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Engineered Carbon Dioxide (CO_2)

Fire Suppression Systems

Design, Installation, Operation and Maintenance Manual

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Kidde Fire Systems

FOREWORD

Note: This Kidde Fire Systems Engineered Carbon Dioxide (CO_2) Fire Suppression System Design, Installation, Operation, and Maintenance manual, P/N 81-CO2MAN-001, is for use only by qualified and factory-trained personnel with working knowledge of applicable standards such as NFPA, as well as a working knowledge of Kidde Fire Systems Engineered Carbon Dioxide (CO_2) Fire Suppression System. Kidde Fire Systems does not authorize or recommend use of this Manual by others.

The data contained herein is provided by Kidde Fire Systems as a guide only. It is not intended to be all inclusive and should not be substituted for professional judgement. Kidde Fire Systems believes the data to be accurate, but this data is provided without guarantee or warranty to its accuracy or completeness.

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TERMS AND ABBREVIATIONS

ABS:	Absolute	N.C.:	Normally Closed
ADA:	Americans with Disabilities Act	NFPA:	National Fire Protection Association
AH:	Ampere Hour	N.O.:	Normally Open
AWG:	American Wire Gauge	N_2:	Nitrogen
BIL:	Basic Installation Level	P/N:	Part Number
C:	Common	PED:	Pressure Equipment Directive
CFM:	Cubic Feet per Minute	TC:	Transport Canada
CO_2:	Carbon Dioxide	TCF:	Temperature Correction Factor
DC:	Direct Current	TPED:	Transportable Pressure Equipment Directive
DOT:	Department of Transportation	UL/ULI:	Underwriters Laboratories, Inc.
FM:	Factory Mutual	ULC:	Underwriters Laboratories of Canada
H_20:	Water	V:	Volts
HVAC:	Heating, Venting and Air Conditioning	Vac:	Volts AC
Hz:	Hertz (Frequency)	Vdc:	Volts DC
mA:	Milliamperes		

MATERIAL SAFETY DATA SHEETS

Hard copies of the Material Safety Data Sheets (MSDS) are not included with this manual. The latest version of the MSDS you are searching for can be found online at the Kidde Fire Systems website (www.kiddefiresystems.com). Use the built-in navigation links to view the desired sheet.

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SAFETY SUMMARY

The Kidde Fire Systems Engineered Carbon Dioxide (CO_2) Fire Suppression System, uses pressurized equipment, and therefore you MUST notify personnel responsible or who may come into contact with the Engineered Carbon Dioxide (CO_2) Fire Suppression System, of the dangers associated with the improper handling, installation, maintenance, or use of this equipment.

Fire suppression service personnel must be thoroughly trained by you in the proper handling, installation, service and use of the equipment in compliance with applicable regulations and codes and following the instructions in this manual, any Safety Bulletins and also the cylinder nameplate.

Kidde Fire Systems has provided warnings and cautions at a number of locations throughout this manual. These warnings and cautions are not comprehensive, but provide a good guide as to where caution is required. These warnings and cautions are to be adhered to at all times. Failure to do so may result in serious injury.

Material Safety Data Sheets (MSDS) for nitrogen and CO_2 are available from Kidde Fire Systems. You should ensure your personnel are familiar with the information contained in these sheets.

DEFINITIONS

WARNING **Indicates an imminently hazardous situation which, if not avoided, could result in death, serious bodily injury and/or property damage.**

CAUTION **Indicates a potentially hazardous situation which, if not avoided, could result in property or equipment damage.**

SUBJECT: SPECIFIC HAZARD

WARNING **Because carbon dioxide reduces the available oxygen in the atmosphere, it will not support life. Care must be taken, and appropriate alarms shall be used, to ensure that all personnel are evacuated from the protected space prior to discharging the system. Suitable warning signs must be prominently displayed in clear view at the point of entry into the protected area to alert people to the asphyxiation properties of carbon dioxide.**

PROCEDURES FOR SAFELY HANDLING CYLINDERS

WARNING **Pressurized (charged) cylinders are extremely hazardous and if not handled properly are capable of violent discharge. This may result in serious bodily injury, death and property damage.**

Before handling Kidde Fire Systems products, all personnel must be thoroughly trained in the safe handling of the containers as well as in the proper procedures for installation, removal, filling, and connection of other critical devices, such as flex hoses, control heads, discharge heads, and anti-recoil devices.

READ, UNDERSTAND and ALWAYS FOLLOW the operation and maintenance manuals, owners manuals, service manuals, etc., that are provided with the individual systems.

The following safety procedures are minimal standards that must be adhered to at all times. These are not intended to be all inclusive.

Moving Cylinders: Cylinders must be shipped compactly in the upright position, and properly secured in place. Cylinders must not be rolled, dragged or slid, nor allowed to be slid from tailgates of vehicles. A suitable hand truck, fork truck, roll platform or similar device must be used while maintaining properly secured cylinders at all times.

Rough Handling: Cylinders must not be dropped or permitted to strike violently against each other or other surfaces.

Storage: Cylinders must be properly secured and safely stored in an upright position and in accordance with any applicable regulation, rule or law. Safe storage must include some protections from tipping or being knocked over.

Nothing in this manual is intended as a substitution for professional judgment and will not serve to absolve any professional from acting in a manner contrary to applicable professional standards.

For additional information on safe handling of compressed gas cylinders, see CGA Pamphlet P-1 titled "Safe Handling of Compressed Gases in Containers". CGA pamphlets may be purchased from The Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly VA 20151-292 or from their website www.cganet.com.

SUBJECT: PROCEDURES FOR SAFELY HANDLING PRESSURIZED CYLINDERS

WARNING **Pressurized (charged) cylinders are extremely hazardous and if not handled properly are capable of violent discharge. This will result in serious bodily injury, death and property damage.**

THESE INSTRUCTIONS MUST BE FOLLOWED IN THE EXACT SEQUENCE AS WRITTEN TO PREVENT SERIOUS INJURY, DEATH OR PROPERTY DAMAGE.

Shipping Cap

1. Each cylinder is factory equipped with a shipping cap over the cylinder valve connected to the cylinder collar. The shipping cap is a safety device and will provide a controlled safe discharge when installed if the cylinder is actuated accidentally.
2. AT ALL TIMES, the shipping cap must be securely installed over the cylinder valve and the actuation port protection cap shall be attached unless the cylinders are connected into the system piping during filling or performing testing.

Protection Cap

A protection cap is factory installed on the actuation port and securely chained to the valve to prevent loss. The cap is attached to the actuation port to prevent tampering or depression of the actuating pin. No attachments (control head, pressure control head) are to be connected to the actuation port during shipment, storage, or handling.

Installation

THIS SEQUENCE FOR CYLINDER INSTALLATION MUST BE FOLLOWED AT ALL TIMES:

1. Position cylinder(s) in designed location and secure with cylinder bracket(s).
2. Remove safety (shipping) cap and actuation port protection cap.
3. Attach flex loops or swivel adapter to discharge heads. Connect assembly to system piping. Then attach assembly to cylinders.

WARNING ⚠

Flex hoses/swivel adapters must always be connected to the system piping and to the discharge heads before attaching the discharge heads to the cylinder valves in order to prevent injury in the event of inadvertent carbon dioxide discharge.

4. Verify control head(s) are in the set position.

WARNING ⚠

Control heads must be in the set position before attaching to the cylinder actuation port in order to prevent accidental discharge.

5. Install control head(s) on cylinder(s).

Removal From Service

1. Remove control head(s) from cylinder(s).
2. Remove discharge head from each cylinder valve.
3. Attach safety (shipping) protection cap and actuation port protection cap to each cylinder.

WARNING ⚠

Do not remove the cylinder from the bracketing if the safety and protection caps are missing. Obtain a new safety (shipping) cap from a local gas supplier. Obtain a new actuation port protection cap from Kidde Fire Systems.

4. Remove cylinder from bracketing and properly secure to hand truck. Properly secure each cylinder for transport. Repeat for remaining cylinders.

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CHAPTER 1
GENERAL INFORMATION

1-1 INTRODUCTION

The Kidde Fire Systems carbon dioxide fire suppression system is an engineered, special-hazard system utilizing a fixed pipe and nozzle distribution network, hose reels, or a combination of both. These systems provide fire protection, using carbon dioxide (CO_2) as the extinguishant, designed in accordance with the National Fire Protection Association (NFPA) 12, "Standard on Carbon Dioxide Extinguishing Systems", (latest edition). All components referenced in this manual are listed by Underwriters Laboratories (UL) and approved by Factory Mutual (FM), unless as noted.

1-2 CLASSIFICATION OF FIRE

The classification of fire is defined as the following:

- Class A: Surface Type Fires; wood or other cellulose-type material (ordinary combustibles)
- Class B: Flammable liquids
- Class C: Energized electrical equipment
- Class D: Combustible metals (such as magnesium, sodium, zirconium, potassium, and titanium, or reactive metals, metal hydrides and chemicals containing their own oxygen supply)
- Class K: Combustible cooking media (vegetable or animal oils and fats)

Note: Kidde Fire Systems carbon dioxide fire suppression system is not suited for Class D type of fires.

Carbon dioxide is an effective agent for Class A, Class B, Class C, and Class K hazards. Carbon dioxide must be applied with due consideration of the hazard being protected and its contents. Carbon dioxide shall not be used on Class D hazards, such as magnesium, potassium, sodium, and cellulose nitrate. These Class D hazards can only be controlled by special extinguishing agents and procedures.

1-3 GENERAL CHARACTERISTICS OF THE SYSTEM

Carbon dioxide fire suppression systems are used for applications where the potential property damage and business interruption from fire are high. Carbon dioxide can control and suppress fires in easily ignitable fast-burning substances such as flammable liquids. It is also used on fires involving electrically energized equipment and, in some instances, on fires in ordinary combustibles such as paper, cloth, and other cellulose materials.

Carbon dioxide is a colorless, odorless, electrically non-conductive gas with a density approximately 50% greater than air. When applied to a fire, it provides a blanket of heavy gas which reduces the oxygen content of the atmosphere to a point in which combustion can not be sustained.

WARNING

Carbon dioxide is present in the atmosphere. It is also a normal product of human and animal metabolism; human life cannot be sustained if this carbon dioxide is not expelled from the body. The concentration of carbon dioxide in the air governs the rate at which the carbon dioxide produced by the human metabolism is released from the lungs. An increasing concentration in the air where humans are present, therefore, can cause serious personal injury or death.

Carbon dioxide offers many advantages as a fire suppressant. It is a clean agent, does not leave a residue, and does not wet material or machinery upon which it is discharged, helping keep costly cleanup or downtime to a minimum. Carbon dioxide may be stored from 0°F (-18°C) to 130°F (54°C). Carbon dioxide does not deteriorate and is non-corrosive. It is readily available throughout the world and is inexpensive. Carbon dioxide is effective for the rapid suppression of Class A (surface or deep seated), B, and C fires and offers a wide range of hazard protection.

1-4 SYSTEM DESCRIPTION

Carbon dioxide is stored in steel cylinders as a liquid under its own vapor pressure which is approximately 850 psi at 70°F. This pressure is used to propel the agent out of the container and through the valve, piping, and nozzles during the discharge. When released, carbon dioxide will change from a liquid to a gas and expand. The ratio of this expansion is high; approximately 9 to 1. This allows a large volume of carbon dioxide to be stored in a small container, minimizing space taken up by the system equipment.

Kidde Fire Systems engineered carbon dioxide suppression systems may be manually operated or integrated with detection and control devices for automatic operation. A single carbon dioxide fire suppression system can protect single or multiple hazards by total flooding, local application, or a combination of both.

1-5 TYPE OF SUPPRESSION SYSTEM

There are two types of fixed carbon dioxide systems: total flooding and local application.

1-5.1 Total Flooding

In a total flooding system, a predetermined amount of carbon dioxide is discharged through fixed piping and nozzles into an enclosed space or enclosure around the hazard. Total flooding is applicable when the hazard is totally enclosed and when all openings surrounding the hazard can be closed automatically prior to or at the start of system discharge. If all the openings cannot be closed, additional carbon dioxide must be provided to compensate for agent loss through these openings during the discharge and appropriate concentration retention periods. The carbon dioxide concentration must be maintained for a sufficient period of time to allow the fuel and any other surfaces or equipment in contact with the fuel to cool below the ignition temperature of the combustibles.

1-5.2 Local Application

Local application systems differ from total flooding in that the nozzles are arranged to discharge directly onto the fire. Local application is practical in those situations where the protected equipment can be isolated from other combustibles so that fire will not spread beyond the area protected, and where the entire hazard can be protected. One of the principal uses of local-application systems is to protect open tanks containing flammable liquids, but this technique can be generalized to protect three-dimensional hazards such as paint spray booths and printing presses. Suppression by local application is transitory, and will not be effective unless suppression occurs quickly and all potential re-ignition sources are eliminated.

Carbon dioxide systems can also consist of hand hose lines permanently connected by means of fixed piping to a fixed supply of suppression agent. These systems are frequently provided for manual protection of small, localized equipment. Although not a substitute for a fixed system, a hose line can be used to supplement a fixed system where the hazard is accessible for manual firefighting.

1-6 GENERAL SYSTEM REQUIREMENTS

The discharge of carbon dioxide in fire suppression concentrations if not properly handled, can create a serious threat to people. Suppression systems must be designed with appropriate safeguards to ensure the safety of all personnel who have reason to occupy a protected area. Suppression systems also employ a variety of actuation methods and specialized components to ensure reliable operation and prompt fire suppression.

1-6.1 Safeguards

Carbon dioxide is present in the atmosphere at an average concentration of about 0.03 percent by volume. It is also a normal end product of human and animal metabolism. The concentration of carbon dioxide in the air governs the rate at which carbon dioxide is released from the lungs and thus affects the concentration of carbon dioxide in the blood and tissues. An increasing concentration of carbon dioxide in air can, therefore, become dangerous due to a reduction in the rate of release of carbon dioxide from the lungs and rate of oxygen intake.

WARNING

Firefighting concentrations of carbon dioxide are lethal. Appropriate safeguards, as outlined in this chapter, shall be provided to prevent death or injury to personnel in the protected space or adjoining areas where released carbon dioxide could migrate.

The safeguards typically used to prevent personnel exposure to fire-fighting concentrations of CO_2 fall into five categories:

- Adequate Path of Egress
- Warning Signs and Personnel Education
- Pre-Discharge Time Delays and Alarms
- Stop Valves and Lock-Out Valves
- Post-Release Warnings and Procedures

Careful study of each particular situation may indicate additional steps that may be required to prevent injury or death to personnel.

1-6.1.1 ADEQUATE PATH OF EGRESS

To promote quick and safe evacuation in the event of a discharge, the path of egress shall include:

- Adequate aisleways and routes of exit, that are kept clear at all times
- Necessary additional or emergency lighting, or both, and directional signs to ensure quick, safe evacuation
- Only outward swinging, self-closing doors at exits from hazardous areas, and, where such doors are latched, provision of panic hardware

1-6.1.2 WARNING SIGNS AND PERSONNEL EDUCATION

Warning signs shall be posted inside and outside all areas protected by a carbon dioxide system, and also in adjoining areas where the suppression agent could migrate. These warning signs shall instruct the occupants to evacuate the area immediately when the alarms operate, as well as to warn personnel not to enter the protected space after a CO_2 discharge until the area has been safely ventilated. See Paragraph 2-9.2 for specific sign and location information.

All personnel shall be informed that discharge of carbon dioxide gas directly at a person will endanger the person's safety by causing frostbite, eye injury, ear injury, or even falls due to loss of balance upon the impingement of the high-velocity discharging gas. All personnel shall be trained on the dangers associated with an increased carbon dioxide concentration, the proper manual and emergency operation of the system, and the appropriate response to pre-discharge alarms.

1-6.1.3 PRE-DISCHARGE TIME DELAYS AND ALARMS

Time delay devices are designed to delay the discharge of carbon dioxide for an appropriate period of time to allow an orderly and safe evacuation from the protected area. Time delays also are used to provide a time interval for equipment shutdown and auxiliary interlocks prior to agent discharge.

Pneumatic discharge delays (See Paragraph 2-8.3) shall be provided for:

- All total flooding carbon dioxide systems protecting normally occupied and occupiable enclosures
- Local application systems protecting equipment or processes in normally occupied and occupiable areas, where the discharge will expose personnel to hazardous concentrations of carbon dioxide

An electric time delay may be employed in any circumstance that does not require a pneumatic discharge delay.

For occupiable spaces where a delayed discharge could result in an unacceptable risk to personnel or unacceptable damage to critical equipment, time delays need not be provided.

An evacuation dry run shall be conducted to determine the minimum time needed for a person to evacuate the protected area. Additional time shall be provided to allow for identification of the evacuation signal.

Pre-discharge alarms, whether electrical or pneumatic in nature, are designed to provide a warning and evacuation signal during the time delay period. Audible and visual indication shall be provided when the system is actuated by either automatic or normal manual operation.

Pneumatic pre-discharge alarms (See Paragraph 2-8.4) shall be provided for all applications that also require a pneumatic discharge delay, as listed above. Electric alarms may be employed in addition to pneumatic alarms or as the sole means of notification in applications that do not require a pneumatic discharge delay.

1-6.1.4 STOP VALVES AND LOCKOUT VALVES

A stop valve, when used as a safety device, is employed to ensure that carbon dioxide is not discharged into a normally occupied area without an evacuation signal. The valve is normally closed to prevent the flow of carbon dioxide into the distribution piping. Automatic or manual action is required to open the valve and allow CO_2 to be discharged.

A lockout valve is a manually operated valve, installed in the distribution pipe, between the supply and nozzles. The valve is normally open, but shall be locked in a closed position to prevent discharge of agent into the protected space when:

- persons not familiar with the system and its operation are present
- persons are present in locations where discharge of the system will endanger them and where they will be unable to proceed to a safe location within the time delay period

A lockout valve shall be provided on all systems, except where dimensional constraints prevent personnel from entering the protected space and where discharged carbon dioxide cannot migrate to adjacent areas, creating a hazard to personnel. Lockout valves shall be supervised to provide notification of a lockout.

1-6.1.5 POST-RELEASE WARNINGS AND PROCEDURES

After a release of carbon dioxide, provisions shall be made to prohibit entry of unprotected personnel to spaces made unsafe by a carbon dioxide discharge until the space is ventilated and appropriate tests of the atmosphere have verified that it is safe for unprotected persons to enter. Persons who are not properly trained in the use of and equipped with self-contained breathing apparatus (SCBA) shall not remain in spaces where the CO_2 concentration exceeds 4 percent. Such provisions shall include one or more of the following:

- Addition of a distinctive odor to the discharging carbon dioxide, the detection of which serves as an indication to persons that carbon dioxide gas is present. Personnel shall be trained to recognize the odor and evacuate spaces wherein the odor is detected.
- Provision of automatic alarms activated by carbon dioxide detectors or oxygen detectors and located at the entry to and within such spaces. The pre-discharge alarms may be used to serve this purpose if they operate until the space is ventilated and the safety of the atmosphere has been verified.
- Establishment and enforcement of confined space entry procedures for such areas.

A means for prompt ventilation of affected areas shall be provided. Forced ventilation will often be necessary. Care should be taken to properly dissipate hazardous atmospheres and not merely move them to another location. Careful consideration should be given to low-lying areas, as carbon dioxide is heavier than air and will settle in such spaces.

Prompt discovery and rescue of persons rendered unconscious in protected areas can be accomplished by having such areas searched by trained personnel equipped with proper breathing equipment. Those persons rendered unconscious by carbon dioxide may be restored without permanent injury by artificial respiration, if removed quickly from the hazardous atmosphere. Self-contained breathing equipment and personnel trained in its use, and in rescue practices including artificial respiration, should be readily available.

1-6.2 Storage

The Kidde Fire Systems high pressure carbon dioxide system uses seamless steel cylinders to store the carbon dioxide at ambient temperature. Each cylinder is equipped with a discharge valve fitted with a siphon tube to discharge liquid carbon dioxide through the distribution piping.

The number of cylinders required for a given application is determined by the size and nature of the hazard being protected. When multiple cylinders are employed, the cylinders are connected to a common piping system through a manifold.

Cylinders with attached releasing devices are defined as pilot cylinders. The system uses pilot cylinders to initiate the suppression system discharge. Actuation of the pilot cylinders creates sufficient pressure in the manifold to actuate the remaining cylinders in the system (called “slave” cylinders). If the suppression system consists of one or two cylinders, one pilot cylinder is used to initiate the carbon dioxide discharge. When the suppression system has three or more storage cylinders, multiple pilot cylinders, actuated simultaneously, are used to initiate the carbon dioxide discharge.

If permitted by the authority having jurisdiction, a group of carbon dioxide cylinders can be used to protect one or more areas by means of directional valves. The system designer must use careful judgment in the design of a directional valve system. The multiple areas protected by the suppression system must be sufficiently isolated from each other so that two or more protected areas cannot simultaneously be involved in a fire.

1-6.3 Discharge Characteristics

The Kidde Fire Systems carbon-dioxide suppression system employs siphon tubes fitted to the valves within the cylinders in conjunction with a variety of discharge nozzles for agent distribution into a protected space or onto a piece of equipment. The liquid carbon dioxide is discharged up through the siphon tube, valve, and distribution piping as a liquid under pressure. The liquid is transformed into gas and the resulting expansion at the discharge nozzle orifice and upon discharge a portion immediately flashes to vapor. The remaining liquid undergoes continuous evaporation and cooling and eventually solidifies as finely divided dry ice (snow) particles. The percentage of carbon dioxide converted to dry ice depends upon the temperature of the stored liquid. Approximately 25 percent of the liquid stored at 70°F (21°C) is converted to dry ice upon discharge. The dry ice particles gasify in a short period of time, without passing through its liquid phase (sublimation), and no wetting or residue occurs.

The discharge of liquid carbon dioxide creates a white, cloudy appearance due to the dry ice component. Because of the low discharge temperatures, some water vapor in the surrounding air will condense, creating a temporary period of fog that lasts after the dry ice particles have settled out or sublimed. The dry ice helps to reduce the high temperatures created by a fire. It is important to avoid direct impingement of carbon dioxide onto people and very temperature sensitive equipment.

Carbon dioxide vapor is approximately one and one-half times as dense as air at the same temperature. An actual discharge of carbon dioxide gas is much more dense than the surrounding air. This accounts for carbon dioxide's ability to replace the air above burning surfaces and maintain an inert atmosphere for a period of time following its discharge.

1-6.4 Actuation Methods

Kidde Fire Systems recommends that carbon dioxide fire suppression systems have an automatic actuation, and that the automatic actuation be supplemented by one or more modes of manual actuation.

The quantity and type of detectors required for a particular application are governed by the type of combustible products being protected. For example, flammable liquids burn in a manner characterized by rapid flame progression and intense heat generation. Automatic heat or flame detectors are the most appropriate fire detection methods for this type of hazard. Electrical fires, on the other hand, progress much more slowly to the stages of ignition and flame development, and frequently undergo relatively long periods of thermal degradation and pyrolysis during which large quantities of particulate matter and smoke are generated. Automatic smoke detectors, usually consisting of a cross-zoned system employing both ionization and photoelectric principles, or high sensitivity smoke detection, are two examples of methods typically employed for this application.

It is common practice to supplement automatic actuation by two modes of manual actuation called the "normal manual control" and the "emergency manual control." The normal manual control consists of a manually operated device located in close proximity to the equipment or materials protected by the suppression system. Typically it consists of an electrical switch, or a mechanical manually operated device designed to transmit a signal via a pull cable. The emergency manual control is one or more fully mechanical devices that are located on the control head(s) of the pilot cylinder(s) and other auxiliary components such as time delays and directional (or stop) valves. Kidde Fire Systems control heads are equipped with a lever-operated mechanism that serves as the "emergency manual control."

The "normal manual control" is designed to initiate the full operation of the system by one manual action. It is the responsibility of the system designer to ensure that such action will not result in immediate carbon-dioxide discharge into a normally occupied area. It is the responsibility of the system operator to ensure that the protected area has been evacuated prior to operating the "emergency manual control."

1-7 APPLICATIONS

Carbon dioxide fire suppression systems are used for a wide variety of industrial, commercial, and marine applications.

Industrial applications typically consist of equipment or processes where flammable liquids are involved. Examples of industrial hazards that can be protected by carbon dioxide are dip tanks, mixing tanks, spray booths, ovens and dryers, quench tanks, coating machines, wet benches, commercial fryers, and printing presses.

Carbon dioxide is used in commercial applications to protect equipment or areas that have:

- high capital costs
- high productivity value
- critical mission role essential to business operations

Examples of commercial applications are cable trenches, computer room subfloors, electrical cabinets, data (tape) storage units, and so on.

There are numerous marine applications for carbon dioxide systems; these include dry cargo spaces, machinery spaces, pump rooms, and paint lockers. Refer to the *Marine Carbon Dioxide Design, Installation, Operation and Maintenance Manual*, Part No. 81-220610-000, for detailed information.

1-8 EXTINGUISHING PROPERTIES OF CARBON DIOXIDE

Carbon dioxide is highly efficient in suppressing surface fires including flammable liquids and solids. When introduced into the combustion zone, carbon dioxide causes almost immediate flame suppression. It suppresses the fire by reducing the oxygen concentration, the fuel vapor concentration, or both, in the vicinity of the fire to the point where these available concentrations are too low to support combustion. In general, a reduction of the oxygen concentration to 15 percent or less by volume is sufficient to extinguish most diffusion-flame fires in flammable liquids. The cooling effect is also helpful in certain applications, especially where carbon dioxide is applied directly on to the burning material.

When deep seated fires are encountered, a higher concentration of carbon dioxide and a much longer hold (retention) time are needed to allow any smoldering fires to be suppressed and to allow the material to cool to a temperature at which it will not re-ignite.

1-9 PHYSICAL PROPERTIES OF CARBON DIOXIDE

The physical properties of carbon dioxide are provided in Table 1-1.

Table 1-1. Physical Properties of Carbon Dioxide

Parameter	US Units	Metric Units
Molecular weight	44	44
Specific gravity, @ 32^{o}F and 1 atm (0^{o}C and 101 kPa abs)	1.524	1.524
Vapor density, @ 32^{o}F and 1 atm (0^{o}C and 101 kPa abs)	0.1234 lb./ft.^{3}	1.98 kg/m^3
Liquid density, @ 70^{o}F (21^{o}C)	47.6 lb./ft.^{3} (@ 70^{o}F)	762 kg/m^3 (@ 21^{o}C)
Triple point	-69.9°F / 75.1 psia	-56.6°C / 518 kPa abs
Sublimation temperature @ 1 atm (101 kPa abs)	-109.3°F @ 1 atm	-78.5°C
Critical temperature	87.9°F	31.1°C
Critical pressure	1071 psia	7382 kPa abs
Latent heat of sublimation, @ -109.3^{o}F (-78.5^{o}C)	245.5 BTU/lb.	199.0 kJ/kg
Latent heat of vaporization, @ 2^{o}F (-17^{o}C)	119.0 BTU/lb.	276.8 kJ/kg

1-10 CLEAN-UP

Since carbon dioxide is a gas, it can penetrate and spread to all parts of a fire area. As a gas or as a finely divided solid called 'snow' or 'dry ice', it will not conduct electricity and therefore, can be used on energized electrical equipment. It leaves no residue, thus eliminating cleanup of the agent itself.

For the safety of the personnel, the area should be thoroughly ventilated and purged with fresh air.

CHAPTER 2
COMPONENT DESCRIPTIONS

2-1 FIRE SUPPRESSION SYSTEM COMPONENTS

This chapter provides detailed descriptions of the components comprising the Kidde Fire Systems CO_2 fire suppression system. The information is arranged in the following categories:

- CO_2 storage
- Actuation components
- Check valves
- Directional (Stop) valves
- Lockout valves
- Discharge nozzles
- Auxiliary equipment
- Instruction and warning plates
- Hose reel and rack systems

2-2 CO_2 STORAGE

Kidde Fire Systems high pressure carbon-dioxide fire suppression systems use liquid carbon dioxide agent stored under its own vapor pressure in seamless steel cylinders at ambient temperature. Each cylinder is equipped with a valve having a connection for attachment of a discharge head. The discharge heads attach to the distribution piping by means of flexible hoses or a swivel adapter.

Actuation of the suppression system is initiated by one or more control heads which are attached to the control ports on the valve(s) of the pilot cylinder(s). Actuation of the pilot cylinders creates sufficient pressure in the discharge manifold to operate the remaining cylinders in the system.

Single or dual cylinder suppression systems utilize cylinder straps to secure the storage cylinders to walls or other rigid structural members. Specially designed racks are utilized for multiple cylinder systems to secure the cylinders, absorb the discharge reactions, and to facilitate system servicing and maintenance.

WARNING

Pressurized (charged) cylinders are extremely hazardous and if not handled properly are capable of violent discharge. This could result in bodily injury, death, or property damage. Always handle carbon dioxide cylinders according to the instructions in this manual.

2-2.1 Cylinder and Valve Assemblies

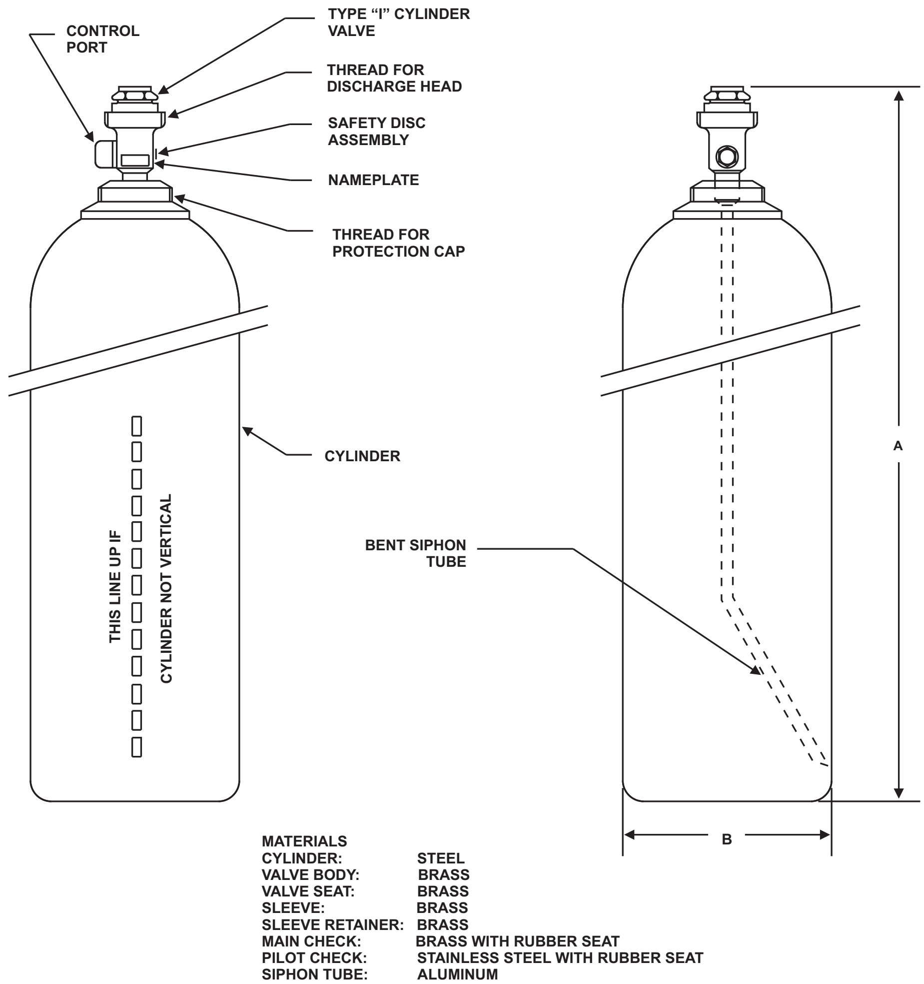
Carbon dioxide agent is stored in steel cylinders as a liquid under its own vapor pressure and at ambient temperature. Each cylinder is equipped with a forged brass valve assembly which contains a safety disc device (Table 2-1) for protection against over pressurization due to elevated temperatures. Each valve is equipped with a side port that serves both as a fill connection and as a control port for attachment of system actuators. The control port is designed to accept all of the control heads listed in this manual.

The threaded connection on the top of each valve mates with a discharge head to allow agent release and distribute the CO_2 from the cylinder into the discharge piping.

Five cylinder and valve assemblies are available, ranging in capacity from 25 lb. to 100 lb. of carbon dioxide. The 25, 35, and 50 lb. cylinders (Figure 2-1) are equipped with a 1/2-inch discharge valve, Part. No. WK-981372-000 (Figure 2-3); the 75 and 100 lb. cylinders (Figure 2-2) have a 5/8-inch discharge valve, Part No. WK-840253-000 (Figure 2-4).

WARNING

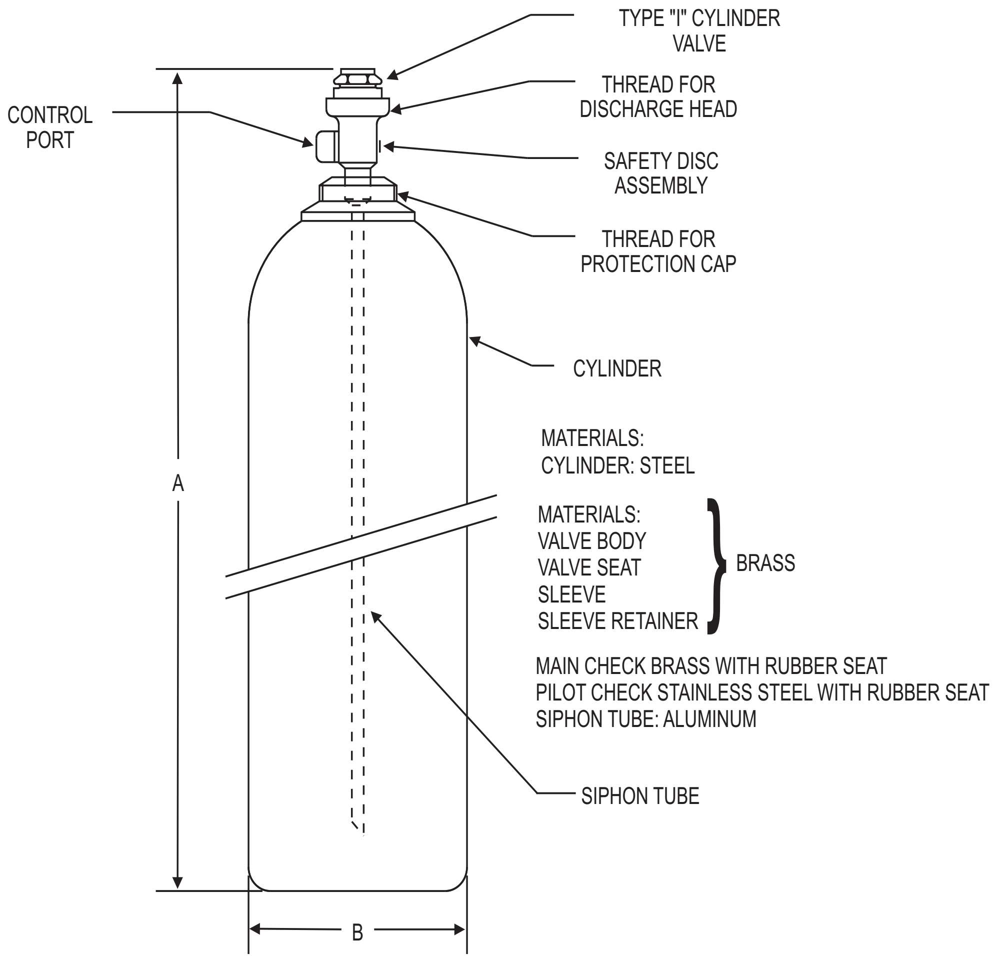
The cylinders are factory-equipped with a protection cap threaded securely over the valve assembly. This device is a safety feature and provides protection during shipment and handling. This cap must be installed at all times, except when the cylinders are connected into the system piping or being filled. Do not move or handle a carbon dioxide cylinder unless the protection cap is installed.



PART NUMBER	CYLINDER CO_2 CAPACITY		VALVE SIZE	SAFETY DISC	SIPHON TUBE	DIM. "A" (HEIGHT)		DIM. "B" (DIAMETER)		CYLINDER VOLUME		NOMINAL CHGD. WEIGHT		DOT RATING
	lbs.	kg				in.	mm	in.	mm	$in.^3$	m^3	lbs.	kg	
81-982548-000	50	22.6	1/2 in.	WHITE	BENT	55.25	1396	8.50	215	2300	0377	155	70.3	3AA-2015
81-982547-000	35	15.8	1/2 in.	WHITE	BENT	39.25	997	8.50	215	1510	0247	114	51.7	3AA-2015
81-870486-000	25	11.3	1/2 in.	WHITE	BENT	29.63	750	8.50	215	1040	0170	84	38.1	3AA-2015

Figure 2-1. 25 through 50 lb. Carbon Dioxide Cylinders, Bent Siphon Tube

Note: Horizontal or Vertical Installation



PART NUMBER	CYLINDER CO_2 CAPACITY		VALVE SIZE	SAFETY DISC	SIPHON TUBE	DIM. "A" (HEIGHT)		DIM. "B" (DIAMETER)		CYLINDER VOLUME		NOMINAL CHGD. WEIGHT		DOT RATING
	lbs.	kg				in.	mm	in.	mm	$in.^3$	m^3	lbs.	kg	
81-870269-000	100	45.3	5/8 in.	RED	STRAIGHT	62	1570	10.55	267	4070	0.0667	288	130.6	3AA - 2300
81-870287-000	75	34.0	5/8 in.	RED	STRAIGHT	60	1520	9.22	233	3055	0.0501	205	92.9	3AA - 2300

Figure 2-2. 75 and 100 lb. Carbon Dioxide Cylinder, Straight Siphon Tube

2-2.1.1 VALVES

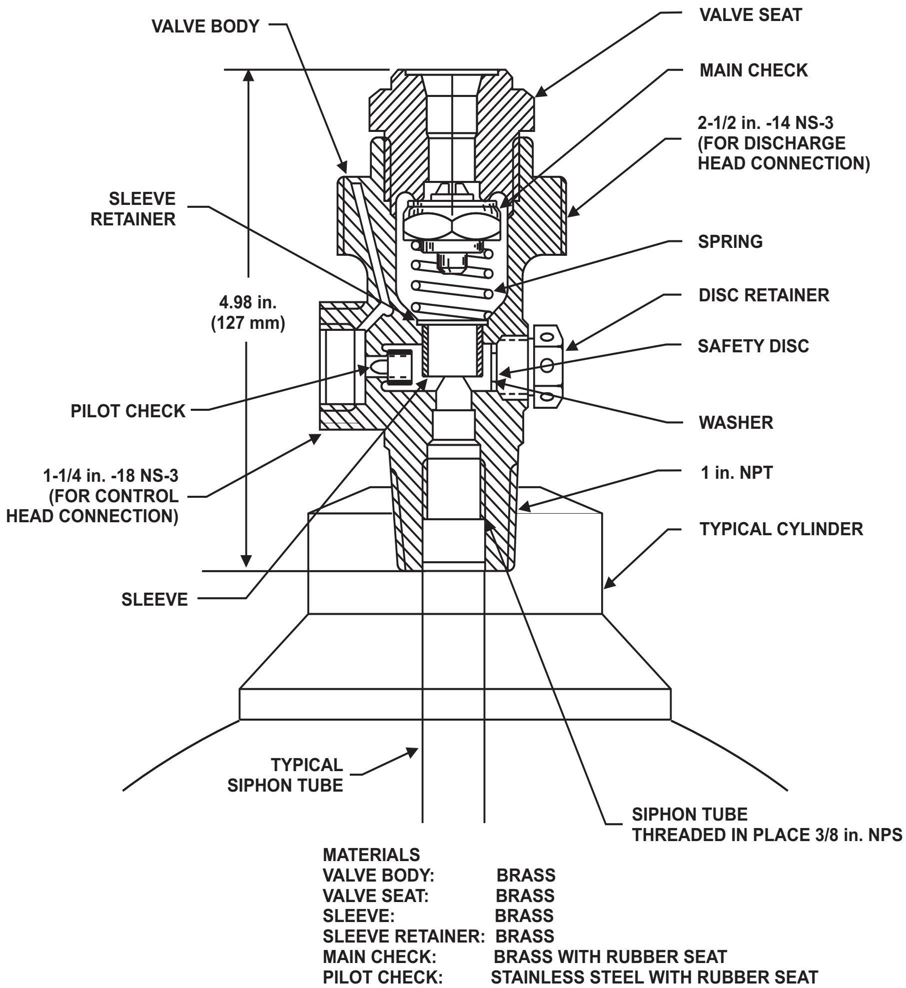


Figure 2-3. I/2-inch Type “I” Cylinder Valve

Table 2-1. Safety Disc Information

Description	Part Number	Cylinder Size	Identification	Burst Pressure
Safety Disc and Washer	81-902048-000	25, 35, and 50 lb.	White	2650 to 3000 psi @ 160°F
Safety Disc and Washer	81-903684-000	75 and 100 lb.	Red	3150 to 3500 psi @ 160°F

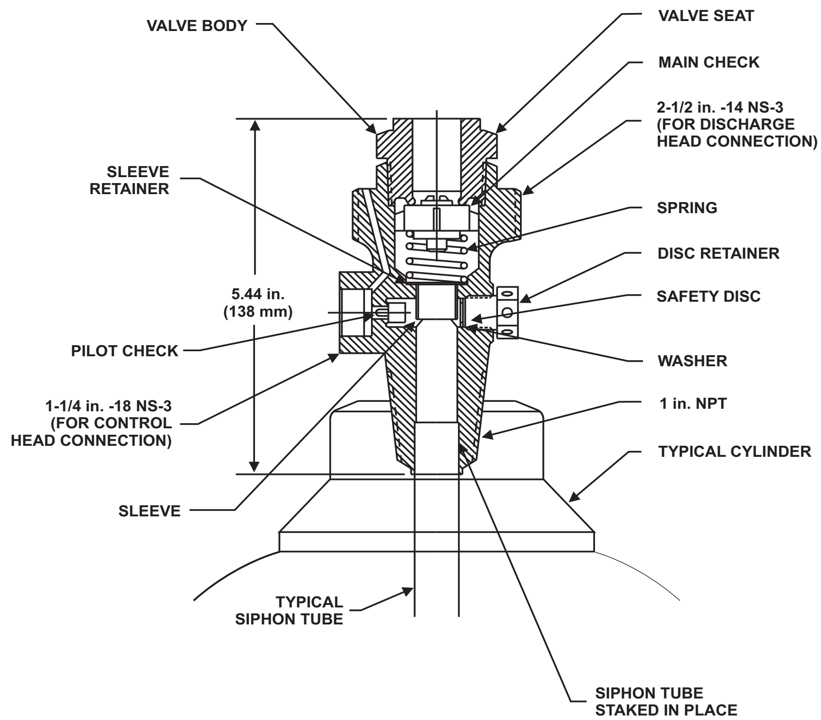
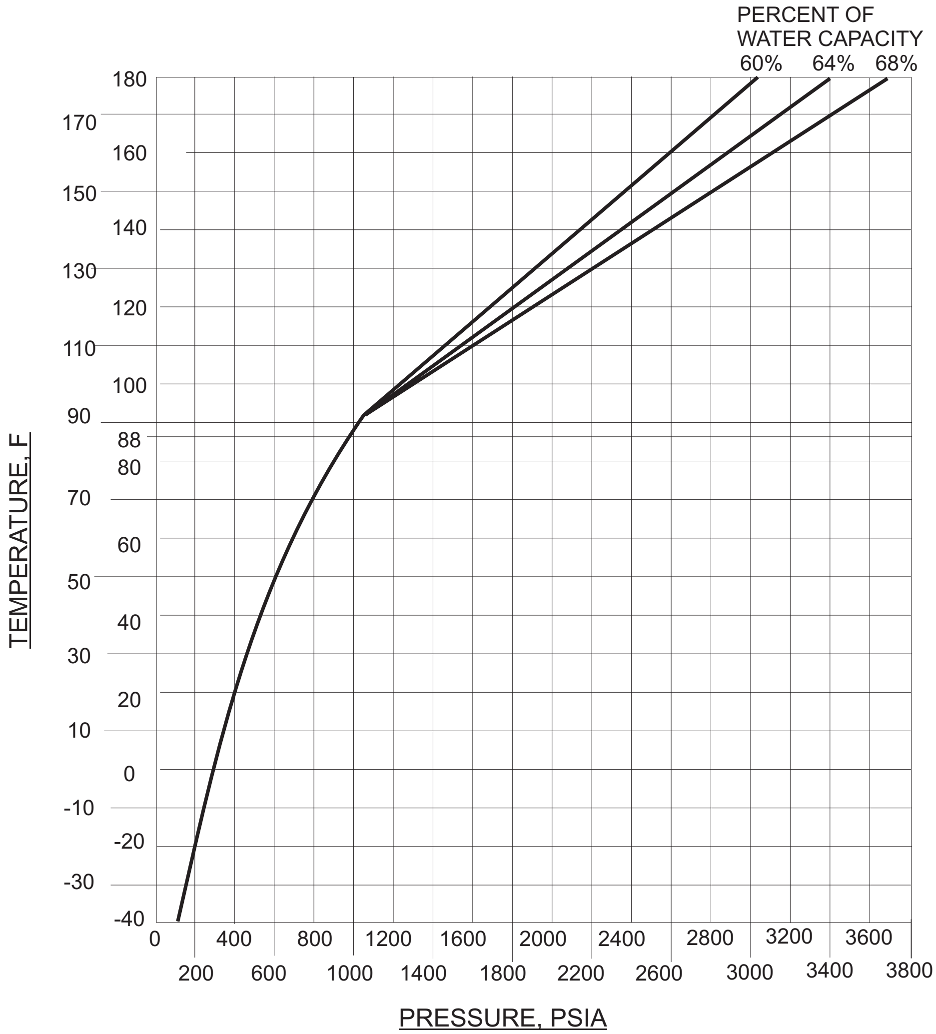


Figure 2-4. 5/8-inch Type “I” Cylinder Valve

2-2.1.2 CYLINDER FILLING

The relationship of cylinder pressure as a function of temperature and fill density is shown in Figure 2-5. In high pressure CO_2 systems the cylinder pressure is directly related to the ambient temperature at the storage location. The pressure is also affected by the fill density or percent fill. This is the ratio (expressed in percent), of the weight of carbon dioxide to the water capacity of the cylinder, expressed in pounds as shown in Table 2-2. The fill density commonly used is between 60 and 68 percent. The US Department of Transportation (DOT) and Transport Canada (TC) limits the maximum fill density to 68% for carbon dioxide.

Care must be taken not to over fill the cylinders above their rated capacity. Over filling is an unsafe practice, is in violation of DOT/TC regulations, and will create rapid increases in pressure for small increases in temperature. Over filling will cause premature actuation of the pressure relief device and result in the loss of the cylinder contents.



$$\% \text{ of } H_2O \text{ capacity} = \frac{\text{Rated } CO_2 \text{ capacity of cylinders (in lbs)}}{H_2O \text{ capacity of cylinders (in lbs) at } 60^0 \text{ F}} \times 100$$

Critical temperature of CO_2 = 88^0 F

Figure 2-5. Pressure vs. Temperature for CO_2 Cylinders

Table 2-2. CO_2 and H_20 Capacity Correlation

Rated CO_2 Capacity of Cylinder (lb)	**H_20 Capacity (%)**
25	67
35	64
50	60
75, 100	68

2-2.2 Discharge Heads

Each cylinder and valve assembly must be equipped with a discharge head at installation to actuate the cylinder valve. The discharge head is assembled to the top of the cylinder valve and contains a spring-loaded piston which when actuated by carbon dioxide pressure is designed to depress the main check in the valve and discharge the contents of the cylinder. The piston provides the necessary mechanical advantage to open the valve's main check. The discharge outlet is designed to mate with a flexible hose or swivel adapter for connection to the distribution piping. The discharge head also contains an integral stop check whose function is to automatically prevent the loss of carbon dioxide during system discharge in the event that a cylinder is removed from the distribution piping. Two different style discharge heads are available:

- Plain-nut discharge head
- Grooved-nut discharge head

2-2.2.1 PLAIN-NUT DISCHARGE HEAD

The plain-nut discharge head, Part No. WK-872450-000 (Figure 2-6), discharges the contents of the cylinder upon activation of its associated control head or upon application of pressure entering through the outlet. The plain-nut discharge head is used on each cylinder (Figure 2-7) of a multiple-cylinder system.

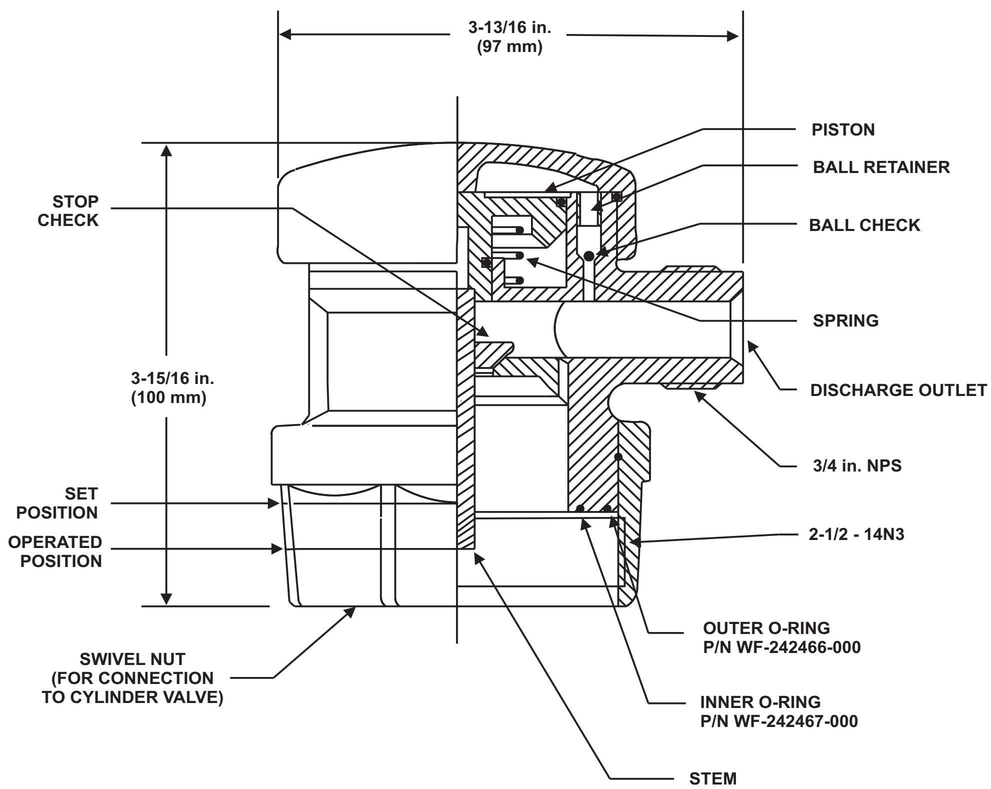
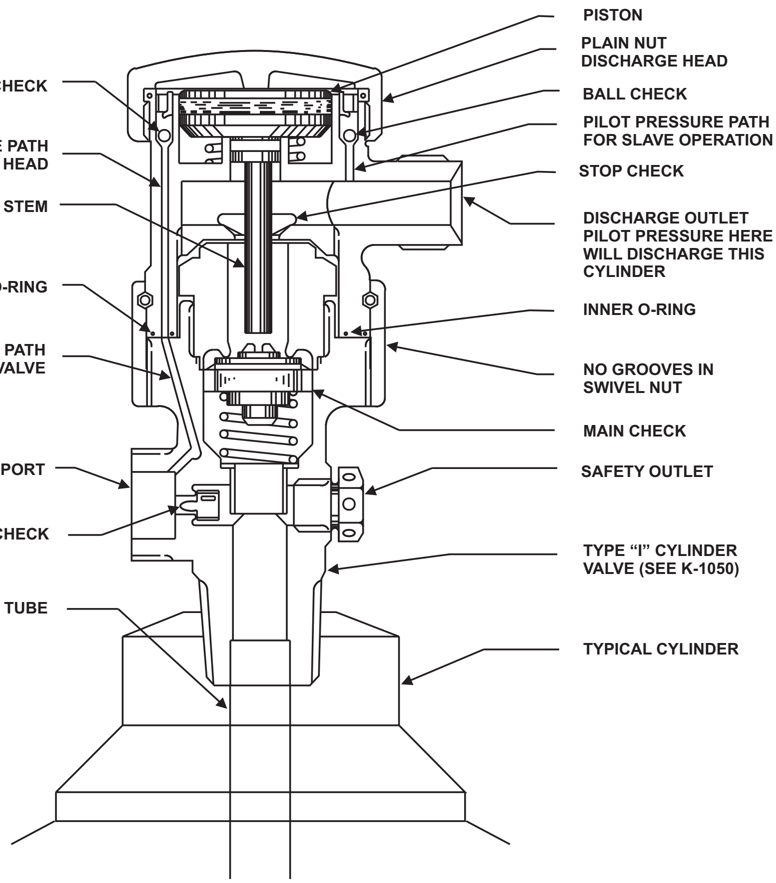


Figure 2-6. Discharge Head, Plain Nut



CAUTION

NEVER CONNECT DISCHARGE HEAD TO CYLINDER VALVE WITHOUT FLEX LOOP ATTACHED TO DISCHARGE OUTLET AND CONNECTED TO SYSTEM PIPING. ARRANGEMENT AS SHOWN IS FOR ILLUSTRATION PURPOSES ONLY.

