FireBus

FBS Mitigation

FireBus, LLC
Mitigation

High-Pressure Carbon Dioxide Fire Extinguishing System

Operation, Design & Service Manual

Literature No: 09-MAN015-B18

FireBus

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Contents

Diagram Index

Table Index

Revision History

Revision	Description of Change	Date
- -	Initial Printing	10/20/2009
- -	Submittal for NRTL Approval	12/24/2009

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Preface

This manual is intended for use with the FireBus, LLC (FireBus®). High-Pressure Carbon Dioxide Fire Extinguishing System. Those who install, operate, or service this panel should read this entire manual.

All design, implementation, and maintenance of the FireBus High-Pressure Carbon Dioxide Fire Extinguishing System must be performed in compliance with the National Fire Protection Association (NFPA) 12 - Standard on Carbon Dioxide Extinguishing Systems, NFPA 70 - The National Electrical Code, NFPA 72 - The National Fire Alarm Code, and the guidelines outlined in this manual.

FireBus reserves the right to revise and improve its products as it deems necessary without prior notification. This manual describes the state of FireBus products at the time of its publication and may not reflect those products at all times in the future.

All references to Codes or Standards in this manual refer to the latest edition of that Code or Standard unless otherwise indicated.

Compressed gases shall be handled and used only by persons properly trained in accordance with Compressed Gas Association, Inc. (CGA) pamphlets C-1, C-6, G-6, and P-1.

CGA pamphlets are published by the Compressed Gas Association Inc. (www.cganet.com).

Refer to www.FireBus.net for Carbon Dioxide Material Safety Data Sheet.

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www.FireBus.net

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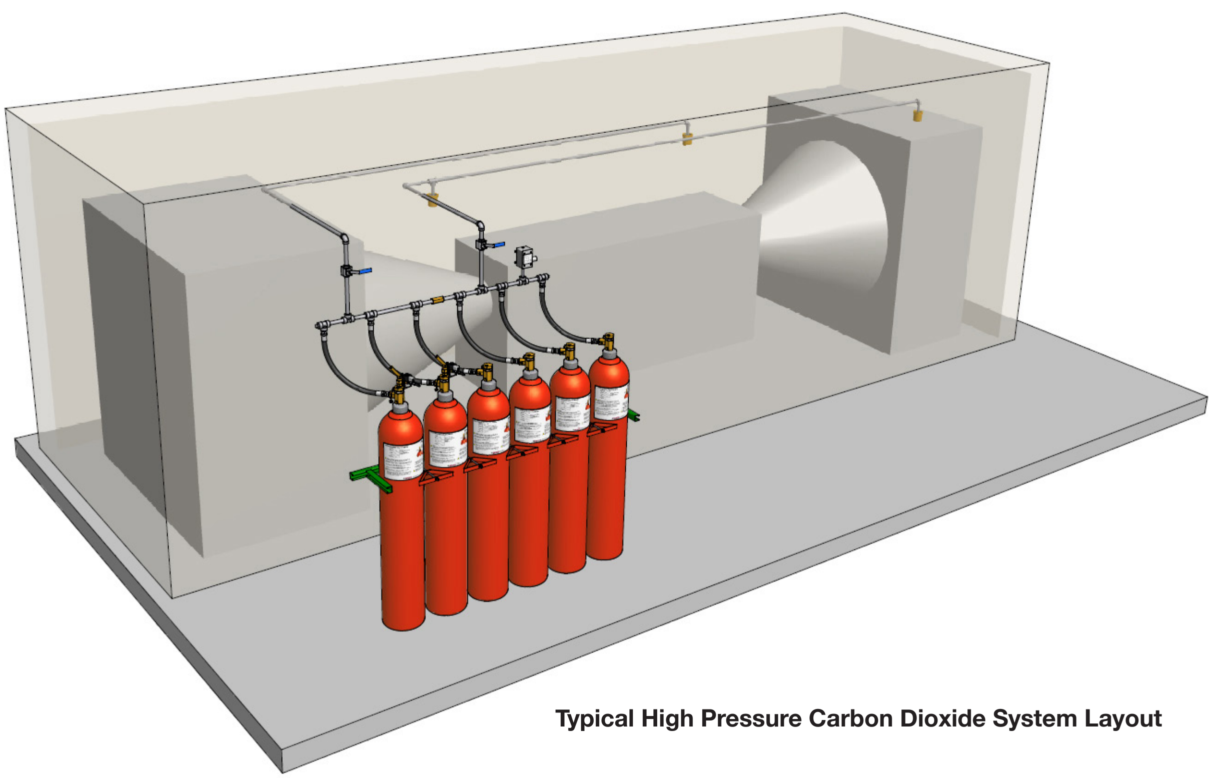
1 General Information

The FireBus High-Pressure Carbon Dioxide Fire Extinguishing System consists of a battery of one or more cylinders manifolded together and connected to a system of distribution pipework terminating with special carbon dioxide discharge nozzles. These systems are custom designed for this specific application. The quantity of carbon dioxide required for the protection of any particular hazard is dependent on the nature and type of the hazard, the type of flammable material involved, and the temperature of the hazard with allowance for special conditions.

More than one hazard can be protected by the same bank of cylinders. These systems are referred to as selector valve systems. Selector or directional valves are utilized to direct the carbon dioxide to the fire area. A connected reserve bank of cylinders is generally recommended for this type of protection.

FireBus High-Pressure Carbon Dioxide Fire Extinguishing Systems may be actuated manually or automatically. Automatic systems incorporate detection and controls. Detection is placed in the hazard area, and when a fire occurs, detectors send a signal to the control panel which releases the carbon dioxide. Automatic systems are electrically operated and always incorporate a manual override feature.



Typical High Pressure Carbon Dioxide System Layout

Section 1 General Information

1.1 Principles of Operation

There are two methods of applying carbon dioxide to hazards:

- **Total flooding** injects a sufficient volume of carbon dioxide into an enclosure so that an inert atmosphere is created. The enclosure should be reasonably well sealed and doors, vents and other openings should be arranged to close on the discharge of the system. Enclosures with openings that cannot be closed can be protected if known at the design stage. For deep-seated type hazards (insulation, exhaust ducts, storage vaults, etc.) the enclosure must be well sealed to retain the carbon dioxide for a long period of time (approximately 20 minutes per NFPA 12). The location and orientation of discharge nozzles for these applications is not of major concern, minor deviations to project design can generally be accommodated.

- **Local application** is the method used to protect a specific hazard (engine, dip tank, etc.) within an enclosure — *without flooding the entire enclosure*. Nozzles are arranged to discharge carbon dioxide directly onto the hazard, to build up an inert atmosphere immediately surrounding the hazard. For this application, the layout of piping and nozzles is critical, and deviations to project design must not be made unless approved by the designer.

1.2 Properties of CO_2 as a Fire Extinguishing Agent

Carbon dioxide (CO_2) is a colorless, odorless, clean, dry, electrically non-conductive, non-corrosive, non-damaging and non-deteriorating inert gas that is approximately 50 percent heavier than air.

Carbon dioxide is a standard commercial product. It is commonly used for carbonating beverages, for fast freezing food, for medical purposes, and for purging pipes and tanks in addition to its use as a fire extinguishing agent. Carbon dioxide is available in most cities and seaports throughout the world.

When inhaled CO_2 produces a tingle in the nostrils, the same as is experienced when drinking carbonated beverages. Carbon dioxide stimulates breathing (increases the rate of breathing) and is useful in small controlled doses in the resuscitation of drowning and electric shock victims.

Carbon dioxide is stored in liquid form in high pressure steel containers at 850 psig (58.6 bar) at 70°F (21°C). One of carbon dioxide's most valuable properties for use as a fire extinguishing agent is its high ratio of expansion, approximately 450 to 1. Carbon dioxide is discharged from the cylinder by the force of its own expansion without the need for pumps or other pressurizing mechanisms. Carbon dioxide then penetrates every corner of the protected hazard space.

On discharge, carbon dioxide creates a cold fog. The temperature of carbon dioxide discharging from a nozzle is approximately 110°F below zero. This cloud effect, or fogging, is due to the moisture in the air being frozen by the extremely low temperature of the carbon dioxide. The fogging will generally dissipate after a few minutes. Carbon dioxide has a low heat absorption potential and so this cold discharge generally has no adverse effect on equipment being protected.

1.3 How Carbon Dioxide Extinguishes Fire

Carbon dioxide extinguishes fire by diluting oxygen content to a point where it will not support combustion. Reducing the oxygen content from the normal 21 percent in air to 15 percent will extinguish most fires. For some materials, the oxygen content must be reduced below 15 percent. In some cases its concentration must be lowered to six percent of the volume. Surface and flash type fire (oils, paints, etc.) are quickly extinguished, while smouldering or deep-seated fires (baled cotton, clothing, etc.) are extinguished by the prolonged action of a high carbon dioxide concentration.

In addition to its smothering action, the reduction in temperature due to its rapid expansion will provide some suppression caused by the cooling effect.

1.4 Cleanup Following a CO_2 Discharge

Carbon dioxide vaporizes completely on discharge. Whereas the cost of clean-up and peripheral damage associated with water, foam, and dry chemical agents can exceed the cost of the fire damage itself, cleanup costs associated with carbon dioxide are negligible.

Carbon dioxide is inert and most materials and equipment are totally unaffected by exposure to it. Carbon dioxide is stable, even at high temperatures, and does not decompose when subjected to fire, therefore it does not cause metals to corrode.

⚠ WARNING
Following discharge, all carbon dioxide must be ventilated from a hazard area and the oxygen content checked to ensure it is within OSHA guidelines before allowing entrance by personnel.

1.5 Use and Limitations

Carbon dioxide fire extinguishing systems may be utilized for Class A, B, and C fires (North American definition). They are particularly useful for extinguishing fires in specific hazard areas or equipment:

a) Where an inert, electrically non-conductive medium is desirable.

b) In high value occupancies particularly susceptible to fire, smoke and water damage.

c) Where clean up another medium would present a problem.

Carbon dioxide will not extinguish fires involving the following materials:

a) Chemical containing their own oxygen supply such as cellulose nitrate.

b) Reactive metals such as sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium.

c) Metal hydrides.

While carbon dioxide will not extinguish these fires, it will not react dangerously with these materials or increase their burning rate. Carbon dioxide if used in this type of situation in a total flooding system will provide protection for adjacent combustibles or can be successfully used if the reactive metals or hydrides are first covered by another material. The following are examples of this latter condition:

a) Sodium stored or used under kerosene.

b) Cellulose nitrate in solution of lacquer thinner.

c) Magnesium chips covered with heavy oil.

For local application systems with attendant high velocity (such as systems utilizing hose reels), directed discharge should not be used per NFPA 12.

Carbon dioxide fire-extinguishing systems protecting areas where explosive atmospheres could exist shall utilize metal nozzles and the entire system shall be grounded. In addition, objects exposed to discharge from carbon dioxide nozzles shall be grounded to dissipate possible electrostatic charge.

1.6 Compatibility with Other Extinguishing Agents

Carbon dioxide may be used simultaneously with other types of fire extinguishing agents for fire fighting purposes. There are no known indications that extinguishing efficiency will be affected.

1.7 Typical High-Pressure CO_2 Cylinder Assembly and Equipment

High-pressure storage systems are comprised of CO_2 cylinders stored at ambient temperatures. At 70°F (21°C), the pressure in this type of storage container is 850 psi (58.6 bar).

Low-pressure storage systems are comprised of CO_2 pressure vessels stored at a controlled low temperature of 0°F (-18°C). At this temperature the pressure in the storage unit is 300 psi (20.7 bar).

Advantages of high-pressure systems:

- High-pressure cylinders are available in 50 lb (20 kg) and 100 lb (45 kg) capacities. Low-pressure containers are typically available in two-ton increments. This greater flexibility among high-pressure systems allows the system designer to allocate storage with greater efficiency, thus saving storage space and money.
- Refrigeration of carbon dioxide is not required in high-pressure systems. Cylinders can be stored without any special treatment at temperatures between 0°F (-18°C) and 130°F (54°C) for total flooding systems and between 32°F (0°C) and 120°F (49°C) for local application.
- Cylinders can be easily adjusted for higher or lower temperatures by underfilling for higher temperatures or adding nitrogen for lower temperatures.
- Flexible space requirements — if a single large space is not available, multiple cylinder banks can be divided and stored in a number of smaller locations.
- Flexible for weight requirements — if floor loading is a problem, multiple cylinder banks can be divided and stored in a number of locations to distribute the floor loading.
- Electric power is not required for high-pressure carbon dioxide storage.

2 SAFETY CONSIDERATIONS

Carbon dioxide (not to be confused with carbon monoxide) is only mildly toxic. It does not carry oxygen in any form for sustaining human life, therefore the principle action of carbon dioxide is to cause suffocation. The following human reactions have been determined by test:

a) At concentrations of 3 to 4 percent by volume in air, the breathing rate increases and can cause headaches.

b) At concentrations of 9 percent by volume, personnel can lose consciousness within minutes, this being preceded by disorientation, visual disturbance, ringing in the ears, tremors, etc.

c) At concentrations of about 20 percent by volume, death will follow in 20 to 30 minutes.

The above effects are important to note because inexperienced personnel may fail to think clearly and take proper action if suddenly exposed to relatively low concentrations of carbon dioxide.

Any person overcome by carbon dioxide should be moved immediately to a location where plenty of fresh air is available and artificial respiration should be applied. ***Do not use carbon dioxide as a stimulant.*** An ammonia inhalant may be used and the person should be kept warm (by the application of friction and heat to the extremities). Call a physician or take the patient to a hospital for examination. A person rendered unconscious by carbon dioxide can usually be revived without any permanent ill effects when promptly removed from such atmospheres.

Direct contact with carbon dioxide will cause frostbite burns to the skin. Carbon dioxide vaporizes rapidly, therefore this hazard is generally limited to the immediate vicinity of the discharge nozzle.

The discharge of carbon dioxide will create a fog and this may seriously interfere with visibility during and immediately after the discharge period. The fog effect could last for several minutes.

If it is necessary to enter a hazard space following a carbon dioxide discharge, a fresh air mask or other type of self-contained breathing apparatus should be worn. ***Do not use a filter type of mask or a canister gas mask.*** No one should enter such a space without another person as observer and standby outside the space. A lifeline is also strongly recommended.

When all traces of the fire have been extinguished and the possibility of re-ignition has been eliminated, thoroughly ventilate the space to make certain that only fresh air is present. Never test the atmosphere by inserting a naked flame as the possible presence of flammable vapors may result in an explosion.

In hazard areas where personnel could be present, suitable safeguards should be provided to ensure prompt evacuation and to prevent entry into such atmospheres. Such safety items as warning signs, discharge delay devices, and pre-discharge alarms should be provided with all automatic carbon dioxide systems as mandated by NFPA 12.

2.1 Safety Precautions

Safeguards must be taken to ensure the safety of personnel in areas where the atmosphere could be made hazardous by the discharge of carbon dioxide. The following list, which is strongly recommended, is generally taken from NFPA 12 - Standard on Carbon Dioxide Extinguishing Systems.

a) Provide adequate aisle ways and routes of exit and keep them clear at all times.

b) Provide emergency lighting and directional signs as necessary to ensure quick, safe evacuation.

c) Provide alarms within such areas that will operate immediately upon detection of the fire, with the discharge of the carbon dioxide and the activation of automatic door closures delayed for sufficient time to allow evacuation of the area before discharge begins.

d) Provide only outward swinging self-closing doors at exits from hazard areas and, where such door are latched, provide panic hardware.

e) Provide continuous alarms at entrances to such areas until the atmosphere has been restored to normal.

f) Provide warning and instruction signs at entrances to and inside such areas. These signs must inform persons in or entering the protected areas that a carbon dioxide system is installed and contain additional instructions pertinent to the conditions of the hazard in compliance with ANSI Z535. Existing signs that are a part of an established training and safety program may be implemented if in compliance with NFPA 12 Section 4.3.2.4.

g) Provide for the prompt discovery and rescue of persons rendered unconscious in such areas. This may be accomplished by having such areas searched immediately by trained persons equipped with proper breathing equipment. Self-contained breathing equipment (and personnel trained in its use and in rescue practices including artificial respiration), should be readily available.

h) Provide instruction and drills for all personnel within or in the vicinity of such areas (including maintenance or construction people who may be brought into the area), to ensure their correct action when carbon dioxide protective equipment operates.

i) Provide the means for prompt ventilation of such areas. Forced ventilation will often be necessary. Care should be taken to really dissipate hazardous atmospheres and not merely move them to another location.

j) Carbon dioxide is much heavier than air and can collect in pits, cellars, and low-lying areas. Care should be taken when entering such areas after carbon dioxide has been discharged. Oxygen levels should be checked to ensure the oxygen content is within OSHA guidelines.

k) Provide means to mechanically lockout the system during periods of system inspection, maintenance, or modification.

l) Provide the fire alarm system with a disconnect switch to allow testing of the alarm system without actuating the fire suppression system. The disconnect shall be a physical switch and not be accomplished by using software.

m) Provide such other steps and safeguards that a careful study of each particular situation indicates are necessary to prevent injury or death.

