Vaporizer Piping
Gas Pressure Feed Applications

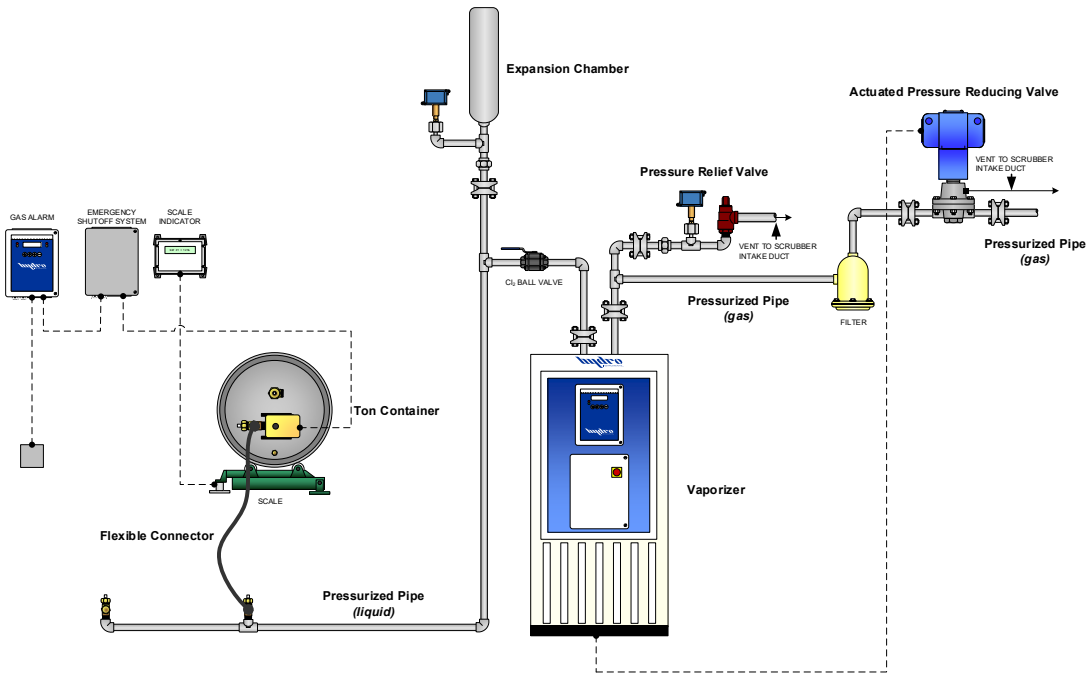
Vaporizers are used for high capacity chemical feed applications when direct gas withdrawal systems are impractical. This document will provide a generalized overview of vaporizer operation and general design information for chlorine liquid manifolds. Throughout the document reference will be made to chlorine (Cl_2), but the information also applies to sulfur dioxide (SO_2) and ammonia (NH_3). This document should be used only as a reference and only after proper engineering consideration has been given to all aspects of the relevant system design. For additional information refer to the Hydro Instruments Chlorine Handling Manual and the Chlorine Institute, Inc. Pamphlet 6.

Vaporizer Overview

The vaporizer pressure chamber is submerged in a hot water bath at approximately 180°F (82°C). Water bath temperature can be adjusted depending on feed rate requirements and also can be set lower during standby usage. As the liquid chlorine flows into the pressure chamber it is vaporized on contact with the hot walls of the chamber. The resultant gas chlorine is then superheated as it travels out of the vaporizer before flowing downstream to the process (See Figure 2). The rate at which chlorine passes through the chamber is dictated by the chemical feed rate of the system. Initially the liquid chlorine level in the pressure chamber will rise until the heat transfer rate from the pressure chamber walls to the liquid chlorine is sufficient to balance the chemical feed rate of the system. If the liquid chlorine level rises above this equilibrium level (or if feed rate demand of the system is reduced) then chlorine gas pressure inside the chamber will build up and push the liquid chlorine level back until a new equilibrium level is reached. As the chlorine feed rate is increased, gas pressure will fall causing the liquid level to rise, and as the liquid chlorine level rises the heat transfer surface area increases between the liquid chlorine and the pressure chamber walls until an equilibrium level is reached. Therefore, the size of the inner chamber and its ability to transfer heat to the liquid chlorine determines the feed rate capacity of the vaporizer.