Figure 2-7. Installation of Plain Nut Discharge Head to Cylinder Valve

2-2.2.2 GROOVED-NUT DISCHARGE HEAD

The grooved-nut discharge head, Part No. 81-872442-000 (Figure 2-8), can only be actuated by a control head. Pressure entering the outlet will not actuate the cylinder. Grooved-nut discharge heads are only used for single-cylinder, or connected single cylinder main and reserve systems (Figure 2-9).

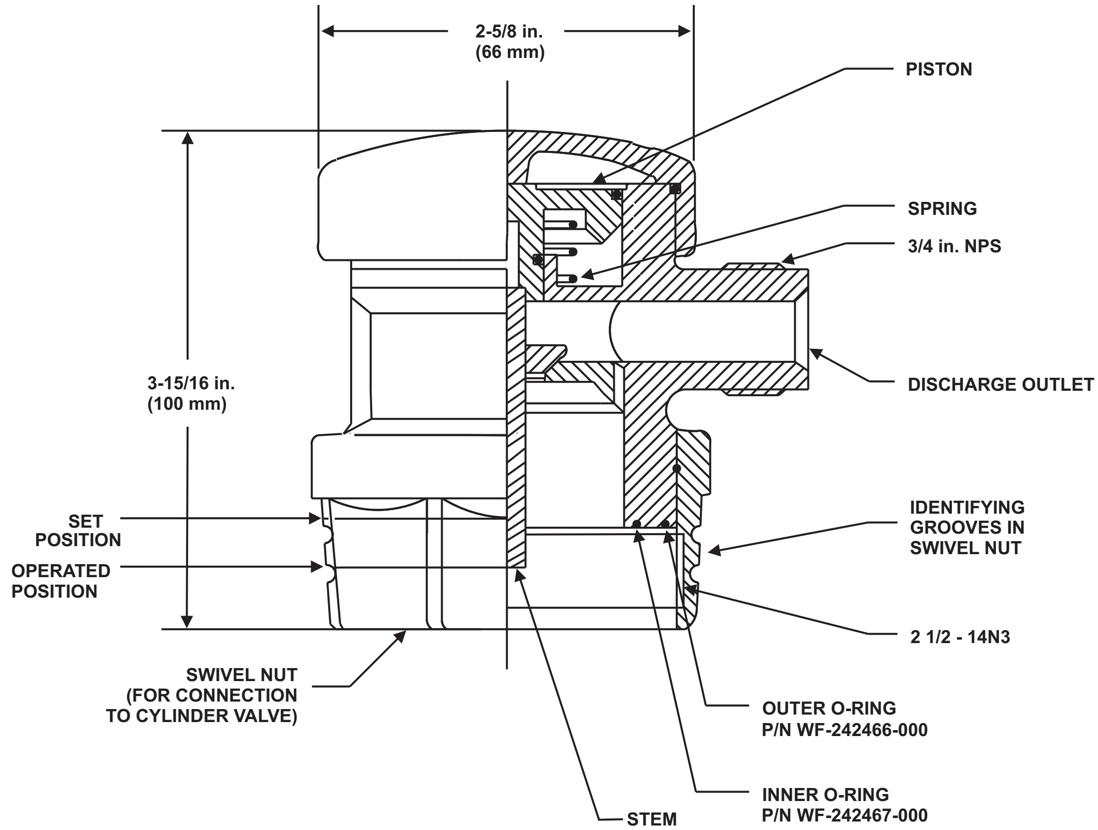
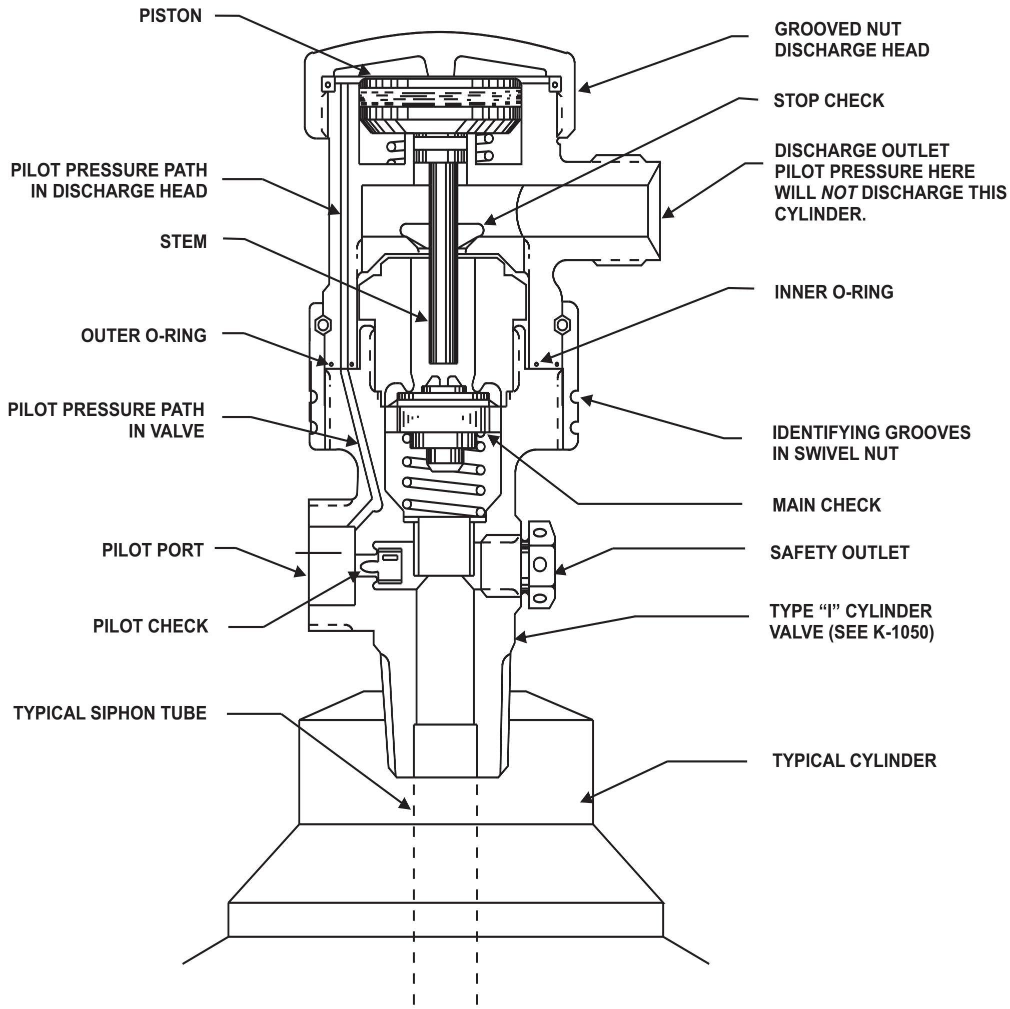


Figure 2-8. Discharge Head, Grooved Nut

WARNING

The discharge head must be permanently connected into the system piping. Never attach the discharge heads to the cylinder valves until the cylinders are secured in brackets or racking. Under no circumstances is the discharge head to remain attached to the cylinder valve after removal from service, during shipment, handling, storage, or during filling. Failure to follow these instructions could result in serious bodily injury, death, or property damage.



CAUTION

NEVER CONNECT DISCHARGE HEAD TO CYLINDER VALVE WITHOUT FLEX LOOP ATTACHED TO DISCHARGE OUTLET AND CONNECTED TO SYSTEM PIPING. ARRANGEMENT AS SHOWN IS FOR ILLUSTRATION PURPOSES ONLY.

Figure 2-9. Installation of Grooved Nut Discharge Head to Cylinder Valve

2-2.3 Flexible Hoses

Flexible discharge hoses are used to provide the interconnection between the discharge head and the distribution manifold or piping. The hoses are made of wire-reinforced rubber.

The 1/2-inch flex hose, Part No. 81-252184-000 (Figure 2-10), is used with the 25, 35, and 50 lb. cylinders.

The 3/4-inch flex hose, Part No. WK-251821-000 (Figure 2-11), is used with the 75 and 100 lb. cylinders.

WARNING **Flexible hoses must always be connected to the system piping and to the discharge heads before attaching the discharge heads to the cylinder valves, in order to prevent injury in the event of inadvertent carbon dioxide discharge.**

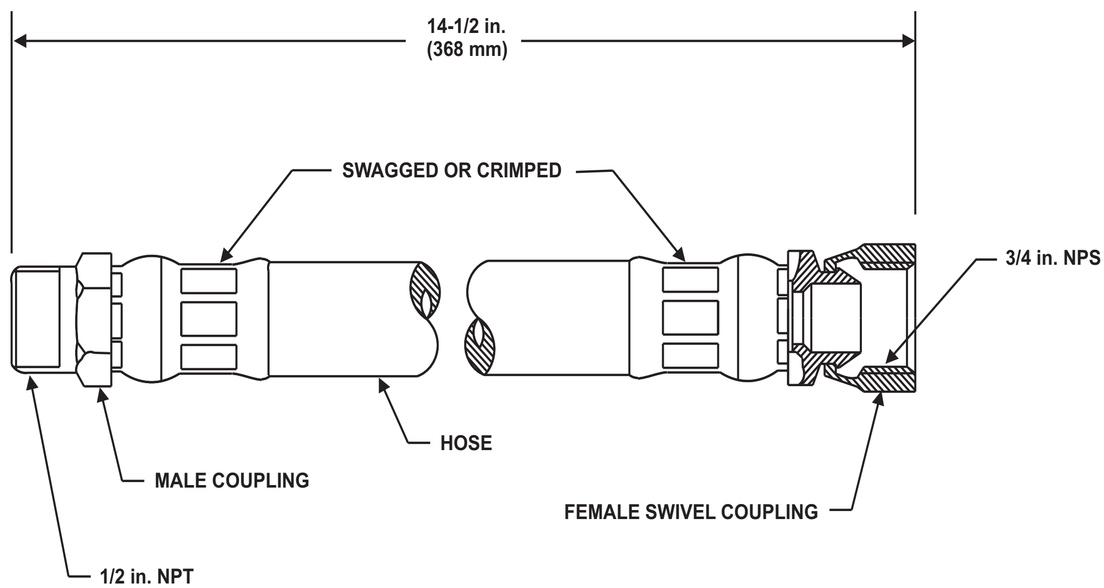


Figure 2-10. 1/2-inch Flex Hose

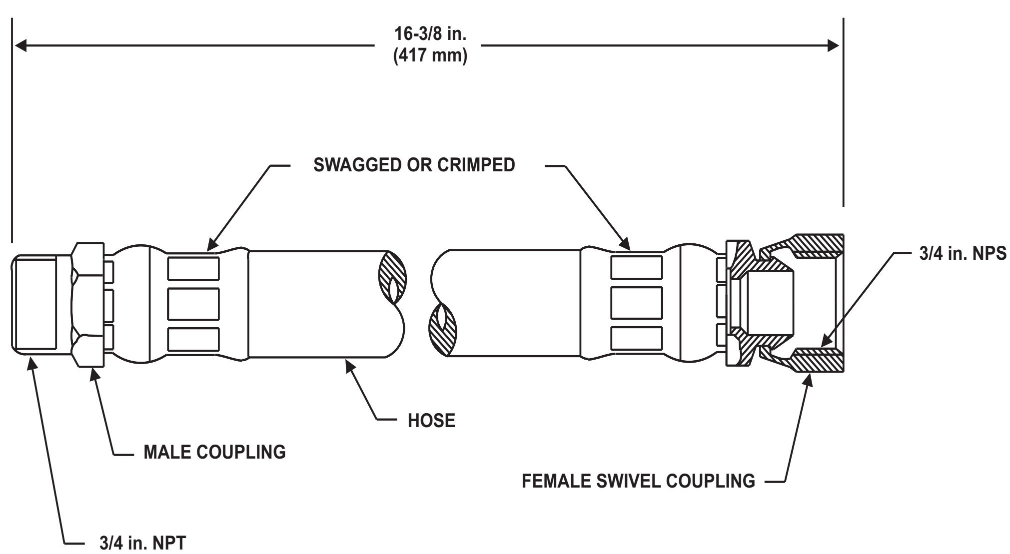


Figure 2-11. 3/4-inch Flex Hose

2-2.4 Swivel Adapter

A swivel adapter, Part No. WK-934208-000 (Figure 2-12), can be substituted for a flexible hose in a single-cylinder suppression system. It is used to connect the discharge head to the distribution piping.

WARNING **The swivel adapter must always be connected to the system piping and to the discharge head before attaching the discharge head to the cylinder valve in order to prevent injury in the event of inadvertent carbon dioxide discharge.**

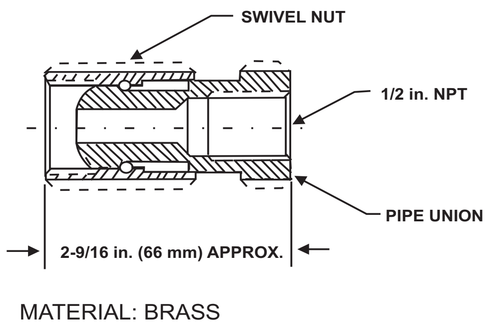


Figure 2-12. Swivel Adapter

2-2.5 Manifold “Y” Fitting

The manifold “Y” fitting, Part No. 81-207877-000 (Figure 2-13), is used in place of a pipe manifold to connect a two (2) cylinder system or for connecting a single cylinder main and reserve system.

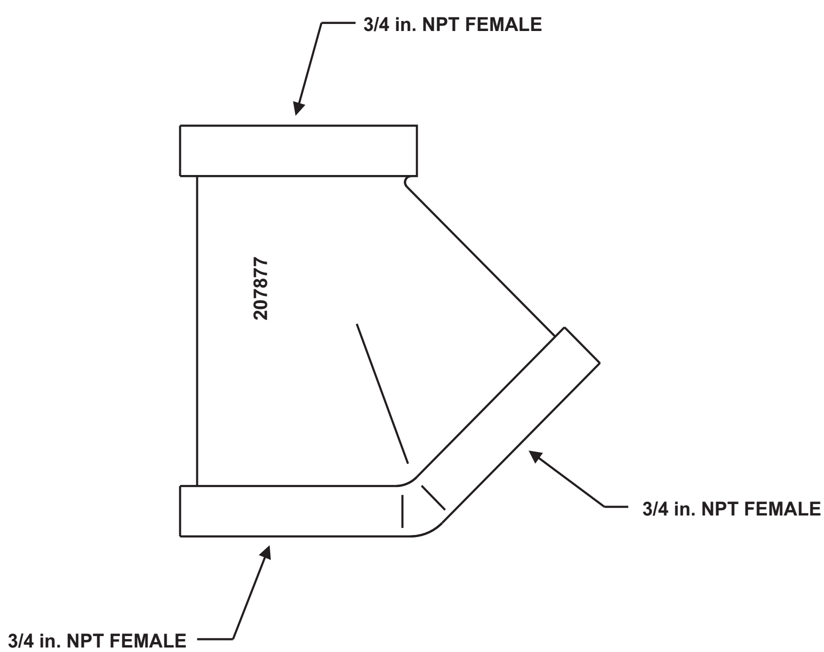


Figure 2-13. Manifold “Y” Fitting

2-2.6 Cylinder Mounting Hardware

Straps are available for securing single or double cylinders against a wall or other supporting structure. Free standing arrangements are not available. If walls are not available, a simple free standing support can be built up from the floor.

Specially designed racks are available to secure multiple cylinders in various arrangements. The racks consist of metal framework with cradles, clamps and spacers to support the cylinders, and also includes cylinder weighing bars to facilitate service and maintenance.

2-2.6.1 SINGLE OR DOUBLE CYLINDER ARRANGEMENTS

2-2.6.1.1 Single Cylinder Straps.

The dimensions for single cylinder straps (Figure 2-14) are provided in Table 2-3.

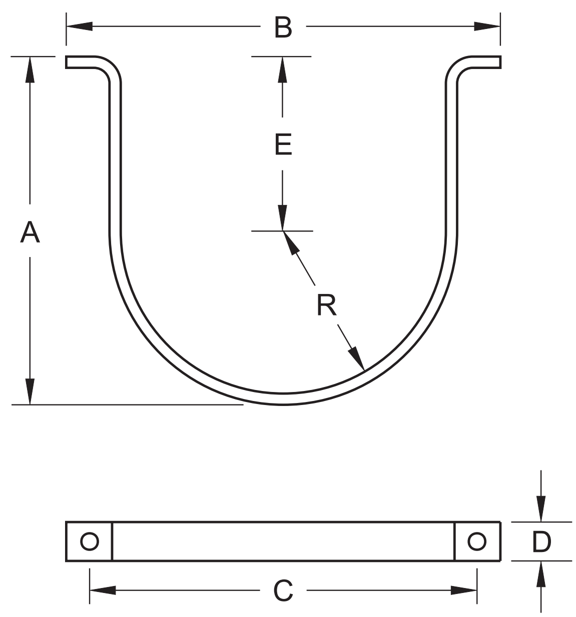


Figure 2-14. Single Cylinder Straps

Table 2-3. Single Cylinder Strap Dimensions

Part Number	Cylinder Size	A		B		C		D		E		R	
		in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
WK-270014-000	25, 35, & 50	7.94	202	11.5	292	10.4	264	1.00	25.4	3.50	88.9	4.25	108
81-626690-000	75	5.63	143	12.3	312	11.1	282	1.25	31.8	3.75	95.2	4.63	118
WK-270157-000	100	10.0	254	14.0	356	12.4	315	1.75	44.4	4.50	114	5.31	135

2-2.6.1.2 Double Cylinder Straps

The dimensions for double cylinder straps (Figure 2-15) are provided in Table 2-4.

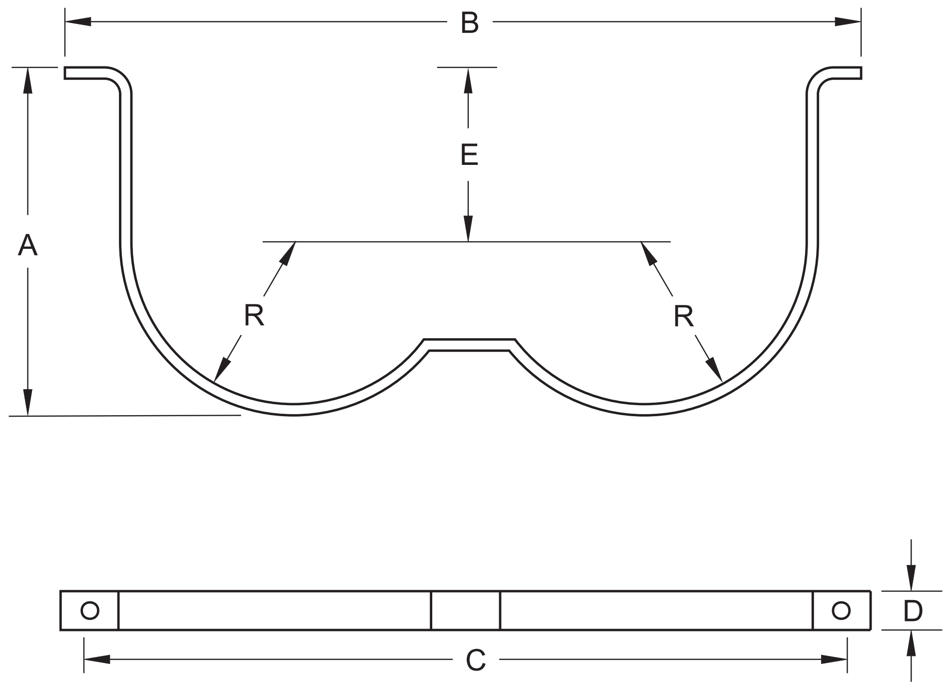


Figure 2-15. Double Cylinder Straps

Table 2-4. Double Cylinder Strap Dimensions

Part Number	Cylinder Size	A		B		C		D		E		R	
		in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
WK-241219-000	50 & 75	7.75	197	22.8	579	21.5	546	1.75	44.4	2.88	73.1	4.63	118
WK-241254-000	100	10.3	262	25.6	650	24.3	617	1.75	44.4	4.72	120	5.28	134

2-2.6.2 MULTIPLE CYLINDER ARRANGEMENTS

Three different styles of framing arrangements are available to provide flexibility of installation for installation of three or more cylinders:

Arrangement A: This style (Figure 2-16) is used for a single row of cylinders, that can be either wall mounted or free standing.

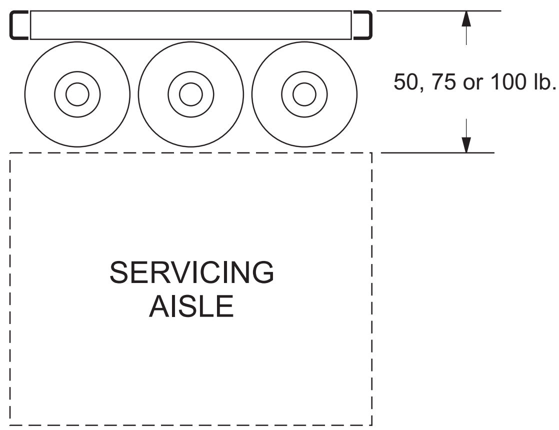


Figure 2-16. Multiple Cylinder Mounting, Arrangement A

Arrangement B: This style (Figure 2-17) provides for one row of cylinders on each side of the framing. This arrangement is free standing and requires two aisles. It has the advantage of permitting free access to any cylinder without disturbing any other cylinder.

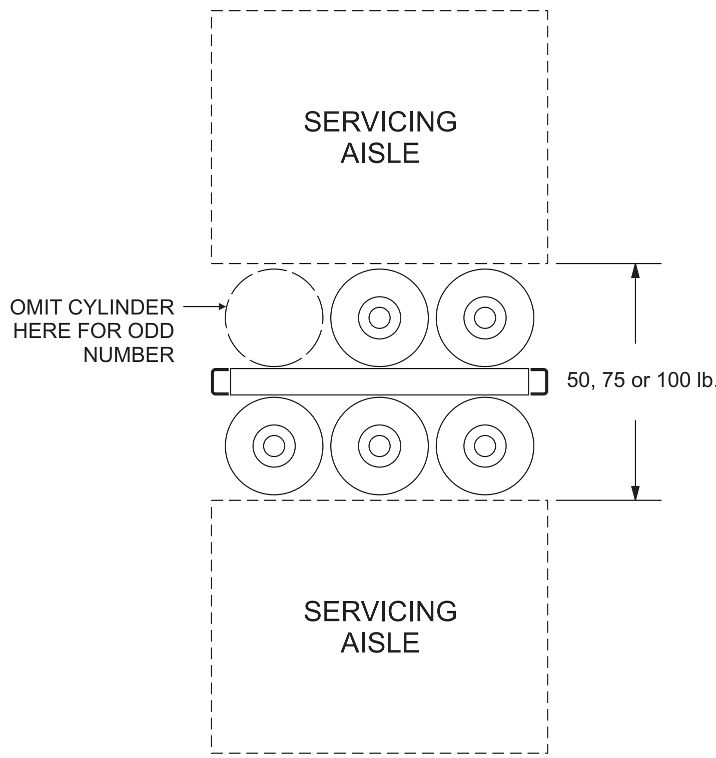


Figure 2-17. Multiple Cylinder Mounting, Arrangement B

Arrangement C: This style (Figure 2-18) provides for a double row of cylinders on the same side of the framing. This arrangement can be free standing or wall mounted. It is generally used when the cylinders are to be wall mounted and sufficient space is not available to arrange them in a single row.

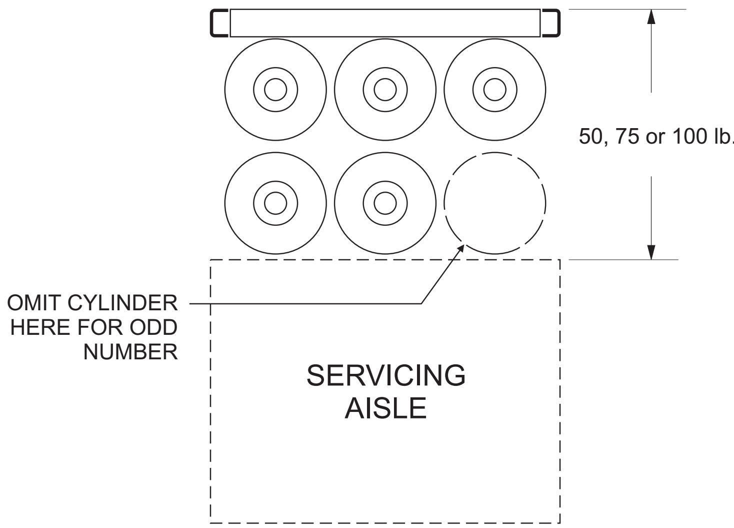


Figure 2-18. Multiple Cylinder Mounting, Arrangement C

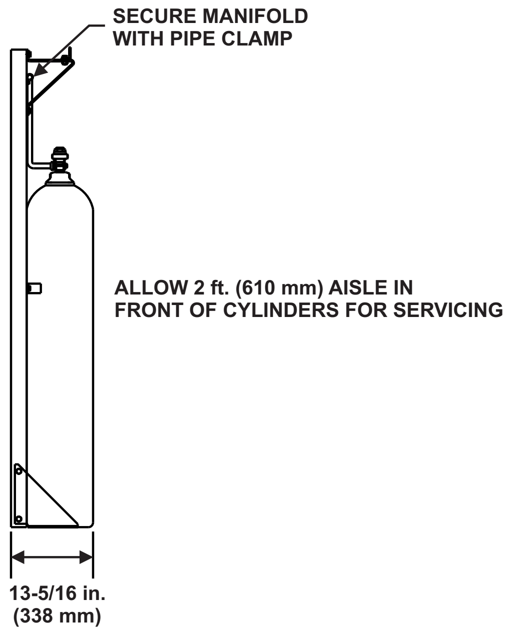
Larger quantities of cylinders can be accommodated by adding additional framing. All framing is supplied with pre-drilled mounting holes. Any combination of cylinder stowage, junction box installation, pneumatic selector valve installation and cylinder manifold support can be accommodated by the holes in the framing. All bolts and nuts are supplied as part of the framing. Drilling is not required at the job site in order to erect the bracketing. In addition the cylinder manifolds are arranged to be fastened to the framing.

2-2.6.2.1 Cylinder Rack and Framing, Example Arrangement

The components comprising a single-row rack and frame (Arrangement A) for six cylinders (Framing Kit 81-010001-006) are identified in the highlighted column of Table 2-5 and illustrated in Figure 2-19. Complete parts information concerning the components required for all single- and double-row rack and framing arrangements are contained in Table 8-19, Table 8-20 and Table 8-21 and illustrated in Figure 4-4 through Figure 4-20

Table 2-5. Framing Kits - One Row, 3 through 15 Cylinders

Number of Cylinders		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Kit Number 81-010001-XXX		**-003**	**-004**	**-005**	**-006**	**-007**	**-008**	**-009**	**-010**	**-011**	**-012**	**-013**	**-014**	**-015**
Part No.	**Description**	**Quantity Supplied in Kit**												
WK-271566-000	Post	2	2	2	3	3	3	3	3	4	4	4	4	4
WK-241211-000	Gusset	2	2	2	2	2	2	2	2	2	2	2	2	2
WK-207281-000	Channel Support	2	2	2	5	5	5	5	5	8	8	8	8	8
WK-271563-000	3 Cylinder Channel	1	—	—	2	1	—	—	—	1	—	—	—	—
WK-271564-000	4 Cylinder Channel	—	1	—	—	1	2	1	—	2	3	2	1	—
WK-271565-000	5 Cylinder Channel	—	—	1	—	—	—	1	2	—	—	1	2	3
WK-271561-000	CRADLE	3	4	5	6	7	8	9	10	11	12	13	14	15
WK-271567-000	1 Row Weigh Bar Bracket	2	2	2	3	3	3	3	3	4	4	4	4	4
WK-243796-000	3 Cylinder Weigh Bar	1	—	—	2	1	—	—	—	1	—	—	—	—
WK-243797-000	4 Cylinder Weigh Bar	—	1	—	—	1	2	1	—	2	3	2	1	—
WK-243798-000	5 Cylinder Weigh Bar	—	—	1	—	—	—	1	2	—	—	1	2	3
WK-241105-000	Front Clamp	2	2	3	3	4	4	5	5	6	6	7	7	8
WK-243795-000	Rack Rod 1 Row	2	2	3	3	4	4	5	5	6	6	7	7	8
ADDITIONAL PARTS TO ORDER FOR MAIN & RESERVE - NOT INCLUDED IN KITS														
WK-241105-000	Front Clamp	—	2	—	4	—	4	—	6	—	6	—	8	—
WK-243795-000	Rack Rod 1 Row	—	2	—	4	—	4	—	6	—	6	—	8	—
HARDWARE - NOT SUPPLIED BY KIDDE FIRE SYSTEMS														
—	3/8-inch -16 x 1-inch Long Bolt	16	16	16	26	26	26	26	26	36	36	36	36	36
—	3/8-inch -16 Nut	16	16	16	26	26	26	26	26	36	36	36	36	36
Main	1/2-inch -13 x 1-inch Long Bolt	2	3	3	4	4	5	5	6	6	7	7	8	8
M & R	1/2-inch -13 x 1-inch Long Bolt	—	3	—	3	—	5	—	5	—	7	—	7	—
Main	1/2-inch-13 Nut	8	9	12	13	16	17	20	21	24	25	28	29	32
M & R	1/2-inch-13 Nut	—	9	—	15	—	17	—	23	—	25	—	31	—
—	1/2-inch Washer	2	2	2	2	2	2	2	2	2	2	2	2	2
Note: No hardware listed for fastening framing to floor or wall.														



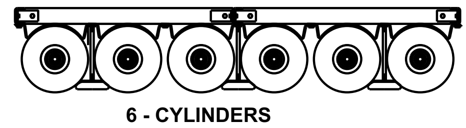


TABLE			
NO CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
6	6 ft. 1-3/4 in. (1873 mm)	(2) WK-271563-000	(2) WK-243796-000

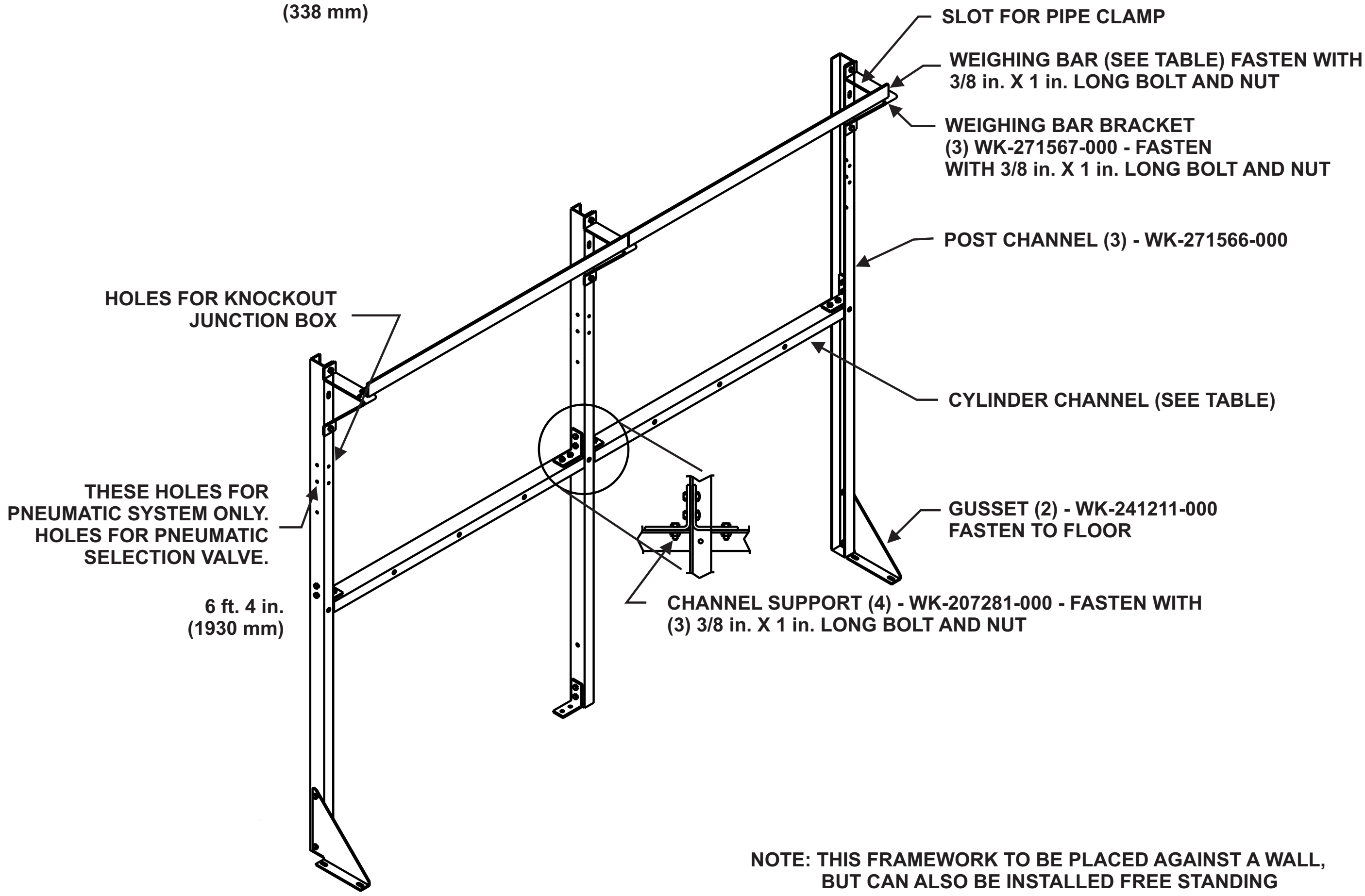


Figure 2-19. Cylinder Rack and Framing, Example Arrangement

2-3 ACTUATION COMPONENTS

Actuation of the suppression system is initiated by use of control head(s). Control heads are components that attach to the control ports of the carbon dioxide cylinder valves. The control head initiates the suppression system discharge by opening the cylinder valve's pilot check. This allows carbon dioxide to pressurize the discharge head piston, which opens the main check in the valve and discharges the contents of the cylinder.

One control head is used for CO_2 systems having one or two cylinders. A minimum of two control heads are required for suppression systems that have three or more carbon dioxide cylinders.

Control heads are also used in conjunction with pressure operated time delays, stop valves, and pneumatic transmitters to control the flow of carbon dioxide throughout the piping network. All of the control heads are self-venting in the set position to prevent accidental discharge in the event of a slow build-up of pressure in a pilot line or a slow leak at the pilot check of the cylinder valve.

WARNING **Control heads must be in the set position before attaching to the cylinder valves to prevent accidental carbon dioxide discharge.**

2-3.1 Lever-Operated Control Head

The lever-operated control head, Part No. WK-870652-000 (Figure 2-20), is used for small, manually-actuated suppression systems using one or two carbon dioxide cylinders. It is also used as an emergency manual release device for pressure operated control heads and used in conjunction with components such as pressure operated time delays and directional (stop) valves.

This control head is equipped with an operating lever secured in the closed position by a safety pull pin and seal wire. The lever can be rotated to the open position by removing the safety pin. This will discharge a cylinder, bypass a time-delay period, or open a directional (stop) valve.

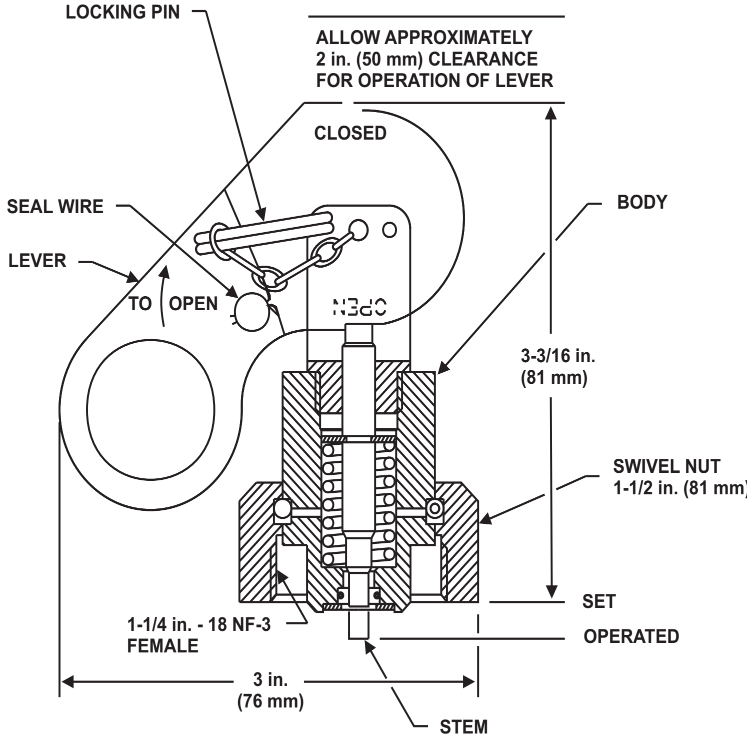


Figure 2-20. Lever-Operated Control Head

2-3.2 Cable-Operated Control Head

The cable-operated control head, Part No. 81-979469-000 (Figure 2-21 and Figure 2-22), is a mechanical device that allows for remote manual actuation of carbon dioxide cylinders, stop valves, and directional valves by means of signals transmitted via pull boxes and cables. A manual lever is also provided on the control head for local operation.

A tension force transmitted by a cable will cause the control head's cable clamp and wheel assembly to travel linearly and depress the actuating pin to open the pilot check on a cylinder valve or directional (stop) valve.

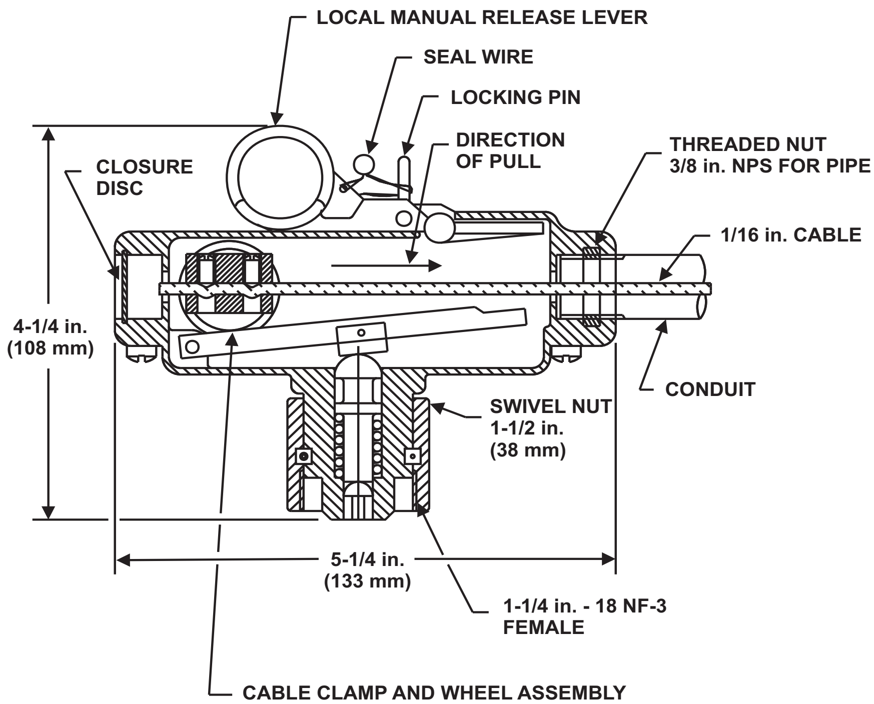


Figure 2-21. Cable-Operated Control Head

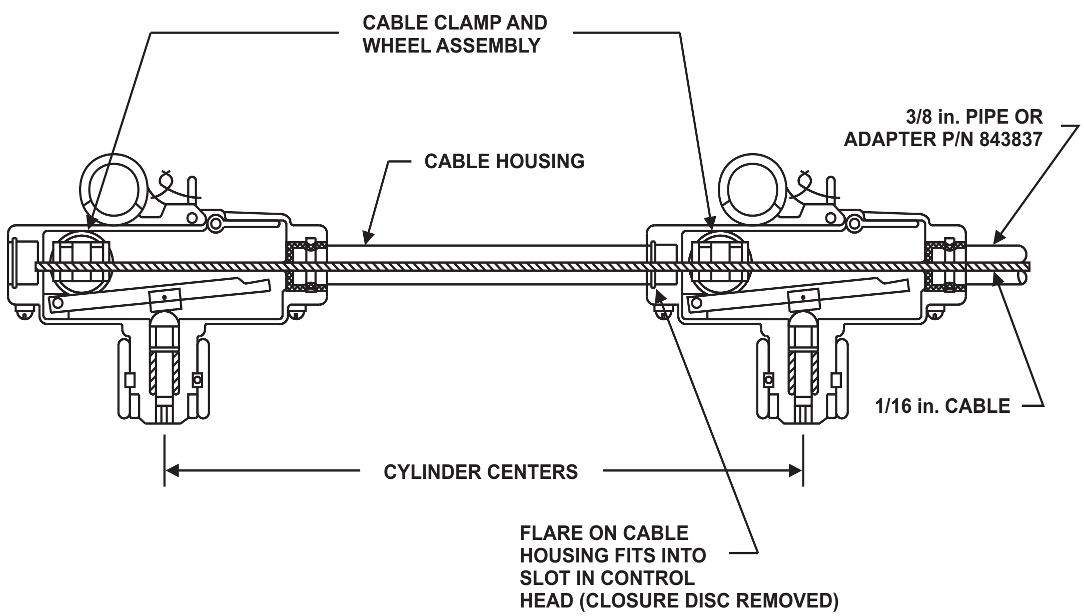


Figure 2-22. Cable-Operated Control Heads in Tandem

2-3.3 Manual Control Equipment

All carbon dioxide fire suppression systems are equipped with one or more manually-operated release stations. These stations are located in easily accessible positions around the protected area or equipment, and activation of any station should permit full operation of the system.

2-3.3.1 MECHANICAL PULL BOX

The mechanical pull box, Part No. 81-871403-000 (Figure 2-23), is a cable connected, pull-handle-type remote release station used for actuating carbon dioxide cylinders and associated directional (stop) valves. The pull box is designed to transmit a force via a 1/16-inch cable to the cable operated control heads attached to the pilot CO_2 cylinders and the appropriate flow-control valves. A hammer is attached to the pull box, and operation is accomplished by breaking the glass front with the hammer and pulling the handle.

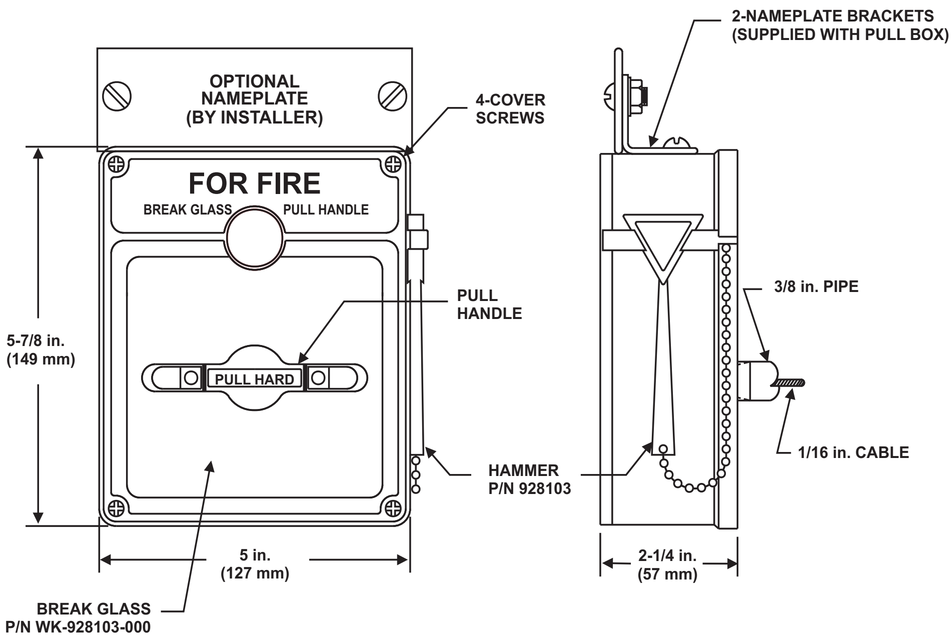


Figure 2-23. Mechanical Pull Box

2-3.3.2 MECHANICAL PULL BOX Z-BRACKET

The mechanical pull box Z-bracket, Part No. 81-605320-000 (Figure 2-24) is used to attach the mechanical pull box to a wall or a rigid structural member. This bracket provides sufficient offset of the pull box from its mounting surface to allow penetration from behind by the cabling system.

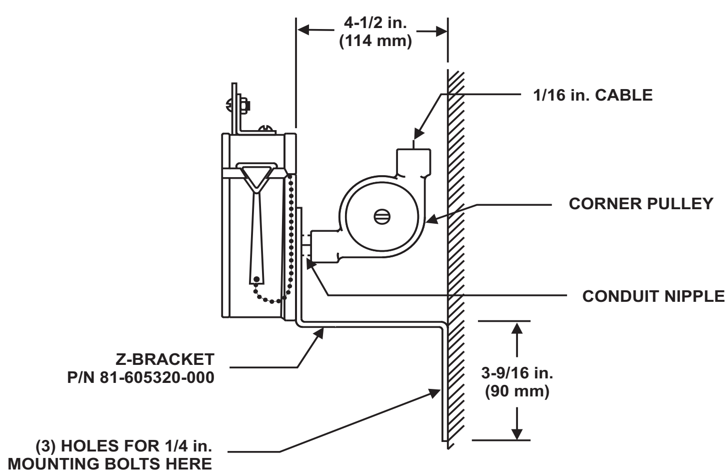


Figure 2-24. Mechanical Pull Box Bracket

2-3.3.3 CORNER PULLEYS

Corner pulleys (Figure 2-25) are used at every change in direction of cable lines and prevent binding to ensure smooth operation. Part No. 81-803808-000 is used for all watertight applications; Part No. WK-844648-000 is used for all industrial applications.

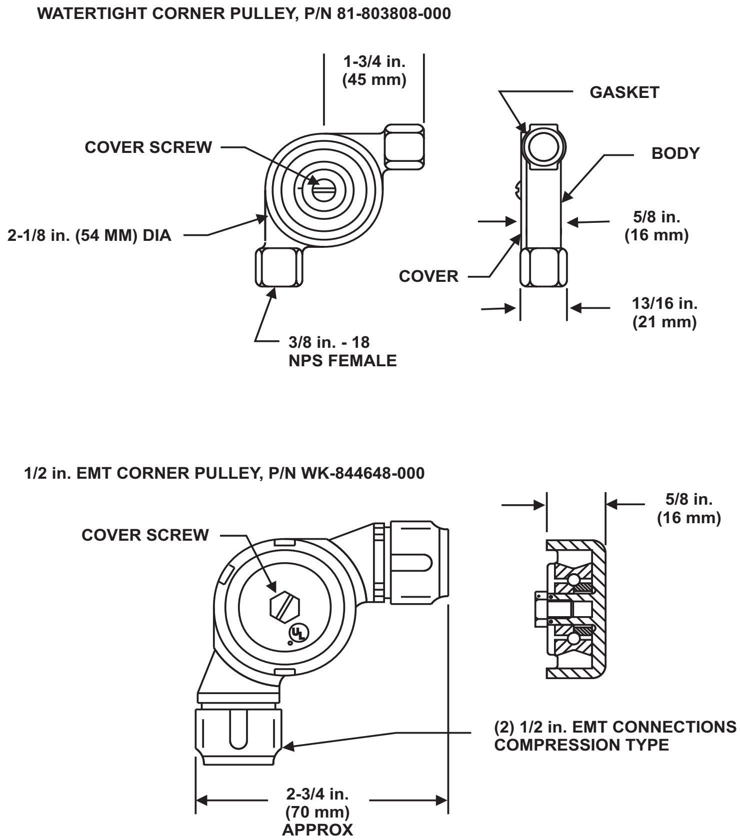


Figure 2-25. Corner Pulleys

2-3.3.4 TEE PULLEY

The tee pulley, Part No. 83-843791-000 (Figure 2-26), is used to branch a pull cable line to multiple remote release stations. The tee pulley is used for cables that are run in 1/2-inch EMT.

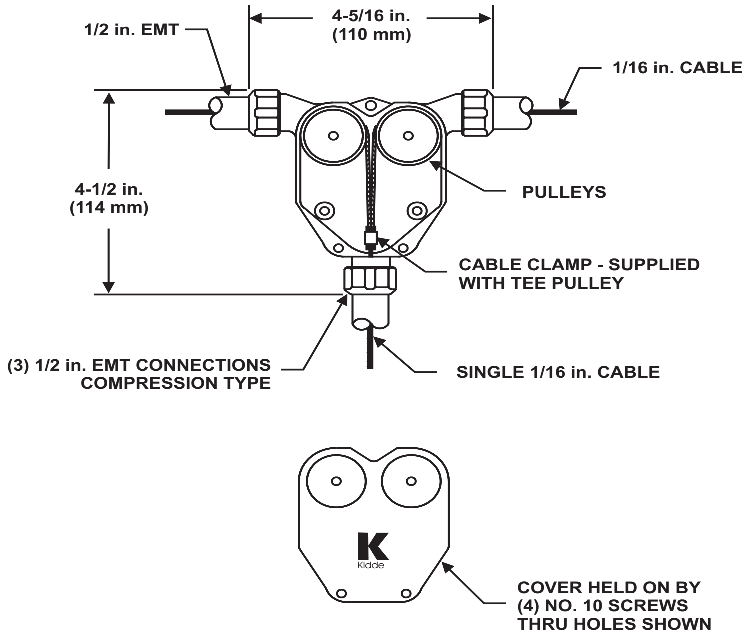


Figure 2-26. Tee Pulley

2-3.3.5 ADAPTER

The adapter, Part No. WK-843837-000 (Figure 2-27), is used to connect 1/2-inch EMT to components with 3/8-inch NPS outlets such as the cable operated control head and the dual pull equalizer. This adapter has a 1/2-inch female EMT connector on one end and a 3/8-inch NPS male connector on the other end.

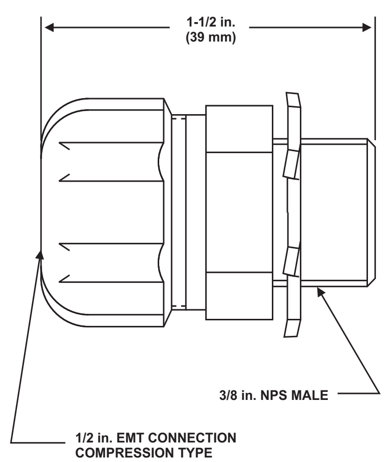


Figure 2-27. EMT Adapter

2-3.3.6 CABLE HOUSING

A cable housing (Figure 2-28) is required when the suppression system consists of three or more cylinders and utilizes two cable-operated control heads. The cable housing protects the interconnecting cable between the two cable-operated control heads and secures the two heads in a fixed position. The length of the cable housing (see Table 2-6) is determined by the size of the cylinders used in the suppression system.

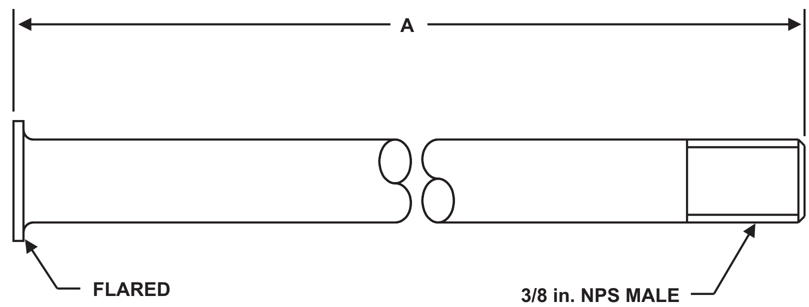


Figure 2-28. Cable Housing

Table 2-6. Cable Housing Part Numbers

Part Number	Cylinders Used With		Cylinder Centers		"A" Dimension	
	lb.	kg	in.	mm	in.	mm
WK-331570-000	25-35	11.3 - 15.8	9.5	241	5.12	130
WK-202355-000	50 - 75	22.6 - 34.0	10.0	254	5.62	143
WK-200822-000	100	45.3	11.625	295	7.12	181

2-3.3.7 DUAL PULL MECHANISM

The dual pull mechanism, Part No. 81-840058-000 (Figure 2-29), performs a similar function as the tee pulley. It is used to branch a pull cable line to two remote release stations, and is used for cables that are run in 3/8-inch pipe.

