a second full tank when the first tank is exhausted. When installed on a pressure system, these valves were also called pressure regulators. The auto switch-over is attached to the cylinder valve with a yoke.



Vacuum Regulator and Automatic Switchover Device

The Details

Pigtail

Traveling from the auxiliary or automatic switchover valve is a pigtail or flexible connector. With a pressure system, it is recommended that this pigtail be either a 1/4" or 3/8" OD, 500 psi type K seamless copper tubing coated inside and out with monel[3].

Header

The most common header system is constructed of seamless, schedule 80 black iron pipe. Header valves are commonly the same valves used on a cylinder. Header valves are installed where the pigtail attaches to the header. This allows isolation of a specific pigtail for replacement.

One-ton Containers

When a pressure type automatic switchover device is used with the one-ton container, a one inch by one foot long black iron drip tube must be installed between the cylinder valve and the automatic switchover device. The function of the drip tube is to collect the liquid from the cylinder eductor tube. Attached to the drip tube is a 120 volt heater assembly. It’s function is to evaporate any liquid chlorine that exits the container.

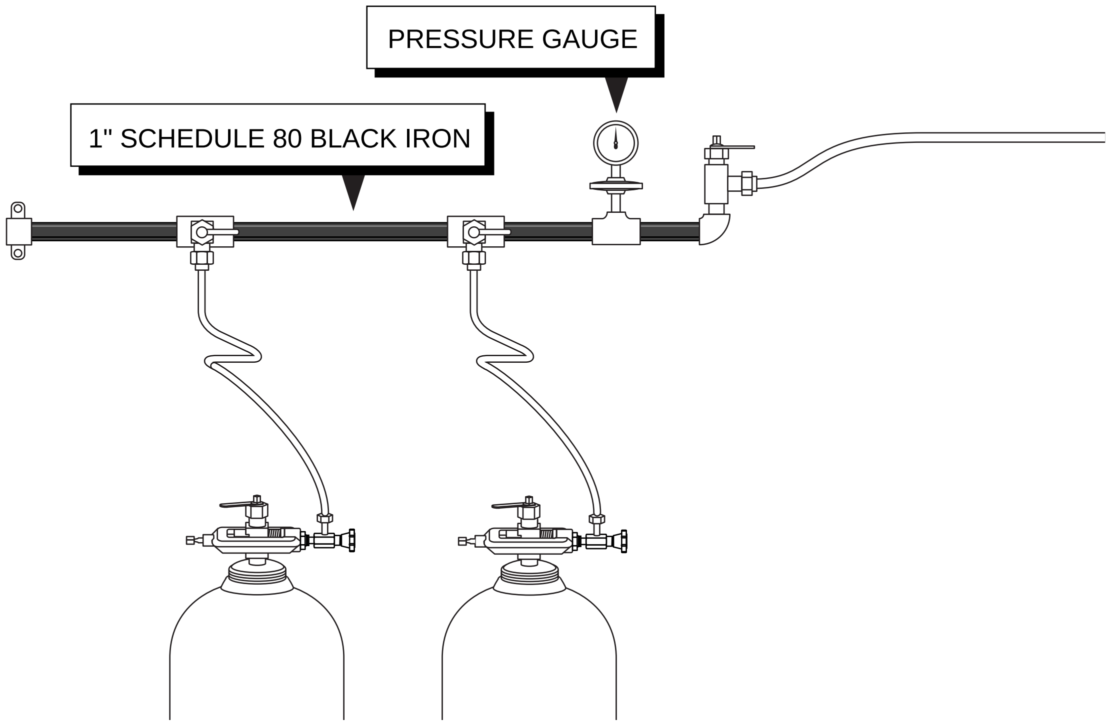
Gauges

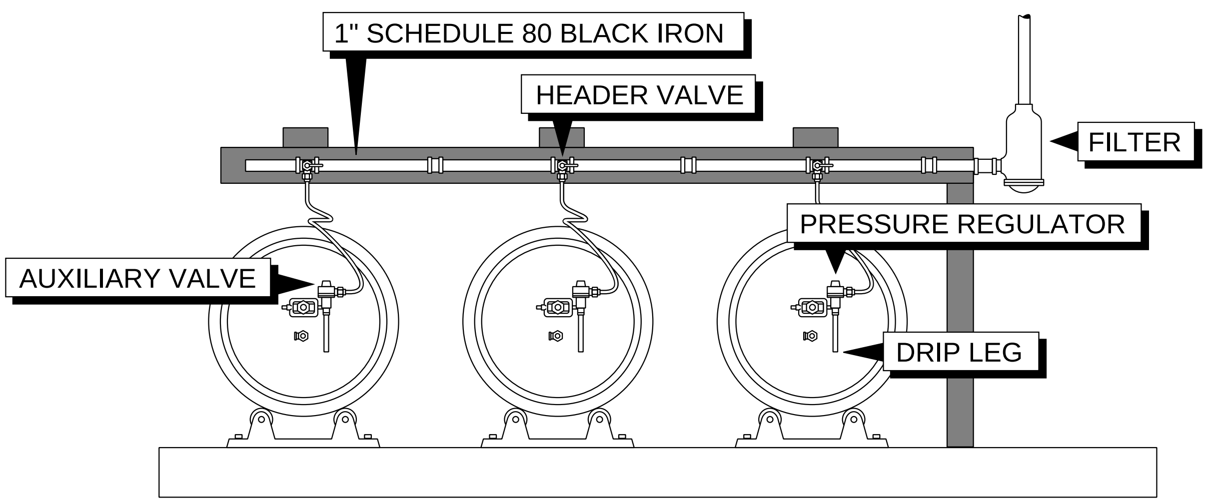
In many instances, a chlorine pressure gauge is installed on the pressure header system. This gauge must contain an isolation diaphragm and is either an oil or glycerin-filled gauge. The glycerin-filled gauges appear to be the most stable.

[3] **Monel** - Also monel metal, an acid resisting alloy of nickel (60 - 70%), copper (25 - 35%), iron, manganese, carbon, and silicon, used in chemical handling. Named after Ambrose Monel.

Line to the Injector

An injector or ejector is a device used to produce a vacuum to operate the chlorinator and provides a mixing point for the chlorine and water. The line leading from the chlorinator to the injector is commonly 1/4" or 3/8" polyethylene tubing.