IMPORTANT: Exceeding this feed rate capacity risks the liquid level rising above the height of the chlorine pressure chamber and flooding liquid chlorine past the vaporizer.

FIGURE 1



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Containers

Connected containers (e.g. ton containers, rail cars and bulk tanks) must be maintained at the same elevation and temperature in order to prevent unequal feed or contents flowing between containers. Scales are recommended to monitor over filling and uneven feeding of the containers, as well as monitor when supply is low.

Pressurized Piping

Pressurized piping should be 1” schedule 80 seamless carbon steel. Fittings must be 3000 pound forged steel, A-105.

Note: Threaded joints must be sealed with Teflon tape or other approved sealant.

Chlorine Liquid Manifold
The liquid manifold can be placed above or below the liquid cylinder valve (e.g. the bottom valve) on the ton container. However, to prevent liquid traps it is recommended it be placed above. If placed above the ton container then the pipe should be pitched back toward the ton containers at approximately 2° to 3°.

Flexible connectors are used to connect the manifold piping to the ton containers. Auxiliary valves (e.g. isolation valves) should be used on all flexible connectors at the ton container.

Pressure Equalization Manifold
The use of a pressure equalization manifold is recommended when utilizing more than one ton container in order to equalize the pressure within the ton containers. This will help to prevent overfilling of the ton containers when liquid chlorine is pushed back into them. The pressure equalization manifold must be placed above the liquid manifold. Pipe size should be 1” schedule 80 seamless carbon steel and fittings must be 3000 pound forged steel, A-105. If adding a secondary gas discharge line, the pipe size should be sized appropriately for the flow rate and it must be tilted back toward the containers and installed with liquid traps and heaters to allow use during times of vaporizer maintenance.

Gas Feed Line (optional)
This piping arrangement can be used for gas feed during times of vaporizer maintenance or as a means to evacuate the gas piping line.

The gas feed line piping should pitch back (approximately 2° to 3°) toward the ton containers and the gas outlet of the vaporizer must be higher than the containers. The valves in the optional gas evacuation pipe line must remain closed during normal operation.

Liquid Reserve Containers

Liquid reserve containers are optional.

Liquid reserve containers can be useful in changeover style systems so that full chemical feed capacity can be maintained while in the process of changing from a depleted chemical supply to a full one.

Expansion Chambers

Expansion chambers must be installed on liquid lines between any two points where liquid could become entrained (i.e. between valves that could be closed on both ends).

The expansion chamber must be sized so that its volume is at least 20% of the overall pipe volume that it is protecting.

Expansion chambers must be located on the highest point of the pipeline section.

The expansion chamber includes:

- A 1" FPT union type (or flange type) holder with rupture disc.
- A suitable diaphragm protected pressure switch for disc rupture indication.
- Either a DOT –or– ASME certified expansion tank.

Pressure Relief Valve

The pressure relief valve assembly must be installed directly at the gas outlet connection of the vaporizer and must be before any type of obstructions (filters, ball valves, etc.).

Piping to the pressure relief valve is 1" NPT and the vent outlet is 1.5" NPT (1.5" vent piping must be schedule 80 seamless carbon steel material).

Outlet vent piping must be directed to a safe, unoccupied area outside and should slope downward to prevent moisture buildup in the line. Alternatively, the piping could be directed to a chlorine scrubber intake. An insect screen should be installed at the vent piping outlet.

The pressure relief valve has a relief pressure of 560 psig (38.6 bar).

Actuated Pressure Reducing Valve

The electronic pressure reducing valve (PRV) is wired to the vaporizer and will be used to stop chlorine feed in the event that any relevant alarm condition exists.

Two PRVs in a duty standby arrangement can be connected to one vaporizer to allow operation during maintenance of one of the PRV's.