3 SYSTEM COMPONENTS

3.1 Cylinder Assemblies

A basic cylinder assembly consists of a cylinder, a valve and dip tube assembly, and a charge of carbon dioxide.

3.1.1 Cylinder

A variety of cylinder sizes are available. They are all designed to hold pressurized carbon dioxide in liquid form at atmospheric temperatures, corresponding to a nominal pressure of 850 psi (58.6 bar) at 70°F (21°C).

All cylinders are seamless. They are manufactured and tested in accordance with the requirements of Transport Canada and/or Department of Transport (USA), Specification 3AA-1800 or higher. Large cylinders have standard capacities of 50 lbs (22.7 kg) and 100 lbs (45 kg) and are made of steel. Small cylinders, used for special applications, are available and may be made of aluminum or steel depending on availability.

Except for special temperature conditions, all cylinders are filled to their specified weight with liquid carbon dioxide. Cylinders are not partially filled.

The pressure inside the cylinder will vary as the temperature changes. In general, the ambient storage temperature for standard cylinders used in total flooding application systems should be between 0°F (-18°C) and 130°F (54°C).

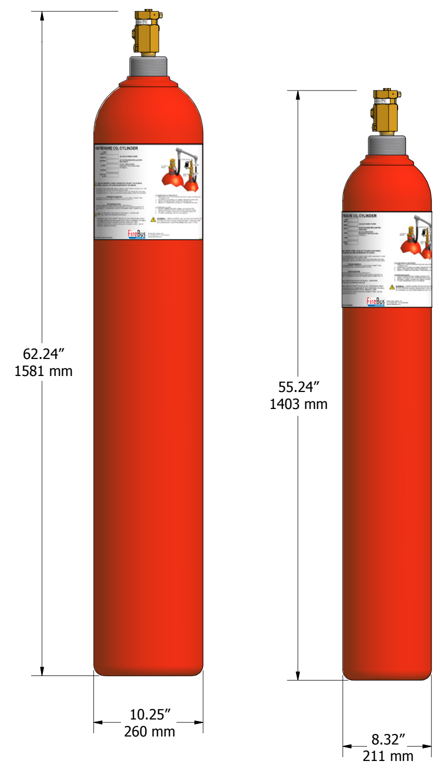


Figure 3.1.1 100 lb and 50 lb Cylinder Assemblies

Table 3.1.1 - Cylinder Sizes						
Nominal Cylinder Size[1]		Assembly P/N	Empty Weight		Full Weight	
lb	kg		lb	kg	lb	kg
50	22.7	9010-FRP-4102	96	43.5	146	66.2
100	45.4	9010-FRP-4100	210	95.3	310	140.6

1 Additional sizes available for special orders.

Section 3 System Components

3.1.2 Cylinder Valve

The cylinder valve (SW50-M) is manufactured of brass. It is of the force differential type using a piston seal. The pressure above the piston is maintained at cylinder pressure, but the area at the top of the piston is greater than the seal area. This results in a higher force above the piston, which acts to keep the valve closed.

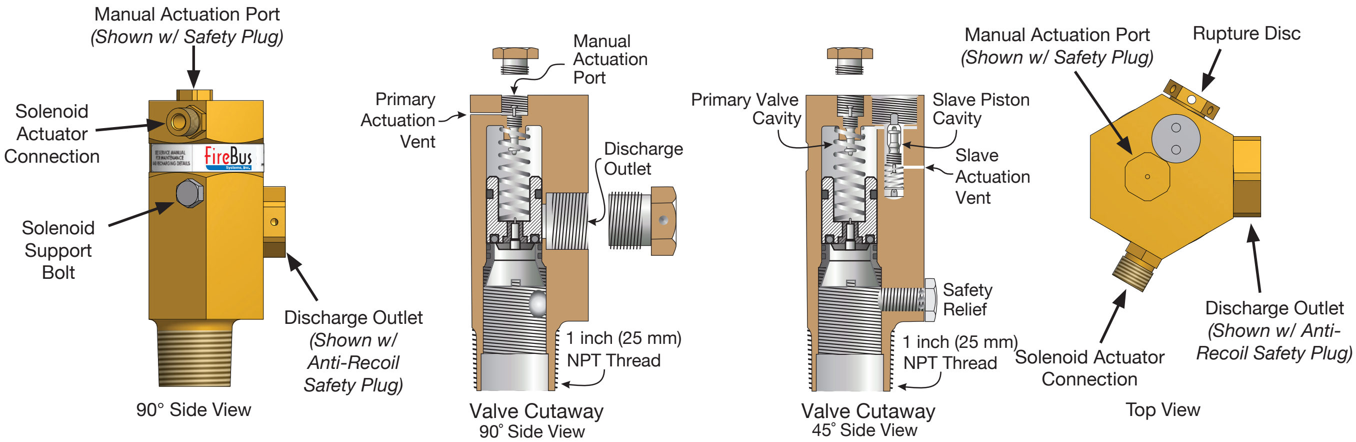


Figure 3.1.2 SW-50M Cylinder Valve

To open the valve, the pressure above the piston is vented and cylinder pressure raises the piston to open the valve. An anti-recoil safety plug is attached to the valve by a chain and must be attached to the discharge port when the cylinder is disconnected from the discharge piping.

A pressure relief rupture disc, incorporated into the cylinder valve, is designed to release pressure should the cylinder be subjected to exceptionally high temperatures or other abnormal conditions. The disc rupture point is in the range of 2,600 to 3,000 psi (182.7 to 206.8 bar). The rupture disc nut is of a type that will relieve pressure without cylinder recoil.

The SW-50M cylinder valve can be operated either manually utilizing the manual actuator, electrically utilizing the solenoid valve kit, or pneumatically through direct back pressure from the discharge manifold.

Single cylinder systems operate with a single cylinder assembly equipped with a manual actuator and/or a solenoid valve called the primary cylinder. For systems with two cylinders connected to a single manifold, one primary cylinder equipped with a manual actuator and/or solenoid valve is required. The other cylinder (called a slave cylinder) actuates from the back pressure produced in the discharge manifold when the primary cylinder is actuated. For systems with three or more cylinders connected to a single manifold, two cylinders must act as primary cylinders and have solenoid and/or manual actuators arranged for simultaneous operation. The rest are slave cylinders.

3.1.3 Dip Tube

A rigid dip tube is used in all cylinders to ensure liquid discharge. All cylinders must therefore be installed in the normal upright position.

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3.2 Trim Components

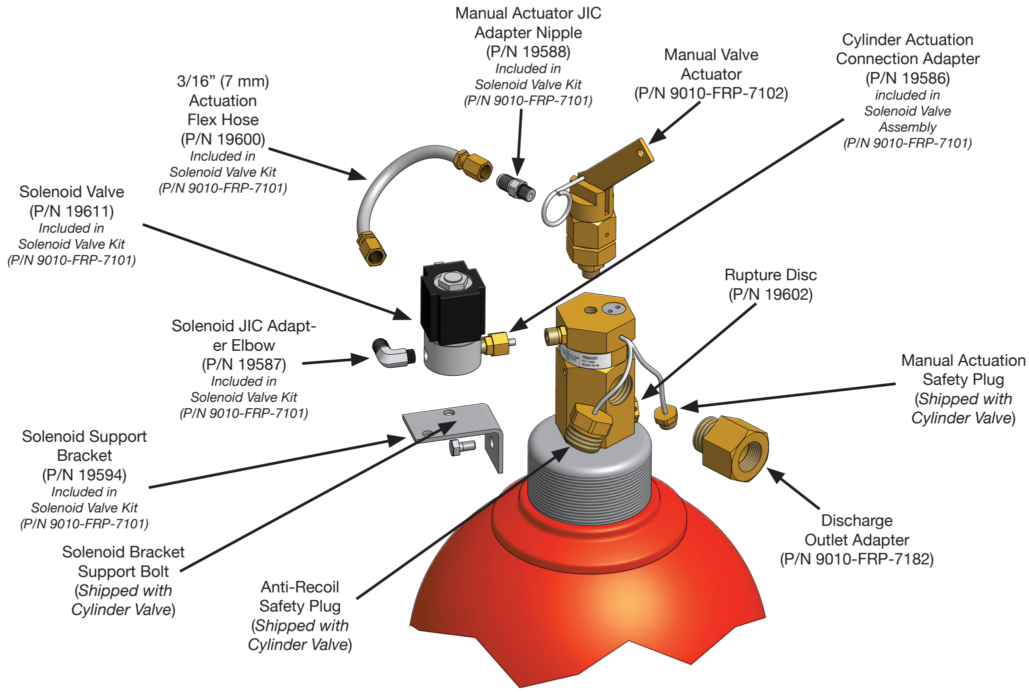
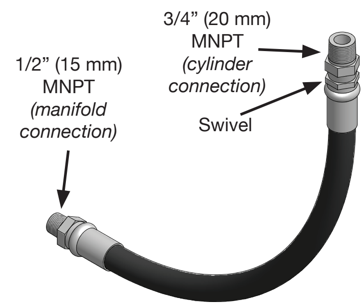


Figure 3.2 Trim Components

3.2.1 Discharge Flex Hose

A 22 in (559 mm) discharge flex hose is used to connect the cylinder valve outlet to the system manifold and discharge piping. This flexible hose allows for the temporary misalignment of the cylinders on installation and for ease of cylinder removal during maintenance. The 3/4 in (20 mm) MNPT cylinder end of the hose has a swivel connection for ease of installation. The flex hose has minimum bend radius of 9.5 inches (241 mm).



a

Figure 3.2.1 Discharge Flex Hose

3.2.2 Discharge Check Valve

Discharge flex hose with a built-in discharge check valve must be used when cylinders are manifolded together. One end of the discharge check valve is locked onto the hose assembly and must not be separated from it. The other end threads into the cylinder valve outlet. When a cylinder assembly is disconnected from the manifold for maintenance, the discharge check valve and discharge flex hose remain attached to the manifold. Should the system actuate while the cylinder is disconnected, the check valve will ensure that an appreciable quantity of carbon dioxide does not discharge from the disconnected flex hose.

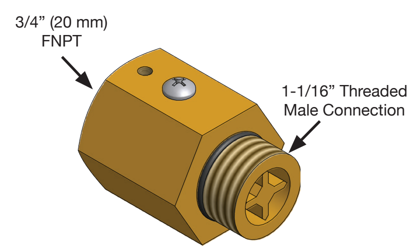


Figure 3.2.2 Discharge Check Valve

Section 3 System Components

3.2.3 Discharge Outlet Adapters

Discharge outlet adapters are used to facilitate the attachment of discharge flex hose in single cylinder systems where a check valve is not required. When the discharge adapter is used without the discharge flex hose, a union connection must be installed close to the cylinder for ease of installation and maintenance.

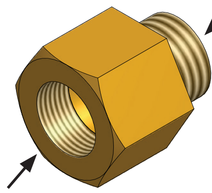


Figure 3.2.3 Discharge Outlet Adaptor

CAUTION

Discharge flex hose, the discharge check valve, or the discharge outlet adapter should **NOT** be mounted onto the cylinder valve during transportation and storage. The anti-recoil safety plug must remain in place in the cylinder valve outlet at all times when the cylinder assembly is not secured in the cylinder bracket and connected to the discharge piping.

3.2.4 Manual Actuation

A manual actuator is used to operate the carbon dioxide system manually and locally at the cylinders. The actuator is screwed into a port on the top of the SW-50M cylinder valve on each primary cylinder.

The actuator has a hole in the side of the main body fitted with a blank plug. This hole allows the actuator to be operated from an external pressure source. It is also used to connect to the outlet port of the solenoid valve. The blank plug is removed from the actuator only for these two purposes. Otherwise the plug must remain tightly connected at all times.

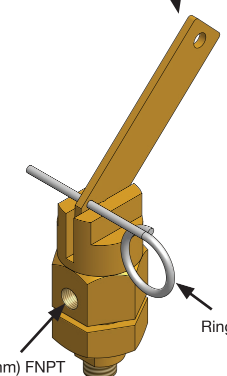


Figure 3.2.4 Manual Valve Actuator

WARNING

Operation of the manual actuator will immediately begin the discharge of carbon dioxide into the protected hazard (unless the system design incorporates a mechanical time delay). Make sure personnel have been evacuated from the hazard space prior to actuating the system.

3.2.5 Electric Actuation

Electric actuation is achieved by using a solenoid valve kit. The solenoid valve is a normally closed device, closed when de-energized and open when energized. The standard solenoid voltage is 24 VDC. The solenoid has a 1/2 inch (15 mm) conduit connection with 18 inch (457 mm) leads.

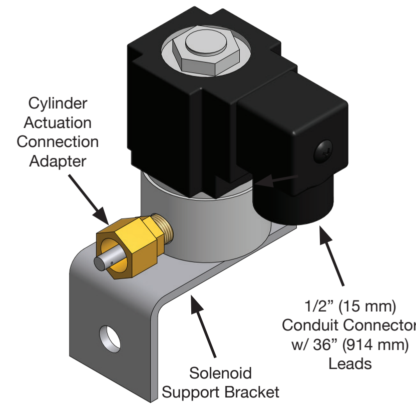


Figure 3.2.5 Solenoid Valve Kit

The solenoid valve connects directly to the solenoid actuation port on the SW-50M cylinder valve. The discharge side of the solenoid valve is connected to the pressure port on the manual actuator with supplied 3/16 inch braided flex hose. When energized, the solenoid valve opens allowing pressure from above the main piston of the cylinder valve to operate the manual actuator and open the cylinder valve.

The solenoid should be connected to a UL Listed and/or FM approved control panel that is powered through a separately fused circuit and that also incorporates battery backup power.

3.2.5.1 Actuation Flex Hose

A 3/16 in (7 mm) Teflon® lined stainless steel wire braided flex hose with 1/4 in (8 mm) 37° female JIC fittings is utilized to connect the solenoid valve outlet port to the pressure port of the manual valve actuator. It is shipped as part of the solenoid valve kit.

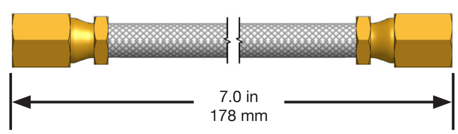


Figure 3.2.5.1 Actuation Flex Hose

3.2.5.2 JIC Adapter Elbow

A 1/8 in (6 mm) MNPT by 1/4 in (8 mm) 37° male JIC adapter elbow is threaded into the discharge port of the solenoid valve to facilitate the connection of actuation flex hose. It is shipped as part of the solenoid valve kit.

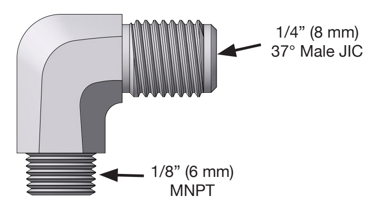


Figure 3.2.5.2 JIC Adapter Elbow

3.2.5.3 JIC Adapter Nipple

A 1/8 in (6 mm) MNPT by 1/4 in (8 mm) 37° male JIC adapter nipple is threaded into the pressure port of the manual valve actuator to facilitate the connection of actuation flex hose. It is shipped as part of the solenoid valve kit.

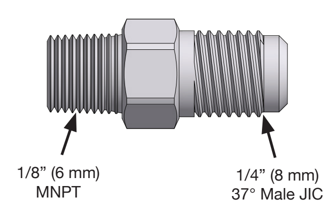


Figure 3.2.5.3 JIC Adapter Nipple

3.2.5.4 Solenoid Bracket

A bracket attaches to the SW40-M cylinder valve using the solenoid support bolt on the side of the cylinder valve. The bracket supports the solenoid valve. It is shipped as part of the solenoid valve kit.

Figure 3.2.5.4 Solenoid Bracket

Section 3 System Components

3.3 Inline Check Valves

A range of inline check valves are available. These are used in main/reserve or initial/extended cylinder arrangements to prevent connected cylinder banks from being actuated by the discharge from an actuated cylinder bank.

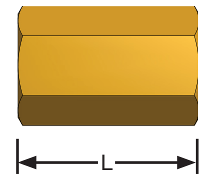


Figure 3.3a
Inline Check Valve

Table 3.3a - Inline Check Valves							
P/N		Valve Size (FNPT)		Length (L)		Weight	
Brass	Stainless Steel	in	mm	in	mm	lbs	kg
9012-FRP-7157	9012-FRP-7164	1/2	15	2.71	69	0.6	0.3
9012-FRP-7103	9012-FRP-7165	3/4	20	2.94	75	0.7	0.3
9012-FRP-7158	9012-FRP-7166	1	25	3.64	92	1.4	0.6
9012-FRP-7159	9012-FRP-7167	1-1/2	40	4.37	111	3.9	1.8
9012-FRP-7160	9012-FRP-7168	2	50	5.85	149	5.8	2.6
9012-FRP-7161	9012-FRP-7169	3	80	6.25	159	16.4	7.4

Additional male connection check valves are available. These check valves have a maximum pressure of 3000 psig @ 70°F (206 bar @ 21°C) and are available in two different sizes and made of brass or stainless steel.