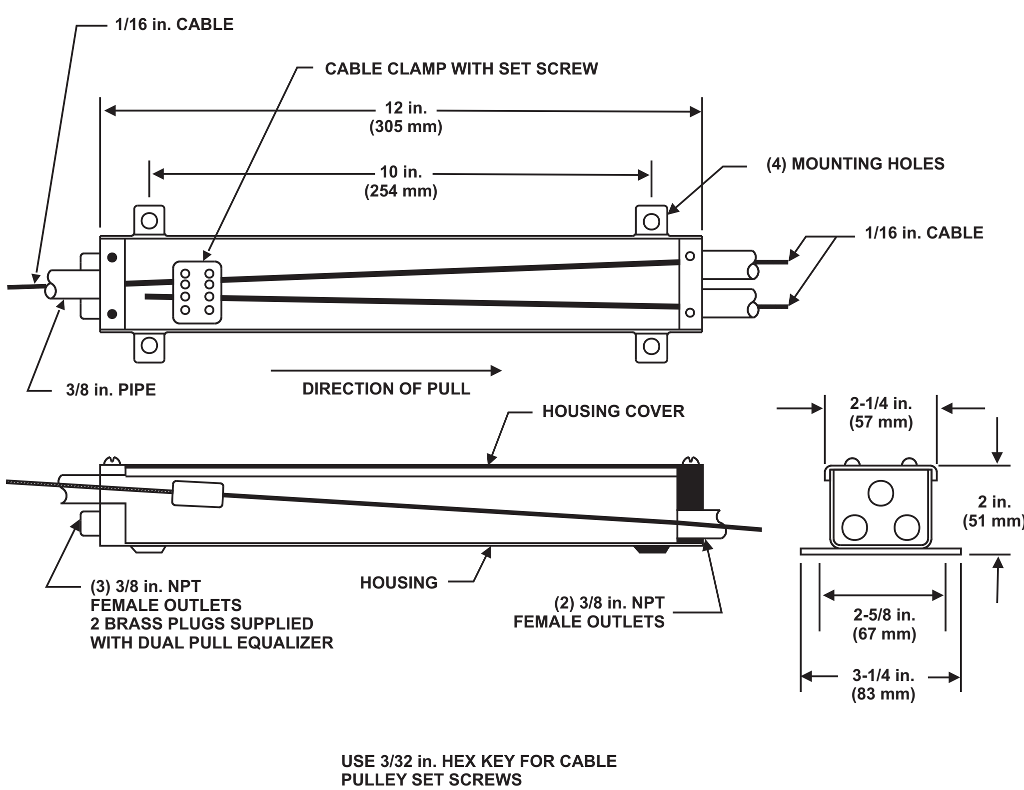


Figure 2-29. Dual Pull Mechanism

2-3.3.8 DUAL PULL EQUALIZER

The dual pull equalizer, Part No. 81-840051-000 (Figure 2-30), is used to equalize the force transmitted via a pull cable to two separate remote control head locations. It contains a pulley mechanism to equalize the cable travel to assure that the control heads fully actuate at both locations.

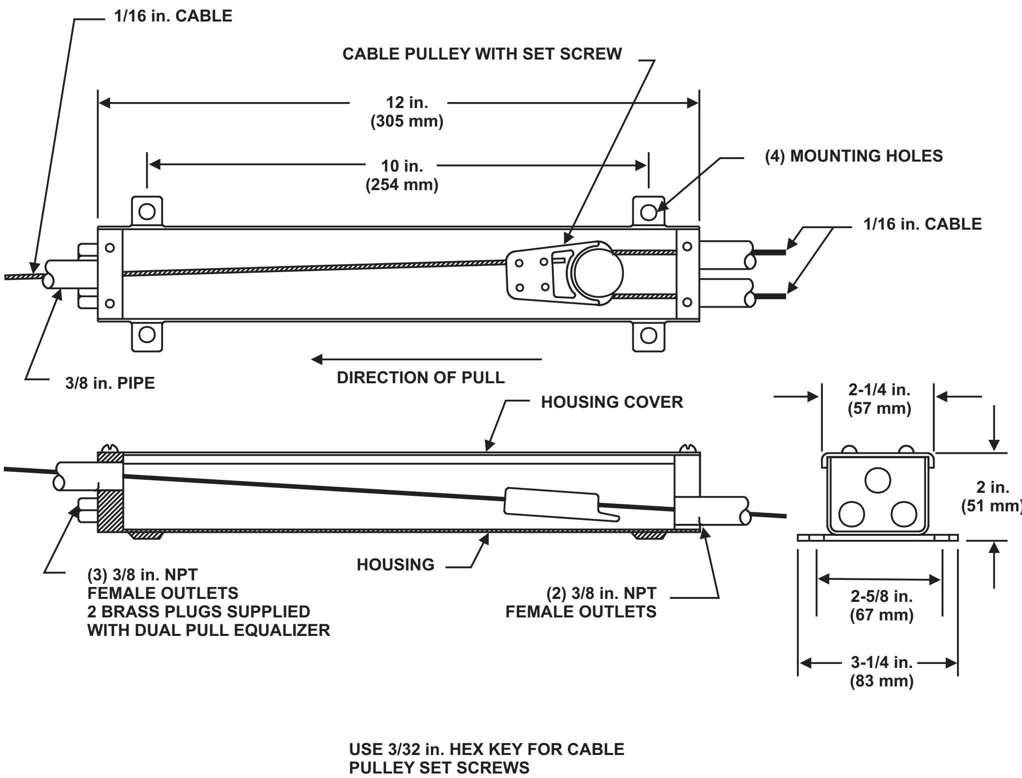


Figure 2-30. Dual Pull Equalizer

2-3.3.9 1/16-INCH PULL CABLE

The 1/16-inch Pull Cable functions as a control cable used to interconnect mechanically actuated components. The cable is made of 1/16-inch O.D., stainless-steel having a multi-strand construction and is available in the lengths identified in Table 2-7.

Table 2-7. 1/16-inch Pull Cable Lengths

Length (feet)	Part Number
50	06-118316-050
100	06-118316-100
250	06-118316-150
350	06-118316-350
500	WK-219649-000

2-3.4 Electric Control Heads

2-3.4.1 ELECTRIC CONTROL HEADS

The electric control heads (Figure 2-31 and Figure 2-32) provide for electric and local manual actuation of the CO_2 cylinder valve, or directional (stop) valves. The control head is operated electrically by a suppression control panel and is equipped with a lever for local manual operation.

The electric control head contains a microswitch whose contacts are used to break the electrical circuit to the solenoid when the head is actuated. This reduces the overall power consumption of the fire suppression system. The actuating pin latches in the released position and must be mechanically reset.

A suitable suppression control panel, specifically listed and/or approved for use with the following control heads, shall be provided for supervision of the releasing circuits per NFPA requirements. In addition, a 24 hour back-up power source shall be provided per NFPA requirements. Electrical data is contained in Table 2-8.

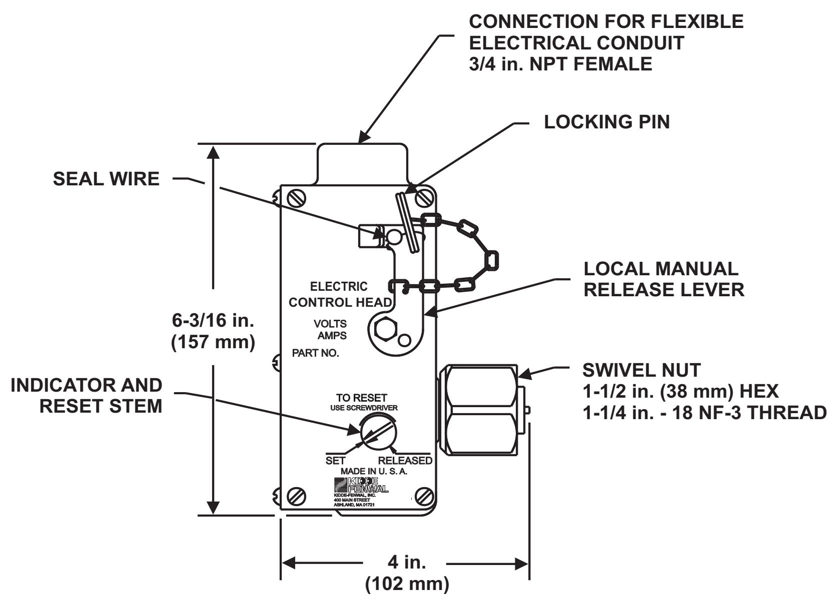


Figure 2-31. Electric Control Head

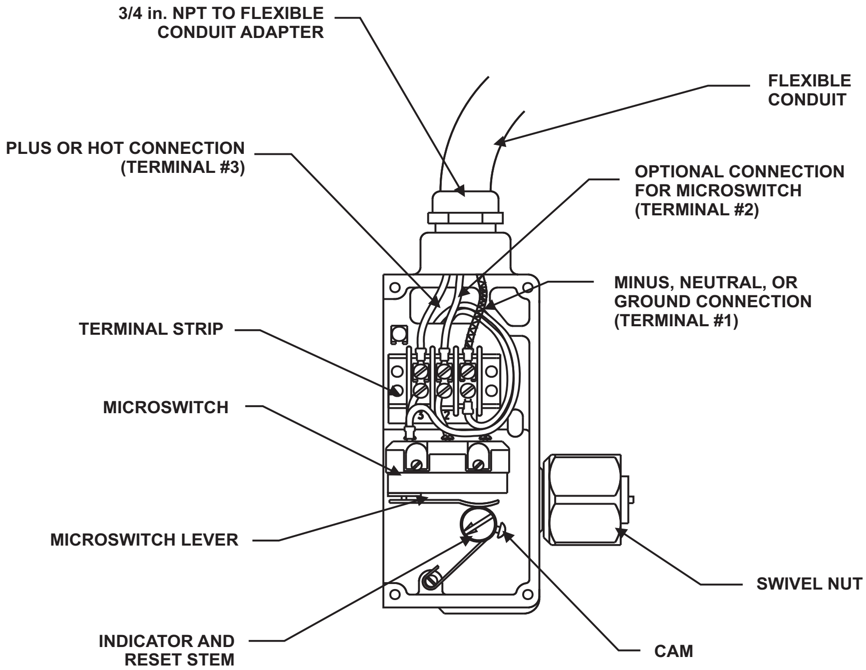


Figure 2-32. Electric Control Head (Cover Removed)

Table 2-8. Electric Control Head

Control Head Part Number	**Voltage**	**Amps.**
WK-890181-000	24 Vdc	2.0 momentary

2-3.4.2 ELECTRIC AND CABLE-OPERATED CONTROL HEADS

These control heads (Figure 2-33) provide for electric, local manual and remote manual actuation of the CO_2 cylinder valve or directional (stop) valve. The control head is operated electrically by a suppression control panel or mechanically by a cable pull box. it is also equipped with a lever for local manual operation.

These heads contain a microswitch whose contacts are used to break the electrical circuit to the solenoid when the head is actuated. This reduces the overall power consumption of the fire suppression system. The actuating pin latches in the released position and must be mechanically reset.

A suitable suppression control panel, specifically listed and/or approved for use with the following control heads shall be provided for supervision of the releasing circuits per NFPA requirements. In addition, a 24 hour back-up power source shall be provided per NFPA requirements. Electrical data is contained in Table 2-9.

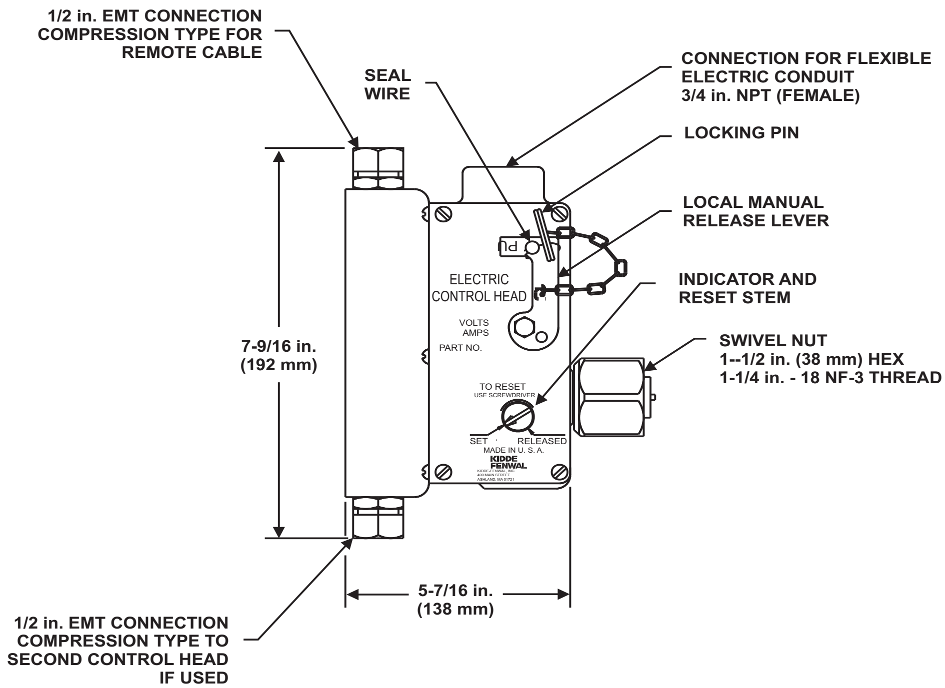


Figure 2-33. Electric and Cable-Operated Control Head

Table 2-9. Electric and Cable Operated Control Head

Control Head Part Number	Voltage	Amps.
81-895630-000	24 Vdc	2.0 momentary

2-3.4.3 EXPLOSION PROOF ELECTRIC AND CABLE OPERATED CONTROL HEADS

The explosion proof electric and cable operated control heads (Figure 2-34) are designed for use in hazardous areas. The electric solenoid housing is rated for use in Class I, Groups C and D; and Class II, Groups E, F, and G hazardous locations.

These control heads provide for electric, local manual and remote manual actuation of the CO_2 cylinder valve or directional (stop) valve. The control head is operated electrically by a suppression control panel or mechanically by a cable pull box. It is also equipped with a lever for local manual operation.

A suitable suppression control panel, specifically listed and/or approved for use with the following control heads shall be provided for supervision of the releasing circuits per NFPA requirements. In addition, a 24 hour back-up power source shall be provided per NFPA requirements. Electrical data is contained in Table 2-10.

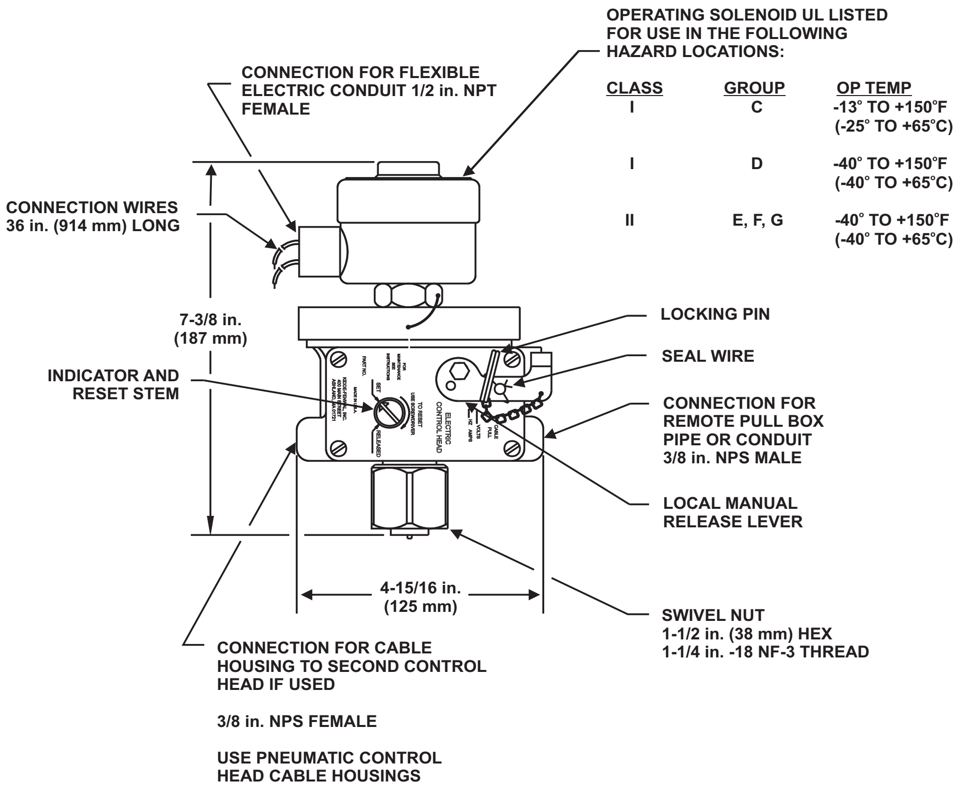


Figure 2-34. Explosion Proof Electric and Cable Operated Control Head

Table 2-10. Explosion Proof Control Head

Control Head Part Number	Type	Voltage	Amps.	Power Rating
WK-897494-000	Explosion Proof	24 Vdc	1.65 continuous	33.0 Watts

2-3.5 Pneumatic Control Heads

The pneumatic control head (Figure 2-35) is a non-electric mechanical device that allows for automatic actuation of carbon dioxide cylinders, stop valves, and directional valves by means of pressure pulses transmitted from heat-actuated detectors (HADs) via copper tubing. These control heads can also be remotely activated using a cable attached from the control head to a cable operated manual pull station. The control heads are also equipped with a manual lever for emergency local operation.

Pneumatic control heads operate on the rate-of-temperature-rise principle. This means that a sudden increase in the temperature must occur to cause the control head to operate.

The control head must be used in conjunction with a pneumatic heat detection system (rate-of rise) and operates as follows: A pneumatic HAD is connected to the control head by copper tubing. As the temperature changes, the pressure within the detector varies. If the pressure increases rapidly, as in the event of fire, a diaphragm in the pneumatic control head will trip a lever mechanism, causing the control head to operate. The pneumatic control head is fitted with a vent so that slight changes in pressure due to normal changes in ambient temperature can be vented to atmosphere. The sensitivity of the pneumatic control head is determined by the internal pressure required to trip the control head lever. This pressure is called the setting and is measured in inches of water. Vent sizes are rated in terms of the time (in seconds) required to relieve two inches of water column pressure in the diaphragm chamber. The higher the vent setting, the smaller the actual size of the vent. A control head with a high setting is actually a very sensitive device.

The combination of diaphragm and vent settings for pneumatic control heads are shown in Table 2-11.

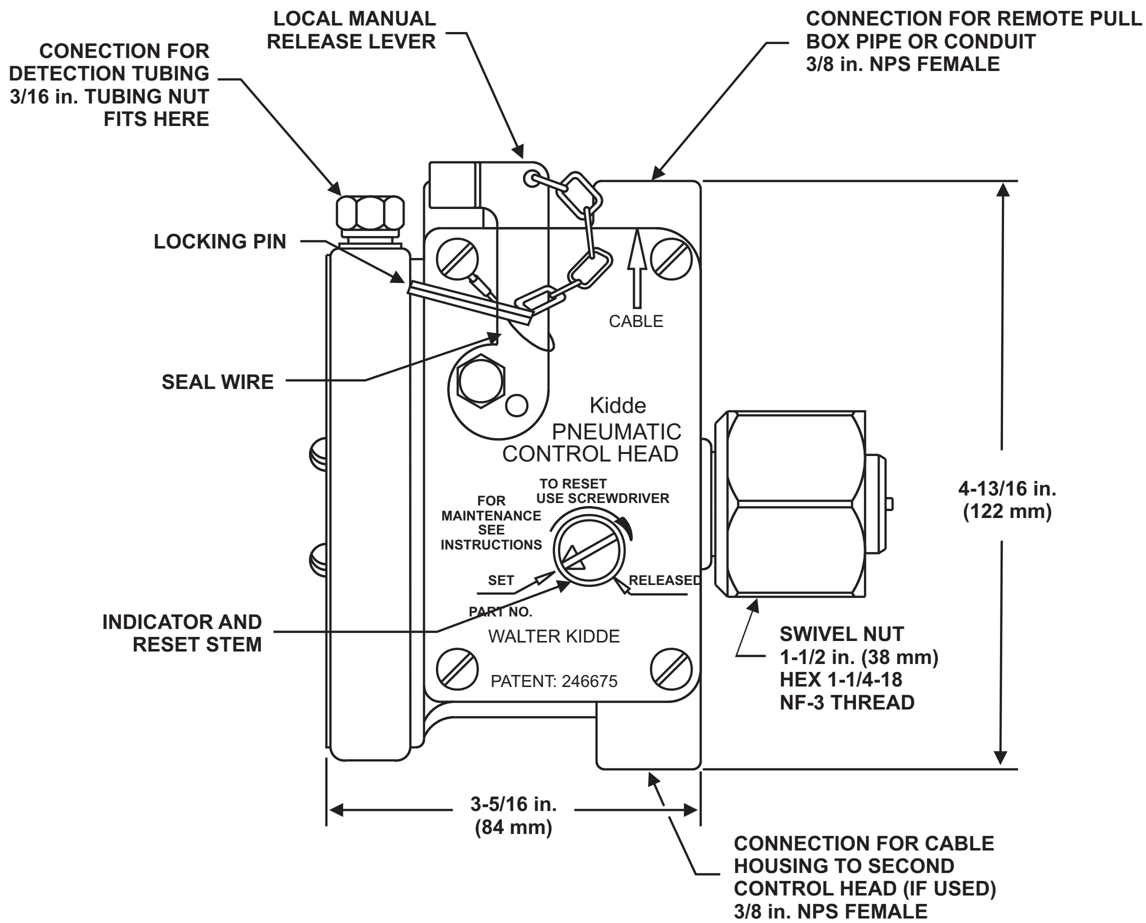


Figure 2-35. Pneumatic Control Head

Table 2-11. Pneumatic Control Head Settings

Setting	Control Head Part Number
3 inches, 5 sec. vent	81-872335-000
6 inches, 5 sec. vent	81-872365-000
6 inches, 2 sec. vent	81-872362-000
1 inch, Tandem	81-872310-000
3 inch, Tandem	81-872330-000
6 inch, Tandem	81-872360-000

2-3.5.1 TANDEM PNEUMATIC CONTROL HEAD

As previously stated, two or more pilot cylinders are required for suppression systems consisting of three or more cylinders. When two pneumatic control heads are used to actuate a bank of cylinders, one control head must be of the type having a vent, and the second must be a tandem control head. The tandem pneumatic control head (Figure 2-36) is identical to the regular pneumatic control head except that its detection chamber has no vent. Thus, all the compensation for normal environmental pressure changes is performed by the vented pneumatic control head. The diaphragm pressure setting of the tandem control head is chosen to match that of its corresponding vented pneumatic control head. The two diaphragm chambers are interconnected via 3/16-inch copper tubing. If the system is to be actuated remotely via a pull box and cable, the manual cable control is connected to both the pneumatic and tandem control heads.

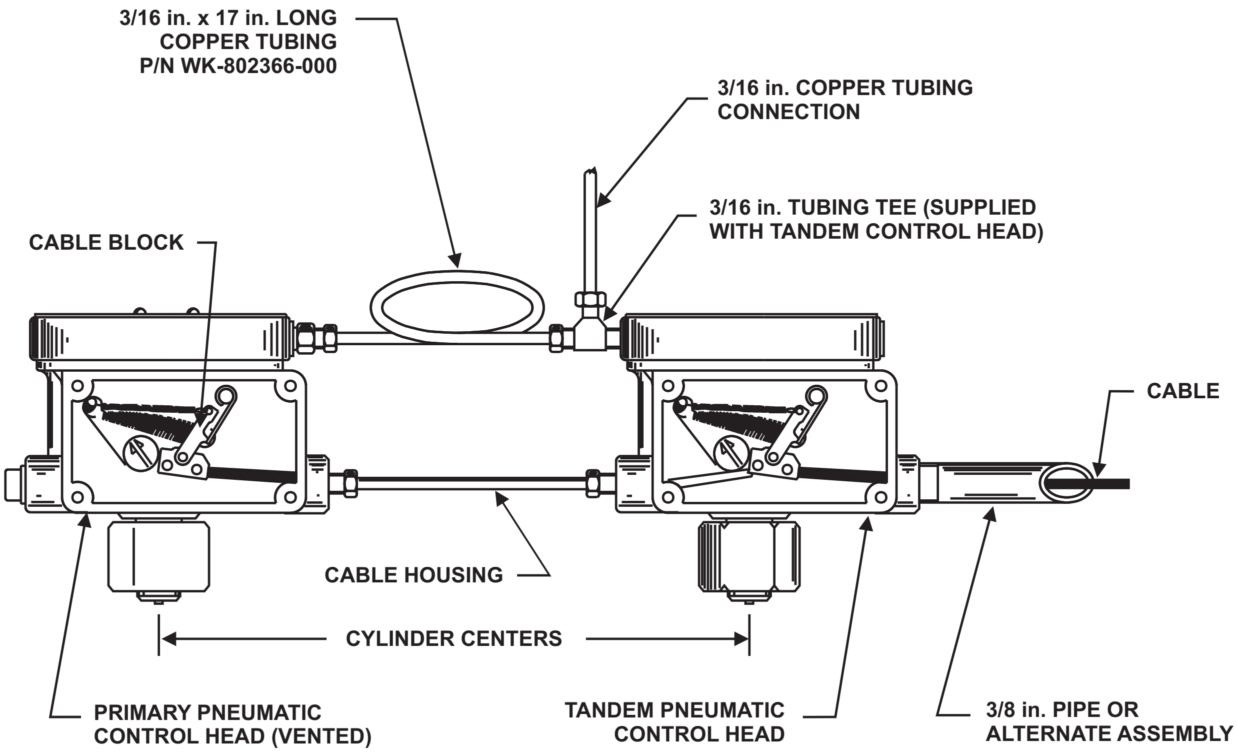


Figure 2-36. Tandem Pneumatic Control Head

2-3.6 Components for Pneumatic Actuation Systems

Pneumatic (rate-of-rise) systems utilize a variety of specialized components to control the actuation of a carbon dioxide suppression system.

2-3.6.1 PNEUMATIC CABLE HOUSING

A pneumatic cable housing (Figure 2-37) is required when a pneumatic control head and a tandem control head are installed for simultaneous actuation by a remote pull box and cable. The housing protects the interconnecting cable between the two pneumatically-operated control heads and to secure the heads in a fixed position. The length of the cable housing (see Table 2-12) is determined by the size of the cylinders used in the suppression system.

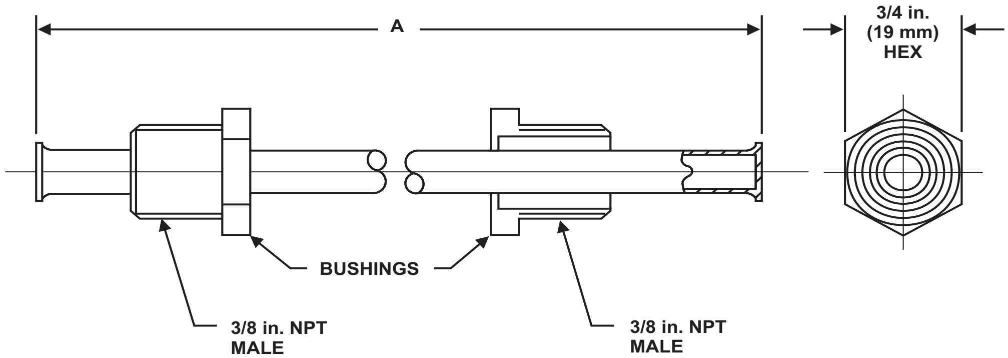


Figure 2-37. Pneumatic Cable Housing

Table 2-12. Pneumatic Cable Housing Part Numbers

Part Number	Cylinders Used With		Cylinder Centers		"A" Dimension	
	lb.	Kg	in.	mm	in.	mm
81-840044-000	25 - 35	11.3 - 15.8	9.5	241	4.68	119
81-840398-000	50 - 75	22.6 - 34.0	10.0	254	5.19	132
81-841739-000	100	45.3	11.625	295	6.82	173

2-3.6.2 HEAT ACTUATED DETECTOR

The pneumatic heat-actuated detector (HAD), Part No. WK-840845-000 (Figure 2-38), consists of a sealed hollow brass chamber having no moving parts. The detector is connected to the pneumatic control head(s) by copper tubing. The air pressure in the detector increases upon a rapid rate-of-rise in temperature, such as in the event of a fire. This pressure increase is transmitted to the pneumatic control head(s) via the copper tubing, causing the control head to actuate the system. The pneumatic heat detector, tubing, and pneumatic control head(s) system is vented to prevent normal ambient temperature changes from actuating the system.

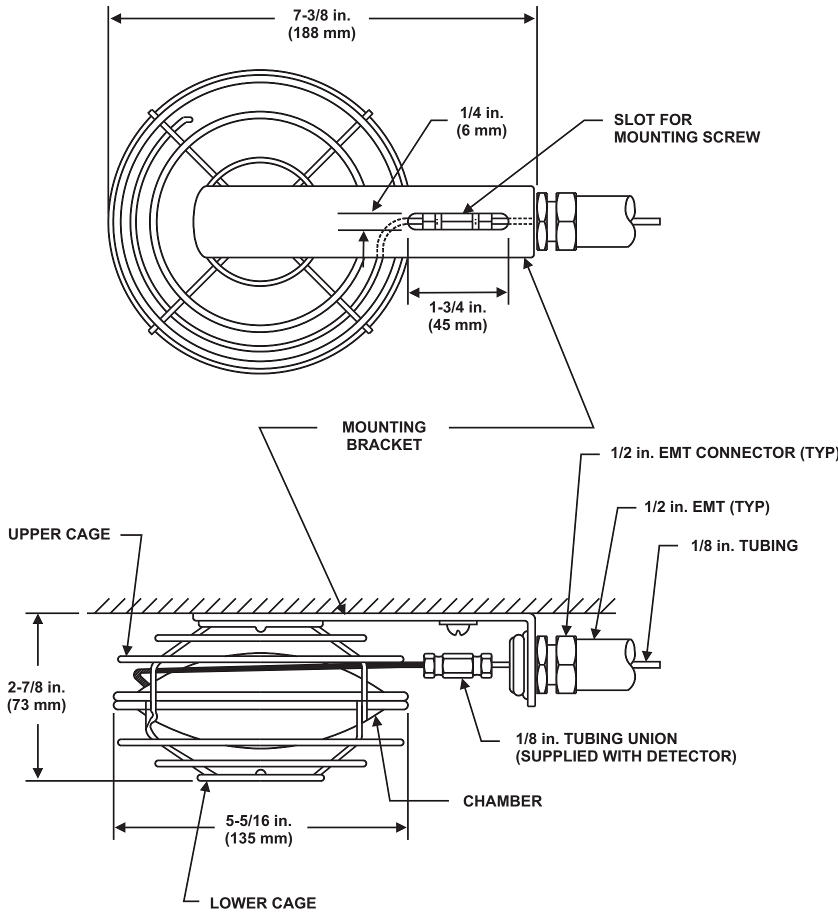


Figure 2-38. Heat Actuated Detector (HAD), Industrial

2-3.6.3 HEAT COLLECTOR

The heat collector, Part No. WK-312720-000 (Figure 2-39), is a 16-inch square baffle plate constructed of 18 gauge galvanized steel and is used to capture rising heated air and combustion products generated by a fire. The heat collector is used when the HADs cannot be mounted at ceiling level.

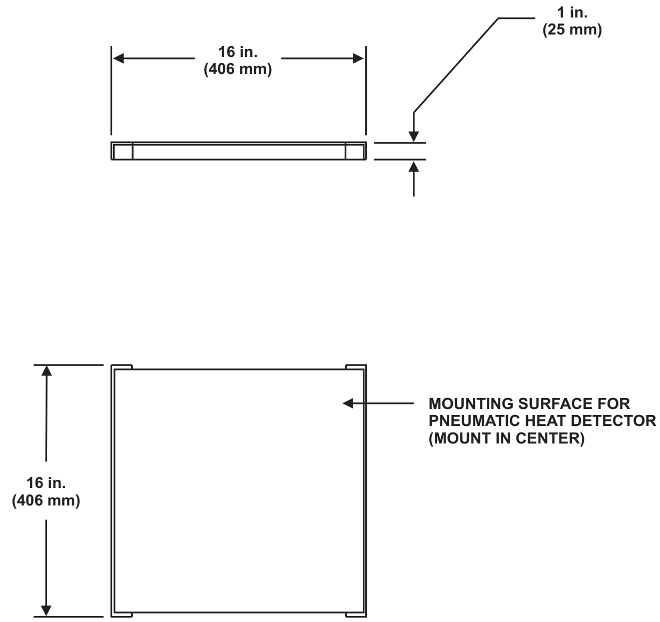


Figure 2-39. Heat Collector

2-3.6.4 VENTS

One of the major factors that determines the response characteristics of a system utilizing heat actuated detectors is the size of the vents in the pneumatic control heads. If the on-site conditions change, the vents in the pneumatic control heads can be replaced to adjust to the new site conditions.

The vent size is measured in terms of seconds, and the number of seconds indicates the time required for venting two inches of water-column pressure. The larger the vent size, the more sensitive the system will be to temperature changes in the protected area. The vent sizes available are listed in Table 2-13.

Table 2-13. Vent Size

Part Number	Vent Size
WK-802742-000	2
81-802743-000	3
WK-802745-000	5
WK-802746-000	10

2-3.6.5 1/8-INCH COPPER TUBING

Within industrial systems, 1/8-inch copper tubing is used to interconnect the principal components of a pneumatically-actuated fire suppression system. The tubing is available in 50-foot, 100-foot and 250-foot bundles as indicated in Table 2-14.

Table 2-14. 1/8-inch Copper Tubing Part Numbers

Part Number	Length (feet)
WK-802555-000	50
WK-802556-000	100
WK-207809-000	250

2-3.6.5.1 Fittings

Fittings (Figure 2-40) are available to join segments of 1/8-inch copper tubing, and to interface the 1/8-inch tubing with 3/16-inch tubing segments used to connect components such as pneumatic transmitters and control heads.

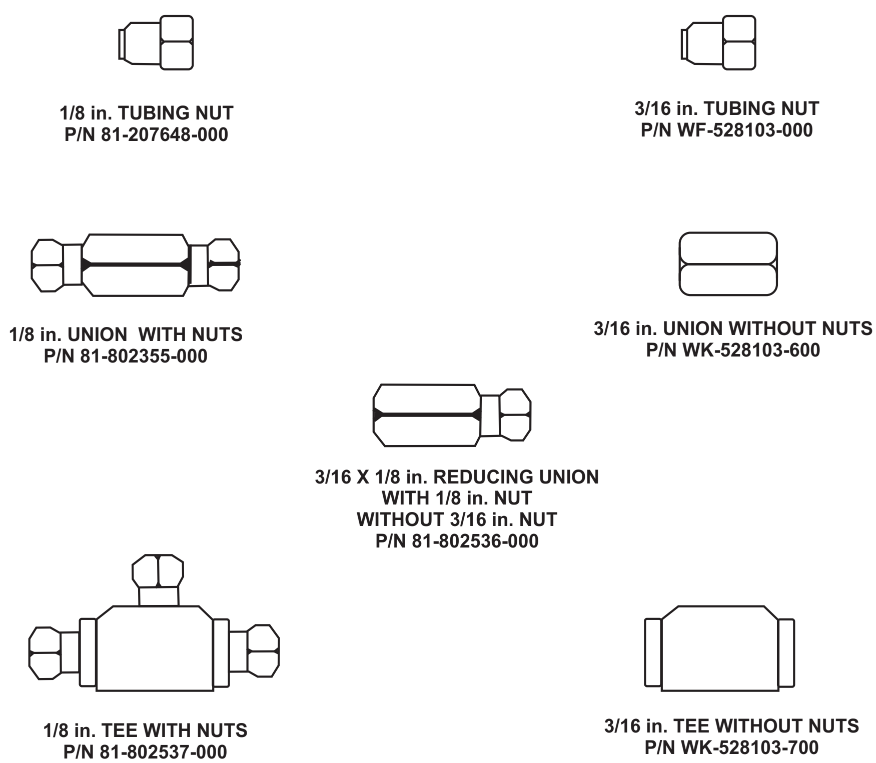


Figure 2-40. Fittings

2-3.6.5.2 Rubber Grommet

The rubber grommet, Part No. WK-207825-000, is used to support and seal a 3/16-inch tubing penetration into a junction box.

2-3.6.6 3/16-INCH COPPER TUBING

In order to prevent damage, 3/16-inch heavy wall copper tubing (Figure 2-41) is used in pneumatic actuated systems where the tubing is exposed. It is specifically used to connect pneumatic control heads and pneumatic transmitters to junction boxes, and main-to-reserve valves. The 17-inch (432 mm) length is used to interconnect tandem control heads; the 46-inch (1168 mm) length is used only for interface between control heads and tubing for HADs.

The tubing is available for these applications in the lengths indicated in Table 2-15.

Table 2-15. 3/16-inch Copper Tubing Part Numbers

Part Number	Length
WK-802366-000	17 in. (432 mm)
81-802367-000	46 in. (1168 mm)

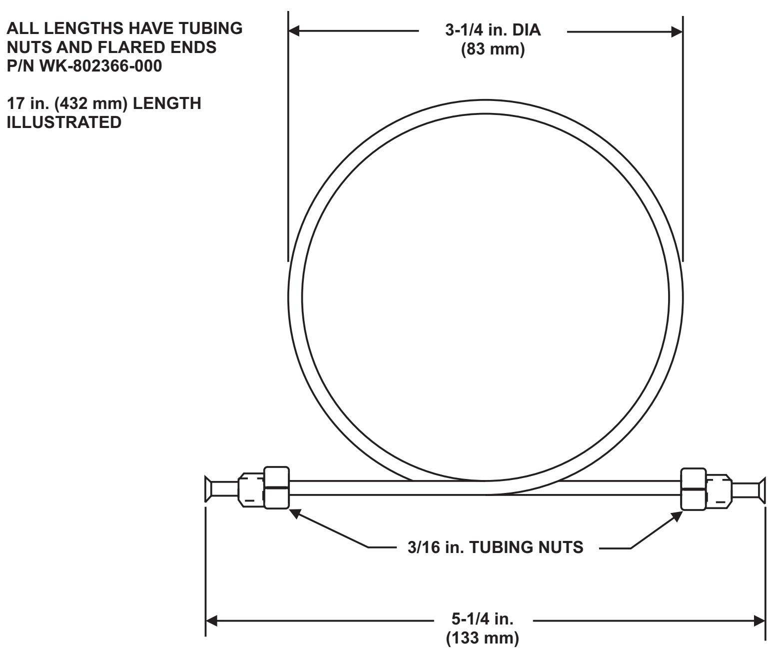


Figure 2-41. 3/16-inch Pneumatic Tubing

2-3.7 Pressure Operated Control Heads

Pressure operated control heads utilize the pressure from either a CO_2 or nitrogen cylinder to actuate CO_2 cylinder valves or directional (stop) valves.

2-3.7.1 PRESSURE OPERATED CONTROL HEAD

This control head, Part No. 82-878737-000 (Figure 2-42), consists of a spring-loaded piston-and-stem assembly housed in a brass body. The body has a threaded inlet port that connects to the pressure line, and a swivel nut for connection to a control port. The supplied pressure actuates the spring-loaded piston-and-stem assembly to engage the pilot check of the control port to which it is connected.

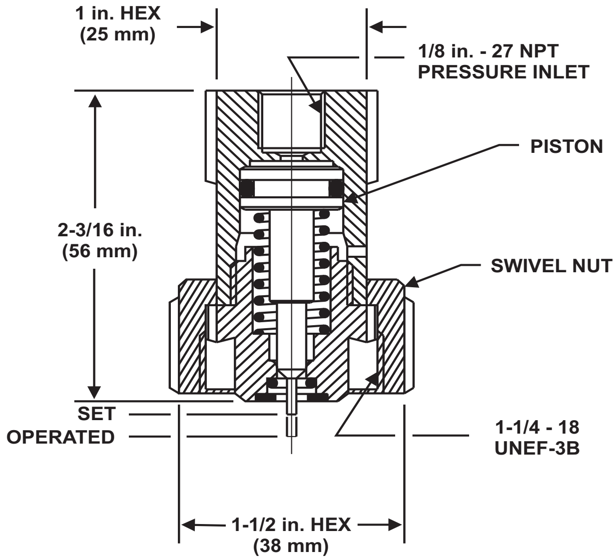


Figure 2-42. Pressure Operated Control Head

2-3.7.2 LEVER AND PRESSURE OPERATED CONTROL HEAD

The lever and pressure operated control head, Part No. 82-878751-000 (Figure 2-43), consists of a spring-loaded piston-and-stem assembly housed in a brass body, and a lever for emergency manual operation. The body has a threaded inlet port that connects to the pressure line and a swivel nut for connection to a control port. The supplied pressure, or manual operation of the lever, actuates the spring-loaded piston-and-stem assembly to engage the pilot check of the control port to which it is connected.

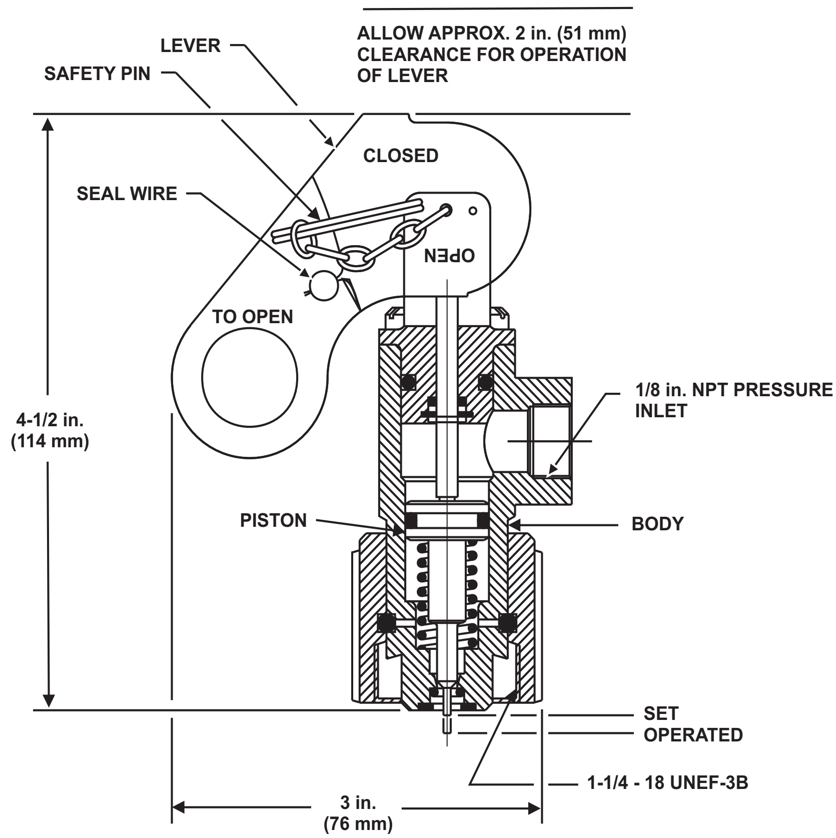


Figure 2-43. Lever and Pressure Operated Control Head

2-3.7.3 STACKABLE PRESSURE OPERATED CONTROL HEAD

The stackable pressure operated control head, Part No. 82-878750-000 (Figure 2-44), is similar in design and construction to the lever and pressure operated control head. It offers a stackable design and is used where a cable operated or electric/mechanical control head is also required.

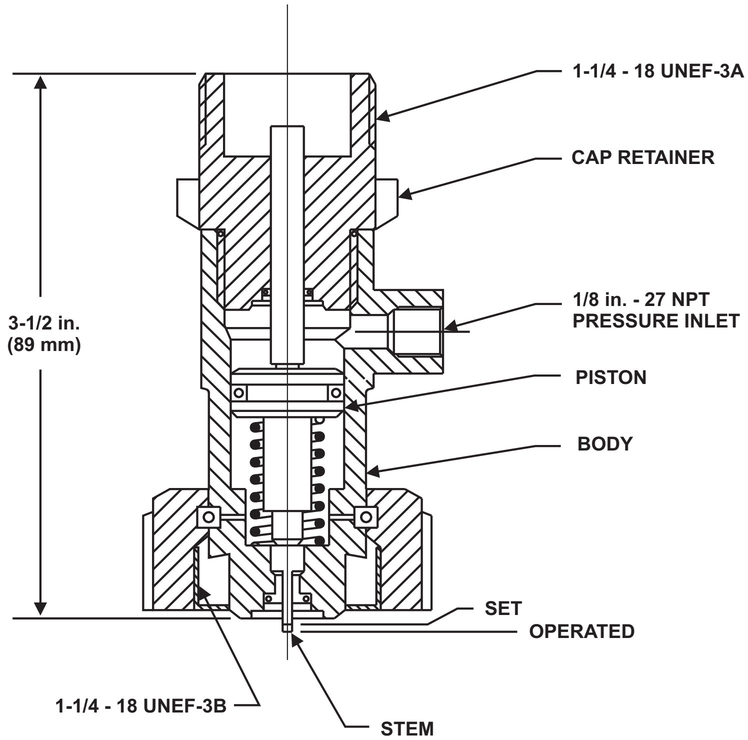


Figure 2-44. Stackable Pressure Operated Control Head

2-3.8 Components for Pressure Operated Actuation Systems

2-3.8.1 NITROGEN PILOT CYLINDER AND BRACKET

Nitrogen pilot cylinders supply pressure to operate (via pressure operated control heads) CO_2 pilot cylinders, stop valves, N_2 discharge delays or N_2 pressure operated sirens. Three different sized cylinder capacities are provided for use with CO_2 systems. Each cylinder is of steel material and designed in accordance with USDOT and TC requirements. Each cylinder is factory pressurized to 1800-psig @ 70F and fitted with a pressure gauge and pressure relief device. Either pipe, tube or flexible hose connects each pilot cylinder to the pressure operated control head(s).

2-3.8.1.1 Nitrogen Pilot Cylinder, 108 cu. in.

The 108 cu. in. N_2 Pilot Cylinder (P/N WK-877940-000) can be used to operate CO_2 pilot cylinders, stop valves, a N_2 discharge delay or a N_2 pressure operated siren. Any compatible control head can be fitted to the cylinder to provide the desired means of operation. The cylinder valve has a 1/8-in NPT outlet. Any of the 1/8-in NPT x 5/16-in flare fittings can be used to connect the valve to the corresponding actuation line. The cylinder is secured using the wall mount bracket (P/N 81-87745-000).

2-3.8.1.2 Nitrogen Pilot Cylinder, 1040 cu. in.

The 1040 cu. in. N_2 Pilot Cylinder (P/N 90-101040-001) can be used to operate CO_2 pilot cylinders, stop valves or multiple N_2 pressure operated sirens. Any compatible control head can be fitted to the cylinder to provide the desired means of operation. The cylinder has a 5/8-in Type "I" style valve affixed with a pressure gauge. In addition to the control head, this valve requires attachment of a discharge head to allow discharge of the cylinder contents. The ½-in NPT N_2 discharge hose (P/N 06-118207-00X) connects the discharge head to the corresponding actuation line. The cylinder is secured using the single cylinder strap (P/N WK-270014-000). Approved for use in environments from 32°F to 130°F.

2-3.8.1.3 Nitrogen Pilot Cylinder, 2300 cu. in.

The 2300 cu. in. N_2 Pilot Cylinder (P/N 90-102300-001) can be used to operate CO_2 pilot cylinders, stop valves or multiple N_2 pressure operated sirens. Any compatible control head can be fitted to the cylinder to provide the desired means of operation. The cylinder has a 5/8-in Type "I" style valve affixed with a pressure gauge. In addition to the control head, this valve requires attachment of a discharge head to allow discharge of the cylinder contents. The ½-in NPT N_2 discharge hose (P/N 06-118207-00X) connects the discharge head to the corresponding actuation line. The cylinder is secured using the single cylinder strap (P/N WK-270014-000) or the dual cylinder strap (P/N WK-241219-000). Approved for use in environments from 32°F to 130°F.

2-3.8.2 ACTUATION HOSE

The actuation hose (Figure 2-45), is used to connect a pilot cylinder to pressure operated control heads or actuation tubing. The 1/4-inch flexible hose is constructed with wire-braided reinforcements and swivel nuts at both ends for ease of assembly. The hose is available in two lengths as shown in Table 2-16.

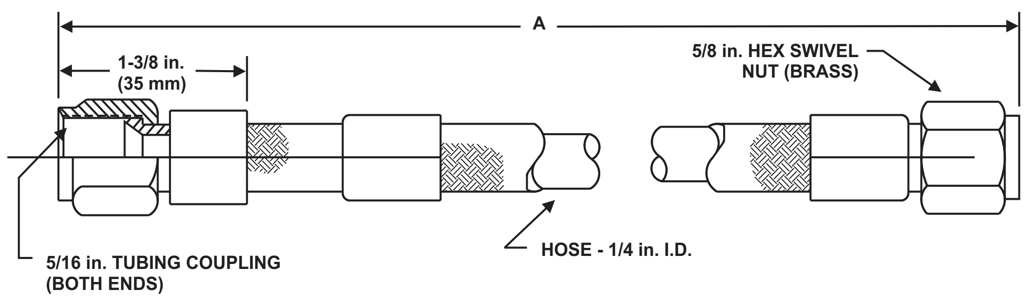


Figure 2-45. 1/4-inch Actuation Hose

Table 2-16. 1/4-inch Actuation Hose Part Numbers

Part Number	Dimension "A"
WK-264986-000	30
WK-264987-000	22

2-3.8.3 FITTINGS

Fittings (Figure 2-46) are available to interconnect the actuation hose to the pressure operated control head(s) or actuation tubing.

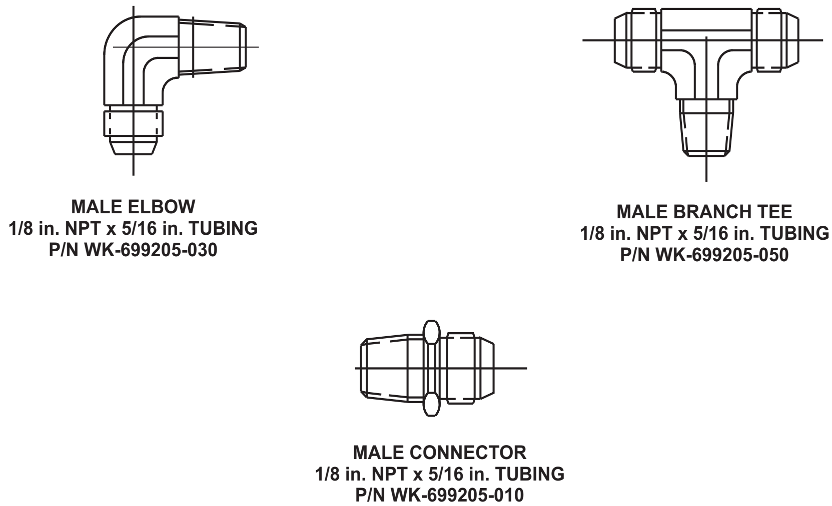


Figure 2-46. Fittings

2-4 CHECK VALVES

Check valves are required for fire suppression systems that are equipped with a main and reserve set of carbon dioxide cylinders. They are installed in each discharge manifold to isolate the main and reserve cylinders from each other.

Check valves are also employed in directional valve systems that use a common set of carbon dioxide cylinders to protect areas or equipment of unequal sizes. The check valves divide the cylinder group into subsets for discharge of the required amounts of carbon dioxide into the protected areas or equipment.

2-4.1 Check Valves (1/4-inch through 3/8-inch)

The 1/4-inch and 3/8-inch check valves (Figure 2-47) are also used in Nitrogen or CO_2 pilot lines; part numbers and dimensions are provided in Table 2-17.

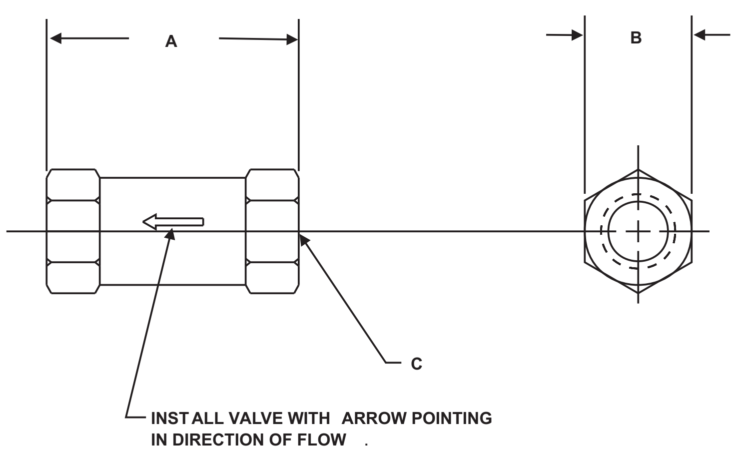


Figure 2-47. Check Valves (1/4-inch and 3/8-inch)

Table 2-17. Check Valve Dimensions (1/4-inch through 3/8-inch)

Part Number	Valve Size	Pipe Thread "C"	"A"		"B"	
			in.	mm	in.	mm
WK-264985-000	1/4 in.	1/4 in. - 18 NPT	2.00	51	0.81	21
WK-261193-000	3/8 in.	3/8 in. - 18 NPT	2.35	60	1.00	25

2-4.2 Check Valves (1/2-inch through 2-inch)

The 1/2-inch through 1 1/4-inch check valves (Figure 2-48) are in-line valves and consist of a threaded brass body which houses a spring loaded piston; part numbers and dimensions are provided in Table 2-18. The piston permits flow through the valve in one direction only.