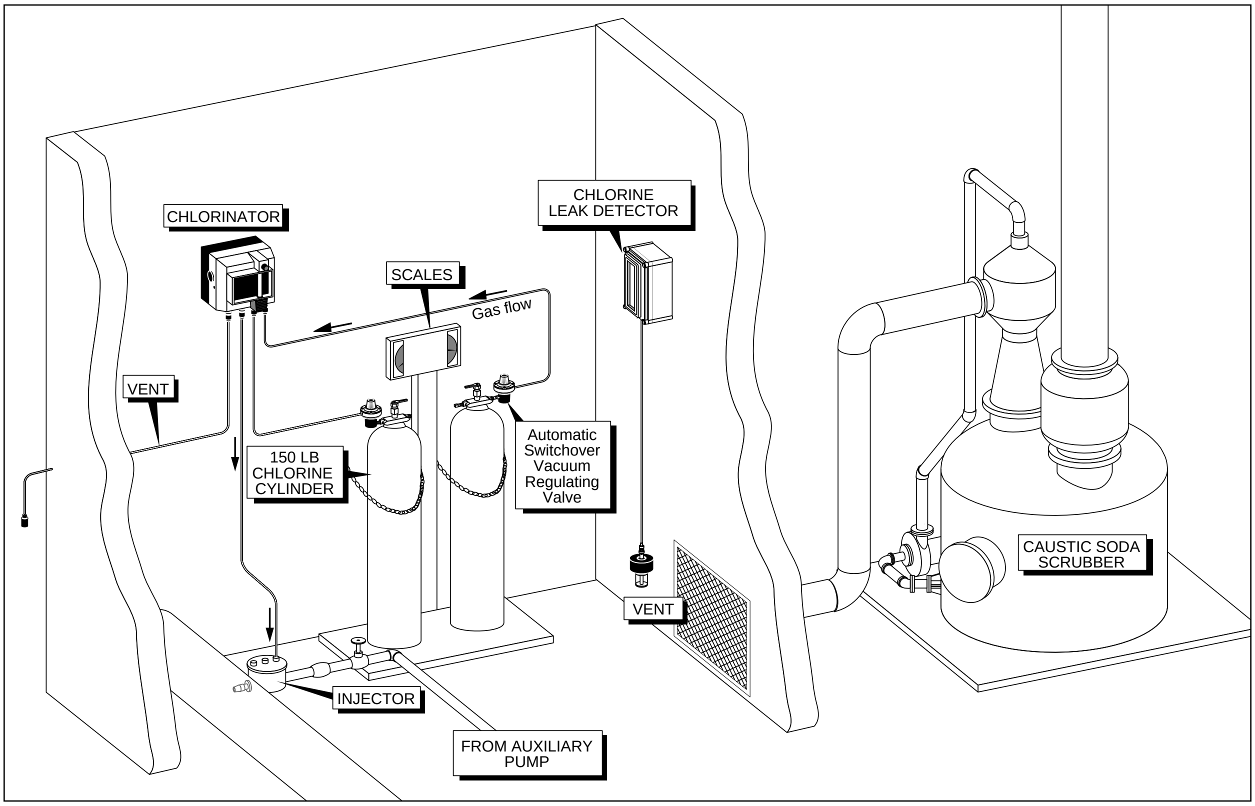




Remote Vacuum Piping System

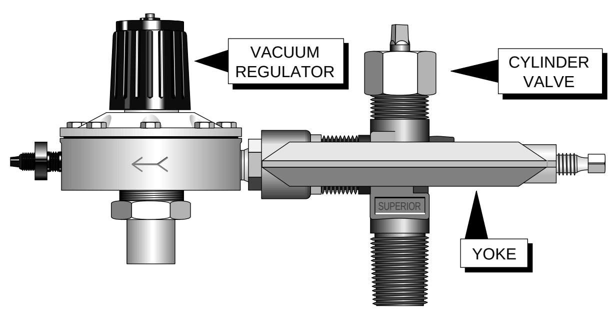
Basic Components

Gas flows from the cylinder through a cylinder valve. Connected to the cylinder valve is the vacuum regulator and/or automatic switch over valve. A pigtail is used to transport the chlorine from the vacuum regulator to the header or directly to the chlorinator. When there is a header, a second pigtail is used to transport the chlorine from the header to the chlorinator.



Remote Vacuum Regulator

The remote vacuum regulator or automatic switch-over device is connected directly to the cylinder valve using a yoke.

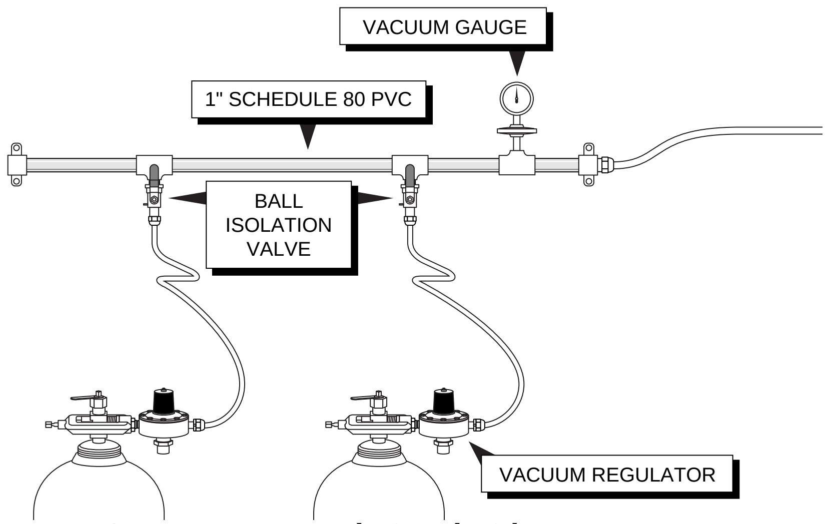


Pigtails

The pigtails used with remote vacuum systems are commonly made of 3/8" polyethylene tubing.

Header

If a header is used, it is typically made from schedule 80 PVC.



Gauges

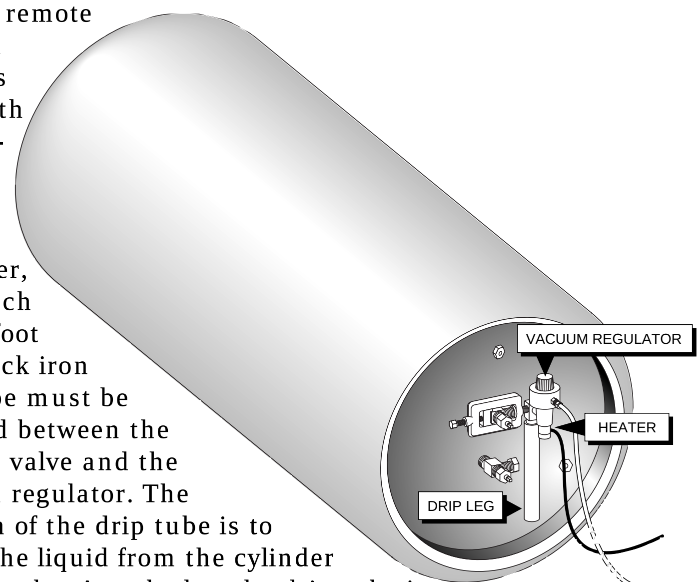
Some systems are designed with vacuum gauges installed in the pigtail or header system. This allows the operator to evaluate the operating condition of the system. These gauges must contain an isolation diaphragm and are either an oil or glycerin-filled gauge. The glycerin-filled gauge appears to be the most stable.

Small Systems

When a small wall mounted chlorinator such as the W & T V-100 chlorinator is used, the pigtail is typically connected directly to the chlorinator control body.

One-ton Containers

When a remote vacuum device is used with the one-ton container, a one inch by one foot long black iron drip tube must be installed between the cylinder valve and the vacuum regulator. The function of the drip tube is to collect the liquid from the cylinder eductor tube. Attached to the drip tube is a 120-volt heater assembly. Its function is to evaporate any liquid chlorine that exits the container.



Line to the Injector

An injector or ejector is a device used to produce a vacuum to operate the chlorinator and provides a mixing point for the chlorine and water. The line leading from the chlorinator to the injector is commonly 1/4" polyethylene tubing.

Cylinder Mounted Chlorinator

Simple System

One of the main advantages of the cylinder mounted system is the removal of all the inlet piping system. The only portion of the piping system remaining is the line from the chlorinator to the injector or ejector.

Line to the Injector

An injector or ejector is a device used to produce a vacuum to operate the chlorinator and provides a mixing point for the chlorine and water. The line leading from the chlorinator to the injector or ejector is commonly 1/4" polyethylene tubing.

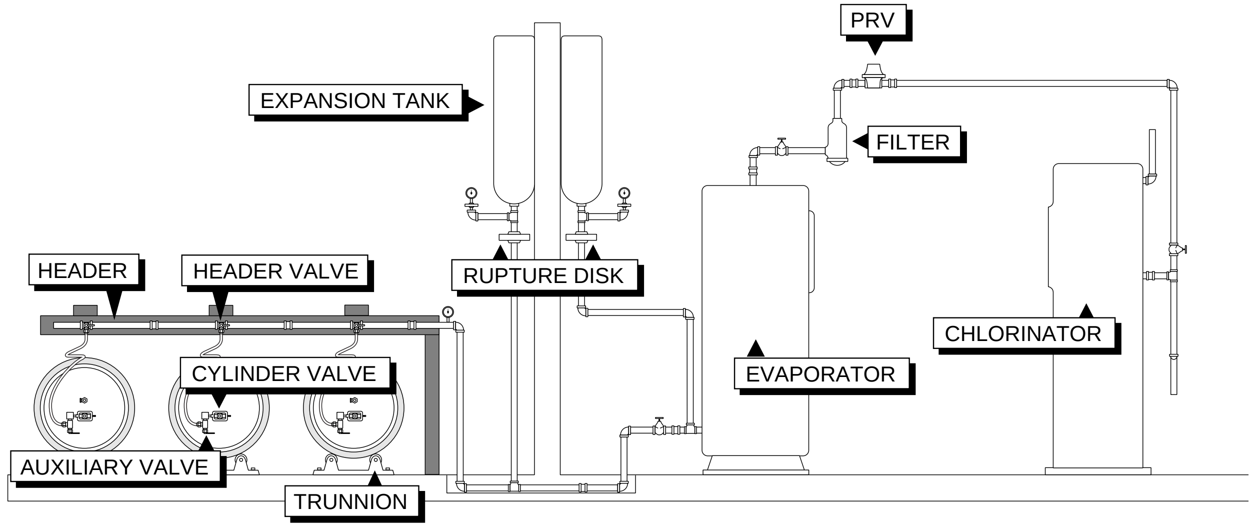
Liquid System

Basic Components

Liquid chlorine flows from the container through a cylinder valve. Connected to the cylinder valve is an auxiliary valve. Liquid flows from the auxiliary valve through a copper pigtail to a header valve and into the header. The header connects directly to an evaporator. Gas is fed from the evaporator through a filter and pressure regulator to the chlorinator.