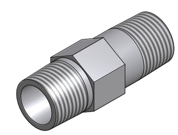


Figure 3.3b
Male Check Valve

Table 3.3b - Male Inline Check Valves							
P/N		Valve Size (MNPT)		Length		Weight	
Brass	Stainless Steel	in	mm	in	mm	lbs	kg
9012-FRP-7155	9012-FRP-7162	1/4	8	1.62	41	0.4	0.2
9012-FRP-7156	9012-FRP-7163	1/2	15	2.28	58	0.6	0.3

3.4 Vent Checks

Vent checks are used in the manifolds of main/reserve systems as well as in the manifolds of systems that have selector valves. When one bank of cylinders discharges, the vent check bleeds off any accidental check valve leakage that could discharge the other bank or banks of cylinders. The vent check is normally open with a ball seal that closes when manifold pressure reaches approximately 20 psi (1.4 bar) to prevent loss of CO_2 under normal discharge conditions. The pipe connection is 1/4 in (8 mm) MNPT.

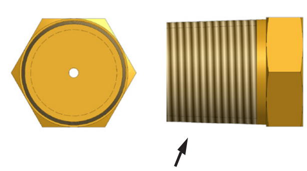
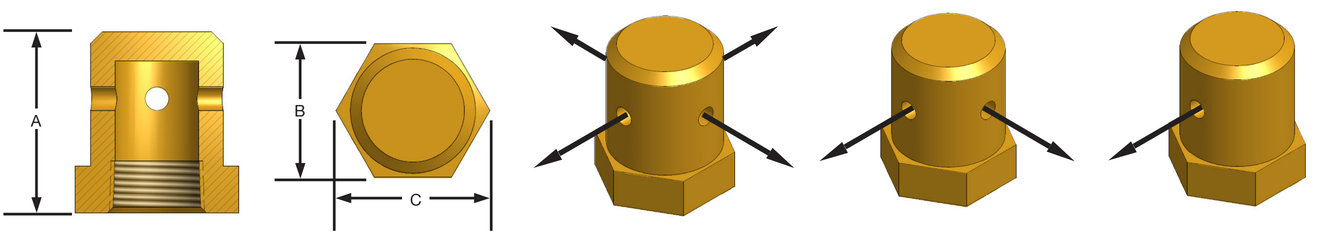


Figure 3.4 Vent Check

3.6 Discharge Nozzles

The brass discharge nozzles are designed to discharge large volumes of carbon dioxide without freezing. The nozzles are performance tested to ensure that the agent is properly distributed throughout the protected area. Discharge nozzles are available with three separate port arrangements to accommodate placement in varying locations around a room or enclosure: 90° (1 port) corner nozzles, 180° (2 port) sidewall nozzles, and 360° (4 port) radial nozzles. All nozzles have drilled orifices. The nozzle orifice size varies depending on the rate of application (flow rate) and the location of the nozzle in the system. Specialized software is used to calculate the orifice drill size (drill code) required. Each nozzle is stamped with the nozzle part number, orifice code, and orifice diameter.



Side Cut View | Top View | 360° Radial Nozzle (4 Port) | 180° Sidewall Nozzle (2 Port) | 90° Corner Nozzle (1 Port)

Figure 3.6 Discharge Nozzle Configurations

Table 3.6 - Discharge Nozzle Sizes

Nozzle Orientation Part Number			Nominal Pipe Size	Nozzle Dimensions					
				A		B		C	
360°	180°	90°		in	mm	in	mm	in	mm
9010-FRP-8002	9010-FRP-8008	9010-FRP-8015	3/8 in (10mm)	1.436	36.5	1.125	28.57	1.30	33.02
9010-FRP-8001	9010-FRP-8009	9010-FRP-8016	1/2 in (15 mm)	1.722	43.7	1.250	37.75	1.44	36.58
9010-FRP-8003	9010-FRP-8010	9010-FRP-8017	3/4 in (20 mm)	1.926	48.9	1.500	38.10	1.73	43.94
9010-FRP-8004	9010-FRP-8011	9010-FRP-8018	1 in (25 mm)	2.176	55.3	1.750	44.45	2.02	51.31
9010-FRP-8005	9010-FRP-8012	9010-FRP-8019	1 1/4 in (32 mm)	2.500	63.5	2.250	57.15	2.60	66.04
9010-FRP-8006	9010-FRP-8013	9010-FRP-8020	1 1/2 in (40 mm)	2.689	68.3	2.250	57.15	2.60	66.04
9010-FRP-8007	9010-FRP-8014	9010-FRP-8021	2 in (50 mm)	3.100	78.7	3.000	76.20	3.46	87.88

Ordering Instructions: Specify the Nozzle P/N followed by a dash and the three digits representative of the drill code as generated by the software.

Example: 18507-XXX = Nozzle: 360°, 3/8” (10 mm), Brass (with drill code as specified)

⚠ CAUTION

Nozzles must be installed exactly as specified on project drawings. Failure to do so may cause one or more nozzles to not discharge the designed quantity of carbon dioxide.

Section 3 System Components

3.7 Discharge Pressure Switch

The discharge pressure switch connects to the carbon dioxide discharge piping and operates off the pressure produced when the system discharges. The switch may be wired with contacts in the open or closed position. Operation causes the electrical switch contacts to reverse position. Discharge pressure switches can be used to send a signal confirming system discharge to the control panel or to initiate the shutdown of equipment that may deplete the agent concentration in the protected hazard.

It is a single pole, double throw (SPDT) switch with contacts rated 10 Amps resistive at 30VDC.

The discharge pressure switch may be mounted in any position, but preferred installation is with the pressure connection (CO_2 supply line) entering from the bottom. The switch enclosure is rated for standard and weatherproof conditions. When the line load of the equipment to be operated is greater than the switch rating, the switch should be used to break a relay holding-coil circuit.

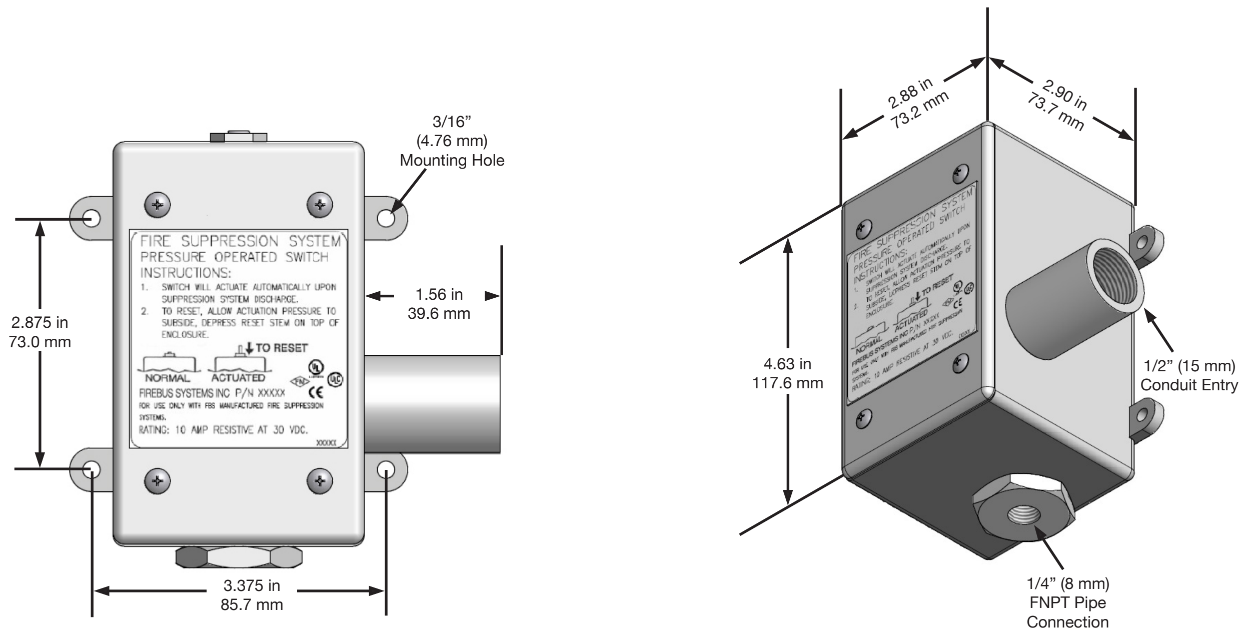


Figure 3.7 Discharge Pressure Switch

⚠ CAUTION

Notification devices may not be wired directly to a discharge pressure switch. NFPA 12 and NFPA 72 mandate notification devices must be supervised.

3.8 Explosion-Proof Discharge Pressure Switch

The FireBus Explosion-Proof Discharge Pressure Switch is used in potentially explosive atmospheres to send indication of agent discharge to a releasing panel and/or initiate the shut down of equipment that may deplete agent concentration. It is a single pole, double throw (SPDT) switch with contacts rated 15 Amps at 125/250/480 VAC resistive.

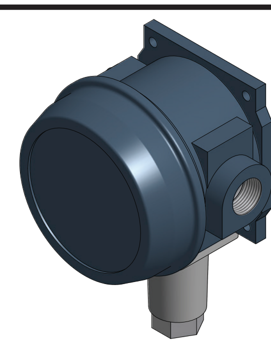


Figure 3.8 Explosion-Proof Pressure Switch

The pressure switch must be manually reset by turning the Manual Reset knob in the direction indicated on the knob itself.

3.9 Main/Reserve Transfer Switch

In a Main/Reserve Cylinder Arrangement, the FireBus, LLC MRS-1 Main/Reserve Transfer Station is used to transfer suppression system releasing circuits from the main bank of cylinders to the reserve bank of cylinders. The MRS-1 is a maintained toggle switch with a ring pin and lead wire seal for additional security.

To operate the MRS-1, break the lead wire seal, remove the safety pin and then push the toggle switch down into the Reserve position. Finally, the pin is replaced and a new lead wire seal is installed to ensure the switch is not accidentally tripped.

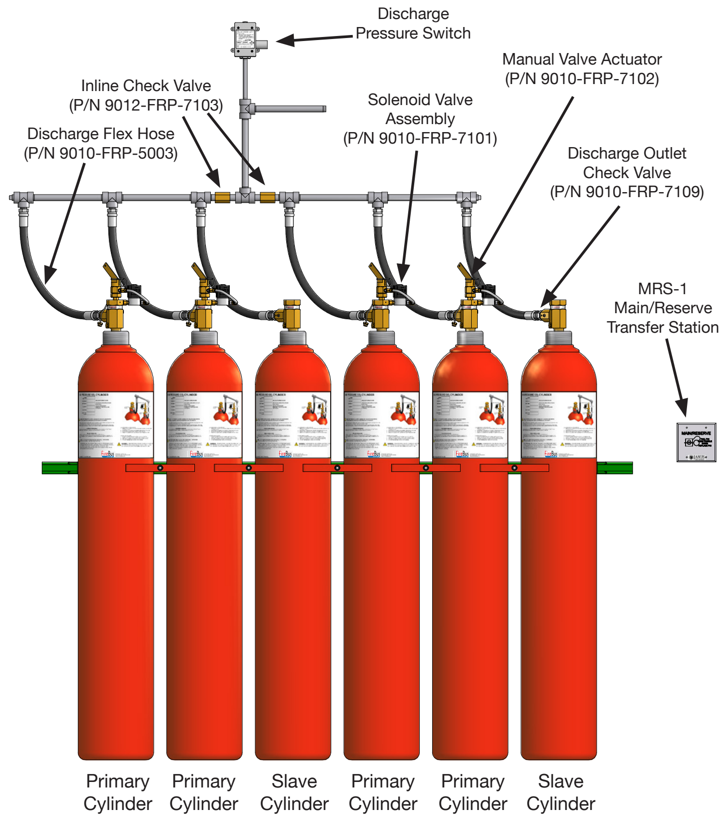


Figure 3.9 Typical Main/Reserve Cylinder Arrangement

3.10 Explosion-Proof Main/Reserve Transfer Switch

The FireBus MRS-2 Explosion-Proof Main/Reserve Transfer Station is used to transfer suppression system releasing circuits from a main supply to a reserve supply in potentially explosive atmospheres.

To transfer control from the main bank to the reserve bank using the MRS-2, remove the safety pin and turn the selector switch from the Main position into the Reserve position. Replace safety pin. To return control to the main bank, remove safety pin and turn the selector switch from the Reserve position into the Main position. Replace safety pin.

3.11 Pressure Release Trip

The pressure release trip can be used to release dampers, close fire doors, windows, louvres, fuel supply valves, to open dump valves, etc., automatically when the system discharges. The equipment to be operated must be weight or spring loaded, or be pivoted off center. The release trip is connected to the carbon dioxide discharge piping for operation when the system discharges. A cable from the equipment to be controlled is looped over the pressure release operating stem. When the trip is operated, the stem retracts and the cable is released.

3.12 Manifold Header Safety

This pressure relief device is installed in sections of closed piping such as between selector valves or lockout valves and the cylinder manifold. It is a frangible disc assembly designed to rupture if trapped CO_2 expands and the line pressure exceeds 2,650 to 3,000 psi (182.7 to 206.8 bar). The body is made of brass and the pipe connection is 1/2 inch (15 mm) MNPT.

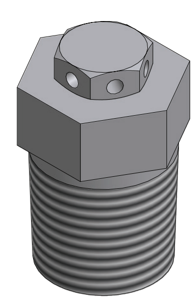


Figure 3.12 Manifold Header Safety

3.13 Pneumatic Pilot Cabinets

NFPA 12 mandates that total flooding CO_2 systems for normally occupied and occupiable enclosures be provided with pneumatic time delays and pneumatic predischarge alarms. This is achieved with the use of a pneumatically actuated selector valve operated by the FireBus "Pneumatic Pilot Cabinet".

When the $HPCO_2$ cylinders are actuated, pneumatic pressure from the discharge manifold is regulated down to 100 psi (6.89 bar) and enters the Pneumatic Pilot Cabinet as pilot pressure. A solenoid valve within the cabinet is opened by a signal from the releasing panel initiating a pneumatic timer and directing pilot pressure to sound a pneumatic predischarge siren. Upon completion of the predischarge period, the pneumatic timer opens allowing pressure to actuate the pneumatic actuation port of the selector valve, opening the valve and beginning discharge.

Multiple Pneumatic Pilot Cabinets may be implemented with multiple selector valves to allow protection over multiple hazards or hazard zones.