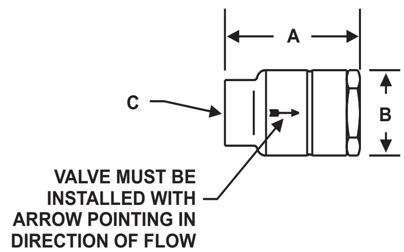


Figure 2-48. Check Valves (1/2-inch to 1-1/4-inch)

Table 2-18. Check Valve Dimensions (1/2-inch through 1-1/4-inch)

Part Number	Valve Size	Pipe Thread "C"	"A"		"B"	
			in.	mm	in.	mm
81-800327-000	1/2 in.	1/2 in. - 14 NPT	3.34	85	2	51
81-800266-000	3/4 in.	3/4 in. - 14 NPT	3.34	85	2	51
WK-800443-000	1 in.	1 in. - 11.5 NPT	3.97	101	3.18	81
81-800444-000	1-1/4 in.	1-1/4 in. - 11.5 NPT	3.97	101	3.18	81

The 1-1/2-inch and 2-inch check valves (Figure 2-49) consist of a brass body which houses a spring loaded stop check; part numbers and dimensions are provided in Table 2-19. The stop check permits flow in one direction only.

These valves are fitted with threaded inlet and outlet ports.

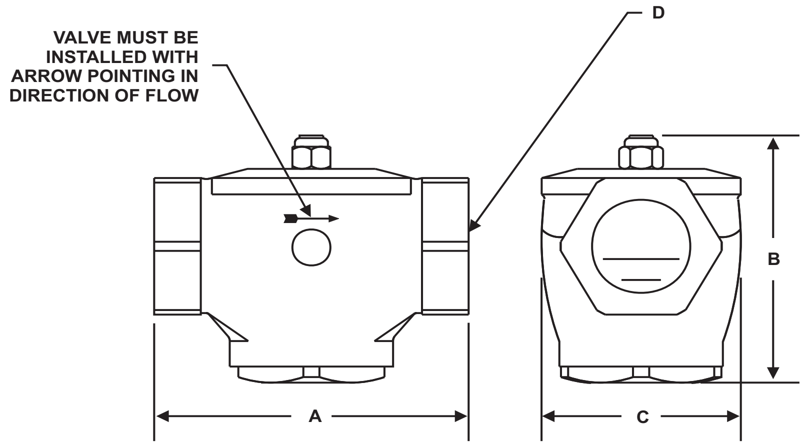


Figure 2-49. Check Valves (1-1/2-inch to 2-inch)

Table 2-19. Check Valve Dimensions (1-1/2-inch through 2-inch)

Part Number	Valve Size	Pipe Thread "D"	"A"		"B"		"C"	
			in.	mm	in.	mm	in.	mm
81-870152-000	1-1/2 in.	1-1/2 in. - 11.5 NPT	7.50	151	6.28	160	4.75	121
81-870151-000	2 in.	2 in. - 11.5 NPT	7.50	151	6.28	160	4.75	121

2-4.3 Check Valves (2 1/2-inch through 3-inch)

The 3-inch check valve, Part No. 81-870100-000 (Figure 2-50) is similar in construction and operation to the 1 1/2-inch and 2-inch check valves.

This valve has flanged inlet and outlet ports and requires two appropriately sized welding neck flanges and gaskets for connection to either 2 1/2-inch or 3-inch distribution piping.

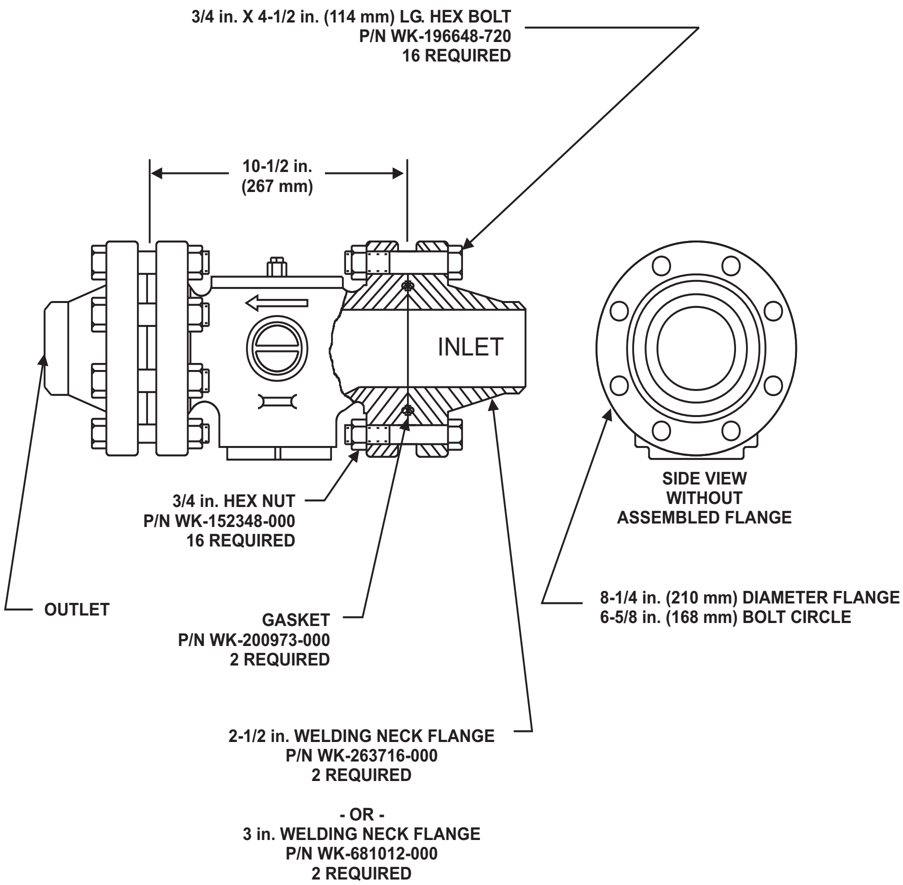


Figure 2-50. Check Valves (2 1/2-inch to 3-inch)

2-4.3.1 2 1/2-INCH WELDING NECK FLANGE

The 2 1/2-inch welding neck flange, Part No. WK-263716-000 (Figure 2-50), is required to attach the 3-inch check valve to 2 1/2-inch distribution piping. Two flanges are required per valve.

2-4.3.2 3-INCH WELDING NECK FLANGE

The 3-inch welding neck flange, Part No. WK-681012-000 (Figure 2-50), is required to attach the 3-inch check valve to 3-inch distribution piping. Two flanges are required per valve.

2-4.3.3 3-INCH FLANGE GASKET

The 3-inch flange gasket, Part No. WK-200973-000 (Figure 2-50) is required to seal the connection between the 3-inch check valve and either the 2 1/2-inch or 3-inch welding neck flange. Two gaskets are required per valve.

2-4.3.4 NUTS AND BOLTS

3/4-inch hex nuts, Part No. WK-152308-000 (Figure 2-50), and 3/4-inch by 4 1/2-inch long bolts, Part No. WK-196648-720 (Figure 2-50), are required to connect the 2 1/2-inch or 3-inch welding neck flanges to the 3-inch check valve. A total of 16 nuts and bolts are required per check valve.

2-5 DIRECTIONAL (STOP) VALVES

Directional (stop) valves find two primary applications in carbon dioxide systems. The first application is in multi-hazard systems which share a common carbon dioxide suppression system. Directional valves are used to route the carbon dioxide from the shared supply to the individual areas or equipment being protected.

The second application for these valves is as a life safety device to prevent the accidental discharge of carbon dioxide into a normally-occupied area. The stop valve prevents the flow of carbon dioxide until the attached control head is operated.

All Kidde Fire Systems directional (stop) valves operate on a differential-pressure principle, utilizing the pressure of the discharging carbon dioxide to open the stop check and allow flow through the valve. All valves automatically reset (close) after discharge is completed.

CAUTION **Directional (stop) valves do NOT prevent flow in the direction opposite the arrow.**

CAUTION **All control heads must be in the set position before attaching to the directional (stop) valves, in order to prevent accidental CO_2 discharge.**

2-5.1 Directional (Stop) Valves (1/2-inch through 2-inch)

The 1/2-inch through 2-inch size directional valves (Figure 2-51) have bronze bodies which house a stop check and an actuating piston, along with an external port for attachment of a control head (part numbers and dimensions are provided in Table 2-20). Actuation of a control head allows the discharged carbon dioxide to apply pressure to the actuating piston to open the stop check.

These directional valves have threaded inlet and outlet ports for connection to the distribution piping.

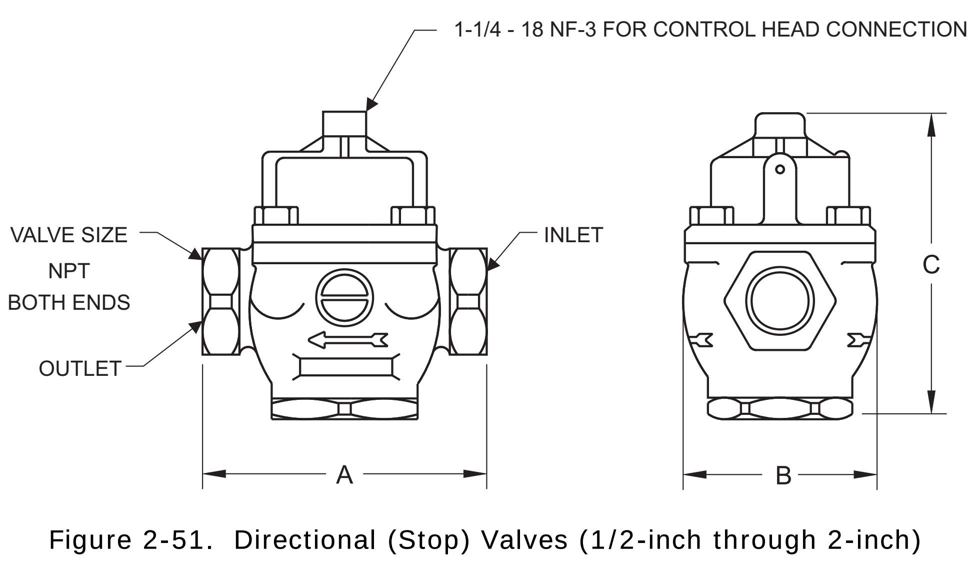


Figure 2-51. Directional (Stop) Valves (1/2-inch through 2-inch)

Table 2-20. Check Valve Dimensions (1 1/2-inch through 2-inch)

Part Number	Valve Size	Pipe Thread "D"	"A"		"B"		"C"	
			in.	mm	in.	mm	in.	mm
81-870023-000	1/2 in.	1/2 in. - 14 NPT	3.75	95	2.50	64	4.68	119
81-870022-000	3/4 in.	3/4 in. - 14 NPT	4.25	108	2.81	71	5.68	144
81-870122-000	1 in.	1 in. - 11.5 NPT	5.50	140	3.62	92	6.87	175
81-870032-000	1-1/4 in.	1-1/4 in. - 11.5 NPT	5.50	140	3.62	92	6.87	175
81-800123-000	1-1/2 in.	1-1/2 in. - 11.5 NPT	7.50	191	4.75	121	8.43	214
81-800049-000	2 in.	2 in. - 11.5 NPT	7.50	191	4.75	121	8.43	214

2-5.2 Directional (Stop) Valves (2 1/2-inch through 4-inch)

The 3-inch and 4-inch directional valves, Part Nos. 81-890010-000 and 81-890208-000 respectively (Figure 2-52 and Figure 2-53), are similar in construction and operation as the 1/2-inch through 2-inch size directional valves. These valves have flanged inlet and outlet ports and require two appropriately-sized flanges and gaskets for connection to the distribution piping.

2-5.2.1 2 1/2-INCH AND 3-INCH VALVES

For the 3-inch valve, Part No. 81-890010-000 (Figure 2-52), see Paragraph 2-4.3.1 through Paragraph 2-4.3.4 for descriptions of the components required for connection to 2 1/2-inch and 3-inch piping.

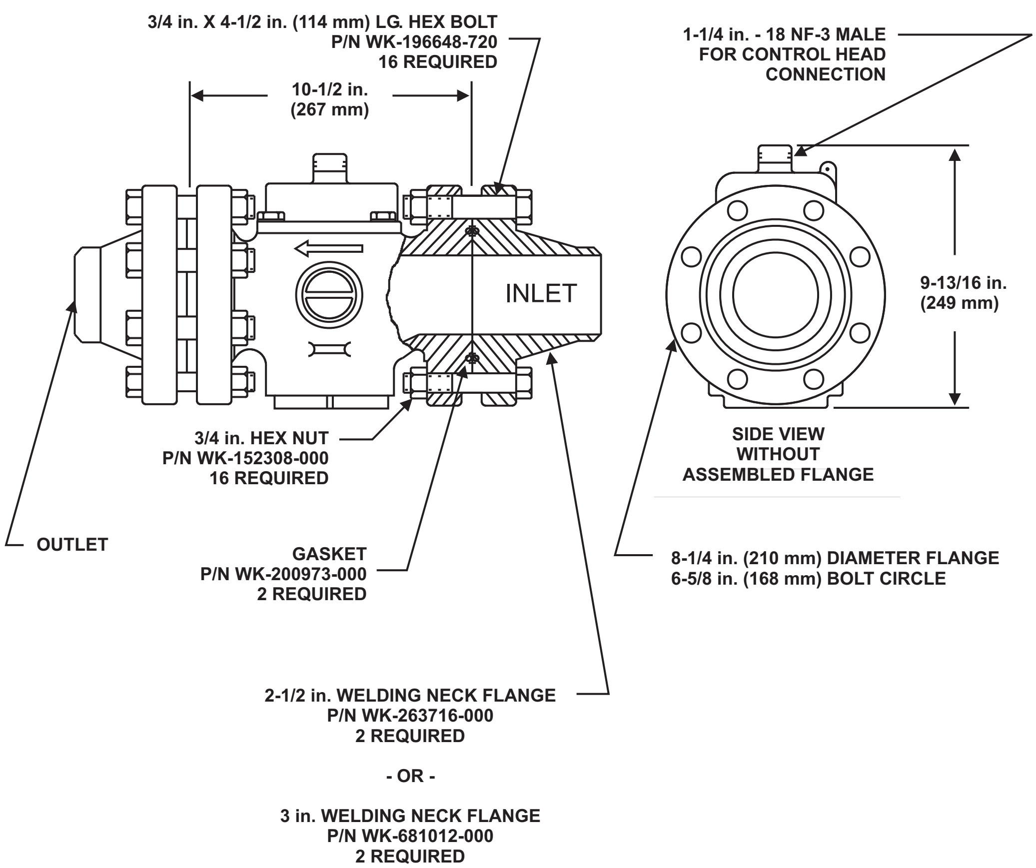


Figure 2-52. Directional (Stop) Valves (2-1/2-inch and 3-inch)

2-5.2.2 4-INCH VALVE

The 4-inch valve, Part No. 81-890208-000 (Figure 2-53), has flanged inlet and outlet ports that require the flanges, gaskets and fasteners described in Paragraph 2-5.2.3, Paragraph 2-5.2.4 and Paragraph 2-5.2.5 for connection to the distribution piping.

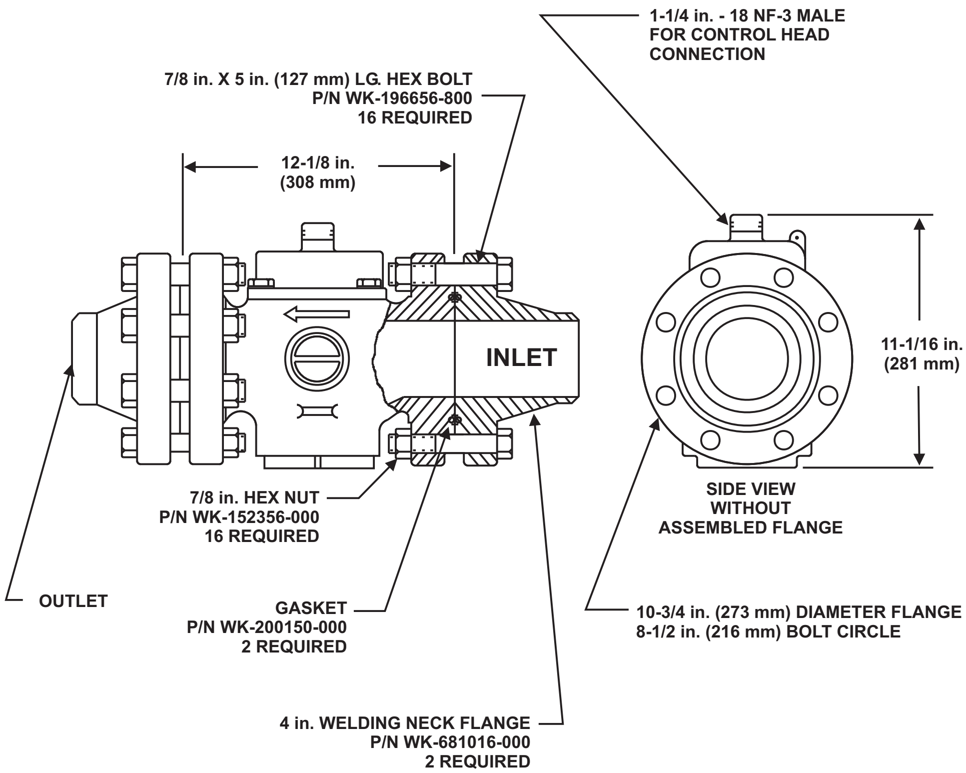


Figure 2-53. Directional (Stop) Valve (4-inch)

The 4-inch valve has flanged inlet and outlet ports that require the following flanges, gaskets and fasteners for connection to the distribution piping.

2-5.2.3 4-INCH FLANGE

The 4-inch welding neck flange, Part No. WK-681016-000 (Figure 2-53), is required to attach the 4-inch directional (or stop) valve to 4-inch distribution piping. Two flanges are required per valve.

2-5.2.4 4-INCH GASKET

The 4-inch flange gasket, Part No. WK-200150-000 (Figure 2-53), is required to seal the connection between the 4-inch directional valve and the 4-inch welding neck flange. Two gaskets are required per valve.

2-5.2.5 NUTS AND BOLTS

7/8-inch hex nuts, Part No WK-152356-000 (Figure 2-53), and 7/8-inch by 5-inch long bolts, Part No. WK-196656-800 (Figure 2-53), are required to connect the 4-inch welding neck flanges to the 4-inch directional valve. A total of 16 nuts and bolts are required per valve.

2-6 LOCKOUT VALVES

A lockout valve is a manually operated valve installed between the CO_2 manifold and the discharge pipe to the protected area. The lockout valve can be locked in the closed position to prevent carbon dioxide from discharging into the protected area. The lockout valve shall be installed at the end of the CO_2 manifold or, if a common manifold protects multiple hazards, after each selector valve.

The lockout valve consists of a carbon steel or stainless steel valve with threaded ends. Either valve style can be provided with or without limit switches.

2-6.1 Lockout Valves without Limit Switches

The lockout valve without limit switches (Figure 2-54) is available in sizes 1/4” thru 2”. The part numbers and dimensions are provided in Table 2-21.

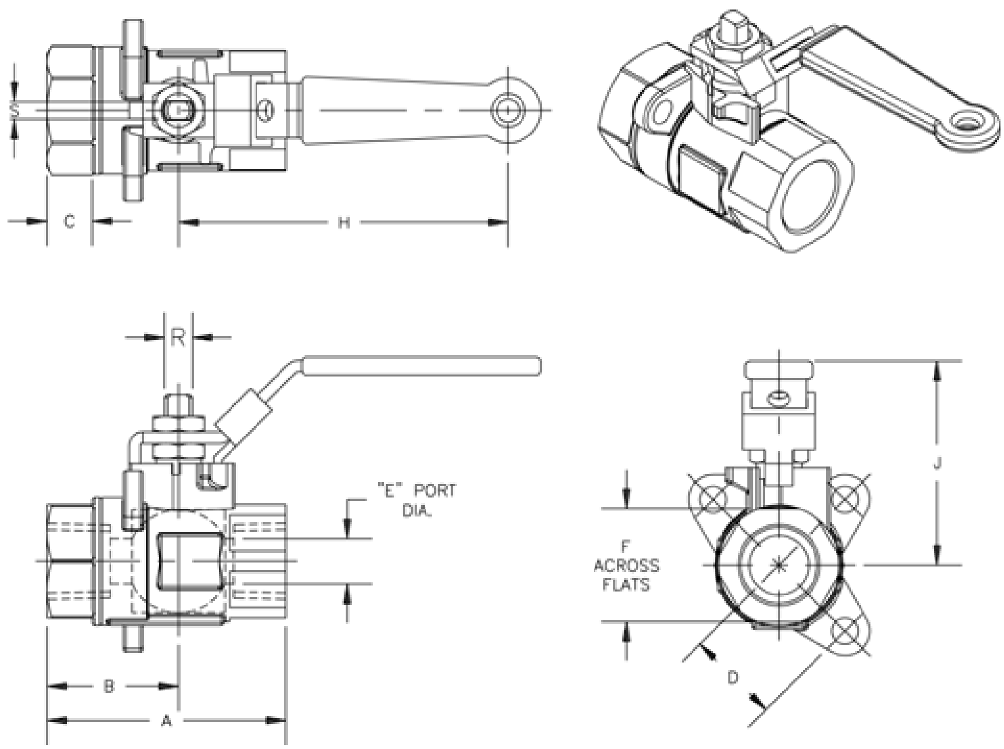


Figure 2-54. Lockout Valves without Limit Switches

Table 2-21. Carbon Steel Lockout Valves without Limit Switches Dimensions and Part Numbers

Valve Size	part number	Approximate Dimensions (inches)										Approx. WT (lb)	Valve Style
		A	B	C	D	E	F	H	J	R	S		
1/4”	10611105	2.73	1.55	0.50	1.03	0.50	1.25	4.00	2.26	0.31	0.19	1.1	Reduced Port
1/2”	70985075	2.73	1.55	0.50	1.03	0.50	1.25	4.00	2.26	0.31	0.19	1.1	Reduced Port
3/4”	70985076	3.50	1.92	0.50	1.38	0.88	1.63	5.50	3.10	0.50	0.31	2.7	Full Port
1”	70985077	3.60	1.92	0.50	1.38	0.88	1.75	5.50	3.10	0.50	0.31	2.8	Reduced Port
1 1/4”	70985078	3.93	2.10	0.56	1.63	1.00	2.00	5.50	3.23	0.50	0.31	3.7	Reduced Port
1 1/2”	70985079	4.55	2.47	0.75	1.88	1.25	2.38	7.00	3.93	0.63	0.38	5.0	Reduced Port
2”	70985080	4.94	2.66	0.75	2.12	1.50	2.88	7.00	4.12	0.63	0.38	6.8	Reduced Port

Table 2-22. Stainless Steel Lockout Valves without Limit Switches Dimensions and Part Numbers

Valve Size	part number	Approximate Dimensions (inches)										Approx. WT (lb)	Valve Style
		A	B	C	D	E	F	H	J	R	S		
1/4”	10611104	2.73	1.55	0.50	1.03	0.50	1.25	4.00	2.26	0.31	0.19	1.1	Reduced Port
1/2”	10611100	2.73	1.55	0.50	1.03	0.50	1.25	4.00	2.26	0.31	0.19	1.1	Reduced Port
3/4”	10611101	3.50	1.92	0.50	1.38	0.88	1.63	5.50	3.10	0.50	0.31	2.7	Full Port
1”	10611099	3.60	1.92	0.50	1.38	0.88	1.75	5.50	3.10	0.50	0.31	2.8	Reduced Port
1 1/4”	10611102	3.93	2.10	0.56	1.63	1.00	2.00	5.50	3.23	0.50	0.31	3.7	Reduced Port
1 1/2”	10611098	4.55	2.47	0.75	1.88	1.25	2.38	7.00	3.93	0.63	0.38	5.0	Reduced Port
2”	10611103	4.94	2.66	0.75	2.12	1.50	2.88	7.00	4.12	0.63	0.38	6.8	Reduced Port

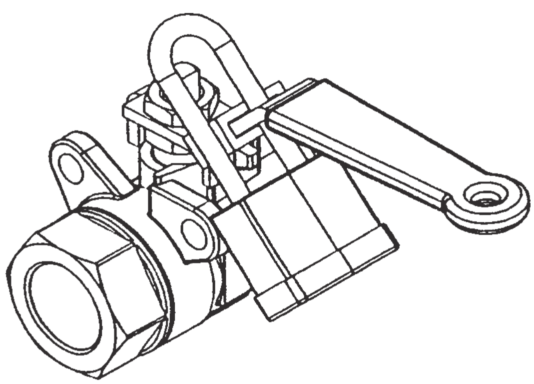


Figure 2-55. Lockout Valves with Lock

2-6.2 Lockout Valves with Limit Switches

The lockout valve with 2 SPDT limit switches and indicator(Figure 2-56) is available in sizes 1/4" thru 2". The part numbers and dimensions are provided in Table 2-23.

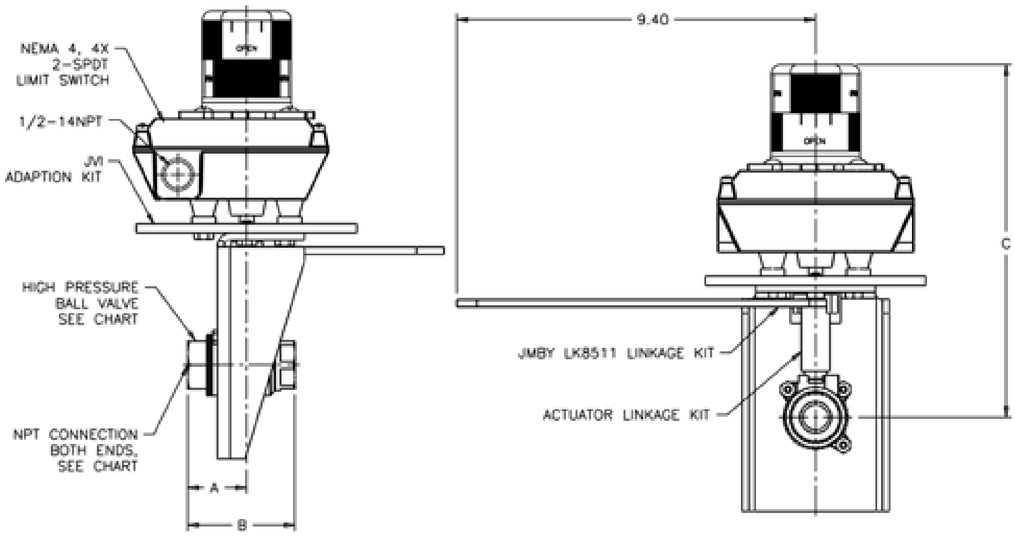


Figure 2-56. Lockout Valves with Limit Switches

Table 2-23. Carbon Steel Lockout Valves with Limit Switches Dimensions and Part Numbers

Valve Size	ASSY P/N	Ball Valve P/N	Dimensions			Approx. WT (lb)
			A	B	C	
1/4"	70985018	10611105	1.55	2.73	9.25	7
1/2"	70985020	70985075	1.55	2.73	9.25	7
3/4"	70985021	70985076	1.92	3.50	9.25	8
1"	70985022	70985077	1.92	3.60	9.25	9
1 1/4"	70985023	70985078	2.10	3.93	9.85	10
1 1/2"	70985024	70985079	2.47	4.55	10.05	12
2"	70985025	70985080	2.66	4.94	10.25	12

Table 2-24. Stainless Steel Lockout Valves with Limit Switches Dimensions and Part Numbers

Valve Size	ASSY P/N	Ball Valve P/N	Dimensions			Approx. WT (lb)
			A	B	C	
1/4"	10611106	10611004	1.55	2.73	9.25	7
1/2"	10611107	10611100	1.55	2.73	9.25	7
3/4"	10611108	10611101	1.92	3.50	9.25	8
1"	10611109	10611099	1.92	3.60	9.25	9
1 1/4"	10611110	10611102	2.10	3.93	9.85	10
1 1/2"	10611111	10611098	2.47	4.55	10.05	12
2"	10611112	10611103	2.66	4.94	10.25	12

2-6.3 Lockout Valve with Explosion Proof Limit Switches

The lockout valve with 2 SPDT explosion proof limit switches and indicator(Figure 2-57) is available in sizes 1/4” thru 2”. The part numbers and dimensions are provided in Table 2-25.

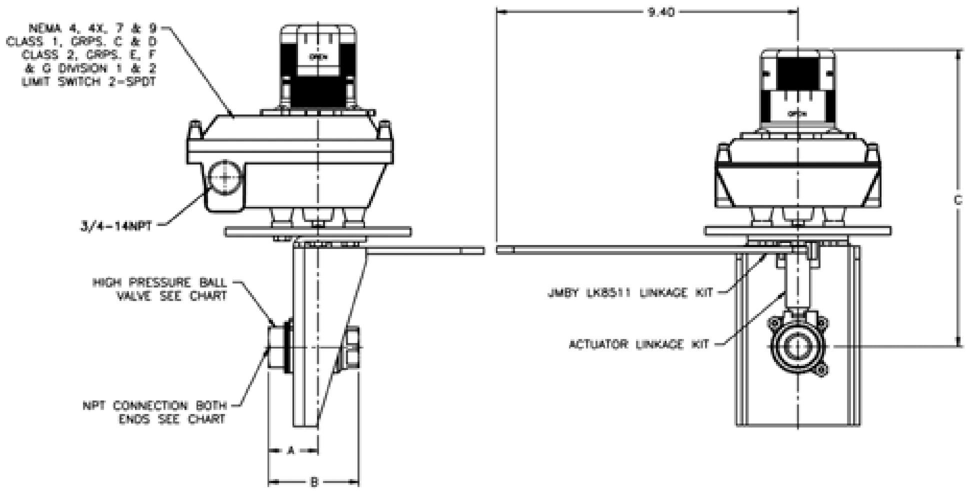


Figure 2-57. Lockout Valve with Explosion Proof Limit Switches

Table 2-25. Carbon Steel Lockout Valve with Explosion Proof Limit Switches Dimensions and Part Numbers

Valve Size	ASSY P/N	Ball Valve P/N	Dimensions			Approx. WT (lb)
			A	B	C	
1/4”	70985090	10611105	1.55	2.73	9.25	7
1/2”	70985069	70985075	1.55	2.73	9.25	7
3/4”	70985070	70985076	1.92	3.50	9.25	8
1”	70985071	70985077	1.92	3.60	9.25	9
1 1/4”	70985072	70985078	2.10	3.93	9.85	10
1 1/2”	70985073	70985079	2.47	4.55	10.05	12
2”	70985074	70985080	2.66	4.94	10.25	12

Table 2-26. Stainless Steel Lockout Valve with Explosion Proof Limit Switches Dimensions and Part Numbers

Valve Size	ASSY P/N	Ball Valve P/N	Dimensions			Approx. WT (lb)
			A	B	C	
1/4”	10611113	10611004	1.55	2.73	9.25	7
1/2”	10611114	10611100	1.55	2.73	9.25	7
3/4”	10611115	10611101	1.92	3.50	9.25	8
1”	10611116	10611099	1.92	3.60	9.25	9
1 1/4”	10611117	10611102	2.10	3.93	9.85	10
1 1/2”	10611118	10611098	2.47	4.55	10.05	12
2”	10611119	10611103	2.66	4.94	10.25	12

2-6.4 CO2 System Lockout Valve Operational Sign

An operational sign, P/N 06-231867-379, may be installed with all lockout valves to provide operational instructions for the lockout valve. The sign is 9” x 5”, made of Aluminium.

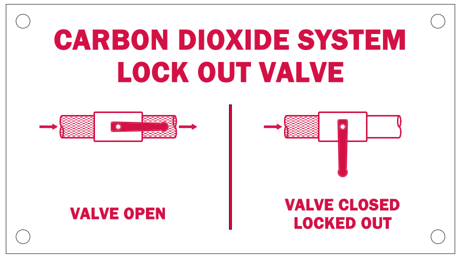


Figure 2-58. CO2 System Lockout Valve Operational Sign

2-7 DISCHARGE NOZZLES

Discharge nozzles control the distribution of carbon dioxide into the protected area or onto the protected equipment (or process). Kidde Fire Systems discharge nozzles are designed to provide the proper combination of flow rate and discharge pattern to protect vital equipment in a total-flooding manner or on a local application basis.

Kidde Fire Systems discharge nozzles are marked to identify the nozzle and show the nozzle's equivalent single orifice diameter. The equivalent diameter refers to the orifice diameter of a "standard" single orifice type nozzle having the same flow rate as the Kidde Fire Systems nozzle.

The orifice code numbers indicate the equivalent single-orifice diameter in 1/32-inch increments. A plus (+) symbol is used to indicate a 1/64-inch increment.

2-7.1 Multijet Nozzle, Type S

The type S multijet nozzles (listed in Table 2-27) have a female 1/2-inch NPT inlet connection for attaching to the CO_2 distribution piping. Strainers are provided with nozzles having orifice code numbers from 2 to 5+.

Type S nozzle sizes and styles are summarized in Table 2-27.

Table 2-27. Type S Nozzles

Orifice Code No.	S	S-Zinc	S-Flanged
2	803381	803897	802990
2+	803365	803881	802974
3	803366	803882	802975
3+	803367	803883	802976
4	803368	803884	802977
4+	803369	803885	802978
5	803370	803886	802979
5+	803371	803887	802980
6	803372	803888	802981
6+	803373	803889	802982
7	803374	803890	802983
7+	803375	803891	802984
8	803376	803892	802985
8+	803377	803893	802986
9	803378	803894	802987
9+	803379	803895	802988
10	803380	803896	802989

The basic type S nozzle (Figure 2-59) has a red painted cold-rolled steel body. A zinc plated finish is available as an option. (previous versions were offered with a cadmium plating.)

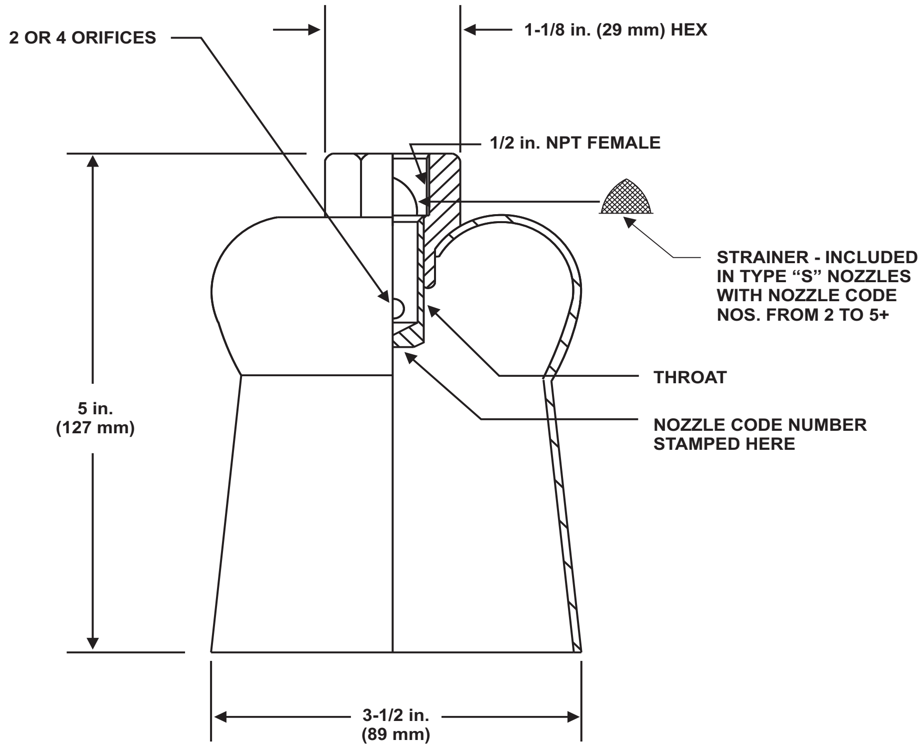


Figure 2-59. Multijet Nozzle, Type S

A flanged type S nozzle (Figure 2-60) and flanged mounting kit are also available for mounting the nozzle on the exterior of a duct or enclosure. The flanged mounting kit includes a frangible disc which ruptures upon discharge to allow flow from the nozzle. The flanged nozzle and mounting kit may be used to prevent particulate and liquid matter from clogging the orifices. The flanged nozzle body is painted red.

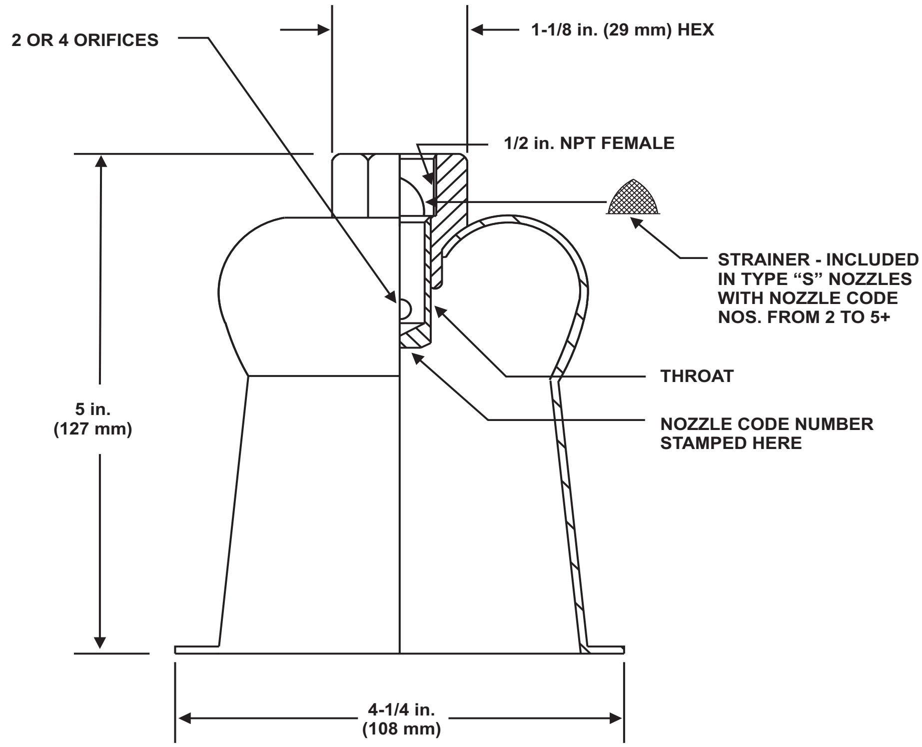


Figure 2-60. Multijet Nozzle, Type S Flanged

2-7.1.1 FLANGED NOZZLE MOUNTING KIT, TYPE S NOZZLE

The flanged mounting kit, Part No. 81-803330-000 (Figure 2-61, Figure 2-62 and Figure 2-63), contains two holding rings and a gasket (Part No. WK-201004-000) required to install a frangible disc on the S-nozzle outlet, or for installation of this nozzle to a duct or an enclosure.

Table 2-28. Flanged Nozzle Mounting Kit BOM

Description	Quantity
Disc, Aluminum, Part Number WK-310020-000	2
Gasket, Part Number WK-201004-000	1
Ring Tapped	1
Ring Holding	2
Bolt, 5/16 in. -18 x 1/2 in.	3
Flat Head Screw - 5/16 in. -18 x 7/8 in.	3
Lockwasher — 5/16 in.	6
Nut, Hex 5/16 in. -18	3

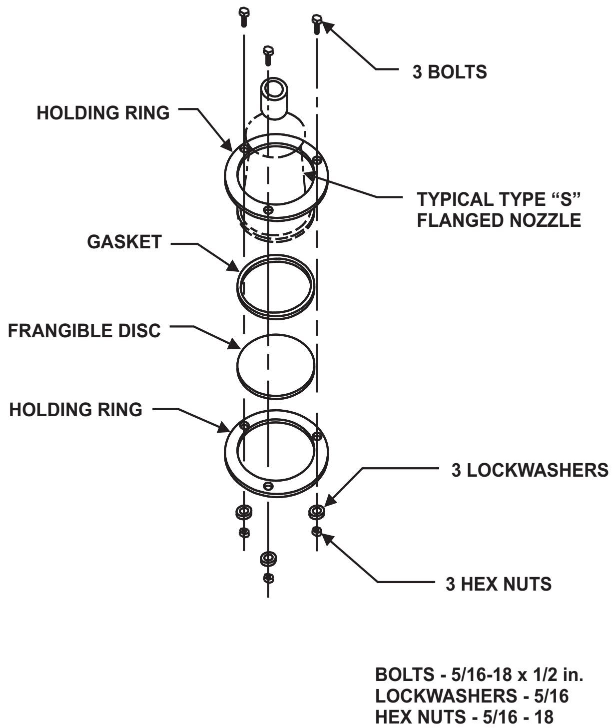


Figure 2-61. Flanged Nozzle Mounting Kit (Orifice Protection Only)

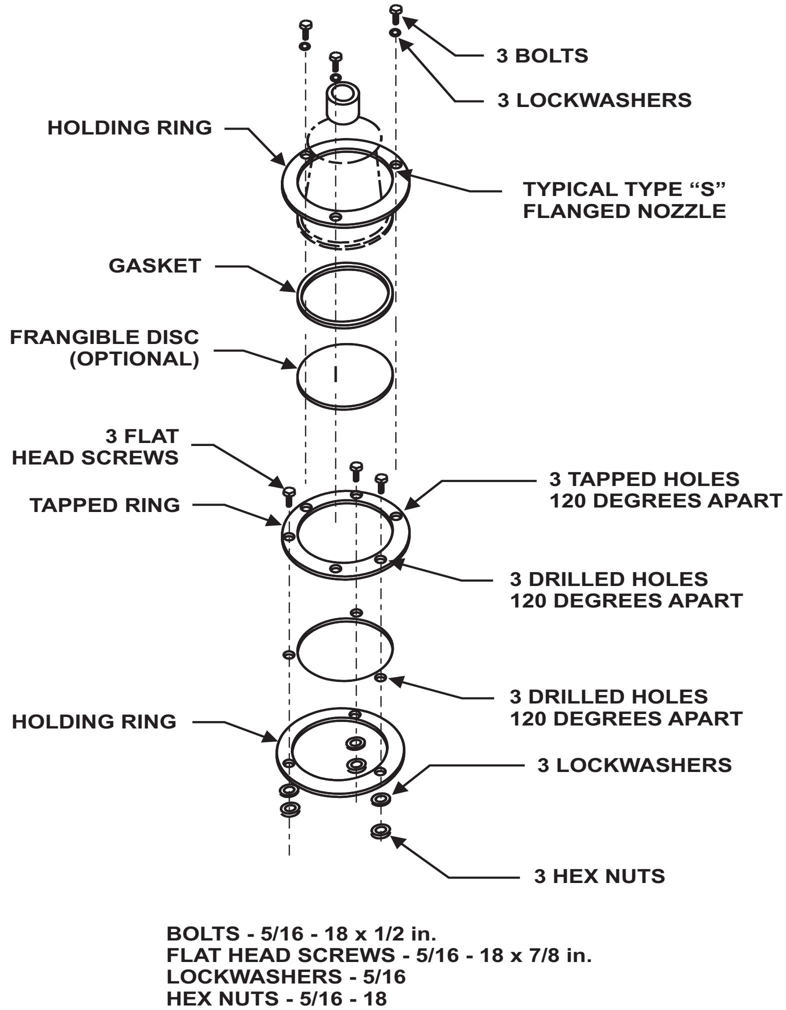


Figure 2-62. Flanged Nozzle Mounting Kit (Duct or Enclosure Mounting)

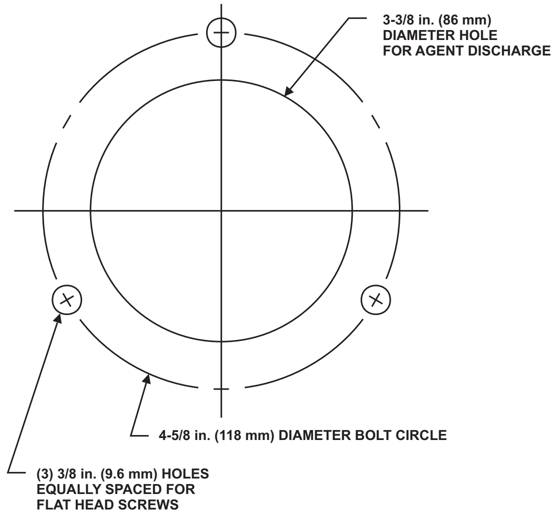


Figure 2-63. Flange Mounting Hole Pattern

2-7.1.2 ALUMINUM DISC

A frangible aluminum disc, Part No. WK-310020-000 (Figure 2-61 and Figure 2-62), is available to prevent the entry of particulate matter into a type S nozzle. This disk is included with the Flanged Nozzle Mounting Kit, Part No. 81-803330-000.

2-7.1.3 STAINLESS STEEL DISC

A frangible stainless steel disc, Part No. 81-220299-000 (Figure 2-61 and Figure 2-62), is available to prevent the entry of particulate matter into a type S nozzle.

2-7.2 Multijet Nozzle, Type M

The type M multijet nozzle (Figure 2-64) is similar in design and operation to the type S nozzle, and is used for applications requiring higher flow rates than those attainable with the type S nozzle. Strainers are provided with nozzles having orifice code numbers from 4 to 5+. The nozzle body is longer than the type S body in order to accommodate the higher flow rates. The type M nozzle has a red painted cold-rolled steel body. The Type M multijet nozzles have a 3/4 inch NPT inlet connection for attaching to the CO_2 distribution piping.

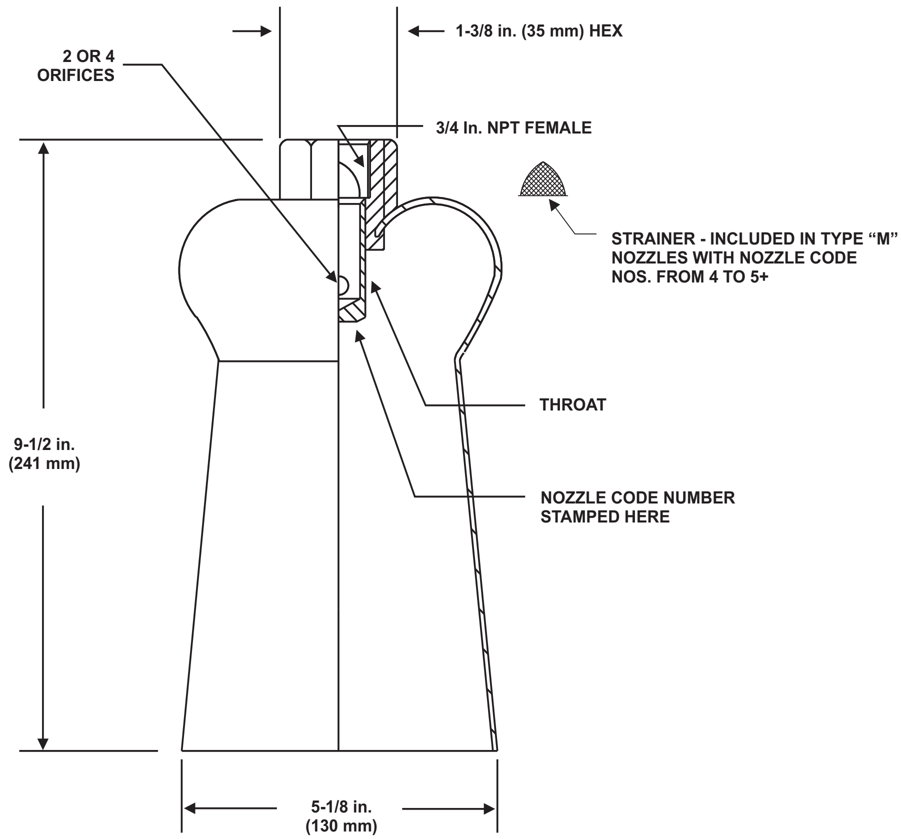


Figure 2-64. Multijet Nozzle, Type M

The type M nozzles are summarized in Table 2-29.

Table 2-29. Type M Nozzles

Size	Part Number
4	842319
4+	842320
5	842321
5+	842322
6	842323
6+	842324
7	842325
8	842326
9	842327
10	842328
11	842329
12	842330
13	842331
14	842332
15	842333

2-7.3 Vent Nozzle, Type V

The type V vent nozzle (Figure 2-65) is a single-orifice nozzle used to discharge a jet of carbon dioxide into an enclosure such as a duct. Strainers are provided with nozzles having orifice code numbers from 1 to 4+. The type V nozzles are only used for total flooding applications.

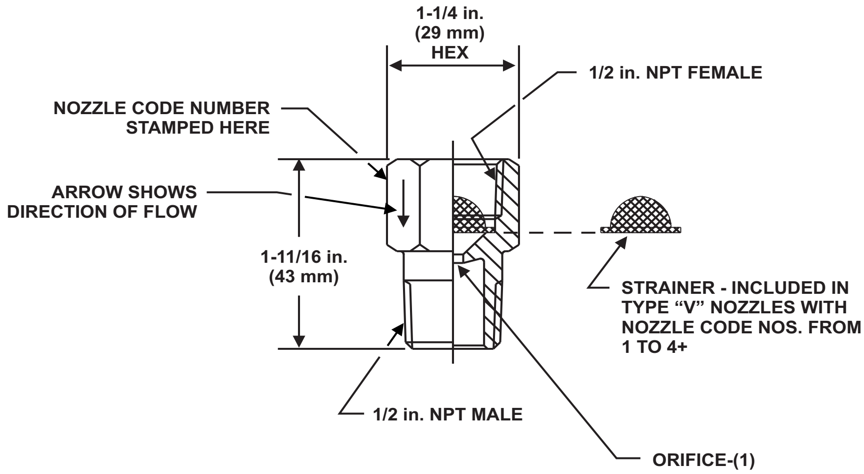


Figure 2-65. Vent Nozzle, Type V

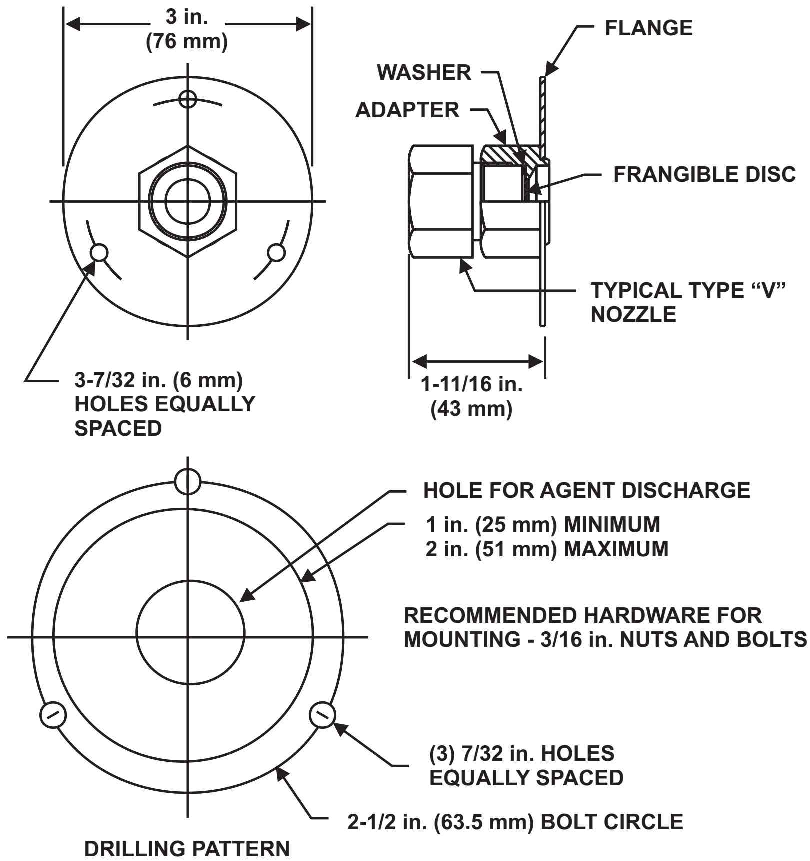
The sizes are summarized in Table 2-30.

Table 2-30. Type V Vent Nozzles

Orifice Code No.	V	V-Stainless
1	930066	81098656
1+	930067	81098657
2	919309	81098658
2+	803327	81098659
3	929242	81098660
3+	803328	81098661
4	915876	81098662
4+	803329	81098663
5	214721	81098664
5+	214722	81098665
6	214723	81098666
6+	214724	81098667
7	214725	81098668
7+	214726	81098669
8	214727	81098670
8+	214728	81098671
9	214729	81098672

2-7.3.1 FLANGE AND COVER ASSEMBLY, TYPE V NOZZLE

The flange and cover assembly, Part No. 81-844492-000 (Figure 2-66), contains a flanged adapter, a washer, and a frangible disc for the installation of a vent nozzle to a duct or an enclosure. The aluminum frangible disc is designed to prevent the entry of particulate matter into the vent nozzle's orifice. Both the frangible disc (Part No. WK-260885-000) and the washer (Part No. WK-260884-000) can be purchased separately.



NOTE: A FULL-SIZE TEMPLATE IS AVAILABLE ONLINE FROM KIDDE. REFERENCE DATASHEET K-81-1141

Figure 2-66. Flange and Cover Assembly, Type "V" Nozzle

2-7.4 Multijet Nozzle, Type L

The type L multijet nozzle (Figure 2-67) has a 1/2-inch NPT female connection for attaching to the CO_2 distribution piping. Strainers are provided with nozzles having orifice code numbers from 3+ to 5+.

The discharge produces a 180^{o} flat fan pattern that is highly effective for protection of dip tanks, drain boards and similar two dimensional hazards. The nozzle is attached to the side of a tank and offers no obstruction to overhead trolleys or dipping operations.

The type L nozzles are only used for local application systems.