Cylinder & Auxiliary Valve

The primary safety valve in a chlorine system is the cylinder valve. Attached to the cylinder valve is a needle valve called an auxiliary valve. This auxiliary valve provides a second line of defense against the accidental release of liquid chlorine during a cylinder exchange. The auxiliary valve is attached to the cylinder valve with a yoke.



Pigtail

Between the auxiliary valve and the header is a pigtail or flexible connector. A 3/8" OD, 500 psi type K seamless copper tubing coated inside and out with monel is commonly used.

Header & Header Valves

The most common header system is constructed of seamless schedule 80 black iron pipe. Header valves are commonly the same valve used on a cylinder. Header valves are typically installed where the pigtail attaches to the header. This allows isolation of a specific pigtail for replacement and provides additional protection against accidental release of liquid chlorine during a cylinder exchange.

Expansion Tanks

One or more expansion tanks must be installed on the liquid chlorine header system. The expansion tanks are sized to hold all the gas that could be produced if all the liquid in the header was converted to gas. This could occur if two or more valves on the liquid header system were shut off, trapping the liquid.

Rupture Disk	Installed at the base of each expansion tank is a rupture disk. Should there be an expansion of the liquid so that the pressure in the system exceeds 400 psi, the disk would rupture, allowing gas and/or liquid to enter the expansion tanks.
Gauges and Alarm	Mounted above the rupture disk is a gauge. The gauge can be equipped with an alarm. Rupture of the disk will be observed by an increase in the pressure at the gauge.
Filter	A filter is installed between the evaporator and the chlorinator. The function of the filter is to collect debris escaping from the evaporator and thus prevent damage to the chlorinator.
PRV	Installed downstream of the filter is a pressure reducing valve (PRV). This valve is installed to assure that any excessive gas pressure cannot be fed to the chlorinator.
Vent	Some PRV's are equipped with a vent. Excessive pressure is vented outside the chlorine room.
Drip Leg	To assure that no droplets of liquid chlorine enter the chlorinator, a drip leg and heater assembly are installed at the back of the chlorinator.
Gauges	In many instances, a chlorine pressure gauge is installed on the pressure header system. These gauges must contain an isolation diaphragm and are either an oil or glycerin-filled gauge. The glycerin-filled gauges appear to be the most stable.
Line to the Injector	A 3/8" polyethylene tubing or 1/2" or larger PVC line leads from the chlorinator to the injector or ejector. The injector or ejector is the device used to produce the vacuum that operates the chlorinator and also provides a mixing point for the chlorine gas and the water.

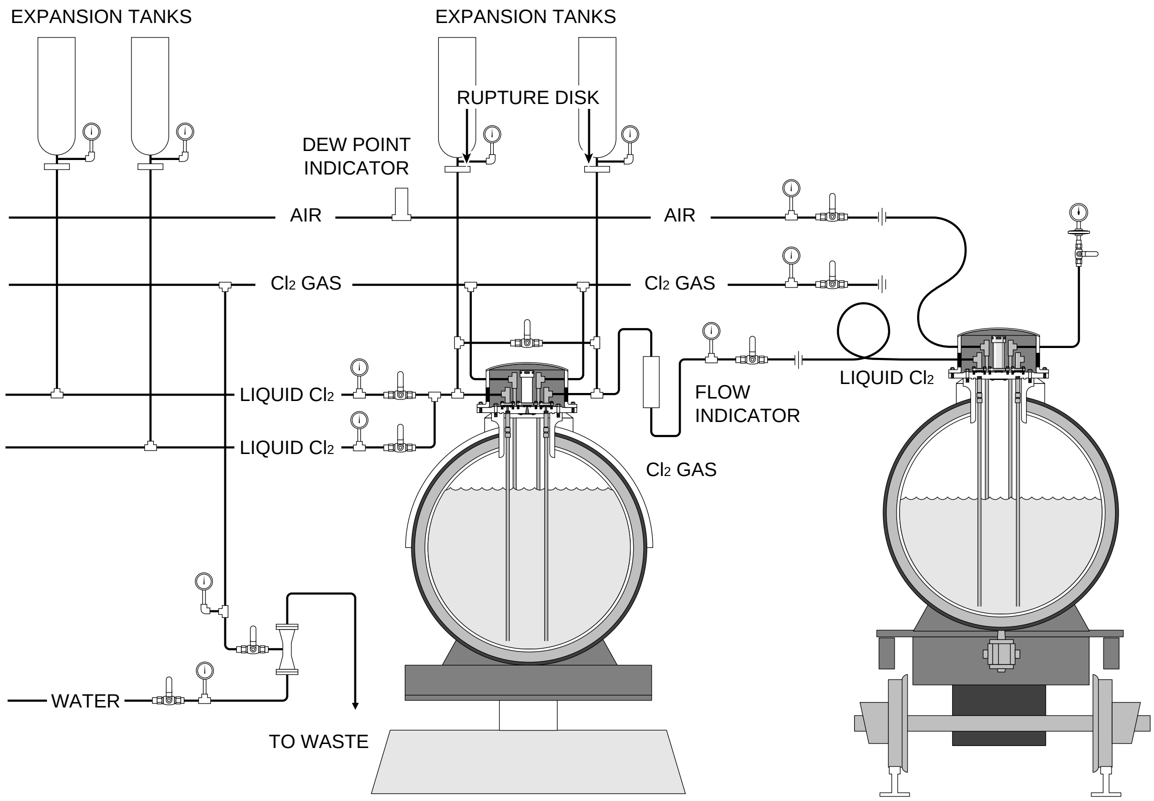
Tank Car System

Basic Components

The tank car system is designed around a stationary tank car filled from a vendor's tank car delivered to an adjacent siding. The system is designed much like a liquid system except for the addition of the tank car unloading components. Chlorine gas or liquid can be drawn directly from the stationary tank car.

Piping

The permanent piping system is made from one inch or larger, schedule 80 black iron pipe with raised face ammonia flanges or welded connections. Auxiliary valves are normally special ball valves designed to handle chlorine.



Expansion Tanks

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Rupture Disk

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Gauges and Alarm

Mounted above the rupture disk is a gauge. The gauge can be equipped with an alarm. Rupture of the disk will be observed by an increase in the pressure at the gauge. In addition, gauges are mounted on the liquid and gas discharge lines leading from the tank.

Remainder of Piping

The remainder of the piping system is similar to other chlorine systems. It may contain filters, pressure reducing valves, and excess pressure vents.

Evacuation System

In addition to the normal piping system, a means of evacuating all the chlorine from the stationary tank car and the delivery car must be provided. A common system uses a water operated injector to develop a vacuum. This vacuum is used to extract the chlorine and mix it with water. The water must then be disposed in a safe manner.In addition, the discharge of large volumes of chlorinated water is regulated by EPA, and may require a special permit.

Lighting

Because unloading tank cars often extends beyond one shift, adequate lighting must be provided in the unloading area.

Platform

A platform that allows the operator to connect and disconnect piping, open and close valves must be installed adjacent to the stationary and mobile tank cars.

Unloading Piping

The unloading system piping is usually made of schedule 80 black iron pipe, one inch or larger.

Flexible Connection

The connection to the tank car is made with one inch copper lop or flexible Monel metal hose. This flexible connection is used to accommodate the changes in height of the tank car when it is unloaded.

Air Padding

In order to expedite removal of the chlorine from the tank car, an air padding system is used. This system must be designed to provide an adequate supply of air dried to -40°F at the padding pressure. To make sure no air enters the tank car, a dew point indicator with an alarm must be installed in the air padding system. The air volume and pressure is dependent upon unloading rates and tank pressures.

Scales

Function

Scales are used to determine the amount of chlorine fed. The only way to determine the actual chlorine used is to weigh the cylinders on a daily basis. Using this data and the system flow volume the actual chlorine dosage can be calculated. By calculating dosage daily, and comparing the results to the residuals, the operator can separate mechanical chlorine problems from contamination problems.