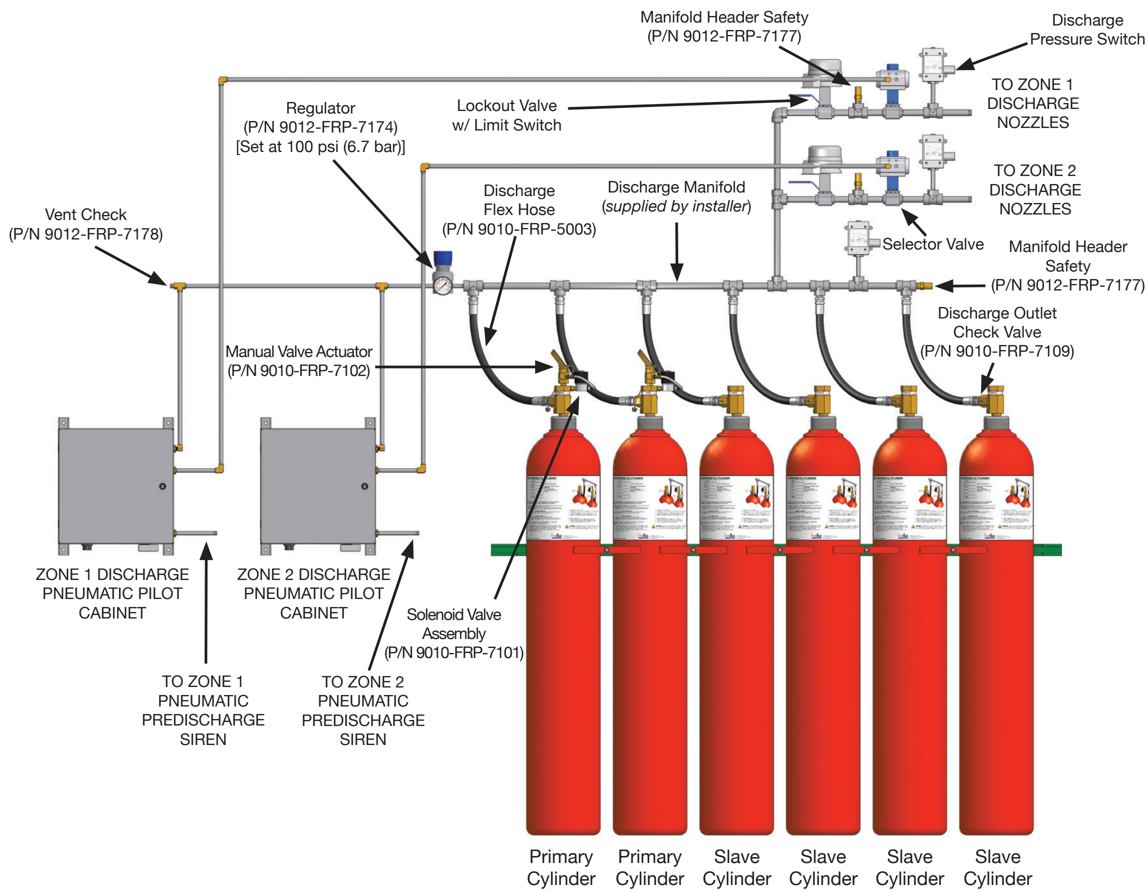


Figure 3.13a Typical Selector Valve Cylinder Arrangement w/ Pneumatic Time Delay

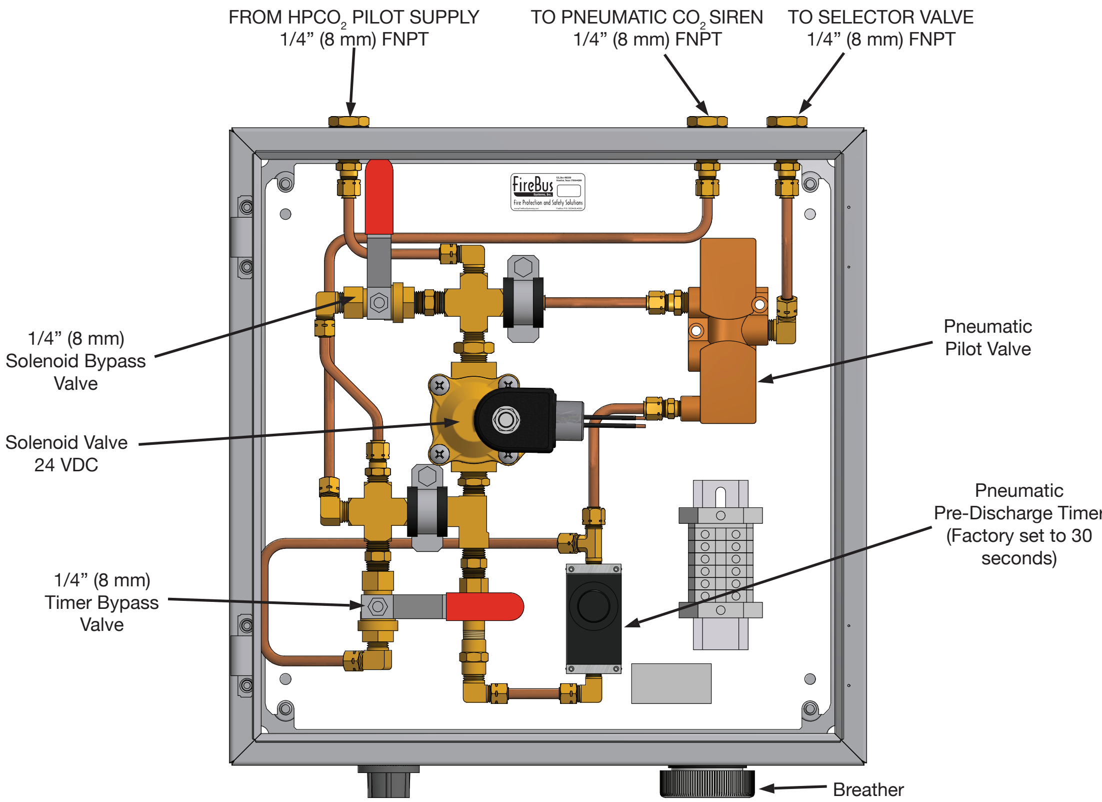


Figure 3.13b Standard Selector Pilot Cabinet

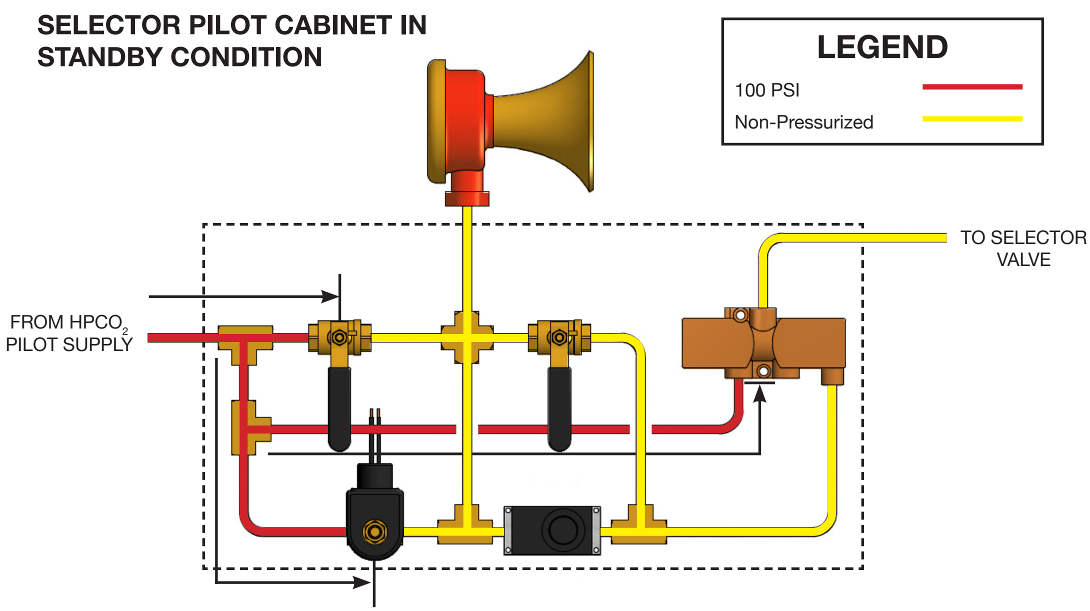


Figure 3.13c Selector Pilot Cabinet P&ID (Standby)

Section 3 System Components

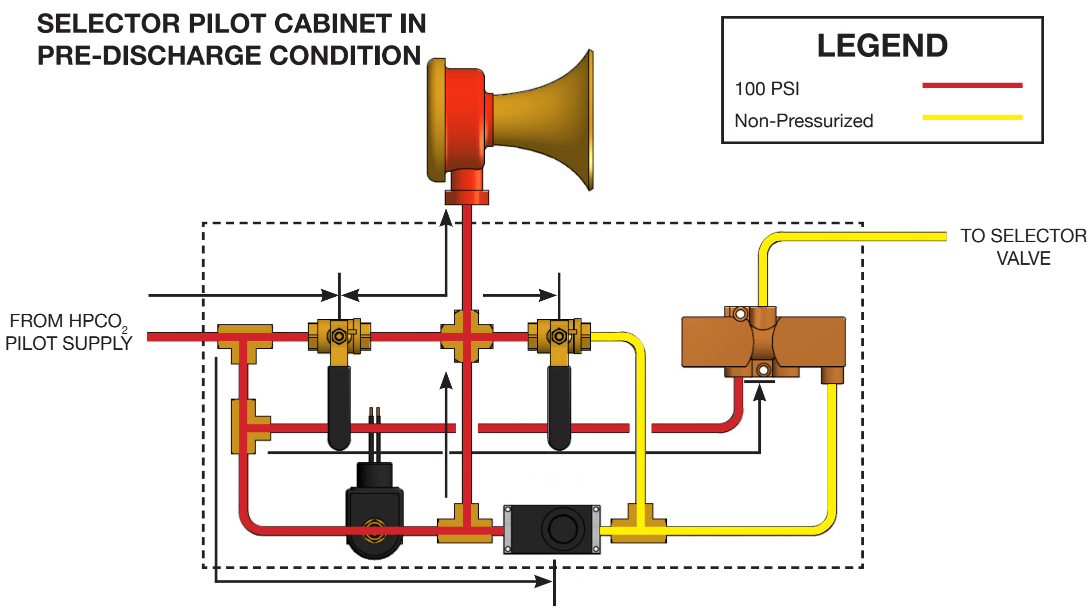


Figure 3.13d Electrically Actuated Cabinet (Pre-Discharge)

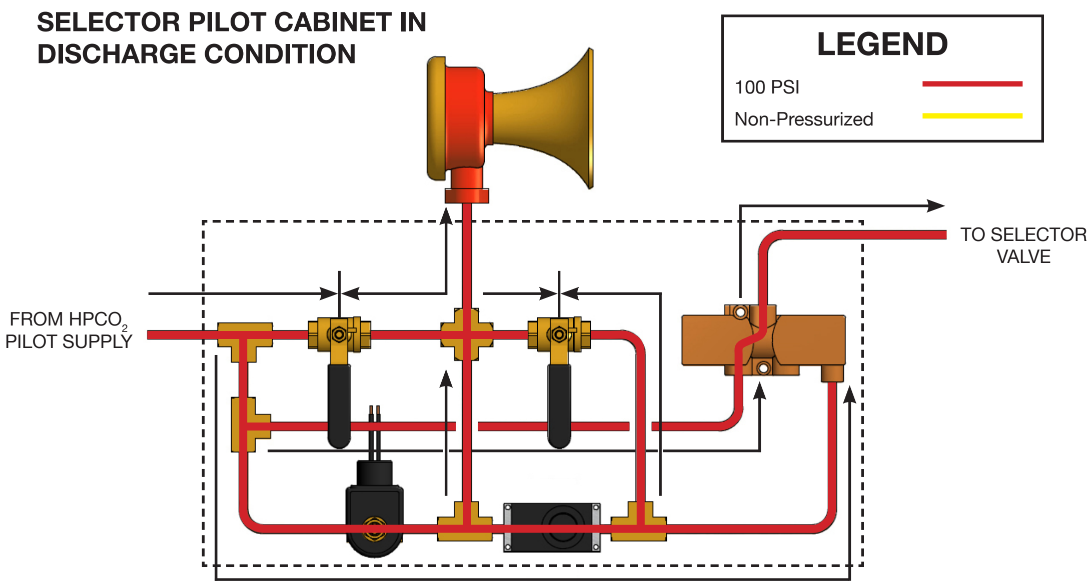


Figure 3.13e Electrically Actuated Cabinet (Discharge)

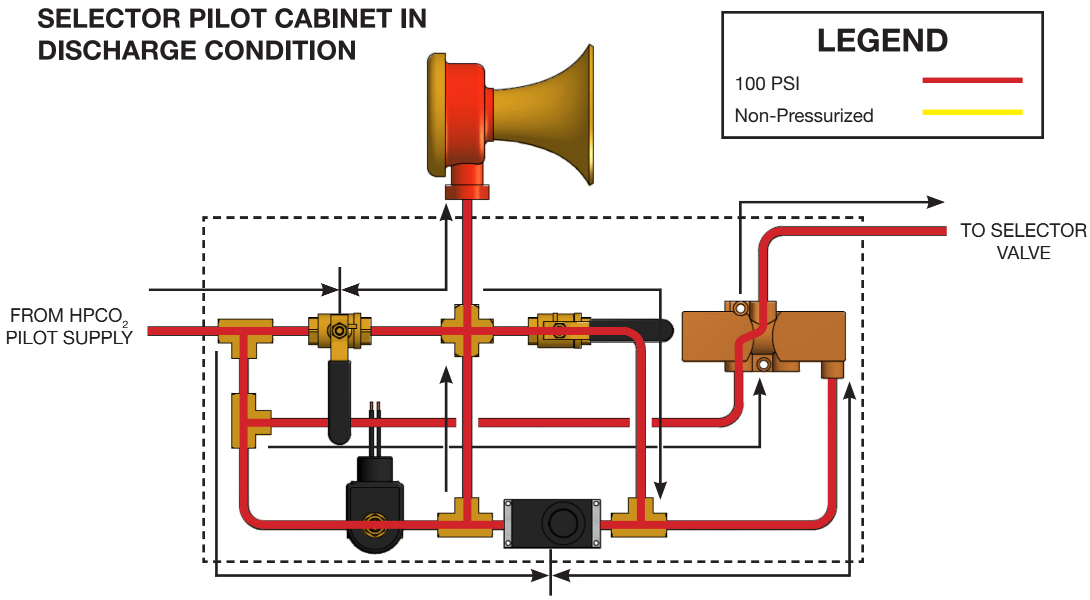


Figure 3.13f Electrically Actuated Cabinet (Timer Bypass)

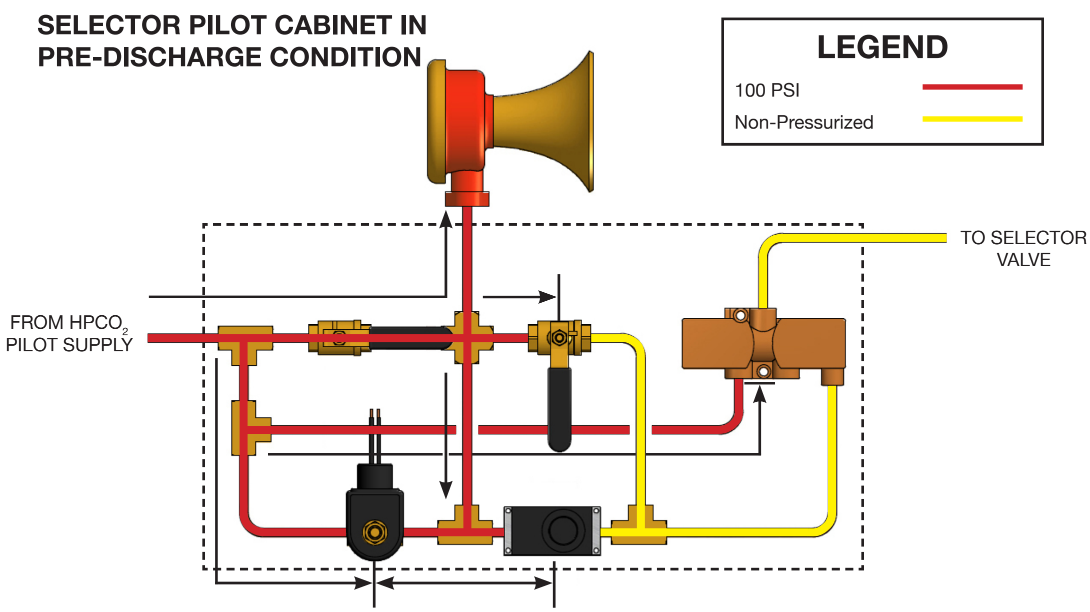


Figure 3.13g Manually Actuated Cabinet (Pre-Discharge)

Note: The $HPCO_2$ primary cylinder manual actuators operate independently of the pilot cabinet. Actuation must occur at both locations to manually actuate the system.

Section 3 System Components

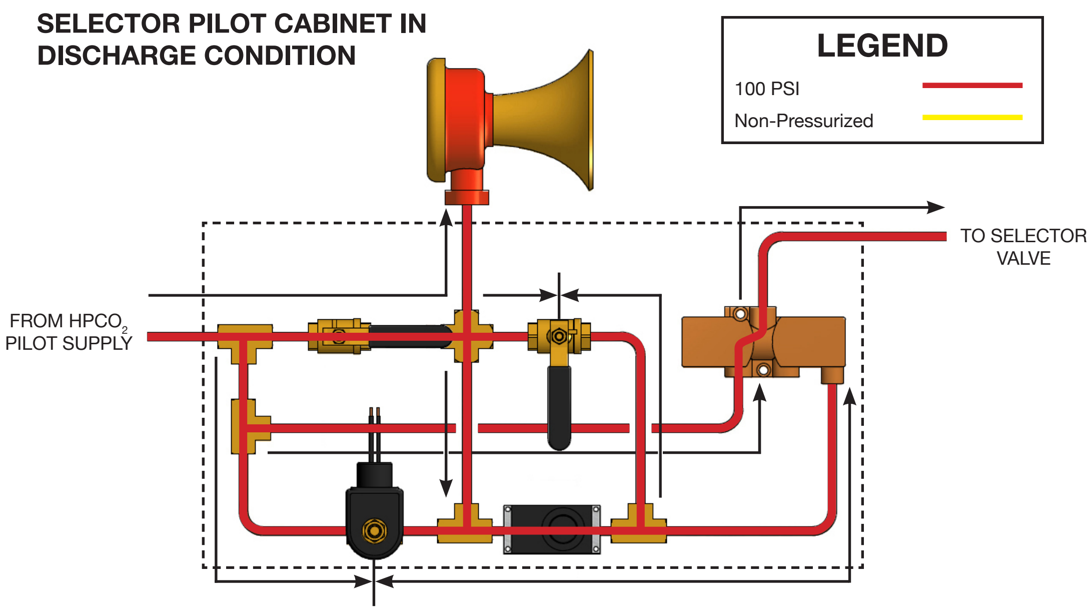


Figure 3.13h Manually Actuated Cabinet (Discharge)

Note: The HPCO$_2$ primary cylinder manual actuators operate independently of the pilot cabinet. Actuation must occur at both locations to manually actuate the system.