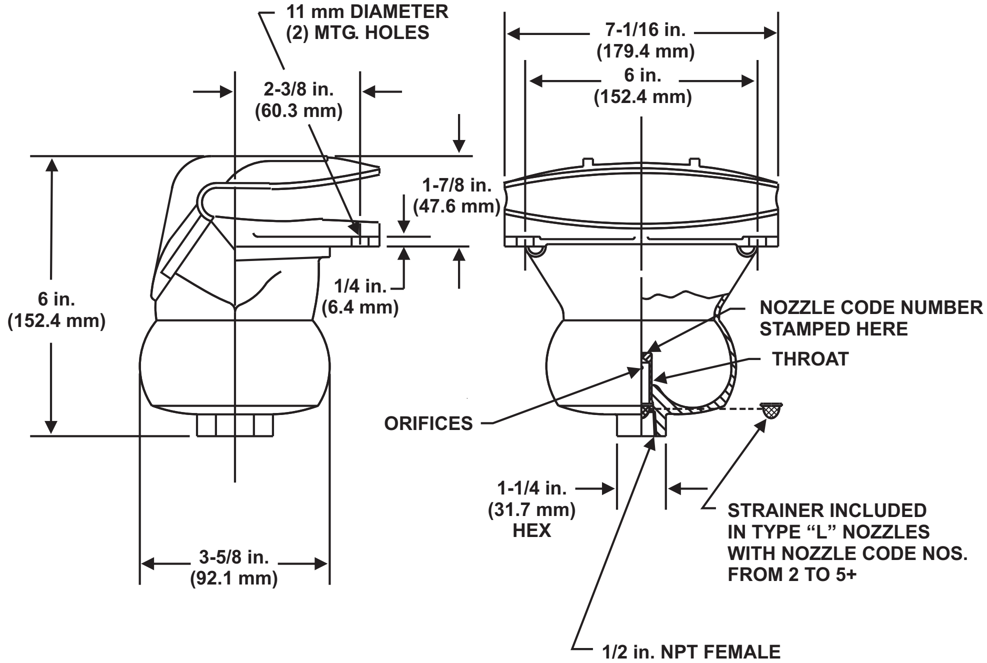


Figure 2-67. Multijet Nozzle, Type L

The sizes are summarized in Table 2-31.

Table 2-31. Type L Nozzles

Size	Part Number
3+	842334
4	842335
4+	842336
5	842337
5+	842338
6	842339
6+	842340
7	842341
7+	842342
8	842343
8+	842344
9	842345
9+	842346
10	842347

2-8 AUXILIARY EQUIPMENT

Auxiliary equipment consists of supplementary items required for a fully-functional carbon dioxide system, such as pressure switches and trips, pressure operated time delays, sirens, and warning and instruction plates.

2-8.1 Pressure Operated Switches

Pressure operated switches (Figure 2-68 and Figure 2-69) are connected to the distribution piping and utilize the pressure of the discharging carbon dioxide for activation. The carbon dioxide actuates a pressure operated stem which toggles the electrical switch. Each switch can also be operated manually by pulling up on the stem. These switches are used to enunciate alarms, to shut down ventilation and/or other electrical equipment and to turn on electrical automatic dampers or other electrical equipment. Each pressure switch must be manually reset, by pushing down on the stem to return the switch to the set position. The minimum operating pressure required is 50 PSI.

Pressure switches are available in standard (Part No. 81-486536-000) and explosion proof (Part No. 81-981332-000) models. The standard switch is three-pole, double-throw; the explosion proof switch is three-pole, single-throw.

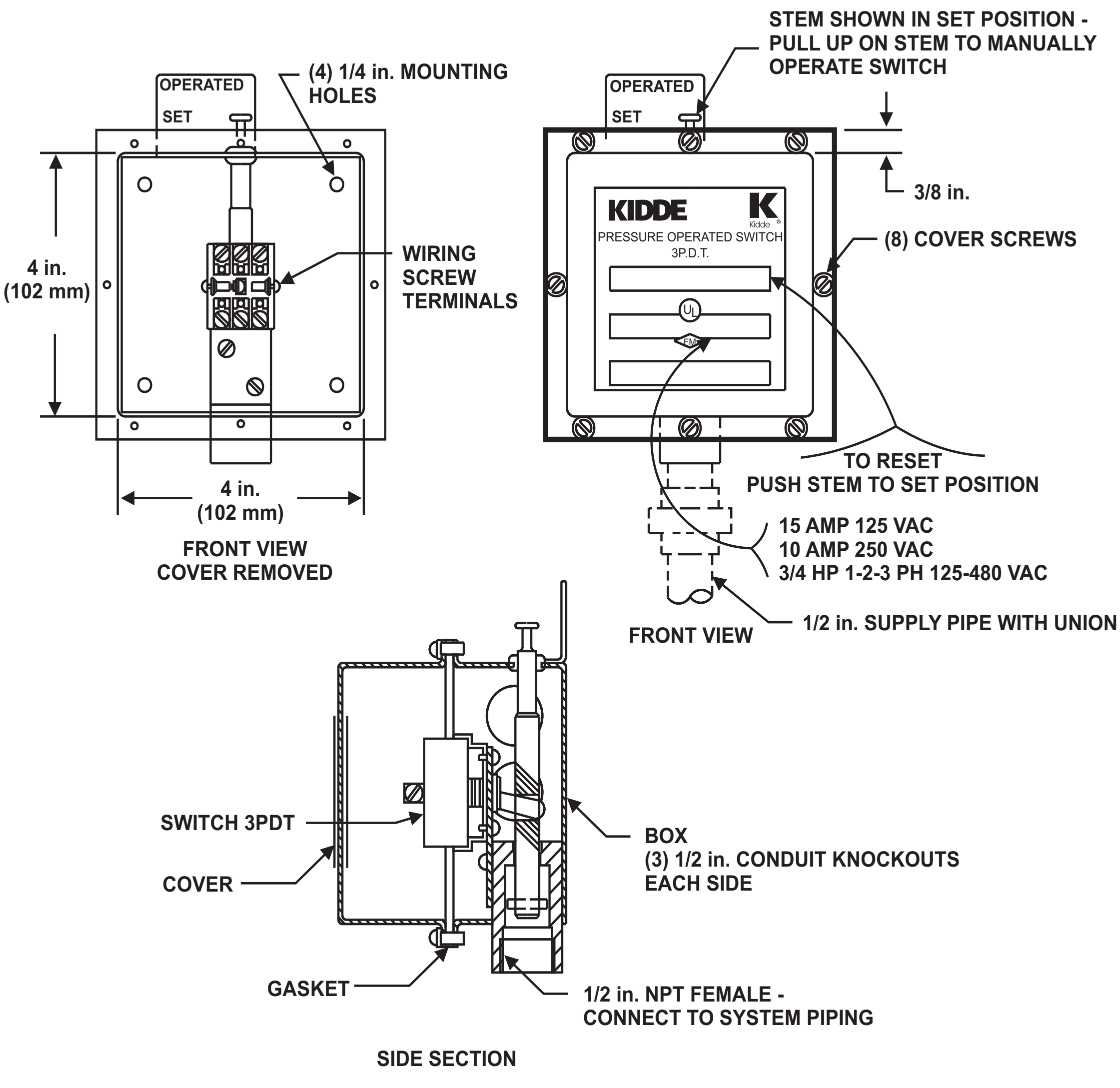


Figure 2-68. Pressure Operated Switch

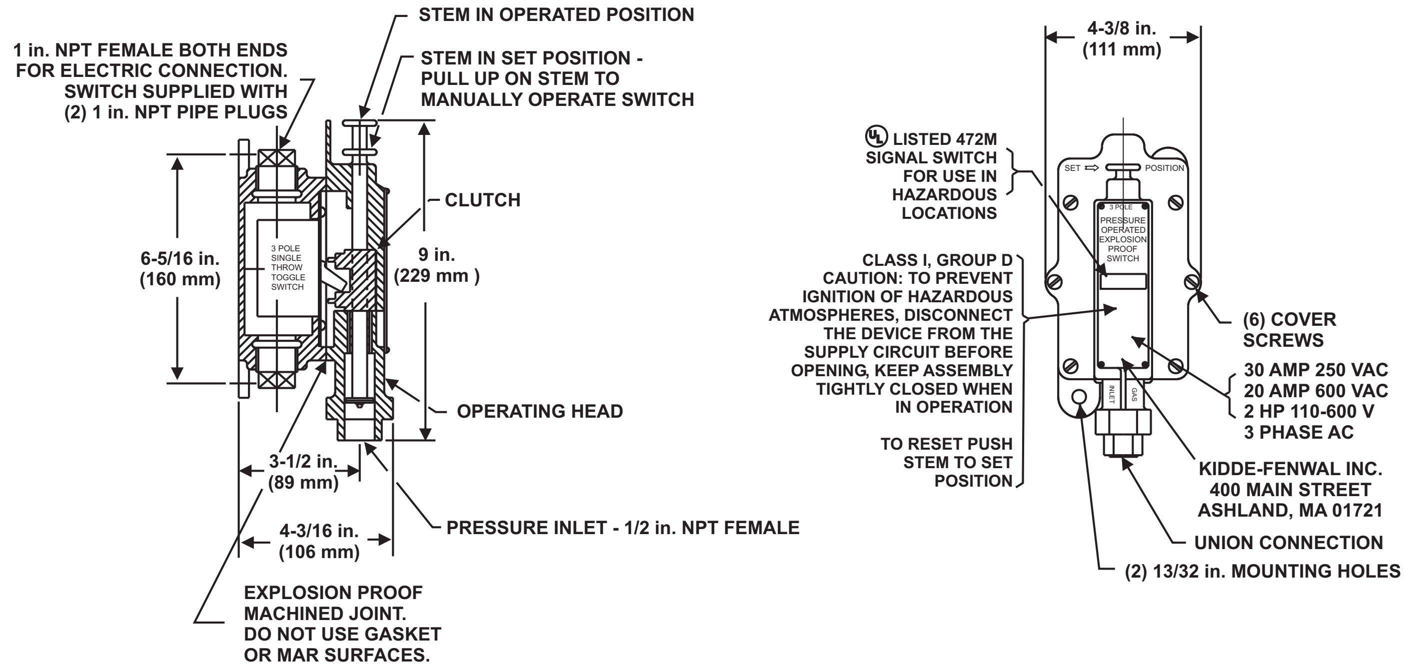


Figure 2-69. Pressure Operated Switch, Explosion Proof

2-8.2 Pressure Operated Trip

The pressure operated trip, Part No. 81-874290-000 (Figure 2-70), is connected to the distribution piping and utilizes carbon dioxide pressure for actuation. The carbon dioxide pressure displaces a spring-loaded piston to disengage a holding ring from the stem connected to the piston. (Typical applications of the pressure operated trip are addressed in Paragraph 3-15.2.)

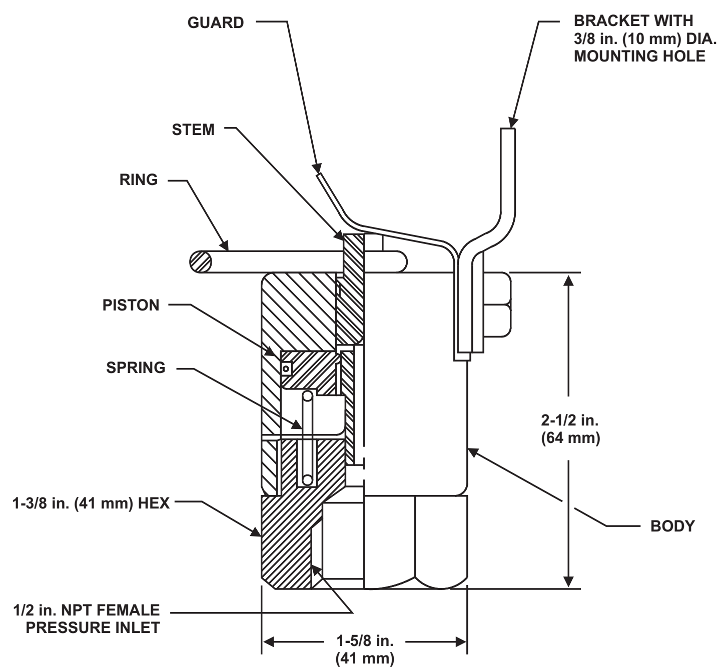


Figure 2-70. Pressure Operated Trip

2-8.3 Pneumatic Discharge Delay

This pneumatic discharge delay (Figure 2-71 through Figure 2-73) uses CO_2 system pressure or N_2 actuation pressure to provide a pneumatic (automatic mechanical) means to delay the CO_2 discharge for a pre-determined period. The pneumatic discharge delay consists of a metering tube, a cylinder, and a differential pressure operated valve with a control port for attaching a compatible control head. This assembly is installed downstream of pressure operated equipment, but upstream of the nozzle, to allow alarms to sound, and equipment and ventilation to shut down prior to the carbon-dioxide discharge.

Discharge delay assemblies are available with non-adjustable, factory pre-set delay periods. Attachment of a compatible control head allows the delay period to be bypassed. Without a control head the delay period cannot be bypassed.

Consult NFPA 12 (latest edition) for guidance selecting appropriate control heads.

Table 2-32. Pneumatic Discharge Delay Part Numbers

Part Number	Description
81-871071-000	CO2 Discharge Delay, 30 Second (Not FM Approved)
81-897636-000	CO2 Discharge Delay, 60 Second (Not FM Approved)
81-871072-001	N2 Discharge Delay, 30 Second (For Use w/108-cuin N2 Cylinder Only)
81-871072-002	N2 Discharge Delay, 60 Second (For Use w/108-cuin N2 Cylinder Only)

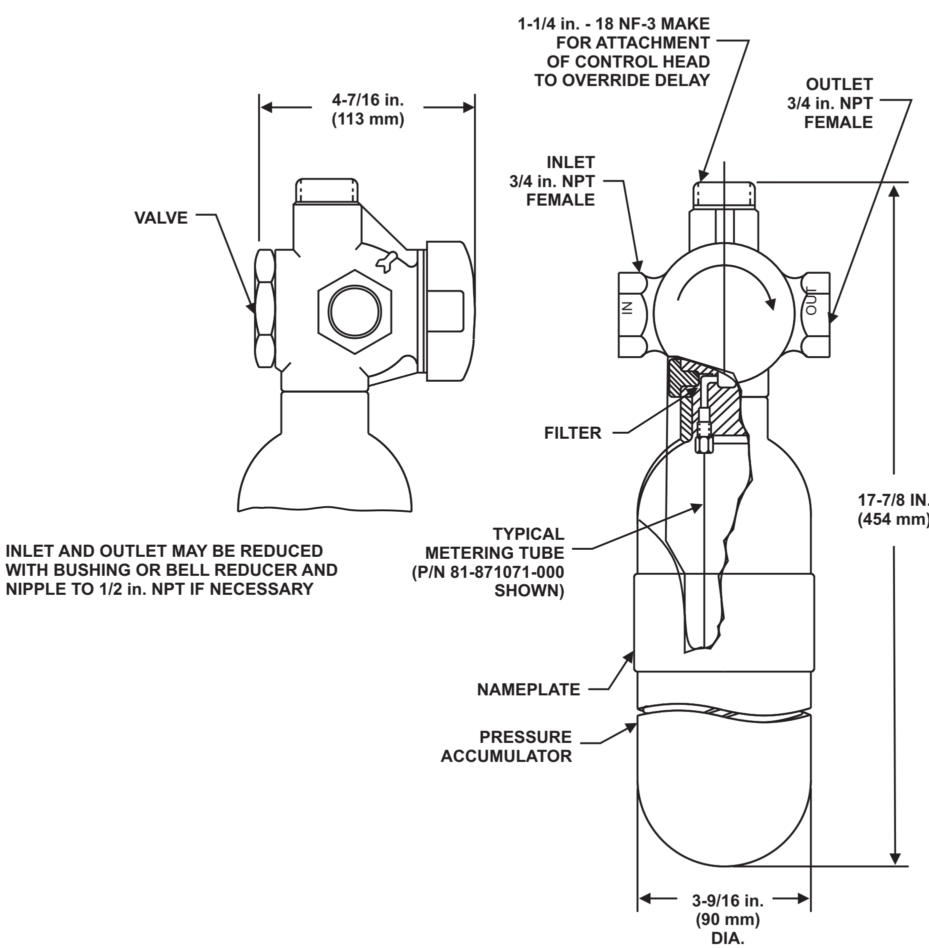


Figure 2-71. Pneumatic Discharge Delay

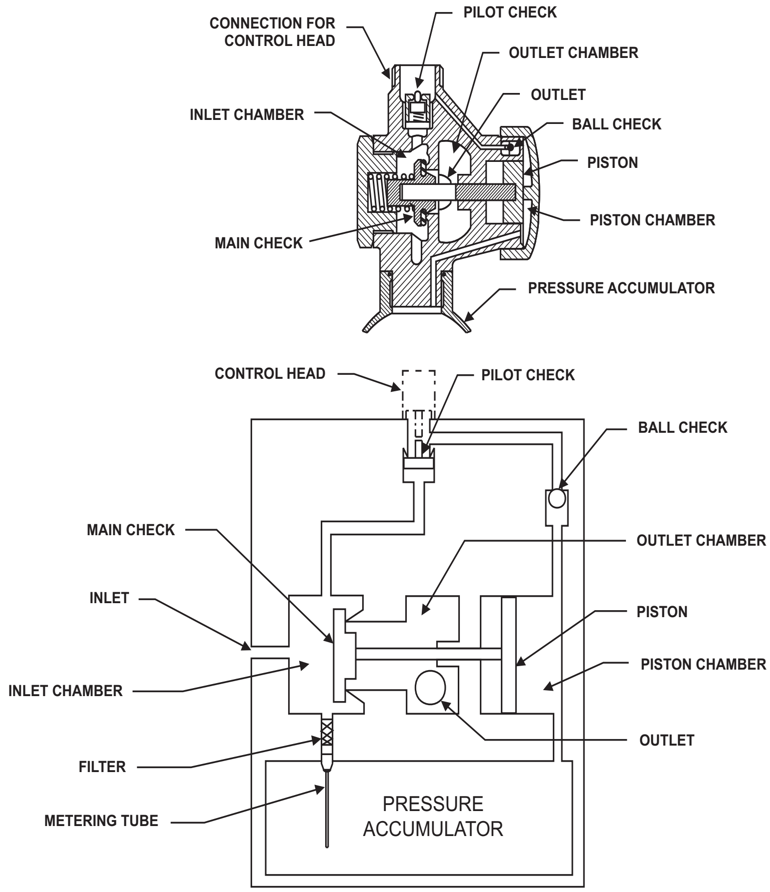


Figure 2-72. Pneumatic Discharge Delay, Detail

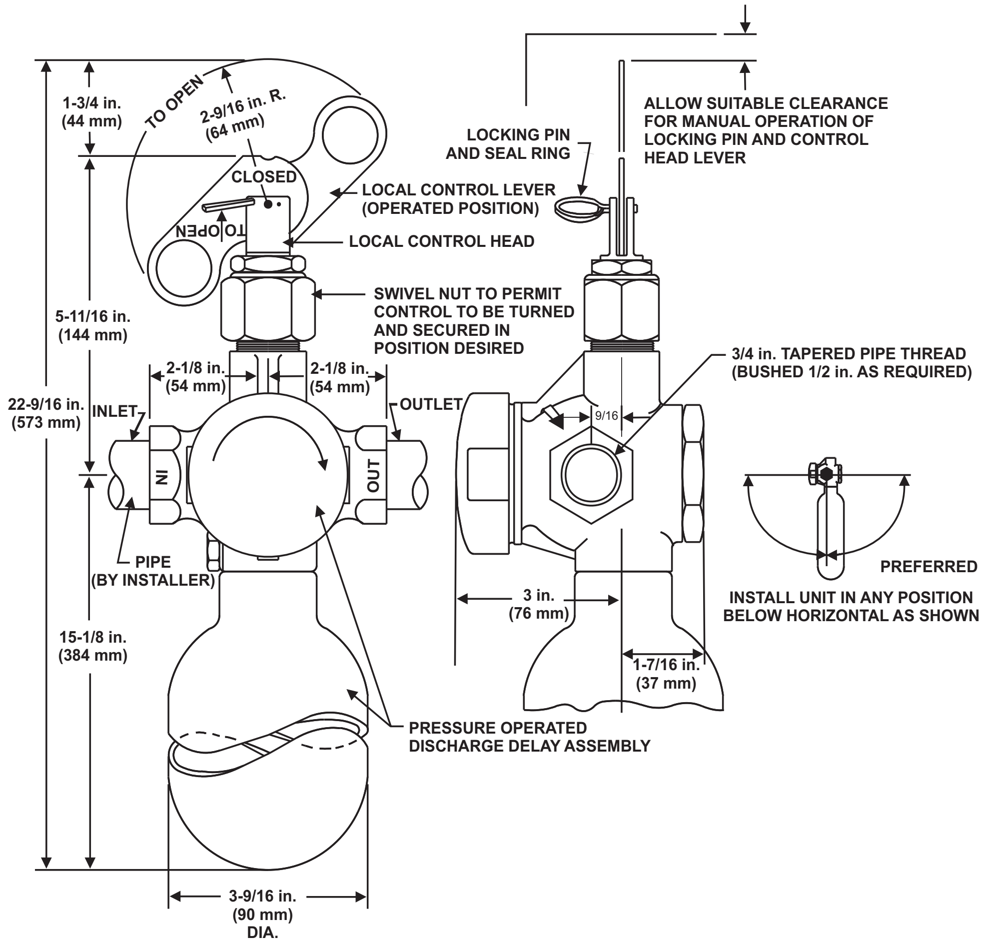


Figure 2-73. Pneumatic Discharge Delay with Manual Control Head

2-8.4 Pressure Operated Siren

The pressure operated sirens provide a mechanical means to generate an audible alarm. The flow of carbon dioxide or nitrogen into the siren spins a rotor and creates a high pitch and high decibel sound. The audible alarm warns personnel of an impending CO2 discharge and the need to immediately evacuate the protected area prior to the discharge. In order to provide a pre-discharge warning, the siren supply line shall be installed upstream of the discharge delay.

NOMINAL FLOW RATE AT 70 DEGREES
CARBON DIOXIDE 20.4 LBS/MIN

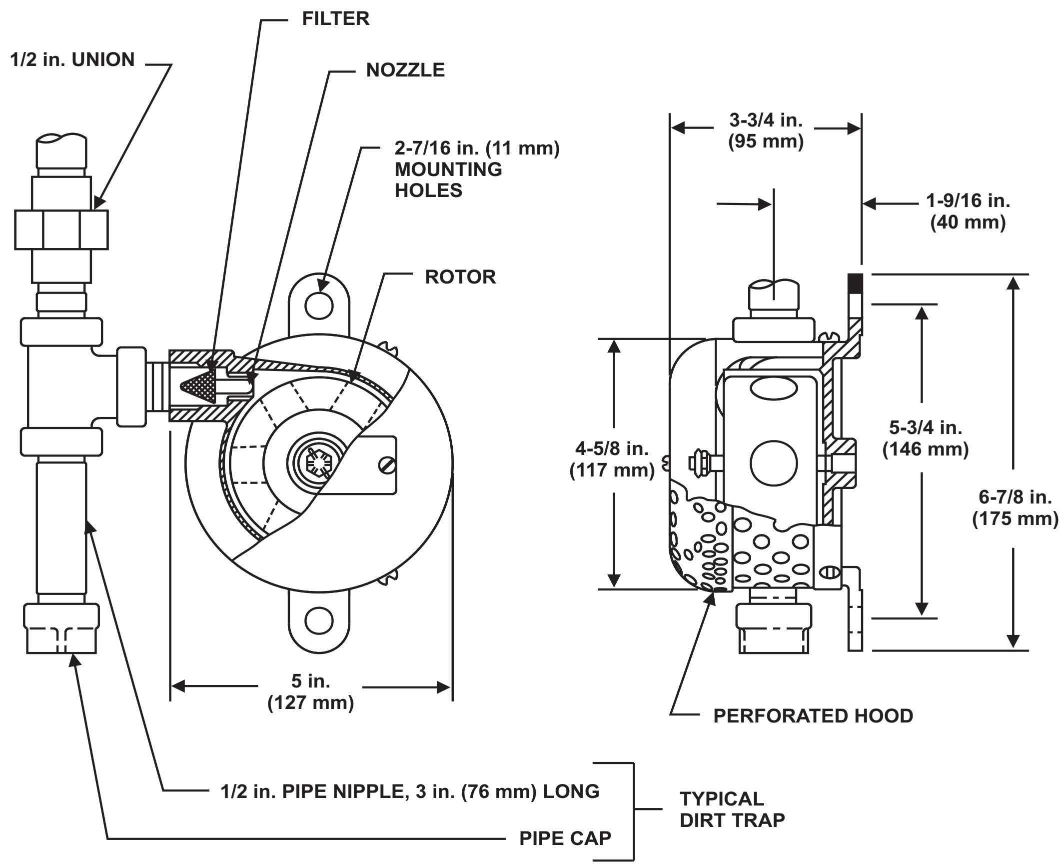


Figure 2-74. Pressure Operated Siren

2-8.5 Safety Outlet

The safety outlet, Part No. 81-803242-000 (Figure 2-75), consists of a safety disc housed in a threaded body. The safety disc is designed to relieve at a pressure of 2400 to 2800 PSIG (166 to 194 Bar).

The safety outlet is utilized in systems with directional (stop) valves and lockout valves where the design of the system creates a closed section of piping. The safety outlet is installed in the piping upstream of the stop valve (s) to prevent over pressurization in the event of entrapment of CO_2 in the closed pipe segment.

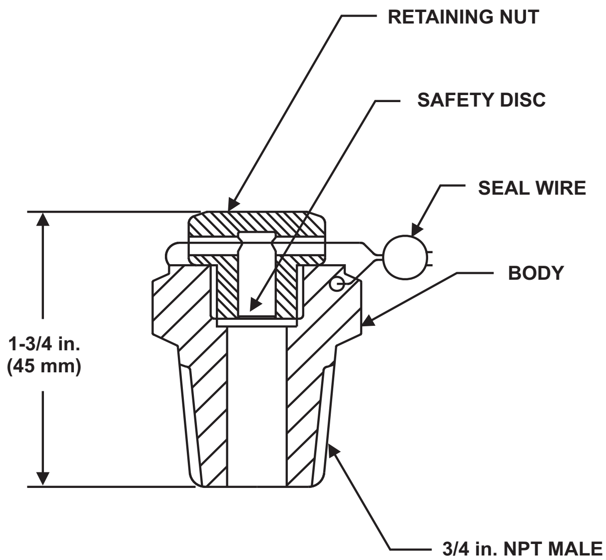


Figure 2-75. Safety Outlet

2-8.6 Discharge Indicator

The discharge indicator, Part No. 81-967082-000 (Figure 2-76), must be installed in the discharge piping to visually indicate a system discharge. In the set position, the discharge indicator acts as a vent allowing CO_2 pressure that may have accumulated in the manifold (due to a leaking cylinder valve) to vent to atmosphere. The discharge indicator is required for all systems.

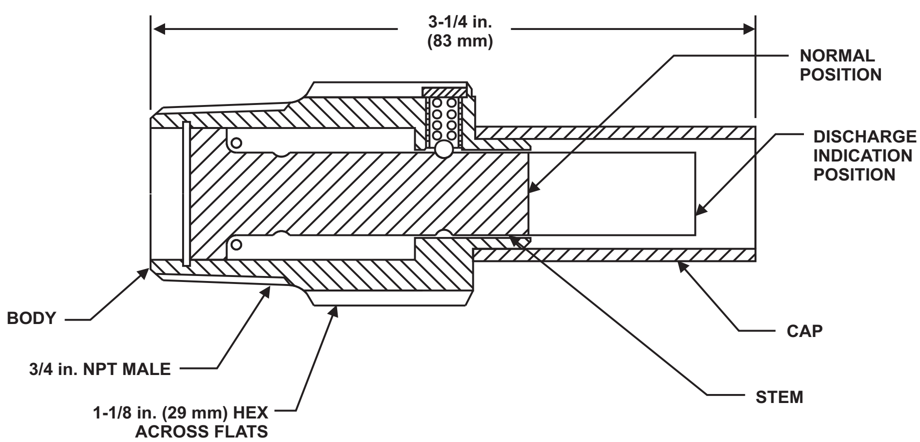


Figure 2-76. Discharge Indicator

2-8.7 Odorizer Assembly

The odorizer assembly injects a scent of wintergreen into the carbon dioxide during a discharge. Upon discharge, the carbon dioxide pressure ruptures a burst disc to release the scent of wintergreen. This scent warns personnel in the vicinity of the area protected by the fire suppression system that carbon dioxide gas is present. An odorizer assembly is required with each CO_2 system regardless of size.

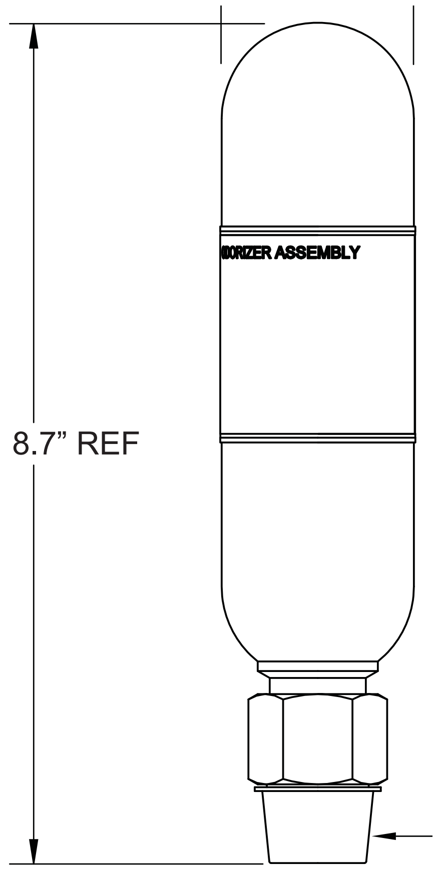


Figure 2-77. Odorizer Assembly

2-8.8 Main to Reserve Transfer Switch

The main to reserve transfer switch, Part No. 84-802398-000 (Figure 2-78), is installed on systems having main and reserve cylinders equipped with electric control heads. Placing the switch in either the “main” or “reserve” position provides uninterrupted fire protection capability during system maintenance or in the event of a system discharge.

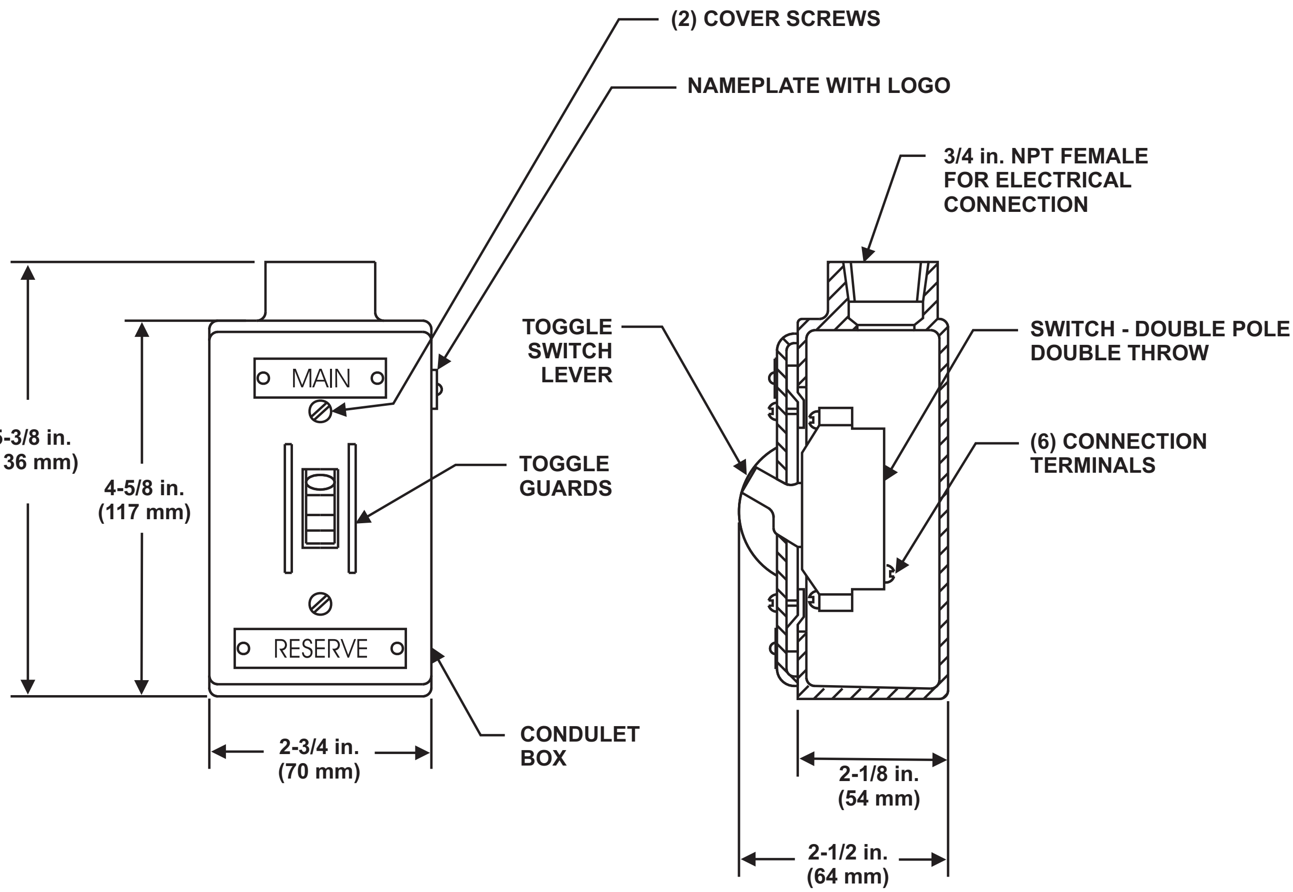


Figure 2-78. Main to Reserve Transfer Switch

2-8.9 Weigh Scale

A weigh scale, Part No. 81-982505-000 (Figure 2-79) is available for weighing the CO_2 cylinders in place without disconnecting them from the cylinder manifold. The weigh scale is used in conjunction with the weigh bars that form part of the framing.

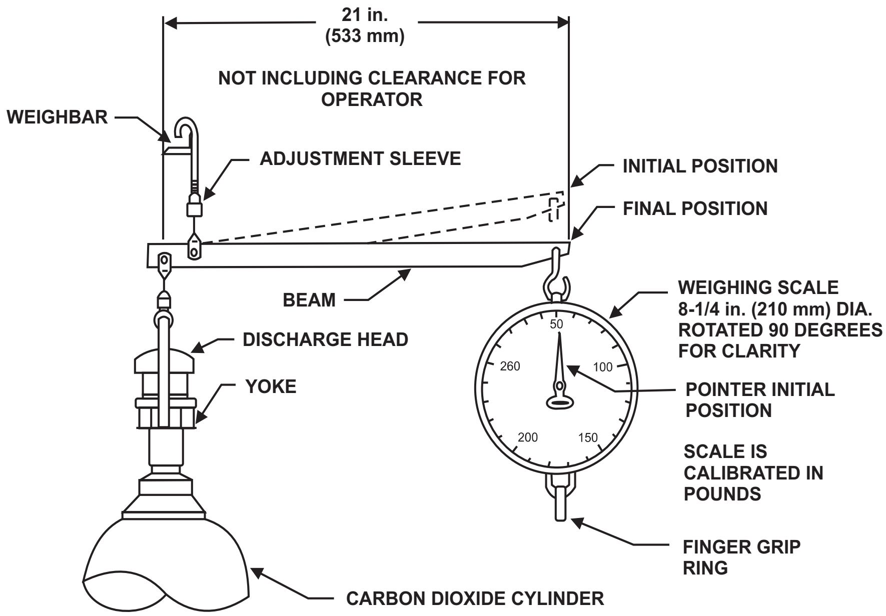


Figure 2-79. Weigh Scale

2-8.10 Recharge Adapter

The recharge adapter, Part No. WK-933537-000 (Figure 2-80), is used to fill the CO_2 cylinder assemblies. The adapter is attached to the cylinder valve pilot port connection during cylinder charging.

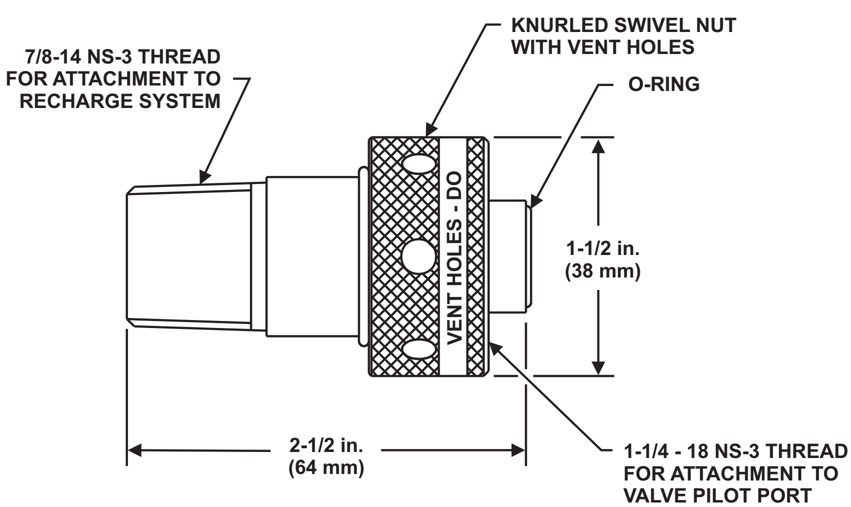


Figure 2-80. Charging Adapter

2-8.11 Blow-Off Fixture

The blow-off fixture, Part No. 81-930117-000 (Figure 2-81), is used to relieve the CO_2 cylinder assemblies of pressure. The blow-off fixture threads onto the cylinder valve pilot port and opens the pilot check for controlled discharge.

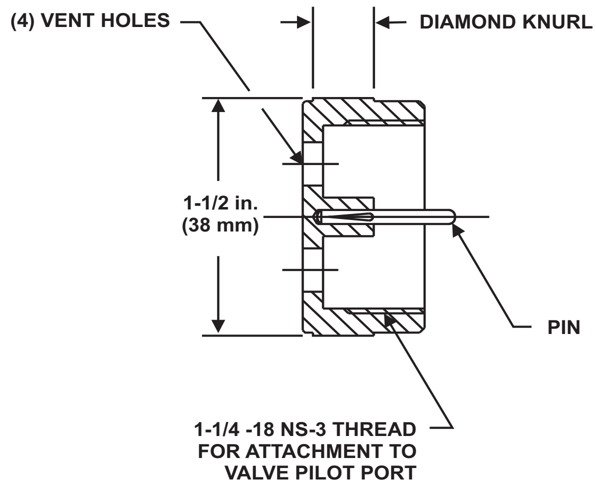


Figure 2-81. Blow-Off Fixture

2-9 INSTRUCTION AND WARNING PLATES

Instruction and warning plates are available for installation throughout the protected area and at the cylinder storage area to provide operating instructions and appropriate precautions in the event of an emergency.

2-9.1 Main and Reserve Nameplates

The main and reserve nameplates, Part Nos. WK-310330-000 and WK-310340-000 respectively (Figure 2-82), are used to identify the primary and backup carbon dioxide suppression.

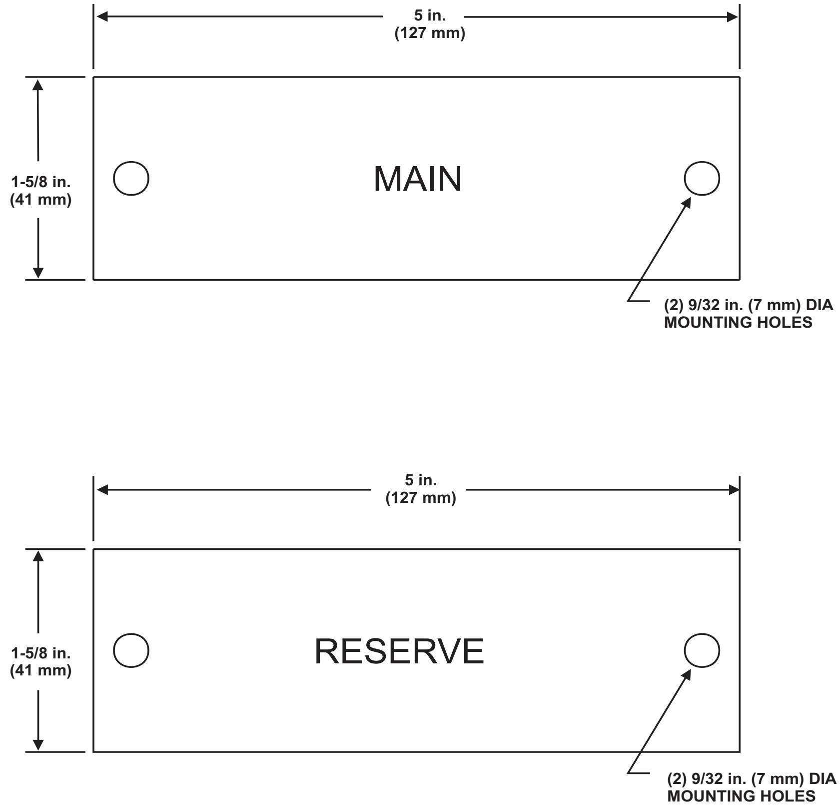


Figure 2-82. Main and Reserve Nameplates

2-9.2 Warning Signs

There are six different safety warning signs with wording specific to each application.

2-9.2.1 VACATE WARNING SIGN, P/N 06-231866-851

The sign shown in Figure 2-83 shall be used in every protected space.⌖

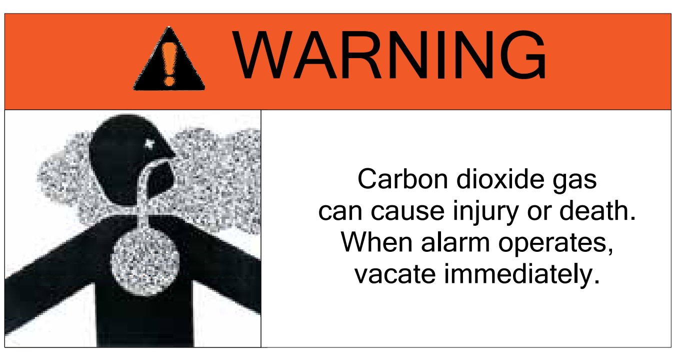


Figure 2-83. Sign in Every Protected Space⌖

2-9.2.2 DO NOT ENTER WARNING SIGN, P/N 06-231866-852

The sign shown in Figure 2-84 shall be used at every entrance to protected space.⌖

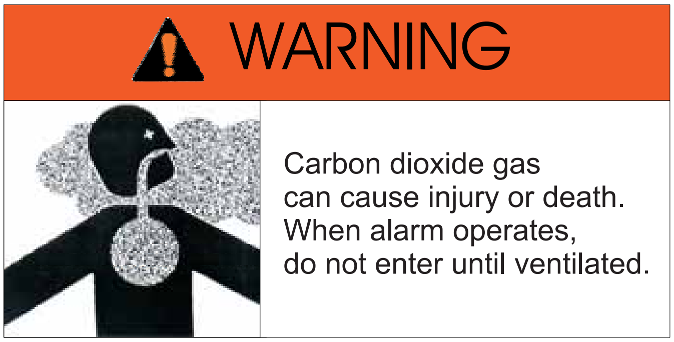


Figure 2-84. Sign at Every Entrance to Protected Space⌖

2-9.2.3 ODORIZER WARNING SIGN, P/N 06-231866-853

The sign shown in Figure 2-85 shall be used at every entrance to protected space for systems provided with a wintergreen odorizer.⌖

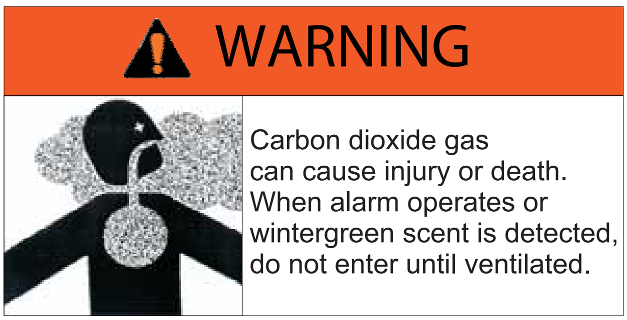


Figure 2-85. Sign at Every Entrance to Protected Space for Systems with a Wintergreen Odorizer⌖

2-9.2.4 MIGRATION WARNING SIGN, P/N 06-231866-854

The sign shown in Figure 2-86 shall be used at every nearby space where carbon dioxide can accumulate to hazardous levels.[⌖]

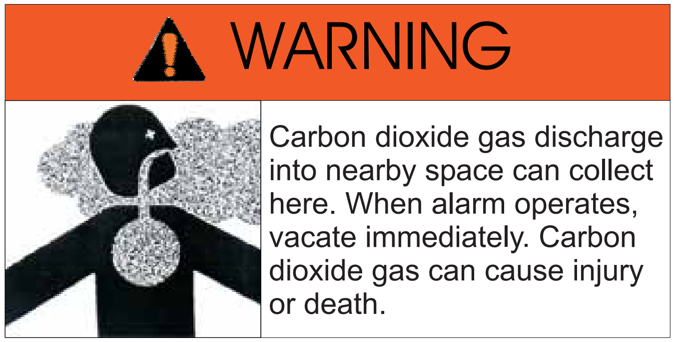


Figure 2-86. Sign in Every Nearby Space Where CO_2 Can Accumulate to Hazardous Levels[⌖]

2-9.2.5 STORAGE WARNING SIGN, P/N 06-231866-855

The sign shown in Figure 2-87 shall be used outside each entrance to carbon dioxide storage rooms.[⌖]

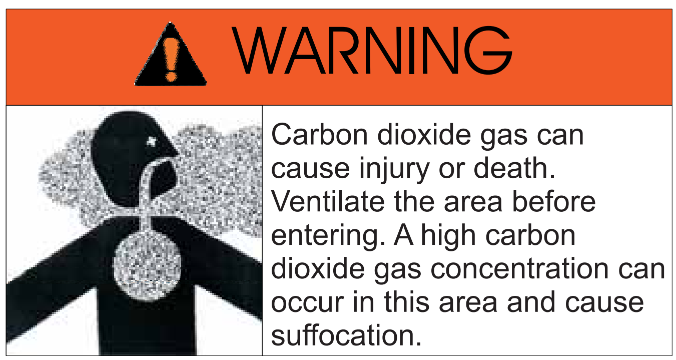


Figure 2-87. Sign Outside Each Entrance to CO_2 Storage Rooms[⌖]

2-9.2.6 ACTUATION WARNING SIGN, P/N 06-231866-856

The sign shown in Figure 2-88 shall be used at each manual actuation station.[⌖]

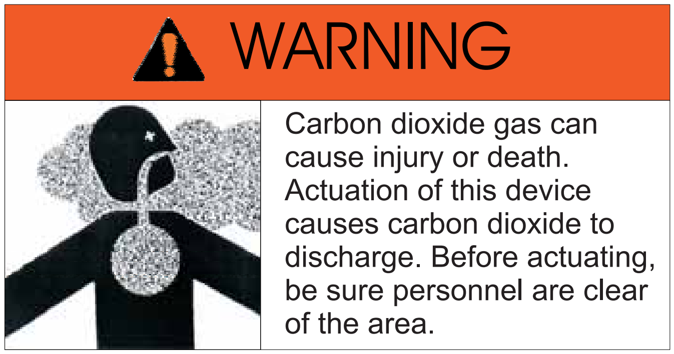


Figure 2-88. Sign at Each Manual Actuation Station[⌖]

2-10 HOSE REEL AND RACK SYSTEMS

The carbon dioxide hose reel and hose rack systems, Part Nos. as listed in Table 2-33 (Figure 2-89 through Figure 2-93), can be used to manually protect small hazard areas, as a stand-alone system or as a backup to an automatic fixed pipe system. The system consists of a carbon dioxide supply, hose reel or rack, and the required size and length of hose connected to a horn and valve assembly. The hose reel is furnished in a painted red finish.

