Engineering, Installation and Operation Manual

7619 Hamilton Avenue
Cincinnati, OH 45231
USA
(513) 729-3473 phone
(513) 729-3444 fax

TABLE OF CONTENTS

SECTION 1

INTRODUCTION

Table of Contents

SECTION 1

INTRODUCTION

1-1 PURPOSE

The intent of this manual is to provide the user with the information necessary to adequately select, operate and maintain low pressure CO_2 fire suppression equipment required to protect a specific hazard.

1-2 DESCRIPTION

A. A low pressure CO_2 system is a specialized fire suppression system designed to maintain the carbon dioxide supply at 0º F and 300 psig in an insulated, refrigerated pressure container ("Storage Tank"). This tank contains the amount of CO_2 required to protect the largest single hazard and any number of back-up discharges required by the authority having jurisdiction.

B. A "Tank Shut-Off Valve" installed between the dip tube flange and header serves as a means of isolating the tank from the system. This valve is maintained in the open position and is only closed to perform maintenance on the system.

C. System control valves (Master or Selector Valves) control the CO_2 flow to the hazard through properly sized pipe, terminating in nozzles that apply the CO_2. Flow rate is controlled by nozzle orifices as well as pipe sizes. When there is one control valve at the storage unit and others located downstream on the piping network, the main valve is called the "Master Valve" and the downstream valves are the "Selector Valves". When only one valve is used, it is designated as a "Master Valve". These system control valves are electronically operated and pressure actuated. The valves are normally closed and held open with pressure. They can be automatically and/or manually operated.

D. Lock-Out Valves

A lock out shall be installed on all systems where carbon dioxide could migrate, creating a hazard to personnel. The valves shall be supervised for both automatic and manual systems unless specifically waived by the authority having jurisdiction. Systems shall be locked out when persons not familiar with the systems and their operation or when persons are present in locations where discharge of the system will endanger them before they can proceed to a safe location within the time delay period. The main tank shut-off valve can be used as a system lock out valve.

E. The equipment listed with this low pressure carbon dioxide system has been tested to operate between -10º F and 120º F. Any approved releasing control panel can provide automatic actuation. Electric release stations provide manual release. The control panel operates the alarm devices, provides shut-down of auxiliary equipment, and supervises all circuits. The control panel also provides delays so alarms (audible and visual) in the protected area can evacuate personnel before the CO_2 discharges. The panel also controls the opening and closing of the system control valves allowing the required quantity of CO_2 to discharge into the protected hazard.

F. Pneumatic Time Delays

A pneumatic pre-discharge alarm and pneumatic time delay shall be provided for all total flooding systems protecting normally occupied and occupiable enclosures and for local application systems protecting normally occupied and occupiable enclosures where the discharge will expose personnel to hazardous concentrations of carbon dioxide. (NFPA 12, Paragraph 4.5.6, 2005 Edition) The pneumatic pre-discharge alarms and pneumatic time delays are required on all new installations and it is mandated that all existing systems be upgraded no later than August 7, 2006.

1-3 PROPERTIES OF CARBON DIOXIDE

A. Under normal atmospheric temperature and pressures, carbon dioxide exists as a colorless, odorless gas which is about 1.5 times heavier than air. Carbon dioxide will not burn or support combustion and will not sustain life.

B. When confined within a suitable pressure vessel and depending on temperature and pressure conditions, carbon dioxide can exist in any of three stages of matter; solid, liquid and gas. The point at which all three states may exist is -69.9º F and 60.4 psig. This is called the triple point. At temperatures and pressures lower than -69.9º F and 60.4 psig, carbon dioxide may be either a solid or gas, again depending on conditions. Solid carbon dioxide (dry ice) at a temperature of -119.4º F and atmospheric pressure, sublimes (transforms directly from a solid to a gas without the formation of liquid).

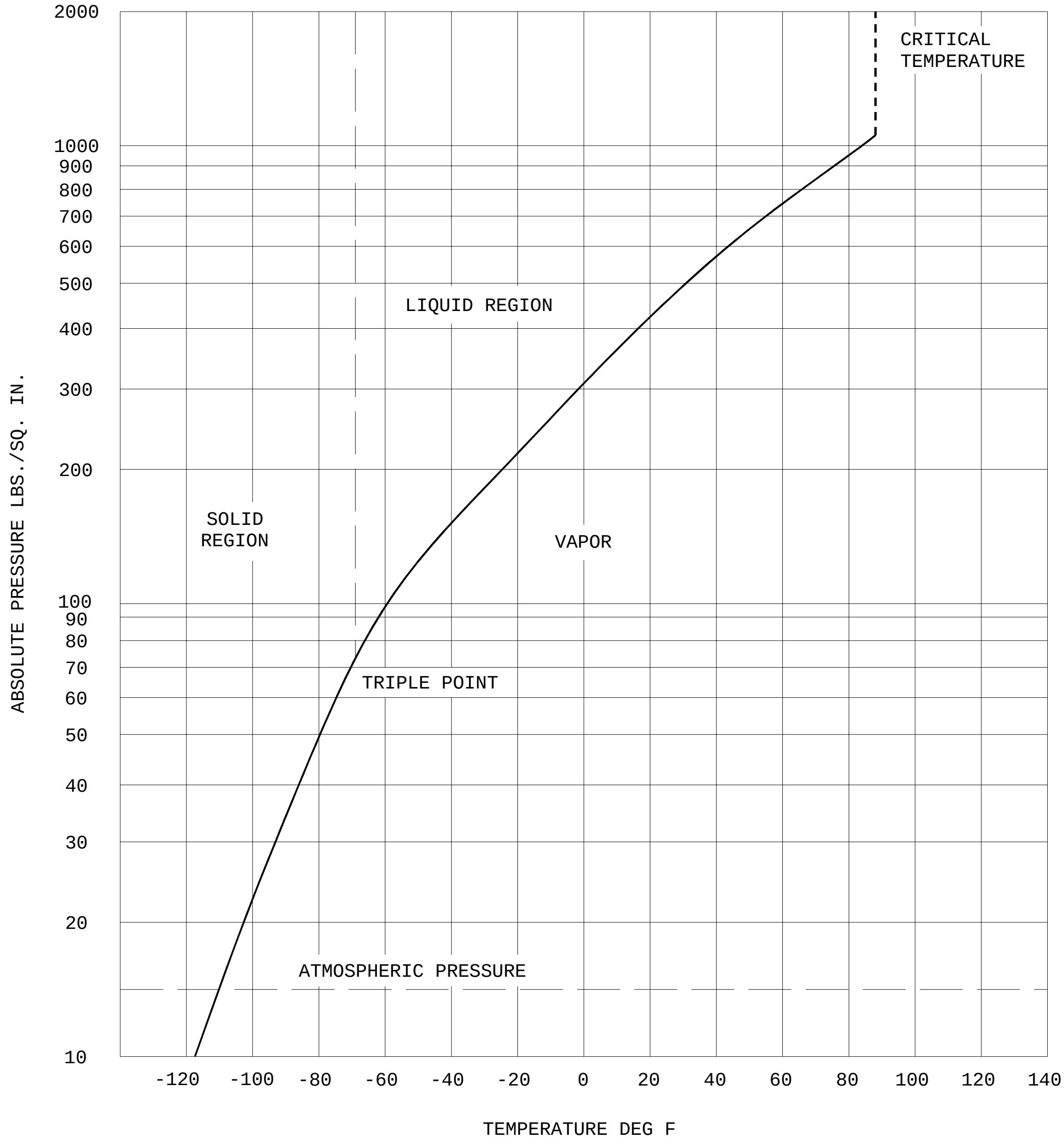
C. The critical point of carbon dioxide is 87.8º F and 1057.4 psig. At temperatures and pressures greater than 87.8º F and 1057.4 psig, carbon dioxide liquid cannot exist.

D. At temperatures and pressures above -69.9º F and 60.4 psig, and below 87.8º F and 1057.4 psig, carbon dioxide liquid with overlying vapor may exist in equilibrium within a closed vessel. Within this range, there is a definite relationship between temperature, pressure and density.

E. By comparing the pressure and liquid density at 70º F (837.8 psig and 47 $lbs./ft^3$), with the pressure and density at 0º F (291.1 psig and 63.65 $lbs./ft^3$), it is obvious that relatively large quantities of carbon dioxide liquid can be stored in relatively small, thin walled pressure vessels, hence, low pressure bulk storage of CO_2. Figure 1-1.

F. The term "low pressure" is used in the industry to describe storage of carbon dioxide at temperatures below ambient, usually around 0º F. The normal operating pressures range from 295 psig to 305 psig.

The term “high pressure” is used to describe storage of carbon dioxide at ambient temperature which is usually 850 psig @ 70° F.



For SI Units: 1 psi = 0.0689 bars: ºC = 5/9(ºF -32).

Figure 1-1 Variation of Pressure of Carbon Dioxide with Change in Temperature (Constant Volume). Below the critical temperature (87.8º F) (31º C), carbon dioxide in a closed container is part liquid and part gas. Above the critical temperature it is entirely gas.

Figure 1-1
Vapor Pressure Curve

1-4 QUALITY OF CARBON DIOXIDE

Carbon dioxide used for initial supply and replenishment shall be of good commercial grade, free of water and other contaminants that might cause container corrosion or interfere with free discharge through nozzle orifices. Carbon dioxide obtained by converting dry ice to liquid will not be satisfactory unless it is properly processed to remove excess water and oil. The vapor phase shall be not less than 99.5 percent carbon dioxide with no detectable off-taste or odor. The water content of the liquid phase shall be not more than 0.01% by weight (-30º F [-34º C] dew point). Oil content shall be not more than 10 PPM by weight.

Caution: Carbon Dioxide should not be used to protect the following hazards:

1. Chemical compounds such as gunpowder or cellulose nitrate which supply their own oxygen.
2. Reactive materials such as sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium.
3. Metal hydrides.
4. Chemicals capable of undergoing auto thermal decomposition (hydrazine and certain organic peroxides).

1-5 SAFETY

A. **Pressure Hazard -** The storage tanks covered in this manual may contain pressures up to 350 psig (24 bar/2,413 kPa). Sudden release of this pressure may cause personal injury by issuing cold gas or liquid, or by expelling parts during servicing. Do not attempt any repairs on these tanks until all pressure is released and the contents have been allowed to vaporize to ensure no pressure buildup can occur.

B. **Extreme Cold** - Cover Eyes and Exposed Skin **-** Accidental contact of the skin or eyes with carbon dioxide may cause a freezing injury similar to frostbite. Protect your eyes and cover your skin when handling the tank or transferring liquid, or in any instance where the possibility of contact with liquid, cold pipes and cold gas may exist. Safety goggles or a face shield should be worn when withdrawing liquid or gas. Long-sleeved clothing and gloves that can be easily removed are recommended for skin protection.

C. **Keep Equipment Well Ventilated** - Although carbon dioxide is non-toxic and non-flammable, it can cause asphyxiation in a confined area without adequate ventilation. An atmosphere of carbon dioxide does not contain enough oxygen for breathing and will cause dizziness, unconsciousness, or even death. Carbon dioxide cannot be detected by the human senses and will be inhaled normally as if it was air. Ensure there is adequate ventilation where carbon dioxide is used and store tanks in a well ventilated area.

D. **Install Relief Valves in Liquid Lines** - When installing piping or extending fill lines, make certain a suitable safety relief valve is installed in each section of piping between shut-off valves. Trapped liquefied gas will expand as it warms and may burst hoses or piping causing property damage or injury.

SECTION 2

SYSTEM COMPONENTS

Table of Contents

SECTION 2

SYSTEM COMPONENTS

2-1 GENERAL

The following section is comprised of the most commonly used components. If a specialty component is required, consult Tomco$_2$ Fire Systems for availability.

2-2 STORAGE TANKS

A. Capacity - 3/4 Ton thru 60 Ton Horizontal Tanks
6, 14, 30 Ton Vertical Tanks

B. All horizontal storage tanks are provided with saddles. Vertical tanks are provided with legs.

C. All pipe connections, except instrumentation, are carbon steel schedule 80 A106 or A53-B seamless, fittings are screw type 2000 lb. forged steel and valves are ball type. Instrumentation lines are copper refrigeration tubing. Flanged discharge outlet is ANSI 300 lb. class.

D. The pressure vessel is insulated with a minimum of 4" (100mm) of urethane foam insulation (classified UL723 maximum flame spread of 25) having a thermal conductivity not greater than 0.03 BTU per square foot of surface area per hour per degree Fahrenheit temperature difference. The insulation is covered with a white aluminum housing. All overlapping seams are sealed with a silicone sealant.

E. All of the storage tanks are equipped with the same basic type of components and controls, and differ only in storage capacity. The components of each tank are listed on drawings TFS-REFRIG-05 and the following pages in this section.

F. The storage tanks consist of a fully insulated pressure vessel protected with an aluminum housing, refrigeration system, relief valve, pressure and liquid level gauges, fill connections and various process connections.

G. The pressure vessel is designed, built and tested to meet code requirements for ASME unfired pressure vessels, Section VIII Division I. All design parameters are stamped on the nameplate. The maximum allowable working pressure is 350 psig. All vessels are hydrostatically tested to 525 psig.

H. The refrigeration system automatically maintains the carbon dioxide at approximately 0º F [-17.8º C] and a corresponding vapor pressure of 300 psig. The system consists of a low temperature, air cooled condensing unit and automatic controls.

I. The hermetic condensing unit consists of a compressor, cooling fan, condensing coils, and receiver tank. The refrigeration coil consists of the patented manifolded U-tube design to greatly increase the efficiency of the system.

J. The refrigeration system is automatically controlled by the pre-wired control panel designed to maintain proper operating pressure. The main control consists of pressure switches to start and stop the refrigeration system and to send a signal to the control panel in case of high or low tank pressure.

2-2.1 Refrigeration System

A. As mentioned in the Introduction, due to the relationship between temperature and pressure, carbon dioxide is most efficiently stored as a liquid at approximately 0º F. This temperature corresponds with an approximate pressure of 300 psig. The tank is designed to maintain carbon dioxide as a liquid at this approximate pressure regardless of outside influences such as ambient temperature, etc. Most of the time in most places, ambient air is warmer than 0º F, therefore the tank will be absorbing heat. To minimize the heat entry, the tank is insulated and to minimize maintenance, the tank is wrapped with pre-painted aluminum housing. Still, there is usually some heat entry. Since liquid carbon dioxide is heavier than carbon dioxide vapor, the liquid accumulates on the bottom of the tank. The space inside the tank between the liquid level and the top of the tank contains carbon dioxide vapor. The job of maintaining a consistent optimum pressure is accomplished by incorporating a refrigeration system that automatically comes on when the pressure reaches 305 psig. The refrigerant is circulated through copper coils inside the vapor space. As in any refrigeration system, the refrigerant is expanded into the coils. Since expansion (evaporation) is a cooling process, the vapor is cooled to the point where it recondenses back to liquid. This process lowers the amount of vapor in the top of the tank, thereby lowering the pressure. When the pressure is lowered to 295 psig the refrigeration shuts off. As the refrigerant cools the vapor it absorbs heat. This heated vapor is returned to the refrigeration compressor where it is compressed back into a liquid ready to begin the cycle again. The heat is removed by a fan circulating air across the condenser coil. The refrigeration system has several major components:

- The expansion valve to regulate the refrigerant flow into the coils in the tank.
- The evaporation coils in the tank.
- The compressor.
- The condenser coil to take the heat back out of the refrigerant.
- The fan motor and fan.
- The automatic controls to operate the preceding system.

B. Occasionally there may be a need to build vapor pressure. If, for example, the ambient temperature is less than -10º F, or if the end use primarily involves removing vapor from the tank, there is available as an option a pressure building system. This system removes liquid carbon dioxide from the tank, heats it by one or more of several methods, (electric heating elements, steam, or water), and returns the heated vapor to the tank. This system is also automatically operated by means of pressure switches.

Note: The above vapor build pressure unit is not approved by FM Approvals.

C. The front panel of the tank contains two gauges, a pressure gauge and a liquid level gauge. These measure the liquid contents of the tank, in pounds/kilograms, and the pressure inside the tank, in pounds-per-square-inch-gauge. Both of the gauges are non-electric and operate without power.

D. The tanks are provided with a series of vapor pressure relief valves that are designed to vent the vapor pressure should the tank be without electrical power to operate the refrigeration system for an extended period of time.

Caution: The expansion valve is factory set and should not be adjusted.

E. The flow of liquid refrigerant to the refrigeration coils is controlled by the expansion valve. This valve is a thermostatic device which maintains a constant pressure under all load conditions.

F. The stored carbon dioxide is cooled to the extent that tank pressure is reduced to 295 psig. At this pressure, the pressure switch opens and the compressor shuts-off. While the compressor is off, the temperature of the refrigerant in the coils will begin to increase to the temperature of the carbon dioxide in the tank. As the temperature increases, the suction pressure of the system increases which holds the expansion valve closed until the compressor starts. After the compressor starts, the expansion valve opens and allows refrigerant stored in the expansion tank to flow into the system to maintain the proper pressure in the system.

G. In summary, the Tomco$_2$ Fire Systems' storage tank is designed to be an efficient, economical, reliable means of storing carbon dioxide with a high degree of safety and a minimum amount of maintenance.

2-2.2 Bleeder Valve

The bleeder valve is set to open at a pressure of 330 psig. When the tank pressure slowly rises, the bleeder valve will open and allow the carbon dioxide vapor to escape from the vessel. If the pressure continues to rise, the bleeder valve will continue to open allowing additional carbon dioxide to escape. If the pressure continues to rise, the main safety relief valve will open.

2-2.3 Main Safety Relief Valve

The pressure vessel is protected from being subject to pressures greater than the maximum allowable working pressure by means of dual ASME approved direct spring loaded or pilot operated safety relief valves, set to open at a pressure of 350 psig. Relief valves are sized for inside installation, which are the more stringent requirements.

2-2.4 Liquid Level Gauge

The 6" liquid level gauge is a differential pressure indicator that measures the height of the liquid inside the tank by measuring the pressure at the top; the net result is a pressure in direct proportion to the height of the liquid. The gauge is graduated in thousands of pounds/kilograms CO_2.

2-2.5 Pressure Gauge

The 6" pressure gauge is calibrated from 0 to 600 psig. Service or replacement of pressure gauge parts should not be attempted. In case of damage or faulty operation of the gauge, the entire gauge should be replaced.

2-2.6 Liquid Fill and Vapor Balancing Valves

The 1 1/2" liquid fill and 1" vapor valves are full port ball valves. Replacement of either valve requires the removal of all pressure from the storage tank. If the valves are removed from the tank, the outlets should be protected to prevent foreign particles from entering the storage tank. Do not remove these valves to extend the fill and balance lines.

2-2.7 Pressure Control

Pressure control is provided to control the starting and stopping of the compressor to maintain tank pressure at between 295 and 305 psig. The compressor will start when tank pressure increases to 305 psig, and stop when tank pressure is lowered to 295 psig.

2-2.8 Pressure Switch

Two pressure switches are provided to activate the control panel when the tank pressure increases above 315 psig or decreases below 250 psig. The pressure switches operate on the principal of responding to changes in pneumatic pressure applied to a bellow. This force is opposed by a main spring. Varying the force on the main spring (by turning the range adjusting screw) allows setting the contacts to trip at the upper pressure setting. Turning the differential adjusting screw varies the force on a secondary spring and allows setting the lower pressure setting, where the contacts reset to their static state.

2-2.9 Supervisory Options

All storage tanks are provided with contacts to monitor:

- High pressure.
- Low pressure.
- Power failure to compressor.

All storage tanks can be provided with optional contacts to monitor:

- Low liquid level.
- High liquid level.

2-3 TANK SHUT-OFF VALVE - 3", 4", 6" & 8"

A. A manually operated butterfly valve located between the dip tube and discharge header is maintained in the open position. Closing this valve takes the system out of service.

B. The valve position should be continuously monitored at the control panel and is equipped with a pad-locking device to lock the valve in the open or closed position. The valve can also serve as a lockout device as required by paragraph 4.5.5 of NFPA 12 (2005).

C. The tank shut-off valve is a high performance butterfly type valve. The valve carries a 300 lb. class ANSI rating. The valve body is carbon steel while the valve stem and disc are 316 stainless steel. The valve seat and packing are Teflon. Special backing materials in the seat compensate for the tendency of Teflon to "cold flow" over a period of time. The valve can be installed in either direction; however, installation with the seat retainer upstream will give longer service life.

D. Each tank shut-off valve is factory tested to be bubble tight at 300 psig.

E. The bolt pattern on the lugged valve body conforms to standard 300 pound class ANSI flange ratings. The design of this valve provides high strength, lightweight and easy operation. The light weight design allows for easy installation while the compact design is particularly advantageous when space is limited

2-3.1 Supervisory Switch

Each tank shut-off valve is equipped with a monitoring switch to provide constant supervision of the position of the valve at the control panel. In addition to the two (2) S.P.D.T. contacts the switch is equipped with a high visibility position monitor that displays the position of the valve.

2-4 MASTER/SELECTOR VALVE ASSEMBLY

A. Tomco$_2$ Fire Systems valves may be used in various locations in the fire suppression system. Therefore, the valve name is derived from the location of the valve within the system. The terms master and selector will be used to describe location of the valve in the system. When a single valve is used to control the discharge into a hazard, it is called a master selector valve. The valve controls the flow of carbon dioxide from the storage unit directly to the hazard. A master valve controls the flow of carbon dioxide to the selector valves. Selector valves control the actual discharge of carbon dioxide to the hazard and are located downstream of the master valve. Master or master selector valves are usually located at the storage unit whereas selector valves are normally located close to the protected hazard. The valves will be only available as a factory assembled unit complete with valve, brackets, couplings, actuator and solenoid assembly with manual override.

B. The function of the master and selector valve is to control the flow and discharge of carbon dioxide. The application for a particular location is described as follows:

C. MASTER VALVE - When the valve is used as a master valve, it is located at the storage unit and controls the flow of carbon dioxide to one or more selector valves. In this position, the valve is constantly under pressure. It can also control the flow of carbon dioxide from the storage tank directly to the hazard.

D. SELECTOR VALVE – The valve is located near the hazard area and controls the flow of carbon dioxide into a specific hazard. When the master valve is opened, it will permit carbon dioxide to flow through the system up to the selector valve. Selector valves can also be located on the main header to serve different hazards. Each selector valve remains closed until actuated by its associated control function.

E. The master and selector valves are of the same design, regardless of its use in the system. The valves consist of full port ball valves in 1/2" thru 2" and butterfly valves in 3" thru 8". The valve actuators are of the "fail-safe" design whereby loss of actuation pressure will not cause the valves to open. Upon activation of the solenoid the pneumatic actuators will be pressurized causing the valves to open.

Warning: The selector valves shall be installed in an easily accessible location to allow operation of the emergency mechanical operator. The valves shall not be exposed to the protected area.

2-4.1 Master/Selector Valves - 1/2" Thru 2"

A. Electro/Pneumatic operated valves in the 1/2"; 3/4", 1", 1 1/4", 1 1/2" and 2" sizes are of the full port ball valve type. Each valve is equipped with a spring return, pneumatic actuator designed to function with CO_2 pressure.

B. The valve body is carbon steel while the valve stem and ball are 316 stainless steel. The valves are rated to a working pressure of 2,200 WOG. Each valve is factory tested and shown to be leak proof and bubble tight at 300 psig.

2-4.2 Master/Selector Valves - 3" Thru 8"

A. Electro/Pneumatic operated valves in the 3"; 4", 6" and 8" sizes are wafer type butterfly valves. Each valve is equipped with a spring return, electro/pneumatic actuator. The valves are designed to be bolted between two 300 pound class ANSI flanges with appropriate gasketing. These valves can be easily installed without the need for costly rigging equipment.

B. The valves carry a 300 pound class ANSI rating. Each valve is factory tested to be bubble tight at 300 psig. The valve body is carbon steel while the valve stem and disc are 316 stainless steel. The valve seat and packing are Teflon. The valve seat contains a special backing material to compensate for any tendency of the Teflon to "cold flow" over a period of time. The stem seals are reinforced to compensate for seal wear.

C. All of the Tomco$_2$ Fire Systems pressure operated master and selector valves are capable of being manually operated. By means of the override on the solenoid, the discharge valves may still be operated even if control power to the system is lost.

2-4.3 Pneumatic Actuators

2-4.3.1 Introduction

A. The actuators are rack and pinion, opposed piston actuators and spring return.

B. The actuators are equipped with unique, lubricated acetal piston guides and rings that have a very low coefficient of friction and absorb the side thrusts of the pistons.

C. All actuators have permanently lubricated, factory packed bearings and guides. No further lubrication is necessary under normal operating conditions. All seals are permanently lubricated buna-A o-rings.

2-4.3.2 Description

A. The actuator is housed in an anodized extruded aluminum alloy housing with polyester coated end caps. It is pressure operated in one direction, which compresses the spring. Upon venting the actuator the spring returns the shaft to the "closed" position. This provides a fail-safe operation in case of loss of pneumatic line pressure. The standard spring units are designed for 80 psig service, and should not be subjected to pressures above 120 psig.

B. The travel stops are factory set and should not be field adjusted. Adjustment of the stops will cause the valve not to seat properly.

2-4.4 Solenoid Valve

A. The solenoid valve is a direct-mounted 24 vdc, normally closed, 3 way valve. When the solenoid is energized, pneumatic pressure is directed through the valve body, directly into the pneumatic actuator to open the master/selector valve. After the solenoid is de-energized, the solenoid valve exhausts the pressure in the pneumatic actuator and closes the appropriate valve. Each solenoid has a mechanical manual override located on the solenoid valve block. In the event of electrical failure, the solenoid is overridden by rotating the manual actuator to divert pneumatic pressure to the actuator.

B. A solenoid valve is a combination of two basic functional units:

1. A solenoid (electro-magnet) with its core.

2. A valve body containing one or more orifices.

C. Standard solenoid valves have an IP65 DIN rating. Solenoid is rated at 3.0 watts.

2-4.5 In-Line Filter

An in-line filter is provided on each master or selector valve in the pneumatic actuation line before the solenoid. The filter cartridge should be checked semi-annually and replaced as necessary.

2-5 LOCK-OUT VALVE ASSEMBLY

A manually operated valve located in various locations within the fire suppression system. The valve is used to prevent accidental or deliberate discharge when persons not familiar with the system are present in the protected space. The valve shall be maintained in the open position. Closing this valve takes the system out of service. The valve position should be continuously monitored at the control panel and is equipped with a pad-locking device to lock the valve in the open or closed position.

2-5.1 Lock-Out Valves - 1/2" Thru 2"

A. Manually operated valves in the ½”, ¾”, 1", 1 ¼”, 1 ½” and 2" sizes are of the full port ball valve type. Each valve is equipped with a pad locking type handle and is normally maintained in the fully open position.

B. The valve body is carbon steel while the valve stem and ball are 316 stainless steel. The valves are rated to a working pressure of 2,200 WOG. Each valve is factory tested and shown to be leak proof and bubble tight at 300 psig.

2-5.2 Lock-Out Valves - 3" Thru 8"

A. The design of the 3", 4", 6" and 8" butterfly valves are similar to that of the master/selector valve body. Each valve is equipped with a manual actuator and is normally maintained in the fully open position. The valves are designed to be bolted between two 300 pound class ANSI flanges with appropriate gasketing.

B. The valves carry a 300 pound class ANSI rating. Each valve is factory tested to be bubble tight at 300 psig. The valve body is carbon steel while the valve stem and disc are 316 stainless steel. The valve seat and packing are Teflon. The valve seat contains a special backing material to compensate for any tendency of the Teflon to "cold flow" over a period of time. The stem seals are reinforced to compensate for seal wear. The valve can be installed in either direction.

2-5.3 Supervisory Switch

Each lock-out valve is equipped with a monitoring switch to provide constant supervision of the position of the valve at the control panel. In addition to the two (2) S.P.D.T. contacts the switch is equipped with a high visibility position monitor that displays the position of the valve.

2-6 ACTUATION LINE SUPERVISORY SWITCH

A two level, self-restoring pressure switch shall be installed in the pneumatic actuation piping at the most remote point in the system. The first set of contacts will cause annunciation upon loss of pneumatic pressure below 80 psig. If the pressure continues to drop to 70 psig, a second set of contacts will close.

2-7 PRESSURE REGULATOR

The pressure regulator is a fully automatic pressure regulating valve. The regulator is installed in the pneumatic actuation line to maintain 100 psig operating pressure for the pneumatic actuated system valves. The regulator should be installed in the vapor process supply line at the storage unit.

2-8 PRESSURE RELIEF VALVES

There are two (2) styles of pressure relief valves that will be provided with the system. A 120 psig pressure relief shall be installed in the actuation line at any point between the regulator and the supervisory pressure switch. A 450 psig pressure relief valve shall be installed within the system piping network where trapped CO_2 pressure could exist. The pressure relief valves are equipped with a “U” tube assembly to prevent blockage of the relief port.

2-9 BYPASS CHECK VALVE

The bypass check valve is used in the bypass line around the master valve to allow the system pressure on the downstream side of the master valve to bleed back to the storage unit. A FM approved check valve shall be provided.

2-10 DISCHARGE NOZZLES

2-10.1 General

A. Nozzle sizes and orifice codes for each system are determined by the hydraulic calculations. The nozzles conform to the spacing requirements and height limitations set forth in the system design section of this manual.

B. Nozzles have been optimized to discharge the carbon dioxide in the most efficient manner to provide protection for any hazard. There are (3) basic types of discharge nozzles used in the design of Tomco$_2$ Fire Systems': radial, cone and orifice.

2-10.2 Radial Nozzle

Limited to use on total flood systems. Refer to System Design section for spacing and limitations. Radial nozzles are available in sizes 1/2", 3/4", 1", 1 1/4", 1 1/2" and 2".

2-10.3 Cone Nozzle

Cone nozzles can be used in total flood or local application systems. Cone nozzles are used in total flood systems where a "cushioned" discharge is required. Spacing of the cone nozzles should be in accordance with radial nozzle coverage limitations when used on total flood systems. There are three sizes of cone nozzles, (4", 5 1/2", 7") that can be used for local application systems. Area of coverage and height above hazard determines the flow rates which are shown on the nozzle charts in the nozzle section of the design manual.

2-10.4 Orifice Nozzle

Orifice nozzles are limited to total flood applications in ductwork, small enclosures, and covered trenches. Spacing is normally 10 to 20 feet depending on the configuration of the hazard.

2-10.5 Specialty Nozzles

Specialty nozzles have not been tested by FM Approvals. Special application nozzles such as linear nozzles, screening nozzles or special projection nozzles are only available when the traditional radial or cone nozzles cannot be used. Consult factory for details.

2-11 WARNING SIGNS

A. Appropriate warning signs shall be affixed outside of those spaces where concentrations of carbon dioxide gas can accumulate, not only in protected spaces but in adjacent areas where the carbon dioxide could migrate.

B. Appropriate warning signs shall be placed at every location where manual operation of the system may occur.

C. In any use of carbon dioxide, consideration shall be given to the possibility that personnel could be trapped in or enter into an atmosphere made hazardous by a carbon dioxide discharge. Suitable safeguards shall be provided to ensure prompt evacuation to prevent entry into such atmospheres and provide means for prompt rescue of any trapped personnel. Personnel training shall be provided.

D. All persons that may at any time enter a space protected by carbon dioxide shall be warned of the hazards involved and provided with safe evacuation procedures.

2-12 PNEUMATIC TIME DELAY

The time delay is a pneumatically operated assembly of a pressure gauge, supervisory pressure switch, two timers, 24vdc solenoid, mechanical override, cabinet operated pressure switch and all interconnection tubing mounted in a NEMA 12, NEMA 4 or NEMA 4X enclosure.

Note: FM Approvals has not verified the NEMA rating of the enclosure.

A.

B. The time delay cabinet uses CO_2 vapor pressure at 100 psig from the storage unit as its source of power. Whether the cabinet is operated electrically from the 24vdc solenoid or mechanically from the emergency mechanical release station, the following functions will occur:

1. Delay discharge for a pre-determined time period. (0 - 60 seconds)

2. Provide pressure to operate a pneumatically operated siren in the affected area, by-passing all time delays.

3. Provide pneumatic pressure to open the appropriate master/selector valve for a pre-determined time, then close and vent the pneumatic pressure allowing the valve to close.

C. The standard pre-discharge timer can be adjusted to provide between 3 to 60 seconds of discharge delay and the standard discharge timer can be adjusted to provide from 18 seconds to 100 minutes of discharge time. Optional discharge timers are available for extended discharge applications.

D. The actuation line from the timer cabinet up to and including the actuator is supervised at 10 psig. Upon loss of the supervisory pressure, a pressure switch is provided to signal the main control system. This circuit is also provided with a 15 psig pressure relief valve to prevent over pressurization of the line in case the pressure regulator fails.

2-12.1 Cabinet Operated Pressure Switch

The discharge pressure switch is used to signal the control panel which in-turn can be used to shut down equipment such as air handling equipment, pumps, etc. which might interfere with the efficiency of the CO_2 discharge. It can also be used to actuate audible and visual annunciation devices.

2-12.2 Emergency Mechanical Override

The Emergency mechanical override is a manually operated 3-way push-button. The push-button is located on the side of the timer cabinet and is held in the non-operated position by a pull pin. The button when pushed, will allow system pressure to pass through and start the time delay and immediately sound a siren located in the hazard area. The button must be manually "pulled out" to reset the system.

2-12.3 Pneumatic Dial Timers

A. The pneumatic time delay cabinet is provided with two pneumatic dial timers. One timer is provided for the discharge delay and is adjustable from 3 - 60 seconds. The other timer is the "soak" timer and will control the discharge time of the master/selector valves and will be available in (2) models having timing ranges of; 3 - 100 seconds, and 18 seconds - 100 minutes. Both timers will be provided with clear plastic covers to allow viewing of the black set time arrow and the red arrow showing the time remaining in the cycle. The timers will be factory set and located behind the cabinet door to prevent tampering.

B. The time delay between the initial application of pressure to the timers and the switching of the output is controlled by a constant speed air motor and reduction gearing, independent of operating pressure. The timers are re-set by venting the pressure.

2-12.4 Pressure Operated Siren

A siren is used to provide an audible alarm during the pre-discharge period of system actuation. A FM approved siren shall be provided.

2-12.5 Pneumatic Actuation Line Supervisory Switch (10 Psig)

A self restoring supervisory pressure switch is provided per NFPA 12 in the timer cabinet. The contact shall cause annunciation upon loss of pneumatic pressure between the timer cabinet and the master/selector valve.

2-12.6 Pressure Regulator (10 Psig)

A 10 psig pressure regulator is installed on the supervisory side of the pneumatic actuation line to maintain supervisory pressure between the timer cabinet and the pneumatic actuated master/selector valves.

2-12.7 Pressure Relief Valve (15 Psig)

A 15 psig pressure relief valve is installed in the actuation line just down stream of the regulator and the supervisory pressure switch, to prevent over pressurization in case of regulator failure.

2-12.8 In-Line Filter

Each timer control cabinet is provided with an in-line filter in the pneumatic actuation line at the inlet to the timer control cabinet. The filter should be checked semi-annually and replaced as required.

Storage Tanks

The low pressure storage tank consists of a pressure vessel, insulation, refrigeration unit, instrumentation, fill connections, instrumentation connections and a flanged outlet to withdraw carbon dioxide at a high rate of flow. Storage tanks are available in sizes ranging from 3/4 ton thru 60 ton.

All storage tanks are listed by FM Approvals for a temperature range of –10° F (-23° C) thru 120° F (49.9° C).