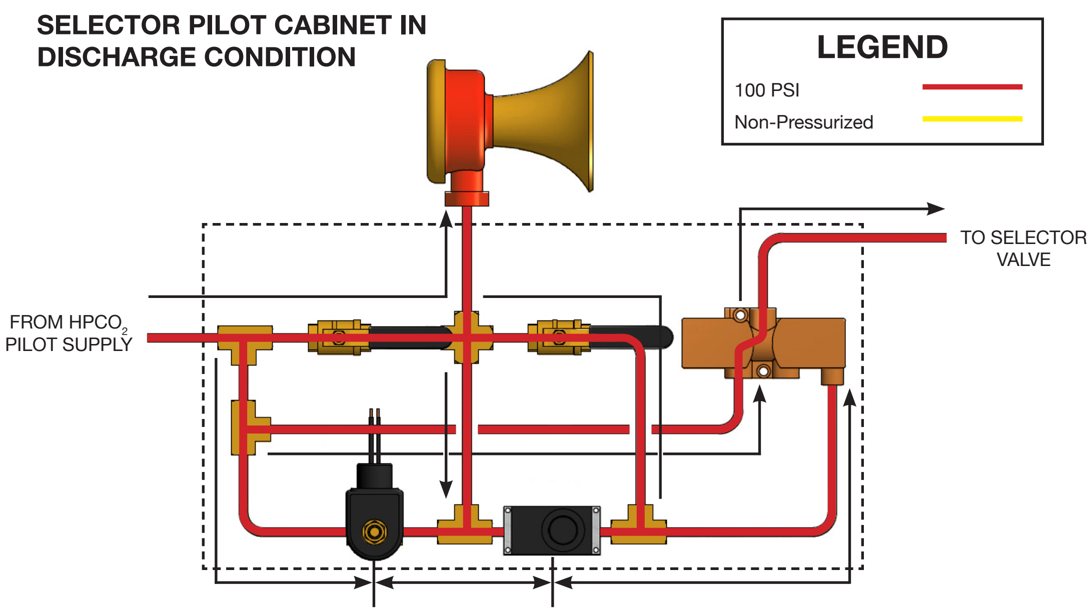


Figure 3.13i Manually Actuated Cabinet (Timer Bypass)

Note: The HPCO$_2$ primary cylinder manual actuators operate independently of the pilot cabinet. Actuation must occur at both locations to manually actuate the system.

3.14 Selector Valves

Selector valves are used in specific cylinder arrangements to allow the protection of multiple hazards or hazard zones by one set of HPCO_2 cylinders or where a time delay is required. FireBus HPCO_2 selector valves are available as 1/2 in (15 mm) through 2 in (50 mm) pneumatically actuated ball valves or a 3 in (80 mm) pneumatically actuated wafer valve. Optional solenoid and lockout with proximity switch are available. Refer to FireBus Selector Valve Datasheet 09-SCS042-A09 for part numbers and ordering information.

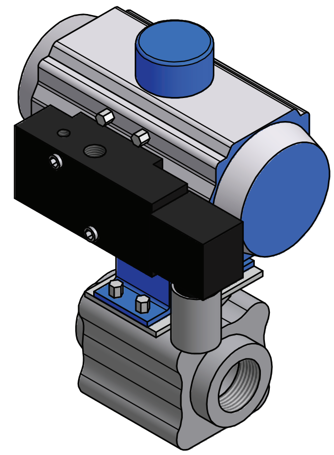


Figure 3.14a Selector Valve

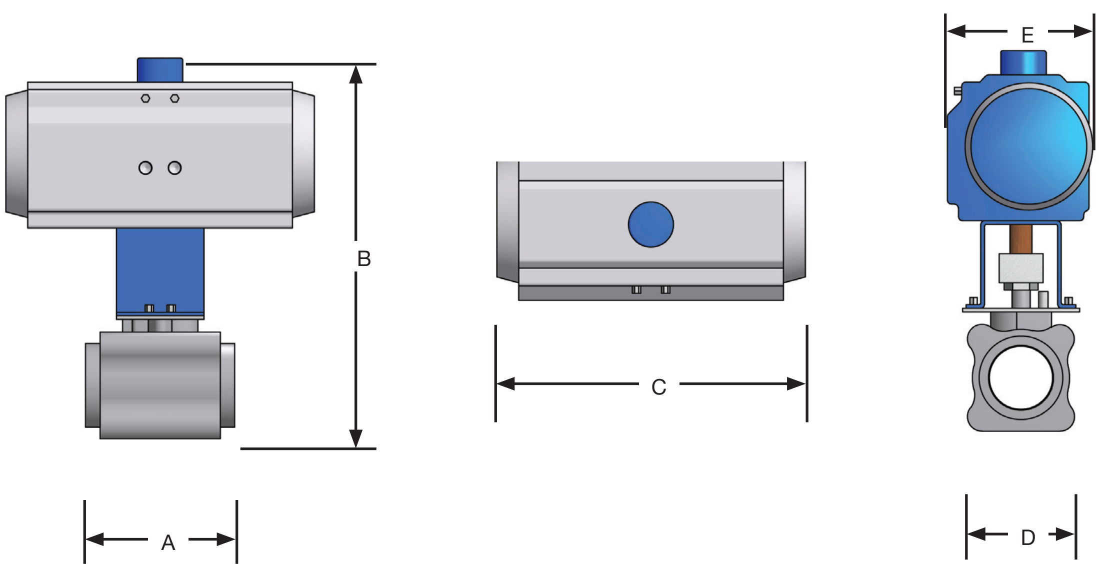


Figure 3.14b Pneumatically Actuated Ball Valve Dimensions

Table 3.14 - Pneumatically Actuated Ball Valve Dimensions											
Valve Size		Dimensions									
		A		B		C		D		E	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
1/2	15	2.59	66	6.73	171	5.53	140	2.06	52	2.77	69
3/4	20	3.01	76	7.17	182	6.24	158	2.25	57	3.27	83
1	25	3.69	94	7.46	189	6.24	158	2.59	66	3.27	83
1-1/2	40	4.58	116	10.56	268	9.74	247	3.33	85	4.19	106
2	50	5.11	130	11.22	285	10.57	268	3.66	93	4.84	123

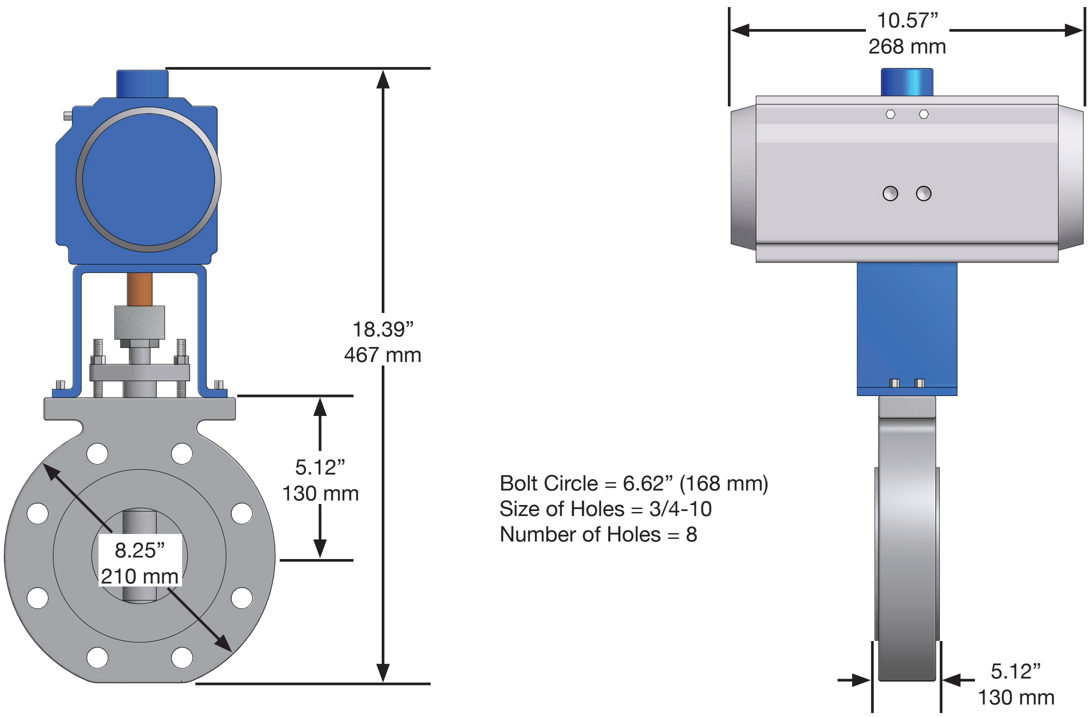


Figure 3.14c Pneumatically Actuated Wafer Valve Dimensions

3.15 Lockout Valves

Lockout valves are used in specific cylinder arrangements where manual isolation of pipe is required. FireBus HPCO_2 lockout valves are available as 1/2 in (15 mm) through 2 in (50 mm) manually actuated ball valves or a 3 in (80 mm) manually actuated wafer valve. Optional stem extension and explosion-proof limit switch are available. Refer to FireBus Lockout Valve Datasheet 09-SCS043-A09 for part numbers and ordering information.

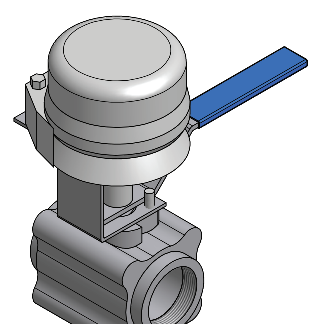


Figure 3.15a Lockout Valve

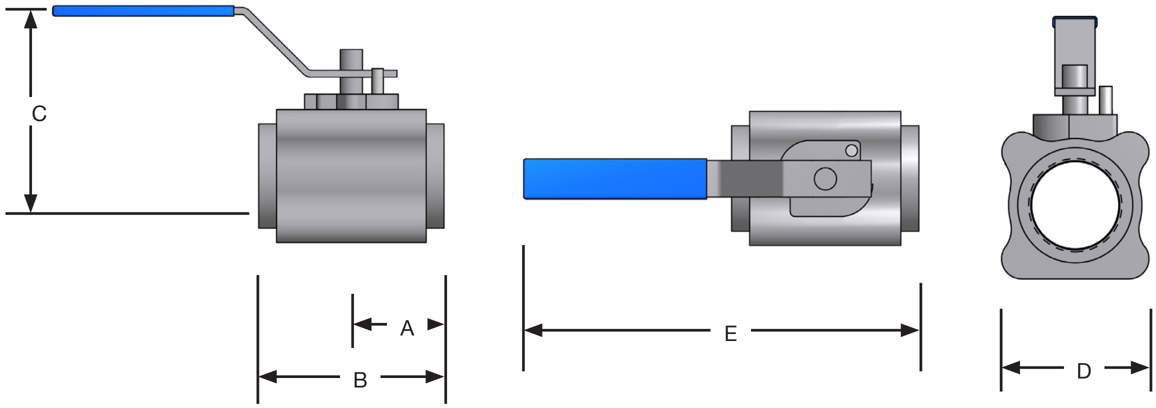


Figure 3.15b Manually Actually Ball Valve Dimensions

Table 3.15 - Manually Actuated Ball Valve Dimensions											
Valve Size		Dimensions									
		A		B		C		D		E	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
1/2	15	1.29	33	2.59	66	2.36	60	2.06	52	5.00	127
3/4	20	1.50	38	3.01	76	2.52	64	2.25	57	5.00	127
1	25	1.85	47	3.69	94	3.29	84	2.59	66	7.50	191
1-1/2	40	2.29	58	4.58	116	4.27	108	3.33	85	8.25	210
2	50	2.55	65	5.11	130	4.46	113	3.66	93	8.25	210

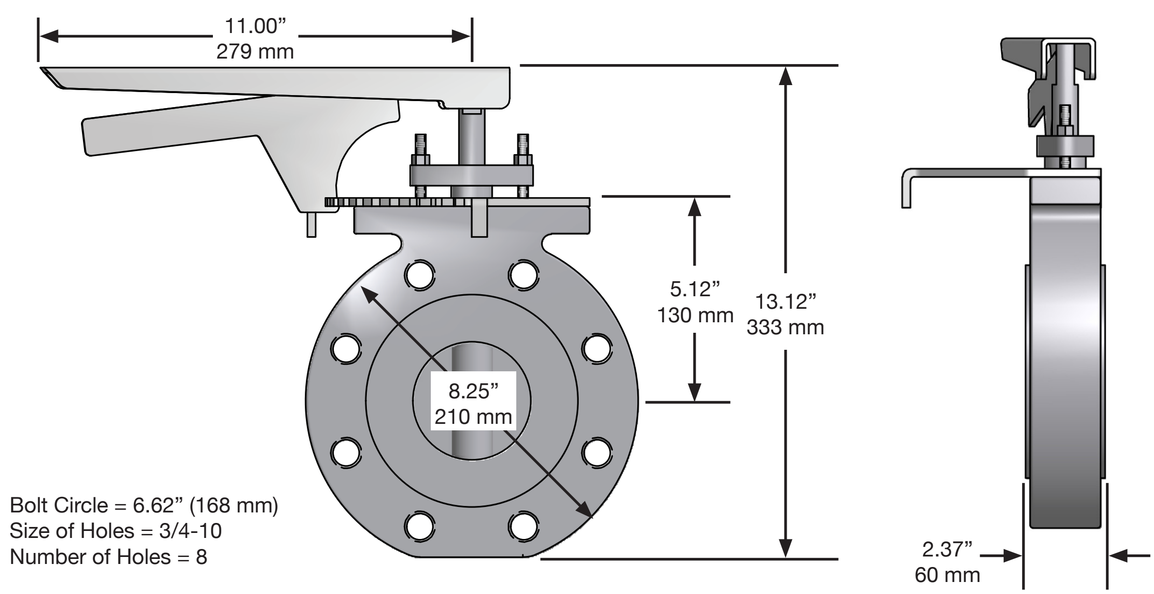


Figure 3.15c Manually Actuated Wafer Valve Dimensions

3.16 Discharge Manifolds

A discharge manifold is used in multiple cylinder systems to direct the flow of agent from two or more cylinders into a common pipe and to allow the actuation of slave cylinders through back pressure. The minimum manifold pressure for slave actuation is 500 psi (34.5 bar). Manifolds are to be supplied by the installer and may be constructed out of threaded or welded pipe and fittings. When two or more cylinders are grouped together with a common manifold, they must be of the same size. Manifold pipe size is determined by flow calculation software.

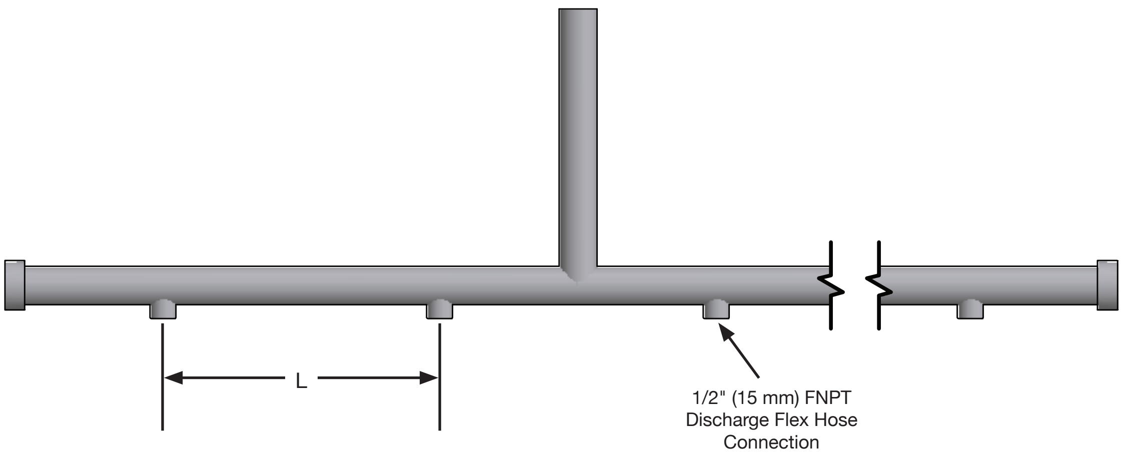


Figure 3.16 Suggested Discharge Manifold Configuration

Table 3.16 - Discharge Manifold Dimensions		
Cylinder	Length (L)	
	in	mm
50 lb	10.13	257
100 lb	12.00	305

3.17 Discharge Indicator

The FireBus Discharge Indicator acts as a nonelectrical visual indicator of system actuation. It is actuated through discharge pressure and remains in the upright (discharged) position until manually reset.

Upon system actuation, pressure within the discharge piping enters the discharge indicator, actuating the internal plunger. This forces the external indication stem into the upright (discharged) position. The stem and plunger remain in the upright position until the discharge indicator is manually reset by depressing the indication stem into the down (standby) position.

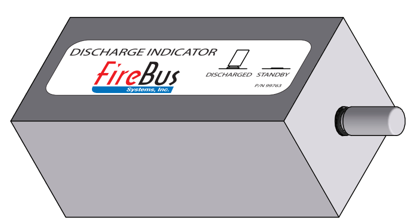


Figure 3.17 Discharge Indicator

3.18 Control Panels

The control panel must be compatible with the solenoid valve and should be UL listed and/or FM approved for releasing device service. The control panel should be located in an accessible area and installed in compliance with NFPA 72 (National Fire Alarm Code).

The FireBus FB-MESH/IP™ Series of panels are recommended for most applications.

Other FireBus control panels are available for advanced installations which require the power and flexibility of a Programmable Logic Controller (PLC), Programmable Automation Controller (PAC) or have Safety Integrity Level (SIL) requirements. Contact FireBus for more information.

3.19 Initiating Devices

Initiating devices such as heat detectors, smoke detectors, and manual stations should be listed devices compatible with the control panel being utilized. See the respective manufacturers instruction manuals for installation and operating details.