Table 2-33. Hose Reel and Rack System Part Numbers

Part Number	Description
WK-994058-000	Reel, Red
WK-909000-000	Hose Reel Coupling Nut (required for 994058)
81-919842-000	Rack
81-907757-000	Hose, 1/2 in. x 25 ft. (7.5 m)
81-961966-000	Hose, 1/2 in. x 50 ft. (15 m)
81-918990-000	Hose, 3/4 in. x 25 ft. (7.5 m)
81-918435-000	Hose, 3/4 in. x 50 ft. (15 m)
WK-834900-000	Hose-to-Hose Thread Protector (Ferrule)
81-980564-000	Horn/Valve Assembly
81-960099-000	Clip, Handle
81-939000-000	Clip, Horn
WK-282386-000	Instruction Plate, Model HR-1

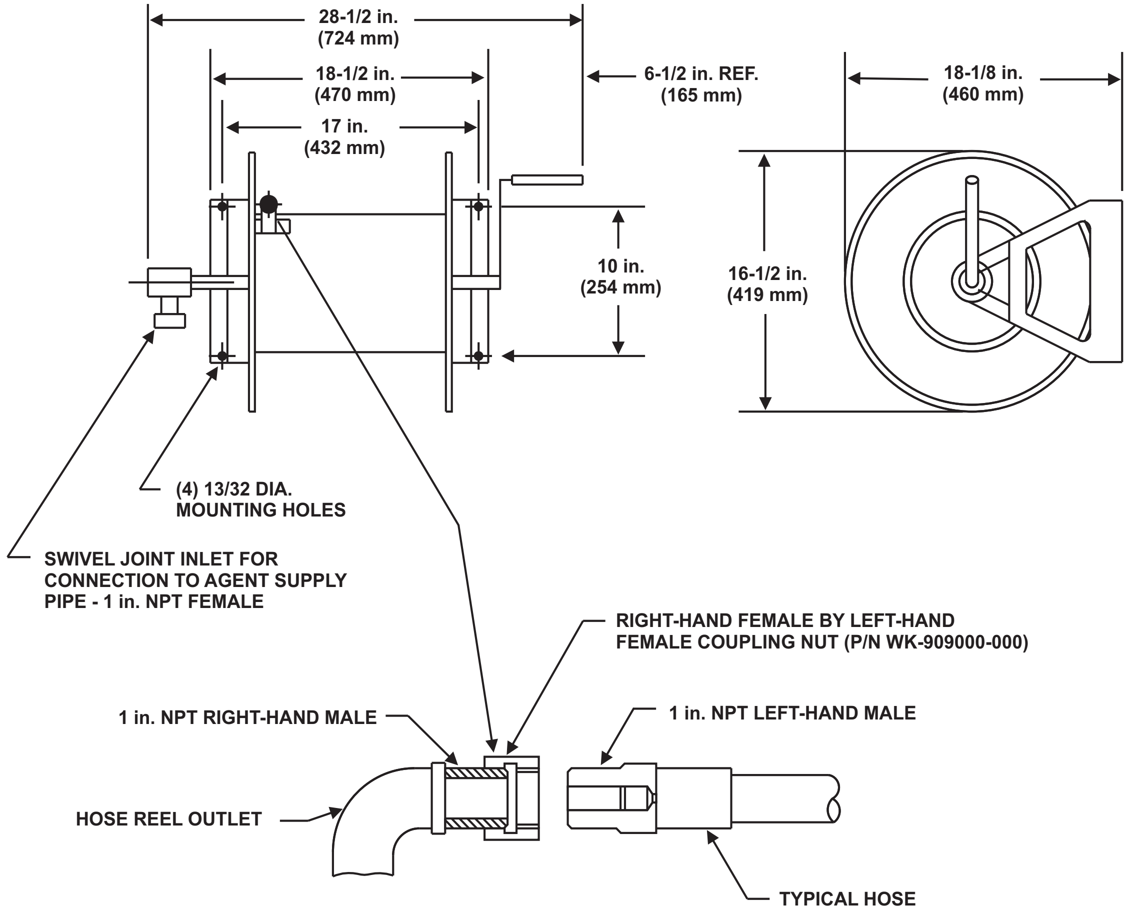


Figure 2-89. Hose-to-Hose Reel Connection

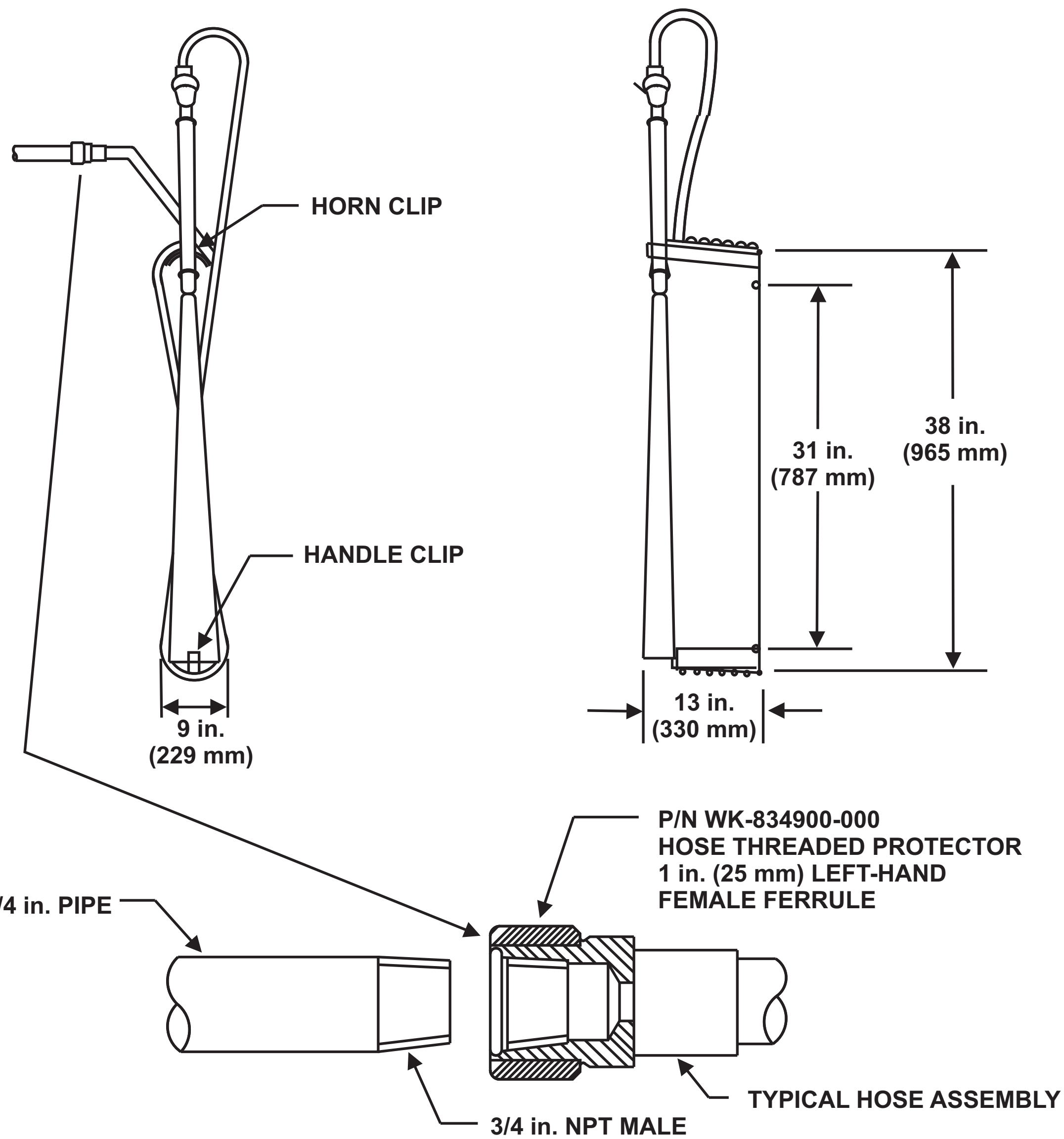


Figure 2-90. Hose-to-Pipe Rack Connection

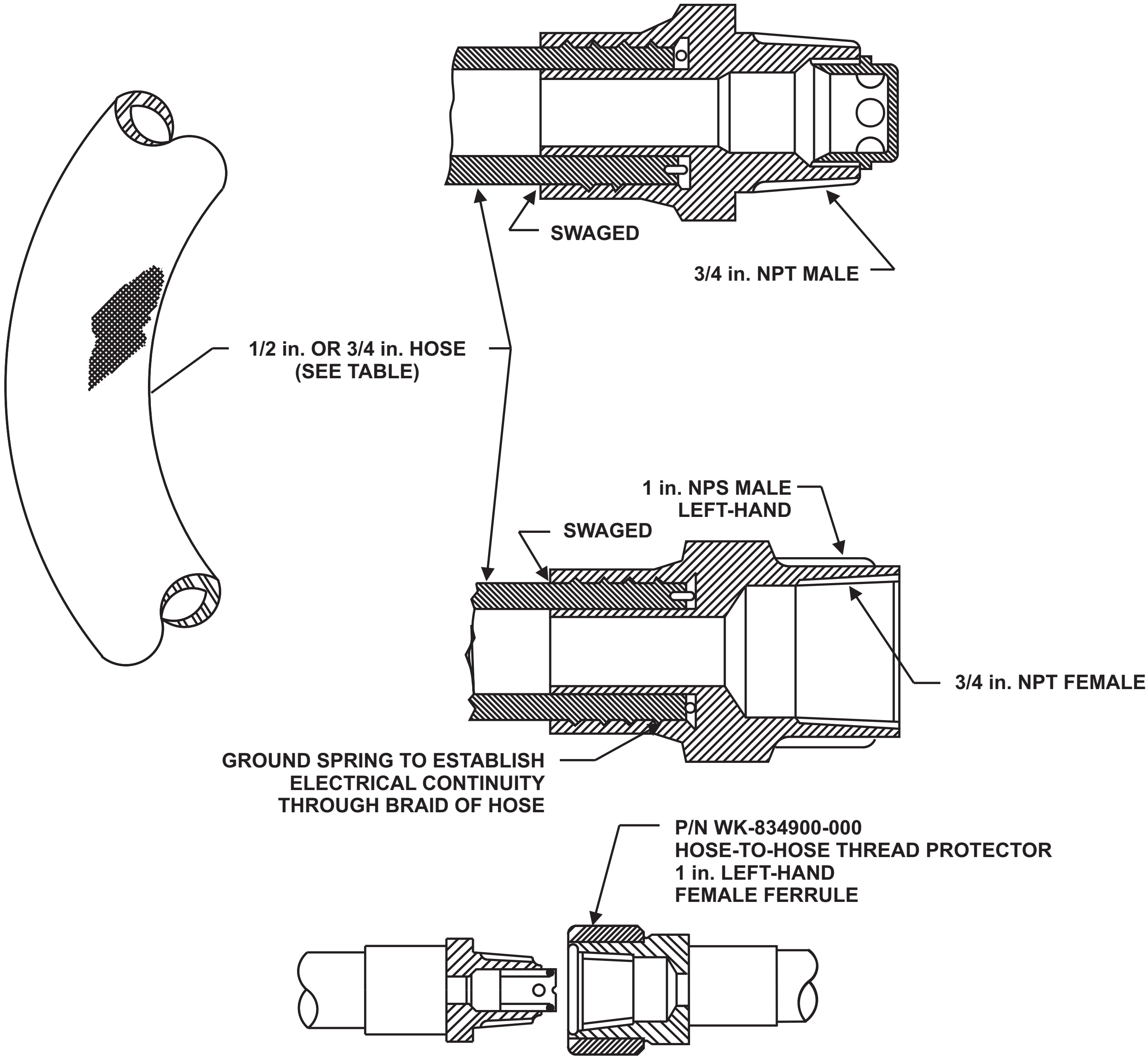


Figure 2-91. Hose Assembly

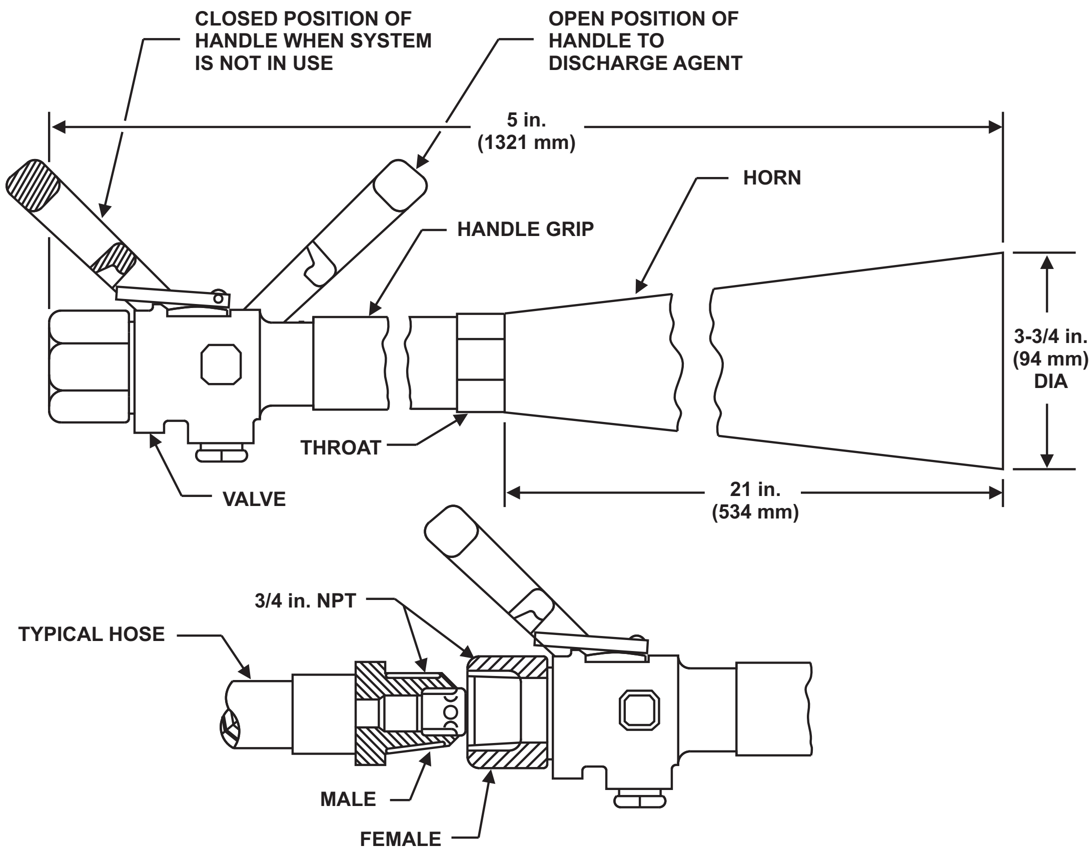


Figure 2-92. Horn and Valve Assembly

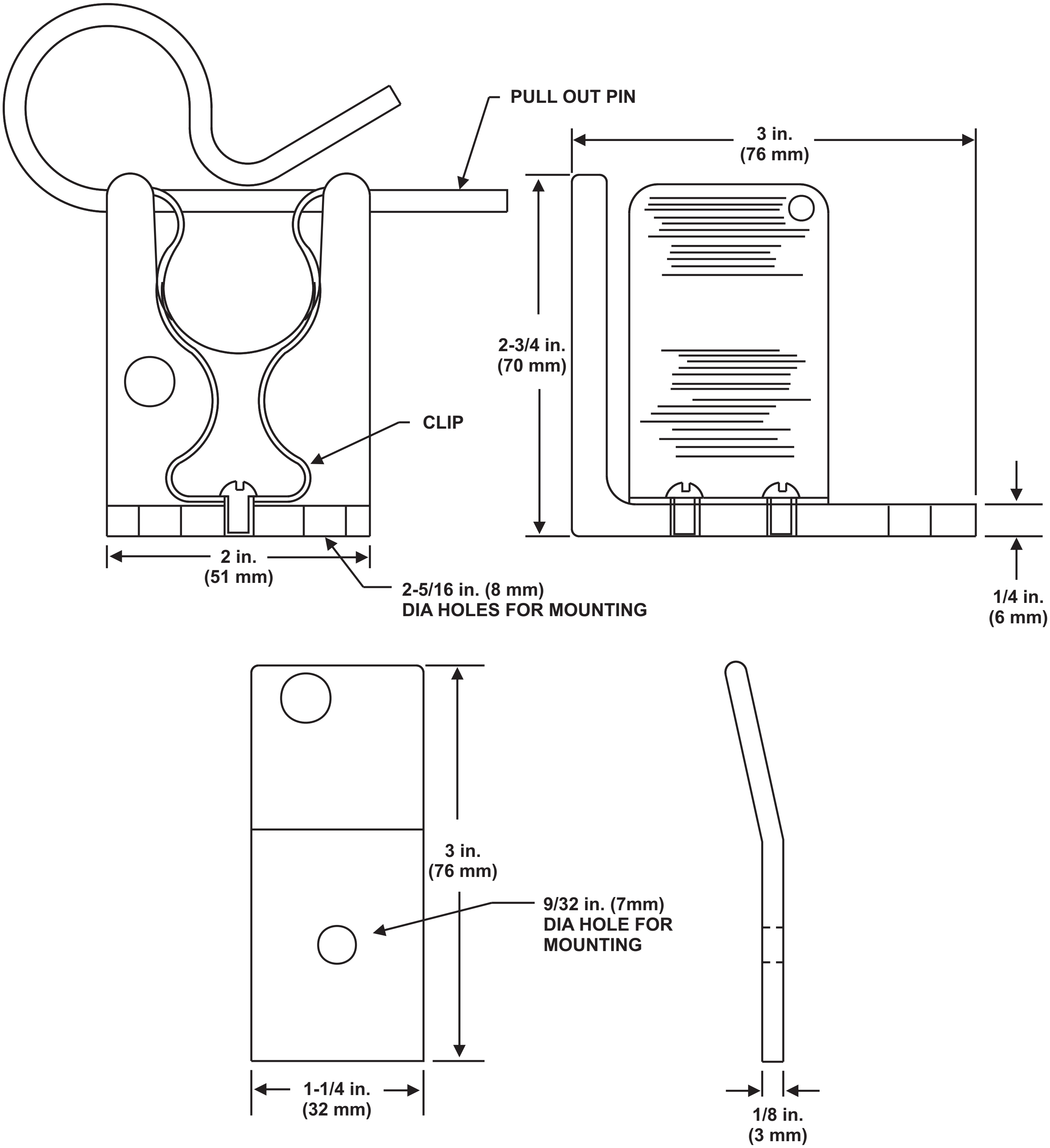


Figure 2-93. Handle and Horn Clips

☐ LBS. CAPACITY   MODEL HR- ☐

MARINE TYPE CARBON DIOXIDE SEMI-PORTABLE EXTINGUISHER

— HOSE APPLICATION —

TO OPERATE

1. OPERATE CYLINDER CONTROL
2. BRING HORN WITHIN TEN FEET OF FIRE
3. OPEN HORN VALVE DIRECTING GAS AT BASE OF FLAME
4. FOLLOW FLAME SLOWLY. DON'T HURRY!

MAINTENANCE

WEIGH CYLINDERS EVERY 6 MONTHS. RECHARGE IF WEIGHT HAS DECREASED BY MORE THAN 10% OF RATED GAS CHARGE (EMPTY WEIGHT OF EACH CYLINDER IS STAMPED ON CYLINDER VALVE.)

— RECHARGE IMMEDIATELY AFTER USE —

SEE INSTRUCTION BOOK

THIS SYSTEM CONSISTS OF ONE OR MORE OF THE FOLLOWING LISTED COMPONENTS.

COMPONENT	KIDDE P/N	COMPONENT	KIDDE P/N
☐ 35 LB. CO_2CYL	982547	HORN/VALVE	980564
☐ 50 LB. CO_2CYL	982528	HANDLE SUPPORT	960099
☐ 75 LB. CO_2CYL	870287	HANDLE CLIP	939
☐ 100 LB. CO_2CYL	870269	DISCHARGE HEAD	872450
BRACKET	270014	DISCHARGE HEAD	872442
BRACKET	62669	Y-FITTING	207877
BRACKET	270157	LEVER CONTROL HEAD	870652
HOSE	961966	SWIVEL ADAPTER	934208
HOSE	907757	DISCHARGE LOOP	251821
HOSE REEL	994058	HOSE RACK	919842

UL LISTED
MARINE TYPE CARBON DIOXIDE
SEMI-PORTABLE EXTINGUISHER   969X

MARINE TYPE
U.S.C.G. TYPE B:C SIZE ☐ 162.039/EX3285

KIDDE FENWAL

KIDDE-FENWAL, INC.
400 MAIN STREET
ASHLAND, MA 01721

PATENTED UNDER ONE OR MORE OF THE FOLLOWING
2492165 2499402 2466750 2563868
OTHERS PENDING

282386

Figure 2-94. Model HR-1 Instruction Plate

CHAPTER 3
DESIGN

3-1 INTRODUCTION

This chapter provides the information and procedures required to properly design the Kidde Fire Systems CO_2 fire suppression system. The information is arranged in the following categories:

- Hazard Survey, Definition and Analysis
- Design for Safety
- Applications
- Total Flooding Application Systems
- Local Application Systems
- Combination Systems
- Multiple Hazard Systems
- Pressure Operated Sirens
- Extended Discharge Systems
- Agent Storage Banks
- Manifold and Pipe Network Design
- Actuation System Design
- Detection Devices, Alarm Devices and Control Panels
- Auxiliary Equipment and Systems

3-2 HAZARD SURVEY, DEFINITION AND ANALYSIS

The first step in any fire protection design project is to survey the area to be protected, define the hazard, and analyze the information to determine the appropriate methods of detecting and suppressing the fire. In addition, several key concepts for overall safety of the system should be considered.

As a minimum, a hazard survey should consist of the following:

- Dimensions of the area to be protected, including interconnected spaces and duct work that extends out of the protected space
- Locations and dimensions of non-closeable openings
- Locations, quantities, and types of likely fuels
- Locations and types of sources of ignition
- Locations and Basic Insulation Level (BIL) of non-insulated live electrical wiring
- Flow rate and wind-down time of forced ventilation that cannot be dampered or shut down
- Minimum and maximum ambient temperatures
- Type of wall construction (for enclosed spaces)
- Occupancy status
- Path of egress
- Hazardous classification (i.e., explosion hazard)
- Locations of pipe, duct work, beams, or other obstructions

- Acceptable locations for agent storage as close to the hazard as possible
- Work flow processes and protected equipment
- Expected emergency response time

Use the information provided in Chapter 1 to determine if carbon dioxide is an appropriate extinguishing agent for the hazard.

After confirming that carbon dioxide is an acceptable extinguishing agent, the designer must then select an appropriate design approach (see Paragraph 3-5 through 3-6).

3-3 DESIGN FOR SAFETY

The designer shall be thoroughly familiar with the life safety features required by NFPA 12 and outlined in Chapter 1. The designer shall be thoroughly familiar with the dangers associated with carbon dioxide as a fire suppressant and the measures taken to mitigate those dangers. NFPA 12 shall be referenced for additional considerations not published in this manual.

3-4 APPLICATIONS

Carbon dioxide suppression systems provide a great deal of flexibility to the designer in dealing with almost any shape, size, or type of hazard. Because of this versatility, CO_2 is suitable for many difficult hazards, including:

Industrial hazards -These typically consist of equipment or processes where flammable liquids are involved. Examples of industrial hazards that can be protected by carbon dioxide are:

- Dip tanks
- Mixing tanks
- Ovens and dryers
- Quench tanks
- Coating machines
- Turbines
- Generators
- Printing presses
- Dust collectors
- Industrial fryers.

Marine hazards - These include shipboard applications. Refer to the *Kidde Marine Carbon Dioxide Design, Installation, Operation and Maintenance Manual*, Part No. 81-220610-000, for detailed information on marine system design.

The versatility of carbon dioxide systems is based on its ability to be used as a total flooding or local application fire-fighting agent.

3-4.1 Total Flooding System

A total flooding system is designed to develop an extinguishing concentration of carbon dioxide in an enclosed space and to maintain an effective concentration until re-ignition will not occur. Such systems may be used to extinguish surface fires (Paragraph 3-5.2) and deep-seated fires (Paragraph 3-5.3). The method of design is similar for both fire types. However, deep-seated fires generally require a more rigorous treatment.

3-4.2 Local Application System

A local application system is designed to apply carbon dioxide directly to a fire in an area or space that essentially has no enclosure surrounding it. Such systems may be used to extinguish surface fires in two-dimensional (Paragraph 3-6.2) or three-dimensional (Paragraph 3-6.3) hazards.

3-4.3 Hand Hose Line Systems

A hand hose line system is designed to supplement fixed fire protection systems or to supplement first response portable fire extinguishers for the protection of specific hazards for which carbon dioxide is the extinguishing agent.

3-5 TOTAL FLOODING SYSTEMS

3-5.1 Introduction

A total flooding system shall consist of a fixed supply of carbon dioxide, permanently connected to a fixed pipe network, with fixed nozzles arranged to discharge carbon dioxide into an enclosed space.

WARNING

Carbon dioxide is present in the atmosphere. It is also a normal product of human and animal metabolism; human life cannot be sustained if this carbon dioxide is not expelled from the body. The concentration of carbon dioxide in the air governs the rate at which the carbon dioxide produced by the human metabolism is released from the lungs. An increasing concentration in the air where humans are present, therefore, can cause serious personal injury or death.

WARNING

Total flooding systems shall NOT be used in normally occupied enclosures except in accordance with the provisions allowed by NFPA 12 (most current edition).

3-5.1.1 ENCLOSURE

For total flooding fire protection, the enclosure around the hazard must be essentially continuous, with as few uncloseable openings as possible, so that an extinguishing concentration can be developed about the hazard. When openings cannot be closed prior to or at the start of discharge, an additional quantity of carbon dioxide shall be discharged to compensate for agent lost through uncloseable openings.

For surface fires, if the quantity of carbon dioxide required to compensate for the openings alone exceeds the quantity required for total flooding with no openings, then the suppression system may be designed using local-application methods.

For deep-seated fires, any uncloseable openings shall be restricted to the ceiling or on the enclosure walls bordering the ceiling. This is to permit the carbon dioxide concentration to be maintained for a sufficient period of time to allow any smoldering to be suppressed and to allow the material to cool below its re-ignition temperature. In situations where the openings do not allow the concentration to be maintained during the required cooling period, additional agent should be discharged over an extended period of time to compensate for losses through the openings (See Paragraph 3-10).

When the position of an opening is such that a fire in the protected area could spread through it to adjacent combustibles or work areas, the opening shall be provided with an automatic closure or local application nozzles. Where such measures are not practical, protection shall be extended to include the adjacent work area or process.

3-5.1.2 VENTILATION

The total flooding agent quantity calculations are designed for a reasonably tight enclosure with static conditions prevailing at the time of system discharge. Static conditions prevail when all forced air ventilating systems servicing the protected area are stopped at the time of agent discharge. Forced air ventilation systems must be shut down or closed (or both) prior to, or simultaneously with, the start of the carbon dioxide discharge. Additional carbon dioxide must be provided if forced ventilation cannot be dampered or shut down.

3-5.1.3 INTERLOCKS

It is essential that all potential re-ignition sources in the protected area be eliminated prior to, or concurrently with, the start of the carbon dioxide discharge. This requires that a control system be designed to shut down all processing equipment, to shut off electrical power to all equipment in the area, and to perform any other interlocks necessary to ensure the effectiveness of the system.

If interlocks cannot be provided, additional carbon dioxide may be required to compensate for openings, forced ventilation, or other factors that are detrimental to system performance.

3-5.1.4 INTERCONNECTED VOLUMES

Where two or more interconnected volumes allow "free flow" of carbon dioxide between the protected spaces, the carbon dioxide quantity for each volume shall be calculated individually. If one volume requires greater than normal concentration, the higher concentration shall be used in all interconnected volumes.

3-5.2 Calculations for Surface Fires

Surface fires involve burning of flammable liquids and of ordinary, non-smoldering combustibles.

3-5.2.1 EXTINGUISHING CONCENTRATIONS

The minimum carbon dioxide design concentration for total flooding systems is 34%. However, the required concentration may be increased when flammable liquids and gases are involved. A list of design concentrations for several known fuels can be found in Table 3-1.

Table 3-1. Minimum Carbon Dioxide Concentrations for Extinguishment

Material	**Minimum Design** CO_2 **Concentration (%)**
Acetylene	66
Acetone	34
Aviation Gas Grades 115/145	36
Benzol, Benzene	37
Butadiene	41
Butane	34

Table 3-1. Minimum Carbon Dioxide Concentrations for Extinguishment

Material	**Minimum Design** CO_2 **Concentration (%)**
Butane-I	37
Carbon Disulfide	72
Carbon Monoxide	64
Coal or Natural Gas	37
Cyclopropane	37
Diethyl Ether	40
Dimethyl Ether	40
Dowtherm	46
Ethane	40
Ethyl Alcohol	43
Ethyl Ether	46
Ethlylene	49
Ethylene Dichloride	34
Ethylene Oxide	53
Gasoline	34
Hexane	35
Higher Paraffin Hydrocarbons C_n $H2_m$ + 2m - 5	34
Hydrogen	75
Hydrogen Sulfide	36
Isobutane	36
Isobutylene	34
Isobutyl Formate	34
JP-4	36
Kerosene	34
Methane	34
Methyl Acetate	35
Methyl Alcohol	40
Methyl Butene-I	36
Methly Ethyl Ketone	40
Methyl Formate	39
Pentane	35
Propane	36
Propylene	36
Quench, Lube Oils	34

3-5.2.2 BASIC TOTAL FLOODING QUANTITY

The discharge of carbon dioxide into an enclosure will displace a portion of the atmosphere in the enclosure. The displaced atmosphere is exhausted freely from the enclosure through openings or vents as the carbon dioxide is discharged. Since some suppression agent is lost with the vented atmosphere, the volume of carbon dioxide required to develop a given concentration will be greater than the volume that actually remains in the enclosure. This method of application is called "free efflux" flooding.

A small volume has proportionally more surface (or boundary) area per unit of enclosed volume than a larger volume, and has a proportionally greater leakage rate. Accordingly, larger quantities of carbon dioxide per unit of enclosed volume are injected into smaller volumes to account for the higher leakage rates anticipated upon discharge. The quantity of carbon dioxide per unit volume is called the Volume Factor and is shown in Table 3-2. Also note that the minimum quantity of CO_2 is specified for the smallest volume in each group to avoid a possible overlap of CO_2 requirements.

(Equation 1) $$W_B = V \div f_1$$

or

$$W_B = V \times f_2$$

Where:

W_B = Basic quantity of agent, lb.(kg)

V = Enclosure volume, ft.^{3} (m^3)

f_1 = Volume factor from Table 3-2, ft.^{3}/lb.(m^3/kg)

f_2 = Volume factor from Table 3-2, lb./ft.^{3} (kg^3/m^3)

Table 3-2A. Volume Factors - Surface Fires (For 34% CO_2 Concentration), US Units

Enclosure Volume (ft.^{3})	Volume Factor f_1 (ft.^{3}/lb.)	Volume Factor f_2 (lb./ft.^{3})	Calculated Quantity Not Less Than (lb.)
Up to 140	14	0.072	--
141 - 500	15	0.067	10
501 - 1,600	16	0.063	35
1,601 - 4,500	18	0.056	100
4,501 - 50,000	20	0.050	250
Over 50,000	22	0.046	2,500
Ducts and Covered Trenches (See Section 3-5.2.2.1)	8	0.125	--

Table 3-2B. Volume Factors - Surface Fires (For 34% CO_2 Concentration), Metric Units

Enclosure Volume (m^3)	Volume Factor f_1 (m^3/kg)	Volume Factor f_2 (kg/m^3)	Calculated Quantity Not Less Than (kg)
Up to 3.96	.086	1.15	--
3.97 - 14.15	.093	1.07	4.5
14.16 - 45.28	0.99	1.01	15.1
45.29 - 127.35	1.11	0.90	45.4
127.36 - 1415.0	1.25	0.80	113.5
Over 1415.0	1.38	0.77	1135.0
Ducts and Covered Trenches (See Section 3-5.2.2.1)	0.50	2.00	--

EXAMPLE 1 - TOTAL FLOODING FOR SURFACE FIRES - Basic Carbon Dioxide Quantity

Consider a room with dimensions of 20 ft. (L) by 30 ft. (W) by 10 ft. (H). Determine the basic carbon dioxide quantity.

From Equation (1): $W_B = V \div f_1$

Where V is Volume Of The Protected Space and f_1 is the Volume Factor.

V = 20 ft. x 30 ft. x 10 ft.

V = 6,000 ft.^{3}

f_1 = 20 ft.^{3}/lb. from Table 3-2 for volumes 4,501 ft.^{3} to 50,000 ft.^{3}

$$W_B = V \div f_1$$

$$W_B = 6,000 \div 20$$

$$W_B = \mathbf{300}\ \text{lb}$$

3-5.2.2.1 Ducts and Covered Trenches

A flooding factor of 8 ft.^{3}/lb. (0.50 m^3/kg), or 0.125 lb./ft.^{3} (2.00 kg/m^3), must be used when total flooding a duct or a covered trench. This results in a concentration of 65% and does not require the use of a Material Conversion Factor (see Paragraph 3-5.2.3). If the accumulation of combustibles on the wall of the duct or trench creates a deep-seated hazard, the system must be designed according to the criteria specified in Paragraph 3-5.3.

3-5.2.3 MATERIAL CONVERSION FACTOR

As shown in Table 3-1, many combustible materials require a carbon dioxide concentration that is higher than 34% for suppression. When such materials are present, the basic quantity of carbon dioxide W_B shall be increased by the appropriate Material Conversion Factor, as determined from the curve shown in Figure 3-1.

(Equation 2)

$$W_C = W_B \times f_C$$

Where:

W_C = Quantity of agent for given concentration, lb.(kg)

W_B = Basic quantity of agent from Equation (1), lb.(kg)

f_C = Material conversion factor from Figure 3-1

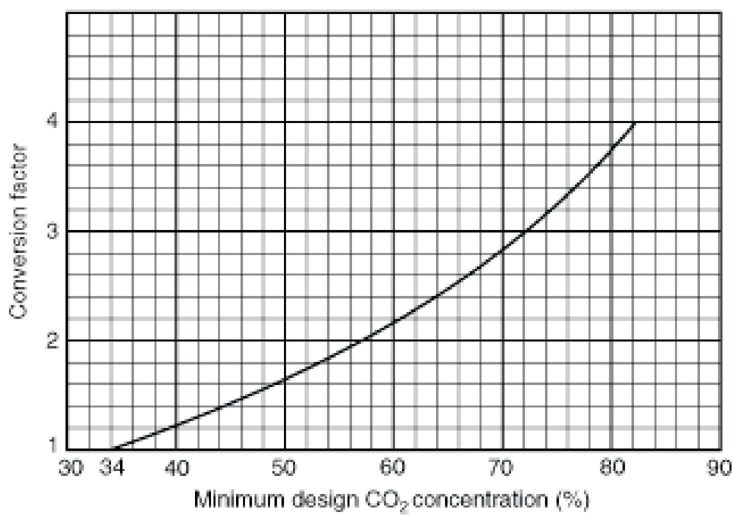


Figure 3-1. Minimum Design CO_2 Concentration⌖

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EXAMPLE 2 - TOTAL FLOODING FOR SURFACE FIRES - Material Conversion Factor

Consider a room with dimensions of 20 ft. (L) by 30 ft. (W) by 10 ft. (H). Determine the carbon dioxide quantity required for suppression, if the hazard contains acetylene.

From Equation (2): $W_C = W_B \times f_C$

Where W_B is the Basic Quantity (34%) and f_C is the Material Conversion Factor.

From Equation (1): $W_B = V \div f_1$

Where V is Volume Of The Protected Space and f_1 is the Volume Factor.

V = 20 ft. x 30 ft. x 10 ft.

V = 6,000 ft.^{3}

f_1 = 20 ft.^{3}/lb. from Table 3-2 for volumes 4,501 ft.^{3} to 50,000 ft.^{3}.

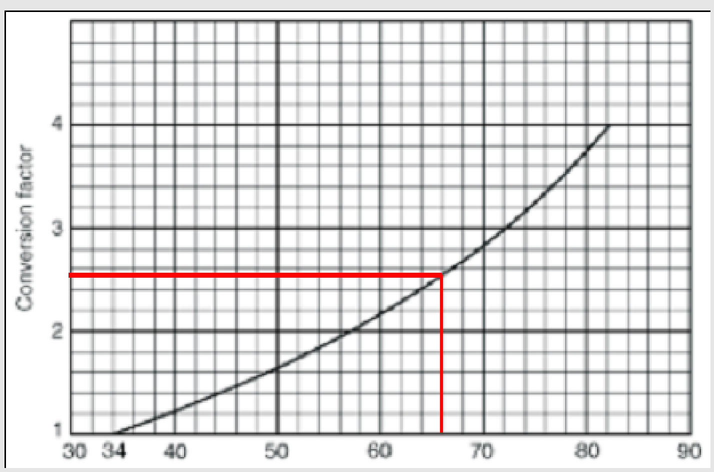
$W_B = V \div f_1$

$W_B = 6,000 \div 20$

$W_B = 300$ lb.

From Table 3-1, the design concentration for acetylene is 66%.

Using Figure 3-1, the Material Conversion Factor f_C for 66% is approximately 2.5.



$W_C = W_B \times f_C$

$W_C = 300 \times 2.5$

3-5.2.4 SPECIAL CONDITIONS

Additional quantities of carbon dioxide are required to compensate for conditions such as openings in the enclosure, forced ventilation, and abnormally high or low ambient temperatures. Such conditions could adversely affect the performance of the carbon dioxide suppression system.

(Equation 3)

$$W_{min} = W_C + W_L + W_V + W_T$$

Where:

W_{min} = Minimum quantity of agent to be supplied, lb.(kg)

W_C = Quantity of agent for design concentration from Equation (2) or Equation (12), lb.(kg)

W_L = Quantity of agent to compensate for uncloseable openings from Equation (6), lb.(kg)

W_V = Quantity of agent to compensate for forced ventilation from Equation (7), lb.(kg)

W_T = Quantity of agent to compensate for extreme temperatures from Equation (10), lb.(kg)

3-5.2.4.1 Uncloseable Openings

Additional carbon dioxide must be provided to compensate for any loss of agent through openings that cannot be closed prior to or at the start of discharge. The additional quantity shall be equal to the anticipated loss at the design concentration for the designed duration of protection, lasting at least 1 minute. This additional quantity of carbon dioxide shall be combined with the basic concentration quantity.

The leakage rate through an opening in an enclosure depends on many factors. If there is no forced ventilation, the leakage will depend on the size and location of the openings. It also will depend on whether there is sufficient leakage in the upper part of the enclosure to allow free flow of air into the enclosure. Since carbon dioxide is heavier than air, there may be little or no loss of carbon dioxide from openings in or near the ceiling. Losses in the walls or at the floor level may be substantial.

To maintain a constant pressure within the enclosure, fresh air must enter through the same opening as the carbon dioxide exits. Therefore, the effective area of the opening is reduced by a factor of 2.

(Equation 4)

$$A_L = A_O \div 2$$

Where:

A_L = Effective leakage area, ft.^{2} (m^2)

A_O = Area of all uncloseable opening, ft.^{2} (m^2)

The leakage rate can be determined using the design concentration, the height from the centerline of the opening to the ceiling, and the graph in Figure 3-2. If multiple openings exist, Kidde suggests using the height to the centerline of the lowest opening in the enclosure, as this will result in the most conservative design.

(Equation 5)

$$q_L = L \times A_L$$

Where:

q_L = Enclosure leakage rate, lb./min (kg/min)

L = Leakage rate from Figure 3-2, lb./min/ft.^{2} (kg/min/m^2)

A_L = Effective leakage area from Equation (4), ft.^{2} (m^2)

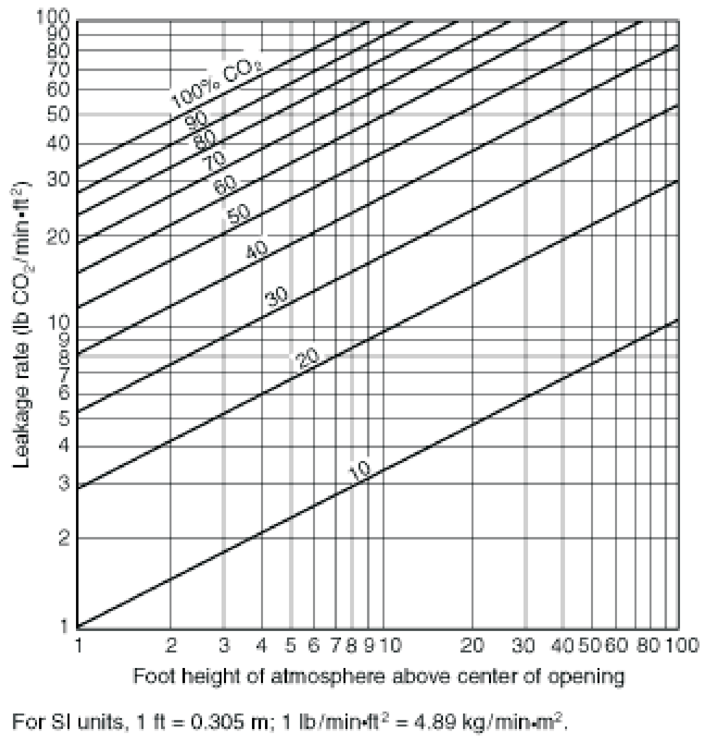


Figure 3-2. Calculated CO_2 Loss Rate[✦]

Note: The loss rate shown in the figure is based on assumed 70°F (21°C) temperature within the enclosure and 70°F (21°C) ambient outside.

Once the leakage rate is determined, the amount of additional carbon dioxide that is required for compensation can be calculated.

(Equation 6)

$$W_L = q_L \times t_P$$

Where:

W_L = Quantity of agent to compensate for uncloseable openings, lb.(kg)

q_L = Enclosure leakage rate from Equation (5), lb./min (kg/min)

t_P = Duration of protection ≥ 1 minute, min

EXAMPLE 3 - TOTAL FLOODING FOR SURFACE FIRES - Uncloseable Openings

Determine the loss rate through a 1 ft. x 1 ft. opening in the wall of an enclosure. The midpoint of the opening is 5 feet below the ceiling, and the system is designed to achieve a 34% concentration.

From Equation (4): $A_L = A_O \div 2$

Where A_L is the Effective Leakage Area and A_O is the Total Leakage Area.

$A_O = 1 \times 1$

$A_O = 1 \text{ ft}^2$

$A_L = A_O \div 2$

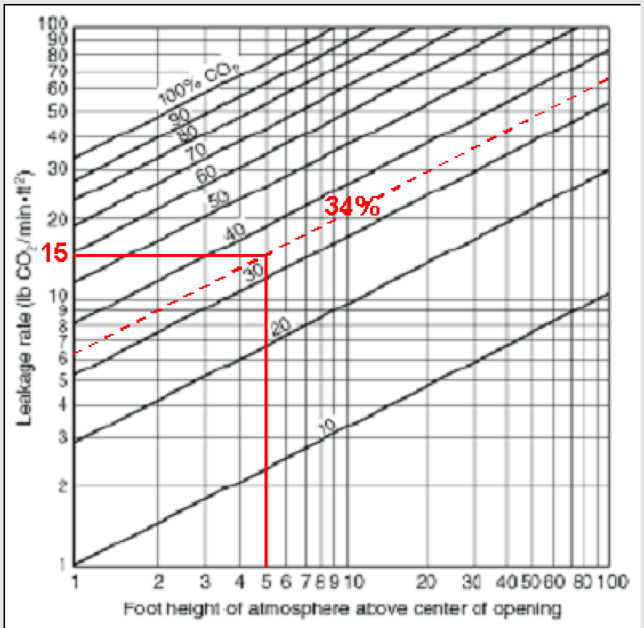
$A_L = 1 \div 2$

$A_L = 0.5 \text{ ft.}^2$

From Equation (5): $q_L = L \times A_L$

Where q_L is the Enclosure Leakage Rate and L is the Leakage Rate from Figure 3-2.

Referring to Figure 3-2, move along the x-axis to the 5 ft. height. Move up at this point to the 34% curve, which must be estimated between the 30% and 40% curves, and then read over to the vertical axis. The approximate leakage rate (L) is determined to be 15 lb./min/ft.^{2}.



For SI units, 1 ft = 0.305 m; 1 lb/min•ft^2 = 4.89 kg/min•m^2.

$q_L = L \times A_L$

$q_L = 15 \times 0.5$

q_L =7.5 lb./min or say 8 lb./min

From Equation (6) $W_L = q_L \times t_p$

Where W_L is the Quantity of Agent Lost and t_P is the Duration of Protection.

$t_p = 1$ min.

$$W_L = q_L \times t_p$$

$$W_L = 8 \times 1$$

$$W_L = 8 \text{ lb.}$$

3-5.2.4.2 Forced Ventilation

Additional carbon dioxide must be provided for any loss of agent due to forced ventilation in the protected area that cannot be shut off or dampered prior to or at the start of discharge. The additional quantity of agent is calculated by dividing the amount of volume moved by the ventilating system during the designed duration of protection, lasting at least 1 minute, by the appropriate flooding factor for the enclosure volume from Table 3-2. The calculated quantity is multiplied by the material conversion factor from Figure 3-1 when the required suppression concentration is greater than 34%. The additional carbon dioxide required to compensate for continuing ventilation shall be combined with the basic concentration quantity.

(Equation 7)

$$W_V = (q_V \times t_p \times f_C) \div f_1$$

or

$$Wv = q_V \times t_p \times f_2 \times f_C$$

Where:

W_V = Quantity of agent to compensate for forced ventilation, lb. (kg)

qV = Ventilation air flow rate, ft.^{3}/min (m^3/min)

t_P = Duration of protection ≥ 1 minute, min

f_1 = Volume factor from Table 3-2 used in Equation (1), ft.^{3}/lb. (m^3/kg)

f_2 = Volume factor from Table 3-2 used in Equation (1), lb./ft.^{3} (kg/m^3)

f_C = Material conversion factor from Figure 3-1 used in Equation (2)

EXAMPLE 4 - TOTAL FLOODING FOR SURFACE FIRES - Forced Ventilation

Consider a room with dimensions of 20 ft. (L) by 30 ft. (W) by 10 ft. (H). Determine the additional carbon dioxide required to compensate for a 1,000 CFM ventilation rate that cannot be shut off. The design concentration is 34% and the duration of protection will be 1 minute.

From Equation (7): $W_V = q_V \times t_P \times f_C \div f_1$

Where W_V is the Quantity of Agent Lost, qV is the Ventilation Air Flow Rate, t_P is the Duration of Protection, f_C is the Material Conversion Factor, and f_1 is the Volume Factor.

qV = 1000 ft.^{3}/min

t_P = 1 min

f_C = 1.0, from Figure 3-1 for 34% concentration

V = 20 ft. x 30 ft. x 10 ft.

V = 6,000 ft.^{3}

f_1 = 20 ft.^{3}/lb. from Table 3-2 for volumes 4,501 ft.^{3} to 50,000 ft.^{3}.

$$W_V = q_v \times t_p \times f_C \div f_1$$

$$W_V = 1000 \times 1 \times 1.0 \div 20$$

$$W_V = \mathbf{50}\text{ lb.}$$

3-5.2.4.3 Extreme Temperatures

An additional quantity of carbon dioxide must be provided to compensate for abnormally low or high ambient temperatures.

For applications where the normal ambient temperature in the enclosure is above 200°F (93°C), a one-percent increase in the calculated total quantity of carbon dioxide must be provided for each additional 5°F (2.78°C) above 200°F (93°C).

(Equation 8)

$$\tau_H = \Delta T_{\text{High}} \div 5 \quad \text{(US Units)}$$

or

$$\tau_H = \Delta T_{\text{High}} \div 2.78 \quad \text{(Metric Units)}$$

Where:

τ_H = High temperature correction factor

ΔT_{high} = Degrees Fahrenheit (Celsius) above 200°F (93°C)

For applications where the normal ambient temperature is less than 0°F (-18°C), a one-percent increase in the calculated total quantity of carbon dioxide must be provided for each 1°F (0.55°C) below 0°F (-18°C).

(Equation 9)

$$\tau_H = \Delta T_{\text{low}} \div 1$$ (US Units)

or

$$\tau_H = \Delta T_{\text{low}} \div 0.55$$ (Metric Units)

Where:

τ_L = Low temperature correction factor

ΔT_{low} = Degrees Fahrenheit (Celsius) below 0°F (-18°C)

The temperature compensation factor, if required, must be added to the basic quantity of agent calculated from the volume factors, and to all of the additional quantities calculated using material conversion factors, leakage equations or curves, and ventilation formulas. The additional carbon dioxide required to compensate for temperature shall be combined with the basic concentration quantity.

(Equation 10)

$$W_T = \tau \times (W_C + W_L + W_V)$$

Where:

W_T = Quantity of agent to compensate for extreme temperatures, lb. (kg)

τ = High or Low temperature correction factor from Equation (8) or (9), whichever factor is greater

W_C = Quantity of agent for given concentration from Equation (2) or Equation (12), lb. (kg)

W_L = Quantity of agent to compensate for uncloseable openings from Equation (6), lb. (kg)

W_V = Quantity of agent to compensate for forced ventilation from Equation (7), lb. (kg)

EXAMPLE 5 - TOTAL FLOODING FOR SURFACE FIRES - Extreme Temperatures

Consider a temperature cycling enclosure with dimensions of 5 ft. (L) by 5 ft. (W) by 5 ft. (H). The design concentration is 34%. The ambient temperature range is -15°F to 250°F. Determine the additional quantity of carbon dioxide to compensate for the extreme temperature range.

From Equation (10): $W_T = \tau \times (W_C + W_L + W_V)$

Where W_T is the Quantity of Agent to Compensate for Extreme Temperatures, τ is the Temperature Correction Factor, W_C is the Quantity of Agent for the Design Concentration, W_L is the Quantity of Agent to Compensate for Leakage, and W_V is the Quantity of Agent to Compensate for Ventilation.

From Equation (2) $W_C = W_B \times f_C$

Where W_B is the Basic Quantity (34%) and f_C is the Material Conversion Factor.

From Equation (1): $W_B = V \div f_1$

Where V is Volume Of The Protected Space and f_1 is the Volume Factor.

V = 5 ft. X 5 ft. X 5 ft.

V = 125 ft.^{3}

f_1 = 14 ft.^{3}/lb., from Table 3-2 for volumes up to 140 ft.^{3}.

$W_B = V \div f_1$

$W_B = 125 \div 14$

W_B = 9 lb.

f_C = 1.0, from Figure 3-1 for 34% concentration

$W_C = W_B \times f_C$

W_C = 9 x 1.0

W_C = 9 lb.

W_L = 0 lb.

W_V = 0 lb.

From Equation (8) $\tau_H = \Delta T_{\text{High}} \div 5$

Where τ_H is the High Temperature Correction Factor and ΔT_{High} is the Degrees Fahrenheit Above 200°F.

$\tau_H = \Delta T_{\text{High}} \div 5$

$\tau_H = 50 \div 5$

$\tau_H = 10\%$

From Equation (9) $\tau_L = \Delta T_{\text{Low}} \div 1$

Where τ_L is the Low Temperature Correction Factor and ΔT_{Low} is the Degrees Fahrenheit below 0°F.

$\tau_L = \Delta T_{\text{Low}} \div 1$

$\tau_L = 15 \div 1$

$\tau_L = 15\%$

$\tau_H < \tau_L$

Therefore, $\tau = \tau_L$

$W_T = \tau \times (W_C + W_L + W_V)$

$W_T = 0.15 \times (9 + 0 + 0)$

$W_T = 1.4 \text{ lb.}$

3-5.2.5 DISCHARGE RATES

For surface fires, the design concentration shall be achieved within 1 minute from the start of discharge.

(Equation 11)

$$q_{min} = W_{min} \div t_{d,\,max}$$

Where:

q_{min} = Minimum discharge rate, lb./min (kg/min)

W_{min} = Minimum quantity of agent to be supplied from Equation (3), lb. (kg)

$t_{d,\,max}$ = Maximum design discharge time ≤1 minute, min

Equation (11) may be applied to determine the minimum discharge rate for a complete system, single hazard, or single nozzle, depending on the value used for W_{min}

Paragraph 3-7 discusses the effect of combination systems with respect to calculating the discharge rate.

EXAMPLE 6 - TOTAL FLOODING FOR SURFACE FIRES - Discharge Rate

Consider a room with dimensions of 20 ft. (L) by 30 ft. (W) by 10 ft. (H). Determine the minimum flow rate required to create a 34% by volume concentration within the acceptable time limit.

From Equation (11): $q_{min} = W_{min} \div t_{d, max}$

Where q_{min} is the Minimum Discharge Rate, W_{min} is the Minimum Agent Quantity, and $t_{d, max}$ is the Maximum Discharge Time.

From Equation (3): $W_{min} = W_C + W_L + W_V + W_T$

Where W_C is the Quantity of Agent for the Design Concentration, W_L is the Quantity of Agent to Compensate for Leakage, W_V is the Quantity of Agent to Compensate for Ventilation, and W_T is the Quantity of Agent to Compensate for Extreme Temperatures.

Equation (2): $W_C = W_B \times f_C$

Where W_B is the Basic Quantity (34%) and f_c is the Material Conversion Factor.

From Equation (1): $W_B = V \div f_1$

Where V is Volume Of The Protected Space and f_1 is the Volume Factor.

V = 20 ft. x 30 ft. x 10 ft.

V = 6,000 ft.^{3}

f_1 = 20 ft.^{3}/lb. from Table 3-2 for volumes 4,501 ft.^{3} to 50,000 ft.^{3}.

$W_B = V \div f_1$

W_B = 6,000 ÷ 20

W_B = 300 lb.

f_c = 1.0, from Figure 3-1 for 34% concentration

$W_C = W_B \times f_C$

W_C = 300 X 1.0

W_C = 300 lb.

W_L = 0 lb.

W_V = 0 lb.

W_T = 0 lb.

$W_{min} = W_C + W_L + W_V + W_T$

W_{min} = 300 + 0 + 0 + 0

W_{min} = 300 lb.

$q_{min} = W_{min} \div t_{d, max}$

q_{min} = 300 ÷ 1

q_{min} **= 300 lb./min**

3-5.3 Calculations for Deep-Seated Fires

Deep-seated fires involve a combination of surface fire and burning within a mass of material. The surface burning is quickly suppressed when a sufficient quantity of carbon dioxide is rapidly discharged into the protected enclosure. However, to extinguish the burning within the mass of material, a sufficiently high concentration must be maintained for an appropriate time period to allow any smoldering to be suppressed and to allow the material to cool to a temperature at which it will not reignite when the carbon dioxide dissipates.

Applications that contain materials that produce surface fires may also contain varying amounts of material that will produce deep-seated fires. Each application must be carefully analyzed to determine the most appropriate suppression approach. The decision to design the suppression system for a surface fire or for deep-seated combustion is usually based upon considerations such as speed of detection versus time to extinguish, mass of materials involved, thermal insulating factors, manual firefighting capabilities and the economic importance of the equipment or materials involved. Often the decision will be made after consultation with the authority having jurisdiction, the owner, and the manufacturer supplying the equipment or material.

To ensure extinguishment of a smoldering fire, the design concentration must be maintained for at least 20 minutes. A longer duration of protection may be necessary, depending on the cooling rate of the smoldering fuel. To accomplish this, a separate extended discharge system may be necessary to compensate for uncloseable openings and forced ventilation that cannot be shut off or dampered. (See Paragraph 3-9).

3-5.3.1 FLOODING FACTORS

Carbon dioxide concentrations for deep-seated fires cannot be determined with the same degree of accuracy as those for surface-burning fires. Flooding factors for deep-seated fires have been determined on the basis of practical testing. The design concentrations shown in Table 3-3 must be used for the applications cited.

Flooding factors for other deep-seated hazards must be determined by specific testing and justified to the satisfaction of the authority having jurisdiction before use.

(Equation 12)

$$W_C = V \div f_1$$

or

$$W_C = V \times f_2$$

Where:

W_C = Quantity of agent for design concentration, lb. (kg)

V = Enclosure volume, ft.^{3} (m^3)

f_1 = Volume factor from Table 3-3, ft.^{3}/lb. (m^3/kg)

f_2 = Volume factor from Table 3-3, lb./ft.^{3} (kg/m^3)

Table 3-3. Volume Factors for Deep Seated Hazards

Specific Hazard	Design Concentration	Volume Factor			
		f_1		f_2	
	(% CO_2)	ft.^{3}/lb.	m^3/kg	ft.^{3}/lb.	m^3/kg
Dry electrical hazards in general spaces ≤ 2000 ft.^{3}) (56.6 m^3)	50	10	0.62	0.100	1.60
Dry electrical hazards in general spaces > 2000 ft.^{3}) (56.6 m^3)	50	12	.75	0.083	1.33
Record (bulk paper) storage, ducts and covered trenches	65	8	0.50	0.125	2.00
Fur storage vaults, dust collectors	75	6	0.38	0.166	2.66

Note that the Volume Factors given in the table will result in the specified concentration. No Material Conversion Factor is required, as used for Surface Fire protection.

EXAMPLE 7 - TOTAL FLOODING FOR DEEP-SEATED FIRES - Basic Carbon Dioxide Quantity

Determine the carbon dioxide quantity required in a bulk paper storage room having dimensions of 20 ft. (L) by 20 ft. (W) by 10 ft. (H) bulk paper storage room.

From Equation (12): $W_C = V \div f_1$

Where W_C is the Basic Quantity of Agent, V is the Volume of the Enclosure, and f_1 is the Volume Factor.

V = 20 ft. x 20 ft. x 10 ft.

V = 4,000 ft.^{3}

f_1 = 8 ft.^{3}/lb. from Table 3-3 for Record (bulk paper) storage

W_C = 4000 $\div 8$

W_C = **500 lb.**

3-5.3.2 SPECIAL CONDITIONS

As with suppression systems for surface fires, suppression systems protecting potential deep-seated hazards require additional quantities of carbon dioxide to compensate for openings in the enclosure, forced air ventilating systems, and abnormally low or high ambient temperatures. The compensating agent quantities are added to the minimum system agent quantity in accordance with Paragraph 3-5.2.4.

3-5.3.2.1 Uncloseable Openings

Any openings in the enclosure that either do not border the ceiling or are not in the ceiling itself and cannot be closed at the time of suppression must be compensated for by additional carbon dioxide equal to the expected leakage rate during the suppression period. The method specified in Paragraph 3-5.2.4.1 shall be used to calculate the additional carbon dioxide quantity. An extended discharge may be required to maintain the concentration for the designed duration of protection, lasting at least 20 minutes (See Paragraph 3-10).