The storage tanks are equipped with contacts to monitor:
- High pressure (above 315 psig [2173 kPa])
- Low pressure (below 250 psig [1724 kPa])
- Power failure to compressor

Storage tanks can be provided with optional contacts to monitor:
- Low liquid level
- High liquid level

Specifications:

Pressure Vessel
- Designed, built and tested according to ASME (American Society of Mechanical Engineers) Boiler & Pressure Vessel Code, Section VIII, Division 1, Pressure Vessels
- Material: SA-612 normalized carbon steel
- MAWP (Maximum Allowable Working Pressure): 350 psig (2414 kPa)
- MDMT (Minimum Designed Metal Temperature): -40° F (-40° C)

Insulation
- 4” (101.6) Polyurethane with 0.063” (1.6) aluminum outer jacket

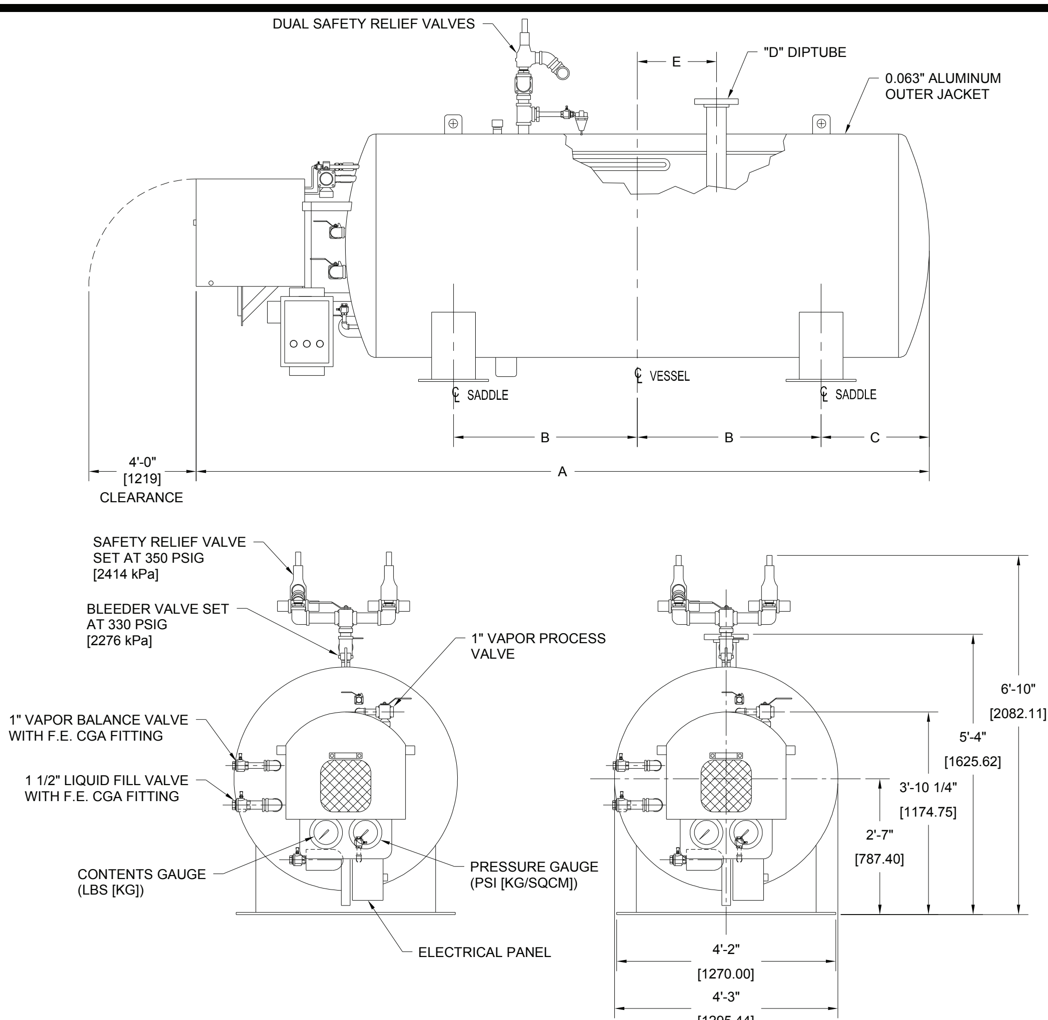
Piping
- Schedule 80 seamless pipe, 2000 lb. forged steel fittings, ball type valves

Safeties
- Dual ASME approved direct spring loaded or pilot operated, sized for indoor installation

Refrigeration
- Low-Temp air cooled condensing units
- Environmentally safe R-404A refrigerant standard
- Most electrical requirements available

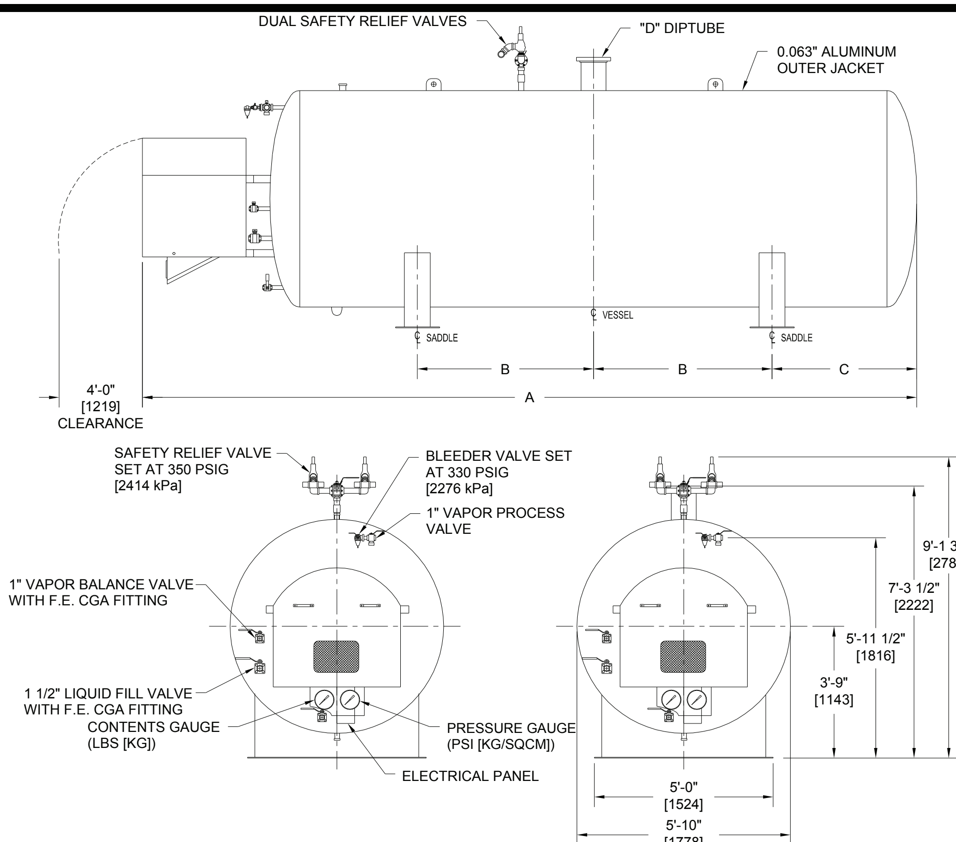
Instrumentation
- Liquid Level Gauge: Differential pressure indicator type with 6” (152.4) dial
- Pressure Gauge: 0-600 psig (0-42.2 Kg/cm^2) with 6” (152.4) dial
- Audible and visual high/low pressure alarm

Storage Tanks



Size (Tons)	Part Number	A	B	C	D	E	Weight Empty
3/4	990460	7'-11" (2413)	6 7/8" (175)	1'-5 1/4" (438)	3" (76)	0" (0)	1,200 lbs 544 kg
1 1/2	990461	4'-8" (1422)	1'-4" (406)	2'-0" (610)	3" (76)	4" (102)	3,500 lbs 1,588 kg
2	990462	12'-8 1/2" * (3874)	2'-1 1/2" (648)	2'-1" (635)	3" (76)	6 1/2" (165)	3,500 lbs 1,588 kg
2 3/4	990463	14'-4 1/2" * (4382)	3'-6" (991)	2'-1 1/2" (648)	3" (76)	0" (0)	4,000 lbs 1,814 kg

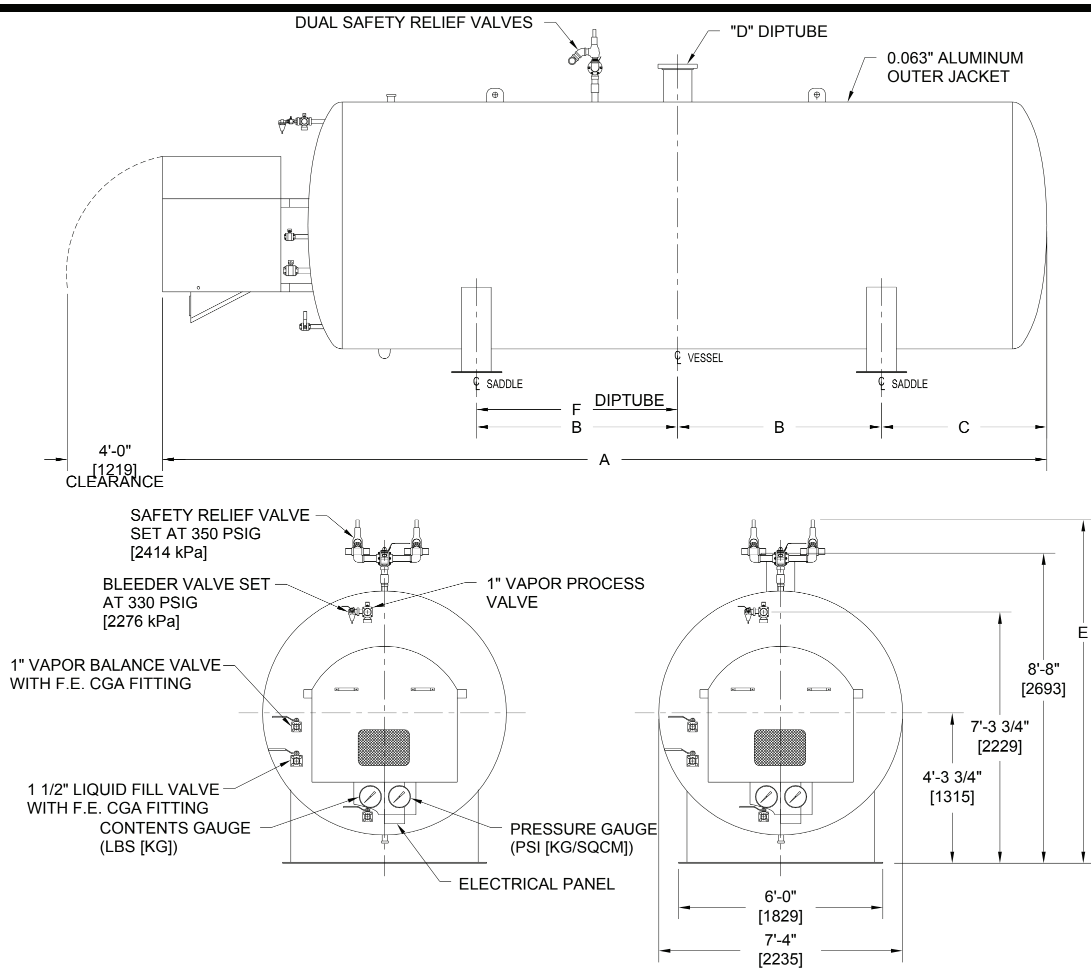
* add 9" [229] for optional 3 phase refrigeration unit



Size (Tons)	Part Number	A	B	C	D	Weight Empty
3 3/4	990464	11’-10” * (3607)	1’-7 3/4” (502)	2’-4 1/2” (724)	4” (102)	7,500 lbs 3,402 kg
4	990465	12’-5 1/2” * (3797)	1’-11 1/2” (597)	2’-5 1/2” (749)	4” (102)	7,730 lbs 4.1 kg
6	990466	15’-6” * (4724)	2’-8” (813)	3’-5” (1041)	6” (152)	9,000 lbs 3,359 kg
8	990467	19’-9” * (6020)	4’-5” (1346)	3’-5” (1041)	6” (152)	10,200 lbs 4,627 kg
10	990468	23’-4” * (7112)	6’-2 1/2” (1892)	3’-5” (1041)	8” (203)	11,500 lbs 5,216 kg
12	990469	26’-5” (8052)	7’-9” (2362)	3’-5” (1041)	8” (203)	12,650 lbs 5,738 kg

* add 9” [229] for optional 3 phase refrigeration unit

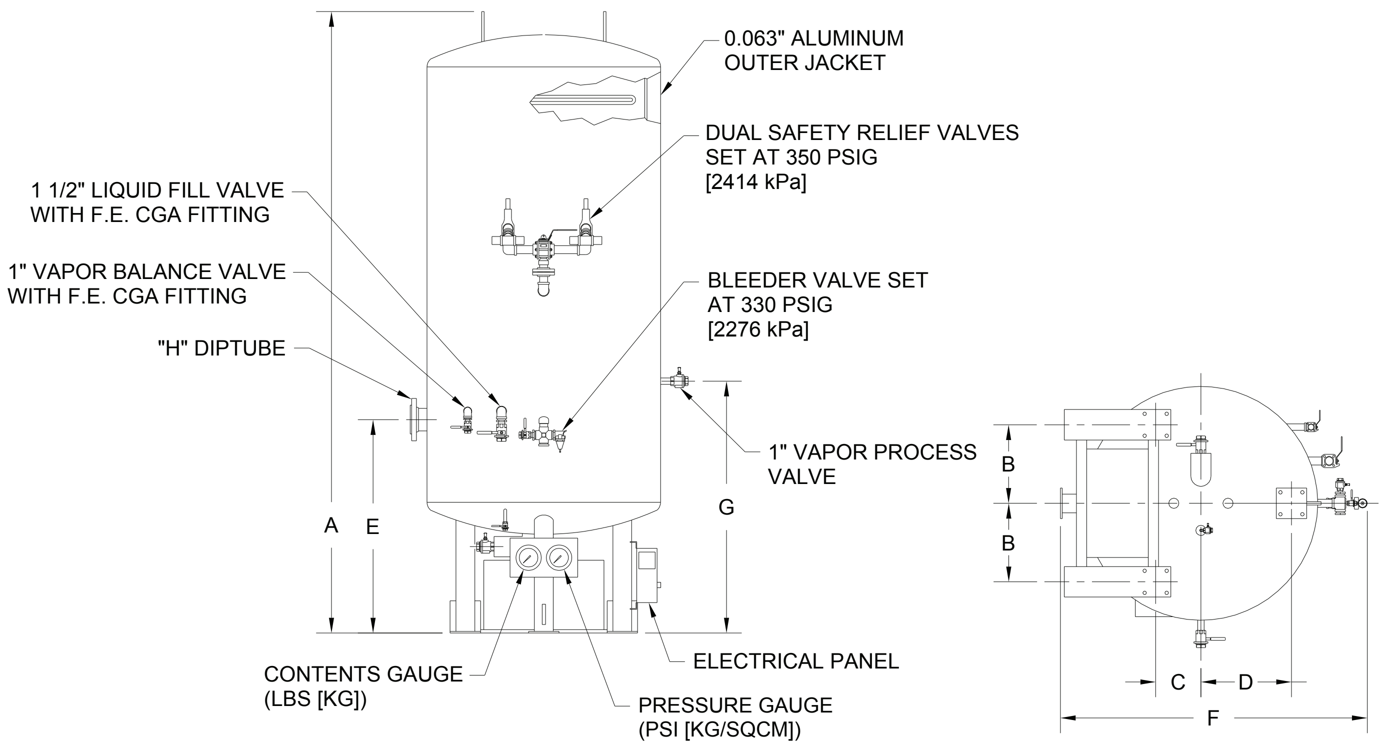
Storage Tanks



Size (Tons)	Part Number	A	B	C	D	E	F	Weight Empty
14	990469	19’-6” (5944)	3’-8” (1118)	4’-6” (1372)	8” (203)	10’-5 1/2” (3188)	3’-8” (1118)	14,000 lbs 6,350 kg
18	990470	25’-0” (7620)	5’-0” (1524)	5’-3” (1600)	8” (203)	10’-5 1/2” (3188)	7’-0” (2134)	16,800 lbs 4.1 kg
22	990471	27’-4” (8331)	7’-0” (2134)	4’-4” (1321)	8” (203)	10’-5 1/2” (3188)	7’-0” (2134)	19,000 lbs 8,618 kg
26	990472	33’-0” (10058)	9’-0” (2743)	5’-3” (1600)	8” (203)	10’-5 1/2” (3188)	9’-0” (2743)	23,500 lbs 10,660 kg
30	990473	37’-0” (11278)	11’-0” (3353)	5’-3” (1600)	8” (203)	11’-3 5/8” (3445)	11’-0” (3353)	26,500 lbs 12,020 kg

TOMCO$_2$ FIRE SYSTEMS

Storage Tanks



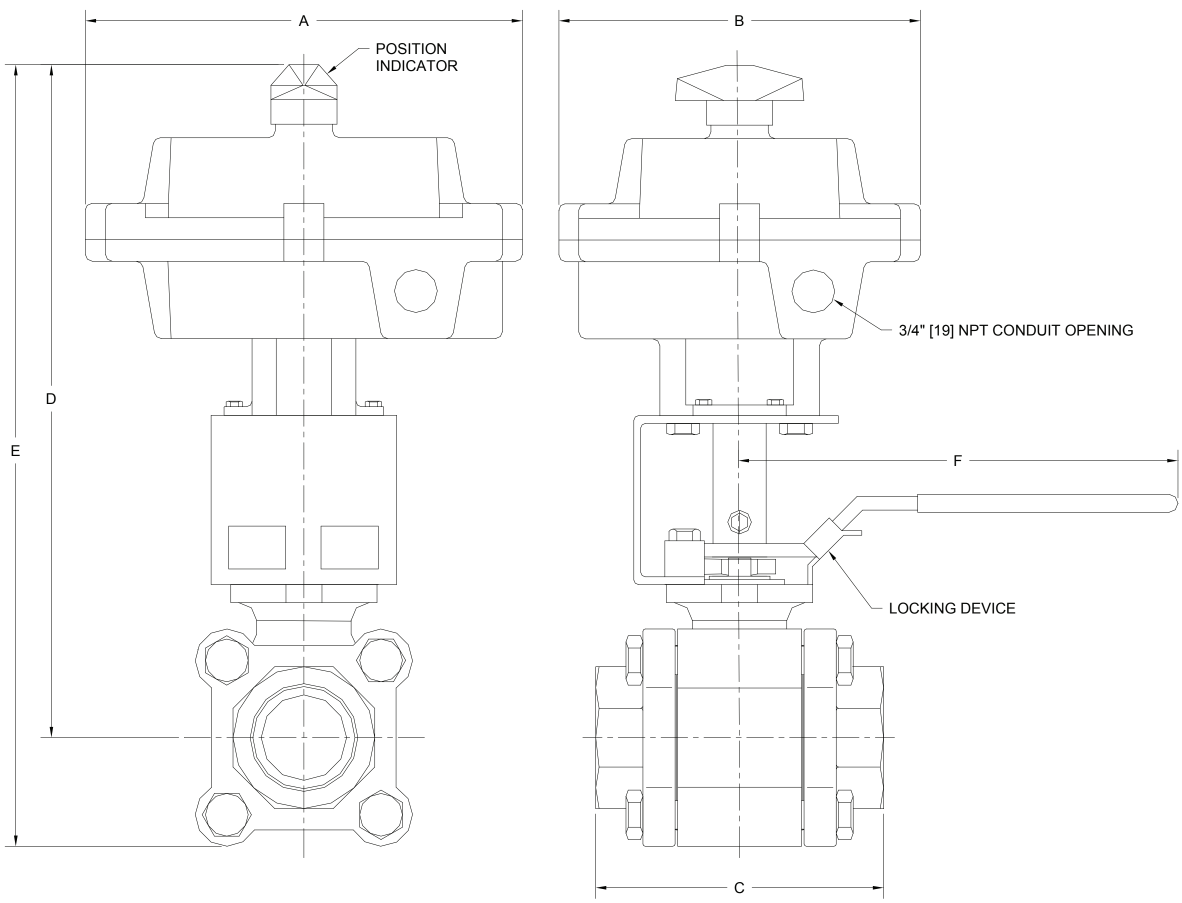
Size (Tons)	Part Number	A	B	C	D	E	F	G	H	Weight Empty
6	990480	15’-3” (4648)	23 3/16” (589)	13 3/8” (340)	26 3/4” (680)	5’-3” (1600)	7’-5 1/2” (2273)	6’-2 3/8” (1889)	6” (152)	10,000 lbs 4,536 kg
14	990481	19’-8 1/2” (6007)	28 9/16” (726)	16 1/2” (419)	33” (838)	6’-0” (1829)	9’-11” (3023)	6’-6 1/2” 1994	8” (203)	15,500 lbs 7,031 kg
30	990483	37’-5” (11405)	28 9/16” (726)	16 1/2” (419)	33” (838)	6’-0” (1829)	8’-9 (2667)	6’-8 1/2” (2045)	8” (203)	15.5 lbs 7.1 kg

1/2” - 2” Lock-out Valve

The lock-out valve is a manually operated valve used to inhibit the discharge of CO_2 into an entire system or specific area of a system. The valves are rated to a working pressure of 2,200psi WOG. The valve is equipped with a supervisory switch for remote monitoring and a locking device to pad lock the valve in the open or closed position.

Material:		Switch Rating:	
Body:	Carbon Steel	Housing:	NEMA 4
Ball/Stem:	Stainless Steel	Contacts:	10a 24vDc/120vac/250vac
Seats:	RTFE	Approval:	FM Approvals

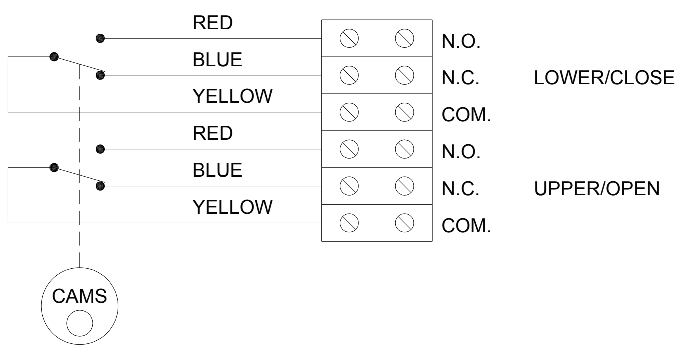
FM Approvals has not verified the NEMA rating of the housing.



Refer to next page for dimensional information

1/2" - 2" Lock-out Valve

Size	Part Number	A	B	C	D	E	F	Weight
1/2"	990920	7 5/8" (194)	6 3/8" (162)	3" (76)	10 1/2" (267)	11 5/8" (296)	6 1/2" (165)	5.5 lbs 2.5 kg
3/4"	990921	7 5/8" (194)	6 3/8" (162)	3 3/8" (86)	10 3/4" (273)	11 15/16" (303)	6 1/2" (165)	7 lbs 3.2 kg
1"	990922	7 5/8" (194)	6 3/8" (162)	4" (102)	11 1/4" (286)	12 11/16" (322)	9 7/8" (251)	8.5 lbs 3.9 kg
1 1/4"	990923	7 5/8" (194)	6 3/8" (162)	4 3/8" (111)	11 7/16" (291)	13 3/16" (335)	9 7/8" (251)	11 lbs 5 kg
1 1/2"	990924	7 5/8" (194)	6 3/8" (162)	5" (127)	11 3/4" (299)	13 5/8" (346)	10 7/16" (265)	14 lbs 6.4 kg
2"	990925	7 5/8" (194)	6 3/8" (162)	5 3/4" (146)	12 1/8" (308)	14 9/16" (370)	10 7/16" (265)	21 lbs 9.5 kg



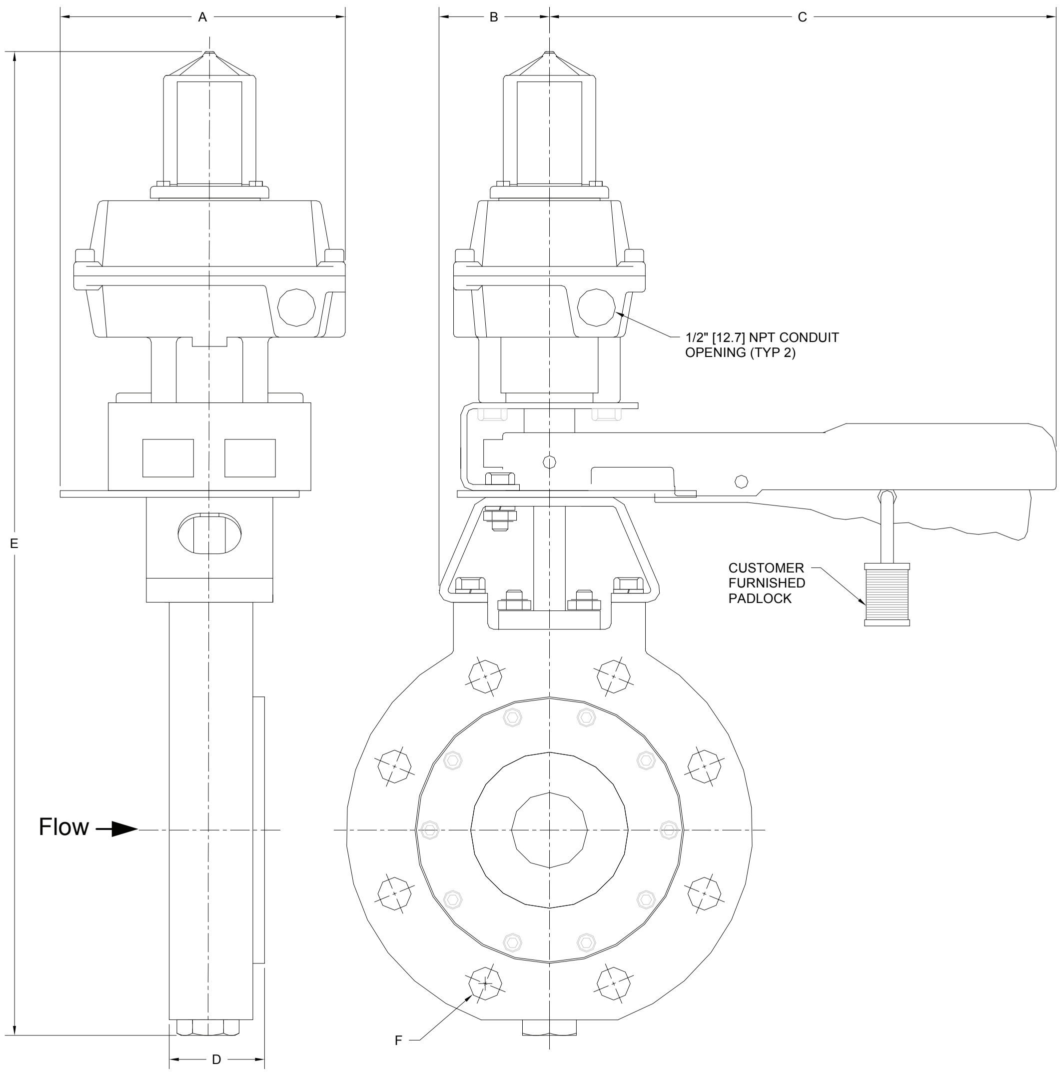
Switch Configuration

3" - 6" Tank Shut-off / Lock-out Valve

The lock-out valve is a manually operated valve used to inhibit the discharge of CO_2 into an entire system or specific area of a system. The valves are rated to a working pressure of 750psi WOG. The valve is equipped with a supervisory switch for remote monitoring and a locking device to pad lock the valve in the open or closed position.

Material:		Switch Rating:	
Body:	Carbon Steel	Housing:	NEMA 4
Disc/Stem:	Stainless Steel	Contacts:	10a 24vDc/120vac/250vac
Seats:	RTFE	Approval:	FM Approvals

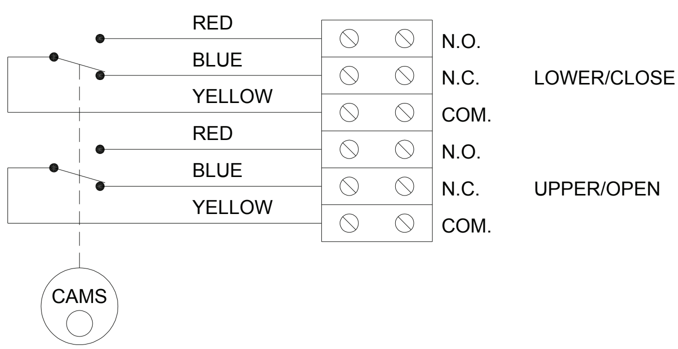
FM Approvals has not verified the NEMA rating of the housing.



Refer to next page for dimensional information

3” - 6” Tank Shut-off / Lock-out Valve

Size	Part Number	A	B	C	D	E	F	Weight
3”	990926	5 5/8” (143)	2 3/16” (56)	10” (254)	1 7/8” (48)	19 5/8” (498)	3/4”-10	22 lbs 10 kg
4”	990927	5 5/8” (143)	2 3/16” (56)	10” (254)	2 1/16” (53)	21” (536)	3/4”-10	31 lbs 14.1 kg
6”	990928	7 5/8” (194)	6 3/8” (162)	15” (381)	2 7/16” (62)	23 7/8” (605)	3/4”-10	66 lbs 30 kg



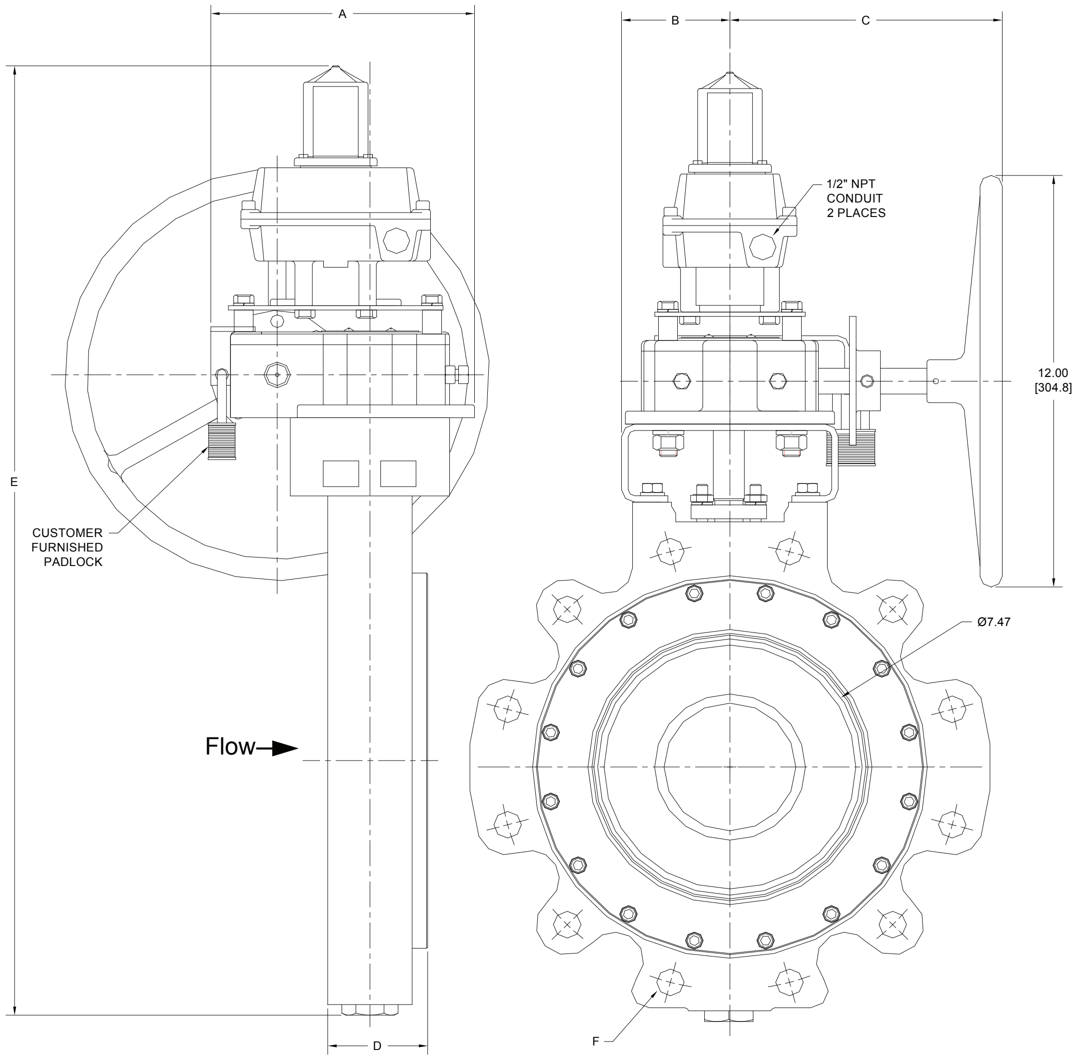
Switch Configuration

8" Tank Shut-off / Lock-out Valve

The lock-out valve is a manually operated valve used to inhibit the discharge of CO_2 into an entire system or specific area of a system. The valves are rated to a working pressure of 750psi WOG. The valve is equipped with a supervisory switch for remote monitoring and a locking device to pad lock the valve in the open or closed position.

Material:		Switch Rating:	
Body:	Carbon Steel	Housing:	NEMA 4
Disc/Stem:	Stainless Steel	Contacts:	10a 24vDc/120vac/250vac
Seats:	RTFE	Approval:	FM Approvals

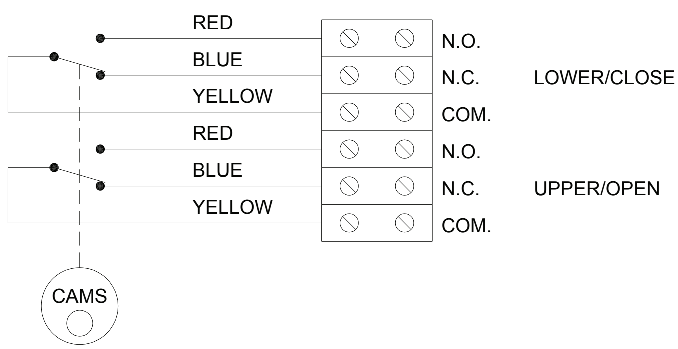
FM Approvals has not verified the NEMA rating of the housing.



Refer to next page for dimensional information

8” Tank Shut-off / Lock-out Valve

Size	Part Number	A	B	C	D	E	F	Weight
8”	990929	7 7/16” (189)	3 1/16” (78)	7 3/4” (196)	2 5/8” (67)	27 5/8” (703)	7/8”-9	108 lbs 49 kg



Switch Configuration

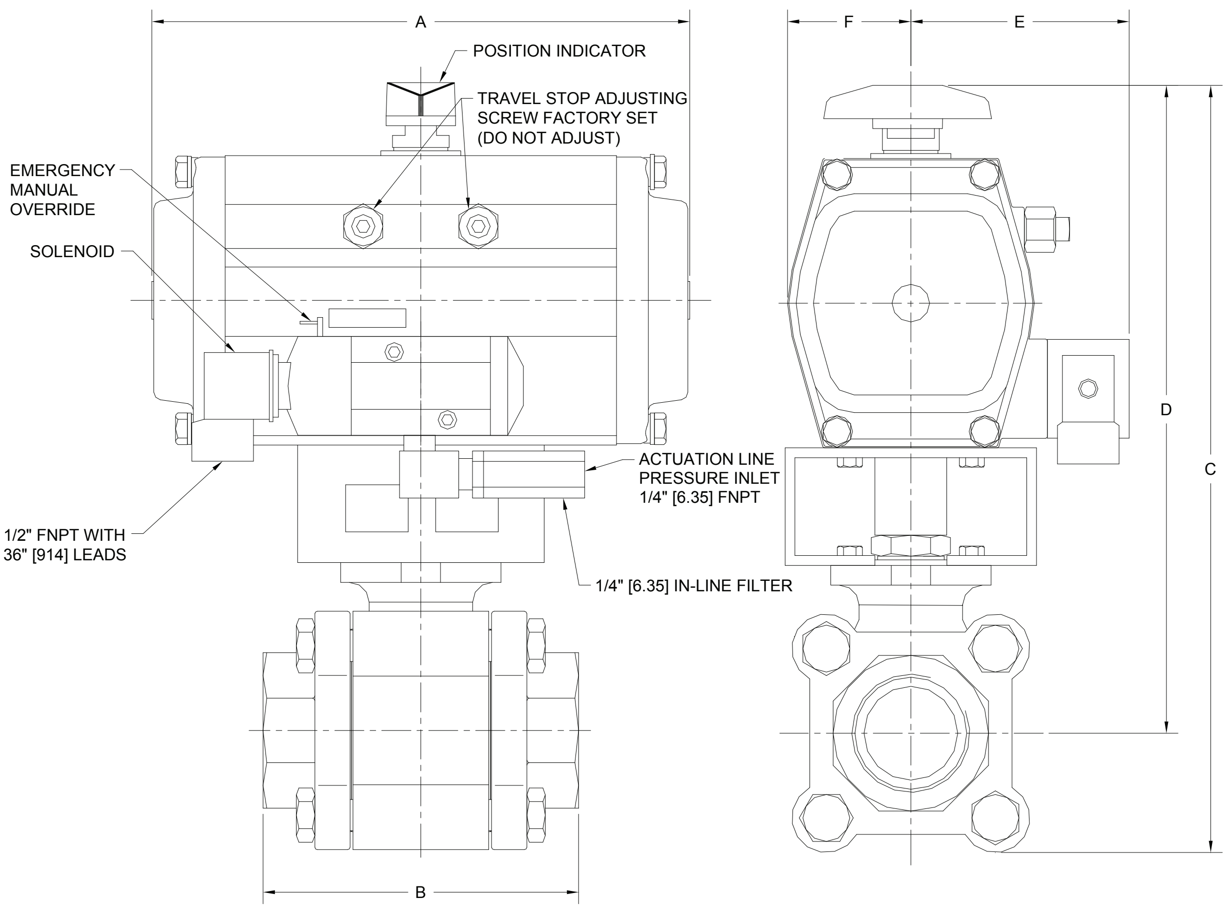
1/2" - 2" Master Selector Valve With Solenoid

The master / selector valves are electro pneumatic operated valves of the full port ball valve type. The valve is equipped with a spring return pneumatic actuator designed to operate with CO_2 pressure. The valves are rated to a working pressure of 2,200psi WOG. The pneumatic actuators are designed to operate at 100psi with a maximum working pressure of 120psi and a minimum working pressure of 80psi. The solenoid valve is a 3-way valve. When the solenoid is energized, pneumatic pressure is directed through the valve body, directly into the pneumatic actuator to open the master / selector valve. After the solenoid is de-energized, the solenoid valve exhausts the pressure in the pneumatic actuator and the master / selector valve closes.