Types

There are two types of scales used to measure chlorine cylinders:

- Balance Beam
- Net Weight

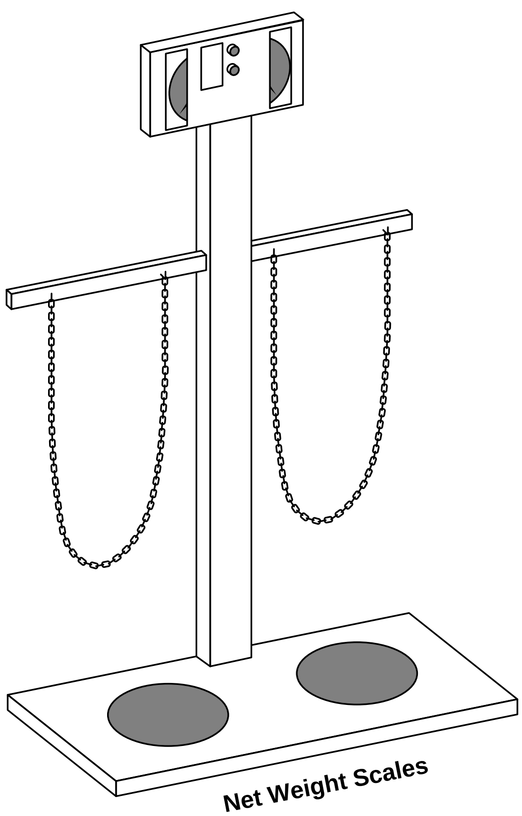
100 - 150 Pound

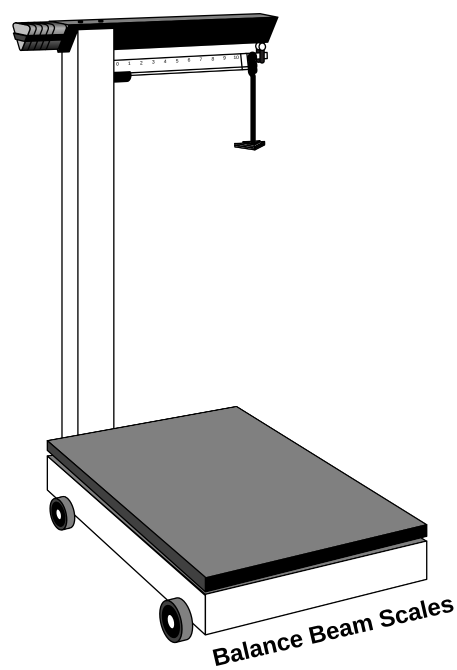
Most Popular

The net weight scales are the most popular. The most common type used with 100 and 150 pound cylinders weighs two cylinders separately. This allows the operator to determine visually the amount of chlorine left in each cylinder.

Chains

When 100 and 150 pound cylinders are placed on the scales, they must be chained up 2/3 from the bottom. In an earthquake zone, a second chain or holding device must be placed near the bottom of the cylinder.





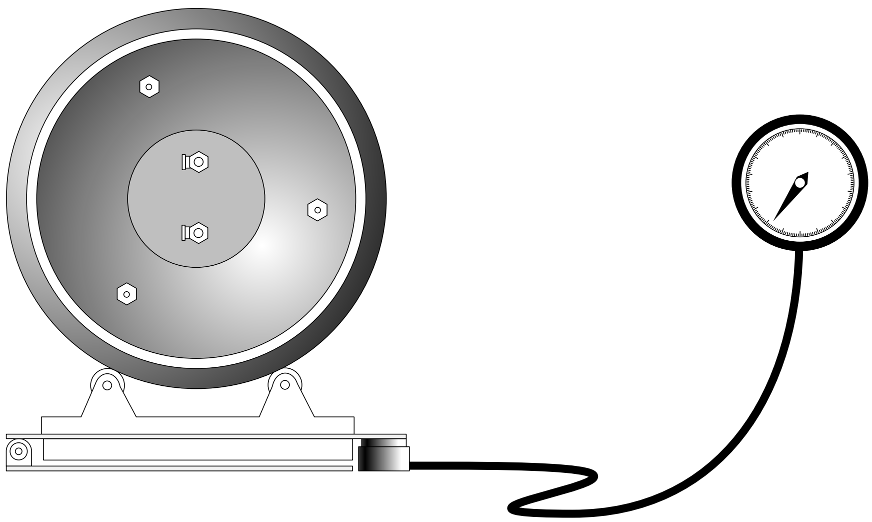
1-ton Containers

Most Popular

The following scale is the most popular for the one-ton containers. This type of scale uses a cradle which is hinged on one side and the center of the opposite side rests on a hydraulic cylinder. The weight of the container is transferred by hydraulics to a gauge.

Restraints

Under normal conditions there is no need for extra constraints on the one-ton containers. However, in an earthquake zone the containers should be secured with one or two straps.



Chlorinators

Types

There are a wide variety of types and brands of chlorinators in use today. The most common are as follows:

- Wallace and Tiernan, Capital Controls, and Fisher and Porter floor mounted units
- The Wallace and Tiernan V-75 wall mounted units
- The Wallace and Tiernan V-100 and V-500 wall mounted units
- The Wallace and Tiernan Sonix 100 cylinder mounted units
- The Capital Controls cylinder mounted units
- Regal cylinder mounted units
- Fisher and Porter cylinder mounted units

Operation

All gas chlorinators sold for use in water and wastewater systems and swimming pools are vacuum operated. The vacuum is created by a venturi device called an injector or ejector (depends on brand). The vacuum is used as a safety feature. If there is a leak in the vacuum system, the chlorinator shuts down and gas will not enter the room.

Remote Vacuum

In recent years there have been many changes in chlorinator systems in order to improve safety. These changes can best be illustrated in the development of the remote vacuum systems. With these systems a portion of the chlorinator is attached directly to the cylinder. The line leading from the cylinder to the chlorinator body contains a vacuum.

Metal or Plastic Lines

If a leak occurs in a metal pigtail that runs between the cylinder and the chlorinator, gas under pressure will enter the room. With a remote vacuum system, a break in the pigtail between the cylinder and the chlorinator will cause the system to shutdown and no gas will enter the room. One of the basic rules in observing a chlorine piping system is, “if it is a metal line, it is chlorine gas under pressure; if it is a plastic line, it is chlorine gas under a vacuum.”

Discussion of Operation

The details of the operation of each of the chlorinators described above can be found in the lesson titled Chlorinators.

Pumping System & Piping

Function

In order to provide the differential in pressure required to operate the chlorinator injector, a pump is often required.

Water Supply

At a swimming pool, the supply water for the pump is provided by either the drinking water system or taken from the line leading from the pool filter. At a wastewater plant, the supply water is obtained from the final effluent or the drinking water system. In a water system, the supply water is taken from the finished water system.

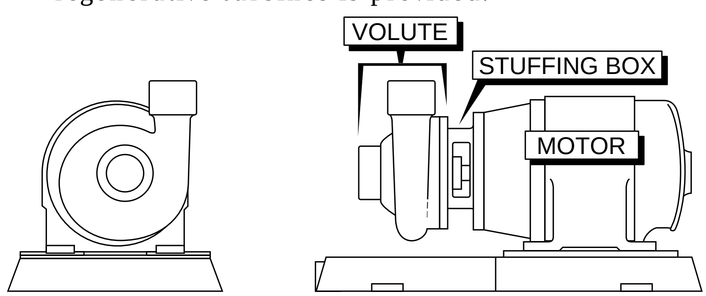
Basic Piping

Water is pumped through the injector and into the discharge line to the contact chamber, wet well, or swimming pool. At a swimming pool, this injection point must be a sufficient distance from the pool to allow proper mixing of the concentrated chlorine solution with the filtered water. If proper mixing does not occur, uneven levels of chlorine will enter the pool.

Types of Pumps

There are two types of pumps used to provide proper pressure and flow for the injectors. The pump may be either an end-suction centrifugal or a regenerative turbine. Most operators are familiar with standard end-suction centrifugal pumps, but may not be familiar with the operation of the regenerative turbine. Therefore, the following basic information about regenerative turbines is provided.

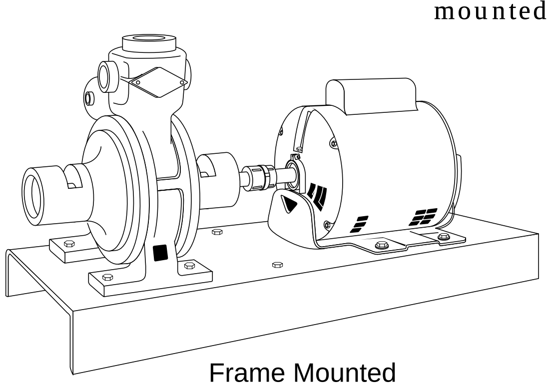
Close Coupled
End-suction Centrifugal Pump



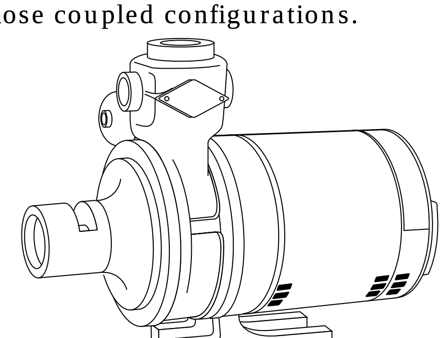
Regenerative Turbine

Configuration

Regenerative turbines are manufactured in frame mounted and close coupled configurations.