A remote, field-located electric manual station should be included in all automatic electric systems. This allows the system to be manually actuated should a fire be visually detected before an automatic detector operates.

FireBus offers a full range of initiating devices for use with the FireBus High-Pressure Carbon Dioxide Fire Extinguishing System.

Refer to www.FireBus.net or contact FireBus, LLC for more information.

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4 CYLINDER MOUNTING

Cylinder straps are available for single cylinder wall mounting.

For installation of three or more cylinders, the single row, wall mounting arrangement may be used. The double row, wall mounting arrangement is generally used when sufficient space is not available for a single row wall mounting arrangement.

For marine applications, additional cylinder supports are required. Two straps or sets of retainers must be used.

Mounting bolts must be anchored to a solid structural member.

4.1 Cylinder Strap

For mounting systems of one or two cylinders, the cylinder strap is recommended.

Table 4.1 - Cylinder Strap Dimensions			
P/N	Cylinder	Length (L)	
		in	mm
9012-FRP-7182	50 lb	10.38	264
9012-FRP-7183	100 lb	12.32	313

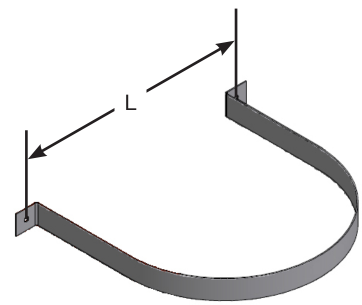


Figure 4.1 Cylinder Strap

4.2 Cylinder Rack Assembly

For installation of three or more cylinders, the cylinder rack assembly is recommended. The single row, wall mounting arrangement is the standard method of mounting using the cylinder rack assembly. The double row, wall mounting arrangement is generally used when sufficient space is not available for a single row wall mounting arrangement.

4.2.1 Threaded Rod

A threaded rod is installed through each rack separator.

Table 4.2.1 - Threaded Rod Dimensions			
P/N	Row Type	Length (L)	
		in	mm
9012-FRP-7184	Single	13	330
9012-FRP-7185	Double	25	635

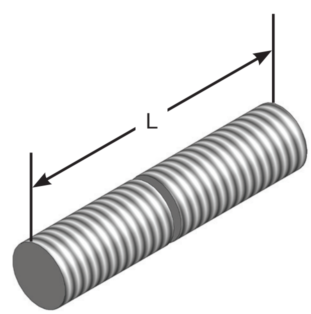


Figure 4.2.1 Threaded Rod

4.2.2 End Bracket

An end bracket is placed on the outside of the first and last cylinders in a row.

Table 4.2.2 - End Bracket Dimensions			
P/N	Row Type	Length (L)	
		in	mm
9012-FRP-7186	Single	11.35	288
9012-FRP-7187	Double, Flat	23.35	593
9012-FRP-7188	Double, Step	11.35	288

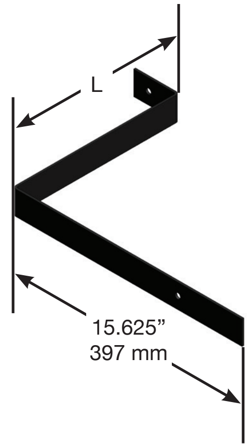


Figure 4.2.2a Single/Double Row, Flat Style End Bracket

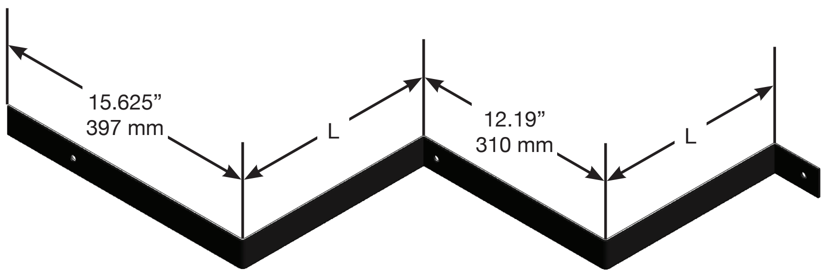


Figure 4.2.2b Double Row, Step Style End Bracket

4.2.3 Rack Separator

The rack separator is installed between each cylinder in a single row arrangement. Three separators are installed between each pair of cylinders in a double row arrangement.

Figure 4.2.3 Rack Separator

4.3 Rack Channel

Unistrut Rail is used as the back channel for both cylinders mounted with the cylinder strap and using the cylinder rack assembly.

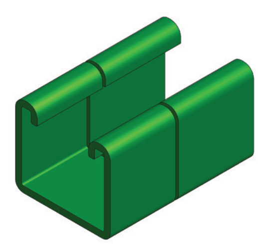
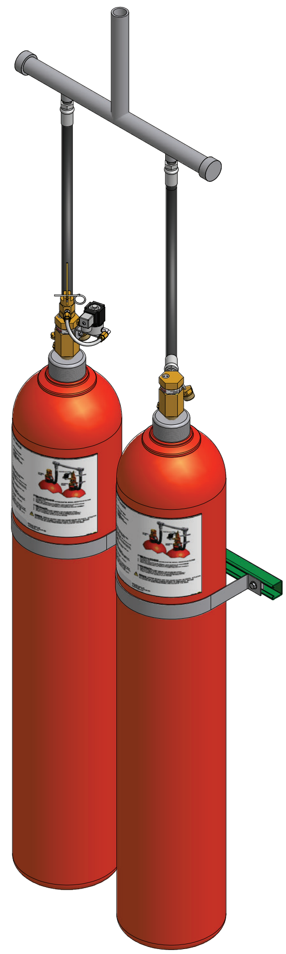


Figure 4.3 Rack Channel

Figure 4.3a Cylinder Strap Example



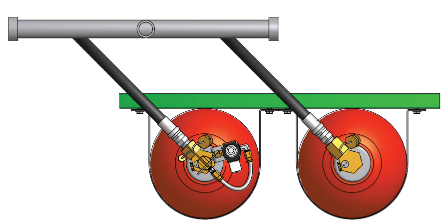
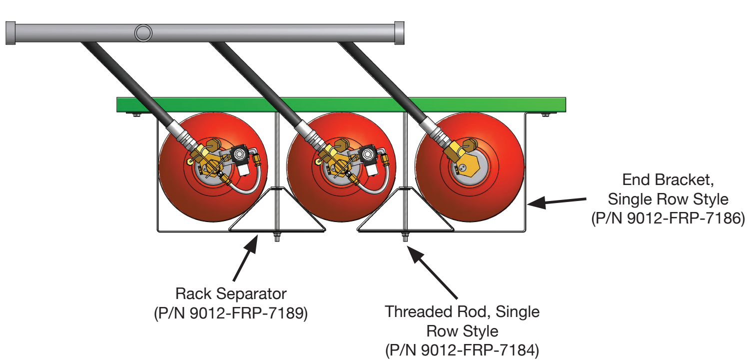


Table 4.3a - Cylinder Strap Mounting Dimensions			
P/N	Cylinder	Length (L)	
		in	mm
9012-FRP-7182	50 lb	32.0	813
9012-FRP-7183	100 lb	39.0	991

Figure 4.3d Single Row Cylinder Rack Assembly



FireBus

Table 4.3a - Cylinder Rack Kit Part Order Matrix - Single Row						
Cylinder Rack Kit P/N	Number of Cylinders	Length of Rail		Number of Separators (P/N 9012-FRP-7189)	Number of Threaded Rods	Number of End Brackets
		in	mm		Single Row Style (P/N 9012-FRP-7184)	Single Row Style (P/N 9012-FRP-7186)
9012-FRP-7190	3	44	1118	2	2	2
9012-FRP-7191	4	56	1422	3	3	2
9012-FRP-7192	5	68	1727	4	4	2
9012-FRP-7193	6	80	2032	5	5	2
9012-FRP-7194	7	92	2337	6	6	2
9012-FRP-7195	8	104	2642	7	7	2
9012-FRP-7196	9	116	2946	8	8	2
9012-FRP-7197	10	128	3251	9	9	2
9012-FRP-7198	11	140	3556	10	10	2
9012-FRP-7199	12	152	3861	11	11	2
9012-FRP-7200	13	164	4166	12	12	2
9012-FRP-7201	14	176	4470	13	13	2
9012-FRP-7202	15	188	4775	14	14	2
9012-FRP-7203	16	200	5080	15	15	2
9012-FRP-7204	17	212	5385	16	16	2
9012-FRP-7205	18	224	5690	17	17	2
9012-FRP-7206	19	236	5994	18	18	2
9012-FRP-7207	20	248	6299	19	19	2
9012-FRP-7208	21	260	6604	20	20	2
9012-FRP-7209	22	272	6909	21	21	2
9012-FRP-7210	23	284	7214	22	22	2
9012-FRP-7211	24	296	7518	23	23	2

Figure 4.3c Double Row, Even Number Cylinder Rack Assembly

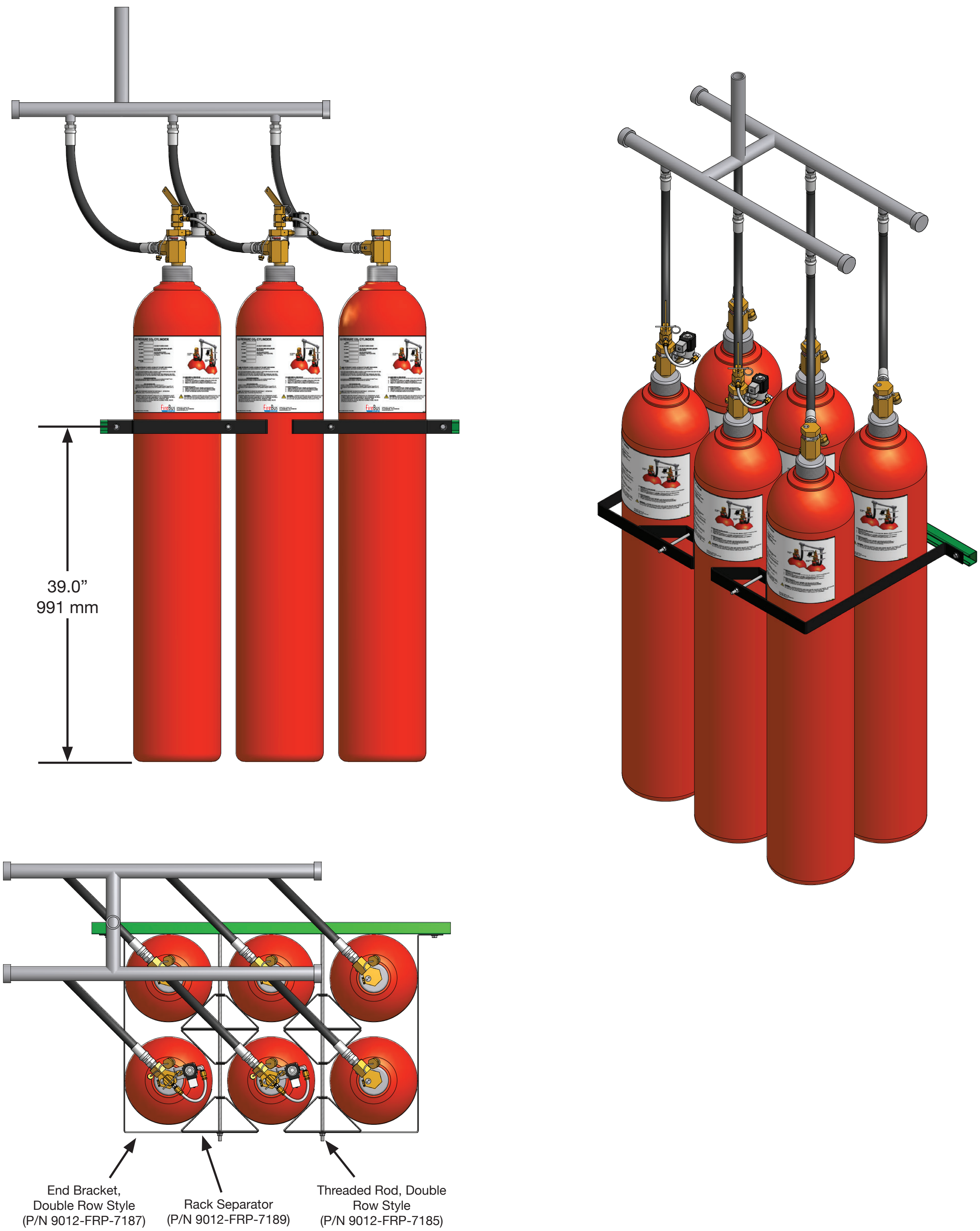


Figure 4.3d Double Row, Odd Number Cylinder Rack Assembly

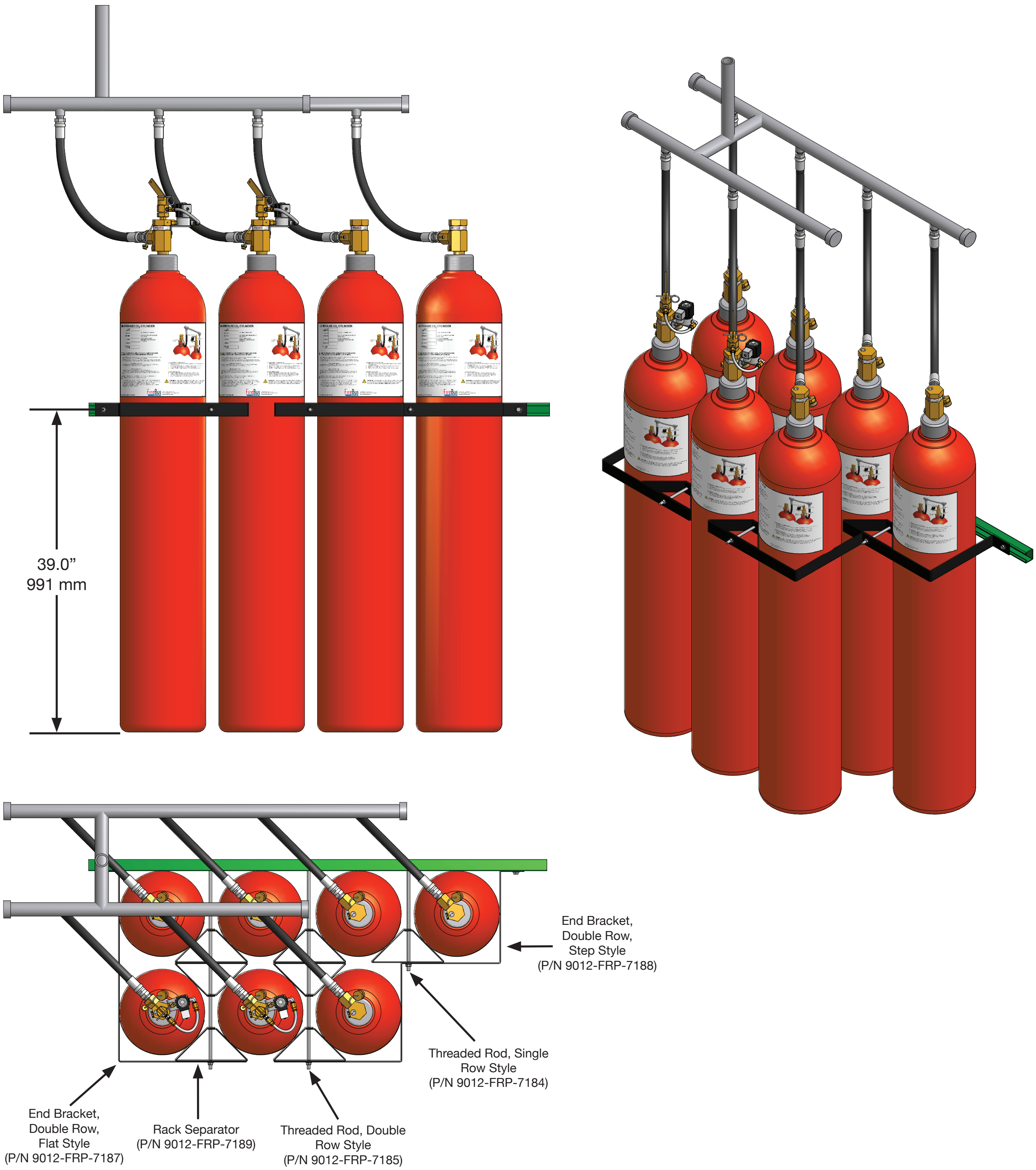


Table 4.3b - Cylinder Rack Kit Part Order Matrix - Double Row								
Cylinder Rack Kit P/N	Number of Cylinders	Length of Rail		Number of Separators (P/N 9012-FRP-7189)	Number of Threaded Rods		Number of End Brackets	
		in	mm		Single Row Style (P/N 9012-FRP-7184)	Double Row Style (P/N 9012-FRP-7185)	Double Row Step Style (P/N 9012-FRP-7188)	Double Row Flat Style (P/N 9012-FRP-7187)
9012-FRP-7212	4	32	813	3	0	1	0	2
9012-FRP-7213	5	44	1118	4	1	1	1	1
9012-FRP-7214	6	44	1118	6	0	2	0	2
9012-FRP-7215	7	56	1422	7	1	2	1	1
9012-FRP-7216	8	56	1422	9	0	3	0	2
9012-FRP-7217	9	68	1727	10	1	3	1	1
9012-FRP-7218	10	68	1727	12	0	4	0	2
9012-FRP-7219	11	80	2032	13	1	4	1	1
9012-FRP-7220	12	80	2032	15	0	5	0	2
9012-FRP-7221	13	92	2337	16	1	5	1	1
9012-FRP-7222	14	92	2337	18	0	6	0	2
9012-FRP-7223	15	104	2642	19	1	6	1	1
9012-FRP-7224	16	104	2642	21	0	7	0	2
9012-FRP-7225	17	116	2946	22	1	7	1	1
9012-FRP-7226	18	116	2946	24	0	8	0	2
9012-FRP-7227	19	128	3251	25	1	8	1	1
9012-FRP-7228	20	128	3251	27	0	9	0	2
9012-FRP-7229	21	140	3556	28	1	9	1	1
9012-FRP-7230	22	140	3556	30	0	10	0	2
9012-FRP-7231	23	152	3861	31	1	10	1	1
9012-FRP-7232	24	152	3861	33	0	11	0	2

5 SYSTEM INSTALLATION

The installation of the FireBus High-Pressure Carbon Dioxide Fire Extinguishing System should be undertaken by competent mechanical and electrical technicians familiar with NFPA 12 and with the installation of high-pressure carbon dioxide systems who have reviewed this manual and all hazard drawings and calculations. No special tools are required to assemble the equipment.