Material:

Body:	Carbon Steel
Ball/Stem:	Stainless Steel
Seats:	RTFE
Actuator:	Aluminum

Solenoid:	IP65
	0.3a at 24vDc
Approval:	FM Approvals



Refer to next page for dimensional information

1/2" - 2" Master Selector Valve With Solenoid

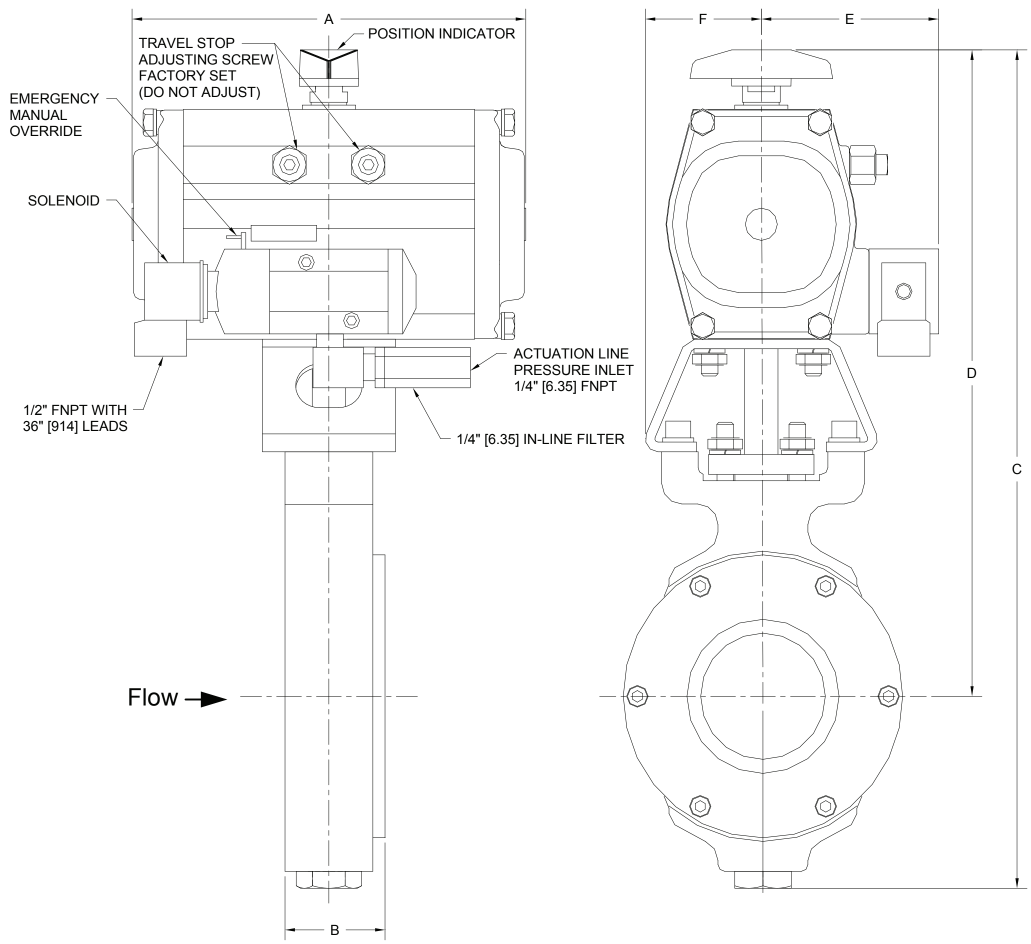
Size	Part Number	A	B	C	D	E	F	Weight
1/2"	990900	6 1/2" (165)	3" (76.2)	8 5/8" (219)	7 1/2" (190.5)	3" (76.2)	1 3/8" (34.9)	7.5 lbs 3.4 kg
3/4"	990901	6 1/2" (165)	3 3/8" (85.7)	9" (228.6)	7 3/4" (196.9)	3" (76.2)	1 3/8" (34.9)	9 lbs 4.1 kg
1"	990902	7 1/2" (190.5)	4" (101.6)	10 7/8" (276.2)	9 7/16" (239.7)	3 3/8" (85.7)	1 3/4" (44.5)	15.5 lbs 7.1 kg
1 1/4"	990903	7 7/16" (188.9)	4 3/8" (111.1)	11 3/8" (288.9)	9 5/8" (245.4)	3 3/8" (85.7)	1 3/4" (44.5)	18 lbs 8.2 kg
1 1/2"	990904	8 5/8" (219)	5" (127)	12 1/4" (311.2)	10 3/8" (263.5)	3 1/2" (88.9)	2" (50.8)	25.5 lbs 11.4 kg
2"	990905	12" (304.8)	5 3/4" (146)	14 5/8" (371.5)	12 1/4" (311.2)	3 7/8" (98.4)	2 3/8" (60.3)	41 lbs 18.6 kg

3" - 8" Master Selector Valve With Solenoid

The master / selector valves are electro pneumatic operated valves of the butterfly valve type. The valve is equipped with a spring return pneumatic actuator designed to operate with CO_2 pressure. The valves are rated to a working pressure of 750psi WOG. The pneumatic actuators are designed to operate at 100psi with a maximum working pressure of 120psi and a minimum working pressure of 80psi. The solenoid valve is a 3-way type. When the solenoid is energized, pneumatic pressure is directed through the valve body, directly into the pneumatic actuator to open the master / selector valve. After the solenoid is de-energized, the solenoid valve exhausts the pressure in the pneumatic actuator and the master / selector valve closes.

Material:

Body:	Carbon Steel	Solenoid:	IP65
Disc/stem:	Stainless Steel		0.3 a @ 24vDc
Seats:	RTFE	Approval:	FM Approvals
Actuator:	Aluminum		



Refer to next page for dimensional information

3" - 8" Master Selector Valve With Solenoid

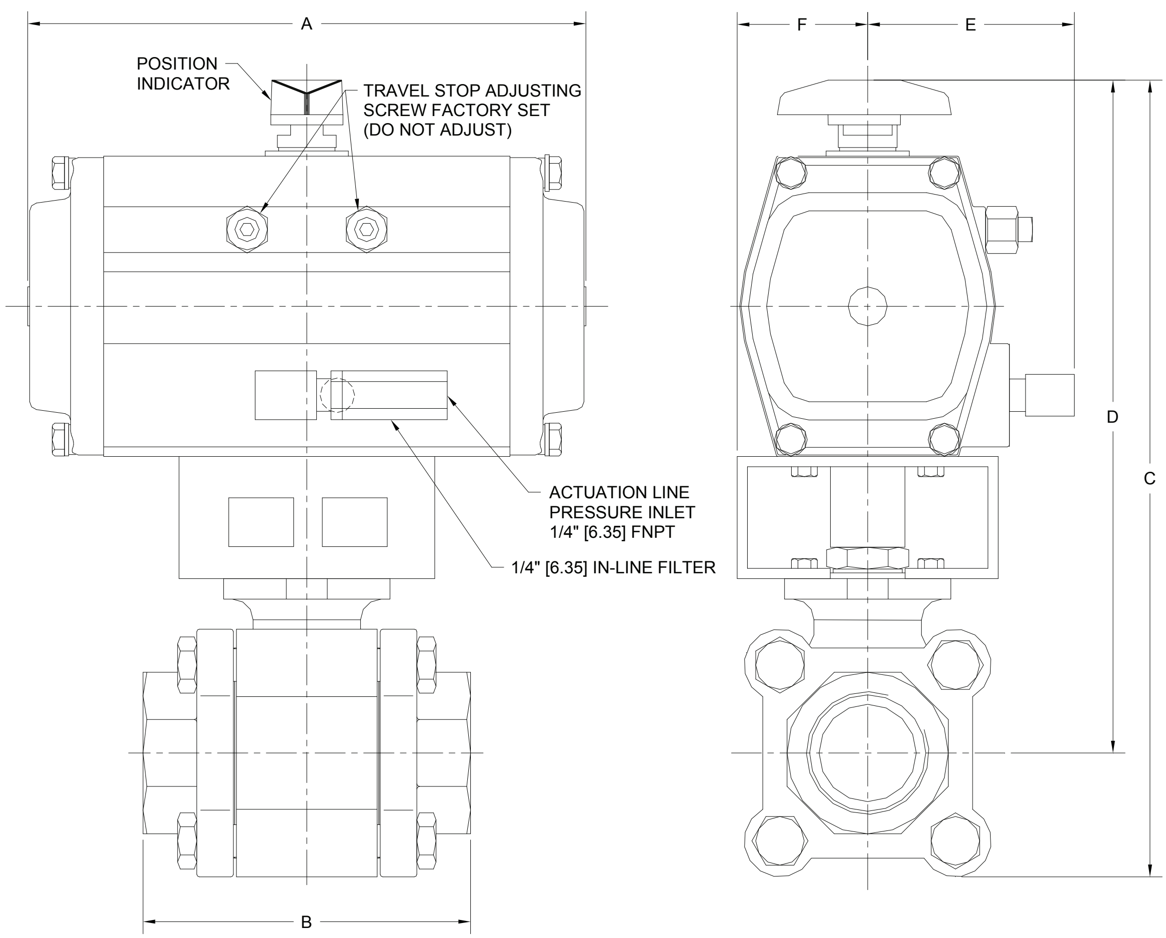
Size	Part Number	A	B	C	D	E	F	Weight
3"	990906	7 7/16" (188)	1 7/8" (48)	15 9/16" (395)	12" (305)	3 5/16" (85)	2 3/16" (55)	25 lbs (11.4 kg)
4"	990907	7 7/16" (188)	2" (50)	17 9/16" (446)	12 7/8" (327)	3 5/16" (85)	2 3/16" (55)	30 lbs (13.6 kg)
6"	990908	11 7/8" (302)	2 7/16" (62)	22 1/4" (567)	16" (407)	3 13/16" (98)	2 9/16" (65)	58 lbs (26.3 kg)
8"	990909	15 9/16" (395)	2 13/16" (72)	26 15/16" (684)	19 3/8" (492)	4 3/4" (121)	3 7/16" (87)	110 lbs (49.9 kg)

1/2" - 2" Master Selector Valve Without Solenoid

The master / selector valves are pneumatic operated valves of the full port ball valve type. The valve is equipped with a spring return pneumatic actuator designed to operate with CO_2 pressure. The valves are rated to a working pressure of 2,200psi WOG. The pneumatic actuators are designed to operate at 100psi with a maximum working pressure of 120psi and a minimum working pressure of 80psi. This assembly is used in conjunction with a pneumatic time delay cabinet. The valve receives actuation pressure from the pneumatic time delay cabinet and closes when pressure from the cabinet is exhausted.

Material:
- Body: Carbon Steel
- Ball/Stem: Stainless Steel
- Actuator: Aluminum
- Seats: RTFE

Approval: FM Approvals



Refer to next page for dimensional information

TOMCO$_2$ FIRE SYSTEMS

1/2” - 2” Master Selector Valve Without Solenoid

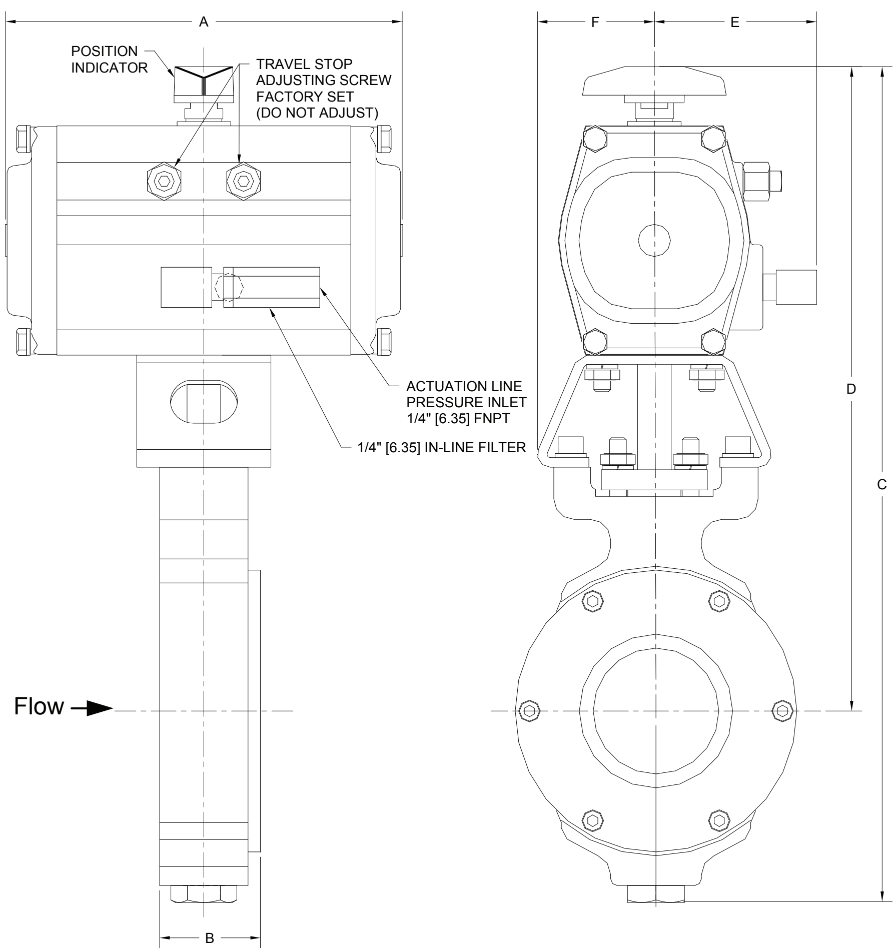
Size	Part Number	A	B	C	D	E	F	Weight
1/2”	990910	5 5/8” (142.5)	3” (76.2)	8 5/8” (219)	7 1/2” (190.5)	2 3/4” (69.1)	1 3/8” (34.9)	7.5 lbs 3.4 kg
3/4”	990911	5 5/8” (142.5)	3 3/8” (85.7)	9” (228.6)	7 3/4” (196.9)	2 3/4” (69.1)	1 3/8” (34.9)	9 lbs 4.1 kg
1”	990912	7 3/8” (188)	4” (101.6)	10 7/8” (276.2)	9 7/16” (239.7)	3” (76.8)	1 3/4” (44.5)	15.5 lbs 7.1 kg
1 1/4”	990913	7 3/8” (188)	4 3/8” (111.1)	11 3/8” (288.9)	9 5/8” (245.4)	3” (76.8)	1 3/4” (44.5)	18 lbs 8.2 kg
1 1/2”	990914	8 5/8” (219)	5” (127)	12 1/4” (311.2)	10 3/8” (263.5)	3 3/16” (80.8)	2” (50.8)	25.5 lbs 11.4 kg
2”	990915	12” (304.8)	5 3/4” (146)	14 5/8” (371.5)	12 1/4” (311.2)	3 1/2” (89.7)	2 3/8” (60.3)	41 lbs 18.6 kg

3" - 8" Master Selector Valve Without Solenoid

The master / selector valves are electro pneumatic operated valves of the butterfly valve type. The valve is equipped with a spring return pneumatic actuator designed to operate with CO_2 pressure. The valves are rated to a working pressure of 750psi WOG. The pneumatic actuators are designed to operate at 100psi with a maximum working pressure of 120psi and a minimum working pressure of 80psi. This assembly is used in conjunction with a pneumatic time delay cabinet. The valve receives actuation pressure from the pneumatic time delay cabinet and closes when pressure from the cabinet is exhausted.

Material:

Body:	Carbon Steel	Approval:	FM Approvals
Disc/stem:	Stainless Steel		
Seats:	RTFE		
Actuator:	Aluminum		



Refer to next page for dimensional information

TOMCO2 FIRE SYSTEMS

3” - 8” Master Selector Valve Without Solenoid

Size	Part Number	A	B	C	D	E	F	Weight
3”	990906	7 7/16” (188)	1 7/8” (48)	15 9/16” (395)	12” (305)	3” (76.8)	2 3/16” (55)	25 lbs (11.4 kg)
4”	990907	7 7/16” (188)	2” (50)	17 9/16” (446)	12 7/8” (327)	3” (76.8)	2 3/16” (55)	30 lbs (13.6 kg)
6”	990908	11 7/8” (302)	2 7/16” (62)	22 1/4” (567)	16” (407)	3 1/2” (89.7)	2 9/16” (65)	58 lbs (26.3 kg)
8”	990909	15 9/16” (395)	2 13/16” (72)	26 15/16” (684)	19 3/8” (492)	4 3/4” (121.4)	3 7/16” (87)	110 lbs (49.9 kg)

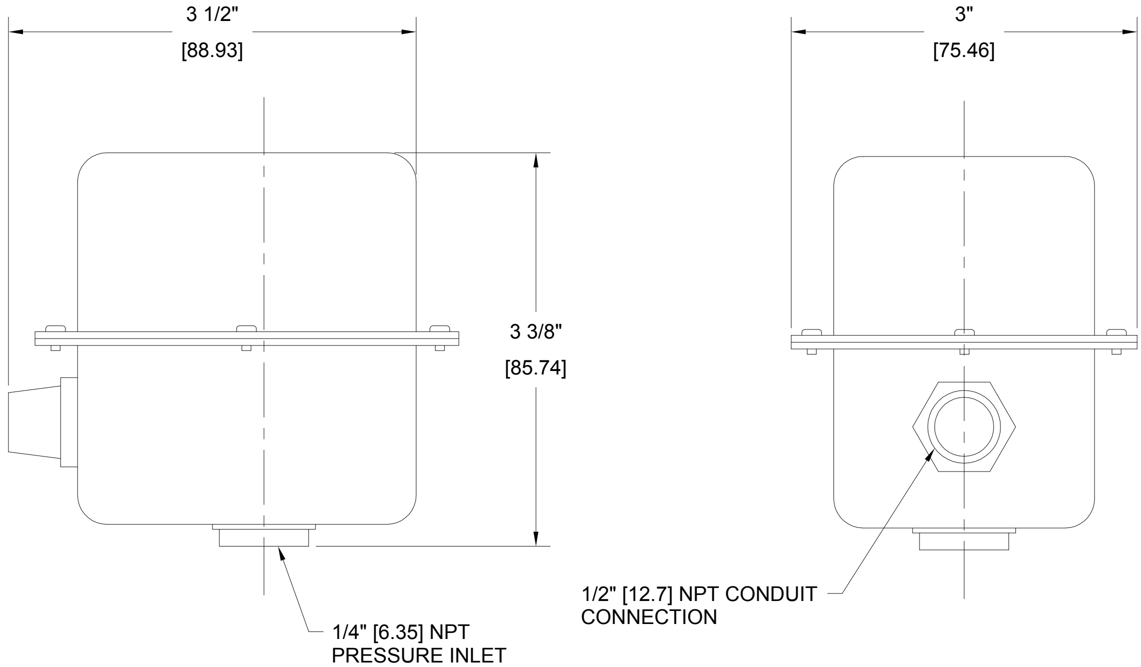
TOMCO2 FIRE SYSTEMS

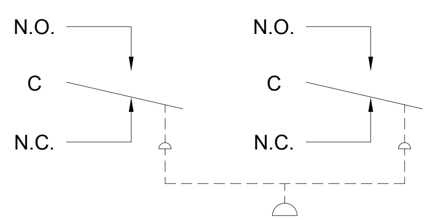
Actuation Line Supervisory Pressure Switch

The actuation line supervisory pressure switch is a self restoring pressure switch. The switch is used to monitor the pressure in the actuation line to ensure there is proper pressure to actuate the master / selector valves. The switch should be installed at the end of the actuation line.

Material:	Stainless Steel
Enclosure Rating:	NEMA 4
Part Number:	990951
Approval:	FM Approvals

FM Approvals has not verified the NEMA rating of the housing.





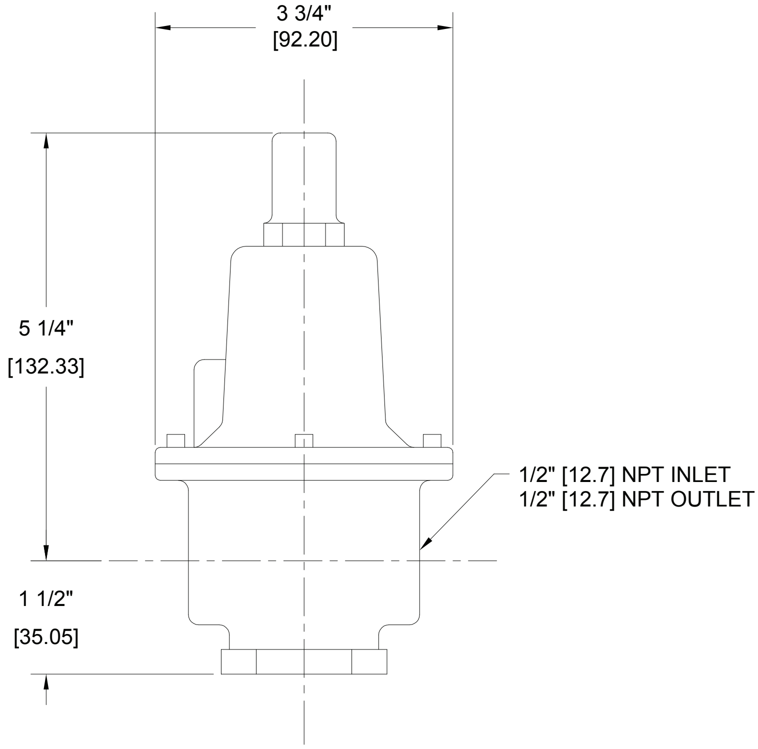
SWITCH CONFIGURATION

Tomco Fire Systems
7619 Hamilton Avenue
Cincinnati, OH 45231

1/2” 100psi Pressure Regulator

The pressure regulator is a fully automatic pressure regulating valve. The regulator is installed in the actuation line to maintain the 100psi required to operate the master / selector valves. The regulator should be installed as close as possible to the vapor source on the storage tank.

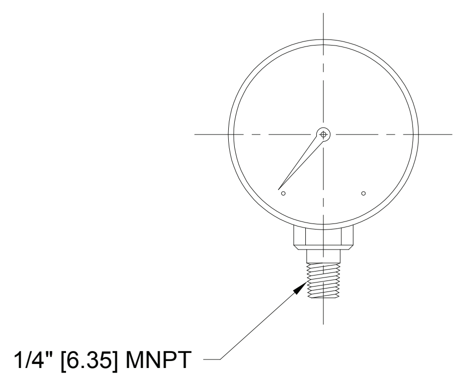
Material:	Brass
Part Number:	990948
Approval:	FM Approvals



Actuation Line Gauge

The gauge is used to indicate the pressure of the actuation line. The gauge should be located near the pressure regulator.

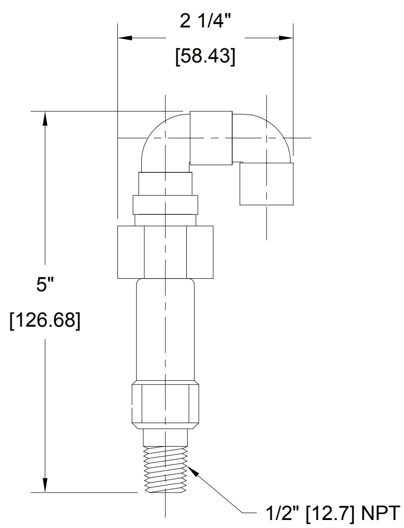
Range:	0-200psi
Gauge Face:	2”
Part Number:	990949
Approval:	FM Approvals



Pressure Relief Valve

The pressure relief valves are used to prevent damage to master / selector valves due over pressurization of the actuation line and to relieve pressure in a potentially trapped section of piping.

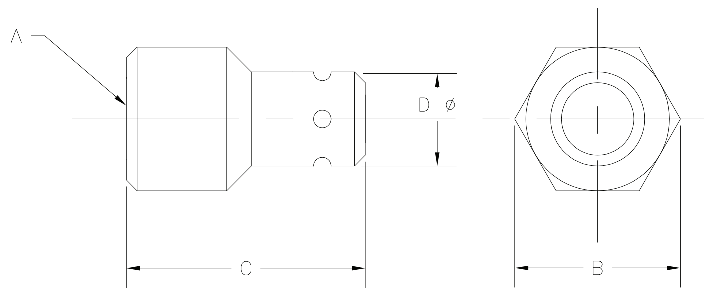
Material:	Brass	
Part Number:	120 psi	990950
	450 psi	990952
Approval:	FM Approvals	

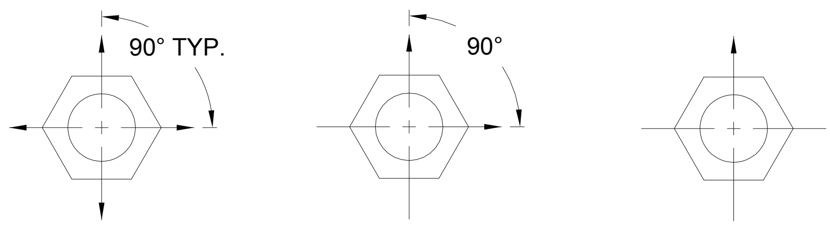


1/2" - 2" Radial Nozzle

The Radial Nozzle is for use strictly on total flood systems. The nozzles are factory drilled in 1/2 code increments. Maximum listed coverage area is 36' x 36' [11m x 11m].

Material: Brass
Approval: FM Approvals





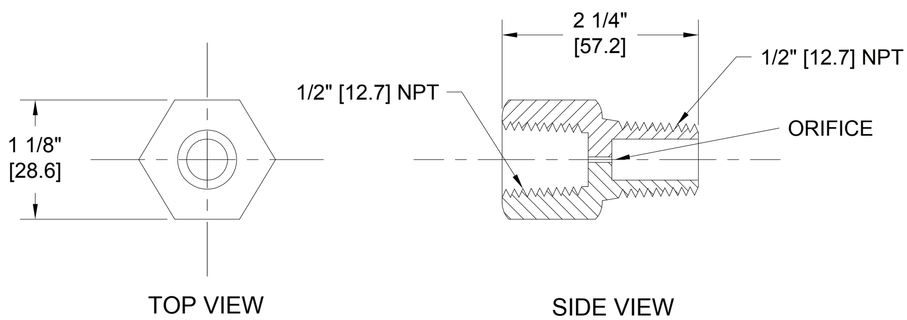
Orifice Arrangement

Size	Part Number	A	B	C	D
1/2"	990957	1/2" (12.7)	1 1/8" (28.6)	2 1/8" (54)	1" (25.4)
3/4"	990958	3/4" (19)	1 3/8" (35)	2 1/2" (63.5)	1 1/4" (31.8)
1"	990959	1" (25.4)	1 7/8" (47.6)	2 7/8" (73)	1 1/2" (38.1)
1 1/4"	990960	1 1/4" (31.8)	2" (50.8)	3 1/2" (88.9)	1 7/8" (47.6)
1 1/2"	990961	1 1/2" (38.1)	2 1/4" (57.2)	3 7/8" (98.5)	2 1/8" (54)
2"	990962	2" (50.8)	3" (76.2)	4 3/4" (120.7)	2 7/8" (73)

1/2" Orifice Nozzle

Orifice Nozzles are for use only in total flood systems. Consult the design manual for spacing limitations.

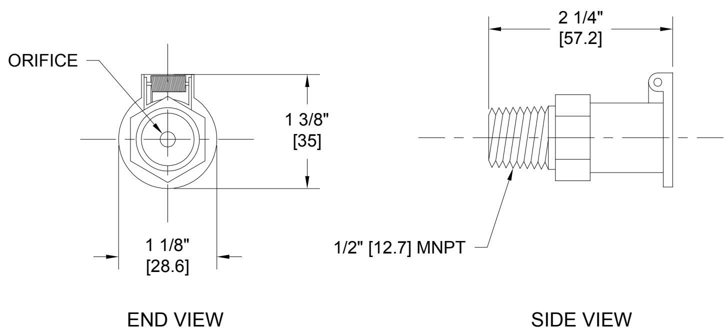
Material:	Brass
Part Number:	990964
	990965 (with strainer)
Approval:	FM Approvals



1/2” Orifice Nozzle with Cap

Orifice Nozzles are for use only in total flood systems. Consult the design manual for spacing limitations.

Material: Carbon Steel Zinc Plated
Part Number: 990966
990967 (with strainer)
Approval: FM Approvals



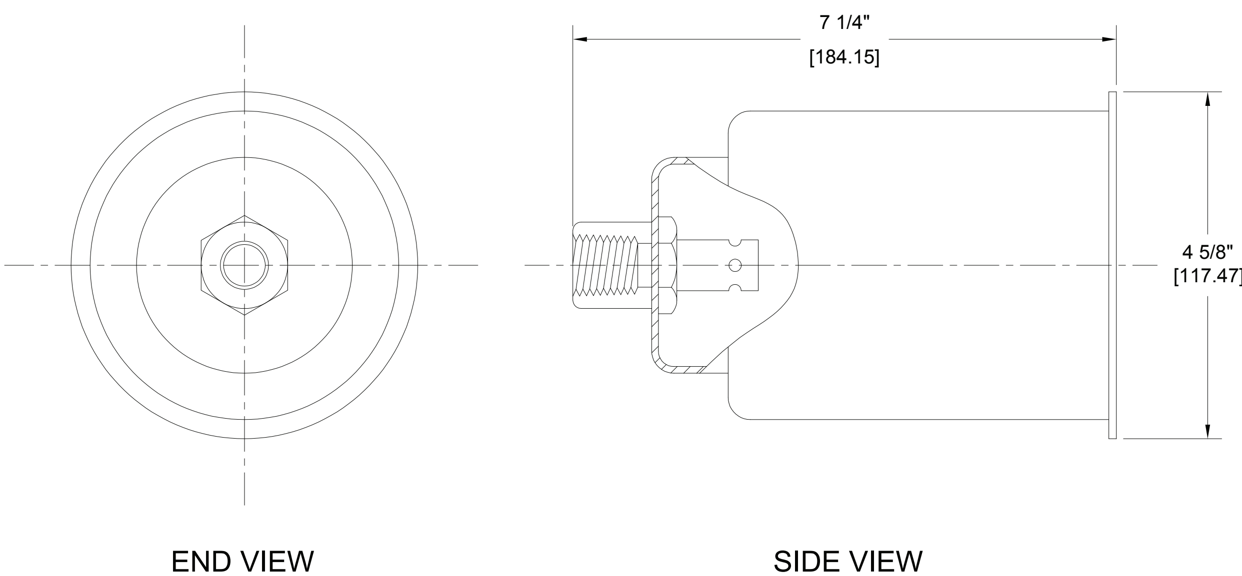
4” Cone Nozzle

Cone Nozzles are for use in both total flood and local application systems. Consult the design manual for spacing limitations.

Material:
- Jet Tip: Brass
- Shell: Carbon Steel (Painted)

Part Number: 990953 1/2” NPT
990954 1/2” NPT with strainer
990955 3/4” NPT
990956 3/4” NPT with strainer

Approval: FM Approvals

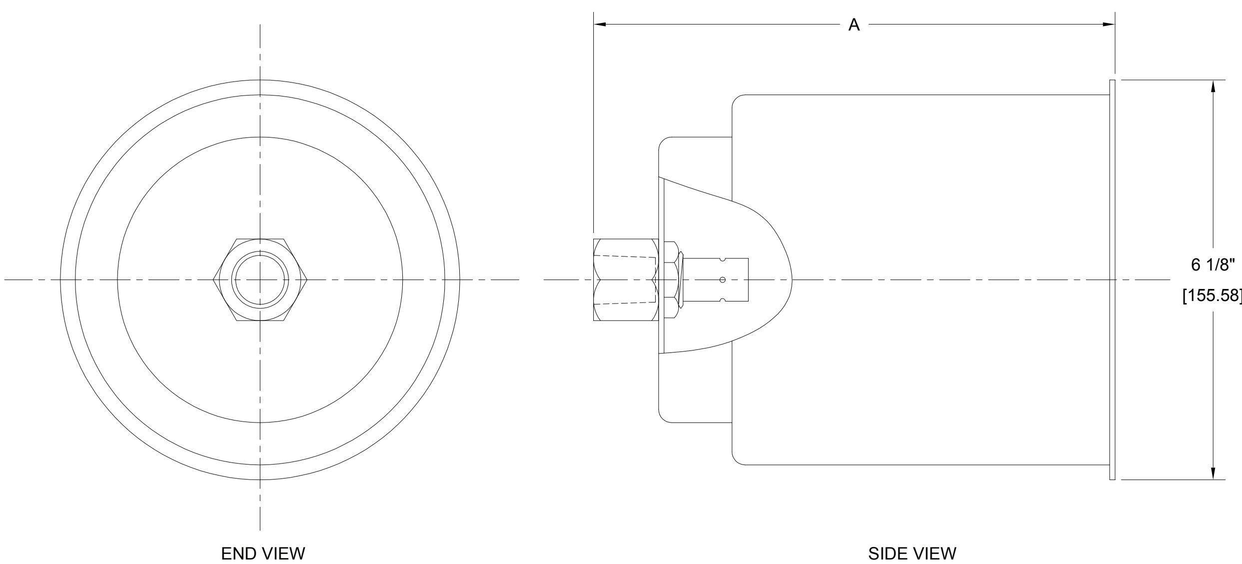


5 1/2” Cone Nozzle

Cone Nozzles are for use in both total flood and local application systems. Consult the design manual for spacing limitations.

Material:
- Jet Tip: Brass
- Shell: Carbon Steel (Painted)

Approval: FM Approvals



Size	Part Number	A
1/2”	990487	8” (203.2)
3/4”	990488	8” (203.2)
1”	990489	8 1/4” (209.6)

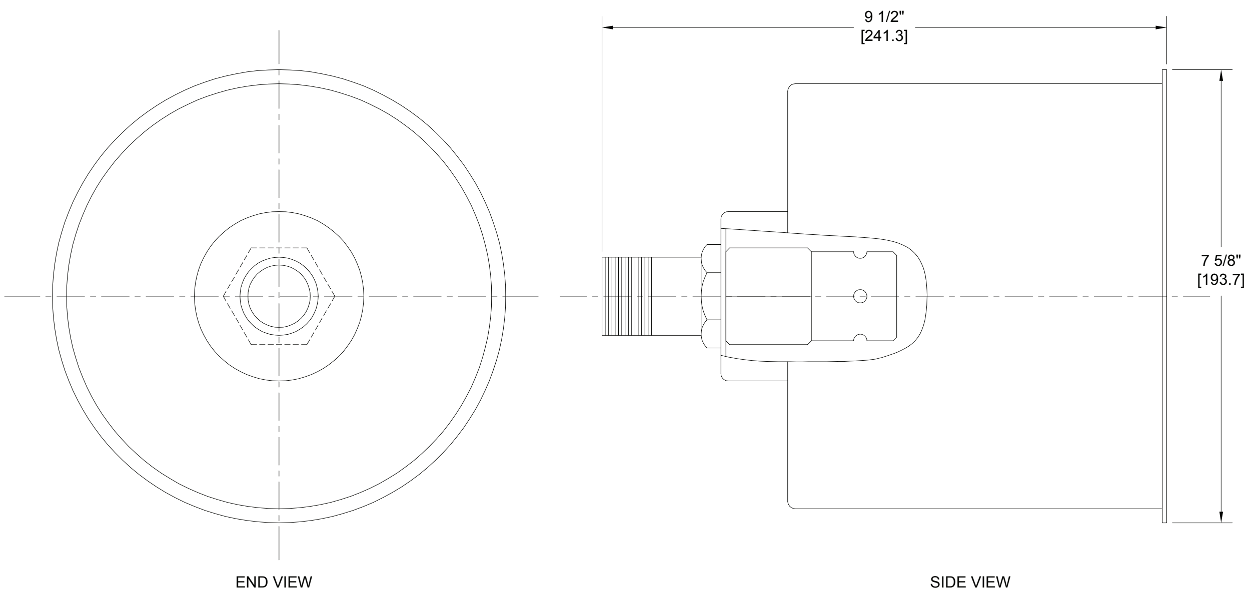
7” Cone Nozzle

Cone Nozzles are for use in both total flood and local application systems. Consult the design manual for spacing limitations.