3-5.3.2.2 Forced Ventilation

Additional carbon dioxide must be provided to compensate for a forced air ventilating system that cannot be shut off or dampered prior to or at the start of discharge. The method described in Paragraph 3-5.2.4.2 shall be used to calculate the additional carbon dioxide quantity. An extended discharge may be necessary to ensure the maintenance of the suppression concentration for the designed duration of protection, lasting at least 20 minutes (See Paragraph 3-10).

3-5.3.2.3 Extreme Temperatures

Additional carbon dioxide is required to compensate for abnormally low or high ambient temperatures in the protected area. The additional quantity shall be calculated using the methods described in Paragraph 3-5.2.4.3.

3-5.3.3 DISCHARGE RATES

For deep-seated fires, the design concentration shall be achieved within 7 minutes, but the rate shall not be less than required to develop a concentration of 30% within 2 minutes.

As a guide, the quantity of carbon dioxide required to achieve a 30% concentration is 0.0428 lb./ft.^{3} (0.686 kg/m^3) (See Appendix A-5). Equation (13) may be used to calculate the discharge rate required to achieve this concentration within 2 minutes.

(Equation 13)

$$q_{30} = 0.0214 \times V \text{ (US Units)}$$

or

$$q_{30} = 0.343 \times V \text{ (Metric Units)}$$

Where:

q_{30} = Minimum flow rate to achieve a 30% concentration within minutes, lb./min (kg/min)

V = Enclosure volume, ft.^{3} (m^3)

Perform a check to ensure that the discharge will be complete within seven (7) minutes.

(Equation 14)

$$t_d = W_{min} \div q_{30}$$

Where:

t_d = Discharge time, min

W_{min} = Minimum quantity of agent to be supplied from Equation (3), lb.(kg)

q_{30} = Flow rate from Equation (13), lb./min (kg/min)

If the discharge time t_d calculated in Equation (14) is greater than seven (7) minutes, the minimum discharge rate must be increased.

(Equation 15)

$$q_{min} = W_{min} \div 7$$

Where:

q_{min} = Minimum flow rate, lb./min (kg/min)

W_{min} = Minimum quantity of agent to be supplied from Equation (3), lb. (kg)

EXAMPLE 8 - TOTAL FLOODING FOR DEEP-SEATED FIRES - Discharge Rate #1

Consider a bulk paper storage room with dimensions of 20 ft. (L) by 20 ft. (W) by 10 ft. (H). Determine the discharge rate required to achieve a 30% concentration within 2 minutes and to complete the agent discharge within 7 minutes.

From Equation (3): $W_{min} = W_C + W_V + W_L + W_T$

Where W_C is the Quantity of Agent for the Design Concentration, W_L is the Quantity of Agent to Compensate for Leakage, W_V is the Quantity of Agent to Compensate for Ventilation, and W_T is the Quantity of Agent to Compensate for Extreme Temperatures.

From Equation (12): $W_C = V \div f_1$

Where W_C is the Quantity of Agent for the Design Concentration, V is the Volume of the Enclosure, and f_1 is the Volume Factor.

V = 20 ft. x 20 ft. x 10 ft.

V = 4,000 ft.^{3}

f_1 = 8 ft.^{3}/lb. from Table 3-3 for Record (bulk paper) storage

W_C = 4000 $\div$ 8

W_C = **500 lb.**

W_L = 0 lb.

W_V = 0 lb.

W_T = 0 lb.

$W_{min} = W_C + W_V + W_L + W_T$

W_{min} = 500+0+0+0

W_{min} = 500 lb.

From Equation (13): $q_{30} = 0.0214 \times V$

Where q_{30} is the Minimum Flow Rate to Achieve 30% Within 2 Minutes.

q_{30} = 0.0214 x V

q_{30} = 0.0214 x 4,000

q_{30} = 85.6 lb./min From Equation (14): $t_d = W_{min} \div q_{30}$

Where t_d is the Discharge Time.

$t_d = W_{min} \div q_{30}$

t_d = 500 ÷ 85.6

t_d = 5.8 min

Since t_d < 7 min, $q_{min} = q_{30}$

q_{min} = 86 lb./min

EXAMPLE 8 - TOTAL FLOODING FOR DEEP-SEATED FIRES - Discharge Rate #2

Consider a dust collector having a volume of 3,000 ft.^{3}*. Determine the discharge rate required to achieve a 30% concentration within 2 minutes and to complete agent discharge within 7 minutes.*

From Equation (3): $W_{min} = W_C + W_V + W_L + W_T$

Where W_C is the Quantity of Agent for the Design Concentration, W_L is the Quantity of Agent to Compensate for Leakage, W_V is the Quantity of Agent to Compensate for Ventilation, and W_T is the Quantity of Agent to Compensate for Extreme Temperatures.

From Equation (12): $W_C = V \div f_1$

Where W_C is the Quantity of Agent for the Design Concentration, V is the Volume of the Enclosure, and f_1 is the Volume Factor.

V = 3,000 ft.^{3}

f_1 = 6 ft.^{3}/lb. from Table 3-3 for Dust Collectors

W_C = 3000 ÷ 6

W_C = **500 lb.**

W_L = 0 lb.

W_V = 0 lb.

W_T = 0 lb.

$W_{min} = W_C + W_V + W_L + W_T$

W_{min} = 500+0+0+0

W_{min} = 500 lb.

From Equation (13): $q_{30} = 0.0214 \times V$

Where q_{30} is the Minimum Flow Rate to Achieve 30% Within 2 Minutes.

q_{30} = 0.0214 x V

q_{30} = 0.0214 x 3,000

q_{30} = 64.2 lb./min

From Equation (14): $t_d = W_{min} \div q_{30}$

Where t_d is the Discharge Time.

$t_d = W_{min} \div q_{30}$

t_d = 500 ÷ 64.2

t_d = 7.8 min

Since t_d > 7 min, the minimum discharge rate must be increased.

From Equation (15): $q_{min} = W_{min} \div 7$

Where q_{min} is the Minimum Flow Rate.

$q_{min} = W_{min} \div 7$

q_{min} = 500 ÷ 7

q_{min} **= 71.4 lb./min**

3-5.4 System Design

3-5.4.1 OCCUPANCY

Carbon dioxide total flooding systems shall not be installed in normally occupied enclosures.

Note: NFPA 12, 2005 Edition, allows use under specified conditions.

Consideration shall be given to the possibility of carbon dioxide drifting and settling into adjacent places outside the protected area and to the possibility that personnel could be trapped in or enter into an atmosphere made hazardous by a carbon dioxide discharge. Safeguards shall be provided to ensure prompt evacuation, to prevent entry into such atmospheres and to provide means for prompt rescue of any trapped personnel. Personnel training shall be provided.

If personnel could be in the protected space at any time, the following safety devices shall be integrated into the carbon dioxide fire suppression system (Reference Paragraph 1-6.1):

- Pneumatic pre-discharge alarm (Pressure Operated Siren)
- Pneumatic Discharge delay (Discharge Delay)
- Addition of a distinctive odor to the discharging carbon dioxide (Odorizer Part No. 81-897637-000 and 10030080), or automatic alarms that are activated by an oxygen or carbon dioxide detector, or establishment and enforcement of confined space entry procedures
- Warning signs in accordance with NFPA 12 (Warning Signs Part No. 06-231866-8XX
- Carbon dioxide system Lock-Out valve (Lockout Valves)

WARNING **The Pneumatic Discharge Delay and any other valve that controls the flow of agent shall be fitted with a manual bypass control that is supervised to alert personnel when the device is in the bypass mode.**

All closed sections of pipe (i.e., upstream of any time delay or lockout valves) shall be fitted with a Safety Outlet (Part No. 81-803242-000).

3-5.4.2 DISCHARGE NOZZLES

For total flooding of large enclosures, Type "S" and Type "M" nozzles are generally used. For total flooding of ducts and small enclosures, the Type "V" nozzle may be used.

The number of nozzles required depends on the following considerations:

- Maximum Spacing: 20 ft. (6.1 m)
- Flow Rate: Up to 120 lb./min (55 kg/min) per nozzle for "S" and "V" nozzles; Up to 240 lb./min (110 kg/min) per nozzle for "M" nozzles

If obstructions within the protected space interfere with the efficient distribution of the carbon dioxide or if lower nozzle flow rates are desired, it may be necessary to increase the quantity of nozzles.

The type of nozzles selected and their placement shall be such that the discharge will not unduly splash flammable liquids or create dust clouds that might extend the fire, create an explosion, or otherwise adversely affect the contents of the enclosure.

3-5.4.3 PRESSURE RELIEF VENTING

Pressure relief venting shall be verified and provided in accordance with NFPA 12.

3-6 LOCAL APPLICATION SYSTEMS

A local application system consists of a fixed supply of carbon dioxide permanently connected to fixed piping with nozzles arranged to discharge directly into the fire where a permanent enclosure about the hazard does not exist.

WARNING

Personnel should be made aware of the hazards associated with the discharge of carbon dioxide in local application systems. Hazards to personnel consist of obstruction of vision and reduction in oxygen to a level that will not support life. These hazards can be expected to occur not only in the immediate area of discharge, but also in adjacent areas to which the carbon dioxide gas may migrate. Appropriate alarms shall be used to alert personnel so that they may be evacuated from the protected space prior to system discharge. Suitable warning signs must be prominently displayed in clear view in the protected area and at the point of entry into the protected area to alert people to the asphyxiation properties of carbon dioxide.

3-6.1 Carbon Dioxide Requirements

Local application design is based on three key factors:

- Nozzle location, orientation, and coverage area
- Rate of discharge
- Duration of liquid discharge

3-6.1.1 NOZZLE LOCATION, ORIENTATION, AND COVERAGE AREA

Since the concept of local application fire suppression is based on discharging suppressant directly onto the burning fuel, the nozzle location, orientation, and coverage area are primary factors in a successful system design. Each design approach, the Rate-by-Area method (See Paragraph 3-6.2) or the Rate-by-Volume method (See Paragraph 3-6.3), has specific requirements.

3-6.1.2 RATE OF DISCHARGE

Since local application systems do not retain an inert atmosphere beyond the end of system discharge, it is extremely important to discharge carbon dioxide at a rate that is sufficient to extinguish a flame, while refraining from spreading the fire.

The rate of carbon dioxide discharge is calculated either by the Rate-by-Area method (See Paragraph 3-6.2) or the Rate-by-Volume method (See Paragraph 3-6.3).

3-6.1.3 DURATION OF LIQUID DISCHARGE

When a cylinder of carbon dioxide is discharged, a portion of the discharge will be liquid and the remainder will be vapor. It has been found that only the liquid portion of the discharge is effective in extinguishing fires by local application methods.

The minimum liquid discharge time for local application systems is 30 seconds (0.5 min). However, the minimum time shall be increased to compensate for any hazard condition that would require a longer cooling period to ensure complete extinguishment.

In the case where the fuel has an auto ignition temperature below its boiling point, such as paraffin wax and cooking oils, the liquid discharge time shall be of a sufficient duration such that the fuel is cooled below the auto ignition temperature. The minimum discharge time for such fuels is 3 minutes.

3-6.1.4 QUANTITY OF CARBON DIOXIDE

The quantity of carbon dioxide to be supplied is based on the total calculated rate of discharge for the hazard and the design duration of liquid discharge. To account for the vapor portion of the discharge, a vaporization factor of 40% is applied.

(Equation 16)

$$W_{min} = 1.4 \times q \times t_{liq}$$

Where:

W_{min} = Minimum quantity of agent to be supplied, lb. (kg)

q = Total calculated rate of discharge for local application hazards, lb./min (kg/min)

t_{liq} = Duration of liquid discharge, min

This quantity shall be increased by a sufficient amount to compensate for vaporization of liquid due to cooling of the discharge pipe. Kidde Fire Systems CO_2 Calculation Software (Part No. 81-190001-XXX) takes this phenomenon into account. NFPA 12 may be referenced for additional information.

3-6.2 Rate-by-Area Method

The Rate-by-Area application of carbon dioxide is used to suppress fires on flat surfaces or low-level hazards associated with horizontal surfaces. These include dip tanks, drain boards, fryers, and floor areas. The basis of this method lies in determining the square footage of the hazard area. Both the discharge rate and area coverage of the nozzles are based upon nozzle height above the hazard. Once the nozzle height, discharge rate, and nozzle area coverage has been established, the nozzle spacing, and consequently, the number of nozzles are determined.

Where deep layer flammable liquid fires are to be protected, a minimum freeboard of 6 in. (152 mm) shall be provided.

3-6.2.1 OVERHEAD NOZZLES

Overhead nozzles are the most common method of applying a rate-by-area local application system. In this case, Type "S" and Type "M" nozzles are used to suppress fires on liquid surfaces (e.g., dip tank) or coated surfaces (e.g., drip board).

3-6.2.1.1 Nozzle Coverage and Carbon Dioxide Requirements

Nozzles are selected for their coverage and flow rate to minimize the amount of carbon dioxide required. Occasionally, hazard conditions may restrict nozzle placements.

Refer to Table 3-4 and Table 3-5 for the height/area coverage/flow rate data, for the Type "S" and Type "M" nozzles. Extrapolations above or below nozzle approval listings are not permitted.

The portion of a hazard protected by a single nozzle is based on its "side of square" coverage and the distance to the protected surface. Generally, the farther the nozzle is from the protected surface, the larger the area covered and the greater the required discharge rate to sufficiently penetrate the fire. However, the discharge must also be tempered to prevent splashing of burning liquid fuels.

The quantity of overhead nozzles needed to protect a hazard may be calculated using Equations (17) through (19).

(Equation 17)

$$N_w = w \div s$$

Where:

N_w = Number of nozzle columns
w = Width of protected area, ft. (m)
s = Side of square from Table 3-4 or Table 3-5, ft. (m)

(Equation 18)

$$N_l = l \div s$$

Where:

N_l = Number of nozzle rows
l = Length of protected area, ft. (m)
s = Side of square from Table 3-4 or Table 3-5, ft. (m)

(Equation 19)

$$N = \bar{N}_w \times \bar{N}_l$$

Where:

N = Quantity of nozzles
$\bar{N}_w$ = N_w from Equation (17) rounded up to the next whole number
$\bar{N}_l$ = N_l from Equation (18) rounded up to the next whole number

The total discharge rate for overhead nozzle protection may be calculated using Equation 20.

(Equation 20)

$$q_{OH} = q_n \times N$$

Where:

q_{OH} = Total discharge rate for overhead nozzle protection, lb./min (kg/min)
q_n = Single nozzle discharge rate from Table 3-4 or Table 3-5, lb./min (kg/min)
N = Quantity of nozzles from Equation (19)

Table 3-4A. Type "M" Multijet Nozzle (US Units)

COATED SURFACE		NOZZLE		LIQUID SURFACE	
Area (ft.^{2})	Side of Square (ft.)	Height	Flow Rate (lb./min)	Area (ft.^{2})	Side of Square (ft.)
12.6	3.54	2'-0"	31.0	9.0	3.00
13.3	3.64	2'-3"	34.5	9.5	3.08
14.0	3.74	2'-6"	38.0	10.0	3.16
14.7	3.83	2'-9"	42.5	10.5	3.24
15.4	3.92	3'-0"	45.0	11.0	3.32
16.1	4.01	3'-3"	47.5	11.5	3.39
16.8	4.09	3'-6"	52.0	12.0	3.46
17.5	4.18	3'-9"	55.5	12.5	3.54
18.2	4.26	4'-0"	59.0	13.0	3.60
18.9	4.35	4'-3"	62.5	13.5	3.67
19.6	4.42	4'-6"	66.0	14.0	3.74
20.3	4.50	4'-9"	69.5	14.5	3.81
21.0	4.57	5'-0"	73.0	15.0	3.87
21.7	4.65	5'-3"	76.5	15.5	3.94
22.4	4.72	5'-6"	80.0	16.0	4.00
23.1	4.80	5'-9"	83.5	16.5	4.05
23.8	4.87	6'-0"	87.0	17.0	4.12
24.5	4.94	6'-3"	90.5	17.5	4.18
25.2	5.01	6'-6"	94.0	18.0	4.24
25.9	5.08	6'-9"	97.5	18.5	4.30
26.6	5.15	7'-0"	101.0	19.0	4.35
27.3	5.22	7'-3"	104.5	19.5	4.41
28.0	5.28	7'-6"	108.0	20.0	4.47
28.0	5.28	7'-9"	111.5	20.0	4.47
28.0	5.28	8'-0"	115.0	20.0	4.47
28.0	5.28	8'-3"	118.5	20.0	4.47
28.0	5.28	8'-6"	122.0	20.0	4.47
28.0	5.28	8'-9"	125.5	20.0	4.47
28.0	5.28	9'-0"	129.0	20.0	4.47

Table 3-4B. Type "M" Multijet Nozzle (Metric Units)

COATED SURFACE		NOZZLE		LIQUID SURFACE	
Area (m^2)	**Side of Square (m)**	**Height (m)**	**Flow Rate (kg/min)**	**Area (m^2)**	**Side of Square (m)**
1.17	1.08	0.61	14.1	0.84	0.91
1.24	1.11	0.69	15.6	0.88	0.94
1.30	1.14	0.76	17.2	0.93	0.96
1.37	1.17	0.84	19.3	0.98	0.99
1.43	1.19	0.91	20.4	1.02	1.01
1.50	1.22	0.99	21.5	1.07	1.03
1.56	1.25	1.07	23.6	1.11	1.05
1.63	1.27	1.14	25.2	1.16	1.08
1.69	1.30	1.22	26.8	1.21	1.10
1.76	1.33	1.30	28.3	1.25	1.12
1.82	1.35	1.37	29.9	1.30	1.14
1.89	1.37	1.45	31.5	1.35	1.16
1.95	1.39	1.52	33.1	1.39	1.18
2.02	1.42	1.60	34.7	1.44	1.20
2.08	1.44	1.68	36.3	1.49	1.22
2.15	1.46	1.75	37.9	1.53	1.23
2.21	1.48	1.83	39.5	1.58	1.26
2.28	1.51	1.91	41.1	1.63	1.27
2.34	1.53	1.98	42.6	1.67	1.29
2.41	1.55	2.06	44.2	1.72	1.31
2.47	1.57	2.13	45.8	1.77	1.33
2.54	1.59	2.21	47.4	1.81	1.34
2.60	1.61	2.29	49.0	1.86	1.36
2.60	1.61	2.36	50.6	1.86	1.36
2.60	1.61	2.44	52.2	1.86	1.36
2.60	1.61	2.51	53.8	1.86	1.36
2.60	1.61	2.59	55.3	1.86	1.36
2.60	1.61	2.67	56.9	1.86	1.36
2.60	1.61	2.74	58.5	1.86	1.36

Table 3-5A. Type “S” Multijet Nozzle (US Units)

COATED SURFACE		NOZZLE		LIQUID SURFACE	
Area (ft.^{2})	Side of Square (ft.)	Height	Flow Rate (lb./min)	Area (ft.^{2})	Side of Square (ft.)
7.0	2.65	1’-0”	16	5.0	2.24
7.7	2.78	1’-3”	17.5	5.5	2.34
8.4	2.9	1’-6”	20	6.0	2.45
9.0	3.0	1’-9”	22	6.4	2.53
9.8	3.13	2’-0”	24	7.0	2.65
10.4	3.22	2’-3”	26	7.4	2.72
10.9	3.3	2’-6”	28	7.8	2.79
11.6	3.41	2’-9”	30	8.3	2.88
12.2	3.49	3’-0”	32	8.7	2.95
12.9	3.59	3’-3”	34.5	9.2	3.03
13.6	3.69	3’-6”	36.5	9.7	3.11
14.3	3.78	3’-9”	38.5	10.2	3.19
15.0	3.87	4’-0”	41	10.7	3.27
15.5	3.94	4’-3”	43	11.1	3.33
16.1	4.01	4’-6”	45	11.5	3.39
16.9	4.1	4’-9”	47	12.1	3.48
17.6	4.19	5’-0”	49	12.5	3.54
18.2	4.26	5’-3”	51	13.0	3.61
18.9	4.34	5’-6”	53	13.5	3.67
19.6	4.42	5’-9”	55	14.0	3.74
20.3	4.5	6’-0”	57	14.5	3.81
21.0	4.57	6’-3”	59.5	15.0	3.87
21.0	4.57	6’-6”	61.5	15.0	3.87
21.0	4.57	6’-9”	63.5	15.0	3.87
21.0	4.57	7’-0”	66	15.0	3.87
21.0	4.57	7’-3”	68	15.0	3.87
21.0	4.57	7’-6”	70	15.0	3.87
21.0	4.57	7’-9”	72	15.0	3.87
21.0	4.57	8’-0”	74	15.0	3.87

Table 3-5B. Type “S” Multijet Nozzle (Metric Units)

COATED SURFACE		NOZZLE		LIQUID SURFACE	
Area (m^2)	**Side of Square (m)**	**Height (m)**	**Flow Rate (kg/min)**	**Area (m^2)**	**Side of Square (m)**
0.65	0.81	0.30	7.3	0.46	0.68
0.72	0.85	0.38	7.9	0.51	0.71
0.78	0.88	0.46	9.1	0.56	0.75
0.84	0.91	0.53	10.0	0.59	0.77
0.91	0.95	0.61	10.9	0.65	0.81
0.97	0.98	0.69	11.8	0.69	0.83
1.01	1.01	0.76	12.7	0.72	0.85
1.08	1.04	0.84	13.6	0.77	0.88
1.13	1.06	0.91	14.5	0.81	0.90
1.20	1.09	0.99	15.6	0.85	0.92
1.26	1.12	1.07	16.6	0.90	0.95
1.33	1.15	1.14	17.5	0.95	0.97
1.39	1.18	1.22	18.6	0.99	1.00
1.44	1.20	1.30	19.5	1.03	1.01
1.50	1.22	1.37	20.4	1.07	1.03
1.57	1.25	1.45	21.3	1.12	1.06
1.64	1.28	1.52	22.2	1.16	1.08
1.69	1.30	1.60	23.1	1.21	1.10
1.76	1.32	1.68	24.0	1.25	1.12
1.82	1.35	1.75	24.9	1.30	1.14
1.89	1.37	1.83	25.9	1.35	1.16
1.95	1.39	1.91	27.0	1.39	1.18
1.95	1.39	1.98	27.9	1.39	1.18
1.95	1.39	2.06	28.8	1.39	1.18
1.95	1.39	2.13	29.9	1.39	1.18
1.95	1.39	2.21	30.8	1.39	1.18
1.95	1.39	2.29	31.8	1.39	1.18
1.95	1.39	2.36	32.7	1.39	1.18
1.95	1.39	2.44	33.6	1.39	1.18

EXAMPLE 9 - LOCAL APPLICATION: RATE-BY-AREA - Overhead Nozzles

Consider a dip tank with surface dimensions 4 ft. (W) x 8 ft. (L). A survey of the hazard indicates nozzles may be located 4 to 6 ft. above the liquid surface without being an obstacle to normal working conditions. Determine the optimum nozzle height that minimizes the carbon dioxide supply and nozzle quantity requirements.

Examine the Type "S" and Type "M" nozzle coverage for liquid surfaces in Table 3-4 and Table 3-5.

For a Type 'M' nozzle at 4 ft. above the protected surface:

From Equation (17): $N_w = w \div s$

Where N_w is the Quantity Of Nozzles Along The Width Of The Protected Surface, w is the Width of the Protected Surface, and s is the Maximum Side of Square.

From Table 3-4A:

s = 3.6 ft.

$N_w = w \div s$

N_w = 4 ÷ 3.6

N_w = 1.1

$N_w \cong 2$

From Equation (18): $N_l = l \div s$

Where N_l is the Quantity Of Nozzles Along The Length Of The Protected Surface and l is the Length of the Protected Surface.

$N_l = l \div s$

N_l = 8 ÷ 3.6

N_l = 2.2

$N_l \cong 3$

From Equation (19): $N = \overline{N}_w \times \overline{N}_l$

Where N is the Total Quantity of Nozzles.

$N = \overline{N}_w \times \overline{N}_l$

N = 2 x 3

N = 6

From Equation (20): $q_{OH} = q_n \times N$

Where q_{OH} is the Total Discharge Rate and q_n is the Discharge Rate of a Single Nozzle.

From Table 3-4A:

q_n = 59 lb./min

q_{OH} = q_n x N

q_{OH} = 59 x 6

q_{OH} = 354 lb./min

Using the same procedure, determine the minimum quantity of agent and nozzles that could be used. It is best to use a spreadsheet for such calculations. The following table provides a summary of the results

Nozzle Type	Height (ft.-in)	Flow Rate (lb./min)	Side of Square (ft.)	Qty of Nozzles			Total Rate (lb./min)
				N_w	N_l	Total	
M	4-0	59	3.6	2	3	6	354
	4-3	62.5	3.67	2	3	6	375
	4-6	66	3.74	2	3	6	396
	4-9	69.5	3.81	2	3	6	417
	5-0	73	3.87	2	3	6	438
	5-3	76.5	3.94	2	3	6	459
	5-6	**80**	**4.0**	**1**	**2**	**2**	**160**
	5-9	83.5	4.05	1	2	2	167
	6-0	87	4.12	1	2	2	174
S	4-0	41	3.27	2	3	6	246
	4-3	43	3.33	2	3	6	258
	4-6	45	3.39	2	3	6	270
	4-9	47	3.48	2	3	6	282
	5-0	49	3.54	2	3	6	294
	5-3	51	3.61	2	3	6	306
	5-6	53	3.67	2	3	6	318
	5-9	55	3.74	2	3	6	330
	6-0	57	3.81	2	3	6	342

Selecting Type 'M' nozzles at a height of 66 in. results in the lowest quantity of nozzles (2) and total flow rate (160 lb./min).

From Equation (16): $W_{min} = 1.4 \times q \times t_{liq}$

Where W_{min} is the Minimum Quantity of Agent to Be Supplied and t_{liq} is the Duration of Liquid Discharge.

From Paragraph 3-6.1.3:

t_{liq} = 0.5 min

W_{min} = 1.4 x q x t_{liq}

W_{min} = 1.4 x 160 x 0.5

W_{min} **= 112 lb.**

3-6.2.1.2 Nozzle Positioning

Overhead nozzles shall be aimed and located over the protected area in accordance with Table 3-6 and as demonstrated in Figure 3-3. The aiming factor is multiplied by the total width of the protected area to determine the location of the aiming point from the edge nearest the nozzle.

The height used in determining the flow rate of the nozzle shall be the distance from the aiming point on the hazard to the face of the nozzle (See Figure 3-3).

The nozzle shall be located so as to be free of possible obstructions that could interfere with the delivery of carbon dioxide to the protected surface and so as to develop an extinguishing atmosphere over coated stock extending above a protected surface.

If air currents, wind, or forced drafts are present, discharged carbon dioxide may be prevented from reaching the protected surface in adequate concentrations to extinguish a fire. Additionally, sufficient air velocity may cause liquid to splash and escape the hazard area, potentially spreading a fire. In the event of such circumstances, nozzles shall be located so as to compensate for these effects and consideration shall be given to installing additional nozzles outside the hazard area.

Table 3-6. Aiming Factors for Angular Placement of Nozzles[1]

Discharge Angle[2]	Aiming Factors[3]
45 - 60	1/4
60 - 75	1/4 - 3/8
75 - 90	3/8 - 1/2
90 (perpendicular)	1/2 (center)

[1] Based on 6-inch (152 mm) freeboard.

[2] Degrees from plane of hazard surface.

[3] Fractional amount of nozzle coverage area.

Note: Also see Figure 3-3.

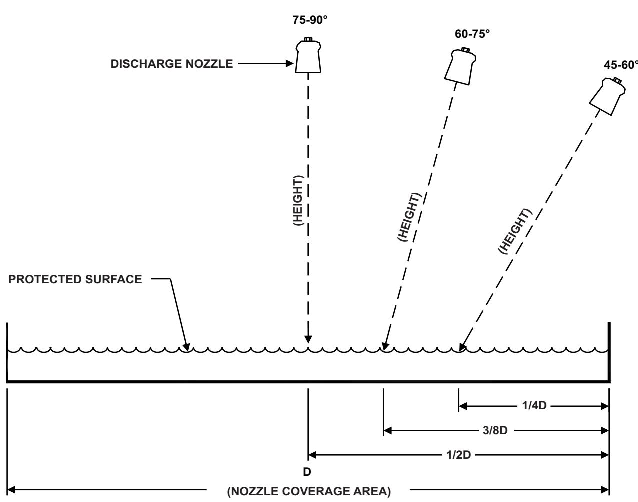


Figure 3-3. Nozzle Aiming

3-6.2.2 TANKSIDE TYPE "L" NOZZLE

Type "L" nozzles provide a fanned discharge that blankets a liquid surface (e.g., dip tank) or coated surface (e.g., drip board) with carbon dioxide. Nozzles are mounted on the freeboard for liquid surface coverage and on the edge of coated surfaces in accordance with spacing requirements.

3-6.2.2.1 Rate for Liquid Surface

The minimum flow rate per coverage area per nozzle for tankside protection of liquid surfaces shall be selected from Table 3-7.

Table 3-7A. Liquid Surfaces[1] (US Units)

Area ($ft.^2$)	**Min. Rate ($lb./min.\text{-}ft.^2$)**	**Max. Rate ($lb./min.\text{-}ft.^2$)**
1	4.14	37.7
2	4.14	19.7
3	4.14	13.7
4	4.14	11.0
5	4.14	8.9
6	4.14	7.8
7	4.14	6.8
8	4.14	6.2
9	4.14	5.7
10	4.14	5.3
11	4.32	5.0
11.75	4.77	4.8

[1] CO_2 required is approximately 3 $lb./ft.^2$

Table 3-7B. Liquid Surfaces[1] (Metric Units)

Area (m^2)	Min. Rate ($kg/min.-m^2$)	Max. Rate ($kg/min.-m^2$)
0.093	20.2	184.1
0.186	20.2	96.2
0.279	20.2	66.9
0.372	20.2	53.7
0.465	20.2	43.5
0.557	20.2	38.1
0.650	20.2	33.2
0.743	20.2	30.3
0.836	20.2	27.8
0.929	20.2	25.9
1.022	21.1	24.4
1.092	23.3	23.4

[1] CO_2 required is approximately 3 $lb./ft.^2$

3-6.2.2.2 Rate for Coated Surface

The minimum flow rate per coverage area per nozzle for tankside protection of coated surfaces shall be selected from Table 3-8.

Table 3-8A. Coated Surfaces[1] (US Units)

Area ($ft.^2$)	**Min. Rate ($lb./min.-ft.^2$)**	**Max. Rate ($lb./min.-ft.^2$)**
1	2.96	37.2
2	2.96	19.4
3	2.96	13.2
4	2.96	10.2
5	2.96	8.4
6	2.96	7.2
7	2.96	6.3
8	2.96	5.7
9	2.96	5.2
10	2.96	4.8
11	2.96	4.5
12	2.96	4.2
13	2.96	4.0
14	2.96	3.8
15	3.09	3.6
16	3.19	3.5
16.5	3.39	3.4

[1] CO_2 required is approximately 2 $lb./ft.^2$

Table 3-8B. Coated Surfaces[1] (Metric Units)

Area (m^2)	Min. Rate ($kg/min.-m^2$)	Max. Rate ($kg/min.-m^2$)
0.093	14.5	181.6
0.186	14.5	94.7
0.279	14.5	64.4
0.372	14.5	49.8
0.465	14.5	41.0
0.557	14.5	35.2
0.650	14.5	30.8
0.743	14.5	27.8
0.836	14.5	25.4
0.929	14.5	23.4
1.022	14.5	22.0
1.115	14.5	20.5
1.208	14.5	19.5
1.301	14.5	18.6
1.394	15.1	17.6
1.486	15.6	17.1
1.533	16.6	16.6

[1] CO_2 required is approximately 2 $lb./ft.^2$

3-6.2.2.3 Nozzle Coverage and Carbon Dioxide Requirements

Whereas overhead nozzles are based on "side of square" coverage (one dimension), tankside coverage is based on surface area (two dimensions). Since the Type "L" nozzle has a limited discharge thrust, it is necessary to maintain a maximum dimension on all sides of the coverage area. The following limits shall be observed:

- Maximum surface area per Table 3-7 or Table 3-8
- Maximum throw (forward): 4 ft. (1.22 m)
- Maximum distance between adjacent nozzles: 5 ft. (1.52 m)
- Maximum distance between first/last nozzle and corner of hazard area: 2-1/2 ft. (0.76 m)

Assuming a row of nozzles on each side of the hazard surface, the maximum hazard width is 8 ft. (2.44 m) for systems using tankside nozzles only. For hazards that exceed this limitation, additional overhead nozzles may be used to provide coverage of the area along the centerline of the protected surface. When overhead nozzles are used in conjunction with tankside nozzles, the flow rate for the overhead portion shall be calculated in accordance with Paragraph 3-6.3.1. The total discharge rate for the hazard shall be the sum of the tankside (q_{TS}) and overhead (q_{OH}) portions.

The quantity of tankside nozzles may be calculated using Equations (21) through (27).

(Equation 21)

$$N_w = w \div 4 \text{ (US Units)}$$

or

$$N_w = w \div 1.22$$

Where:

N_w = Number of nozzle rows

w = Width of protected area, ft. (m)

(Equation 22)

$$S_w = w \div \bar{N}_w$$

Where:

S_w = Width of nozzle coverage area, ft. (m)

w = Width of protected area up to 8 ft. (2.44 m), ft. (m)

$\bar{N}_w$ = N_w from Equation (21) rounded up to the next whole number

(Equation 23)

$$S_{l,\,max} = A_{max} \div S_w$$

Where:

$S_{l,\,max}$ = Maximum length of nozzle coverage area, ft. (m)

A_{max} = 11.75 ft.^{2} (1.092 m^2) for liquid surfaces; 16-1/2 ft.^{2} (1.533 m^2) for coated surfaces

s_w = Width of nozzle coverage area from Equation (22), ft. (m)

(Equation 24)

$$N_l = l \div S_{l,\,max}$$

Where:

N_l = Number of nozzles per row

l = Length of protected area, ft. (m)

$S_{l,\,max}$ = Maximum length of nozzle coverage area from Equation (23) up to 5 ft. (1.52 m), ft. (m)

(Equation 25)

$$s_l = l \div \overline{N}_l$$

Where:

s_l = Length of nozzle coverage area, ft. (m)

l = Length of protected area, ft. (m)

$\overline{N}_l$ = N_l from Equation (24) rounded up to the next whole number

(Equation 26)

$$A_{act} = s_w \times s_l$$

Where:

A_{act} = Actual nozzle coverage area, ft.^{2} (m^2)

s_w = Width of nozzle coverage area from Equation (22), ft. (m)

s_l = Length of nozzle coverage area from Equation (25), ft. (m)

(Equation 27)

$$N = \overline{N_w} \times \overline{N_l}$$

Where:

N = Quantity of nozzles

$\overline{N_w}$ = N_w from Equation (21) rounded up to the next whole number

$\overline{N_l}$ = N_l from Equation (24) rounded up to the next whole number

The total discharge rate for tankside nozzle protection may be calculated using Equation 28.

(Equation 28)

$$q_{TS} = q_n \times A_{act} \times N$$

Where:

q_{TS} = Total discharge rate for tankside nozzle protection, lb./min (kg/min)

q_n = Single nozzle discharge rate from Table 3-7 or Table 3-8, lb./min (kg/min)

A_{act} = Actual nozzle coverage area from Equation (26), ft.^{2} (m^2)

N = Quantity of nozzles from Equation (27)

EXAMPLE 10 - LOCAL APPLICATION: RATE-BY-AREA - Tankside Nozzles

Consider a quench tank with liquid surface dimensions of 3 ft. (W) x 7 ft. (L). Minimize carbon dioxide and nozzle requirements while using a tankside nozzle location. Calculate the quantity of nozzles, minimum flow rate and the minimum carbon dioxide supply for the hazard.

From Equation (21): $N_w = w \div 4$

Where N_w is the Quantity Of Nozzle Rows and w is the Width of the Protected Area.

$N_w = w \div 4$

$N_w = 3 \div 4$

$N_w = 0.75$

$N_w \cong 1$ row

From Equation (22): $s_w = w \div \bar{N}_w$

Where s_w is the Width of the Nozzle Coverage Area.

$s_w = w \div \bar{N}_w$

$s_w = 3 \div 1$

$s_w = 3$ ft.

From Equation (23): $S_{l, max} = A_{max} \div S_w$

Where $s_{l, max}$ is the Maximum Nozzle Coverage Length and A_{max} is the Maximum Nozzle Coverage Area.

From Table 3-7A:

$A_{max} = 11.75$ ft.^{2}

$S_{l, max} = A_{max} \div S_w$

$s_{l, max} = 11.75 \div 3$

$s_{l, max} = 3.9$ ft.

From Equation (24): $N_l = l \div S_{l, max}$

Where N_l is the Quantity of Nozzles per Row and l is the Length of the Protected Surface.

$N_l = l \div S_{l, max}$

$N_l = 7 \div 3.9$

$N_l = 1.8$

$N_l \cong 2$ nozzles

From Equation (25): $s_l = l \div \overline{N}_l$

Where s_l is the Length of the Nozzle Coverage Area.

$s_l = l \div \overline{N}_l$

s_l = 7 ÷ 2

s_l = 3-1/2 ft.

From Equation (26): $A_{act} = s_w \times s_l$

Where A_{act} is the Actual Nozzle Coverage Area.

A_{act} = s_w x s_l

A_{act} = 3 x 3.5

A_{act} = 10-1/2 ft.^{2}

From Equation (27): $N = \overline{N_w} \times \overline{N_l}$

Where N is the Total Quantity of Nozzles.

$N = \overline{N_w} \times \overline{N_l}$

N = 1 x 2

N **= 2 nozzles**

From Equation (28): $q_{TS} = q_n \times A_{act} \times N$

Where q_{TS} is the Total Discharge Rate and q_n is the Discharge Rate of Single Nozzle.

q_n = 4.23 lb./min./ft.^{2}.

$q_{TS} = q_n \times A_{act} \times N$

q_{TS} = 4.23 x 10.5 x 2

q_{TS} **= 89 lb./min**

From Equation (16): $W_{min} = 1.4 \times q \times t_{liq}$

Where W_{min} is the Minimum Quantity of Agent to Be Supplied and t_{liq} is the Duration of Liquid Discharge.

From Paragraph 3-6.1.3:

t_{liq} = 0.5 min

W_{min} = 1.4 x q x t_{liq}

W_{min} = 1.4 x 89 x 0.5

W_{min} = 63 lb.

3-6.3 Rate by Volume Method

The Rate-by-Volume application of carbon dioxide is used when the hazard is an irregular, three-dimensional object that cannot be easily reduced to equivalent surface areas (Rate-by-Area) and/or enclosed volumes (Total Flooding). Examples of hazards that can be protected by this method include: printing presses, metal grinders, wave solder machines, pumps, and motors.

The Rate-by-Volume method is applied by assuming an enclosure about the hazard. Nozzles are located in and around the hazard to evenly distribute the agent throughout the protection envelope and to direct the discharge at the expected flame locations. Since an enclosure does not actually exist, the duration of protection is only as long as the agent discharge. Reference Paragraph 3-6.1.3 for guidance on the duration of discharge.

3-6.3.1 ASSUMED ENCLOSURE

The total carbon dioxide discharge rate of the system shall be based on the volume of an assumed enclosure, entirely surrounding the hazard. The walls and ceiling of the assumed enclosure shall be a minimum of 2 ft. (0.6 m) from the hazard's actual edges, unless walls or ceilings are present. The assumed enclosure shall include a solid floor.

No deductions are made to the volume for solid objects within the assumed enclosure. A minimum dimension of 4 feet must be used during volumetric calculation of the assumed enclosure. The assumed volume shall be increased to compensate for the losses due to winds and forced drafts.

3-6.3.2 DISCHARGE RATE

The discharge rate for a basic system shall be 1 lb./min-ft.^{3} (16 kg/min-m^3). If the assumed enclosure has a closed floor and is partly defined by continuous walls that extend at least 2 ft. (0.6 m) above the hazard and that are not part of the hazard, the minimum design flow rate may be proportionately reduced to not less than 0.25 lb./min-ft.^{3} (4 kg/min-m^3).

(Equation 29)

$$q_V = 0.75 \times (A_O \div A_W) + 0.25 \text{ (US Units)}$$

or

$$q_V = 12 \times (A_O \div A_W) + 4 \text{ (Metric Units)}$$

Where:

q_V = Design flow rate per unit volume, lb./min-ft.^{3} (kg/min-m^3)
A_O = Open area of assumed enclosure "walls", ft.^{2} (m^2)
A_W = Total area of assumed enclosure "walls", ft.^{2} (m^2)

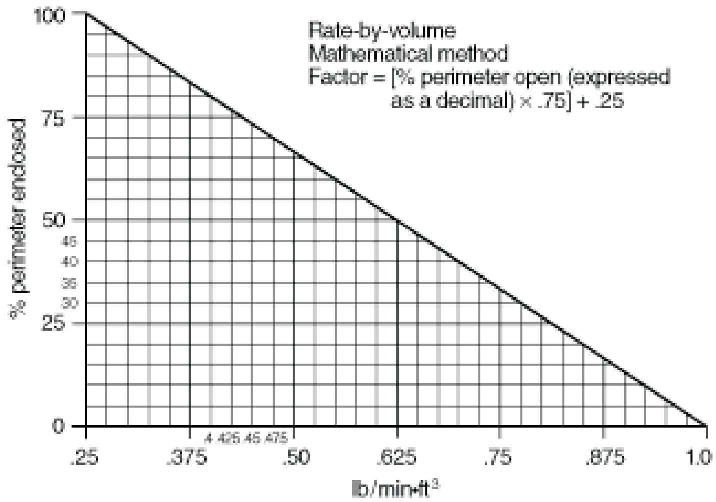


Figure 3-4. Partial Enclosure Flow Rate Reduction*

Determine the minimum rate of discharge for the hazard by multiplying the design flow rate by the assumed enclosure.

(Equation 30)

$$q_{min} = q_v \times V$$

Where:

q_{min} = Minimum discharge rate, lb./min (kg/min)

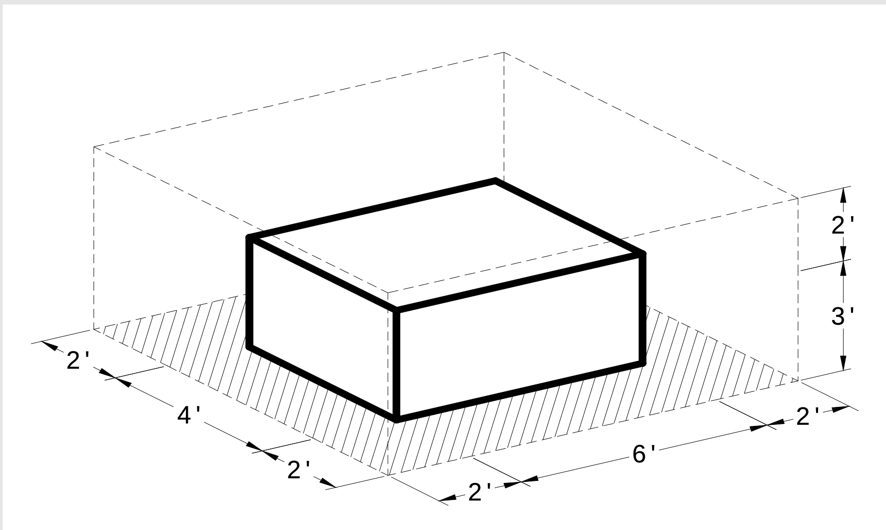
q_V = Design flow rate per unit volume from Equation (29), lb./min-ft.^{3} (kg/min-m^3)

V = Volume of assumed enclosure, ft.^{3} (m^3)

EXAMPLE 11 - LOCAL APPLICATION: RATE-BY-VOLUME - Assumed Enclosure

Consider a hazard with outside dimensions 4 ft. (W) *x 6 ft.* (L) *x 3 ft.* (H)*. Calculate the design discharge rate and minimum agent supply for a Rate-by-Volume application.*

Assume an enclosure about the hazard:



Assumed Enclosure Dimensions: ft. (W) x 10 ft. (L) x 5 ft. (H)

V = 8 ft. x 10 ft. x 5 ft. = 400 ft.^{3}

From Equation (30): $q_{min} = q_v \times V$

Where q_{min} is the Minimum Discharge Rate, qV is the Design Flow Rate per Unit Volume, and V is the Volume of the Assumed Enclosure.

From Equation (29): $q_V = 0.75 \times (A_O \div A_W) + 0.25$

Where A_O is the Open Area of the Assumed Enclosure Walls and A_W is the Total Area of Assumed Enclosure Walls.

A_W = (8 x 5) + (10 x 5) + (8 x 5) + (10 x 5)

A_W = 180 ft.^{2}

A_O = (8 x 5) + (10 x 5) + (8 x 5) + (10 x 5)

A_O = 180 ft.^{2}

qV = 0.75 x ($A_O \div A_W$) + 0.25
qV = 0.75 x (180 ÷ 180) + 0.25

qV = 1.0 lb./min./ft.^{3}

q_{min} = qV x V

q_{min} = 1.0 x 400

q_{min} **= 400 lb./min**

From Equation (16): $W_{min} = 1.4 \times q \times t_{liq}$

Where W_{min} is the Minimum Quantity of Agent to Be Supplied and t_{liq} is the Duration of Liquid Discharge.

From Paragraph 3-6.1.3:

t_{liq} = 0.5 min.

W_{min} = 1.4 x q x t_{liq}

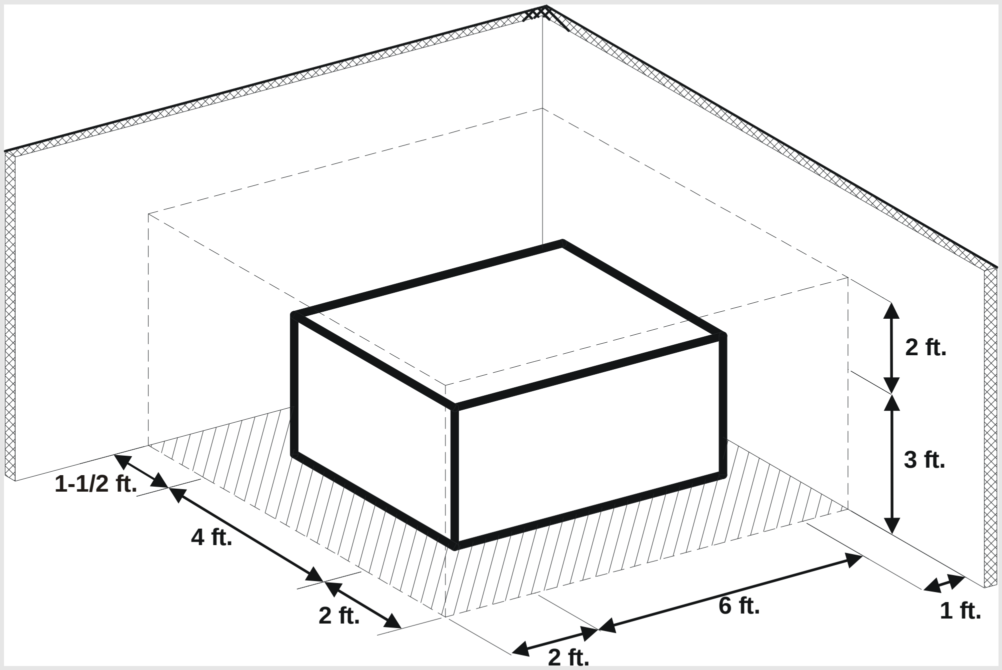
W_{min} = 1.4 x 400 x 0.5

W_{min} **= 280 lb.**

EXAMPLE 12 - LOCAL APPLICATION: RATE-BY-VOLUMBE - Assumed Enclosure with Walls

Consider a hazard with outside dimensions 4 ft. (W) *x 6 ft.* (L) *x 3 ft.* (H) *that is located in a corner. The 6 ft. side of the hazard is 1-1/2 ft. away from the wall and the 4 ft. side is 1 ft. away from the wall. The walls extend at least 10 ft. beyond the hazard. Calculate the design discharge rate and minimum agent supply for a rate-by-volume system.*

Assume an enclosure about the hazard:



Assumed Enclosure Dimensions:

7-1/2 ft. (W) x 9 ft. (L) x 5 ft. (H)

V = 7-1/2 ft. x 9 ft. x 5 ft. = 337.5 $ft.^3$

From Equation (30): $q_{min} = q_v \times V$

Where q_{min} is the Minimum Discharge Rate, qV is the Design Flow Rate per Unit Volume, and V is the Volume of the Assumed Enclosure.

From Equation (29): $q_V = 0.75 \times (A_O \div A_W) + 0.25$

Where A_O is the Open Area of the Assumed Enclosure Walls and A_W is the Total Area of Assumed Enclosure Walls.

A_W = (7-1/2 x 5) + (9 x 5) + (7-1/2 x 5) + (9 x 5)
A_W = 165 ft.^{2}

A_O = (7.5 x 5) + (9 x 5)
A_O = 82.5 ft.^{2}

qV = 0.75 x ($A_O \div A_W$) + 0.25
qV = 0.75 x (82.5 ÷ 165) + 0.25
qV = 0.625 lb./min./ft.^{3}

q_{min} = qV x V
q_{min} = 0.625 x 337.5

q_{min} = 211 lb./min.

From Equation (16): $W_{min} = 1.4 \times q \times t_{liq}$

Where W_{min} is the Minimum Quantity of Agent to Be Supplied and t_{liq} is the Duration of Liquid Discharge.

From Paragraph 3-6.1.3:

t_{liq} = 0.5 min.

W_{min} = 1.4 x q x t_{liq}

W_{min} = 1.4 x 211 x 0.5

W_{min} **= 148 lb.**

3-6.3.3 NOZZLES

Type "S" and Type "M" nozzles are used when applying a Rate-by-Volume local application system.

A sufficient number of nozzles shall be used to adequately cover the entire assumed volume. Nozzles shall be located and directed so as to retain the discharged carbon dioxide within the hazard volume by suitable cooperation between nozzles and flow obstructions. Nozzles shall be located so as to compensate for any possible effects of air currents, winds, or forced drafts. Figure 3-5 is provided as an illustrated example. Actual configurations may differ significantly, as dictated by the geometry of the hazard.

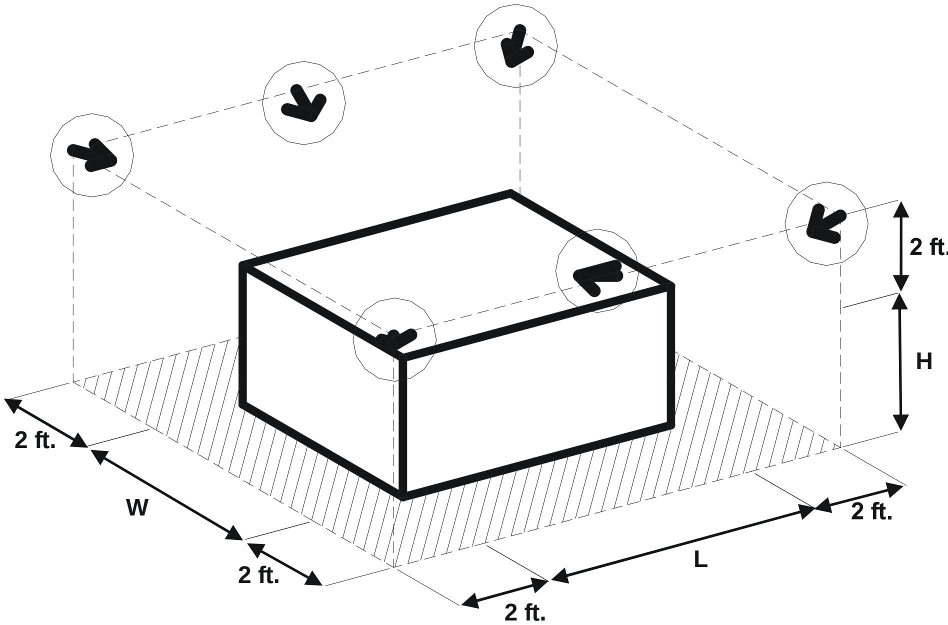


Figure 3-5. Nozzle Placement Example

When liquid or coated hazards are present within the assumed volume, Table 3-4 and Table 3-5 shall be consulted to determine the appropriate discharge rate for each nozzle to prevent splashing of the liquid.

3-6.4 Safeguards for Local Application Systems

Consideration shall be given to the possibility of carbon dioxide drifting and settling into adjacent places outside the protected area and to the possibility that personnel could be trapped in or enter into an atmosphere made hazardous by a carbon dioxide discharge. Safeguards shall be provided to ensure prompt evacuation, to prevent entry into such atmospheres and to provide means for prompt rescue of any trapped personnel. Personnel training shall be provided.

If personnel could be in the protected space at any time, the following safety devices shall be integrated into the carbon dioxide fire suppression system (Reference Paragraph 1-6.1):

- Pneumatic pre-discharge alarm (Pressure Operated Siren)
- Pneumatic Discharge delay (Discharge Delay)
- Addition of a distinctive odor to the discharging carbon dioxide (Odorizer Part No. 81-897637-000 and 10030080), or automatic alarms that are activated by an oxygen or carbon dioxide detector, or establishment and enforcement of confined space entry procedures
- Warning signs in accordance with NFPA 12 (Warning Signs Part No. 06-231866-85X)
- Carbon dioxide system Lock-Out valve (Lockout Valves)

WARNING **The Pneumatic Discharge Delay and any other valve that controls the flow of agent shall be fitted with a manual bypass control that is supervised to alert personnel when the device is in the bypass mode.**

All closed sections of pipe (i.e., upstream of a Pneumatic Discharge Delay, Lockout Valve, Stop Valve, etc.…) shall be fitted with a Safety Outlet (Part No. 81-803242-000).