A complete hazard analysis and system design, including a drawing of the system layout, must be completed before the installation of any system and submitted to the authority having jurisdiction (AHJ). The design, drawings, and material list should be compared with conditions found on site. Cylinder size and agent fill must match design calculations. Temperature and humidity of the area must be within system limitations and room integrity must be consistent with the initial design. All components should be inspected for shipping damage.

Materials such as pipe, pipe fittings, tubing, tube fittings, conduit, EMT, wire, hangers and brackets, and all standard mounting hardware, etc., are not typically provided as part of the system supply. These items are to be provided by the installer to suit the installation specifications and the requirements for the specific system.

All materials used for the installation must be new, free from all defects and imperfections, and be of a grade and type as indicated below. Items not specifically covered should be of a grade and type to suit the intended service. All materials should be produced by recognized commercial manufacturers.

The complete installation should be carried out in accordance with the current issue of the applicable national, state, provincial, municipal and local codes and standards. Typically these consists of NFPA 12 - Carbon Dioxide Extinguishing Systems, NFPA 72 - The National Electrical Code, as well as local building and fire codes or local norms.

Specific projects may have requirements for other special codes or standards such as the Fire Commissioner, Coast Guard, Armed Forces, Factory Mutual, etc. Where two or more standards or codes are in conflict, the most stringent requirement applies.

Prior to installation, all materials should be protected from damage and stored in a clean, dry location.

All tools and installation equipment should be provided by the installer. Wrenches and other tools must be the correct size for the components to be installed. Unless stated otherwise, all components should be installed wrench tight. Where a gasket is provided, components should be tightened to ensure an effective seal.

The project drawings will generally identify the work to be performed, however, it is the installer's responsibility to visit the site and become familiar with both the jobsite and the working conditions.

Section 5 System Installation

5.1 Distribution System

Piping shall be of metallic noncombustible material having physical and chemical characteristics such that its deterioration under stress can be predicted with reliability.

Where piping is in severely corrosive atmospheres, special corrosion-resistant materials or coatings shall be used.

At a minimum, pipe and fittings shall conform to National Fire Protection Association (NFPA) 12 - Standard on Carbon Dioxide Extinguishing System (current edition) or ASME B31.1: Power Piping (or equivalent).

This includes the use of other materials such as brass, copper, stainless steel, flexible hose, etc. provided that they satisfy the system pressure/temperature requirements (working pressure of 3,000 psi [207 bar]). Pipe and fittings should have a minimum burst pressure (not working pressure) of 5,000 psi (345 bar).

The project drawings will indicate the specific piping materials to be utilized for each project. As the type of piping materials to be utilized are incorporated into the system flow/pressure loss design, the system designer must be contacted if materials other than those specified are used, and the designers approval must be received.

5.2 Hangers and Bracing

All system piping, both vertical and horizontal, must be suitably supported with hangers conforming to the latest requirements of ASME B31.1.

Pipe hangers should be capable of supporting the pipe under all conditions of operation and service. They should allow for the expansion and contraction of the piping, and should prevent pipe loads and stresses from being transmitted into connected equipment. Hangers and supports should be of rugged design and installed so that they will not be loosened by movement of the supported pipe. U-bolts with double nuts should be used.

Pipes must be braced or anchored to the building structure such as beams, columns, concrete walls, etc., in order to prevent longitudinal and lateral movement and sway. Carbon dioxide piping must not be hung or supported from other piping systems (i.e. water, compressed air, etc.).

Large forces are exerted on the system cylinders and piping during discharge. Each section of pipe must be braced or secured to restrict both the vertical and lateral movement. Where practical, riser piping should be supported independently of the connected horizontal piping. A support must be installed adjacent to each discharge nozzle and wherever a change in pipe direction occurs.

In addition, for some regions classified as earthquake zones, or for projects such as nuclear sites subject to unique code requirements, special sway bracing and/or hangers may be required. Refer to the project and/or contract drawings for requirements of special bracing.

Generally, no section of pipe should be without a hanger or brace. Maximum spacing between hangers and hanger rod sizes should be as indicated as shown, which are in accordance with ASME B31.1.0.

Table 5.2 Hangar Spacing

Rod Size	3/8 in						1/2 in			5/8 in		3/4 in
Max Spacing	5 ft	6 ft	7 ft	9 ft	9 ft	10 ft	11 ft	12 ft	13 ft	14 ft	16 ft	17 ft
Pipe Size	1/2 in	3/4 in	1 in	1-1/4 in	1-1/2 in	2 in	2-1/2 in	3 in	3-1/2 in	4 in	5 in	6 in

5.3 Expansion Joints

A certain amount of contraction can occur, which is caused by a maximum temperature change in long continuous pipe runs. Approximately 1 inch per 100 feet of steel pipe. Often, as part of the natural layout of the system, a swing joint can serve to give the desired flexibility. In straight runs an expansion joint should be installed on the basis of one after approximately 100 feet of continuous run and after each 100 feet run thereafter.

5.4 Installing Cylinder Assemblies

Each cylinder assembly has safety features and components to ensure against accidental discharge during installation. Prior to starting work, the installer should become familiar with these features by reviewing the equipment, the appropriate data sheets, and the installation instructions.

All SW-50M cylinder valves are supplied with anti-recoil safety plugs screwed into the discharge ports. These plugs have a small hole drilled at right angles to the axis of the discharge port, so that if accidental discharge does occur, it will be diffused in a safe manner. In addition, the SW-50M cylinder valves have safety plugs to shield the manual actuation and solenoid actuation ports. These plugs must be in position whenever the cylinder assemblies are not secured and/or disconnected from the discharge piping. (The SW-50M valve is initiated by depressing the pilot valve stem in either of these ports.)

Actuators must only be assembled to the cylinder valves after the cylinders are secured in their brackets and connected to the discharge piping, which must be complete with nozzles, using the correct discharge bend assemblies.

5.4.1 Cylinder Location

Carbon dioxide cylinders may be located inside or outside the protected space, although it is preferable to locate them outside the space. When they are installed within the space they protect, a remote manual control must be installed to ensure the system can be actuated from a safe location outside the fire area.

The cylinders should be located to provide convenient access so that they can be readily inspected and also easily removed after use for recharging. Do not install the cylinders where they will be exposed to the weather elements or the direct rays of the sun. Do not install the cylinders where they will be subjected to temperatures of less than 0°F (-18°C) or higher than 130°F (54°C) for total flooding systems, unless otherwise specified on the project drawings.

If cylinders are located in a hazardous (explosion-proof) area, ensure that the cylinder solenoid control and all other components are approved for such use, and that the installation of all materials is made in an approved manner.

Cylinders are to be installed in the normal upright position. All cylinders are provided with a rigid dip tube.

5.4.2 Cylinder Installation

1. Fasten cylinder bracketing and manifold brackets securely onto a solid wall or floor or structural member using 1/2 in bolts with suitable anchors. Bolts must not be anchored into plaster or other facing materials. Cylinder brackets must be absolutely secure to withstand the discharge thrust forces. Be sure that threaded rods are inserted in channel before channel is permanently mounted.

2. Fasten cylinder securely in bracketing.

3. All carbon dioxide system cylinders are shipped with valve protection caps. Remove protection cap from the cylinder and coat it with a light film of grease. Protection caps should be stored close to the cylinders, where they will be readily available for re-installation when cylinders are disconnected from the system and/or transported for recharging.

5.5 Installing Pipe and Nozzles

Generally, drawings provide schematic piping layouts showing pipe diameter, pipe fittings, and conceptual pipe lengths utilized for the design calculations. The information shown should not be used for fabrication of pipe. The installer must verify that the pipe can be installed as indicated, and establish fabrication data based upon his inspection of the site. Changes to the piping that may be necessary to suit site conditions can critically affect the system flow balance. Any deviations to the piping must be approved by the designer prior to their implementation.

Where reducing fittings are called for on the installation drawings, hexagon bushing of 3,000 lbs forged steel may be used. Under no conditions should flush bushings or cast iron bushings be used. Bushings are not allowed for more than one pipe size reduction. If two reducing fittings are required to make the necessary reduction, they should be chosen to split the reduction equally.

Pipe should be reamed and cleaned before assembly, and after assembly the entire piping system should be blown out before nozzles and other devices are installed.

All valves (isolation and selector) not flanged should be installed with a flanged joint or union immediately downstream of the valve to facilitate inspection, repair, or replacement.

All pressure relief devices should be located and orientated so that the discharge of carbon dioxide will not injure personnel, damage equipment, or be otherwise objectionable.

A dirt trap and blow-out, consisting of a tee with a capped nipple 3 to 6 inches (76 to 152 mm) long, should be installed at the end of each pipe run.

Piping through walls, floors, etc. should be run through sleeves of Schedule 40 pipe at least two sizes larger than the pipe being run and not smaller than 1 inch. Sleeves through floor slabs should extend at least 2 inches above the floor. Sleeves should be packed with a fire resistant material so as to be dust and weather tight, as specified on project drawings.

5.5.1 Pipe and Manifold Installation

1. With cylinders properly mounted, attach discharge flex hose to cylinder valves, hand tight only.

2. Mount the header manifold using the discharge flex hose so that the least possible strain is put on the connections.

3. Disconnect the discharge flex hose from the cylinder valve. Connect the discharge flex hose to the manifold and tighten until wrench tight. NOTE: Male threads of the discharge flex hose must be wrapped with Teflon tape or pipe sealant.

4. For total flooding applications, nozzles should be located at the highest practical elevation within the enclosure. Except where more than one tier of nozzles is used, or special application conditions apply, the bottom of the orifice should not be more than 12 inches (305 mm) from the top of the enclosure. For local applications, nozzles must be located exactly as shown on the project drawings.

5. There must not be any obstructions adjacent to the nozzles (structural columns or beams, ducts, cable trays, racks, equipment, etc.) that will affect the discharge patterns or disbursement of the carbon dioxide.

6. Install nozzle piping at the hazard as shown on the project drawings. Be sure to fasten piping securely at each nozzle and change in direction of flow.

7. Run supply pipe from the hazard to the cylinder manifold.

8. Reconnect the discharge bends to the cylinders.

5.6 Installing Manual Actuator

⚠ CAUTION
The manual actuator should not be installed on the cylinder assemblies until the cylinders have been secured into the cylinder bracket, all piping has been completed, and nozzles installed.

1. Remove the manual actuation safety plug from the manual actuation port on top of the SW-50M cylinder valve.

2. Ensure that the piston in the actuator is in the retracted position and that the hand lever is secured with a lock-pin and sealed. Then install the actuator into the manual actuation port of the cylinder valve, wrench tight. (During servicing, if piston does not retract, the pressure on top of the piston must be relieved. Loosen then retighten the tube connector.)

   If any hissing or discharge of gas is noticed during connection of the actuator, stop at once and remove the actuator from the cylinder valve. Check the actuator. If no cause for the discharge is found contact the manufacturer.

3. To orientate the manual lever, unscrew the locking nut one quarter turn, rotate main body of the actuator to the position required, then retighten locking nut.

   IMPORTANT: Do not unscrew the locking nut more than one quarter turn.

4. If the manual actuator is to be used with the solenoid valve, remove the blank plug from the pressure port of the manual actuator and install the 1/8 inch (6 mm) solenoid JIC adaptor elbow that is supplied in the solenoid valve kit.

5.7 Installing Solenoid Valve Kit

Check the solenoid nameplate to ensure that the coil voltage agrees with the supply voltage of the system and the site conditions.

⚠ CAUTION
The solenoid valve should not be connected to cylinder until after completion of all testing.

1. A cable and connector assembly is provided to connect the solenoid to the electric actuating circuit. It is therefore necessary to provide only a junction box conveniently located close to the cylinder valve for connection to the electric actuating circuit.
2. On completion of all testing, connect the solenoid valve to the solenoid actuation port near the top of the SW-50M cylinder valve, after first confirming that there is no electric power being applied to the solenoid and that all o-rings are in place. A slight discharge (puff) of carbon dioxide might occur as this connection is made:

   This connection should be made as follows:

   a) Secure the mounting bracket square to the valve.

   b) Connect the solenoid valve to the bracket with the screws supplied.

   c) Attach the solenoid to the pressure connection of the cylinder valve and tighten until wrench tight.

   d) Tighten the screws holding the solenoid to the bracket.
3. Install the 3/16 inch actuation flex hose to connect the solenoid valve exhaust port to the manual actuator.

5.8 Electrical Installation

The power supply for the system operation or for the control panel, must be from a separate circuit breaker or fuse taken from the building's main power supply, preferably with an emergency back-up supply. No other equipment is powered from the same circuit breaker or fuse.

The carbon dioxide system wiring, devices, and components should not have any connection to ground except as may be specifically noted on the drawings or in the manuals. All wiring must be tested to ensure it is free of any grounds or shorts prior to connection to system components. In addition, prior to final connection of the electrical control to the solenoid actuators, the completed electrical system must be tested.

For the installation of the system control panel and associated devices, refer to the panel manufacturer's installation manual for the acceptable installation, connection and testing information. Only materials listed or approved for the intended purpose are to be used in the installation. All wiring must be mechanically protected from damage.

Ensure that the initiating devices (detectors and manual stations) to be installed are listed and/or approved.

If a control panel is utilized, the devices must be compatible with the panel.

The detectors must be installed in accordance with their listings and manufacturer's recommendations for the specific detector in addition to NFPA 72. Installation codes and other Authorities Having Jurisdiction may specify the location for detectors. However, the more stringent of all requirements should be followed to ensure an acceptable system is provided.

1. Install electric junction boxes suitable for mounting each device and for making the necessary wiring connections.

2. Generally, initiating devices have four terminals or wire pigtails for wiring connections. Two are for the wires from the control panel and the others are for the outgoing wires to feed additional devices. Ensure that all field wires are individually terminated.

3. The manual stations should be installed 4' 6" (1372 mm) above finished floor level and on a permanent wall or structure adjacent to the main egress from the protected area.

CAUTION

Detectors must not be painted or similarly covered as this will alter their thermal or smoke entry characteristics and void their listings and warranties.

5.9 Installing Discharge Pressure Switch

The discharge pressure switch has a SPDT contact and is normally located adjacent to the cylinder(s) and connected to the discharge manifold. When a lockout valve is installed, a discharge pressure switch must be installed between the cylinders and the lockout valve.

1. Mount the switch box securely onto a wall or structural member using the mounting holes provided. Preferred mounting is upright with pipe and conduit connections to the bottom.

2. Connect 1/2 inch conduit and appropriate wiring to the electrical connection on the switch box.

3. To switch loads heavier than the switch rating, or requiring more than two contacts, the switch should be used to operate a relay or contactor to control the load.

4. Connect the 1/4 inch NPT connection at the bottom of the front plate to the carbon dioxide piping using 1/4 inch steel pipe or 1/4 inch or 3/16 inch O.D. copper tube. Install a union fitting at base of cover to allow removal of front plate for testing.

5.10 Installing Pressure Release Trip

The pressure release trip is used to release loads of up to a maximum of 75 lbs (34 kg), which are hung on the piston stem.

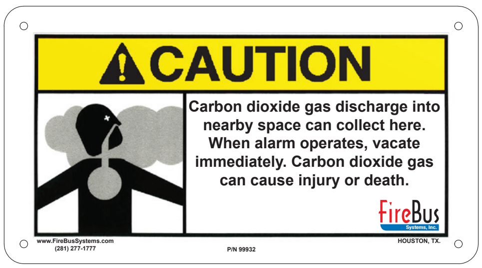
1. Mount the pressure release trip onto a solid structural member using 5/16 inch bolts and appropriate anchors. Fixing must be suitable for the loading, including spring tension and/or dead weight of operated equipment.

2. Connect the release trip 1/4 inch NPT connection to the carbon dioxide discharge piping using 1/4 inch steel pipe or 1/4 inch or 3/16 inch O.D. copper tube. The release trip must be installed to the top of the discharge piping to avoid liquid CO2 entering the pressure release trip during discharge.