Material:
- Jet Tip: Brass
- Shell: Carbon Steel (Painted)

Part Number: 990985 1” NPT
990986 1 1/4” NPT
990987 1 1/2” NPT

Approval: FM Approvals



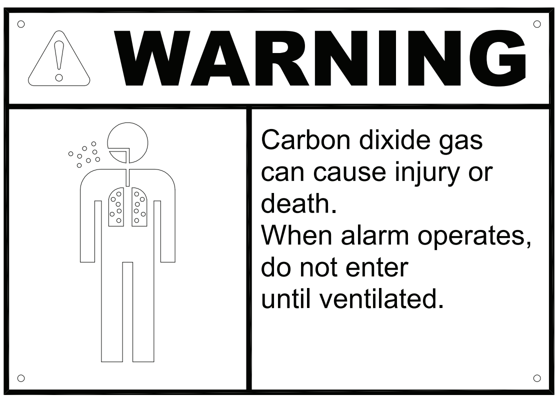
Tomco Fire Systems
7619 Hamilton Avenue
Cincinnati, OH 45231

TOMCO₂ FIRE SYSTEMS

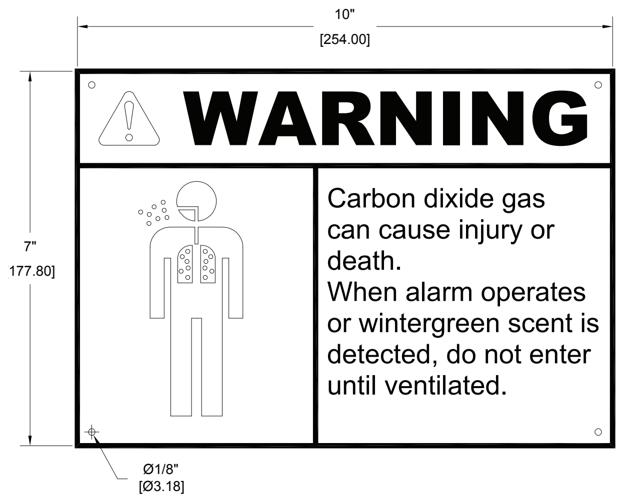
Warning Signs

Warning signs are for installation in and around a protected space to alert personnel in case of an alarm. Signs are furnished with 4 holes and an adhesive backing or ease of installation.

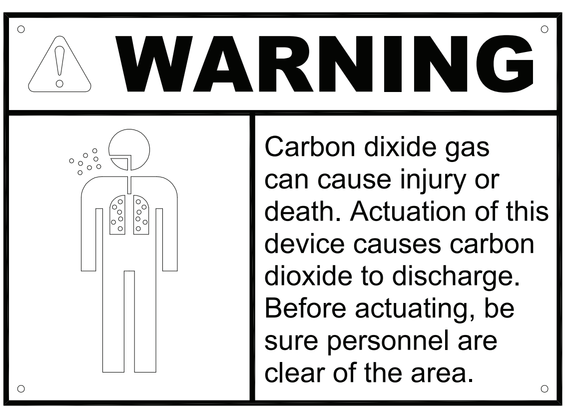
Material: Vinyl on plastic
Approval: FM Approvals



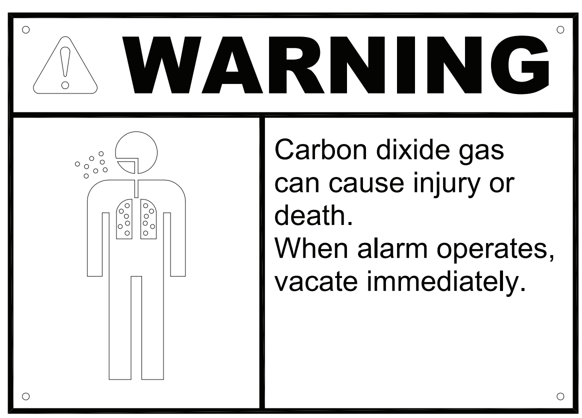
Part Number: 990490



Part Number: 990491



Part Number: 990494

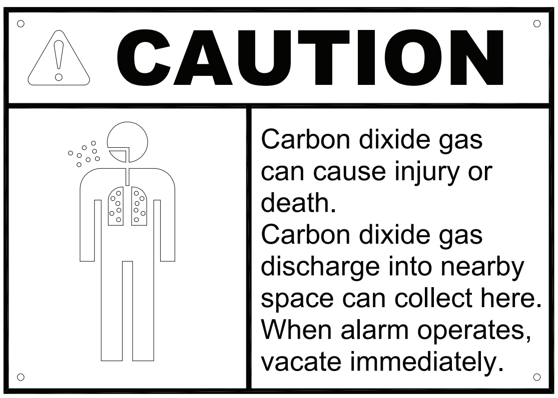


Part Number: 990495

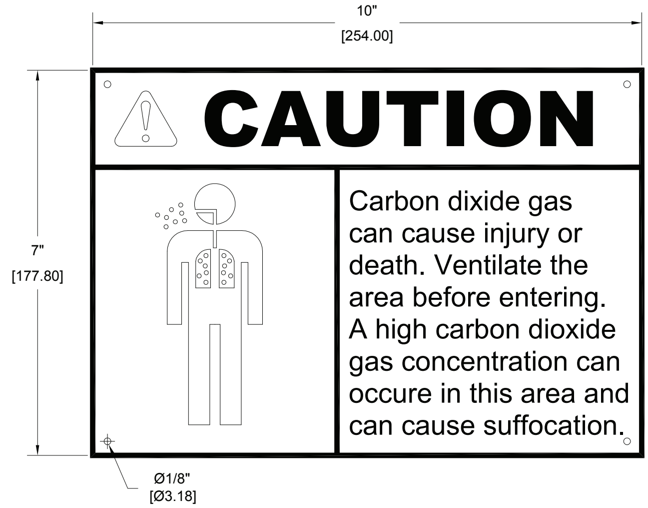
Caution Signs

Caution signs are for installation in and around a protected space to alert personnel in case of an alarm. Signs are furnished with 4 holes and an adhesive backing or ease of installation.

Material: Vinyl on plastic
Approval: FM Approvals



Part Number: 990492



Part Number: 990493

Pneumatic Time Delay Cabinet

The Tomco Fire Systems pneumatic time delay cabinet is a pneumatically operated assembly of a pressure gauge, supervisory pressure switches, dial timers, 24vdc solenoid and mechanical override all interconnected by tubing and mounted in a NEMA 12, 4 or 4x enclosure. Three 1/2" [12.7] NPT connections on the enclosure provide connections for the necessary external piping.

One time delay cabinet should be provided for each master/selector valve within the system and should be located at or near the valve being controlled. The emergency manual push-button located on the side of the cabinet should only be used in the event of failure to the automatic or normal manual actuation devices.

The actuation line from the timer cabinet up to and including the actuator is supervised at 10 psig. The circuit includes a 15 psig pressure relief valve to prevent over pressurization of the line if the pressure regulator fails. Upon loss of the supervisory pressure, a pressure switch sends a signal to the main control system.

The storage unit provides 100 psig of CO_2 vapor pressure through a regulator for operation of the timer cabinet. When the solenoid or emergency manual operator are actuated, the CO_2 vapor pressure will accomplish the following:

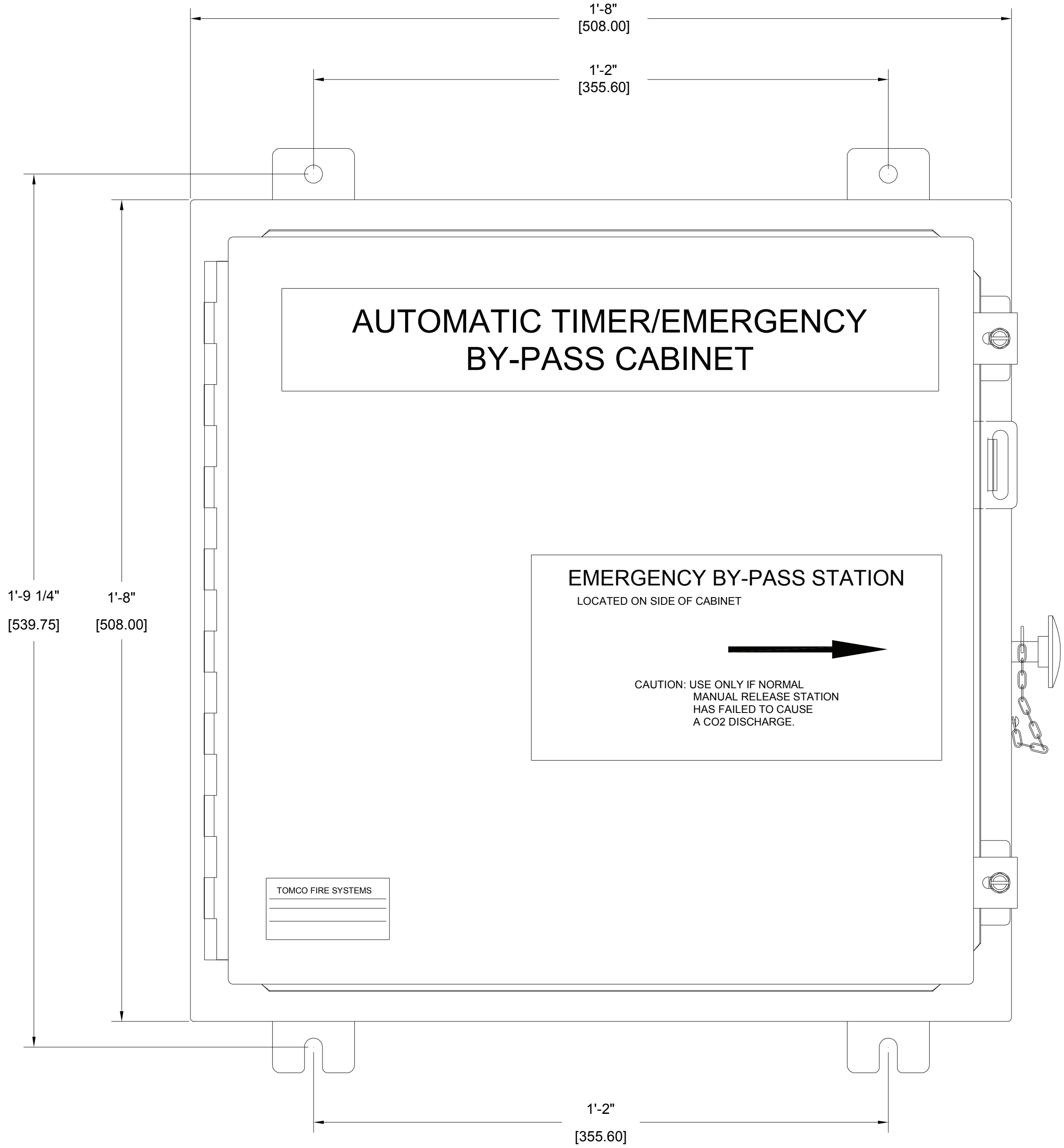
A. Delay discharge for a pre-determined, adjustable time period.
B. Immediately alert personnel of the pending CO_2 discharge with a pneumatic operated siren that by-passes all time delays.
C. Provide pneumatic pressure to open the master/selector valves to begin the discharge and then, after a predetermined time, vents the pneumatic pressure which will cause the valves to close.

The delay timer provides 3 to 60 seconds of pre-discharge time. The discharge timer causes the master/selector valves to remain open for predetermined discharge time adjustable between 18 seconds to 10 minutes. An optional timer is available for extended discharges up to 100 minutes.

Part Number:	
NEMA 4x:	990400
NEMA 4:	990401
NEMA 12:	990402
Approval:	FM Approvals

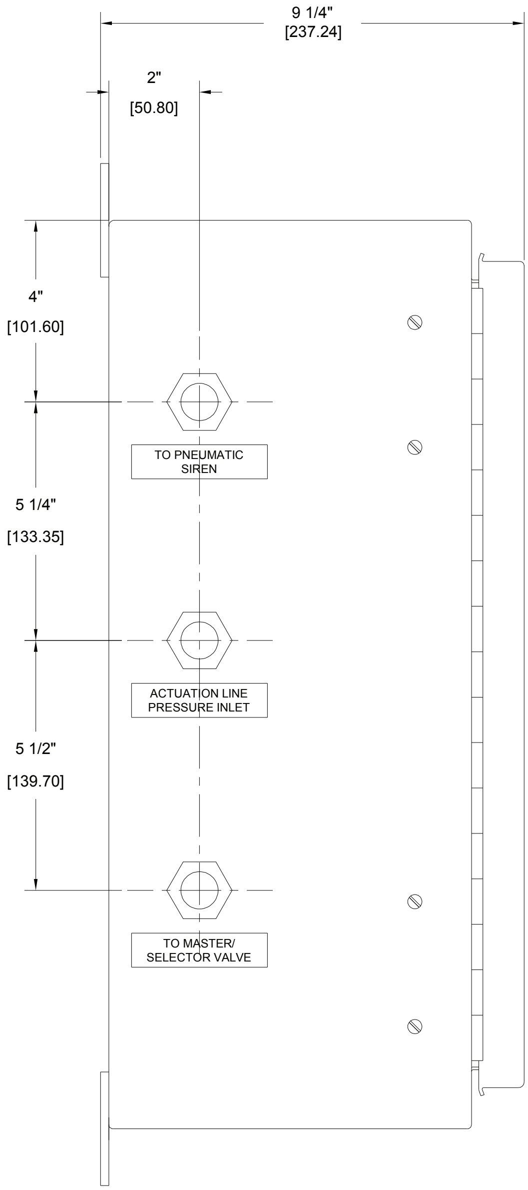
FM Approvals has not verified the NEMA rating of the enclosure.

Pneumatic Time Delay Cabinet

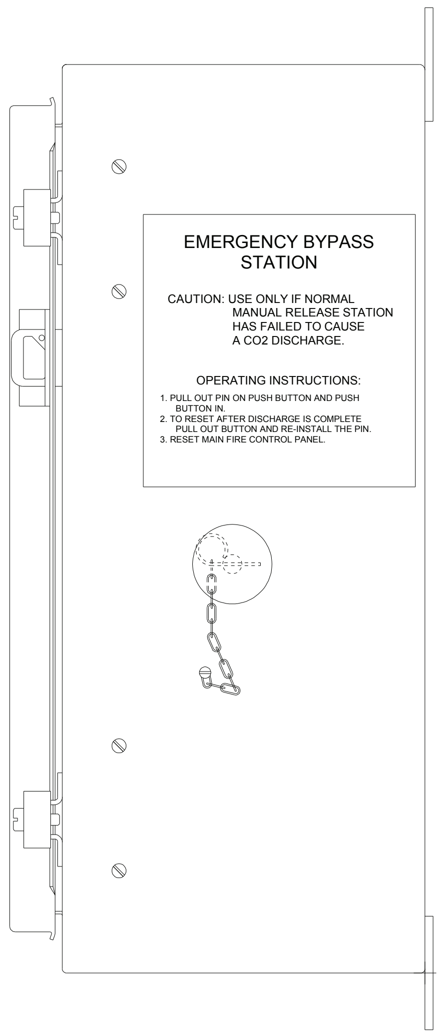


Front View

Pneumatic Time Delay Cabinet

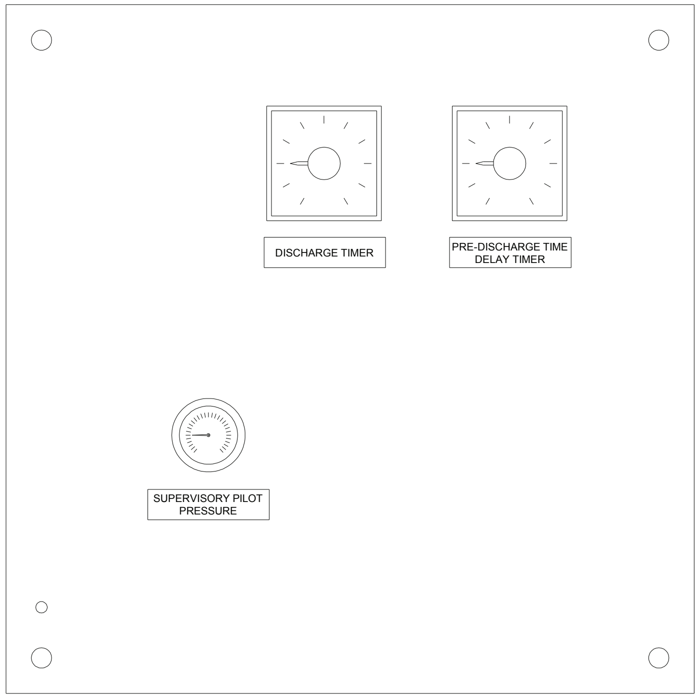


Left Side View

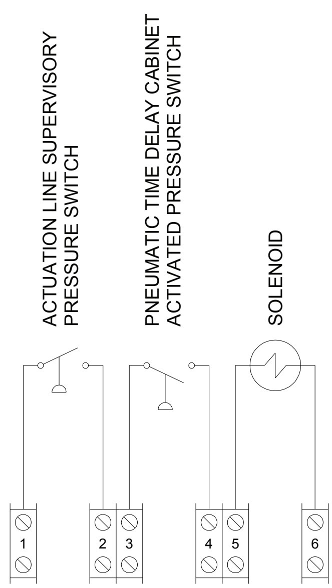


Right Side View

Pneumatic Time Delay Cabinet



Top Plate Layout

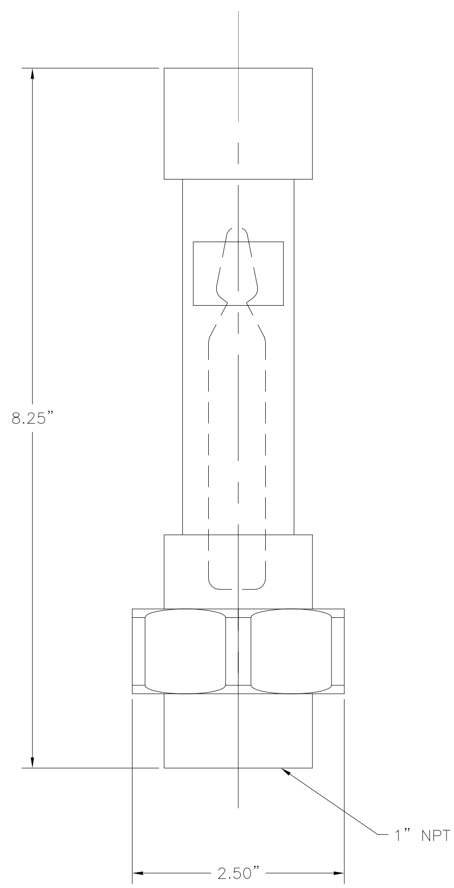


Wiring Schematic

Odorizer

The odorizer is used to add a distinctive wintergreen scent to the carbon dioxide as it discharges. This wintergreen scent serves as warning to personnel in the area that the system has discharged and to take proper precautions. The ampoule containing the oil of wintergreen must be replaced after each system discharge.

Material:	Stainless Steel
Part Number:	990496
Replacement ampoule:	990514
Approval:	FM Approvals



SECTION 3

SYSTEM DESIGN

Table of Contents

SECTION 3

SYSTEM DESIGN

3-1 GENERAL

This section is provided as a guide in designing a low pressure CO_2 fire extinguishing system. The two major types of systems covered in this section are total flooding and local application.

3-2 TOTAL FLOOD SYSTEM DESIGN

A. A total flooding system consists of a fixed supply of carbon dioxide connected to a piping network with fixed nozzles that discharge into an enclosed space. This type of system may be used whenever an enclosure exists about the hazard. The enclosure must be adequate to contain the discharge of agent to achieve the required carbon dioxide concentration. Figure 3-1 illustrates a total flood design process.

B. Fires which can be extinguished by total flooding methods may be divided into two categories:

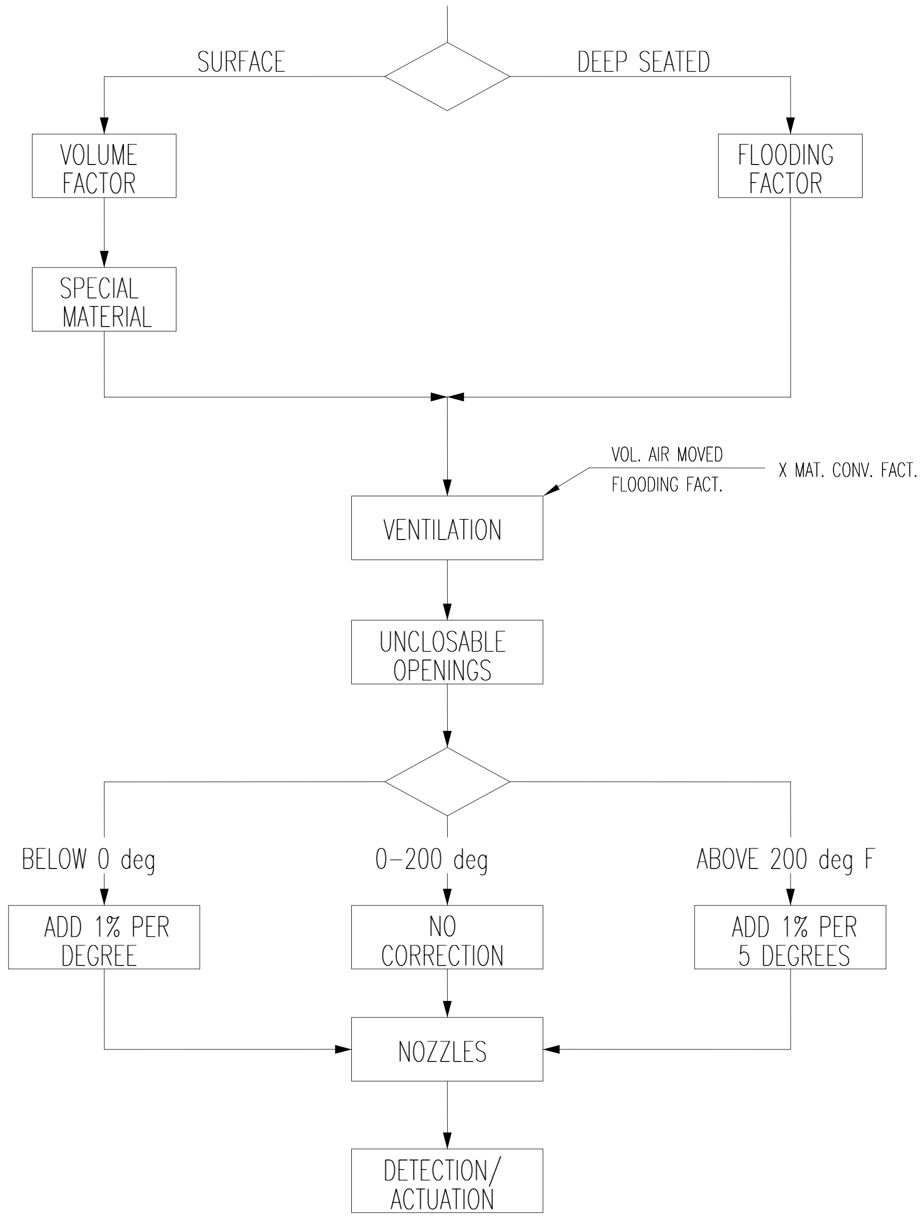
1. Surface fires involving flammable liquids, gases and solids.

2. Deep seated fires involving solids subject to smoldering.

C. Surface fires are the most common hazard and are usually subject to prompt extinguishment when carbon dioxide is quickly introduced into the enclosure in sufficient quantity.

D. For deep-seated fires, the required extinguishing concentration shall be maintained for a sufficient period of time to allow the smoldering to be extinguished and the material to cool to a point to prevent re-ignition.

SYSTEM DESIGN PROCESS
TOTAL FLOODING



Caution: This design criteria is for enclosure temperature only. Equipment listed for the low pressure CO_2 system has an operable range of -10º F to 120º F.

Figure 3-1
Total Flood Design Process

3-2.1 Quantity Calculations for Surface Fires

A. Section 5-3 of NFPA Standard 12 2005 gives the guidelines for determining the quantity of carbon dioxide quantities for surface fires.

B. The minimum design concentration of carbon dioxide required in no case shall be less than 34%.

C. Table 3-1 lists the minimum design concentrations required for extinguishment of some common liquids and gases.

Material	**Minimum Design CO_2 Concentration (%)**
Acetylene	66
Acetone	34
Aviation Gas Grades 115/145	36
Benzol, Benzene	37
Butadiene	41
Butane	34
Butane 1	37
Carbon Disulfide	72
Carbon Monoxide	64
Coal or Natural Gas	37
Cyclopropane	37
Diethyl Ether	40
Dimethyl Ether	40
Dowtherm	46
Ethane	40
Ethyl Alcohol	43
Ethyl Ether	46
Ethylene	49
Ethylene Dichloride	34
Ethylene Oxide	53
Gasoline	34
Hexane	35
Higher Paraffin Hydrocarbons	34
Hydrogen	75
Hydrogen Sulfide	36
Isobutane	36
Isobutylene	34
Isobutyl Formate	34
JP - 4	36
Kerosene	34
Methane	34
Methyl Acetate	35
Methyl Alcohol	40
Methyl Butane 1	36
Methyl Ethyl Ketone	40
Methyl Formate	39
Pentane	35
Propane	36
Propylene	36
Quench, Lube Oils	34

Note: The theoretical minimum extinguishing concentrations in air for the above materials were obtained from a compilation of Bureau of Mines Limits of Flammability of Gases and Vapors (Bulletins 503 and 627).

Table 3-1
Minimum Carbon Dioxide Concentrations for Extinguishment
(TABLE 5.3.2.2 from NFPA 12 2005)

D. In figuring the net cubic volume to be protected, the volume of permanent, non-removable, impermeable structures may be subtracted from the gross volume to be protected, however, this allowance is not recommended.

E. In two or more interconnected volumes where "free flow" of carbon dioxide can take place, the carbon dioxide quantity shall be the sum of the quantities for each volume, using its respective volume factor from table 3-2. If one volume requires greater than 34% concentration, the higher concentration shall be used in all interconnected volumes.

Volume of Space (ft^3 Incl.)		**Volume Factor (ft^3/lb. CO_2)**	**(lb. CO_2/ft^3)**	**Calculated Quantity Not Less Than**
Up to	140	14	.072	----
141	500	15	.067	10
501	1,600	16	.063	35
1,601	4,500	18	.056	100
4,501	50,000	20	.050	250
Over	50,000	22	.046	2,500

Table 3-2
Flooding Factors For 34% Concentration
(Table 5.3.3(a) NFPA 12 2005)

3-2.2 Material Conversion Factor

For materials requiring a design concentration over 34%, the basic quantity of carbon dioxide calculated from the volume factor given in table 3-2 shall be increased by multiplying this quantity by the appropriate conversion factor given in table 3-3.

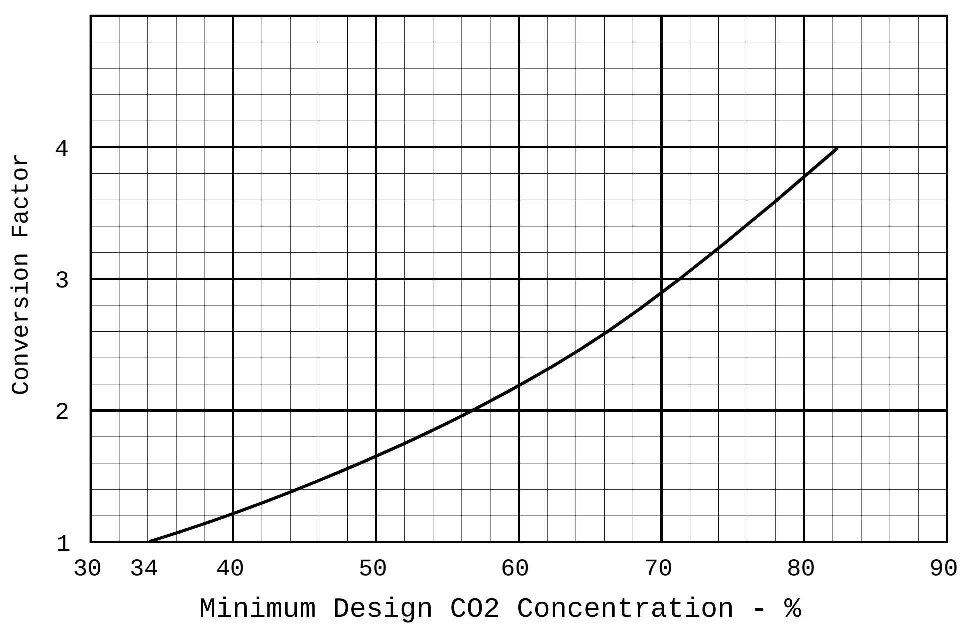


Table 3-3
Material Conversion Factors
(Table 5.3.4 NFPA 12 2005)

3-2.3 Special Conditions

A. Additional quantities of carbon dioxide shall be provided to compensate for any special condition that may adversely affect the extinguishing efficiency.

B. Any openings that cannot be closed at the time of extinguishment shall be compensated for by the addition of a quantity of carbon dioxide equal to the anticipated loss at the design concentration during a one (1) minute period. This amount of carbon dioxide shall be applied through the regular distribution system. See 5.4.4.1 of NFPA Standard 12 2005.

C. For ventilating systems which cannot be shut-down, additional carbon dioxide shall be added to the space through the regular distribution system in an amount computed by dividing the volume moved during the liquid discharge period by the flooding factor. This shall be multiplied by the material conversion factor determined in table 3-3 when the design concentration is greater than 34%.

D. For applications where the normal temperature of the enclosure is above 200º F (93º C), a 1% increase in the calculated total quantity of carbon dioxide shall be provided for each additional 5º F (-15º C) above 200º F (93º C).

E. For applications where the normal temperature of the enclosure is below 0º F (-18º C), a 1% increase in the calculated total quantity of carbon dioxide shall be provided for each degree below 0º F (-18º C).

F. Under normal conditions, surface fires are usually extinguished during the discharge period. Except for unusual conditions, it will not be necessary to provide extra carbon dioxide to maintain the concentration.

G. A flooding factor 8 ft^3/lb. shall be used in ducts and covered trenches. If the combustibles represent a deep-seated fire, it shall be treated as described in section 3.2.4.

3-2.4 Quantity Calculations for Deep Seated Fires

The quantity of carbon dioxide for a deep-seated type fire is based on a fairly tight enclosure. After the design concentration is reached, the concentration shall be maintained for a substantial period of time, but not less than 20 minutes. Any possible leakage shall be given special consideration since no allowance is included in the basic flooding factors.

3-2.5 Combustible Materials

A. For combustible materials capable of producing deep-seated fires, the required carbon dioxide concentrations cannot be determined with the same accuracy possible with surface burning materials. The extinguishing concentration will vary with the mass of material present because of the thermal insulating effects. Flooding factors have therefore been determined on the basis of practical test conditions.

B. The design concentrations listed in table 3-4 shall be achieved for the hazards listed. Generally, the flooding factors have been found to provide proper design concentrations for the rooms and enclosures listed.

C. Flooding factors for other deep seated fires shall be justified to the satisfaction of the authority having jurisdiction before use. Proper consideration shall be given to the mass of material to be protected because the rate of cooling is reduced by the thermal insulating effects.

Design Concentration %	ft^3/lb. CO_2	m^3/kg CO_2	lbs. CO_2/ft^3	kg CO_2/m^3	Specific Hazard
50	10	0.62	0.100	1.60	Dry electrical hazards in general. (Spaces 0-2000 ft^3)
50	12	0.75	0.083 (200 lb. minimum)	1.33 (91 kg minimum)	Dry electrical hazards in general. (Spaces greater than 2000 ft^3)
65	8	0.50	0.125	2.00	Record (bulk paper) storage, ducts and covered trenches.
75	6	0.38	0.166	2.66	Fur storage vaults, dust collectors.

Table 3-4
Flooding Factors for Specific Hazards
(Table 5.4.2.1 NFPA 12 2005)

D. For deep seated fires the design concentration shall be achieved within 7 minutes as specified in Paragraph 5.5.2.3 of the NFPA Standard 12 2005. In addition to the basic quantity, any leakage or temperature factors must be added. The discharge rate shall develop a concentration of 30% that must be achieved within 2 minutes. To develop the 30% concentration within 2 minutes a flooding factor of 0.043 lbs/fr^3 should be used.

3-2.6 Estimated Flow Rate Calculations

A. The problem encountered in flow rate calculations is complicated by the physical characteristics of carbon dioxide. The agent leaves the storage tank as a liquid at saturation pressure (300 psig @ 0º F).

B. As the temperature of the liquid increases as it flows through the discharge piping, the liquid CO_2 begins to vaporize producing a mixture of liquid and vapor. As the pressure increases, the density of the vapor over the liquid increases. On the other hand, the liquid expands as the temperature goes up and its density decreases. This phenomenon reduces the density of the agent and results in an increase in the flow velocity.

C. Since the flow rate for the vapor phase is considerably less than the flow rate for the liquid phase, compensation must be made during the calculation of the actual flow rate.

D. A basic rule to follow when estimating the flow rate for total flood systems involving surface fires is as follows:

1. FOR SYSTEMS WITH LESS THAN 200 FT
For systems with 200 ft. of pipe or less from the storage unit to the hazard, a 30% increase (1.3 multiplier) in the vapor factor should be used to calculate the

actual flow rate in pounds per minute to achieve the design concentration within the required discharge period.

2. FOR SYSTEMS WITH MORE THAN 200 FT BUT LESS THAN 500 FT
For systems with more than 200 ft. of pipe but less than 500 ft. of pipe from the storage unit to the hazard, a 50% increase (1.5 multiplier) in the vapor factor should be used to calculate the actual flow rate in pounds per minute to achieve the design concentration within the required discharge period.

3. SPECIAL FACTORS
Special factors such as systems containing master valves with smaller selector valves, the above factors should be increased to compensate for the heavier wall thickness of the pipe and the larger volumes inside the pipe. For short runs of pipe the vapor factor should be increased by 60% (1.6 multiplier) and for longer runs (usually more than 150 ft.) the vapor factor should be increased by 100% (2.0 multiplier) to achieve the estimated pipe sizes.

Note: These factors should only be used for estimating purposes. To determine the exact pipe sizes, the customized hydraulic program should be used, which accounts for special factors that have not been factored into the estimating guides. These special factors include: ambient enclosure temperatures, extended discharges, purging systems, combinations of hazard types and approved authorities guidelines.

3-2.7 Nozzle Placement Guide

A. Tomco$_2$ Fire Systems uses both radial, orifice or cone discharge nozzles for total flood hazards. All of these types of nozzles have proven to be effective in providing a uniform concentration throughout the hazard enclosure.

B. The radial nozzle usually creates a high velocity discharge that provides a thorough mix of CO_2 throughout the entire enclosure. Cone nozzles are usually used when a slower more "cushioned" discharge is required in areas such as computer rooms, sub-floor areas or records vaults where a high velocity discharge could seriously damage the contents. Orifice nozzles are typically used in small spaces, such as duct work.

C. It is not necessary to place the nozzles directly at the ceiling level. In applications where obstructions are encountered at the ceiling level, the nozzles should be installed lower than these obstructions. In no case should the nozzles be installed less than 3' above the highest object within the protected enclosure.

D. Table 3-5 gives guidance. A full discharge test shall be conducted on all systems. The coverage of nozzles in the actual installation will be verified by this test except when waived by the authority having jurisdiction. More often the area of coverage per nozzle will be reduced from the above recommended maximums due to:

   1. Inability of single nozzle to deliver the required flow rate to flood the maximum area.

   2. Consideration of obstructions within the hazard that require additional nozzles to cover the space on both sides of the obstruction.