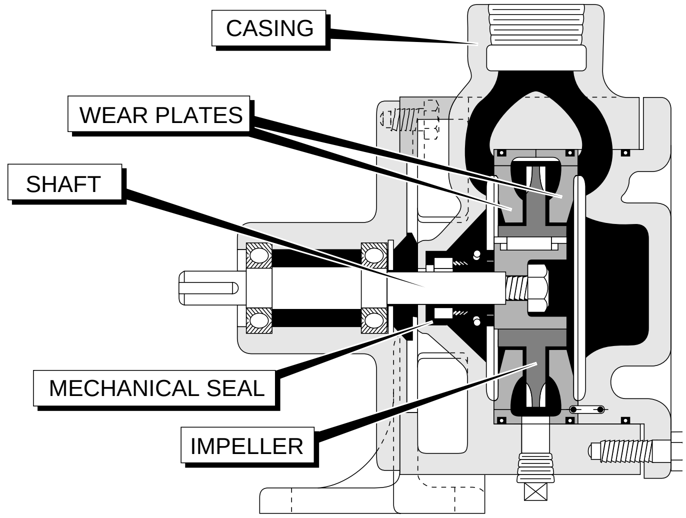
Frame Mounted



Close Coupled

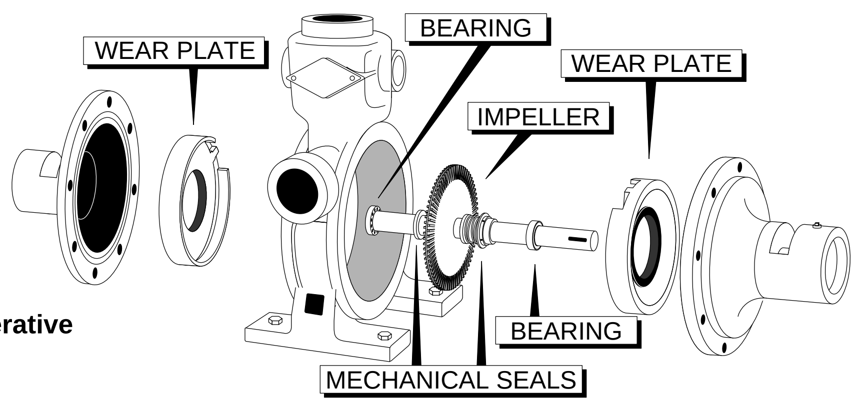
Two Styles - Frame Mounted

There are two styles of the frame mounted units. In one style the pump is made very much like an end suction with the impeller supported by two bearings on one end of the shaft.



Frame Mounted Regenerative Turbine

The second, and more popular version, uses a bearing on each end of the shaft, much like a split case pump.



Frame Mounted Regenerative Turbine

Uses

The regenerative turbine is used because it provides adequate high pressure at low flow requirements of the injector.

Self-Priming

This type of pump is classified as self-priming. This is due to the fact that the pump will develop a vacuum, prime, and pump with much higher quantities of air and vapor than a centrifugal pump.

Unique Case

The regenerative turbine pump is easy to identify. The case will be perfectly round, not like the eccentric volute of centrifugal pumps. The suction and discharge piping will be close together and usually the same pipe size.

Component Nomenclature

Impeller - Wear Plates

The heart of the regenerative turbine is the impeller and the two casing wear plates which are a machined set and can be purchased in steel, bronze, or stainless steel. The bronze set is the most common in the water and wastewater industry.

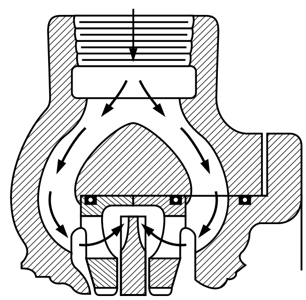
Mechanical Seals and Packing

The cast case holds the plates together and houses the packing or mechanical seals. This type of pump may be designed with only one set of packing or mechanical seals. When one set of packing or one mechanical seal is used, the pump is either a close-coupled design or the frame mounted that is similar to the end-suction centrifugal pump. Some manufacturers prefer to mount bearings on either side of the impeller so two mechanical seals are also needed.

Theory of Operation

Water Enters Impeller

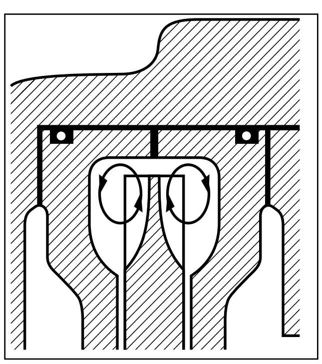
The impeller has many small vanes on each side. As water enters the suction of the pump, it is equally divided by a separator sending one half of the water to each side of the impeller.



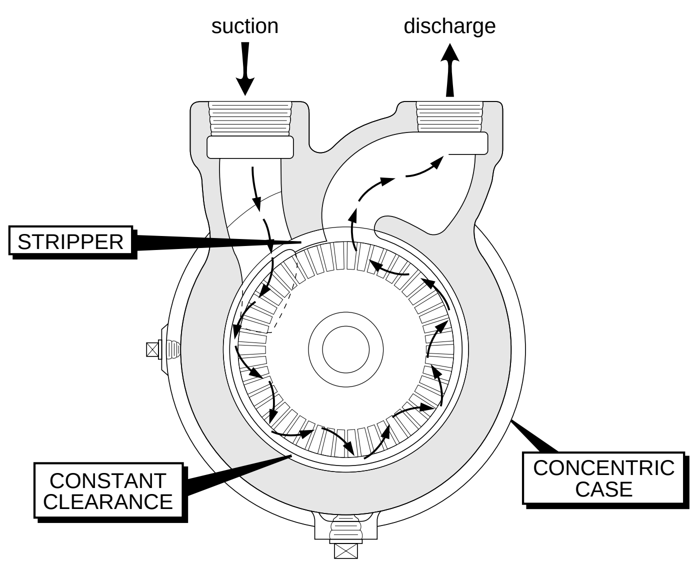
Interaction with Case

The clearance between the edge of the impeller and the outside of the case is identical all around the case. As water enters the case, the moving impeller strikes the water. The water is thrown from the impeller against the case by centrifugal force. When it strikes the case, it is directed back to the impeller where more energy can be added.

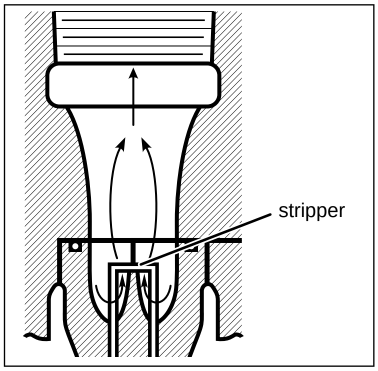
This process may happen as many as 50 times as the water travels around the case.

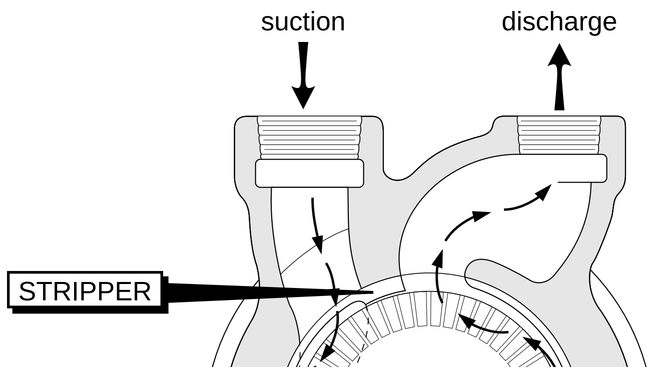


Cross-section of impeller and case



As the water reaches the discharge port, it is prevented from continuing on by a small metal device called a stripper, which lies very close to the impeller. The water is then directed out of the pump.





Normal Operating Conditions

Comparison/Positive Displacement

The regenerative turbine is smaller than positive displacement pumps that deliver the same head and volume and may be run for short periods with a closed discharge.

Comparison/Centrifugal

A centrifugal pump could produce the same head and capacity, but in most cases the pump would need to be multi-stage and would be more costly. There is also the added advantage with the regenerative turbine of pumping fairly high quantities of air or vapor. It is for these reasons that the regenerative turbine is often selected as the booster pump in gas chlorine stations.

Subject to Wear

On the other hand, the regenerative turbine is subject to the loss of head as a result of abrasive material wearing on the impeller, plates, and stripper. The regenerative turbine is also more costly to maintain and repair than equivalent-sized centrifugal pumps.

Sized at Twice the Head

Due to the problem of loss of head, the regenerative turbine is typically sized to produce twice the needed head.