The PRV should be installed using Ammonia type unions at the inlet and outlet with a bypass line to allow for quick installation and maintenance. This bypass line must include a manual chlorine ball valve and must run horizontally around the PRV.

NOTE: Do not run the PRV bypass line below the PRV because this could be a trap for liquid chlorine.

The PRV's vent line connection is ¼" FPT, but it is recommended that the vent line be at least ½" size. This vent line should be ½" schedule 80 seamless carbon steel material. This vent line must be directed to a safe, unoccupied location, outside of the building or directed to a scrubber intake. The PRV vent piping must slope downward toward the outlet at approximately 2° to 3° to allow any condensation to naturally drain away from the PRV. An insect screen should be installed at the vent outlet.

The PRV will tend to get cool due to the pressure drop through it, making it susceptible to condensation. An optional heater is available to mount on the PRV in order to avoid this condensation.

Vaporizer Pressure Chamber

1” Ammonia type unions are to be installed on the ASME certified vaporizer pressure chamber liquid inlet and gas outlet. Liquid inlet and gas outlet are identified on the pressure chamber and must be installed appropriately. Inaccurate installation of the liquid and gas lines into the vaporizer will result in serious malfunction of the unit and potential damage to other equipment.

Piping in and out of the vaporizer must be installed in a way that will allow relatively easy disconnection from the piping and allow for vertical removal of the vaporizer pressure chamber for inspection and maintenance. Hydro Instruments recommends at least 12ft. (3.65m) of clearance space above the vaporizer and the use of a 4,000+ lbs. (1,800 kg) capacity lifting crane.

The chlorine feed rate is proportional to the heat transfer rate from the hot water to the chlorine liquid. Heat transfer rate is proportional to…

$$\left(Temp_{Water} - Temp_{Liquid\ Cl2}\right)\ x\ Area_{Chamber}$$

Therefore, the chamber size determines maximum capacity and the water temperature is the only variable the vaporizer can adjust under operating conditions.

As illustrated in Figure 2 below, the superheat is an indication of how high the liquid level is in the chamber. If the superheat falls to zero then this means that liquid has reached the top of the pressure chamber and will flood past the vaporizer. The Hydro Instruments Vaporizer monitors the superheat and has a superheat alarm feature that will stop liquid chlorine flow by cutting power to the actuated pressure reducing valve in the gas outlet line should the superheat fall below the alarm set point. This is critically important because if liquid chlorine passes through the vaporizer it could enter equipment downstream of the vaporizer or reach the process, which could cause a chlorine release or downstream process malfunction.