3. The hazard contains delicate or fragile materials that might be damaged by a highly turbulent discharge.

Type Of Nozzle	Recommended Maximum Coverage	
4-Port Radial	36' x 36'	Center nozzle in area.
2-Port Radial	36' x 18'	Mount within 5 feet of wall.
1-Port Radial	36' x 18'	Center on wall.
1-Port Orifice	20' x 20' 20' Linear Spacing	Normally used in ducts or to flood interior of equipment. (See Note)

Note: Use additional nozzles at changes in direction and on either side of any obstruction.

Table 3-5
Nozzle Spacing

E. The particular shape or the contents of a hazard may also necessitate a greater number of nozzles than what is shown on the above chart.

F. The radial nozzle can be used in most total flood applications.

G. Radial nozzles should not be used for protecting ducts, pits or covered trenches.

H. In special applications requiring a low velocity discharge, cone nozzles usually associated with local application may be used in total flooding systems and should not exceed a maximum side dimension of 16 feet.

I. Protection of any unusual shaped volumes or excessive ceiling heights should be directed to Tomco$_2$ Fire Systems.

3-2.8 Examples of Hazard Protection

Example No. 1

Hazard Classification: Paint Storage Building

Occupancy Category: Normally unoccupied

Dimensions: 50' x 150' x 20'H

Volume of Mix Room: 150,000 ft^3

Special Conditions: None (no un-enclosable openings, ventilation, hazard temperature or abnormal pipe temperature).

Type of Hazard: Surface type fire

Length of Pipe Run: 400 Feet (Actual) Linear.

Surface Type Fire: 34% Concentration within 1 minute: 150,000 ft^3 x 0.056 lb. CO_2 ft^3 = 8,400 lbs. CO_2 plus loss allowance of 10%: 8,400 lbs. x 1.1 = 9,240 lbs.

Estimated Design Flow Rate: 9,240 lbs. x 1.5 (vapor factor) =13,860 lbs./min.

Example No. 2

Hazard Classification: Acetylene storage room

Occupancy Category: Normally unoccupied

Dimensions: 15' W x 15' L x 12' H

Volume of Mix Room: 15' x 15' x12' = 2,700 ft^3

Special Conditions: Design concentration of 66% required per table 3-1

Type of Hazard: Surface type fire.

Length of Pipe Run: 100 Ft. (Actual) Linear

Surface Type Fire: 66% concentration within 1 minute: 2,700 ft^3 x .056 lb. CO_2/cu. ft. x 2.5 material conversion factor from table 3-3 = 378 lbs. CO_2 plus loss allowance of 10% = 378 lbs. x 1.1 = 416 lbs. CO_2 required.

Estimated Design Flow Rate: 416 lbs. x 1.3 (vapor factor) = 540 lbs./min.

Example No. 3

Hazard Classification: Record Storage Room

Occupancy Category: Normally unoccupied

Dimensions: 30' W x 50' L x 20' H

Volume of Warehouse: 30' x 50' x 20' = 30,000 ft^3

Special Conditions: Deep seated hazard with no extreme temperatures, excessive leakage, un-enclosable openings, hazard temperature or piping environmental temperature.

Length of Pipe Run: 200 Feet (Actual) Linear

Deep Seated Fire: 65% concentration within 7 minutes: 30,000 x 0.125 lbs./ft^3 = 3,750 lbs. plus loss allowance of 10% (3,750 lbs. x 1.1 = 4,125 lbs.)

Total CO_2 Required: 4,125 lbs.

As described earlier in this manual, a 30% concentration within 2 minutes is required: 30,000 x 0.043 lbs./ft^3 = 1,290 lbs.

To estimate the flow rate, multiply amount of CO_2 required in 1 minute by appropriate vapor factor:

1,290 lbs. / 2 minutes = 645 lbs. in 1 minute 645 x 1.3 (vapor factor) = 838 lbs./min.

Estimated Design Flow Rate: 838 lbs./min.

Example No. 4

Hazard Classification: Computer Room Sub-Floor

Warning: CO_2 discharge into subfloor may result in agent drifting into and occupied area.

Dimensions: 100' W x 50' L x 1' H

Volume of Space: 100' x 50' x 1' = 5,000 ft^3 (includes sub-floor)

Special Conditions: No excessive openings, ventilation to be shut-down and dampered. Non combustible construction, cables only, hazard temperatures and piping environment at ambient.

Type of Hazard: Dry electrical fire.

Length of Pipe Run: 100’ (Actual) Linear

Dry Electrical Fire: 50% concentration within 7 minutes: 5,000 x 0.083 lbs./ft^3 = 415 lbs. plus loss allowance of 10% (415 lbs. x 1.1 = 456 lbs.)

Total CO_2 Required: 456 lbs.

Note: FM Global requires that 30% concentration is achieved within one minute.

5,000 cu. ft. x 0.043 lb. CO_2/cu. ft. = 215 lbs. divided by 2 minutes = 108 lbs.

Estimated Design Flow Rate: 108 lbs. x 1.3 (vapor factor) = 139 lbs./min.

3-3 LOCAL APPLICATION SYSTEM DESIGN

3-3.1 General

A. A local application system consists of a fixed supply of carbon dioxide permanently connected to a system of fixed piping with nozzles arranged so as to discharge the agent directly onto the hazard.

B. Local application systems are used for the suppression of surface fires in flammable liquids, gases and shallow solids where the hazard is not enclosed or where the enclosure does not conform to the requirements for total flooding. Examples of hazards that may be protected by local application systems include dip tanks, quench tanks, spray booths, machining operations and printing presses. Figure 3-2 illustrates a local application design process.

C. A discharge test must be conducted to verify complete coverage of the hazard based on nozzle placement.

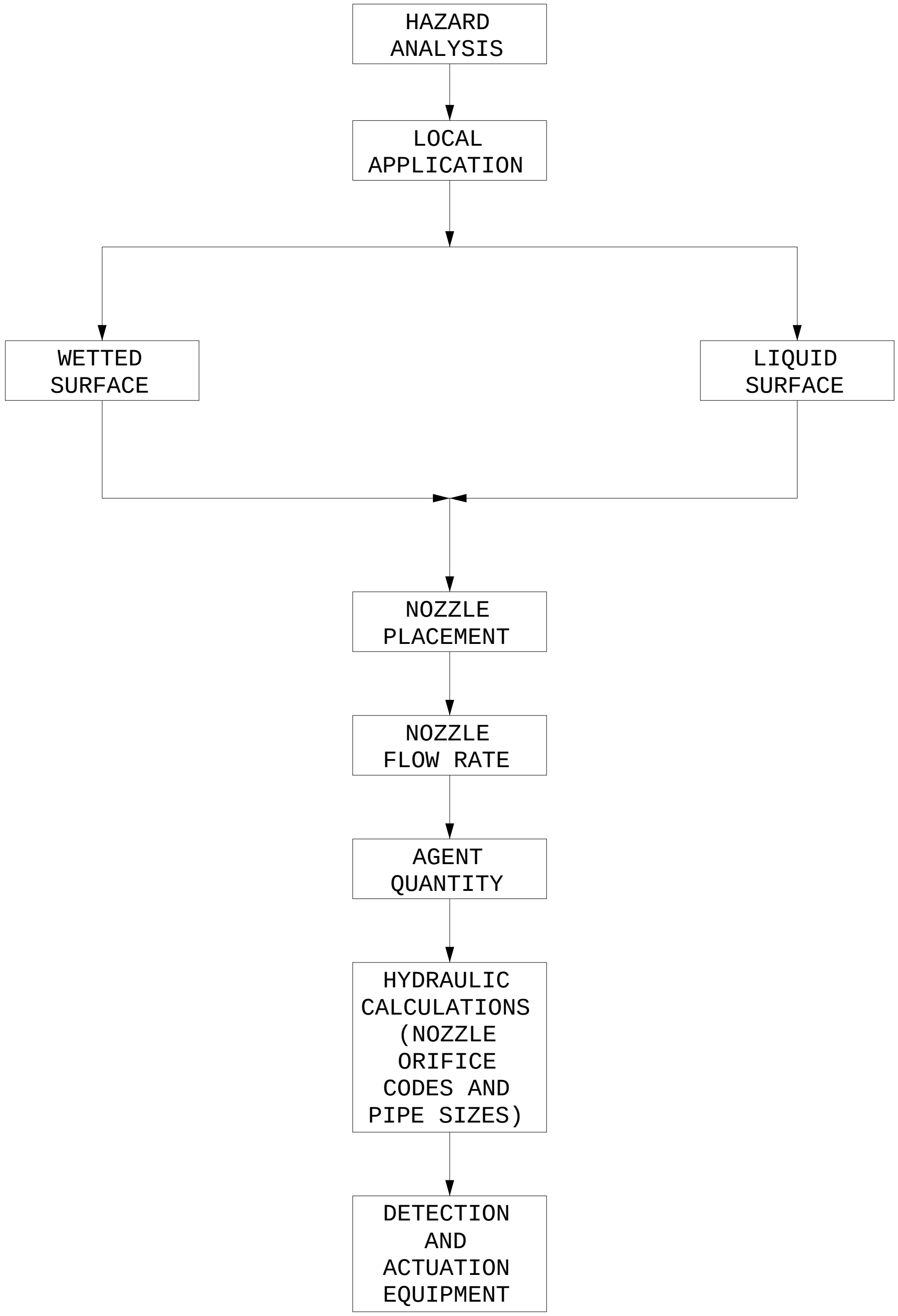


Figure 3-2
Local Application Design Process

3-3.2 Types of Surface Fires

A. Within the scope of this manual, two types of surfaces must be considered: liquid surfaces and wetted or coated surfaces. The liquid surface is that surface of deep layer of flammable liquid usually more than 1/4" in depth that is exposed to the atmosphere. Wetted or coated surfaces are defined as those designed for drainage which are constructed and maintained so that no pools of liquid usually less than 1/4" in depth and will accumulate over a total area exceeding 10% of the protected surface. This does not apply where there is a heavy buildup of residue.

B. National Fire Protection Association NFPA 12 Standard For Carbon Dioxide Systems and FM Global Property Loss Control Data Sheets should be referenced when determining the suitability of a hazard for the local application method of protection.

3-3.3 Duration of Discharge

The minimum effective discharge time for computing quantity of agent shall be 30 seconds of liquid discharge at the nozzles. Where there is a possibility that metal or another material may become heated above the ignition temperature of the fuel, the effective (liquid) discharge time shall be increased to permit adequate cooling of the material. Special fuels such as paraffin wax or cooking oil require a minimum discharge time of 3 minutes because the auto-ignition point is below its boiling point.

3-3.4 Methods of Application

There are two accepted methods of calculating the quantity of CO_2 required for local application systems. The RATE-BY-AREA METHOD is used where the fire hazard consists primarily of a flat surface or low level objects associated with horizontal surfaces. The RATE-BY VOLUME METHOD of system design is used where the fire hazard consists of three dimensional irregular objects that cannot easily be reduced to equivalent surface areas.

3-3.5 Rate-By-Area Method

A. For rate-by-area local application systems, the quantity of CO_2 required to protect a hazard is based on the summation of the listed discharge rates from all individual nozzles. The discharge rate for each nozzle is determined by the distance from the surface to be protected to the nozzle. The discharge rate and distance from the protected surface to nozzle determines the maximum area which a nozzle can protect. The flow rates, area of coverage and height limitations are found in tables 3-8, 3-9, 3-10.

B. Overhead type nozzles shall be installed perpendicular to the hazard and centered over the area protected by the nozzle. They may also be installed at angles between 45 degrees and 90 degrees from the plane of the hazard surface as described in table 3-7. The height used in determining the necessary flow rate and area coverage shall be the distance from the aiming point on the protected surface to the nozzle measured along the axis of the nozzle.

C. When installed at an angle, nozzles shall be aimed at a point measured from the near side of the area protected by the nozzle, the location of which is calculated by multiplying the fractional aiming factor in table 3-7 by the width of the area protected by the nozzle.

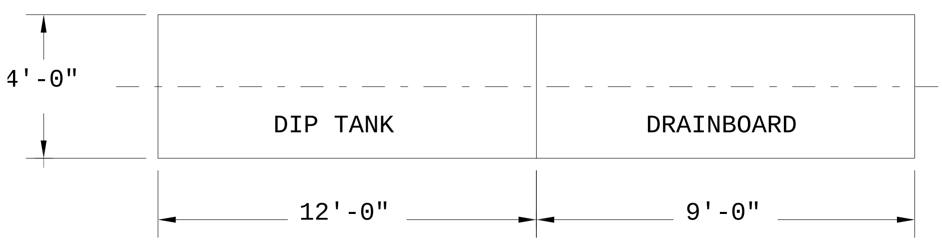
D. If there is a physical limitation on the height of the nozzle above the protected surface, this height limitation may determine the number and type of nozzles that must be used. If there are no restrictions on nozzle height, the minimum number of nozzles may be used based on the maximum allowable distance.

E. When coated stock or parts extend above a protected surface more than two feet additional nozzles may be required to protect this stock. When determining the location of nozzles, considerations should be given for the possible affects of air currents, winds and forced drafts, as additional nozzles may be required.

The following examples will illustrate the use the tables 3-8, 3-9, 3-10.

Example No. 1: No nozzle placement restrictions.

Hazard: 4'-0" x 12'-0" dip tank and 4'-0" x 9"-0" drainboard. Parts are within 2' of the protected surface.



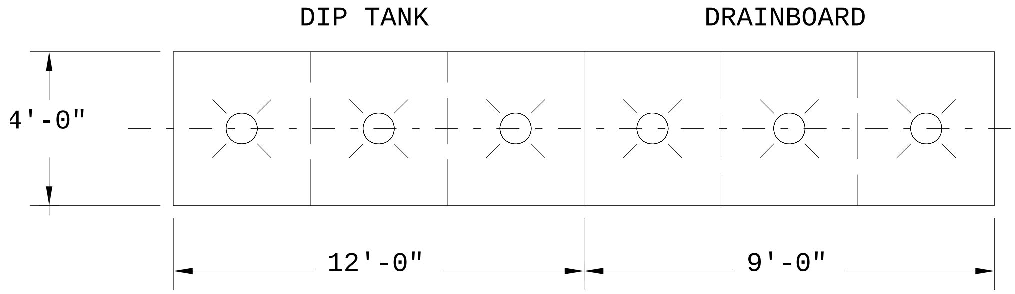
Step 1. Divide hazard area into squares using width of hazard as one side of square.

Dividing the dip tank into squares yields three (3) areas of 4' x 4'. Using the maximum width of coverage of 4', determine the nozzle height above the surface from the nozzle chart.

Step 2. At 4' width the liquid surface nozzle height is 5.25 ft. from the surface. The drainboard is a coated surface and the nozzles will be located 3.25 ft. above the surface.

Step 3. Determine rate of discharge based on nozzle height. At 5.25 ft. height a nozzle has a flow rate of 106 lbs./min. At 3.25 the rate would have to be 65 lbs./min. (based on table 3-8).

Step 4. Locate Nozzles - One per Square Area of Coverage, directly overhead.



Step 5. System Discharge Rate is: Single Nozzle Rate x Number of Nozzles
106 lbs./min. x 3 = 318 lbs./min.
65 lbs./min. x 3 = 195 lbs/min.

Total System Flow Rate = 318 lbs./min. + 195 lbs./min. = 513 lbs./min.

Step 6. Assuming an ordinary flammable liquid, calculate the total quantity of CO_2 required:

513 lbs./min. x 1/2 minute = 256.5 lbs. of LIQUID CO_2. However, since the initial discharge will be vapor, additional CO_2 must be added. Using the factors in table 3-6, the base quantity must be corrected to attain the actual quantity required from the storage unit. Assume that 125 feet of actual pipe will run from storage to the hazard.

Basic Quantity x 1.3 = Actual quantity required from storage unit.

256.5 lbs. x 1.3 = 333.5 lbs. CO_2 required.

Example No. 2: Consider the same dip tank and drainboard with a restricted nozzle height. The nozzles over the dip tank MUST be located 4'-0" above the surface because of obstructions. Nozzles over the drainboard must be located 2' above the drainboard surface.

Step 1. From table 3-8 determine the maximum width of coverage for an cone Nozzle at 4'-0" above a liquid surface.

Width of liquid surface coverage at 4' height for a 4" nozzle is 3.67 ft. with a 81 lbs./min. flowrate (based on table 3-8).

Step 2. Based on the maximum allowable width of 3.67, we will need to use 2 rows of (4) 4" cone nozzles to protect the 4' x 12' dip tank.

Step 3. Based on a 2' nozzle height above the drainboard, two rows of (3) 4" cone nozzles should be used.

Step 4. Determine system flow rate.

8 - 4" nozzles at 81 lbs./min.

6 - 4" nozzles at 39 lbs./min.

(8 x 81 lbs./min.) + (6 x 39 lbs./min.) = 882 lbs./min.

Step 5. Liquid Discharge 882 lbs./min. x 1/2 min. = 441 lbs.

Step 6. Multiply basic liquid quantity by vapor factor from table 3-6. For example:

Assume 125 feet of pipe from the storage unit to the hazard. The vapor factor is 1.3.
441 lbs. x 1.3 = 573.3 lbs. of liquid must discharge from the storage unit.

Linear Feet Of Pipe Run	Local Application Vapor Factor
50 - 100	1.2
100 - 150	1.3
150 - 250	1.4
250 - 500	1.5

Table 3-6
Local Application - Vapor Factors

3-3.6 Rate-By-Volume Method

A. If a hazard is three dimensional in nature and cannot be easily reduced to equivalent surface areas, rate-by-area protection is not recommended. For such three dimensional solid type hazards a rate-by-volume approach should be used when designing a local application system using the rate-by-volume method.

B. The total discharge rate of the system shall be based on the volume of an assumed enclosure entirely surrounding the hazard.

C. The assumed enclosure shall be based on an actual closed floor unless special provisions are made to take care of bottom conditions.

D. The assumed walls and ceiling of this enclosure shall be at least 2 ft (0.6 m) from the main hazard unless actual walls are involved and shall enclose all areas of possible leakage, splashing or spillage.

E. No deductions shall be made for solid objects within this volume.

F. A minimum dimension of 4 ft (1.2 m) shall be used in calculating the volume of the assumed enclosure.

G. If the hazard may be subjected to forced drafts, the assumed volume shall be increased to compensate for losses on the windward sides.

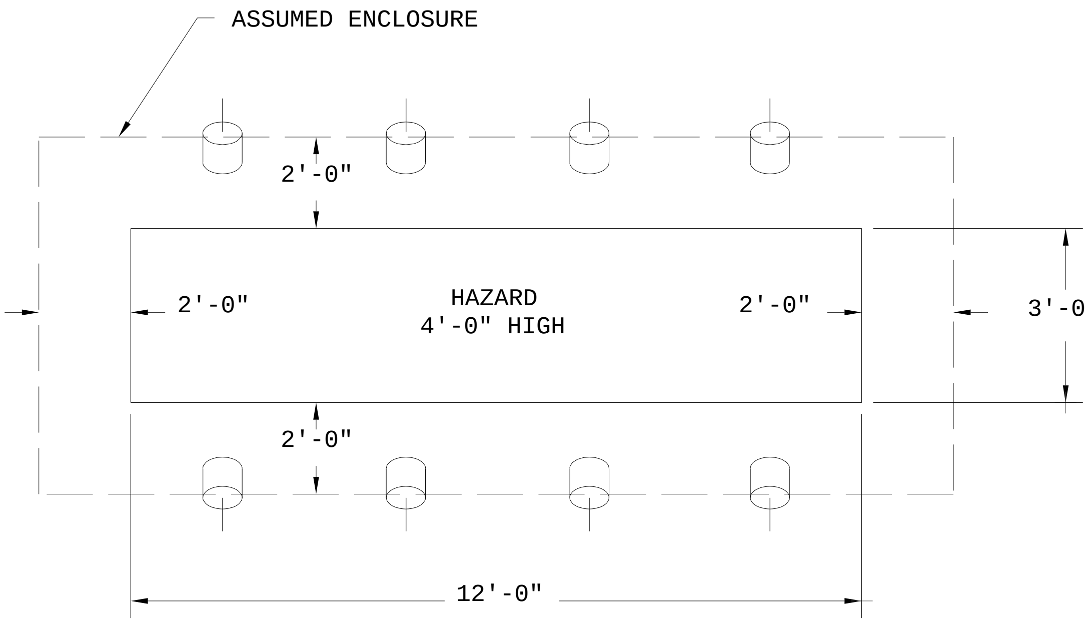
H. Calculation of the system discharge rate and quantity of CO_2 required is based on the volume of an assumed enclosure surrounding the hazard. The assumed enclosure is based on the presence of a closed floor under the hazard. The assumed enclosure is at least two feet in all directions from the actual hazard. The basic system discharge rate is then calculated using one lb. per min. per cubic foot of assumed volume.

I. **Location and Number of Nozzles.** A sufficient number of nozzles shall be used to adequately cover the entire hazard volume on the basis of the system discharge rate as determined by the assumed volume.

J. Nozzles shall be located and directed so as to retain the discharged carbon dioxide in the hazard volume by suitable cooperation between nozzles and objects in the hazard volume.

K. Nozzles shall be located so as to compensate for any possible effects of air currents, or forced drafts.

Example No. 1: Rate-By-Volume (Assumed Volume)



The hazard is a valve body machine operation having actual dimensions 12' long, 3' wide and 4' high. The operation is located in an open production area and is not exposed to any adjoining hazards.

Assuming an enclosure will extend two feet from each surface (except the bottom which rests on the floor).

The assumed volume is:

$$(12 + 2 + 2) \times (3 + 2 + 2) \times (4 + 2) = 672 \text{ ft}^3$$

The total system discharge rate is:

$$672 \text{ ft}^3 \times 1 \text{ lb./min./ft}^3 = 672 \text{ lbs./min.}$$

Total system requirement:

(8) Nozzles required to protect the hazard therefore each nozzle to have a flow rate of 672/8 or 84 lbs./min. referring to table 3-8 with a flow rate of 84 lbs./min. the nozzles should be located 4.25 ft. above the hazard surface.

Locate the nozzles so as to cover the entire hazard. The nozzles should be aimed in such a way as to concentrate and direct the CO_2 around the protected machine. Although the height/flow rate/area restrictions do not apply in the rate-by-volume calculation method, these ratings should be used to determine proper nozzle placement.

3-3.7 Rate-By-Volume Partial Enclosure

A. If the assumed enclosure has a closed floor and is partly defined by permanent continuous walls extending at least 2 ft. above the hazard (where the walls are not normally part of the hazard) the discharge rate may be proportionately reduced to not less than 0.25 lbs./min./cu. ft. (NFPA 12 2005 paragraph 6.5.3.2)

B. Refer to figure 3-3 to determine the allowable flow rate reduction for a hazard with a partial enclosure.

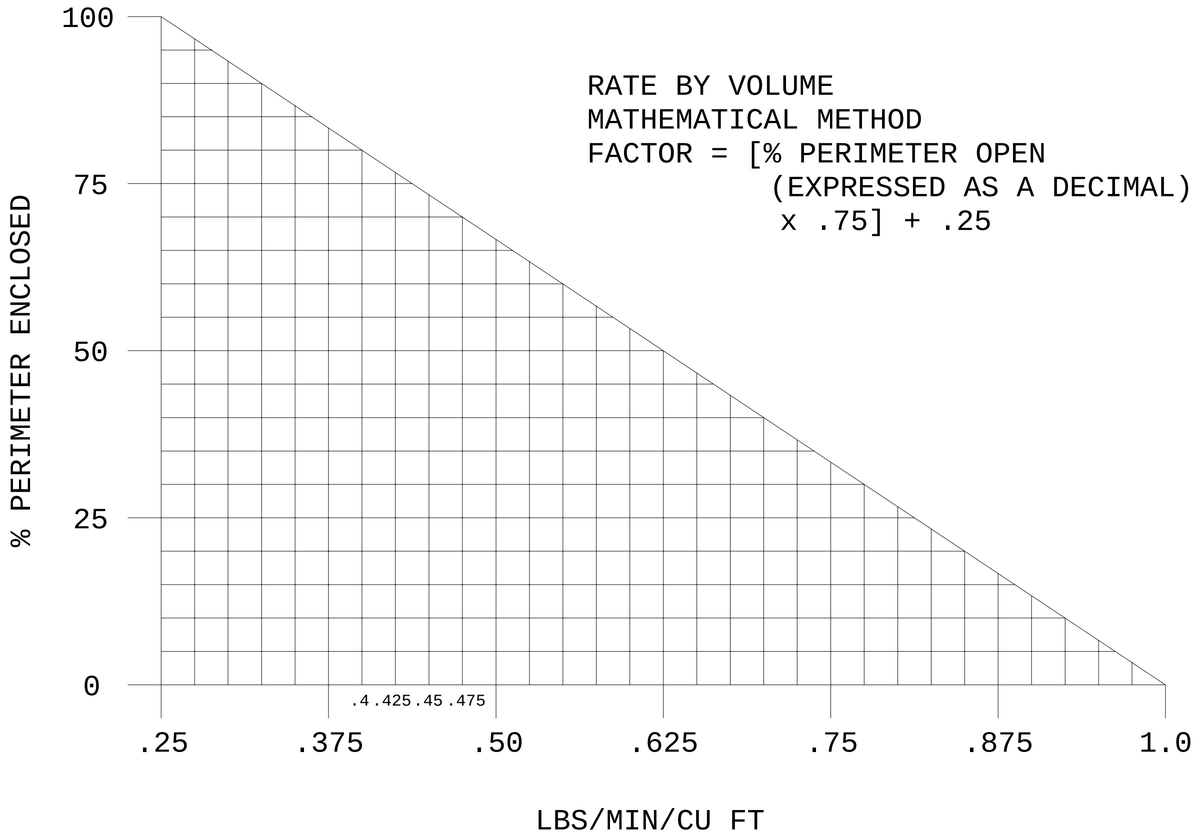
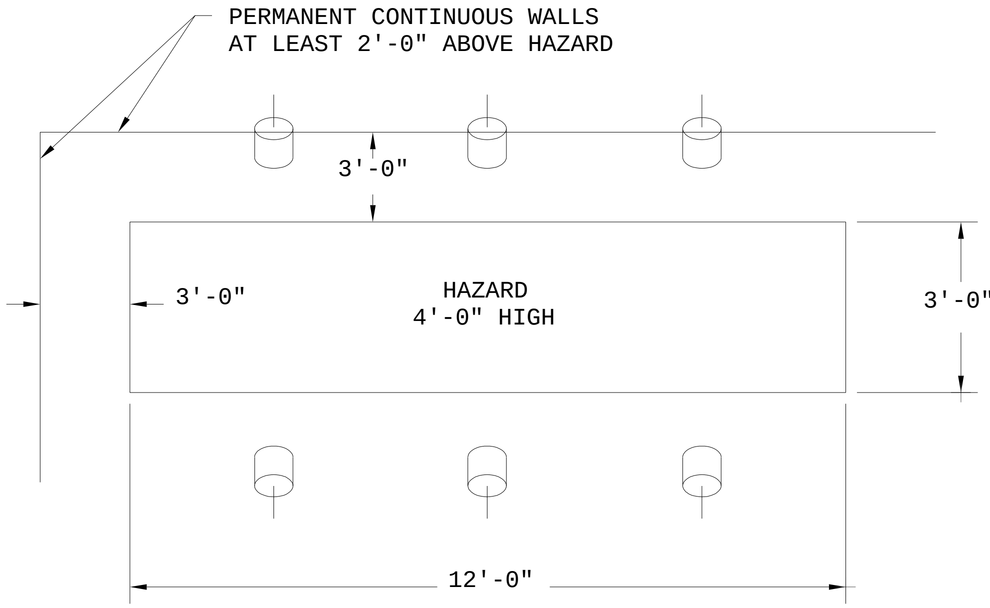


Figure 3-3
Partial Enclosure Flow Rate Reduction per NFPA 12

Example No. 2: Rate-By-Volume (Partial Enclosure)

Consider the same hazard as calculated above, located in a corner. The walls form a partial enclosure on two sides of the hazard. Distance from the machine to the walls is 3 feet.



The assumed volume is calculated as follows:

$$(12 + 2 + 3) \times (3 + 2 + 3) \times (4 + 2) = 816 \text{ ft}^3.$$

Referring to figure 3-3 based on 50% of the perimeter enclosed, a factor of 0.625 lbs./min./ft^3 is used.

The total amount of carbon dioxide required to protect the above hazard is: 0.625 lbs./min./ft^3 = 510 lbs./min.

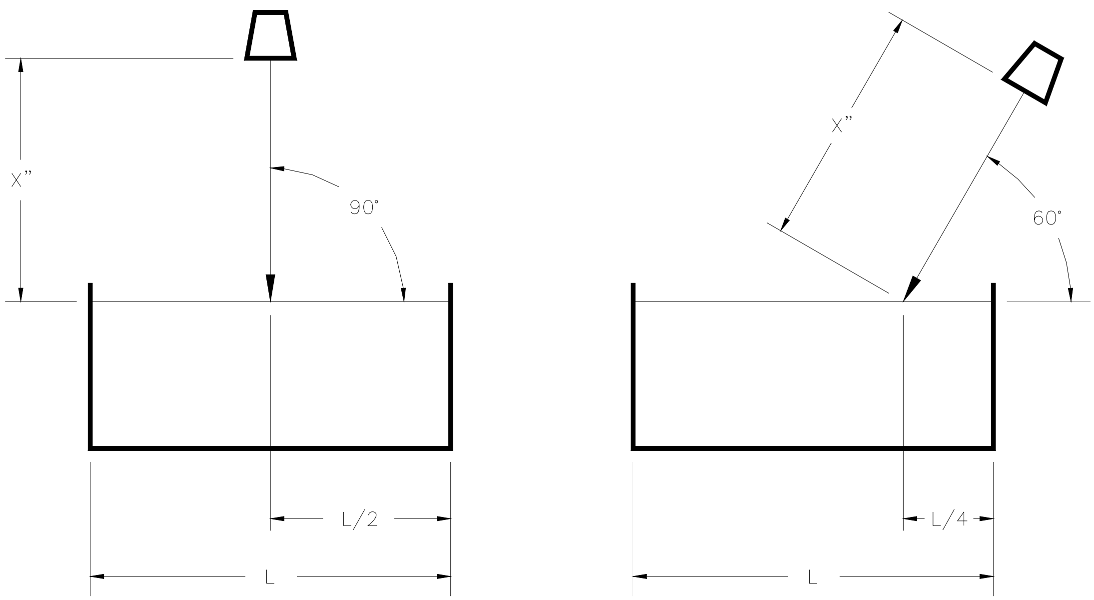
Therefore, the same hazard requires only 510 lbs./min. flow rate verses 672 lbs./min. when the hazard has a percentage of the perimeter permanently enclosed.

This same hazard, with a partial enclosure will only require (6) nozzles verses (8) nozzles for a hazard without any walls, when located at the same height above the hazard.

Discharge Angle (1)	Aiming Factor (2)
45-60	1/4
60-75	1/4-3/8
75-90	3/8-1/2
90 (Perpendicular)	1/2 (Center)

Note: (1) Degrees from plane of hazard surface.
(2) Fractional amount of nozzle coverage side-of-square.

Example:



Note: Distance "X" and the flow rate are the same in both examples, only the aiming point for the nozzle changes.

Table 3-7
Aiming Factors for Angular Placement of Nozzles, Based on 6" (152 mm) Freeboard

	Liquid		Coated		
Height (ft)	**Area (ft^2)**	**Side of Square**	**Area (ft^2)**	**Side of Square**	**Flowrate (lbs/min)**
2.00	8.85	2.98	12.39	3.52	39
2.25	9.42	3.07	13.25	3.64	45
2.50	10.00	3.17	14.06	3.75	50
2.75	10.57	3.26	14.82	3.85	55
3.00	11.14	3.34	15.60	3.95	60
3.25	11.71	3.43	16.40	4.05	65
3.50	12.28	3.51	17.22	4.15	70
3.75	12.86	3.59	18.06	4.25	75
4.00	13.43	3.67	18.84	4.34	81
4.25	14.00	3.75	19.62	4.43	86
4.50	14.57	3.82	20.43	4.52	91
4.75	15.15	3.90	21.25	4.61	96
5.00	15.72	3.97	22.09	4.70	101
5.25	16.29	4.04	22.85	4.78	106
5.50	16.86	4.11	23.62	4.86	112
5.75	17.43	4.18	24.40	4.94	117
6.00	18.01	4.25	25.30	5.03	122
6.25	18.58	4.32	26.11	5.11	127
6.50	19.15	4.38	26.83	5.18	132
6.75	19.72	4.45	27.67	5.26	137
7.00	20.30	4.51	28.52	5.34	142
7.25	20.87	4.57	29.27	5.41	148
7.50	21.44	4.64	30.03	5.48	153
7.75	22.01	4.70	30.91	5.56	158
8.00	22.58	4.76	31.70	5.63	163
8.25	23.16	4.82	32.49	5.70	168
8.50	23.73	4.88	33.29	5.77	173
8.75	24.30	4.93	34.11	5.84	179
9.00	24.87	4.99	34.93	5.91	184

Table 3-8
4” Cone Nozzle

	Liquid		**Coated**		
Height (ft)	**Area (ft^2)**	**Side of Square**	**Area (ft^2)**	**Side of Square**	**Flowrate (lbs/min)**
7.00	16.00	4.00	22.47	4.74	111
7.25	16.75	4.10	23.52	4.85	120
7.50	17.50	4.19	24.50	4.95	130
7.75	18.25	4.28	25.60	5.06	139
8.00	19.00	4.36	26.63	5.16	149
8.25	19.75	4.45	27.67	5.26	158
8.50	20.50	4.53	28.73	5.36	168
8.75	21.25	4.61	29.81	5.46	178
9.00	22.00	4.70	30.80	5.55	187
9.25	22.75	4.77	31.92	5.65	197
9.50	23.50	4.85	32.95	5.74	206
9.75	24.25	4.93	33.99	5.83	216
10.00	25.00	5.00	35.05	5.92	225
10.25	25.00	5.00	35.05	5.92	240
10.50	25.00	5.00	35.05	5.92	254
10.75	25.00	5.00	35.05	5.92	268
11.00	25.00	5.00	35.05	5.92	282
11.25	25.00	5.00	35.05	5.92	297
11.50	25.00	5.00	35.05	5.92	311
11.75	25.00	5.00	35.05	5.92	325
12.00	25.00	5.00	35.05	5.92	339

Table 3-9
5 1/2" Cone Nozzle

	Liquid		Coated		
Height (ft)	Area (ft^2)	Side of Square	Area (ft^2)	Side of Square	Flowrate (lbs/min)
12.00	16.10	4.02	22.56	4.75	284
12.25	16.91	4.12	23.72	4.87	299
12.50	17.70	4.21	24.80	4.98	313
12.75	18.47	4.30	25.91	5.09	328
13.00	19.23	4.39	26.94	5.19	342
13.25	19.98	4.47	27.98	5.29	356
13.50	20.71	4.56	29.05	5.39	369
13.75	21.43	4.63	30.03	5.48	383
14.00	22.13	4.71	31.02	5.57	396
14.25	22.82	4.78	32.04	5.66	408
14.50	23.50	4.85	32.95	5.74	421
14.75	24.17	4.92	33.87	5.82	433
15.00	24.83	4.99	34.81	5.90	446
15.25	25.48	5.05	35.76	5.98	458
15.50	26.11	5.11	36.60	6.05	469
15.75	26.74	5.18	37.45	6.12	481
16.00	27.35	5.23	38.32	6.19	492
16.25	27.96	5.29	39.19	6.26	504
16.50	28.56	5.35	40.07	6.33	515
16.75	29.15	5.40	40.83	6.39	526
17.00	29.73	5.46	41.73	6.46	536
17.25	30.30	5.51	42.51	6.52	547
17.50	30.86	5.56	43.30	6.58	557
17.75	31.41	5.61	44.09	6.64	568
18.00	31.96	5.66	44.76	6.69	578
18.25	32.50	5.71	45.56	6.75	588
18.50	33.03	5.75	46.38	6.81	598
18.75	33.56	5.80	47.06	6.86	607
19.00	34.08	5.84	47.75	6.91	617
19.25	34.59	5.89	48.44	6.96	626
19.50	35.09	5.93	49.14	7.01	636
19.75	35.59	5.97	49.84	7.06	645
20.00	36.08	6.01	50.55	7.11	654

Table 3-10
7” Cone Nozzle

SECTION 4

INSTALLATION

Table of Contents

SECTION 4

INSTALLATION

4-1 GENERAL

This specification is to be used as a minimum standard for installation of piping, supports, hangers and system components. If the requirements of local codes or the authority having jurisdiction are more stringent, these more stringent requirements shall take precedence. Installation shall be performed in a workman like manner according to the highest standards.