Bypass Valve

To allow for progressive loss of head, a bypass valve is installed between the discharge and suction lines. As the stripper wears, this valve is adjusted to obtain the desired discharge pressure.

Piping System

Not Pump Dependent

The following piping system is based on the use of a regenerative turbine. However, with the exception of the bypass valve and piping there is no difference between the desired piping system on an end-suction centrifugal pump and a regenerative turbine.

Components

Valves

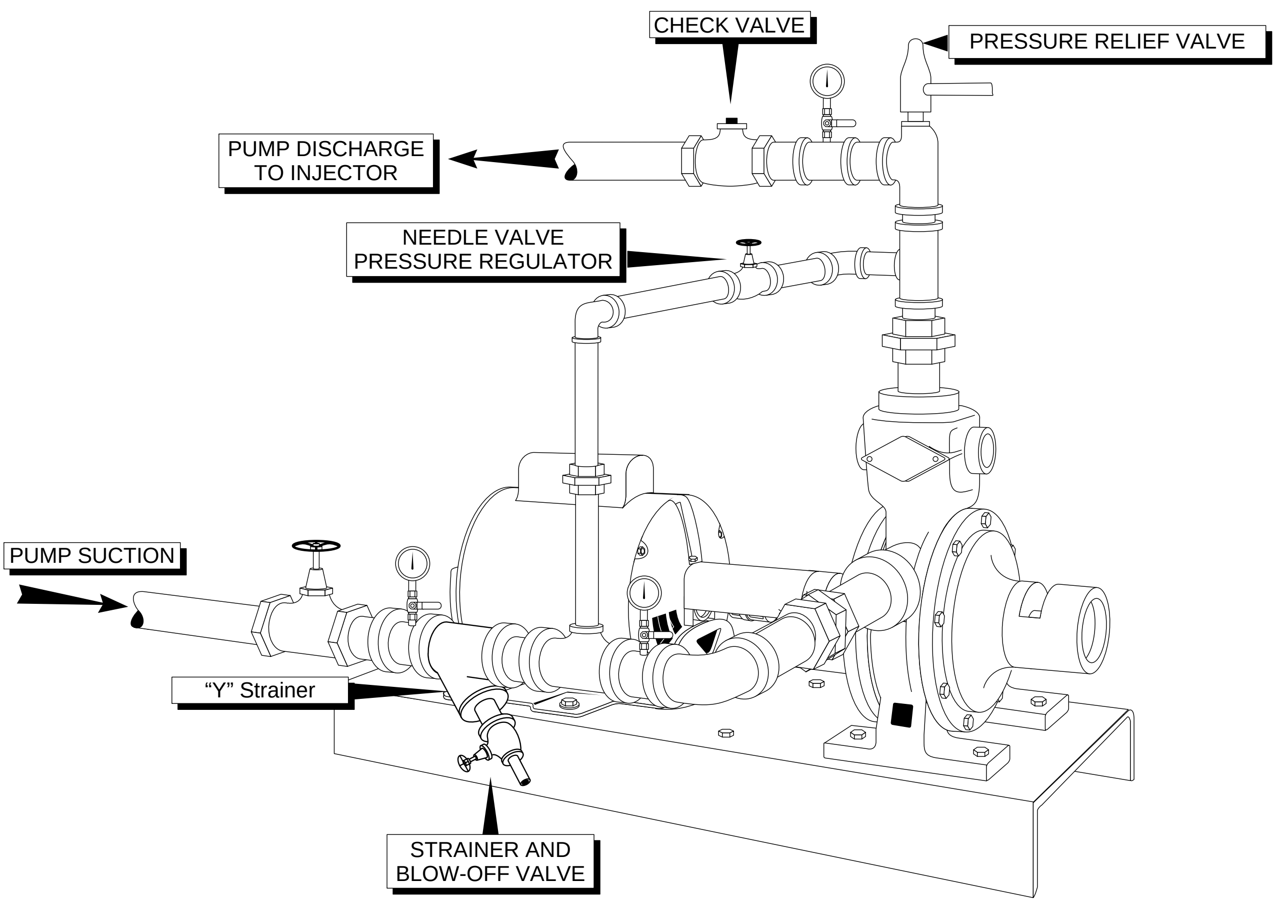
A control valve should be placed on the suction line just prior to the pump and on the discharge line just after the check valve. This allows isolation of the pump for repair.

"Y" Strainer

Because the impeller can be easily damaged from small debris, a "Y" strainer is placed in the suction line. The strainer should be equipped with a blow-off valve and be positioned so that the internal screen can be easily removed for cleaning.

Check Valve

To prevent concentrated chlorinated water from being forced back into the pump, a check valve is placed in the pump discharge line. Most of the pumps used for this process utilize bronze impellers. Chlorine will quickly deteriorate bronze.



Pressure Relief

Because the regenerative turbine can generate high pressures, a pressure relief valve is installed in the discharge line. This valve should be set to discharge at a pressure less than the line breakage pressure. Should the discharge valve accidentally be shut off with the pump running, this valve will relieve the pressure.

Injector

Water from the auxiliary pump passes through the injector or ejector where it produces a vacuum that is used to operate the chlorinator. In addition, chlorine gas is added to the water in the injector or ejector.

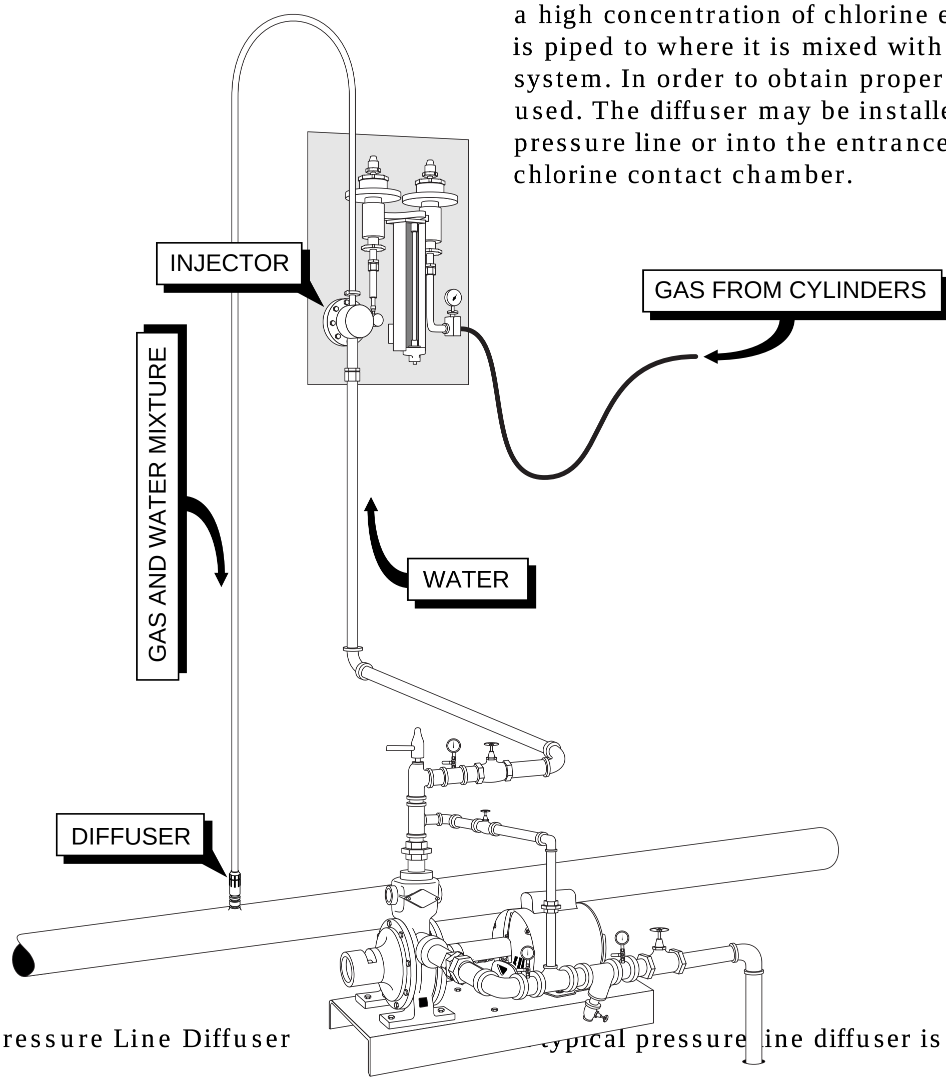
Gauges

In order to evaluate the operation of the pump, injector, and "Y" strainer, gauges should be placed on inlet and outlet sides of the "Y" strainer, on the discharge side of the pump, and on the discharge of the injector. These pressures become critical data when attempting to solve chlorinator problems.