FIGURE 2

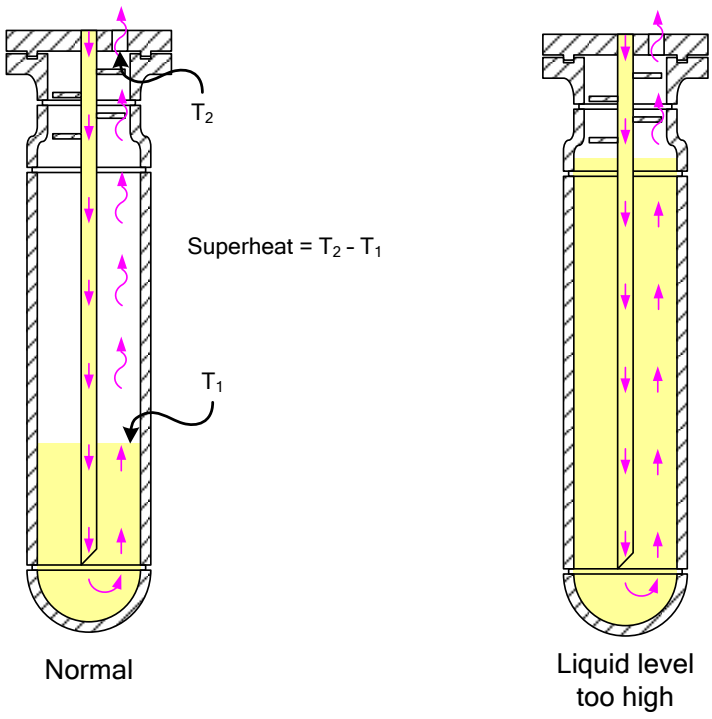

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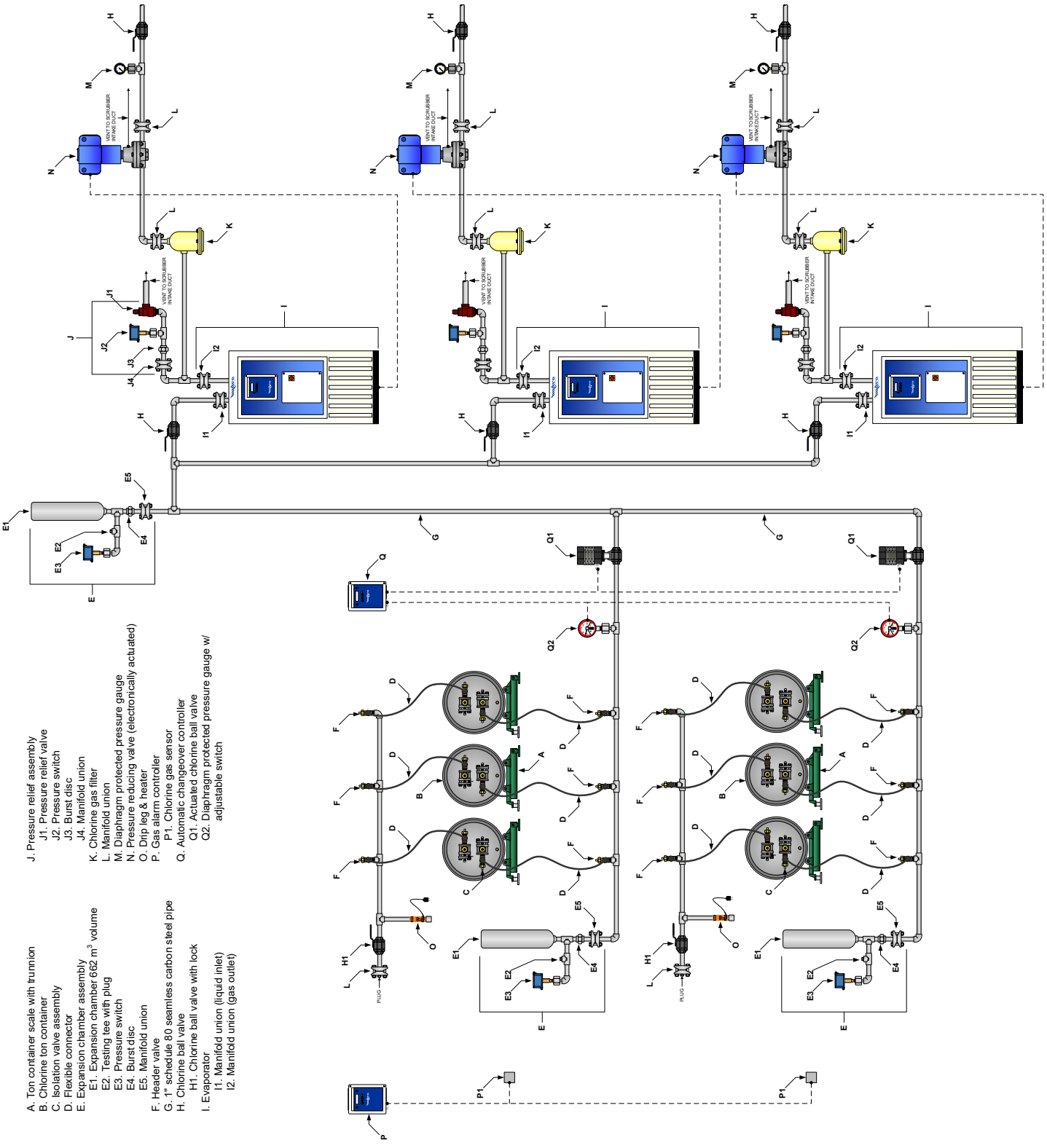
FIGURE 3



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