A. All pipe and fittings shall be new and of recent manufacture.

B. All pipe shall be reamed after cutting so that all burrs and sharp edges are removed.

C. All pipe shall be blown clean and swabbed thoroughly with solvent inside before installation to remove foreign matter and oil. Some effective solvents are trichlorethylene, perchlorethylene or trichlorethane.

D. All pipe and fittings installed outdoors or in corrosive areas should be galvanized or coated with a proper rust inhibitor.

E. All screwed pipe shall be coated with Teflon tape or an approved pipe joint compound. Coating of the threads must start at least two threads back from the pipe end.

4-2 STORAGE UNIT

4-2.1 Location

A. The storage unit should not be located in an area where it will be subjected to temperatures above 120° F (34.6° C) or temperatures below -10° F (-23.3° C).

B. Dusty, oily locations should be avoided. The collection of such material on the refrigeration condenser may reduce it's efficiency. A dry, well ventilated location is preferable. The storage unit should not be located in an area where it might be subject to damage by moving or falling objects. A break in the insulation shell could destroy the vapor seal and allow water to enter the insulation and cause deterioration or loss of insulation efficiency.

C. Sufficient clearance should be provided at the front and rear of the storage unit to permit easy access to the refrigeration unit and manway access panel. Allow at least 4' (1.3 m) of clearance to service the refrigeration unit. Do not obstruct or restrict the flow of air to the refrigeration unit.

D. The installation of a carbon dioxide storage unit in or on a building, platform, or any existing surface should only be made after it has been determined that the surface can support the system.

E. If the storage unit is to be installed on concrete foundations, structural steel supports on concrete foundations or piers the foundations shall extend below the frost line.

F. A concrete slab without footing may be used if acceptable to local codes or other authority having jurisdiction. When so installed, flexibility should be provided in piping and electrical conduit.

G. Storage unit shall be located as near as possible to the hazard or hazards they protect, but they shall not be located where they will be exposed to a fire or explosion in these hazards. (NFPA 12, 2005 Paragraph 4.6.4.3)

H. Storage units shall not be located so as to be subject to severe weather conditions or be subject to mechanical, chemical, or other damage. (NFPA 12, 2005 Paragraph 4.6.4.4)

I. When excessive climatic or mechanical exposures are expected, suitable guards or enclosures shall be provided. (NFPA 12, 2005 Paragraph 4.6.4.5)

J. Carbon dioxide storage units are generally filled from large cargo tank trailers, up to 20 tons capacity. Therefore, the location selected should be within 20’ (6 m) of driveways capable of supporting these delivery units or the fill lines must be extended. The storage unit should also be as close to the point of use as is possible.

K. If a small enclosed location is used, the outlet from the safety relief valves should be piped to the outside or a point where discharge of carbon dioxide vapor will not result in a high concentration of carbon dioxide. Such piping must be provided with drain holes at low points and must not be equipped with valves or other means of restricting or stopping the flow of gas. The size of the discharge line should be such that any pressure that may exist or develop will not reduce the relieving capacity of the pressure relief device below that required.

L. If the storage unit is located indoors, the relief valves must be piped outside. The relief valves are calculated with 50’ (15 m) of discharge piping. If more than 50’ (15 m) of piping is required consult Tomco$_2$ Fire Systems and the relief valves can be re-calculated.

4-2.2 Handling

A. Upon arrival, the storage unit and all other components should be inspected for transit damage. Any such damage should be reported to the carrier at once and noted on the freight bill.

B. The storage unit should be unloaded by a crane using cables and spreader bars, unless it can be rolled on dollies or pipe rollers. Lifting lugs are located on top of the vessel. (See figure 4-1)

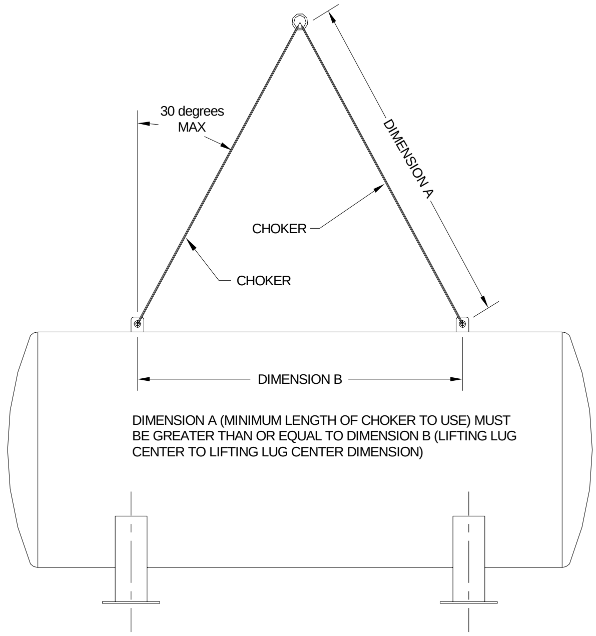


Figure 4-1
Rigging Detail

C. When the storage unit is in position, it shall be inspected for rigging damage.

4-2.3 Initial Fill of Storage Unit

Caution: Initial fill of storage unit shall be performed by a qualified refrigeration and carbon dioxide equipment specialist.

A. Ensure the following storage unit conditions are as specified:

1. Compressor horsepower/voltage.
2. Mounting and anchoring.
3. Tank shut-off valve mounted and in closed position.
4. Power supply voltage.
5. Electrical feed voltage and overcurrent protection.
6. Field wiring terminations.
7. Electrical supply’s disconnect means.
8. Refrigeration unit’s disconnect switches in OFF position.
9. Electrical grounding.
10. Refrigerant sight glass indicates a dry system.

B. Prepare the storage unit for filling: (See figure 4-2)

1. Loosen shipping bolts on compressor unit.

2. Momentarily energize motor starter and check for correct rotation of condenser fan.

3. Open service valve at liquid reservoir, pressurizing refrigeration system.

4. Close service valve and check refrigeration piping for leaks.

5. Open all refrigeration service valves.

Caution: Failure to purge storage unit will adversely affect the unit's cooling efficiency.

C. Purge the storage unit:

Your CO_2 supplier should follow his standing procedure for purging a new system. If your supplier has no set procedure for purging or does not have a purity tester to check for air, the following procedure should be followed.

1. Blow tank pressure down to 0 psig through vapor process valve.

2. Pressurize to 10 psig, allow to stand 2 minutes.

3. Blow down to 2 psig through vapor process valve.

4. Repeat steps 2 and 3 at least 5 times.

D. Fill the storage unit: (See figure 4-3)

1. Pressurize with carbon dioxide vapor to 100 psig.

2. Check for leaks.

3. Open instrument vapor supply valve.

4. Purge instrument piping at pressure gauge.

5. Verify gauge pressure with CO_2 supply pressure.

6. Open instrument equalizer valve.

7. Check for leaks.

8. Check pressure on suction side of compressor for a possible carbon dioxide leak in evaporator coil.

   a. Connect refrigeration test gauge to the suction side at the compressor test fitting.

   b. If pressure of 300 psig is found, contact $Tomco_2$ Fire Systems for direction.

   c. Remove refrigeration test gauge.

9. Open all refrigerant service valves.

10. Put approximately 1,000 lbs. of liquid carbon dioxide into the storage unit.

11. Check all liquid piping and valves for leaks.

12. Build storage unit pressure to 308 psig.

13. Close refrigeration disconnect switch - ON position.

14. Refrigeration system should start.

15. Monitor suction and discharge pressures for 15 minutes.

Caution: Do not adjust the refrigeration unit's expansion valve. The valve is factory set. Improper adjustment could cause compressor failure and void all warranties.

   a. Suction pressure should settle between 15 and 22 psig at ambient temperature of 60º F (16ºC) or above. However, it is not uncommon for the suction pressure to fluctuate slightly as the thermostatic expansion valve throttles.

   b. Refrigerant level is factory set by the superheat method. Superheat method should not exceed 15º F (-9º C), however, 9º F (-13º C) to 12º F (-11º C) superheat is preferred. Coil temperature should be -20º F (-29ºC) and suction line temperature should be approximately -8º F (-22º C).

16. Finish filling storage unit.

17. Monitor suction and discharge pressures during the on cycle.

18. Turn the refrigeration system off and check the oil level in the compressor after it has operated for approximately two hours.

19. Allow the refrigeration system to cycle (lower the unit pressure to 295 psig). At or about 295 psig, an electrical signal will close the liquid line solenoid valve. The refrigeration unit will continue to run until all the refrigerant in the system is pumped into the refrigerant reservoir. Once this cycle is completed, the refrigeration dual pressure control (set at 6 psig off and 20 psig on) will shut the system off. System will continue to cycle on and off if pressure goes higher than 20 psig. This cycle is commonly referred to as a "repeat pump down cycle".

20. Check the Storage unit's pressure, 290 to 305 psig, during the first few days of operation.

4-2.4 Fill Level

The level of the liquid carbon dioxide in the storage unit must be kept below the evaporator coils. After the tank is filled, the vapor balancing line valve should be opened slightly to observe the discharge of carbon dioxide. If the discharge is clear to slightly foggy, the unit is properly filled. If the discharge is dense and containing particles of dry ice, the liquid level in the tank is too high indicating an overfill condition. If the unit has been overfilled, open the vapor balancing line valve until the discharge becomes clear or only slightly foggy.

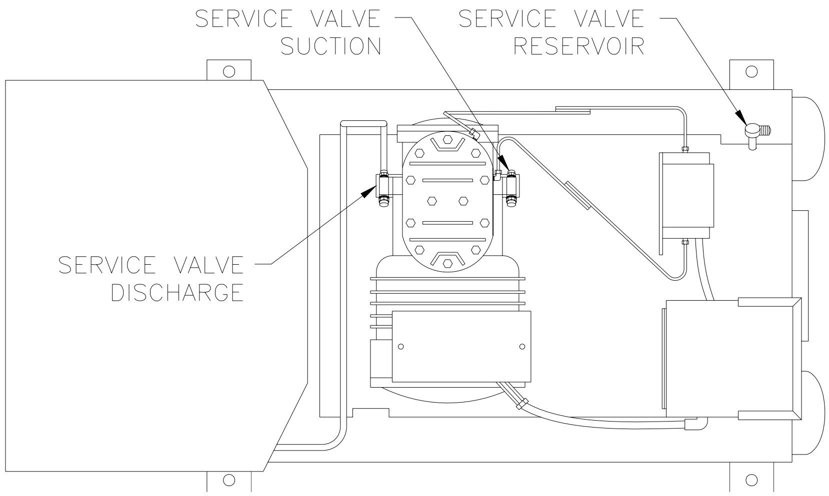


Figure 4-2
Compressor Service Valve Location

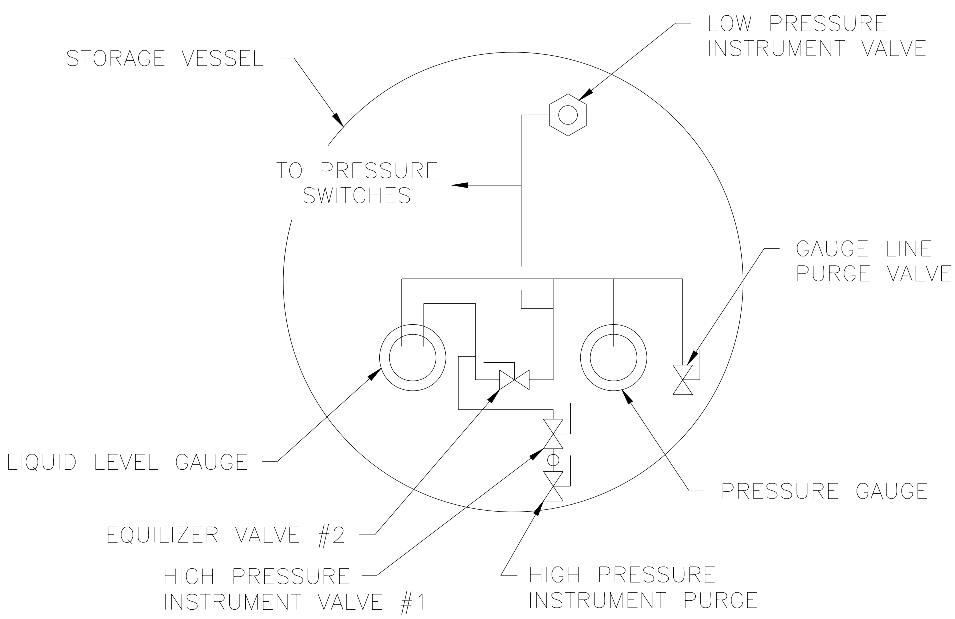


Figure 4-3
Instrument Piping Detail

4-2.5 Check for Leaks

A. Carbon dioxide leaks should be easily detected by the appearance of a white gas or by frost or ice on piping. It maybe necessary to test pipe connections and valves with a bubble solution to locate small leaks.

B. Evidence of refrigerant loss is usually associated with the refrigeration system "short cycling", continuous operation of the refrigeration unit or high storage unit pressure although refrigeration system is operating.

C. Refrigerant leaks can best be detected by a leak detector.

D. Whenever checking for refrigerant leaks, be sure to test all connections in the refrigerant lines. Start at the compressor and follow through the entire system

4-2.6 Check Operation of High and Low Pressure Alarms

The pressure switches are normally activated whenever tank pressure drops below 250 psig or rises above 315 psig. The pressure switch should be tested to verify that the switch is in good working order and will activate the control panel and properly operate the compressor. To test the pressure switches:

A. Close pressure gauge shutoff valve.

B. Open valve located below the pressure gauge. Alarm should sound indicating low pressure switch is operative.

C. Open pressure gauge shutoff valve. Alarm panel should reset.

4-2.7 Storage Tank Power Requirements

A. Refer to table 4-9 and drawing TFS-Wiring-1PH-05 (single phase) or drawing TFS-Wiring-3PH-05 (three phase) for recommended wire sizes, circuit ratings and fuse sizes to supply the AC power to the storage tank.

B. POWER SUPPLY DEPENDABILITY - Careful consideration shall be given in each case to the dependability of the electrical supply and wiring system. This shall include the possible effect of fire that may threaten the service to the storage unit.

C. Electrical service shall be installed in accordance with NFPA 70 (National Electric Code) and all state and local codes.

4-3 TANK SHUT-OFF VALVE

Caution: Do not force the valve in either extreme direction when operating with the handwheel. Operating the valve hard against its stops may cause mis-alignment between the disc and its seat, resulting in possible leakage.

A. The tank shut-off valve is designed to be mounted between standard 300 lb. ANSI flanges. When the valve is open, the disc will extend into the pipe on both sides of the valve, further on the body side than the seat retainer side of the valve. Piping must be large enough to allow the disc to clear the pipe. The valve is operated by turning the handwheel counter clockwise to open, clockwise to close. The minimum pipe ID allowable and standard pipe ID’s are listed in tables 4-2 and 4-3.

B. Install the valve with the seat retainer upstream.

C. When the disc is in the closed position, carefully center valve between flanges. Tapped holes match ANSI pipe flanges and assist in positive alignment.

D. Tighten bolts in sequential order in 20% (40 ft. lbs.) increments until final torque of 200 ft. lbs. is reached. Refer to figure 4-5 and 4-6 for bolt torque order.

E. Gaskets should conform to the requirements of API Standard 601, Edition 3 for ANSI B16.5 class flanges ‘garlock’ blue-gard style 3200 compressed non-asbestos or equal.

Note Tables 4-2 and 4-3:

A. Minimum I.D. of pipe with recommended clearances (per API 609) have been calculated by adding the minimum I.D. with zero clearance to a minimum recommended diametric clearance for each pipe size.

B. These tables assume that the pipe is on the body side of the valve and that the pipe is perfectly centered. The seat retainer side of the valve will always have more clearance than the body side.

C. A minimum of 1/8" thick gasket is used between the pipe flange and valve body face.

D. When using a pipe whose I.D. is smaller than the recommended minimum inside diameter of pipe with adequate clearance, a chamfer of 45 degrees should be provided on the end of the pipe so that it clears the disc.

Minimum Inside Diameter Of Pipe With The Recommended Clearance	
Valve Size	Class 300
3	2.867
4	3.745
6	5.710
8	7.600

Table 4-2

Nominal Inside Diameter Of Pipe		
Valve Size	Sch. 40	Sch. 80
3	3.068	2.900
4	4.026	3.826
6	6.065	5.761
8	7.981	7.625

Table 4-3

4-3.1 Attaching Hardware

Warning: Failure to use correct attaching hardware may result in joint failure. Ensure bolt/stud length is correct for the specific stack-up.

A. Bolts, threaded rod and nuts used to attach the valve to a 300 lb. ANSI flange shall be:

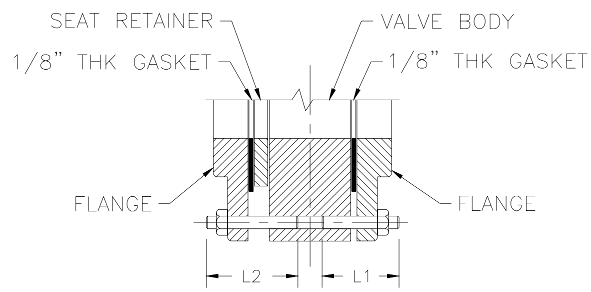
1. North American manufacture.
2. Grade 8, heat treated steel.
3. Zinc or dichromate plated.

B. Gaskets used between the pipe flange and valve body shall:

1. Conform to the requirements of API Standard 601, Edition 3 for ANSI B16.5 Class flanges ‘garlock’ blue-gard style 3200 compressed non-asbestos or equal.
2. Be 1/8” minimum thickness.

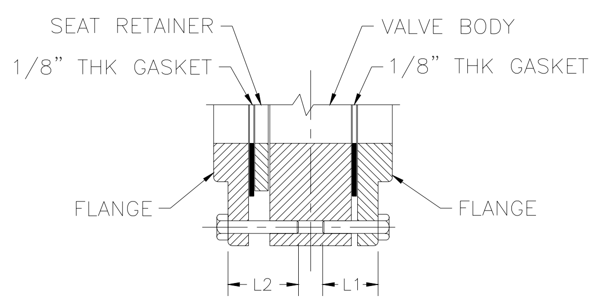
C. Bolting information and dimensional data in figure 4-4 can be used for tank shut-off/lock-out valves (3” - 8”) mounted between gaskets and standard 300 lb. ANSI flanges. Measure actual stack-up of assembly to ensure correct bolt length.

Studs & Hex Nuts



Valve Size	Lugged		
	L1	L2	Qty.
3"	¾ - 10 x 2.75	¾ - 10 x 3.25	8
4"	¾ - 10 x 3.00	¾ - 10 x 3.50	8
6"	¾ - 10 x 3.25	¾ - 10 x 4.00	12
8"	7/8 - 9 x 4.00	7/8 - 9 x 4.50	12

Hex Head Machine Bolts



Valve Size	Lugged		
	L1	L2	Qty.
3"	¾ - 10 x 2.25	¾ - 10 x 2.25	8
4"	¾ - 10 x 2.50	¾ - 10 x 2.50	8
6"	¾ - 10 x 3.00	¾ - 10 x 3.00	12
8"	7/8 - 9 x 3.50	7/8 - 9 x 3.50	12

Figure 4-4
Flange Bolting Guide - Lug Pattern Valves

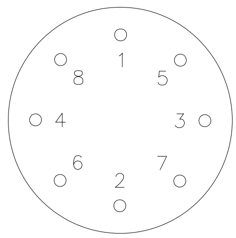


Figure 4-5
3” & 4” Valve
Bolt Torque Order

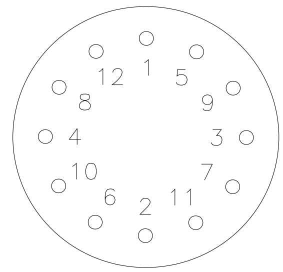


Figure 4-6
6” & 8” Valve
Bolt Torque Order

4-4 MASTER/SELECTOR VALVE ASSEMBLY

A. The master/selector valve sizes ½” - 2" are threaded ball valves.

1. When installing the threaded ball valves, be sure the threads on the mating pipe are free from grit, dirt, or burrs. Care must be taken to assure that any pipe sealants used are not so excessively applied to the pipe threads that the valve cavity becomes obstructed.

B. The master/selector valve sizes 3” - 8” are designed to be mounted between standard 300 lb. ANSI flanges. When the valve is open, the disc will extend into the pipe on both sides of the valve, further on the body side than the seat retainer side of the valve. Piping must be large enough to allow the disc to clear the pipe. The valve is operated by turning the handwheel counter clockwise to open, clockwise to close. The minimum pipe ID allowable and standard pipe ID’s are listed in tables 4-2 and 4-3.

1. The valve shall be installed with the seat retainer upstream.

2. With the disc in closed position, carefully center valve between flanges.

3. Tighten bolts in sequential order in 20% (40 ft. lbs.) increments until final torque of 200 ft. lbs. is reached. Refer to figure 4-5 and 4-6 for bolt torque order.

C. Since the emergency mechanical operator is located on the solenoid, the master/selector valves should be located in an easily accessible location.

4-4.1 Attaching Hardware

Warning: Failure to use correct attaching hardware may result in joint failure. Ensure bolt/stud length is correct for the specific stack-up.

A. Bolts, threaded rod and nuts used to attach the valve to a 300 lb. ANSI flange shall be:

1. North American manufacture.

2. Grade 8, heat treated steel.

3. Zinc or dichromate plated.

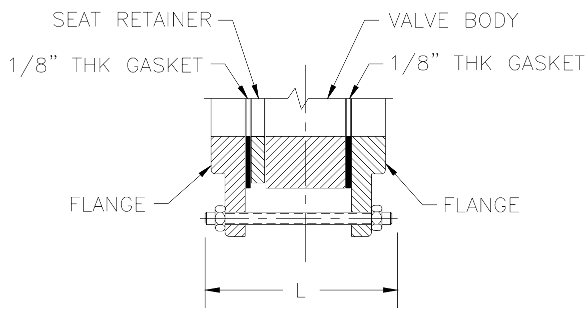
B. Gaskets used between the pipe flange and valve body shall:

1. Conform to the requirements of API Standard 601, Edition 3 for ANSI B16.5 Class flanges ‘garlock’ blue-gard style 3200 compressed non-asbestos or equal.

2. Be 1/8” minimum thickness.

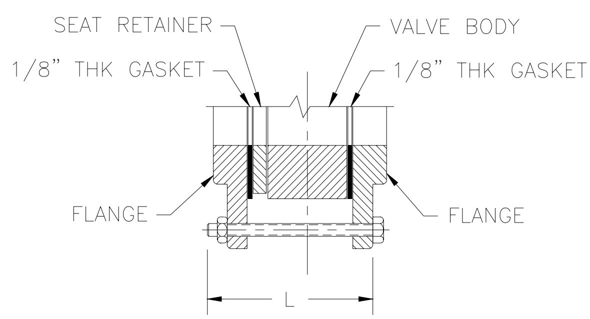
C. Bolting information and dimensional data in figure 4-7 can be used for master/selector valves (3” - 8”) mounted between gaskets and standard 300 lb. ANSI flanges. Measure actual stack-up of assembly to ensure correct bolt length.

Stud Bolts & 2 Hex Nuts



Valve Size	Wafer	
	L	Qty.
3	¾ - 10 x 6.00	8
4	¾ - 10 x 6.25	8
6	¾ - 10 x 7.25	12
8	7/8 - 9 x 8.25	12

Hex Head Bolts



Valve Size	Wafer	
	L	Qty.
3	¾ - 10 x 5.50	8
4	¾ - 10 x 5.25	8
6	¾ - 10 x 6.50	12
8	7/8 - 9 x 7.50	12

Figure 4-7
Flange Bolting Guide - Wafer Pattern Valves

4-4.2 Solenoid Valve

4-4.2.1 Positioning

The solenoid valve is factory installed on the valve actuator.
Exception: If a timer cabinet is used the solenoid is factory installed in the cabinet.

4-4.2.2 Piping

Caution: To insure operation of the valve, the pressure and exhaust lines must be full flow without restriction, and a minimum differential pressure as stamped on the nameplate must be maintained between the pressure and exhaust. Do not install any restrictive devices in either the pressure (inlet) connection or the exhaust (outlet) connection of the valve. Restricting either of these lines may cause valve malfunction.

A. Connect piping to the ¼″ (6.35 mm) in-line filter. The solenoid valve is factory installed on the actuator.

B. For protection of the solenoid valve, a filter is installed in the inlet side of the valve. Periodic cleaning is required, depending on the service conditions.

4-4-2.3 Wiring

A. Wiring must comply with local and national electrical codes. Housings for all solenoids are made with connections for 1/2 inch conduit.

B. Solenoid valves are only available with 24 vdc coils having a current draw of 0.30 amps.

C. Wiring to solenoids should be minimum No. 16 AWG, 300V ins color coded wire. The wiring between the releasing panel and solenoid shall be fully supervised.

4-5 LOCK-OUT VALVE ASSEMBLY

A. The lock-out valve sizes ½” - 2" are threaded ball valves.

1. When installing the threaded ball valves, be sure the threads on the mating pipe are free from grit, dirt, or burrs. Care must be taken to assure that any pipe sealants used are not so excessively applied to the pipe threads that the valve cavity becomes obstructed.

B. The lock-out valve sizes 3” - 8” are designed to be mounted between standard 300 lb. ANSI flanges. When the valve is open, the disc will extend into the pipe on both sides of the valve, further on the body side than the seat retainer side of the valve. Piping must be large enough to allow the disc to clear the pipe. The valve is operated by turning the handle to open and close. The minimum pipe ID allowable and standard pipe ID’s are listed in tables 4-2 and 4-3.

1. The valve shall be installed in any direction for the ball valve and with the retaining ring on the upstream side for butterfly valves.

2. With the disc in closed position, carefully center valve between flanges.

3. Tighten bolts in sequential order in 20% (40 ft. lbs.) increments until final torque of 200 ft. lbs. is reached. Refer to figure 4-5 and 4-6 for bolt torque order.

4. Refer to paragraph 4-3.1 for attaching hardware requirements.

C. Since the mechanical operator is located on the valve, the lock-out valves should be located in an easily accessible location.

4-6 WELDING

A. All welding must be performed by a certified welder.

B. All welded pipe 3/4" and smaller shall be welded using a gas welding or other approved method.

C. All welds shall be clean from scale, flux and weld beads.

D. No backing rings (chill rings) are permitted.

4-7 MATERIALS

A. All materials shall be of the highest grade, free from defects and imperfections.

B. Piping shall be of noncombustible material having physical and chemical characteristics such that its deterioration under stress can be predicted with reliability. Special corrosion resistant materials or coatings may be required in severely corrosive atmospheres. Examples of materials for piping and the standards covering these materials are:

1. Ferrous Piping: Black or galvanized steel pipe shall be either ASTM A-53 seamless or electric welded, Grade A or B, or ASTM A-106, Grade A, B, or C. ASTM A-120 and ordinary cast-iron pipe shall not be used. Pipe shall be a minimum of Schedule 40. Furnace butt weld ASTM-53 may be used.

2. This standard does not preclude the use of other materials such as stainless steel or other piping or tubing providing for low pressure supply, an internal pressure of 450 psig, which will not cause material stress greater than the material's yield point when calculated according to ANSI B-31.1, Power Piping Code.

C. Flexible piping, tubing, or hoses (including connections), where used, shall be of approved materials and pressure ratings. It shall be inspected regularly.

Warning: Class 150 and cast-iron fittings shall not be used.

D. Fittings shall be class 300 malleable or ductile iron fittings through 3" and 1000 lb. ductile iron or forged steel fittings in all larger sizes. Flanged joints shall be class 300.

E. Welded joints, screwed or flanged fittings (malleable iron or ductile iron) may be used. Mechanical grooved couplings and fittings may be used if they are specifically listed for carbon dioxide service. Flush bushings shall not be used. When hex bushings are used, more than one pipe size reduction or a 3,000 lb. (6,615-kg) forged steel bushing shall be provided to maintain adequate strength. Suitable flared, compression-type, or brazed fittings shall be used with copper or brass tubing. Where brazed joints are used, the brazing alloy shall have a melting point of 1,000° F (538° C) or higher.

F. The piping system shall have a minimum bursting pressure of 1800 psig (124.1 bars).

G. Reductions in welded pipe shall be by one of the following methods:

1. Butt weld concentric reducers.

2. Swaged nipples.

3. Weld-o-lets.

4. Where socket weld fittings are permitted, a socket weld reducing coupling can be used only for a one size reduction. All other reductions in socket weld pipe shall be made using the above permitted methods.

When methods 2, 3, or 4 are used, it is imperative that these fittings be installed in strict accordance with the manufacturer's installation instructions. In each case they must be installed so as to permit full flow. All entrance holes from the main pipe run to the fitting must be of proper size and free of sharp edges, ridges or burrs.

H. All reductions in screwed pipe shall be by means of concentric reducers or swaged nipples. Hex bushings, although permitted by NFPA 12, are not recommended.

I. All pipe branching shall be from the side or bottom of the header or sub-header. Where branching involves a reduction of several pipe sizes, a bottom take-off is preferred.

J. Flanges:

1. All flanges must be 300 lb. ANSI Class forged steel.

2. All weld neck flanges used with schedule 80 pipe must have extra heavy pipe wall (Bore schedule 80). All weld neck flanges used with schedule 40 pipe must have standard weight pipe wall (Bore schedule 40).

3. Where flanged pipe connections are used, they shall be gasketed with 1/8" thick gasket "garloc", Blue-Gard style 3200 compressed non-asbestos or approved equal.

4. High grade steel bolts (Grade 8 as per ASTM A-193) or studs with graded nuts shall be used on all flanged connections. All nuts shall have full engagement on the bolt or stud. (Use Grade 8 per ASTM A-194 or better).

K. Grooved fittings can be used on the distribution piping downstream of the master valve. The pipe shall be grooved in accordance with the manufacturers' installation instructions. Grooved fittings shall be approved for carbon dioxide service at 1000 psig working pressure. The fittings shall be Victaulic Style HP-70, 75, 77 or 07 with an EPDM gasket, Gustin-Bacon Gruvagrip number 100, 120 or 125 with EPDM or Buna-N gasket or Grinnell number 7001, 7013 or 7401 with rubber gasket. Bolts and nuts to meet manufacturers' specifications.

Note: Grooved fittings have not been approved by FM Approvals for CO_2 service.

4-8 TANK HEADER

The tank header is under continuous pressure; therefore, it shall be constructed of Schedule 80 black steel pipe as outlined in section 4-7 paragraph B.1 with extra heavy butt welding fittings and ANSI 300 lb. Class flanges.

A. The tank header can be fabricated using one of the following procedures or by a combination of these procedures.

   1. By the use of extra heavy butt welding fittings.

   2. By the use of extra heavy Weld-o-lets or Thread-o-lets. Thread-o-lets shall only be used for those devices which are only available with treaded connections.

   When procedure 2 is used, it is imperative that these fittings be installed in full accordance with the manufacturer's installation instructions.

B. All welds must allow full flow. No miter weld fittings shall be used. Backing rings (chill rings) shall not be used.

C. The ends of the header pipe should be blanked off with butt-welding caps or blind flanges.

D. A 450 psig pressure relief valve shall be installed in the header.

4-9 ACTUATION LINE

A. All piping shall be either 1/2" threaded schedule 40 black pipe or stainless steel tubing 0.035 wall thickness.

B. All threaded actuation line pipe connections shall be treated with a suitable pipe sealant. The use of Teflon tape is not permitted.

C. All pipe fittings shall be 300 lb. malleable or ductile iron. A 300 lb. brass to steel union shall be installed near the terminations of all pneumatic actuation lines. 150 lb. Fittings are not permitted.

D. Copper tubing shall not be used.

E. If stainless steel tubing is used, the following applies:

   1. All steel tubing shall be 1/2" x 0.035 wall thickness.

   2. All tubing must be reamed after cutting.

   3. Tube fittings shall be of the same material as the tubing and shall be of the compression type. Tube to pipe fitting shall be treated with a pipe sealant as described above.

   4. All tubing shall be properly supported.

F. The in-line filter shall be installed before the solenoid and pneumatic actuator on all master/selector valves.

G. A 120 psig pressure relief valve shall be provided at the end of the actuation line.

H. A pressure regulator must be installed in the actuation line to maintain 100 psig.

4-10 MASTER VALVE PIPING

Caution: Ensure the check valve direction of flow is correct.

Master valve shall be provided with a by-pass check valve to allow trapped pressure to bleed back to the storage tank.

All piping downstream of master valve (between master valve and selector valves or between master valves) shall be either:

A. Sch. 40 black steel pipe welded with welded fittings.

1. Standard weight socket weld fittings are acceptable with the exception that no reducing bushings are to be used and a socket weld reducing coupling can be used only for a one size reduction. All other reductions shall be made using a butt-welding concentric reducer.

2. Standard weight butt-welding fittings. BACKING RINGS (CHILL RINGS) SHALL NOT BE USED.

3. 1000 lb. forged steel screwed fittings, back-welded.

B. Sch. 40 black steel pipe with listed grooved type fittings.

1. Where grooved couplings and fittings are used, they shall be listed/approved for use with low pressure carbon dioxide fire systems.

2. Pipe preparation and installation must be in strict accordance with the manufacturers recommended procedure.

3. Grooved fittings shall be installed so as to allow contraction of the pipe (ends butted together).

4. Grooved fittings must be approved in advance by the authority having jurisdiction with approval obtained prior to start of design.

C. Sch. 80 black steel pipe with threaded fittings.

1. Threaded pipe fittings shall be class 300 lb. malleable iron or ductile iron for pipe through 3". 1000 lb. ductile iron or forged steel shall be used in all larger sizes.

4-11 DISCHARGE PIPING

Piping downstream of selector valves and master valves, that is, piping which is open to atmosphere shall be schedule 40. Screwed pipe joints are always permitted and in most installations, approved grooved pipe connections may be used. Approval from the authority having jurisdiction must be sought prior to the start of design for the project.

A. Threaded Pipe Fittings:

1. Threaded pipe fittings shall be class 300 lb. malleable iron or ductile iron for pipe through 3". 1000 lb. ductile iron or forged steel shall be used in all larger sizes.

B. Grooved Fittings:

1. Grooved couplings and fittings shall be listed/approved for use with low pressure carbon dioxide fire systems.

2. Pipe preparation must be in strict accordance with the manufacturers' recommended procedure. Installation must be exactly as per the manufacturers' specification in all respects.

3. Grooved couplings shall be installed so as to allow contraction of the pipe (pipe ends butted together).

4-12 PRESSURE RELEASE AND PRESSURE OPERATED SIREN PIPING AND FITTINGS

Piping shall be as specified for discharge piping. All branch connections for pressure release piping shall be from the top of the discharge piping.

4-13 DIRT TRAP

A. Dirt traps are to be installed:

1. Beyond the last branch connection of each main header.

2. Beyond the last branch connection of each subheader.

3. Beyond the last branch connection of each nozzle piping arrangement.

B. The dirt trap shall be at least 2" long, terminating in a malleable iron or ductile iron threaded cap. A longer nipple up to approximately 18" is preferred where space permits.

C. The nipples for dirt traps in headers involving schedule 40 pipe with welded joints shall be schedule 80, threaded one end to receive threaded cap as shown in figure 4-8.

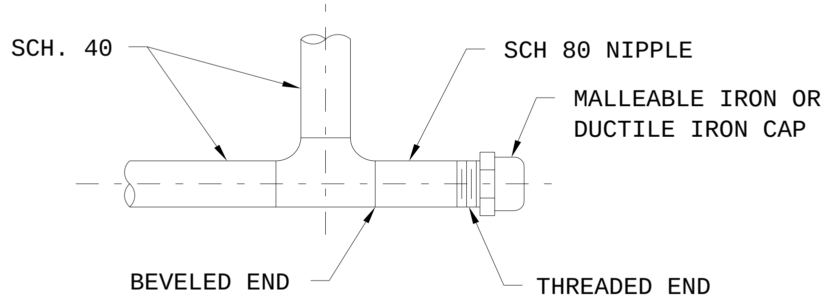


Figure 4-8
Typical Dirt Trap

4-14 FILL AND EQUALIZING LINES

A. Fill and Equalizing lines, figure 4-9, must be terminated in plugged unions (Crane Cat. No. 252H - no exceptions). These termination points must be a minimum of 8" apart, centerline to centerline, 3' 6" (1 m) above grade or floor and securely anchored. The male side of the unions must be connected to the pipe. Since the unions are furnished on the storage unit fill and equalizing lines, they can be removed and used at the termination points of the extended fill and equalizing lines. 300 pound malleable iron, galvanized unions can then be substituted at the storage unit.