Mixing with Flow

From the Injector

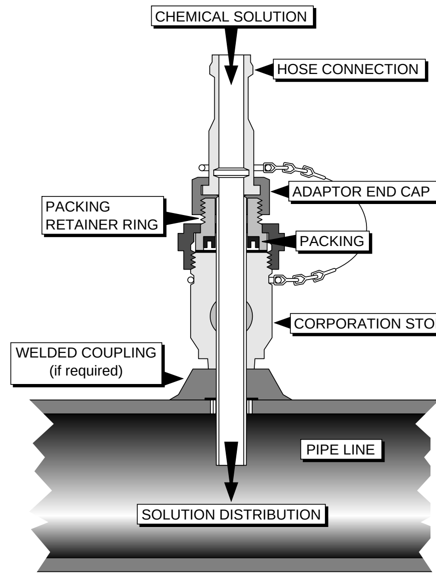
In a swimming pool or water system, water containing a high concentration of chlorine exits the injector and is piped to where it is mixed with the flow of the system. In order to obtain proper mixing, a diffuser is used. The diffuser may be installed directly into a pressure line or into the entrance to the clearwell or chlorine contact chamber.



Pressure Line Diffuser

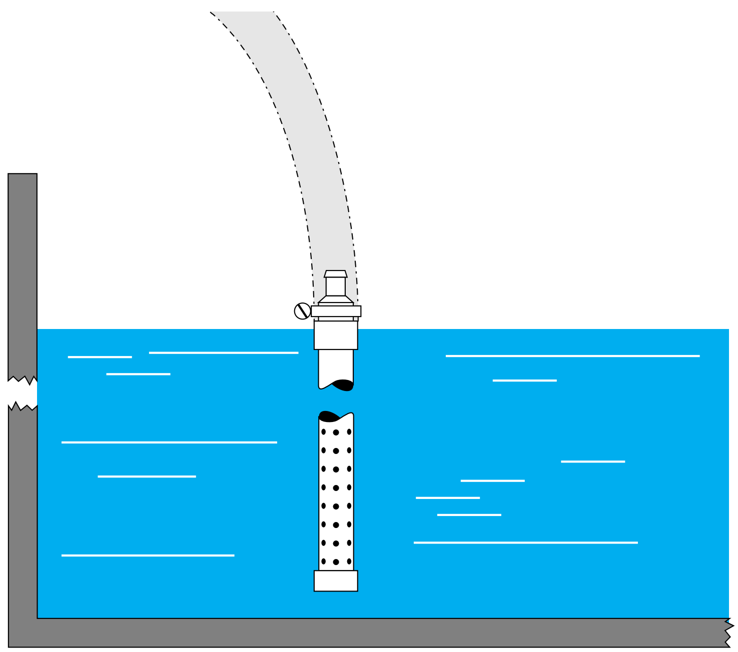
typical pressure line diffuser is a half inch PVC pipe that is placed through a corporation stop or gate valve. To provide the best possible mixing, the diffuser pipe is allowed to extend from a third to half of the diameter of the flow pipe.

Diffuser



Tank Diffuser

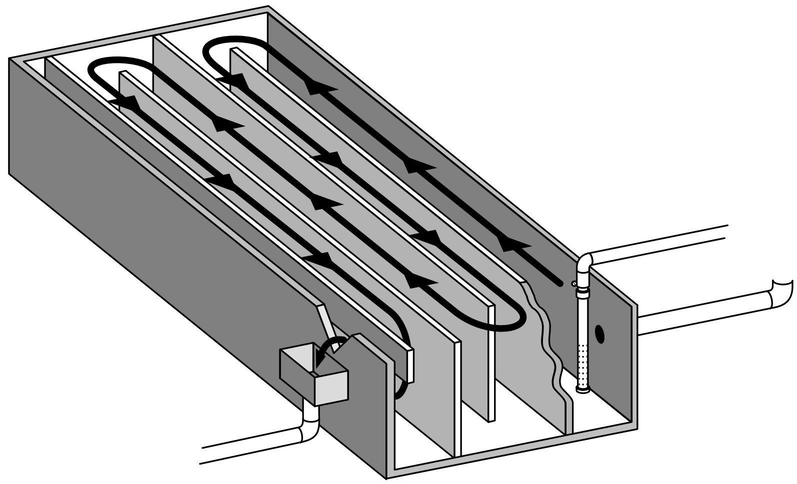
A diffuser that is placed in the entrance to a clearwell or chlorine contact chamber may be a pipe with a special nozzle or a pipe with several holes or slots that provide proper diffusion of the chlorine.



Contact Time

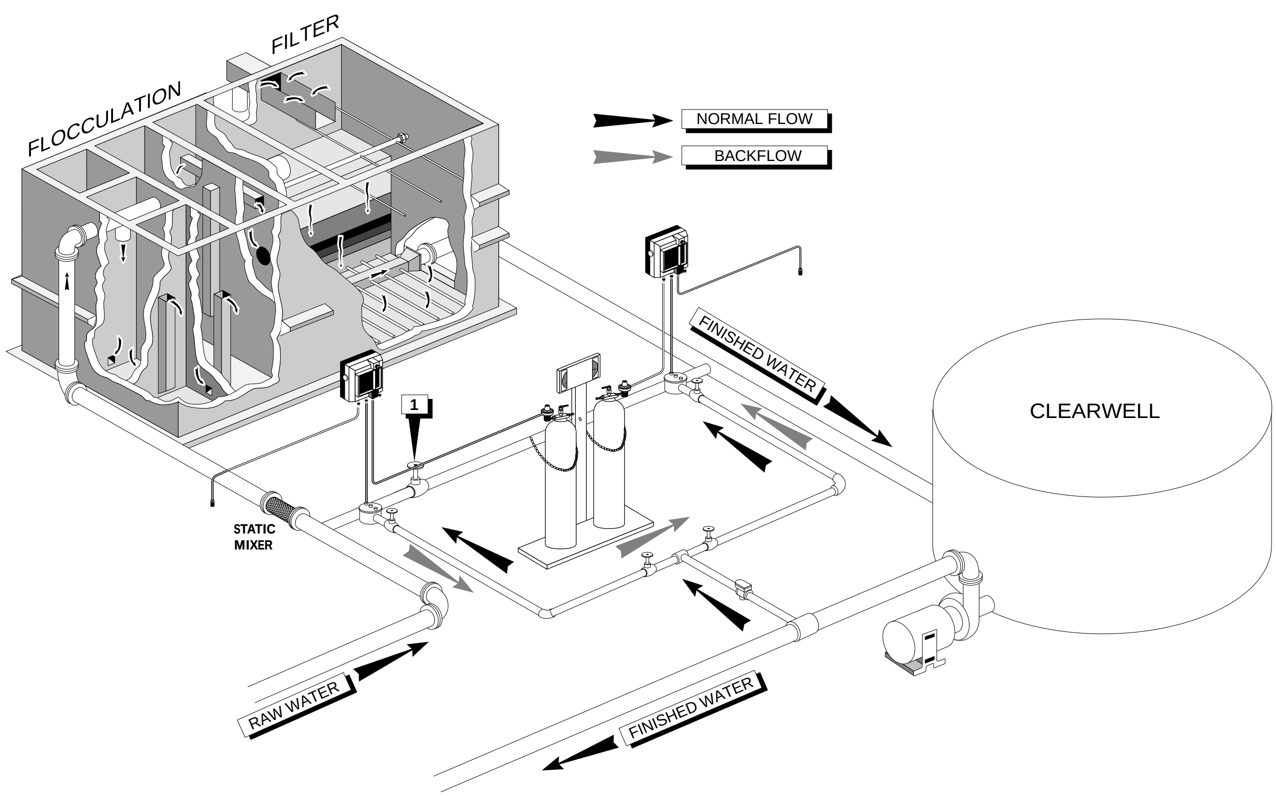
In a water treatment plant, proper contact time is provided in a clearwell or reservoir. In a wastewater treatment plant, contact time is provided in a chlorine contact chamber. These chambers are designed to provide maximum contact time and plug flow.

Wastewater Treatment Plant
Chlorine Contact Chamber



Cross Connection

When a chlorine system is designed to provide pre and post chlorine feed at a water treatment plant utilizing two injectors with a common water source, a cross connection can occur. Under normal conditions water flows from the clear well through the two injectors without incident. However, if the source water is shut off, raw water can flow through the raw water injector across the common line, through the finished water injector and into the clear well. In addition, a failure of the valve (1) connecting the common injector discharge header can allow raw water to enter the clear well.