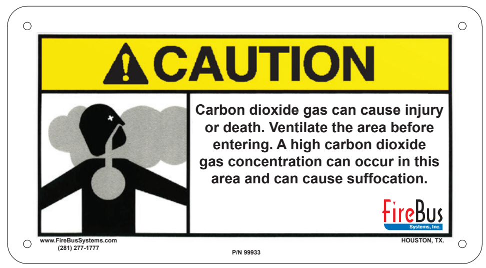
3. Using 1/16 inch stainless steel cable and cable clamp (or equivalent), connect the equipment to be operated to the piston stem. The cable must be suspended at right angles to the piston stem so that it neither binds nor slides off the stem.

5.11 Installing Warning Signs

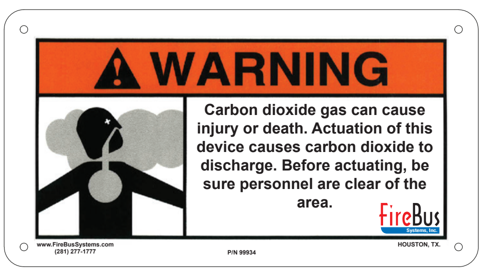
NFPA 12 mandates that warning signs designed in compliance with ANSI Z535 be placed in and around areas protected by CO_2 fire extinguishing systems. FireBus offers the ANSI Z535 compliant sign options illustrated in Figure 5.12 Each warning/caution sign is 6-1/2 in x 12 in (165 mm x 305 mm).



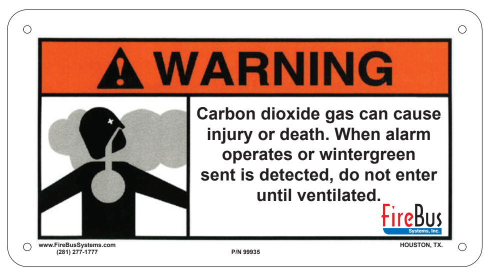
Caution – Nearby – P/N 9010-FRP-9001
Post sign in every nearby space where carbon dioxide can accumulate to hazardous levels.



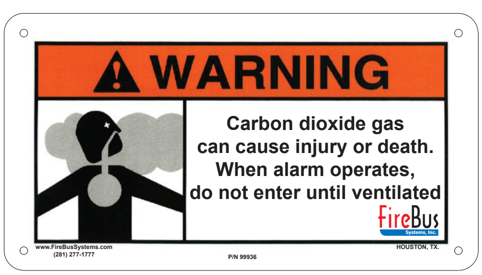
Caution – Storage –P/N 9010-FRP-9002
Post sign outside each entrance to carbon dioxide storage rooms.



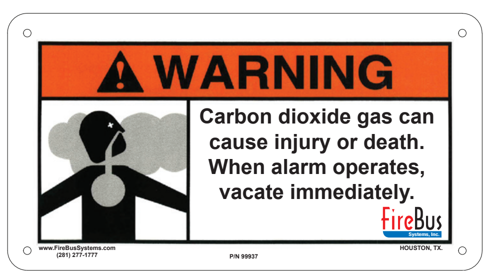
Warning – Manual Actuation – P/N 9010-FRP-9003
Post sign at each manual actuation station.



Warning – Wintergreen – P/N 9010-FRP-9004
Post sign at every entrance to protected space for systems provided with wintergreen odorizer.



Warning – Entrance – P/N 9010-FRP-9005
Post sign in every protected space.



Warning – Exit – P/N 9010-FRP-9006
Post sign at every entrance to protected space.

Figure 5.11 Warning Signs

Note: Existing signs that are a part of an established training and safety program may be implemented if in compliance with NFPA 12 Section 4.3.2.4.

6 SYSTEM COMMISSIONING

Prior to placing the completed system in service, the installation should be inspected and tested to confirm:

1. Conformance to system design.
2. Suitability of piping, its correctness to project design, and its support and bracketing.
3. Conformance to the required system operating sequence.
4. The suitability of the hazard environmental control, safety precautions, sealing, etc.
5. Compliance with the requirements of NFPA 12 – Standard on Carbon Dioxide Extinguishing Systems and other applicable standards.

If there is any doubt of the ability of the system to operate and provide the necessary protection, a full discharge test should be considered. A discharge test will verify the total system operation, check the agent concentration achieved, determine the duration (soaking time) that the concentration is retained, check acceptability of nozzle discharge, check audibility and/or visibility of alarms, ensure interlocks and all auxiliary equipment operate as required, and allow personnel to become completely familiar with the discharging system and to practice response.

If a full discharge test is not performed, a puff test, using a minimum of one cylinder, must be conducted. A full discharge test must be conducted for all Extended Discharge type systems.

6.1 Design

Measure the room and calculate the actual room volume. Check actual volume against design volume (volume shown on project drawings) and ensure correct quantity of carbon dioxide is provided.

6.2 Piping

Check the pipe layout to ensure it agrees with the system layout drawings.

Inspect the piping supports and ensure that the pipe is secure and restrained so that unacceptable movement will not occur.

After the installation of the system piping is completed, and prior to the connection of the cylinders, nozzles and other equipment, the discharge piping should be blown out and then pressure tested for leakage. Plug or cap all piping outlets and apply 100 psi (7 bar) pressure with dry nitrogen or dry air for 10 minutes. At the end of 10 minutes, the pressure loss should not be greater than 5 psi (0.35 bar). When pressurizing piping, the pressure should be increased in 50 psi (3.5 bar) increments.

⚠ CAUTION

Pneumatic pressure testing creates a potential risk of injury to personnel in the area as a result of airborne projectiles if piping should rupture. Prior to conducting the pneumatic pressure test, the protected area must be evacuated and appropriate safeguards must be provided for test personnel and for equipment in the area.

6.3 Cylinders

1. Inspect cylinders and ensure bracketing and cylinders are secure.
2. Verify the weight of carbon dioxide in all cylinders, using either an accurate weigh scale or an approved liquid level gauge. The contents should be within +/-10% of the normal capacity.
3. Check cylinder discharge bends and check valves for proper connection and tightness.
4. Ensure that appropriate identification, operating and warning signs are mounted or posted.

6.4 Nozzles

Each nozzle has an orifice drilled to suit the specific location and discharge flow requirements. The orifice identification number is stamped on each nozzle.

1. Verify that orifice sizes and drill codes are as indicated on the project drawings and that the nozzles are orientated to discharge correctly.

⚠ CAUTION

Ensure discharge will not splash flammable liquids or create dust clouds that could extend the fire. Also ensure the discharging agent will not injure personnel in the area.

2. Ensure that each nozzle pipe drop is bracketed or braced against the nozzle discharge thrust, and that the nozzle cannot swivel on its pipe fitting.
3. Check the cleanliness of the protected area to determine if protective caps or seals are required to prevent orifices from clogging.

6.5 Manual Control: Local and Remote Type

Ensure the manual actuators and the remote manual controls, for all parts of the system—primary cylinders for main and reserve systems, all primary cylinders in a selector valve arrangement, and selector and lockout valves—are accurately identified and will be accessible during a fire.

All testing should be carried out with the manual actuator(s) disconnected from the cylinders and other devices.

1. With the manual actuator disconnected from the cylinder or other device, pull the lock pin and operate the lever to verify the movement of the operating piston 1/8 inch (3.2 mm).

⚠ CAUTION

Manual controls should no require a pull of more than 40 lbs (178 Newtons), nor a movement of more than 14 inches (356 mm) for system operation.

6.6 Electric Actuation

Perform all inspections and tests on the controls panels, detectors, signals, and other devices indicated in the specific equipment manufacturer's manuals.

⚠ CAUTION

The solenoid actuator and the manual actuator must be removed from the cylinder valve before any testing is performed.

1. Ensure the solenoid actuator is of the correct voltage for the service.
2. Connect the 3/16 inch hose (supplied) to the respective solenoid valve and manual actuator. Apply dry nitrogen pressure of 1000 psi (7 bar) or dry, clean air pressure to the inlet port of the solenoid valve (cylinder connection port).
3. Apply the appropriate voltage to the solenoid by actuating a manual station or firing a detector to operate the discharge circuit. Note: Do not operate fixed thermal detectors unless they are of the restorable type. The solenoid should operate, which will be indicated by the movement of the piston stem in the manual actuator. Also there will be an escape of nitrogen from the small vent hole in the side of the manual actuator.
4. Remove the electric power from the solenoid. The solenoid valve should close, indicated by the cessation of nitrogen discharge, and the return of the piston stem in the manual actuator to its normal standby position. Check for leakage at the vent hole.
5. Shut off the pressure supply and exhaust the line pressure using the exhaust valve which should be part of the pressurizing equipment.
6. After all testing has been satisfactorily completed, remove the 3/16 inch hose, reinstall all actuators to the cylinder valve, and ensure all electrical connections, including ground connections, are in order. Replace the 3/16 inch hose, taking care to ensure the pressure connections are gas tight.

6.7 Optional Devices

1. Pneumatic Pilot Cabinet: Refer to Manual 09-MAN016-A09 for Pneumatic Pilot Cabinet testing and commissioning procedures.
2. Pneumatically Operated CO_2 Sirens: All sirens should be tested to ensure operation and that the sound is readily heard throughout the protected space. This should be done under normal background noise conditions.
3. Pressure Release Trip: With a screwdriver or other blunt instrument manually push the stem to the retracted position. Allow the cable to fall and ensure the connected equipment operates as required.

6.8 Carbon Dioxide Puff Test

The purpose of this test is to check the integrity of the piping system and to ensure the pipes are not blocked. It will not check the concentration of carbon dioxide that will be obtained under a full discharge conditions or check the integrity (tightness) of the enclosure.

1. Disconnect all cylinders, except one master cylinder, from the system.

2. Operate the remaining master cylinder and ensure carbon dioxide does discharge from all nozzles.

3. Ensure that there is no undue pipe movement.

4. Ensure all pressure-operated devices operate and that the connected equipment, alarms, and other functions are controlled as required.

6.9 Carbon Dioxide Discharge Test

NFPA 12 mandates that a full discharge test be performed for all carbon dioxide extinguishing systems to ensure that carbon dioxide is discharged into the hazard, that the concentration is achieved and maintained for the period of time required by the design specifications, and that all pressure-operated devices function as intended. Where multiple hazards are protected from a common supply, a full discharge test must be performed for each hazard. It is recommended that a full discharge test also be performed whenever cylinders are removed for hydrostatic testing.

During this test:

1. Make checks as indicated under the Puff Test.

2. With a concentration meter, check the carbon dioxide concentrations achieved at several locations within the enclosure and specifically adjacent to the primary hazard within the enclosure. Should concentrations not be met, modifications to nozzle drill codes and/or piping shall be made and the system shall be retested.

3. Check the discharge time.

4. Check the holding time (the length of time the carbon dioxide concentration is maintained).

5. Ensure that the enclosure is reasonably well sealed and that there is no major leakage.

6. Ensure all alarms function for the required period of time and that they can be heard and/or seen throughout the area. This should be done under normal area operating condition, i.e. normal background noise and lighting, etc.

7 AFTER OPERATION

1. Notify your local fire department.

2. Do not open doors or windows or remove the carbon dioxide from the protected area until the fire is completely out.

3. Do not enter the area until the carbon dioxide has been removed and the area ventilated. If it is necessary to enter the area while it still contains carbon dioxide, self-contained breathing apparatus should be used. In systems implementing an olfactory warning device, any trace of wintergreen scent indicates the area is not safe for occupancy without a self-contained breathing apparatus.

In general, providing the system discharges during the early stages of the fire and providing all plant shutdown functions are operated and safety precautions are taken, the fire should be extinguished within one minute of the end of carbon dioxide discharge. However, the area should be kept closed for at least fifteen minutes following discharge to allow the area to cool and to prevent re-ignition. For deep seated hazards, the space should be kept tightly closed for at least twenty minutes following discharge.

To check if fire is out:

1. Look for smoke and steam coming from cracks around doors, windows, vents, etc.

2. Feel the doors and walls. If they are hot do not open doors. The fire is still burning or is in the cooling stage.

3. Listen for crackling sounds.

Have your fire department check the space for you.

Do not enter area with a lighted cigarette or open flame as flammable vapors may be present which could cause re-ignition or an explosion.

After opening the door:

1. Completely ventilate the space. CO_2 is heavier than air and will drift into low level spaces (e.g. rooms below grade). Use fans to remove CO_2, smoke, and fumes from low areas.

2. Clean up residue from fire.

3. Determine cause of fire and take corrective action.

7.1 Refurbishing The System

Have the system completely serviced by FireBus, LLC or a FireBus approved service agency. After operation, the system should be recharged without delay in order to maintain protection.

1. Remove, inspect, and recharge all cylinders.

2. Inspect the piping system and ensure pipe supports are still secure.

3. Inspect all components, including nozzles, switches, detectors, alarms, etc. Replace all equipment that has been damaged or that has been exposed to direct flame or excessive heat from the fire.

4. Reinstall system in accordance with the Installation Instructions.

5. Verify and test system in accordance with Section 6 of this manual.

8 SYSTEM MAINTENANCE

In order to ensure that the system has not been tampered with and is in a fully operational condition, it must be inspected and tested on a regular basis by trained competent service personnel. In accordance with NFPA 12 – Standard on Carbon Dioxide Extinguishing Systems, insurance, and other code requirements, all carbon dioxide systems should be thoroughly inspected and tested annually. It is recommended that a service and maintenance contract be established with a FireBus, LLC approved service agency.

All persons who may be expected to inspect, test, maintain, or operate carbon dioxide fire suppression systems should be thoroughly trained, and be kept thoroughly trained, in the functions they are expected to perform.

8.1 Monthly Inspections

1. Check system components for mechanical damage and tampering. All system lead and wire seals (or similar) should be intact. Manual actuators should be installed and with ring pins in place.

2. Ensure that all cylinders are in place and properly secured.

3. Ensure that there are no obstructions that would prevent system operation or prevent proper distribution of carbon dioxide from discharge nozzles.

4. Verify that egress is clear to allow safe evacuation of personnel from the hazard area and safe access to the manual controls.

5. Check that all electrical circuits show normal. If a control panel is utilized, check that power is on and the system is in a "normal-ready" condition. Ensure detectors are in place and free from obstructions.

8.2 Semi-Annual Inspections

1. Perform all the monthly inspections.

2. Check if there have been any changes in the shape, size, contents, or use of the protected space. Any changes will necessitate a review of the system design. Contact FireBus, LLC should this occur.

3. Check the cylinder contents (weight). This may be done by using a platform or beam scale or an approved liquid level gauge. Record weight on the cylinder tag or in the log book. If the cylinder has a loss in net weight of more than 10 percent, it should be recharged or replaced. The cylinder full weight is indicated on the valve.

4. Check the date of the last hydrostatic test. If the system has never been discharged and more than 12 years have elapsed since the last test OR the system has previously been discharged and more than 5 years have elapsed since the last test, the cylinders should be discharged and retested before being returned to service. If (It is recommended that a full discharge test be performed when cylinders are emptied for hydrostatic testing.)

5. Examine cylinders, piping, and nozzles for evidence of corrosion or other physical damage.

6. Check cylinder bracketing, piping, pipe hangers, and straps to ensure all are secure and suitably supported. This is particularly important where shock and vibration are encountered as a normal part of the environment (e.g. on board ships, etc.)

7. Ensure discharge nozzles are still located as originally installed, that the nozzle discharge orifices are clear and unobstructed, and that the nozzles are properly positioned and aligned. Ensure seals are used where necessary.

8. Remove the manual actuators from all cylinders that they operate and operate the hand lever. The actuator should operate freely and the operating stem should travel 1/8 inch (3.2 mm).

⚠ CAUTION

When two actuators are connected together, both actuators must be removed from the equipment they control before testing.

9. Inspect and clean all fire detectors. Check the sensitivity and adjust all smoke detectors.

10. If the system is automatically electrically actuated, disconnect the solenoid actuators and manual actuators from the cylinder valves, then:

    a) Operate all electric initiating devices (detectors, manual stations, etc.) one at a time and ensure the respective actuators operate. There will be a click sound when the solenoid operates. This check should be made for both main and reserve banks of cylinders, if used. Reinstall the solenoid and manual actuators after all testing is completed.

       Alternatively, unplug the cable connectors from all solenoid valves and insert light bulbs in the cable connectors. The bulbs will light when each circuit is energized. Also, the operating stem of the manual actuator should travel down 1/8 inch (3.2 mm).

    b) Verify that all electric alarm signals function and that all audible devices can be heard and all illuminated devices can be seen throughout the protected space. This should be done in the normal working environment with normal background noises and lighting in place.

    c) If the system has an extinguishment control panel, refer to the panel manufacturer's instruction manual for maintenance procedures.

11. Confirm operation of all auxiliary and supplementary components such as time delays, pressure operated switches, release trips, damper releases, shutoff valves, etc. by manual operation where possible. Pressure operated time delays and gas operated sirens should be checked using a carbon dioxide portable extinguisher as a pressurizing source.

12. Ensure all equipment is reset and all components are installed and left in the normal standby condition on completion of testing.