B. The pipe size for fill and equalizing lines shall be as called for on drawings and shall be:

1. Schedule 80 black steel pipe with class 300 malleable iron or ductile iron, fittings.

2. Schedule 40 black steel pipe with welded joints. Fittings to be butt-welding, Tube-Turns or equal, or class 1000 minimum socket weld fittings.

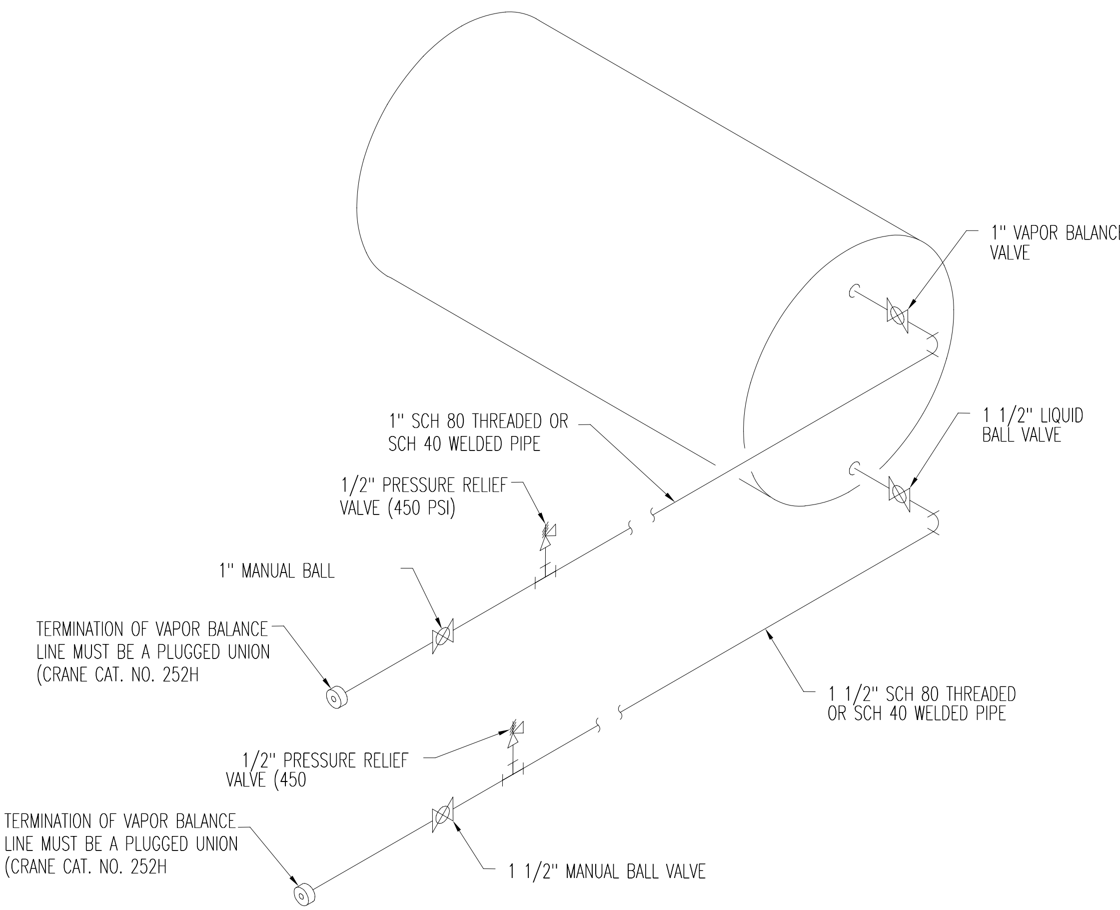


Figure 4-9
Fill Line Extension

4-15 VENT LINE

When a storage unit is located in a building, all vent lines should be piped to the outside. The pipe size of this extension of the vent line shall be as called for on the drawings and shall be Sch. 40. Fittings shall be class 300 malleable iron or ductile iron. A class 300 malleable iron union shall be used to connect the extended vent line to the storage unit. Any weather-preventive fittings supplied with the storage unit are to be moved to the termination point of the extended vent line to prevent rain, snow, etc. from entering the piping. TOMCO$_2$ FIRE SYSTEMS MUST BE CONSULTED FOR PIPE LIMITATIONS.

4-16 NOZZLES

Since there are many different types of hazards, a wide variety of nozzles are used. Pipe connection type and size are to be as specified on the system drawings.

4-17 UNDERGROUND PIPING

Underground piping is to be avoided. If unavoidable, a routing for underground piping will be submitted for approval to system designer prior to the start of design.

A. Unless otherwise specified, all underground piping shall be schedule 80 black steel pipe with butt-welded joints. Fittings to be either extra heavy steel butt-welding fittings or socket-weld fittings, class 1000 minimum, in sizes up to and including 2". NO CHILL RINGS ARE PERMITTED. In hazardous locations where welding is not permitted, flanged connections are to be used. Welding of flanges can be accomplished in a non-hazardous area.

B. Pipe joints to be tested for leaks at 300 psig before corrosion prevention coating is applied.

C. All underground piping is to be treated and wrapped with a suitable material to provide an absolute seal so as to prevent ground moisture from coming in contact with the pipe. Pre-wrapped schedule 80 pipe is acceptable if joints are properly treated.

D. Trench depth for underground piping to be a minimum of 3' but in no case less than lowest frost depth. Piping run in the ground but beneath a building floor slab need not be as deep unless the building is unheated and the ground is subject to freezing.

4-18 PIPE SLEEVES

All piping through building walls, partitions, floor slabs, roof slabs and the like, shall be sleeved.

A. Sleeves shall be schedule 40 pipe at least two sizes larger than the pipe being sleeved. One inch pipe is the minimum size to be used as a sleeve.

B. Sleeves shall be packed with an approved sealing material to maintain the fire rating of the wall or floor being penetrated.

C. Sleeves through floor slabs must extend at least 2" above the floor. A greater extension may be used if required by local building codes.

D. Sleeves extending through roof slabs must extend above the roof and be flashed in accordance with local building codes.

4-19 EXPANSION JOINTS

A. Contraction of steel piping during discharge is based on 1" of contraction per 100 feet of steel pipe.

B. Allowance must be made for this contraction by using either a joint which permits movement, a piping system which contains natural swing joints, fabricated circular type of "U" type bends or, in cases where space is limited, an approved manufactured expansion joint. See figure 4-10.

C. In piping which utilizes grooved type couplings, these couplings shall be installed to permit contraction of the piping.

D. In straight runs using welded or screwed joints, an expansion joint must be installed within approximately 100 feet of continuous run and each approximate 100 feet of run thereafter. For runs using grooved pipe, a representative of the manufacturer should be contacted to determine the location and number of expansion joints in long runs.

E. Pipe anchors shall be capable of withstanding any contraction thrusts that may be imposed by the piping while permitting movement intended in the design of the piping system to relieve stress. This will require rigid anchoring of certain points in the piping system while leaving other points of the pipe free to move longitudinally so as to relieve stress.

4-20 VAPOR TRAPS

Vapor traps must be installed in the system where shown on the system drawings. These traps are used in systems with master valves that supply selector valves or hosereels. A vapor trap provides a means of limiting liquid flow to only the selector valve or hosereel called upon for discharge. The vapor trap will assure that the initial vapor time will be minimized to the shortest possible period. See figure 4-11.

A. Vapor traps must be located at all possible splits in the discharge flow. These splits are identified at the branch point when gas flow could be diverted to multiple hazards or hosereels. This will be noted on the system drawings.

B. A vapor trap is comprised of a short rise in pipe elevation at the branch splits in the direction of the flow. The vapor trap often forms a U trap. The elevation changed must be a minimum of 2 pipe diameters to provide an effective trap. Refer to the detail below for a variety of acceptable trap arrangements.

C. A vapor trap can serve additionally as an expansion loop. When the loop serves dual purposes the minimum requirement of both arrangement guidelines must be met.

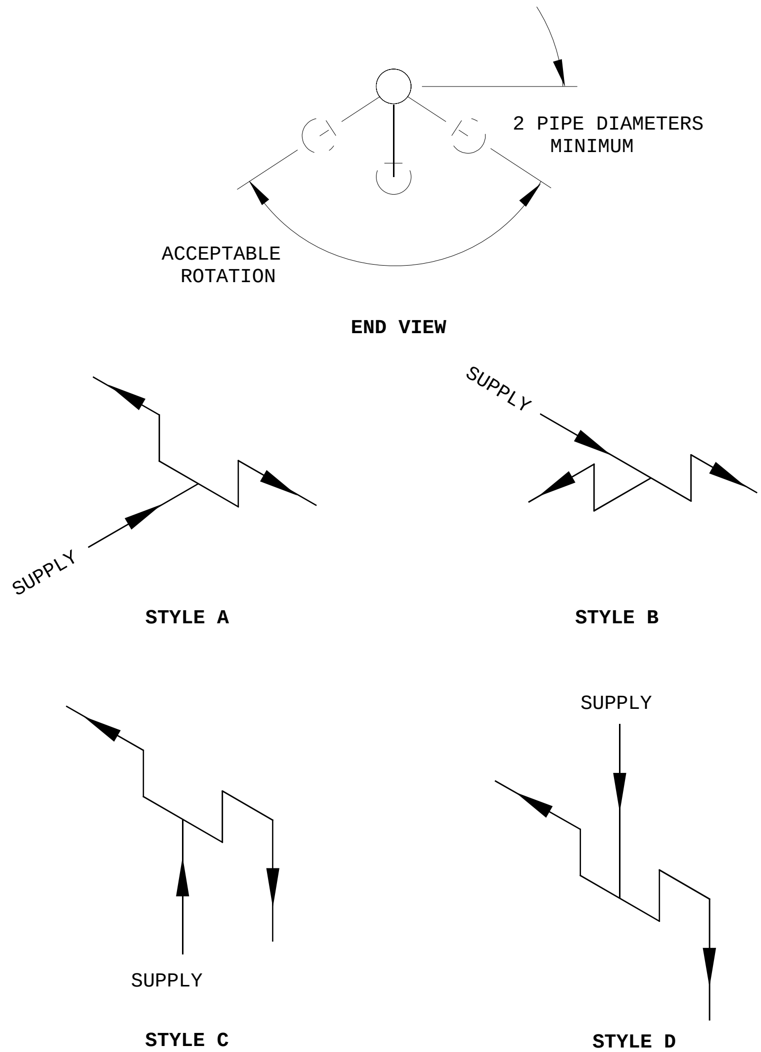


Figure 4-11
Typical Vapor Traps

4-21 PIPE HANGERS AND SUPPORTS

All pipe hangers and supports shall conform to the provisions outlined in ANSI B31.1, latest edition, except as modified and supplemented by this specification. All pipe must be solidly anchored to structural members where longitudinal or lateral movement is possible with due allowance for agent thrust forces, thermal expansion and contraction and shall not be subject to mechanical damage. See figures 4-12, 4-13, 4-14, 4-15 and 4-16.

A. Rigid hangers are required wherever a change in direction or change in elevation in the piping system occurs. On long straight runs as a minimum, every other hanger shall be rigid.

B. Most installations lend themselves to the use of support systems such as Unistrut. Before using such materials for installation approval by the manufacturer's test representative must be obtained in writing.

C. All hangers shall be fabricated of steel and installed in a workmanlike manner.

D. All piping shall be attached to rigid hangers by means of U-bolts locked with double nuts. The pipe shall be free to move longitudinally within the U-bolt except where the piping design requires it to be anchored.

E. Hangers and pipe shall be designed to prevent stresses from being induced into the piping during the temperature change caused by a system discharge.

F. All piping supports shall be fabricated and installed so that they will not be disengaged by the movement of supported pipe.

G. Pipe shall not be hung using one pipeline as a support for another.

H. Piping supports shall be arranged so that no excessive bending stresses are induced into the piping from concentrated loads between supports.

I. The maximum spacing between pipe supports for screwed or welded piping is given in table 4-4. Maximum spacing between pipe supports is given in table 4-5 for systems utilizing the grooved coupling method for system discharge piping.

J. Cast iron supports, conduit clips, C-clamps, malleable iron ring type hangers, etc. shall not be acceptable for fabrication or installation of pipe supports.

K. Where rod type hangers are acceptable for intermediate supports between rigid hangers, they shall be the steel clevis hanger type of the proper pipe size with a solid bar type hanger rod. These hangers shall be used only where hanger rods are not subject to stresses due to bending. See table 4-6.

Nominal Pipe Size (Inches)	Maximum Span (Feet)
1/2	5
3/4	6
1	7
1-1/4	8
1-1/2	9
2	10
2-1/2	11
3	12
4	14
5	6
6	17
8	19

TABLE 4-4
Maximum Spacing Between Supports For Screwed Or Welded Pipe

Nominal Pipe Size (Inches)	Maximum Span (Feet)
3/4	7
1	7
1-1/4	7
2	7
2-1/2	8
3	10
4	10
5	12
6	12
8	12

TABLE 4-5
Maximum Spacing Between Supports For Pipe With Grooved Joints

Pipe Size	Rod Size
1" and smaller	3/8"
1-1/4" to 3"	1/2"
4" and 5"	5/8"
6"	3/4"
8"	7/8"

TABLE 4-6
Rod Size As Determined By Pipe Size

4-22 INSPECTION FOR MECHANICAL INTEGRITY

A. All testing and inspection shall be done in the presence and under the supervision of the equipment manufacturer's test representative and the authority having jurisdiction.

B. Concealed pipe joints such as those in walls, ceilings, trenches and the like shall be tested before the joint is concealed.

C. The following piping tests are to be done using CO_2 or dry nitrogen. Water must NOT be used for this testing.

1. Pressure testing always involves some risk to those in the vicinity of the materials being tested. Ensure the following before testing:

    a. Only those directly responsible for performing and officially witnessing the test shall be permitted in the spaces through which the pipe under test passes.

    b. Before pressure or leak testing, the entire piping network shall be visually inspected to determine that the proper weight of pipe and class of fittings and flanges are installed.

    c. Pressure switches should be disconnected from the pipeline and connection points plugged or capped with extra heavy pipe fittings.

d. Personnel conducting and witnessing the tests shall wear appropriate protective clothing and equipment.

e. The pipe shall be slowly brought up to full test pressure.

f. If any audible or visible leakage is present or if any pipe movement is present while the system is being tested, the test pressure shall be relieved at once.

2. Pressure/Leakage Test

a. System Piping

The entire piping system from the tank shutoff valve up to and including the branch lines to individual protected spaces shall be subjected to a pressure test. Test pressure shall be 450 psig. With no additional gas introduced into the system, it shall be demonstrated that the leakage of the system is such as not to permit a pressure drop of more than 65 psig per minute for a 2 minute period. For purposes of this test, piping shall be capped within the space protected at the first joint ahead of the nozzles.

After the pressure/leakage test, the piping from the flanged discharge outlet of the storage unit to the master valve or master selector valves shall be subjected to an additional leak test. This piping shall be pressurized to 300 psig. All joints shall be tested for leaks using a liquid leak detector (“Leak-Tec” or approved equal). **No Leakage is permitted.**

b. Actuation Piping

Warning: Observe safety precautions - assure that ventilation in the area where nitrogen or CO_2 is being emitted from the control line is sufficient to prevent oxygen depletion or hazardous concentration of CO_2 or nitrogen.

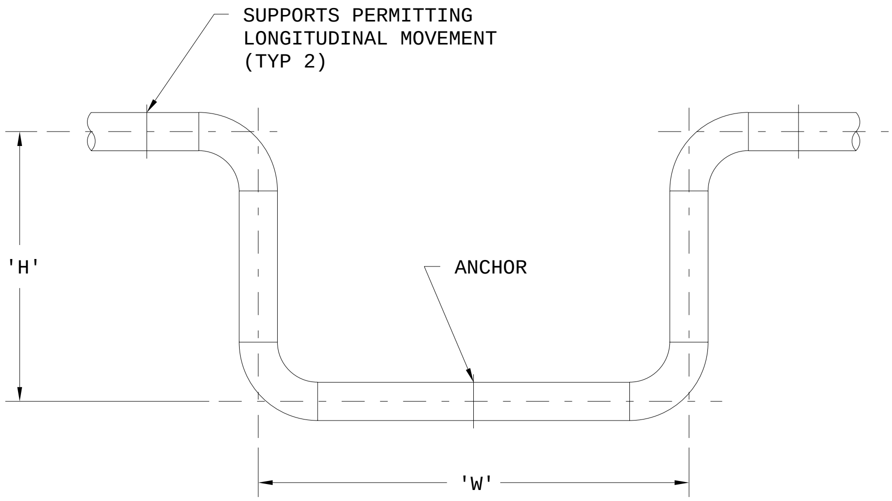
Disconnect pneumatic actuation lines from pressure switches and pressure operated valves. Blow out control lines using CO_2 vapor or dry nitrogen. If pipe has been properly cleaned during assembly, no water or particulate matter should be present. If particulate matter or liquid is evidenced, continue blowing out control lines until they are clear. Persons in the area should wear protective equipment, safety glasses, hearing protection, protective clothing, etc. Only persons directly involved in the blow out procedure should be in the area.

Pneumatic actuation lines are under continuous CO_2 vapor pressure and shall be leak tested at 120 psig. **No leakage is permitted**.

C. Table 4-7 can act as a review of mechanical installation:

Paragraph	Subject	Corrective Action Required	Acceptable
4-2	Storage Unit		
4-3	Tank Shut-Off Valve		
4-4	Master/Selector Valve Ass'y		
4-5	Lock-Out Valve Assembly		
4-6	Welding		
4-7	Materials		
4-8	Tank Header		
4-9	Actuation Line		
4-10	Master Valve Piping		
4-11	Discharge Piping		
4-12	Pressure Release Piping		
4-13	Dirt Trap		
4-14	Fill & Equalizing Lines		
4-15	Vent Line		
4-16	Nozzles		
4-17	Underground Piping		
4-18	Pipe Sleeves		
4-19	Expansion Joints		
4-20	Vapor Traps		
4-21	Pipe Hangers & Supports		

Table 4-7
Mechanical Installation Checklist



PLAN VIEW

Note: Rigid hangers should be installed at all three (3) points noted above. However, the tension on the ‘U’ bolts supporting the pipe to the hanger must be adjusted to allow longitudinal movement on either side of the loop.

PIPE SIZE	DIM H	DIM W
1/2"	1'-0"	5'-6"
1/2"	2'-0"	1'-6"
1/2"	3'-0"	0'-6"
3/4"	1'-0"	8'-6"
3/4"	2'-0"	3'-0"
3/4"	3'-0"	1'-0"
3/4"	4'-0"	0'-6"
1"	1'-0"	10'-0"
1"	2'-0"	3'-6"
1"	3-0"	1'-0"
1"	4'-0"	0'-6"
1 1/4"	1'-0"	12'-0"
1 1/4"	2'-0"	5'-0"
1 1/4"	3'-0"	1'-0"
1 1/4"	4'-0"	0'-6"
1 1/2"	1'-0"	13'-6"
1 1/2"	2'-0"	6'-0"
1 1/2"	3'-0"	2'-0"
1 1/2"	4'-0"	0'-6"
2"	1'-0"	15'-6"
2"	2'-0"	7'-6"
2"	3'-0"	2'-6"
2"	4'-0"	0'-6"

PIPE SIZE	DIM H	DIM W
3"	1'-0"	20'-0"
3"	2'-0"	10'-0"
3"	3'-0"	5'-0"
3"	4'-0"	1'-0"
3"	5'-0"	0'-6"
4"	1'-0"	21'-6"
4"	2'-0"	11'-6"
4"	3'-0"	5'-0"
4"	4'-0"	2'-0"
4"	5'-0"	0'-9"
5"	2'-0"	13'-6"
5"	3'-0"	6'-6"
5"	4'-0"	2'-3"
5"	5'-0"	0'-9"
6"	2'-0"	14'-0"
6"	3'-0"	7'-6"
6"	4'-0"	2'-6"
6"	5'-0"	1'-0"
8"	2'-0"	14'-0"
8"	3'-0"	9'-6"
8"	4'-0"	3'-6"
8"	5'-0"	1'-6"

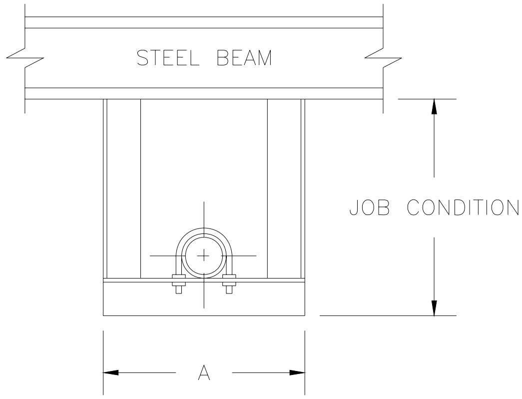
Figure 4-10
Estimating Guide for Expansion Loops

Flow Rate		**Pipe**	
Average Runs 400-425 Feet	Short Runs 100-150 Feet max.	Schedule	Size
40 lbs./min.	50 lbs./min.	40	1/2"
80 lbs./min.	100 lbs./min.	40	3/4"
175 lbs./min.	250 lbs./min.	40	1"
125 lbs./min.	200 lbs./min.	80	1"
400 lbs./min.	450 lbs./min.	40	1 1/4"
300 lbs./min.	375 lbs./min.	80	1 1/4"
500 lbs./min.	650 lbs./min.	40	1 1/2"
400 lbs./min.	500 lbs./min.	80	1 1/2"
900 lbs./min.	1,200 lbs./min.	40	2"
800 lbs./min.	1,000 lbs./min.	80	2"
1,500 lbs./min.	2,000 lbs./min.	40	2 1/2"
1,300 lbs./min.	1,700 lbs./min.	80	2 1/2"
2,500 lbs./min.	3,200 lbs./min.	40	3"
2,200 lbs./min.	2,700 lbs./min.	80	3"
5,500 lbs./min.	6,500 lbs./min.	40	4"
4,500 lbs./min.	5,500 lbs./min.	80	4"
10,000 lbs. min.	11,500 lbs./min.	40	5"
8,000 lbs./min.	10,500 lbs./min.	80	5"
15,000 lbs./min.	18,000 lbs./min.	40	6"
13,500 lbs./min.	16,000 lbs./min.	80	6"
24,000 lbs./min.	30,000 lbs./min.	40	8"

Note: This chart is an estimating guide only.

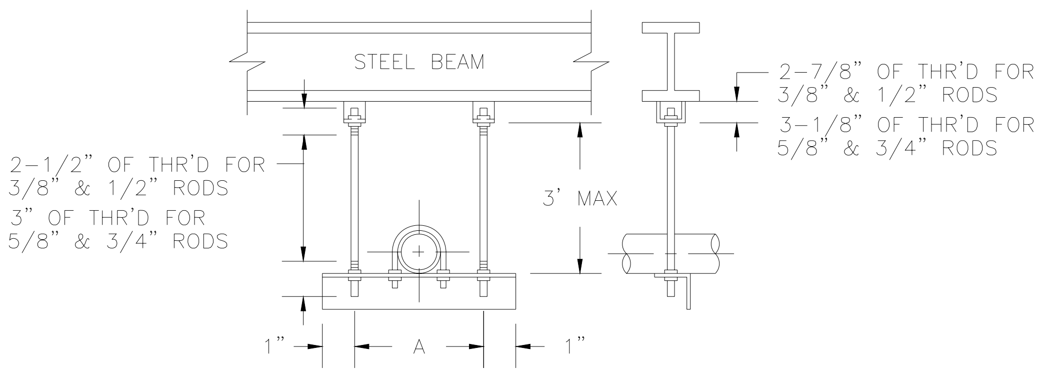
Table 4-8
Pipe Size Estimating Guide

Rigid Pipe Hanger
(Trapeze)



Pipe Size	"A"	Angle Size	U-Bolt Dia.
1" thru 2"	8"	1-1/2" x 1-1/2" x 1/4"	3/8"
2-1/2" thru 4"	12"	3" x 3" x 1/4"	1/2"
5" & 6"	16"	3-1/2" x 3-1/2" x 3/8"	5/8"

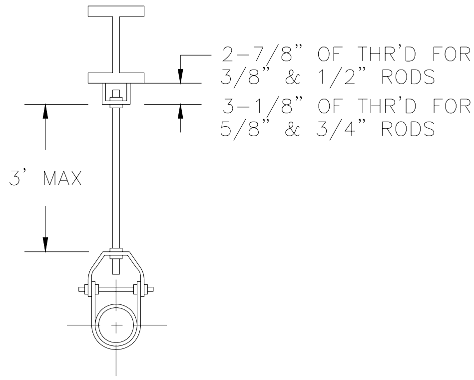
Intermediate Pipe Hanger
(Trapeze)



Pipe Size	"A"	Angle Size	Rod Size
1" and smaller	6"	2" x 2" x 1/4"	3/8"
1-1/4" thru 3"	9"	2" x 2" x 3/4"	1/2"
4"& 5"	12"	2-1/2" x 2-1/2" x 1/2"	5/8"
6"	15"	3" x 3" x 1/2"	3/4"

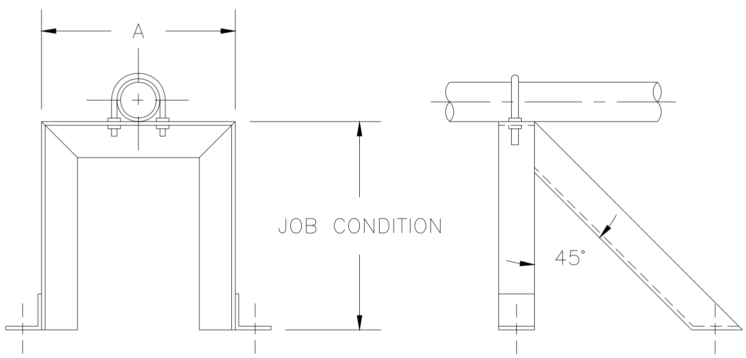
Figure 4-12
Typical Pipe Supports

Intermediate Pipe Hanger
(Trapeze)



Pipe Size	Rod Size
1" and smaller	3/8"
1-1/4" thru 3"	1/2"
4"& 5"	5/8"
6"	3/4"

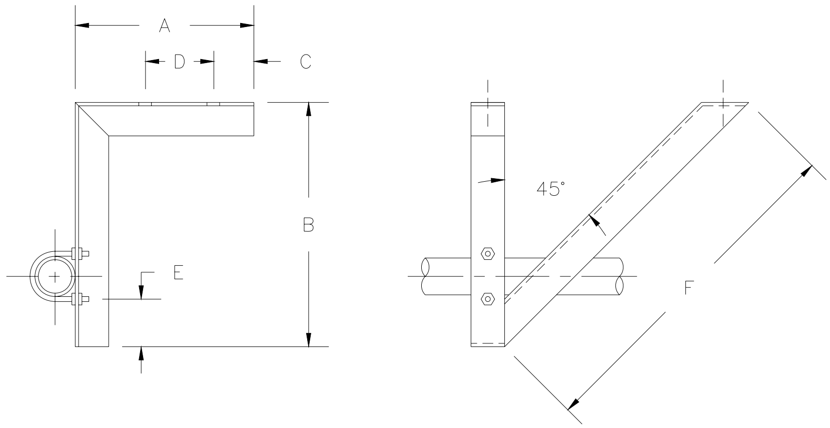
Rigid Pipe Hanger
(Roof and Floor)



Pipe Size	"A"	Angle Size	U-Bolt Dia.
1" thru 2"	8"	1-1/2" x 1-1/2" x 1/4"	3/8"
2-1/2" thru 4"	12"	3" x 3" x 1/4"	1/2"
5" & 6"	16"	3-1/2" x 3-1/2" x 3/8"	5/8"

Figure 4-13
Typical Pipe Supports

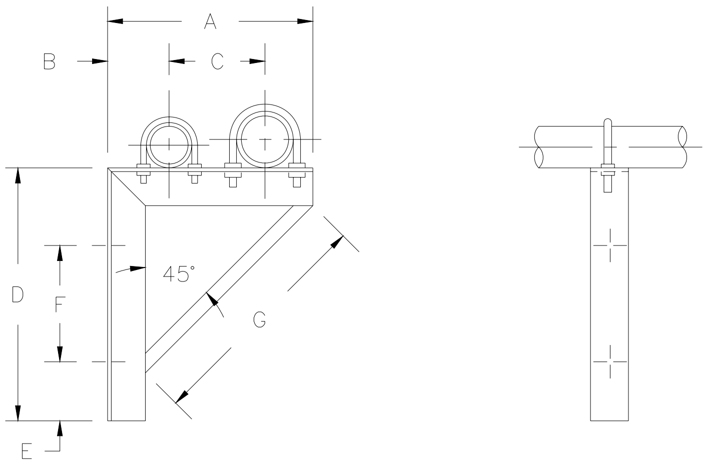
Intermediate Pipe Hanger
(Roof)



Letter	1" - 2" Pipe	2-1/2" - 4" Pipe	5" - 6" Pipe
A	6"	8"	10"
B	10"	14"	18"
C	1-1/2"	1-1/2"	1-1/2"
D	3"	5"	7"
E	1-3/4"	1-3/4"	1-3/4"
F	13-1/4"	19-1/2"	24-3/4"
Angle Size	1-1/2" x 1-1/2" x 1/4"	3" x 3" x 1/4"	3-1/2" x 3-1/2" x 3/8"
U-Bolt Dia.	3/8"	1/2"	5/8"
Anchor Size	3/8"	1/2"	5/8"

Figure 4-14
Typical Pipe Supports

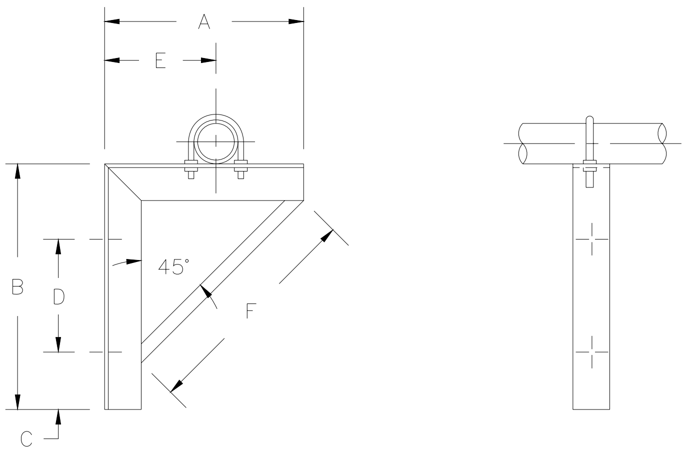
Rigid Pipe Hanger
(Wall)



Letter	1/2" - 3/4" Pipe	1" - 1-1/2" Pipe	1-1/2" - 2" Pipe
A	6"	9"	12"
B	1-1/2"	3"	4"
C	3"	4"	5"
D	10"	14"	18"
E	1-1/2"	2"	2-1/2"
F	7"	10"	13"
G	8-1/4"	12-3/4"	17"
Angle Size	1" x 1" x 3/16"	2" x 2" x 1/4"	3" x 3" x 3/8"
U-Bolt Dia.	1/4"	3/8"	3/8"
Anchor Size	1/4"	3/8"	1/2"

Figure 4-15
Typical Pipe Supports

Rigid Pipe Hanger
(Wall)



Letter	1" - 2" Pipe	2-1/2" - 4" Pipe	5" - 6" Pipe
A	8"	12"	16"
B	12"	18"	20"
C	2"	2"	2"
D	7"	13"	15"
E	5"	8"	11"
F	9-1/4"	12-3/8"	17-1/2"
Angle Size	1-1/2" x 1-1/2" x 1/4"	3" x 3" x 1/4"	3-1/2" x 3-1/2" x 3/8"
U-Bolt Dia.	3/8"	1/2"	5/8"
Anchor Size	3/8"	1/2"	5/8"

Figure 4-16
Typical Pipe Supports

Tank Capacity (tons)	Voltage	Horsepower	Phase	Amps	Fuse	Wire
0.75	230	0.5	1	5.2	10	#12
1.5	230	0.5	1	5.2	10	#12
2	208/230	0.5	1	5.2	10	#12
3.75	208/230	1	1	9.8	15	#12
	460	1	3	4.2	6	#12
6	208/230	1	1	9.8	15	#12
	230	1	3	7.2	10	#12
	460	1	3	4.2	5	#12
8	230	2	3	10.2	15	#12
	460	2	3	6.2	10	#12
10	230	2	3	10.2	15	#12
	460	2	3	6.2	10	#12
12	230	2	3	10.2	15	#12
	460	2	3	6.2	10	#12
14	230	2	3	10.2	15	#12
	460	2	3	6.2	10	#12
18	230	3	3	25.4	30	#10
	460	3	3	12.5	15	#12
22	230	3	3	25.4	30	#10
	460	3	3	12.5	15	#12
26	230	3	3	25.4	30	#10
	460	3	3	12.5	15	#12
30	230	3	3	25.4	30	#10
	460	3	3	12.5	15	#12

Consult factory for information regarding tank sizes larger than 30 tons.

Table 4-9
Storage Tank Electrical Requirements

SECTION 5

OPERATION AND SERVICE

Table of Contents

SECTION 5

OPERATION AND SERVICE

5-1 GENERAL

A. Operation and service procedures in this section are provided as a guide for identifying and correcting systems faults. The use of these procedures by competent personnel will reduce system down time and minimize unnecessary costs. Troubleshooting tables are provided for identifying and isolating system/component faults.

B. The CO_2 system shall be maintained in full operating condition at all times. Use, impairment and restoration of this protection shall be promptly reported to the authority having jurisdiction.

5-1.1 Inspection and Testing

All carbon dioxide systems shall be thoroughly inspected and tested for proper operation by competent personnel.

5-2 CONTROL ACTUATION OPERATION

A. The Tomco$_2$ Fire Systems pneumatic actuation system is designed to minimize the dependence on vapor (pilot) pressure. Pilot actuation pressure is still used, but limited to those conditions when normal and standby electric actuation methods are fully operational. If system electrical power is lost, the control panel is equipped with sufficient battery back-up power to maintain 24 to 48 hour standby power plus enough power for one actuation sequence. In addition, a system emergency mechanical override feature is incorporated as required by NFPA 12. The override feature is a mechanical device, not relying on electrical power. This override provides the most dependable means of emergency operation.

B. There are three basic operating conditions for all CO_2 fire protection systems. These conditions include standby, actuation and system reset which will functionally restore the system to standby. Each of these conditions are described as follows:

1. Standby

   When the system is in standby, the control panel awaits a signal from the detection network or one of the manual stations about the hazard area. The Master, Master-Selector and Selector Valves, which limit gas flow, are normally in a closed position. Each discharge valve is factory fitted with a 24 vdc solenoid valve, an in-line filter and connectors for pneumatic-electric operation via a signal from the control panel. Figure 5-1 illustrates that CO_2 vapor pressure is reduced from 300 psig to 100 psig throughout the actuation pressure network. A supervisory pressure switch monitors the network, signaling the control panel if actuation pressure is decreased due to leak or a break in the pipe. The discharge line is charged with CO_2 from the diptube up to the Master and/or Master-Selector Valve(s) on the storage unit manifold. In standby, the all electric-pneumatic discharge valves remain closed and their corresponding solenoid valves are normally de-energized and in a closed position also.

2. Actuation

   a. When the system is activated by the detectors or a manual release station, the actuation is initiated. Normal system actuation should **always** depend primarily upon the electrical devices to actuate the system to assure proper system operation and the safety of the facility personnel. The control panel energizes the appropriate discharge solenoid valve(s). Vapor pressure flows through the solenoid to the pneumatic operator atop the discharge valve, as shown in figure 5-2. The discharge valve opens allowing liquid CO_2 to flow through the pipe to the discharge nozzles. The discharge will continue until the solenoid release duration setting has expired, then power is removed from the solenoid coil.

   b. In rare situations when both primary and standby power are lost should the emergency override feature of the system be used to actuate the system. The emergency override operation uses a manual valve on the solenoid. When the override feature is operated, the CO_2 discharge will continue until the discharge valve(s) is manually closed or the storage unit contents are exhausted.

3. System Reset

   Following the normal (electrically initiated) discharge period, the discharge valve(s) will close automatically. After the solenoid (release) circuit has timed out, power is removed from the solenoid coil. Figure 5-3 shows that when the solenoid valve closes, flow is blocked from the discharge actuation port. Actuation pressure trapped between the solenoid and the discharge valve actuation port is released out the solenoid vent port. This allows the discharge valves to close. Liquid CO_2 trapped between the Master Valve and the Selector Valve will be reclaimed to the storage unit via the check valve bypass around the Master Valve. Vapor pressure from the storage unit maintains actuation pressure to reactivate the system if a second discharge is required. The system control panel and other devices will require additional reset procedures to bring the system to normal standby condition.