Normal Operation

Typical Inspection

A typical chlorine station does not require a great deal of routine maintenance. The following are suggested inspection, cleaning, and/or replacement intervals:

- Check and record cylinder weight daily.
- Record system flow on each visit. Use this data along with amount of chlorine used to calculate the dosage.
- Observe and record the rotometer setting. Compare this setting with the previous visit.
- Observe and record the gas and pump system pressure and/or vacuum gauges. Compare with previous readings.
- Test and record chlorine residual at least daily.
- Inspect the room interior and clean the floors weekly.
- Inspect for vandal damage weekly.
- Test air ventilation system weekly.
- Test alarm system monthly.
- Replace pigtail annually.
- Replace auxiliary valves annually.
- Replace black iron header system every five years.
- Replace leak detector sensor annually.

Routine Testing

Auxiliary Valves

While it is recommended that pigtails and auxiliary valves be replaced annually, there are circumstances where they last for several years. The auxiliary valve should be replaced when it no longer shuts off the flow.

Pigtails - Copper

Metal pigtails need to be replaced if a “crinkling” sound can be heard when it is bent. The sound is produced when the monel coating is breaking up.

Pigtail - Plastic

Clear plastic pigtails should be replaced when they begin to discolor. The black plastic should be replaced when it becomes brittle. Exposure to sunlight will increase the rate of deterioration.

Black Iron Header

Once a year, inspect the interior of the black iron header for a buildup of ferric chloride. Inspect the exterior joints for noticeable liquid leaks. If there is a noticeable leak or a significant buildup of ferric chloride, the header must be replaced.

Safety Equipment

Later Discussion

The safe handling of chlorine containers is discussed in the lesson on cylinders and connections. The response to O & M releases of chlorine or chlorine emergencies is discussed in the safety lesson. However, besides the safety equipment already discussed, there are two more specific items that should be considered.

Respiratory Protection

Proper respiratory protection must be provided for any person who is handling gas chlorine containers. The most common protection is the self contained breathing apparatus (SCBA) and the canister gas mask. As a result of changes in regulations, it is recommended that all personnel be equipped with either a five minute escape SCBA or a cartridge or canister escape gas mask.

Regulation Requirements

Any time an employee is expected to use a respiratory protection device, the organization is obligated to implement a respiratory protection program. This program must have at least the following elements:

- An evaluation of the types of potential hazards that require the use of respiratory protection
- A written policy and written procedures on the proper use of respiratory protection
- Initial training of all personnel expected to use the respiratory protection
- Monthly inspection of the devices
- Annual retraining on the use of the devices
- Annual physical examination
- Annual respiratory protection device fit test
- Documentation of training and evaluation

Not in the Regulation

There is no federal regulation that requires the use of a SCBA when changing a chlorine cylinder.

Emergency Response

In order for individuals to respond to a chlorine emergency, they must be trained as described in 29 CFR 1910. The minimum training is the 40 hour hazardous material response training. The responders must be part of an official emergency response team.

Repair Kits

The second safety item of consideration is the emergency repair kit. There are three different emergency repair kits:

- Kit “A” is for 100 and 150 pound cylinders
- Kit “B” is for one-ton containers
- Kit “C” is for tank cars and tank trucks

Use of the Kits

The kits must only be used by those individuals who are properly trained and a part of an official hazardous material response team.

Chlorine Station Checklist and Data Collection

Use the list below and the following two (2) pages to develop a daily data collection and P.M. checklist for chlorine station. If more than two pages are needed, white out the page number and type in additional page numbers.

Items to add to the data form:

- ❑ Air quantity in SCBA or date on cartridge respirator
- ❑ Booster pump inlet pressure
- ❑ Booster pump outlet pressure
- ❑ Injector vacuum
- ❑ System pressure
- ❑ Chlorine cylinder pressure
- ❑ Exercise valves
- ❑ Chlorine residual
- ❑ Exhaust fan operation
- ❑ Exhaust fan louvers operation
- ❑ pH
- ❑ Room temperature
- ❑ Clean "Y" strainer
- ❑ Exercise rate of flow control valve - weekly
- ❑ Vent line check - weekly
- ❑ Chlorine room alarm check - weekly

Chlorine Station Data Sheet									Month
Day	Meter Reading	Production	Cylinder wt.	Pounds Used	Dosage mg/L	Residual mg/L	Porameter Position		Operator
31									
30									
29									
28									
27									
26									
25									
24									
23									
22									
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10									
9									
8									
7									
6									
5									
4									
3									
2									
1									
Totals									

Chlorine Station Data Sheet							Month		
Day									Operator
31									
30									
29									
28									
27									
26									
25									
24									
23									
22									
21									
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2									
1									
Totals									

Gas Chlorination Stations

Worksheet

1. The most common type of pump used as a booster pump in gas chlorination stations is the _______________ _______________.

2. In a gas chlorine room:

   The air exhaust inlet should be near the _____________ and the fresh air intake should be near the ____________.

   All electrical fixtures must be _______________ proof.

   The door should open ❑ IN or ❑ OUT.

   The room should be kept at ______° F.

3. What problems can occur when electrical panels and electric motors are placed inside a gas station?

4. Full and empty chlorine cylinders should be stored so that:

5. The two most common types of scales used to weigh gas cylinders:

   a. ____

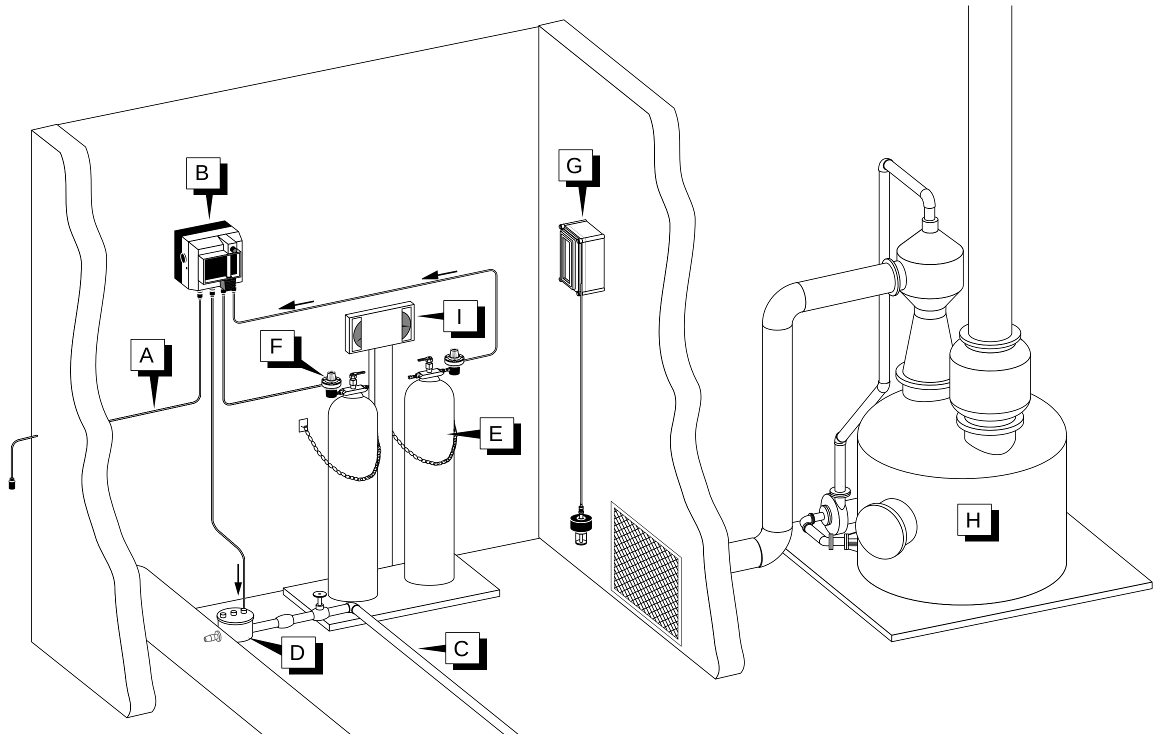
   b. ____

6. Chlorine cylinders should be weighed ______________________.

7. The diffuser is used to ____

   ____

8. In the drawing below, identify the items indicated.



A. ______________________ F. ______________________

B. ______________________ G. ______________________

C. ______________________ H. ______________________

D. ______________________ I. ______________________

E. ______________________

9. What is the normal life expectancy of each of the following items?

a. Pigtails ______________________

b. Auxiliary Valves ______________________

c. Black Iron Headers ______________________

10. What are the indicators to determine that the following items need to be replaced?

    a. Pigtails ____

    b. Auxiliary Valves ____

    c. Black Iron Headers ____

11. .. will occur any time chlorine gas is moved from a ____________ temperature to a ____________ temperature. One of the ways to prevent reliquifaction is to place a ____________________ in the gas line.