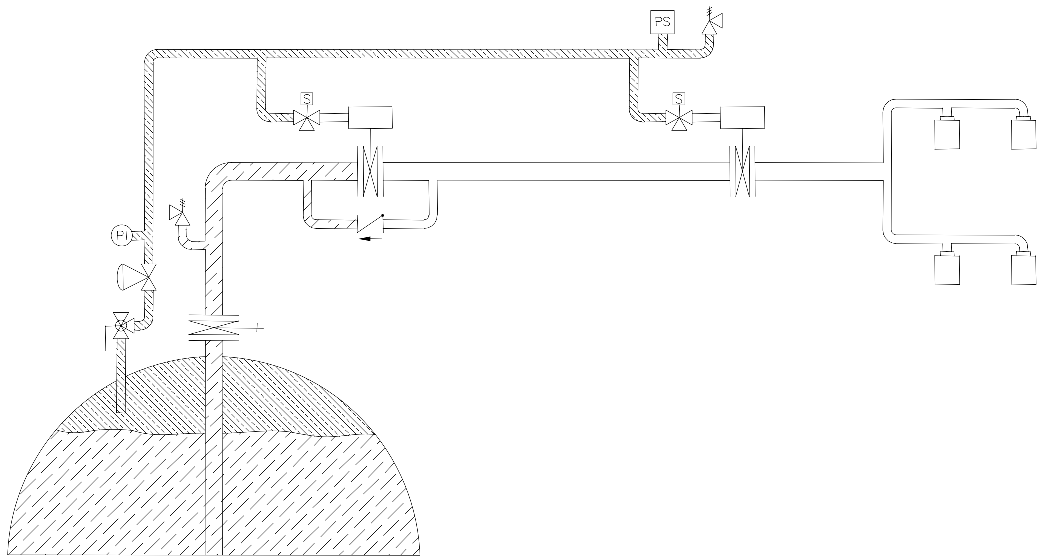


Figure 5-1
Standby Condition

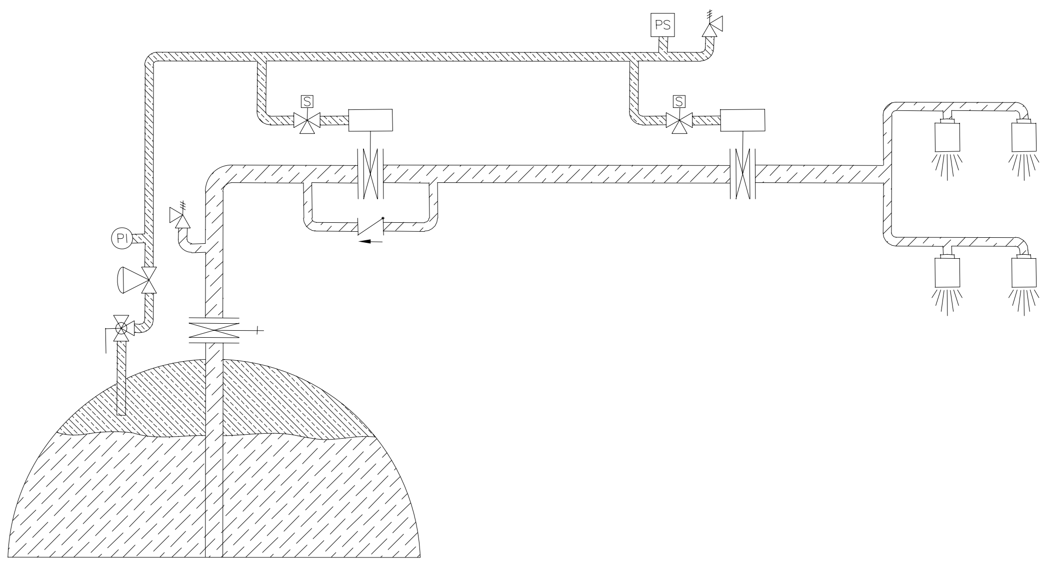


Figure 5-2
Actuation Condition

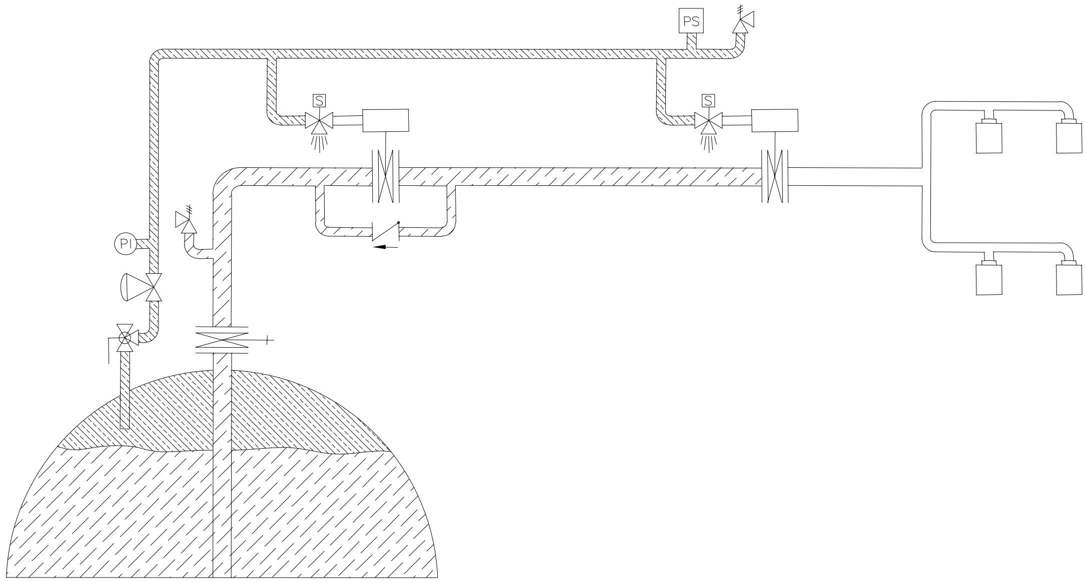


Figure 5-3
System Reset

5-3 SCHEDULED MAINTENANCE

Table 5-1 is provided as a guide to assist in designing a specific maintenance program. These items should be incorporated into the complete maintenance program. Maintenance shall only performed by competent personnel.

Table 5-1
Recommended Test and Maintenance Procedure

Check	Weekly	Monthly	Annually	What to Check
Complete System			X	All components of the system should be thoroughly inspected and tested for proper operation to insure the system is in full operating condition.
Liquid Level	X			Visually inspect liquid level gauge. Also inspect after each operation. If container shows more than 10% loss, it shall be refilled.
Tank Pressure	X			Visually inspect pressure gauge to see that pressure in tank is within normal range of 295-305 psig.
Power to unit refrigeration	X			Check to see that all disconnect switches are closed and that main power is energized.
Vapor and fill lines	X			Check that liquid fill line and vapor equalizing valves are closed.

Check	Weekly	Monthly	Annually	What to Check
Carbon dioxide leakage		X		Check for carbon dioxide leakage around at all valve packing glands, fittings and through seats of relief valves.
Exterior condition of storage tank	X			Check for deterioration or separation of covering. Replace deteriorated covering or insulation as required.
Refrigeration system		X		1. Check all refrigerant line connections for leakage. 2. Check condensing unit coils and motor for heavy dust and dirt deposits. Clean as necessary.
Safety relief valves (tank & system)		X		Check for visible signs of leakage, tampering or blockage.
High & low tank pressure supervision		X		Check operation of pressure switch.
Tank shut-off valve	X		X	1. Valve position. 2. Operate valve to fully closed position, then re-open valve. Check for leakage.
Master/Selector Valves	X			Check tamper indicator on emergency manual actuator. Verify valve stem is in neutral position and sealed.
Master/Selector Valves	X			With tank shut-off valve closed energize the solenoid and observe operation of valve. Reset system and operate mechanical operator on valve. Return operator to neutral position. Check for any leaks.
Solenoid valve sintered bronze filter	X			Check to make sure filter is not plugged or clogged.
Actuation line supervisory pressure switch		X		With tank shut-off valve closed close the control valve on the actuation line and bleed pressure out of line.
Actuation line	X			Check to make sure 100 PSIG is being maintained in actuation line.

Note: The above recommended inspection schedule is considered as a minimum requirement. Authorities having jurisdiction or insurance companies may require a more stringent inspection schedule.

5-4 STORAGE UNIT

5-4.1 General

A. Once the storage unit is properly installed and checked out for proper operation, it requires very little attention. Check the pressure and liquid level gauges at the beginning and end of each work day. If the pressure is not within the normal pressure range, it should be reported at once. If the liquid level is at or below the re-order quantity, the proper authority should be notified.

B. These systems shall be maintained in full operating condition at all times. Use, impairment, and restoration of this protection shall be reported promptly to the authority having jurisdiction.

C. Maintenance procedures for the storage unit and refrigeration system are divided into three categories:

1. Maintenance by an experienced technician.

2. Maintenance by experienced plant personnel.

3. Preventive maintenance.

D. When trouble develops in the storage unit, it is recommended that maintenance be performed in accordance with the following schedule:

1. Category (1) Maintenance

   To be performed by competent field service personnel familiar with the storage unit, and equipped with the proper tools and test equipment for servicing the pressure vessel and / or refrigeration unit. See table 5-2.

2. Category (2) Maintenance

   To be performed by facility maintenance personnel familiar with the pressure vessel or refrigeration unit. See table 5-3.

3. Category (3) Preventive Maintenance

   To be performed by competent field service personnel where complete maintenance on the refrigeration system is required. See paragraph 5-4.2.

Table 5-2
Minor Maintenance
Minor Trouble Shooting

COMPLAINT	POSSIBLE CAUSE	REMEDY
Unit pressure high, refrigeration system not running.	1. Blown fuse. 2. Electric power off.	1. Replace fuse. 2. Check power source.
Refrigeration system does not start, hums but trips on overload protector.	1. Low voltage. 2. Blown fuse.	1. Check power source. 2. Check power source.
Unit pressure high, refrigeration system running.	1. Air passage across condenser coil restricted. 2. Condenser coils dirty. 3. Condenser fan blade slipping on shaft.	1. Remove obstruction. 2. Turn off refrigeration system and clean coils. 3. Turn off refrigeration system and tighten set screw.
Refrigeration system operates long or continuously.	1. Condenser coils dirty. 2. Air passage across condenser coil restricted.	1. Turn off refrigeration system and clean coil. 2. Remove obstruction.
Refrigeration system noisy.	1. Loose parts or mountings. 2. Tubing rattle.	1. Locate and tighten. 2. Re-form to be free of contact.
Pressure relief valve venting when unit pressure is not high.	1. Defective valve.	1. Empty tank and replace valve with new safety valve. Refill tank and check for leaks.
Liquid level gauge shows 0. Unit known to contain liquid.	1. Equalizer valve open. 2. Liquid supply to instruments valve closed. 3. Liquid supply frozen/ restricted. 4. Out of calibration. 5. Defective gauge	1. Close equalizer valve. 2. Open valve. 3. Thaw and purge liquid supply to instrument line. 4. Calibrate gauge. 5. Replace gauge.
Liquid level gauge shows over-full.	1. Tank overfilled. 2. Vapor supply to instruments valve closed. 3. Gauge out of calibration. 4. Leak in instrument piping 5. Defective gauge.	1. Bleed off excess liquid through vapor return valve. Bleed-off should exhibit vapor only. Liquid through the vapor bleed valve is evidence of overfill. 2. Open valve. 3. Calibrate gauge. 4. Repair leak. 5. Replace gauge.
Liquid level gauge shows below zero.	1. Liquid supply to instruments valve closed. 2. Gauge out of calibration 3. Liquid supply to instruments valve frozen or otherwise restricted. 4. Defective gauge.	1. Open valve. 2. Calibrate gauge. 3. Thaw & purge liquid supply line. 4. Replace gauge.

COMPLAINT	POSSIBLE CAUSE	REMEDY
Liquid level gauge reading erratic.	1. Equalizer valve not completely closed. 2. Instrument bleed-off valve not completely closed. 3. Leak in instrument piping. 4. Liquid supply to instruments partially frozen or restricted. 5. Defective gauge.	1. Close equalizer valve. 2. Close bleed-off valve. 3. Repair leak. 4. Thaw & purge liquid supply. 5. Replace gauge.

Table 5-3
Maintenance

The following troubleshooting is intended for in-plant maintenance, provided the person chosen for this work is a qualified refrigeration service technician and has studied the material contained in this manual. In the event of malfunction not covered in either trouble shooting chart or failure of remedy to correct the trouble, an industrial rated refrigeration service technician qualified with Copeland refrigeration units or $Tomco_2$ Fire Systems should be called for further instructions.

TROUBLE SHOOTING

COMPLAINT	POSSIBLE CAUSE	REMEDY
Unit pressure too high, refrigeration not running.	1. Blown fuse. 2. Electric power off. 3. Controls out of adjustment.	1. Replace fuse. 2. Check power source. 3. Adjust controls.
Unit pressure too high, refrigeration system is running.	1. Insufficient air across condenser coils. 2. Condenser coils dirty. 3. Low on refrigerant. 4. Suction pressure too high or too low. 5. Bad compressor valves. 6. Internal mechanical trouble in compressor.	1. Determine reason and correct. 2. Clean coils. 3. Find & stop leak, add refrigerant. 4. Replace expansion valve, never adjust. 5. Replace valves. 6. Replace compressor.
Refrigeration system does not start - hums but trips on overload compressor.	1. Low voltage to unit. 2. Compressor motor has a winding open or shorted. 3. Internal mechanical trouble in compressor.	1. Determine reason and correct. 2. Replace compressor. 3. Replace compressor.

COMPLAINT	POSSIBLE CAUSE	REMEDY
Refrigeration system starts, but short cycles on overload protector.	1. Low or unbalanced voltage to unit. 2. Excessive discharge pressure 3. Suction pressure too high. 4. Compressor too hot 5. Overload protector defective	1. Determine reason and correct. 2. Check ventilation. Check fans for proper operation. Check for air or other non-condensable in system. 3. Bad expansion valve, do not adjust - replace. 4. Check refrigerant charge, repair leak, add refrigerant. 5. Check current, replace overload protector.
Refrigeration system runs okay but short cycles on CO_2 pressure switch.	1. Differential set too close. 2. Defective switch.	1. Widen differential to 10 psig. 2. Replace switch.
Refrigeration system short cycles on dual refrigerant pressure control. 1. High side. 2. Low side.	1a. Insufficient air across condenser coils. 1b. System overcharged. 1c. Air in system. 1d. Carbon dioxide leak in evaporator coil. 2a. System under charged. 2b. Suction pressure too low. 2c. Liquid line crimped. 2d. Restriction in expansion valve.	1a. Determine reason and correct. 1b. Reduce charge. 1c. Purge. 1d. Call factory. 2a. Fix leak, add refrigerant. 2b. Replace expansion valve, never adjust. 2c. Replace crimped section. 2d. Clean expansion valve. Replace if necessary.
Refrigeration system operates long or continuously.	1. Low on refrigerant. 2. CO_2 pressure control differential too wide. 3. CO_2 control contacts stuck closed. 4. Condenser coils dirty. 5. Insufficient air across condenser coils.	1. Fix leak, add refrigerant. 2. Adjust differential to 10 psig. 3. Replace control. 4. Clean coils. 5. Determine reason and correct.
Refrigeration system operating, but suction line (and compressor) is frosted.	1. Expansion valve passing excess refrigerant. 2. Expansion valve stuck open. 3. Over charge of refrigerant.	1. Replace expansion valve, never adjust. 2. Clean valve of foreign particles Replace if necessary. 3. Reduce charge.

5-4.2 Preventive Maintenance

Every six months, a complete preventive maintenance inspection should be performed by a qualified carbon dioxide equipment specialist and should consist of the following:

- Sheet metal enclosure and base assembly (if applicable); repair, clean and repaint as needed.
- Remove manway access panel and check manway insulation for water ice buildup and any signs of a leak around manway. The visible portions of the entire unit, including the tank insulation, its appurtenances, such as safety relief valves, piping, etc., should be inspected for frost spots, leaks, cracks in the insulation coating, or any other indication of a possible unsafe condition, such as mechanical damage or corrosion, and repaired as needed.
- Refrigeration system: Check voltage, making sure actual voltage is within plus or minus 10% of name plate voltage.
- Check disconnect switch for good contact when closed.
- Check fuses, fuse holders and fuse size.
- Remove all junction box covers and check wiring for cracks and loose connections.
- Check amperes and compare with FLA on compressor name plate.
- Check contactor or starter contacts.
- Check refrigeration pressure switch contacts and check switch for proper operation (on at 305 psig, off at 295 psig).
- Check dual refrigerant pressure control for proper operation. Off at 6 psig, on at 20 psig, off at 300 psig.
- Check oil level in compressor.
- Clean all refrigeration piping for leaks.
- Check refrigerant level.
- Check moisture indicator for dry system indication.
- Check suction pressure, should be between 15 and 22 psig at ambient temperatures of 60° F (15.5° C) or above.
- Check discharge pressure, compare reading with normal operation for existing ambient temperature.
- Check compressor mounts and refrigeration pipe bracing.
- Check condenser fan blade and motor mounting.

- Check voltage.
- Check disconnect switch for good contact when closed.
- Check fuses, fuse holders and fuse size.
- Remove all junction box covers and check wiring for cracks and loose connections.
- Check amperes and compare with FLA rating given on storage unit data report.
- Check contactor contacts.

Spare or replacement parts may be purchased locally or ordered from Tomco$_2$ Fire Systems. When ordering parts, please give unit serial number.

5-4.3 Refilling Storage Unit

Refilling the storage unit is basically the same as the initial filling procedure, 4-2.3, except operating power to the refrigeration unit is not disconnected and the purging procedure is not required. Prior to refilling, the initial fill section should be reviewed.

A. Check the pressure and temperature of the carbon dioxide which is to be transferred into the storage unit. The temperature should be approximately 0° F (-17.8° C). If the temperature is too high or too low, it could adversely affect the pressure in the storage unit. If the pressure of the carbon dioxide is higher than 330 psig, it may increase the storage unit pressure and cause the safety valve to open and discharge carbon dioxide.

B. Remove the pipe plugs from the vapor and fill lines.

C. Connect the liquid fill line hose between the liquid fill line union on the storage unit and the liquid fill connection on the supply truck.

D. Connect the vapor balancing hose between and 1" vapor balancing union on the storage tank and the vapor balancing connection on the supply truck.

E. Open both the liquid fill valve and the vapor-balancing valve on the storage unit.

F. Open the vapor line and liquid fill line on the supply truck and start the transfer pump.

G. When the liquid level gauge indicates full or liquid enters the balancing line, close the liquid fill and vapor balancing valves on the storage unit.

H. Stop the transfer pump on the supply truck.

I. Close the fill and equalizing valves on the supply truck.

J. Remove the hose from the fill and equalizing lines and install the pipe plugs.

5-5 TANK SHUT-OFF VALVE ASSEMBLY

5-5.1 Operation

A. The tank shut-off valve is operated by a manual gear actuator or handle. Rotation of the handwheel rotates the valve open or closed.

B. Seepage at the valve stem during and after a CO_2 discharge is not uncommon. Immediate contraction, due to the liquid CO_2, at the valve stem has a greater effect to the stem than the packing seal. This seepage will subside as the temperature equalizes.

5-5.2 Service

A. During its' life, the only service that may be required should be periodic stem seal adjustment. If leakage at the stem is noted, simply tighten the valve stem gland nut until leakage subsides. Table 5-4. It is impractical to predict frequency of stem adjustment as it is influenced by such factors as frequency of cycling and service media. IMPORTANT: As is the case with any valve, it is important that stem leaks do not go unattended. Lack of maintenance of stem leakage could cause a premature need to replace stem seals.

Caution: Do not over tighten gland nuts, as this may cause increased operating torque and improper valve operation or closure.

B. If the leakage cannot be stopped by this action, the system seals require replacement. Consult Tomco$_2$ Fire Systems.

Size	In-Lb
3”	35
4”	35
6”	35
8”	40

Table 5-4
Gland Nut Torque

5-5.3 Replacement

A. Depressurize the storage tank and system.

B. Open the vapor balance valve on tank. This will vent any residual pressure build-up within the tank.

C. Close the tank shut-off valve.

Caution: Remove dirt and debris from the valve area. Foreign objects may fall into the opening during valve removal resulting in seal damage when system is pressurized.

D. Clean valve/flange area of all dirt and debris.

E. Remove valve assembly:

1. Loosen flange bolts in a sequential order.

2. Attach lifting device to assembly, if needed.

3. Remove flange bolts and remove assembly.

F. Care should be taken not to scratch the valve disc or seats.

G. Valve assemblies requiring further disassembly or part replacement should be returned to $Tomco_2$ Fire Systems for repair.

H. Install valve assembly:

Caution: Failure to have disc to seat retainer within 1/32" of parallel may result in disc to seal leakage.

1. Measure the distance between disc and seat retainer. The distance side to side must be no greater than 1/32". Figure 5-2.

2. Using a straight-edge and vernier or depth caliper, measure the distances from the face of the seat retainer to the disc (valve closed) face at the 3 o'clock and 9 o'clock positions (stem is at 12 o'clock position). The measurements must agree within 1/32" (0.03125").

3. If the difference in measurement is more than 1/32" consult $Tomco_2$ Fire Systems.

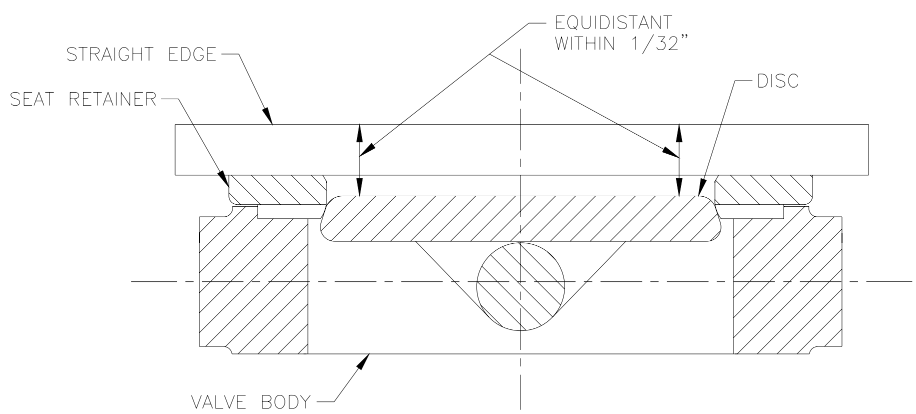


Figure 5-2

Caution: Remove dirt and debris from the valve area. Foreign objects may fall into the opening during valve removal resulting in seal damage when system is pressurized.

4. Ensure valve and flange area is clean. Remove any dirt or debris from adjoining pipe.

5. Care should be taken not to scratch the valve disc or seats.

6. Position valve assembly between its' mating flanges with new gaskets in place.

7. Secure with bolts. Tighten bolts in sequential order in 20% (40 ft. lb.) increments until final torque is reached.

5-5.4 Manual Gear Actuator (8" Tank Shut-off Lock-out Valves Only)

Warning: Under no circumstances should the actuator be removed from the valve body while the valve assembly is mounted in the system. The eccentric design of the valve may allow line pressure to open the valve. Also, valve seat and disc will be mis-aligned.

Caution: Do not adjust stop nuts on actuator, the valve seat and disc may become mis-aligned and cause valve to leak.

The manual gear actuator is mounted on the valve body by the factory. Consult Tomco$_2$ Fire Systems for removal or disassembly of the actuator.

5-5.4.1 Service for 8” Gear Driven Actuators

Periodic servicing on the worm gear actuators is normally not necessary, but for those customers having such programs, the following procedures would certainly not be detrimental.

A. Remove indicator plate.

B. Remove actuator lid, (being careful not to get foreign material into unit.

C. Add number 2-EP grease to gear case around sector, worm and bearings, as necessary.

D. Be certain mating surfaces between lid and housing are clean.

E. Apply a thick film of grease or gasket sealer to housing.

F. Apply a thick film of 2-EP grease around sector gear (drive sleeve) bearing where the lid bore fits.

G. Carefully install actuator lid, (being careful not to get foreign material into unit).

H. Replace lid bolts and tighten.

I. Grease top of sector hub where indicator plate mounts.

J. Put indicator in place and tighten bolts.

5-6 MASTER/SELECTOR VALVE ASSEMBLY

5-6.1 Operation

A. The master/selector valves utilize carbon dioxide vapor pressure to operate the pneumatic actuators on the valves. A three-way solenoid valve located at the valve, controls the pressure to the actuators. Upon activation of the solenoid valve, pressure is permitted to enter the pneumatic actuator. The valve remains open for a pre-determined time period at which point the solenoid is de-energized, exhausting the pneumatic pressure causing the valve to close. The carbon dioxide pressure in the pneumatic actuation line is regulated and supervised to operate at 90 - 100 psig. A supervisory pressure switch is installed in the actuation line to provide a signal at the control panel when the pneumatic pressure drops below 80 PSIG. In the event of failure of the pressure regulator, a 120 psig pressure relief valve is installed to prevent excessive pressure in the pneumatic actuators.

B. Seepage at the valve stem during and after a CO_2 discharge is not uncommon. Immediate contraction, due to the liquid CO_2, at the valve stem has a greater effect to the stem than the packing seal. This seepage will subside as the temperature equalizes.

5-6.2 Service

5-6.2.1 Ball Valve

During its' life, the only service that may be required should be periodic stem seal adjustment. If leakage at the stem is noted, simply tighten the valve stem gland nut until leakage subsides. It is impractical to predict frequency of stem adjustment as it is influenced by such factors as frequency of cycling and service media. IMPORTANT: As is the case with any valve, it is important that stem leaks do not go unattended. Lack of maintenance of stem leakage could cause a premature need to replace stem seals.

5-6.2.2 Butterfly Valve

Caution: Do not disconnect actuator from butterfly valve. Removal of the actuator from the valve will result in mis-alignment of the valve disc. Disc to seal leakage will occur.

During its' life, the only service that may be required should be periodic stem seal adjustment. If leakage at the stem is noted, simply tighten the valve stem gland nut until leakage subsides. It is impractical to predict frequency of stem adjustment as it is influenced by such factors as frequency of cycling and service media. IMPORTANT: As is the case with any valve, it is important that stem leaks do not go unattended. Lack of maintenance of stem leakage could cause a premature need to replace stem seals.

5-6.3 Replacement

5-6.3.1 Ball Valves and Butterfly Valves

Caution: Remove dirt and debris from the valve area. Foreign objects may fall into the opening during valve removal resulting in seal damage when system is pressurized.

Do not disconnect actuator from butterfly valve. Removal of the actuator from the valve will result in mis-alignment of the valve disc. Disc to seal leakage will occur.

A. Clean valve/flange area of all dirt and debris.

B. Relieve actuation line and discharge piping pressure.

C. Remove valve assembly.

D. The valve assembly should be returned to Tomco$_2$ Fire Systems for repairs or replacement.

E. The valve assembly should not be repaired or disassembled in the field.

5-6.4 Pneumatic Actuators

5-6.4.1 Operation

The actuators provide the means of converting lineal to rotary motion through a rack and pinion design. The operating medium is filtered carbon dioxide gas.

5-6.4.2 Service

Caution: Do not disconnect actuator from butterfly valve. Removal of the actuator from the valve will result in mis-alignment of the valve disc. Disc to seal leakage will occur.

A. The actuators are permanently lubricated. Additional lubrication is not required.

B. The actuator should be returned to Tomco$_2$ Fire Systems for repair or replacement.

5-6.5 Solenoid Valve

5-6.5.1 Operation

A. Coils are designed for industrial operating voltages and can be used on a voltage range of 20 - 25 vdc at 0.3a.

B. When the solenoid is de-energized, there is no flow thru the solenoid. Exhaust connection is open.

C. When the solenoid is energized, flow is from Port 1 to pressure connection. Exhaust connection is closed.

5-6.5.2 Maintenance

Warning: Turn off electrical power and line pressure to valve before inspecting or making repairs.

Caution: Clogging of the exhaust port could adversely affect the performance of the solenoid valve.

Inspect the exhaust port on the solenoid valve to ensure proper operation in atmospheres that could result in clogging.

5-6.5.3 Preventive Maintenance

A. Keep the medium flowing through the valve as free from dirt and foreign material as possible.

Note: Operation of the solenoid will cause selector valve to operate. The solenoid should be electrically isolated from the system before performing maintenance.

B. Operate the valve periodically to insure proper opening and closing.

5-6.5.4 Service

Warning: System should be disabled before working on solenoid.

A. Faulty Control Circuit: Check the electrical system by energizing the solenoid. A metallic click signifies the solenoid is operating. Absence of the click indicates loss of power supply. Check for loose or blown-out fuses, open-circuited or grounded coil, broken lead wires or splice connections.

B. Burned-Out Coil: Check for open-circuited coil. Replace solenoid if necessary.

C. Low Voltage: Check voltage across the coil leads. Voltage must be at least 85% of nameplate rating.

D. Incorrect Pressure: Check valve pressure. Pressure to valve must be within the range specified on nameplate.

E. Excessive Leakage (Improper Opening and Closing of Ports): Remove solenoid from system and replace with a new solenoid.

F. Slow exhaust operation: Check to make sure exhaust port is not plugged or clogged. If so, clean or replace.

5-6.5.5 Replacement

Caution: Remove dirt and debris from the solenoid valve area. Foreign objects may fall into the opening during valve removal resulting in a possible malfunction.

A. Clean valve/actuator area of all dirt and debris.

B. Relieve actuation line pressure to the valve.

C. Disconnect actuation line and wiring.

D. Remove valve from actuator.

E. Ensure the valve port of the actuator is clear of dirt and debris.

F. Install new solenoid valve.

G. Connect actuation line and wiring.

H. Test solenoid valve for proper operation.

5-6.6 In-Line Filter

5-6.6.1 Operation

Positioned before each solenoid valve, the in-line filter prevents dirt and debris from entering the solenoid valve.

5-6.6.2 Service

The filter cartridge should be checked periodically. Replace the filter if clogging is evident.

5-7 LOCK-OUT VALVE ASSEMBLY

5-7.1 Operation

A. The tank shut-off/lock-out valve is operated by the manual gear actuator or handle. Rotation of the handle or handwheel rotates the valve open or closed.

B. Seepage at the valve stem during and after a CO_2 discharge is not uncommon. Immediate contraction, due to the liquid CO_2, at the valve stem has a greater effect to the stem than the packing seal. This seepage will subside as the temperature equalizes.

5-7.2 Service

5-7.2.1 Ball Valve

During its' life, the only service that may be required should be periodic stem seal adjustment. If leakage at the stem is noted, simply tighten the valve stem gland nut until leakage subsides. It is impractical to predict frequency of stem adjustment as it is influenced by such factors as frequency of cycling and service media. IMPORTANT: As is the case with any valve, it is important that stem leaks do not go unattended. Lack of maintenance of stem leakage could cause a premature need to replace stem seals.

5-7.2.2 Butterfly Valve

Caution: Do not disconnect operator from butterfly valve. Removal of the actuator from the valve will result in mis-alignment of the valve disc. Disc to seal leakage will occur.

During its' life, the only service that may be required should be periodic stem seal adjustment. If leakage at the stem is noted, simply tighten the valve stem gland nut until leakage subsides. It is impractical to predict frequency of stem adjustment as it is influenced by such factors as frequency of cycling and service media. IMPORTANT: As is the case with any valve, it is important that stem leaks do not go unattended. Lack of maintenance of stem leakage could cause a premature need to replace stem seals.

5-7.3 Replacement

5-7.3.1 Ball Valves and Butterfly Valves

Caution: Remove dirt and debris from the valve area. Foreign objects may fall into the opening during valve removal resulting in seal damage when system is pressurized.

Do not disconnect operator from butterfly valve. Removal of the operator from the valve will result in mis-alignment of the valve disc. Disc to seal leakage will occur.

A. Clean valve/flange area of all dirt and debris.

B. Relieve discharge piping pressure.

C. Remove valve assembly.

D. The valve assembly should be returned to $Tomco_2$ Fire Systems for repairs or replacement.

E. The valve assembly should not be repaired or disassembled in the field.

5-7.4 Manual Gear Actuator (8" Tank Shut-off/Lock-out Valve Only)

Warning: Under no circumstances should the actuator be removed from the valve body while the valve assembly is mounted in the system. The eccentric design of the valve may allow line pressure to open the valve. Also, valve seat and disc will be mis-aligned.

The manual gear actuator is mounted on the valve body by the factory. Consult $Tomco_2$ Fire Systems for removal or disassembly of the actuator.

5-7.4.1 Service

Periodic servicing on the worm gear actuators is normally not necessary, but for those customers having such programs, the following procedures would certainly not be detrimental.

A. Remove indicator plate.

B. Remove actuator lid, (being careful not to get foreign material into unit.

C. Add number 2-EP grease to gear case around sector, worm and bearings, as necessary.

D. Be certain mating surfaces between lid and housing are clean.

E. Apply a thick film of grease or gasket sealer to housing.

F. Apply a thick film of 2-EP grease around sector gear (drive sleeve) bearing where the lid bore fits.

G. Carefully install actuator lid, (being careful not to get foreign material into unit).

H. Replace lid bolts and tighten.

I. Grease top of sector hub where indicator plate mounts.

J. Put indicator in place and tighten bolts.

5-8 ACTUATION LINE SUPERVISORY PRESSURE SWITCH

5-8.1 Operation

When pressure is applied to the transducer it is converted into movement of the piston. This piston movement is then used to control the operation of the electrical snap-action switch.

5-8.2 Maintenance

Warning: Turn off electrical power supply and remove actuation line pressure to switch before removal or inspection

Repair of the switch shall never be attempted in the field. The switch must be returned to the factory or serviced only by an authorized factory representative.

5-8.3 Preventive Maintenance

A. While in service, operate (cycle between the desired signal) the two-stage dual adjustment compact line switch at least once a month to insure proper operation. If necessary, electrical wiring and pipe connection should be made so that switch can be test operated without affecting other equipment.

B. Periodic inspection of the switch, external surfaces only, be carried out. Switch should be kept clean and free from paint, foreign matter and corrosion.

C. Keep the medium entering the switch as free from dirt and foreign material as possible.

5-8.4 Improper Operation

A. Switch will not actuate or actuates and reactuates undesirably:

1. Incorrect Electrical Connection: Check leads to switch. Be sure they are properly connected. Switch is marked "NO" for Normally Open, "NC" for Normally Closed and "C" for Common.

2. Faulty Control Circuit: Check electrical power supply to switch. Check for loose or blown-out fuses, open-circuited or grounded wires or loose connections at terminals of switch. See nameplate for electrical rating and range.

3. Incorrect Pressure: Check pressure in system with suitable pressure gauge. Pressure must be within range of 90-100 PSIG.

4. External Leakage: Check to see that bolts (4) holding transducer to pressure switch are properly torqued (8 - 10 inch pounds). If bolts are tight and leakage is still evident, replace transducer. Refer to paragraph on "Assembly of Switch Unit and Transducer Unit."

5. Excessive vibration or surges causing switch to actuate and reactuate: Check for fluctuations in system and install pressure surge suppresser. Check switch mounting and be sure there is no excess vibration.

6. Incorrect Temperature: Check temperature in system with suitable thermometer. Temperature must be within 0° F - 120° F. Check location of capillary and bulb for incorrect mounting. Refer back to paragraphs on "Installation of Temperature Transducers."

B. If the operation of the switch cannot be corrected by the above means, the entire switch unit should be replaced or an authorized factory representative consulted.

5-9 PRESSURE REGULATOR

5-9.1 Operation

The regulator is supplied by 300 psig of main tank pressure and maintains 100 psig of output pressure.

5-9.2 Service

Adjustment of pressure output is the only service required.

5-9.3 Adjustment

The regulator is factory set at 100 psig. If field adjustment is required, remove protective cap and turn screw clockwise to increase pressure and counterclockwise to reduce pressure.

5-10 PRESSURE RELIEF VALVE

Caution: Clogging could adversely affect the performance of the relief valve. Clean and inspect on a regular basis.

5-10.1 Operation

Pressure relief valves of the 120 psig and 450 psig type are utilized to relieve an over-pressure condition. The valves are equipped with a U-tube arrangement to prevent debris from entering the exhaust port.

5-11 DISCHARGE NOZZLES

5-11.1 Operation

The discharge nozzles control the carbon dioxide discharge at a pre-determined rate as determined by the flow calculations.

5-11.2 Service

The nozzles should be checked periodically for proper location and blockage of the orifices.