3-7 COMBINATION SYSTEMS

Large, complex hazards may be divided into smaller hazards that are protected by either a total flooding or local application design. In such cases, a single agent bank and pipe network may be used for the entire hazard. When a system utilizes both total flooding and local application design methods, it is necessary to make adjustments to the design flow rate of the total flooding portion. The discharge rate for the total flooding portion shall be computed in accordance with Equation (11), using the total discharge time (i.e., liquid and vapor) calculated from Equation (31).

(Equation 31)

$$t_d = 1.4 \times t_{liq}$$

Where:

t_d = Total system discharge time (liquid and vapor), min

t_{liq} = Duration of liquid discharge of local application portion, min

EXAMPLE 13 - COMBINATION SYSTEMS - Total Flooding Discharge Rate

Consider a room with dimensions of 20 ft. (L) by 30 ft. (W) by 10 ft. (H) and containing ordinary combustibles. Determine the minimum discharge rate for this hazard if the carbon dioxide system will also include a local application portion.

From Equation (11): $q_{min} = W_{min} \div t_{d,\,max}$

Where q_{min} is the Minimum Discharge Rate of the Total Flooding Portion, W_{min} is the Minimum Agent Quantity of the Total Flooding Portion, and td is the Total System Discharge Time.

From Equation (3): $W_{min} = W_C + W_L + W_V + W_T$

Where W_C is the Quantity of Agent for the Design Concentration, W_L is the Quantity of Agent to Compensate for Leakage, W_V is the Quantity of Agent to Compensate for Ventilation, and W_T is the Quantity of Agent to Compensate for Extreme Temperatures.

From Equation (2): $W_C = W_B \times f_C$

Where W_B is the Basic Quantity (34%) and f_C is the Material Conversion Factor.

From Equation (1): $W_B = V \div f_1$

Where V is Volume Of The Protected Space and f_1 is the Volume Factor.

V = 20 ft. x 30 ft. x 10 ft.

V = 6,000 ft.^{3}

f_1 = 20 ft.^{3}/lb. from Table 3-2 for volumes 4,501 ft.^{3} to 50,000 ft.^{3}.

W_B = V ÷ f1

W_B = 6,000 ÷ 20

W_B = 300 lb.

f_c = 1.0, from Figure 3-1 for 34% concentration

W_C = W_B x f_C

W_C = 300 x 1.0

W_C = 300 lb.

W_L = 0 lb.

W_V = 0 lb.

W_T = 0 lb.

W_{min} = W_C + W_V + W_L + W_T

W_{min} = 300 + 0 + 0 + 0

W_{min} = 300 lb.

From Equation (31): $td = 1.4 \times t_{liq}$

Where t_{liq} is the Duration of Liquid Discharge of the Local Application Portion.

From Paragraph 3-6.1.3:

t_{liq} = 30 s

t_{liq} = 0.5 min.

t_d = 1.4 x t_{liq}

t_d = 1.4 x 0.5

t_d = 0.7 min.

q_{min} = $W_{min} \div t_d$

q_{min} = 300 ÷ 0.7

q_{min} **= 428.6 lb./min.**

3-8 MULTIPLE HAZARD SYSTEMS

When two or more hazards are reasonably close together, it may be desirable to use one central supply of carbon dioxide and to utilize directional valves to route the agent to the required area. In such an arrangement, the amount of agent shall be at least sufficient for the largest single hazard or group of hazards being protected simultaneously.

Directional valves are normally set in the closed position. When a fire is detected, the directional valve leading to the fire location is opened to allow agent to flow to that area.

It is strongly recommended to provide a reserve agent supply. Reference Paragraph 3-11.2 for additional information.

Since the directional valves will remain open until reset, the system is capable of protecting only one hazard at a time, regardless of whether a reserve agent supply is provided. Therefore, it is vitally important to accurately determine which hazard areas are completely separate, such that fire will not spread from one area to another. Where the spread of fire from one hazard to another is possible, both areas must be protected simultaneously.

All closed sections of pipe (i.e., upstream of any directional valves) shall be fitted with a Safety Outlet (Part No. 81-803242-000).

3-9 PRESSURE OPERATED SIRENS

Pressure Operated Sirens, Part No. 81-981574-000, necessarily discharge carbon dioxide to operate. When this discharge does not contribute to a firefighting concentration (i.e., within a total flooding hazard), the total system agent quantity must be compensated to account for the carbon dioxide discharged by the siren. Operation of the siren requires 20.4 lb./min. (9.3 kg/min.).

(Equation 32)

$$W_s = 20.4 \times n \times (t_d + t_p) \text{ (US Units)}$$

or

$$W_s = 9.3 \times n \times (t_d + t_p) \text{ (Metric Units)}$$

Where:

W_s = Minimum agent discharged through pneumatic siren, lb. (kg)

n = Quantity of Pressure Operated Sirens

t_d = Total system discharge time (liquid and vapor), min

t_p = Pneumatic delay time, min

EXAMPLE 14 - PRESSURE OPERATED SIRENS - Siren Agent Discharge

Consider a combination system with a Pressure Operated Siren located inside the total flooding hazard and one located outside. A 30-second Pneumatic Discharge Delay will provide a pre-discharge alarm period. Determine the additional quantity of agent that is needed to compensate for losses through the sirens.

From Equation (32): $W_s = 20.4 \times n \times (t_d + t_p)$

Where n is the Quantity of Pressure Operated Sirens, t_d is the Discharge Time, and t_P is the Pneumatic Delay Time.

Since only one siren is located outside the total flooding hazard:

n = 1

From Equation (31): $t_d = 1.4 \times t_{liq}$

Where t_{liq} is the Duration of Liquid Discharge of the Local Application Portion.

From Paragraph 3-6.1.3:

t_{liq} = 30 s

t_{liq} = 0.5 min

$t_d = 1.4 \times t_{liq}$

$t_d = 1.4 \times 0.5$

$t_d = 0.7$ min.

$t_p = 30\ s$

$t_p = 0.5$ min.

$W_s = 20.4 \times n \times (t_d + t_P)$

$W_s = 20.4 \times 1 \times (0.7 + 0.5)$

$W_s = 24.48$

$W_s \cong$ **25 lb.**

3-10 EXTENDED DISCHARGE SYSTEMS

An extended discharge is used to provide protection beyond the normal duration. It may be applied either by increasing the agent supply or by providing a secondary system.

The duration of the extended discharge should be specified and agreed upon with the system owner and Authority Having Jurisdiction.

Examples of special considerations that will necessitate an extended discharge include:

- Hazards containing a liquid having an auto-ignition temperature below its boiling point, such as cooking oils, require an extended duration of protection to permit cooling of the oil
- Hazards containing a metal or other material that may become heated and remain a persistent source of ignition beyond the duration of protection
- Hazards protected by a total flooding system that are not capable of maintaining the minimum design concentration for the specified duration of protection

3-10.1 Increased Agent Supply

An increased agent supply is used when the carbon dioxide must be applied at the original design rate. This approach is most appropriate for local application systems, which have no duration of protection beyond the end of discharge. The agent supply is calculated in accordance with Paragraph 3-6.1.4, adjusting the liquid discharge time to meet the requirements of the hazard. It is imperative to verify that the excess carbon dioxide will not create hazardous conditions in enclosed environments.

3-10.2 Secondary System

A secondary system is used when the carbon dioxide must be applied at a rate other than the original design rate. This approach is most appropriate for total flooding applications that must maintain concentration in an enclosure with appreciable leakage and/or forced ventilation. In such cases, the primary system is designed to discharge at a high rate to achieve the minimum concentration within 1 minute, while the secondary system discharges at a much lower rate to compensate for losses. The secondary system flow rate and agent quantity are based on the Uncloseable Opening (Paragraph 3-5.2.4.1) and Forced Ventilation (Paragraph 3-5.2.4.2) calculations for total flooding systems. Note that if the primary and secondary systems are actuated simultaneously, the compensation for Uncloseable Openings and/or Forced Ventilation need not be added to both systems.

3-10.3 Common Applications

Common applications that require an extended discharge include:

- Commercial/industrial food processing deep-fat (hot oil) cookers
- Enclosed rotating electrical equipment, such as emergency generators

3-10.3.1 DEEP-FAT COOKERS

For deep-fat cookers, the duration of protection shall be sufficient to allow the oil to cool a minimum of 60°F (33°C) below its auto-ignition temperature. In cases where a local application design is used, the minimum liquid discharge time shall be 3 minutes. However, tests have shown that longer discharges may be necessary to allow sufficient cooling of the oil.

Several safety devices must be employed to protect personnel from the carbon dioxide discharge, splashed hot oil, fire, and products of combustion.

The NFPA 12 standard and Kidde Fire Systems shall be consulted before protecting deep-fat cookers.

3-10.3.2 ENCLOSED ROTATING ELECTRICAL EQUIPMENT

For Enclosed Rotating Electrical Equipment, the NFPA 12 Standard requires that a minimum concentration of 30% shall be maintained for the duration of the deceleration period and for not less than 20 minutes.

3-10.3.2.1 Recirculating Ventilation

For enclosed, recirculating-type ventilation, NFPA 12 provides tables that can be used as a guide to estimate the carbon dioxide quantity needed for the extended discharge to maintain a minimum concentration of 30% during the deceleration time. The quantity is based on the deceleration time and the internal volume of the machine, assuming average leakage.

3-10.3.2.2 Dampered, Non-Recirculating Ventilation

For dampered, non-recirculating-type ventilation, the extended discharge quantity is calculated by added 35% more agent to the indicated quantity for recirculating-type ventilation. Reference NFPA 12 for additional information.

3-11 AGENT STORAGE BANKS

This paragraph covers the design and layout of the agent storage bank.

3-11.1 Agent Supply

All cylinders connected to a common manifold shall be interchangeable and of one select size. Therefore, the supplied quantity of agent is generally greater than the minimum design quantity that is calculated for the system.

(Equation 33)

$$W_{\mathrm{min,sys}} = W_{\mathrm{min,TF}} + W_{\mathrm{min,LA}} + W_s$$

Where

$W_{\mathrm{min,sys}}$ = Minimum agent supply for the system, lb. (kg)

$W_{\mathrm{min,TF}}$ = Minimum agent quantity for total flooding portion(s), lb.(kg)

$W_{\mathrm{min,LA}}$ = Minimum agent quantity for local application portion(s), lb.(kg)

W_s = Minimum agent discharged through Pressure Operated Siren(s), lb.(kg)

Calculate the quantity of cylinders to be supplied.

(Equation 34)

$$n_{cyl} = W_{\mathrm{min,sys}} \div W_{cyl}$$

Where

n_{cyl} = Number of cylinders required

$W_{\mathrm{min,sys}}$ = Minimum agent supply for the system from Equation (33), lb.(kg)

W_{cyl} = Selected cylinder capacity, lb.(kg)

Round up the calculated quantity of cylinders and calculate the actual quantity of agent to be supplied.

(Equation 35)

$$W_{sys} = \overline{n_{cyl}} \times W_{cyl}$$

Where

W_{sys} = Total carbon dioxide supplied, lb.(kg)

$\bar{n}_{cyl}$ = Number of cylinders required, rounded up

W_{cyl} = Selected cylinder capacity, lb.(kg)

EXAMPLE 15 - AGENT SUPPLY - Supplied Quantity

Consider a local application that requires 448 lb.of carbon dioxide. A Pressure Operated Siren will be located near the protected equipment. Determine the actual quantity of agent to be provided.

From Equation (33): $W_{\text{min,sys}} = W_{\text{min,TF}} + W_{\text{min,LA}} + W_s$

Where $W_{\text{min,sys}}$ is the Minimum Agent Supply for the System, $W_{\text{min,TF}}$ is the Minimum Agent Quantity for the Total Flooding Portion(s), $W_{\text{min,LA}}$ is the Minimum Agent Quantity for the Local Application Portion(s), and W_s is the Quantity of Agent Discharged Through the Pressure Operated Siren(s).

$W_{\text{min,TF}}$ = 0 lb.
$W_{\text{min,LA}}$ = 448 lb.

From Equation (32): $W_s = 20.4 \times n \times (t_d + t_p)$

Where n is the Quantity of Pressure Operated Sirens, td is the Discharge Time, and t_P is the Pneumatic Delay Time.

n = 1

From Equation (31): $t_d = 1.4 \times t_{liq}$

Where t_{liq} is the Duration of Liquid Discharge of the Local Application Portion.

From Paragraph 3-6.1.3:

t_{liq} = 30 s
t_{liq} = 0.5 min.

t_d = 1.4 x t_{liq}
t_d = 1.4 x 0.5
t_d = 0.7 min

t_P = 30 s
t_P = 0.5 min

W_s = 20.4 x n x (t_d + t_P)

W_s = 20.4 x 1 x (0.7 + 0.5)

W_s = 24.48

$W_s \cong$ 25 lb.

W_{sys} = $W_{\text{min,TF}}$ + $W_{\text{min,LA}}$ + W_s

W_{sys} = 0 + 448 + 25

W_{sys} = 473 lb.

From Equation (34): $n_{cyl} = W_{\min,\text{sys}} \div W_{cyl}$

Where n_{cyl} is the Quantity of Cylinders Required and W_{cyl} is the Selected Cylinder Capacity.

To minimize the quantity of cylinders needed, select the largest possible cylinder size:

W_{cyl} = 100 lb.

$n_{cyl} = W_{\min,\text{sys}} \div W_{cyl}$

n_{cyl}l = 473 ÷ 100

n_{cyl} = 4.73

$n_{cyl} \cong$ **5 cylinders**

From Equation (35): $W_{sys} = \overline{n_{cyl}} \times W_{cyl}$

Where W_{sys} is the Total Quantity of Agent Supplied.

$W_{sys} = n_{cyl} \times W_{cyl}$

W_{sys} **= 500 lb.**

3-11.2 Main and Reserve Supplies

A reserve agent supply provides a means of rapidly returning the system to its ready state after a fire or discharge event. A system of controls and valves is used to select a secondary agent supply and to provide continuous protection while the discharged cylinders are refilled. Occasionally, the reserve supply is also used to provide a "second shot" of agent during the same fire event.

The reserve supply shall be equal to the main supply (calculated in Paragraph 3-11.1) and shall be permanently connected to the piping, except where the authority having jurisdiction permits an unconnected reserve.

It is strongly recommended to provide a reserve agent supply when multiple hazards are protected from a common bank of cylinders using directional valves (See Paragraph 3-8).

3-11.3 Cylinder Location

The cylinder location is an important factor in system design, as this will affect the installation of pipe, mechanical or pneumatic detection lines, and remote cable pull stations.

The carbon dioxide cylinders must be located as close to the hazard area as possible. Storage containers and accessories shall be so located and arranged that inspection, testing, recharging, and other maintenance is facilitated and interruption to protection is held to a minimum. Storage containers shall not be located where they will be exposed to:

- fire or explosion
- direct sunlight
- outdoor weather
- mechanical, chemical, or other damage.

When excessive climatic or mechanical exposures are expected, suitable guards or enclosures shall be provided.

The weight of the agent supply, racking, piping, and other equipment shall not exceed the maximum load rating of the supporting structure(s).

The cylinders must be located in an environment where ambient storage temperatures shall be:

- 0°F (-18°C) to 130°F (54°C) for total flooding systems
- 32°F (0°F) to 120°F (49°C) for local application or combination systems

External heating or cooling may be required to maintain this temperature range.

3-11.4 Single and Double Cylinder Arrangements

For installation of one or two cylinders, simple cylinder straps are used to secure the cylinders. A 2 ft. (0.6 m) wide service aisle shall be maintained. Reference Paragraph 2-2.6.1 for component descriptions and Paragraph 4-3.5 for installation information.

3-11.5 Multiple Cylinder Arrangements

For installation of three or more cylinders, two different styles (1 side x 1 row; 1 side x 2 rows) of framing arrangements are available to provide flexibility of installation. A 2 ft. (0.6 m) wide service aisle shall be maintained in front of all cylinder rows. Reference Paragraph 2-2.6.2 for component descriptions and Paragraph 4-3.5 for installation information.

3-12 MANIFOLD AND PIPE NETWORK DESIGN

The discharge network can be broken into two distinct sections: the cylinder manifold and the distribution network.

3-12.1 Pipe and Fitting Specifications

Pipe and tube used in the discharge network shall be in accordance with NFPA 12, current edition.

Pipe that does not meet the specifications in Paragraph 3-12.1.1 shall be designed in accordance with ASME B31.1, Power Piping Code, current edition and the requirements of NFPA 12, current edition. The internal pressure for this calculation shall be 2800 psi (19.3 MPa).

The *Piping Design Handbook For Use With Special Hazard Fire Suppression Systems*, published by the Fire Suppression Systems Association (FSSA), is one resource that may be consulted for the allowable working pressures for various pipe and tube materials and for guidance on pipe support selection.

3-12.1.1 PIPE SPECIFICATIONS

Material Specification:

- Black or galvanized steel pipe shall be ASTM A-53 seamless or electric welded, Grade A or B; or ASTM A 106, Grade A, B, or C.
- Stainless steel pipe shall be TP304 or TP316 for threaded connections, or TP304, TP316, TP304L, or TP316L for welded connections.
- Furnace butt-weld ASTM A-53, ASTM A120, and ordinary cast iron pipe shall not be used.
- Flexible piping system components shall have a minimum burst pressure of 5,000 psi (34.5 MPa).

Schedule:

- Pipe sizes 3/4-inch (DN20) NPT and smaller may be Schedule 40 or greater.
- Pipe sizes 1-inch (DN25) through 4-inch (DN100) NPT shall be a minimum of Schedule 80.

3-12.1.2 FITTING SPECIFICATIONS

Class 300 malleable or ductile iron fittings shall be used through 2-inch (DN50) internal pipe size (IPS). Larger internal pipe sizes shall be forged steel fittings. Flanged joints used in open sections of pipe shall be permitted to be Class 300. Flanged joints used in closed sections of pipe shall be Class 600.

Stainless steel fittings shall be type 304 or 316 in accordance with ASTM A182, Class 3000, threaded or socket welded, for all sizes 1/8-inch (DN6) through 4-inches (DN100).

3-12.1.3 TUBING SPECIFICATIONS

The use of stainless steel tubing materials is allowed provided the thickness of the tubing is calculated in accordance with ASME B31.1 Power Piping Code. The internal pressure for this calculation shall be 2800 psi (19.3 MPa).

3-12.1.4 CLOSED PIPING SECTIONS

NFPA 12 requires the installation of a pressure relief device where a valve arrangement (i.e., Time Delay, Stop Valve, Lock-Out Valve, etc.) introduces sections of closed piping.

The maximum allowable working pressure of the pipe shall be equal to or greater than the maximum operating pressure of the pressure relief device. The maximum operating pressure of the Safety Outlet, Part No. 81-803242-000, is 2800 psi (19.3 MPa).

The *Piping Design Handbook For Use With Special Hazard Fire Suppression Systems*, published by the Fire Suppression Systems Association (FSSA), may be consulted for pipe selections used in closed piping sections.

3-12.2 Pipe Size Estimates

For budgetary estimating purposes only, Table 3-9 may be used to estimate pipe sizes. The actual system pipe sizes required may vary when hydraulic calculations are performed.

Table 3-9. Pipe Size Estimates

Flow Rate		**Pipe Size**	**Min Pipe Schedule**
lb./min	**kg/min**	**in. (mm)**	
Up to 100	Up to 50	3/8 in. (10mm)	40
101 - 130	51-60	1/2 in. (15mm)	40
131 - 270	61-125	3/4 in. (20mm)	40
271 - 390	126-180	1 in. (25mm)	80
391 - 800	181-365	1-1/4 in. (32mm)	80
801 - 1200	366-545	1-1/2 in. (40mm)	80
1201 - 2300	546-1045	2 in. (50mm)	80
2301 - 3600	1046-1635	2-1/2 in. (65mm)	80

3-12.3 Pipe Hangers and Supports

The design of pipe hangers and supports shall be based on the Power Piping Code, ASME B31.1. This Code requires that the materials, design and manufacture of standard pipe supports shall be in accordance with the rules of MSS-SP-58; the companion document MSS-SP-69 provides recommendations for the selection and application of pipe support types. This MSS Standard Practice is published by the Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., located at 127 Park Street, NE, Vienna, Virginia 22180; phone (703) 281-6613.

The *Piping Design Handbook For Use With Special Hazard Fire Suppression Systems*, published by the Fire Suppression Systems Association (FSSA), provides general information and guidelines for the selection and application of pipe supports.

3-12.4 Cylinder Manifolds

The carbon dioxide cylinder bank is connected to the discharge pipe network through a manifold. The manifold consists of an arrangement of pipe and fittings, called a header, which collects the discharge from each cylinder into a single pipe. One or more headers are connected to a single outlet connection, called a riser.

3-12.4.1 MANIFOLD ARRANGEMENTS

The manifold may be arranged as an End, Center, or H manifold, with additional design considerations for connected Main and Reserve systems. The figures shown are exemplary only and do not represent the only possible configurations. It is permissible to include elbows in the manifold.

3-12.4.1.1 End

An "End" manifold consists of a single header. Any number of cylinders may be connected.

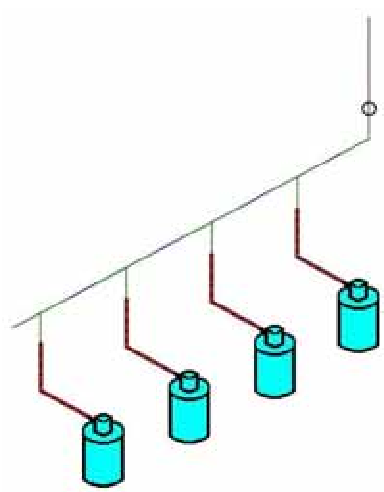


Figure 3-6. Example of an "End" Manifold

3-12.4.1.2 Center

A "Center" manifold consists of two identical headers connected to a single riser. The total quantity of cylinders shall be a multiple of 2.

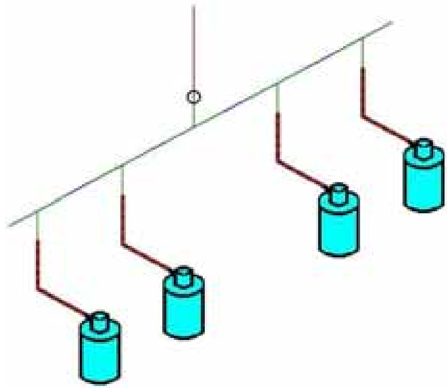


Figure 3-7. Example of a "Center" Manifold

3-12.4.1.3 H

An "H" manifold consists of four identical headers connected to a single riser. The headers are arranged to form two identical center manifolds, connected to the riser through identical pipe sections. The total quantity of cylinders shall be a multiple of 4.

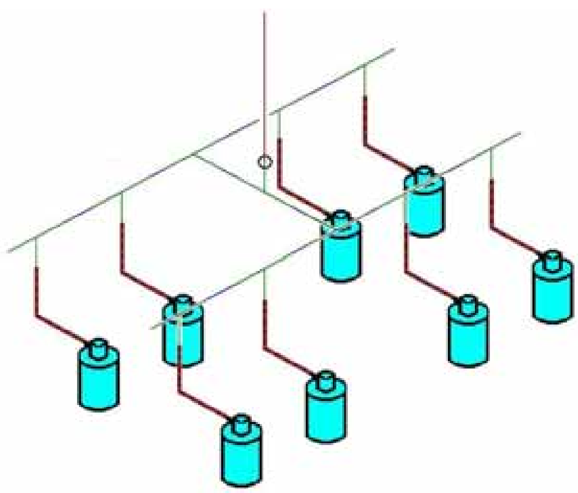


Figure 3-8. Example of an "H" Manifold

3-12.4.1.4 Main And Reserve

A "Main and Reserve" manifold consists of two identical "End", "Center", or "H" manifolds connected to a single riser and isolated by check valves.

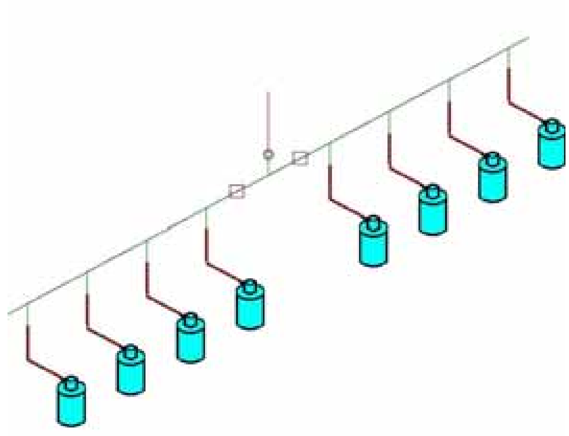


Figure 3-9. Example of a "Main and Reserve" "End" Manifold

3-12.4.2 MANIFOLD PIPE SELECTION

A cylinder manifold may be designed by either of two methods: Single Pipe Size or Stepped Pipe Size. Each approach has its own benefits with respect to cost/ease of fabrication, flow resistance, and developed back pressure.

3-12.4.2.1 Single Pipe Size Manifolds

A manifold may be fabricated from a single pipe size that is appropriate for the flow rate of the entire cylinder bank. This design allows for the maximum flow rate and simpler fabrication. However, large pipe sizes will result in lower manifold pressures, adversely affecting actuation of multiple cylinder systems. See Paragraph 3-13 for information regarding actuation.

Single size pipe manifolds may be best suited to Multiple Hazard Systems using Directional (Stop) Valves. In such cases, it is recommended to actuate the carbon dioxide cylinders first and to operate the appropriate Directional (Stop) Valve only after completing the time delay period. This sequence provides an opportunity to develop sufficient manifold pressure for complete system actuation (See Paragraph 3-8).

3-12.4.2.2 Stepped Pipe Size Manifolds

A manifold may be fabricated from multiple pipe sizes, where the size of each pipe section is appropriate for the quantity of cylinders upstream of the section. This design allows for the maximum manifold back pressure to be developed. See Paragraph 3-13 for information regarding actuation.

3-12.4.3 MANIFOLD OBJECTS

A manifold generally includes several control valves and safety devices. Familiarity with the principles of System Actuation, as outlined in Paragraph 3-13, may be necessary to fully understand the purposes of the following devices. All devices shall be located, installed, or suitably protected so that they are not subject to mechanical, chemical, or other damage that would render them inoperative.

3-12.4.3.1 Safety Outlets

Safety Outlets (Part No. 81-803242-000) are used to provide a pressure relief device where a valve arrangement (i.e., Time Delay, Stop Valve, Lock-Out Valve, etc....) introduces sections of closed piping. The device may be located anywhere within the closed section.

See Paragraph 2-8.5 for additional information

3-12.4.3.2 Discharge Indicators

Discharge Indicators (Part No. 81-967082-000) are used to show that the system has operated and needs recharging. The device must be located upstream of any flow-controlling valves, typically at the capped end of the manifold header. Multiple indicators may be necessary if a valve arrangement results in isolated groups of cylinders.

See Paragraph 2-8.6 for additional information.

3-12.4.3.3 Lockout Valve

Lockout Valves are used to manually prevent flow of agent to the distribution piping. The valve shall be located downstream of all cylinders and upstream of all nozzles.

Model the lock out valves within the hydraulic calculation program by adding the corresponding equivalent length to the applicable pipe node. Contact the Application Engineering team at Kidde Fire Systems for assistance.

When providing a lockout valve fitted with a limit switch, refer to Figure 3-10 for wiring the release circuit(s) through the limit switches.

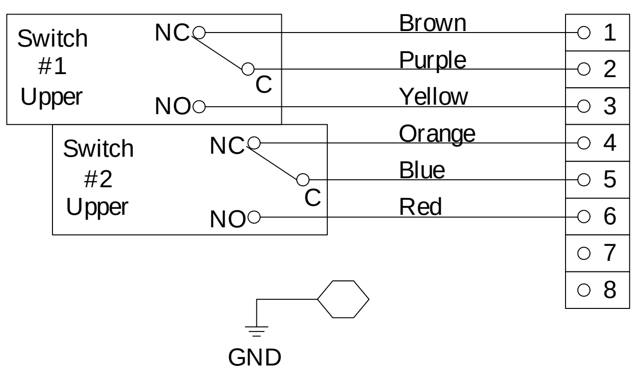


Figure 3-10. Lockout Valve Release Circuit Wiring

The Lockout Valve shall be supervised to warn occupants that the system has been locked out. See Paragraph 1-6.1.4 for additional information.

3-12.4.3.4 Directional (Stop) Valves

Directional (Stop) Valves (See Paragraph 2-5 for Part Numbers) may be used for two purposes.

In Multiple Hazard Systems, two or more Directional Valves are arranged to isolate the protected hazards and to allow agent to flow to only one hazard at a time. See Paragraph 3-12.5.2 for additional information.

For safety purposes, a single Stop Valve, located downstream of all cylinders and upstream of all nozzles, may be arranged to prevent the flow of agent to the nozzles until a secondary action occurs. See Paragraph 1-6.1.4 for additional information.

3-12.4.3.5 Pneumatic Discharge Delays

Pneumatic Discharge Delays (N_2 or CO_2 operated) are used to delay the start of discharge while an evacuation signal is given and the enclosure is prepared.

The CO_2 operated delay (Not FM Approved) may be located in the manifold header between the pilot and slave cylinders (see Paragraph 3-13.2.1). Note that the Pneumatic Discharge Delay has a 3/4-inch (DN20) NPT pipe thread, which limits the flow rate that may be passed through the valve.

The N_2 operated delay cannot be installed in the CO_2 cylinder manifold. The N_2 operated delay shall be installed within the N_2 actuation line terminating at the CO_2 pilot cylinders connected to the CO_2 manifold.

When the actuation strategy and design flow rate are such that the Delay cannot be located in a 3/4-inch (DN20) NPT pipe section, the Delay may be used in conjunction with a Stop Valve. In this arrangement, a Stop Valve is located in accordance with Paragraph 3-12.4.3.4 and is controlled by a pressure-operated control head (Part No. 82-878737-000, 82-878750-000, or 82-878751-000). A side tee is installed upstream of the Stop Valve and is piped to the Pneumatic Discharge Delay. The outlet of the Delay is connected to the pressure-operated control head.

The Pneumatic Discharge Delay shall be fitted with a manually operated control head to provide a by-pass. The control head shall be supervised to warn occupants that the time delay has been by-passed.

See Paragraph 1-6.1.3 for additional information.

3-12.4.3.6 Pressure Operated Sirens

Pressure Operated Sirens (N_2 or CO_2 operated) are used to provide an audible alarm prior to the start of and during discharge. The siren must be located upstream of the Pneumatic Discharge Delay. A union should be installed at each siren connection, and a dirt trap shall be installed after the last siren.

The total length of 1/2-inch (DN15) pipe between the cylinders and the sirens cannot exceed 250 ft. (76 m).

See Paragraph 1-6.1.3 and Paragraph 4-5.3.1 for additional information.

The N_2 pressure operated siren (P/N 90-981574-001) consumes approximately 0.5 to 0.9 lb. (0.23 to 0.5 kg) of nitrogen per minute. Each siren driver cylinder can operate one or more sirens. Table 3-10 indicates the number of sirens that can be installed on a line from any one siren driver; the total length of actuation pipe that can be used must not exceed the limits shown in this table.

108 cu. in. and 1040 cu. in. siren driver cylinders cannot be manifolded. A maximum of two 2300 cu. in. siren drivers can be manifolded to provide up to twenty sirens on one circuit. No other manifold combination is permitted.

Table 3-10. Siren Driver Cylinder Actuation Limits

Pilot Cylinder Size	Siren Part Number	Number of Sirens per Siren Driver	Maximum Length of 1/4 in. Sch. 80 Pipe	Maximum Length of 1/4 in. Sch. 40 Pipe	Maximum Length of 5/16 in. x 0.032 in. Wall Tubing
108 cu. in.	90-981574-001	1	90 ft.	90 ft.	90 ft.
1040 cu. in.	90-981574-001	4	500 ft.	500 ft.	500 ft.
2300 cu. in.	90-981574-001	10	500 ft.	500 ft.	500 ft.
2 x 2300 cu. in.	90-981574-001	20	500 ft.	500 ft.	500 ft.

3-12.4.3.7 Check Valves

Check Valves (See Paragraph 2-4 for Part Numbers) are used to isolate groups of cylinders in Main and Reserve systems or in Directional Valve systems designed to discharge a different quantity of cylinders for each hazard.

See Paragraph 3-12.4.1.4 (Main and Reserve Manifolds) and Paragraph 3-12.5.2 (Directional Valve Systems) for more information.

3-12.4.3.8 Pressure Operated Switches

A Pressure Operated Switch (Part No. 81-486536-000 or 81-981332-000) shall be installed between the manifold and the Lockout valve and shall provide an alarm-initiating signal to the suppression control panel.

3-12.4.3.9 Odorizers

An odorizer assembly, Part No. 81-897600-000, shall be installed upstream of the lock-out valve. In the event a safety outlet ruptures in a locked-out system, the scent from the odorizer will provide a warning that carbon dioxide has vented into the area by the safety outlet.

3-12.5 Distribution Networks

The distribution network should be routed in the most efficient manner possible.

3-12.5.1 HYDRAULIC CALCULATIONS

Hydraulic flow calculations are used to determine the pipe sizes and nozzle orifice codes for the system. Kidde Fire Systems CO_2 Calculation Software (Part No. 81-190001-XXX) or the guidelines in NFPA 12 may be used to perform these calculations.

The equivalent lengths for all Kidde pipe objects are included in the software.

See the Kidde Fire Systems CO_2 Calculation Software User's Manual for additional information.

3-12.5.2 DIRECTIONAL VALVE SYSTEMS

Directional Valve Systems are used to protect multiple, separate hazards with a single agent supply. In this arrangement, the cylinder manifold is connected to a manifold of Directional Valves, which lead to different hazards. Upon system actuation, the appropriate valve is opened, along with the agent cylinders, to direct the discharge to the hazard where the fire is occurring.

In cases where the protected hazards do not require the same quantity of agent, it is possible to discharge only a portion of the cylinder bank.

A hydraulic flow calculation shall be performed for each hazard.

3-12.5.3 ODORIZER ASSEMBLY

An odorizer assembly shall be installed downstream of each directional valve. The scent from the odorizer will provide a post-discharge warning to any personnel entering the protected area or adjacent areas.

3-12.5.4 ELECTRICAL CLEARANCES

All system components shall be located so as to maintain minimum clearances from live parts. Reference NFPA 12 for additional guidance.

3-13 ACTUATION SYSTEM DESIGN

The carbon dioxide suppression system is actuated by a sub-system of components that responds to an alarm condition and opens the carbon dioxide cylinder valves.

3-13.1 Discharge Heads

A discharge head must be attached to every CO_2 cylinder. Plain nut and grooved nut discharge heads shall not both be used in a common manifold. See Paragraph 2-2.2 for additional information.

3-13.2 Cylinder Actuation

Each cylinder may be actuated by either of two methods: with a control head or with manifold back pressure.

3-13.2.1 ACTUATION WITH A CONTROL HEAD

A cylinder fitted with a Plain Nut or Grooved Nut Discharge Head, Part No. WK-872450-000 or 81-872442-000 respectively, may be actuated with any of the control heads described in Paragraph 2-3.

3-13.2.2 ACTUATION WITH MANIFOLD BACKPRESSURE

A cylinder fitted with a Plain Nut Discharge Head, Part No. WK-872450-000, may be actuated by manifold back pressure, as described in Paragraph 2-2.2.

Manifold back pressure is developed when one or more cylinders are actuated with control heads. These are pilot cylinders. The remaining cylinders, which are not fitted with control heads and are actuated with manifold back pressure, are slave cylinders.

Since a successful system actuation is dependent on developing sufficient back pressure, the quantity of pilot cylinders is of vital importance.

- CO_2 systems with no more than two cylinders may employ a single pilot cylinder.
- CO_2 systems with three or more cylinders shall employ one more pilot cylinder than the minimum required for actuation of the entire cylinder bank.

For systems with three or more cylinders, it is recommended to employ an additional pilot cylinder per every ten cylinders, provided the manifold uses stepped pipe sizes (see Paragraph 3-12.4.2.2). The pilot cylinder quantity shall be proven acceptable by the discharge test described in Paragraph 4-7.7. During this test, one pilot cylinder shall be operated as a slave cylinder.

It is generally practiced to locate the pilot cylinder(s) together, starting at the second cylinder. See Figure 3-11 for an example.

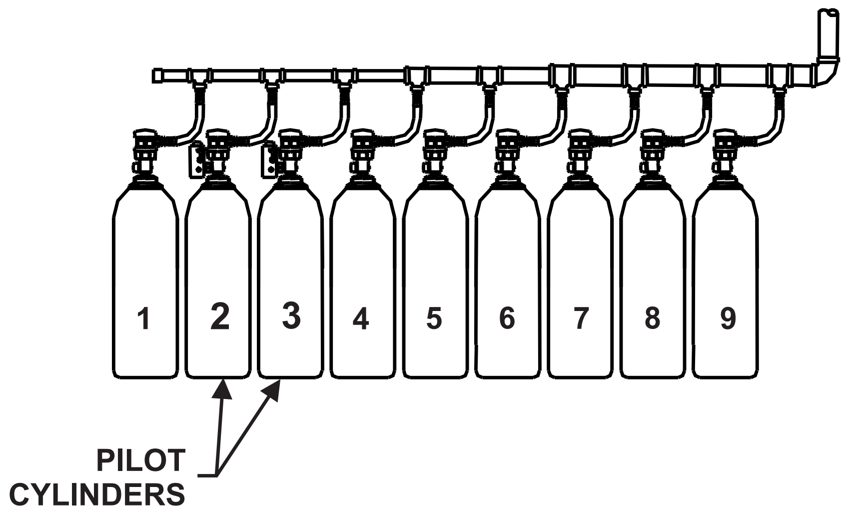


Figure 3-11. Pilot Cylinder Position within Manifold

3-13.3 Actuation Classifications

Three actuation classifications apply to CO_2 systems: automatic, normal manual, and emergency manual.

3-13.3.1 AUTOMATIC

Automatic actuation is a system operation that does not require any human action. Automatic detection and actuation shall be used, except where manual only actuation is acceptable to the authority having jurisdiction and where automatic actuation could result in an increased risk. Automatic detection shall be by any listed or approved method or device that is capable of detecting and indicating heat, flame, smoke, combustible vapors, or an abnormal condition in the hazard such as a process trouble that is likely to produce fire.

3-13.3.2 NORMAL MANUAL

Normal manual actuation is a system operation that requires human action. The actuating device shall be easily accessible to the hazard at all times and shall be clearly recognizable for the purpose intended. Operation of the device shall cause complete operation of the system and shall not cause the time delay to recycle. Normal manual actuation may incorporate electrical, mechanical, pneumatic, or other devices.

3-13.3.3 EMERGENCY MANUAL

Emergency manual actuation is a system operation that requires human action and that is fully mechanical in nature. All valves that control the release and distribution of carbon dioxide shall be provided with an emergency manual control. The actuating device shall be easily accessible, shall be located at or near the valve being controlled, and shall be clearly recognizable for the purpose intended.

3-13.4 Control Systems

The hazard survey (See Paragraph 3-2) should be used to determine the most effective means of actuating the system, based on the expected fire growth rate, personnel safety, process characteristics, and other factors. The actuation system may incorporate one or more of the methods described in Paragraph 3-13.4.1 through 3-13.4.5, dependent on the selected control head(s). Table 3-11 summarizes the actuation methods featured on each control head. Stackable control heads may be coupled with one other control head, subject to the limitations in Paragraph 2-3.

Table 3-11. Control Head Actuation Features

P/N	Description	Actuation Features					
		Lever	Cable	Electric	Pneumatic	Pressure	Stackable
WK-870652-000	Lever Operated	X	—	—	—	—	—
81-979469-000	Cable Operated	X	X		—	—	—
WK-890181-000	Electric Operated, 24 VDC	X	—	X	—	—	—
81-895630-000	Electric & Cable Operated, 24 VDC	X	X	X	—	—	—
WK-897494-000	Electric & Cable Operated, 24 VDC, Explosion Proof	X	X	X	—	—	—
81-872335-000	Pneumatic, 3 in. / 5 sec	X	X	—	X	—	—
81-872365-000	Pneumatic, 6 in. / 5 sec	X	X	—	X	—	—
81-872362-000	Pneumatic, 6 in. / 2 sec	X	X	—	X	—	—
81-892330-000	Pneumatic, 3 in. Tandem	X	X	—	X	—	—
81-872360-000	Pneumatic, 6 in. Tandem	X	X	—	X	—	—
82-878737-000	Pressure Operated	—	—	—	—	X	—
82-878751-000	Lever and Pressure Operated	X	—	—	—	X	—
82-878750-000	Stackable Pressure Operated	—	—	—	—	X	X

3-13.4.1 LEVER OPERATED ACTUATION

Lever operated actuation uses a lever, located directly on the control head, to provide both normal manual and emergency manual actuation at a valve.

3-13.4.2 CABLE OPERATED ACTUATION

Cable operated systems provide normal manual actuation by using a stainless steel cable to transmit an actuating force from a pull station to a control head.

The actuating cable shall be housed in a protective casing, such as EMT or pipe, and corner pulleys (Part No. 81-803808-000 for watertight applications or WK-844648-000 for industrial applications) shall be used at each change in direction. It is not accept to bend the EMT. See Table 3-12 for corner pulley quantity and cable length limitations.

Table 3-12. Corner Pulley Quantity and Cable Length Limits

Control Head Type	**Part Number**	**Maximum Corner Pulleys**		**Maximum Cable Length**
		P/N 81-803808-000	**P/N 81-844648-000**	**ft. (m)**
Cable Operated	81-979469-000	15	30	100 ft. (30m)
Electric/Cable	ALL	6	30	100 ft. (30m)
Pneumatic	ALL	6	30	100 ft. (30m)

Cable Pull stations shall not require a pull of more than 40 lb.(178 N) force or a movement of more than 14" (356 mm) to actuate the system.

3-13.4.2.1 Tandem Control Heads

For actuation of two or more adjacent pilot cylinders, cable operated control heads may be connected in tandem from a single pull station. A cable housing (See Paragraph 2-3.3.6) shall be installed between each control head to protect the cable.

3-13.4.2.2 Multiple Pull Stations

Either the Tee Pulley (Part No. 83-843791-000) or the Dual Pull Mechanism (Part No. 81-840058-000) will allow multiple pull stations to be used with a single cable operated control head. Each device counts as one corner pulley. The cable length from each pull station to the control head may not exceed the maximum cable length specified in Table 3-12.

3-13.4.2.3 Multiple Cylinder Banks

The Dual Pull Equalizer (Part No. 81-840051-000) allows a single pull station to operate two control heads. The Equalizer counts as one corner pulley. The cable length from each pull station to the control head may not exceed the maximum cable length specified in Table 3-12.

3-13.4.3 PNEUMATIC HEAT DETECTOR OPERATED ACTUATION

Pneumatic heat detection systems provide a fully mechanical means of automatic actuation.

Heat Actuated Devices (HAD) are to be installed in an anticipated path of convective heat flow from the fire and spaced at a maximum on-center distance of 20 ft.(6.1 m), or 15 ft.-10 in. (4.8 m) for FM applications, for ceiling heights up to 12 ft.(3.7 m). Consult NFPA 72 for reduction in spacing for ceiling heights greater than 12 ft. and for spacing guidelines when different ceiling configurations are encountered. Ensure that no HAD is mounted at a location where normal process conditions can cause temperature increases to occur at rates faster than 20°F (11°C) per minute. The HAD (See Figure 2-38) is attached to a mounting bracket for ease of installation in industrial applications. Up to five HAD's may be connected to a single pneumatic control head. They are connected to the control head using 1/8-in. (3 mm) copper tubing. The tubing shall be housed in a protective casing, such as pipe or EMT.

Note: *The final leg of the copper tubing system connects to the pneumatic control head by means of 3/16-in. OD heavy wall copper tubing provided by Kidde Fire Systems. The 1/8-in. copper tubing to the HAD's must be protected by 1/2-in. EMT or pipe.*

The response time of a pneumatic detection system is dependent upon a number of factors, such as:

1. Fire intensity
2. HAD spacing and location
3. Control head setting and vent size
4. Volume of tubing

The system will actuate when the entire sensing volume (i.e., HAD's, copper tubing, and pneumatic control head sensing chamber) is pressurized to a level greater than the control head setting (e.g., 4-inches of water). To ensure adequate response to a fire, the tubing system must be limited to a total length of 200 ft. (61 m) or less.

3-13.4.3.1 Tandem Control Heads

For actuation of two or more adjacent pilot cylinders, pneumatic operated control heads may be connected in tandem to a single set of HAD's and actuation cable. The tandem control head shall have the same actuation pressure as the primary control head (See Paragraph 2-3.5). A cable housing (See Paragraph 2-3.6.1) shall be installed between each control head to protect the cable, if used.

3-13.4.3.2 Main and Reserve System Actuation

For systems with a connected reserve agent supply, a single set of HAD's is connected to the Pneumatic Main-to-Reserve Valve, Part No. 81-871364-000. The two valve outlets are connected to the pneumatic control heads on either the main or reserve supply, providing a means of manually selecting either supply.

NOTE: *There is no means of providing main/reserve selection for a connected cable operation.*

3-13.4.4 ELECTRICALLY OPERATED ACTUATION

Electrical actuation uses an electrically operated control head and a suppression-releasing panel, which is alarmed by automatic detectors and manual pull stations. See Paragraph 3-14 for additional information.

3-13.4.5 NITROGEN PRESSURE OPERATED ACTUATION

Nitrogen pressure actuated systems provide a means of actuating multiple components from a single control. Pressure from a nitrogen cylinder actuates one or more pressure operated control heads attached to carbon dioxide cylinders or stop valves. In addition to these components, N_2 actuation is required to drive the discharge delay when FM Approval is required. The nitrogen cylinder is actuated by a lever, cable, electrical, or pneumatic heat detector operated system, as discussed in previous sections.

3-13.4.5.1 Direct N2 Operation of CO2 Cylinders and Stop Valves

To achieve minimum actuation pressure in the pilot line, length limitations must be observed. See Table 3-13 for limits.

Table 3-13. Nitrogen Pilot Line Length Limitations

Pipe or Tubing	Maximum Linear Distance Permitted Between N_2 and CO_2 Cylinders
1/4-inch (DN6) NPT Schedule 40 Galvanized Steel Pipe	300 ft. (91.44 m)
1/4-inch (DN6) NPT Schedule 80 Galvanized Steel Pipe	436 ft. (132.89 m)
1/4-inch (4mm) OD x 0.035 in. (1mm) Wall Thickness Stainless Steel Tubing	427 ft. (130.14 m)
5/16 in. OD x 0.032 wall	436 ft. (132.89 m)

As an alternative to the above limits for the 108 cu. in. nitrogen cylinder, the 1040 cu. in. nitrogen cylinder may also be used for direct operation of CO2 cylinders and stop valves. The 1040 cu. in. nitrogen cylinder cannot be used to drive the nitrogen operated discharge delay unit. Therefore, the 1040 cu. in. nitrogen cylinder may be employed upstream of a 108 cu. in. nitrogen cylinder or downstream of the discharge delay unit. A maximum actuation line length of 460-ft is allowed between the 1040 cu. in. nitrogen cylinder and all of the downstream pressure operated control heads. Either schedule 80 stainless steel pipe or 5/16" x 0.032 wall stainless steel tubing may be used for the entire actuation line. Also in this arrangement, the 1040 cu. in. nitrogen cylinder assembly can actuate up to three additional nitrogen cylinders, which will be used to drive nitrogen pressure operated sirens. When actuating siren driver cylinders, a maximum actuation line length of 90-ft is allowed. This length is in addition to the 460-ft maximum allowed length between the pilot cylinder and the discharge delay. When the length between the pilot cylinder and discharge delay is less than 460-ft, the resulting difference may be added to the 90-ft actuation line length to the siren driver cylinders.

3-13.4.5.2 Nitrogen Actuation with In-Line Discharge Delay

When using a nitrogen operated discharge delay unit, the 108 cu. in. nitrogen cylinder assembly shall be used to supply nitrogen to the delay unit. Either ¼" schedule 80 stainless steel pipe or 5/16" x 0.032 wall stainless steel tubing may be used for the entire actuation line. No more than 4-ft of actuation line length can be used to connect the nitrogen cylinder to the discharge delay unit. A maximum actuation line length of 225-ft may be used from the outlet of the discharge delay to all of the downstream pressure operated control heads. Also in this arrangement, the 108 cu. in. nitrogen cylinder assembly can actuate up to a pair of additional nitrogen cylinders, which will be used to drive the nitrogen pressure operated siren. When actuating siren driver cylinders, a maximum actuation line length of 20-ft is allowed. This length is in addition to the 4-ft maximum allowed length between the pilot cylinder and the discharge delay. When the length between the pilot cylinder and discharge delay is less than 4-ft, the resulting difference may be added to the 20-ft actuation line length to the siren driver cylinders. Refer to Figure 3-12 for a typical acuation arrangement utilizing an in-line discharge delay.

NO.	EQUIPMENT DESCRIPTION
1	CONTROL HEAD, PRESSURE OPERATED
2	ACTUATION HOSE, 1/4"
3	MALE BRANCH TEE, 5/16" FLARE X 1/8 NPT"
4	CONTROL HEAD LEVER OPERATED
5	TIME DELAY, N2 OPERATED
6	NITROGEN PILOT CYLINDER, 108 CUIN (1.77 L)
7	MOUNTING BRACKET, NITROGEN PILOT CYLINDER
8	SAFETY OUTLET, 3/4" (20 MM)

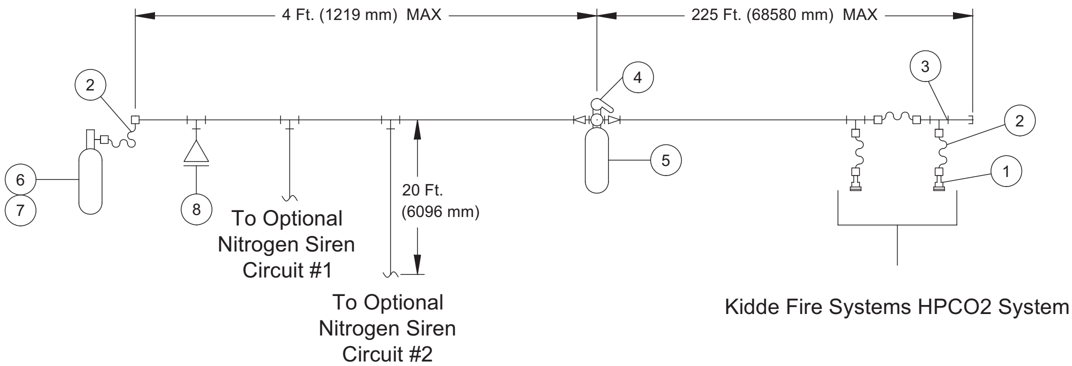


Figure 3-12. Typical Actuation Arrangement Using In-line Discharge Delay

3-14 DETECTION DEVICES, ALARM DEVICES AND CONTROL PANELS

The majority of carbon dioxide suppression systems will include electrical detection, notification, and actuation. This section covers the requirements of NFPA 12 for carbon dioxide releasing systems. NFPA 70 and 72 shall be referenced for additional information.

3-14.1 Suppression Control Panels

The Suppression Control Panel shall be listed for use with all field devices, including the electrical control heads.

All input (alarm initiation and supervisory) and output (notification and actuation) circuits shall be supervised for system trouble.

The suppression control panel should be connected to existing protective signaling (fire alarm) system(s) to aid life safety and property protection as outlined in NFPA 72, National Fire Alarm Code.

3-14.2 System Power Supply

The power supply for the operation and control of the system shall be comprised of a primary source and a secondary source.

The primary source of energy shall have the capacity for the intended service and shall be supervised and reliable.

On loss of primary source or due to low voltage of the primary energy source, an independent secondary (standby) power supply shall supply energy to the system. The secondary (standby) supply shall be capable of operating the system under maximum normal load for 24 hours and then be capable of operating the system continuously for the full design discharge period.

3-14.3 Automatic Detection

The type of detector required for a particular application is dependent upon the type of combustible products being protected. When designing a detection system, the system designer must consider the following factors:

- Type and quantity of fuel
- Possible ignition sources
- Ranges of ambient conditions
- Value of protected property

The detection shall be by any listed or approved method or device that is capable of detecting and indicating heat, flame, smoke, combustible vapors or an abnormal condition in the hazard such as a process trouble that is likely to produce fire. When designing a suitable detection system, it is necessary to survey the premises and gather intricate details such as ceiling types, ceiling obstructions, (e.g. beams, joists, light fixtures, location of air diffusers and return grills), ambient conditions (e.g., temperature and humidity) and elevation with respect to sea level. When using smoke detectors for system actuation, it is recommended to space the detectors at a maximum of half the listed spacing. Refer to NFPA 72 and manufacturer's recommendations for coverage area and detector spacing.

3-14.4 Manual Controls

Manual pull stations for carbon dioxide release should be located at all exit/entrance doors and shall be easily accessible at all times. For areas protected with total flooding applications, the manual pull stations should be installed outside the protected area. At least one manual control shall be located no more than 4 ft. (1.2 m) above the floor.

Abort switches shall not be used in CO_2 suppression systems.

3-14.5 Notification

Pre-discharge alarm shall be provided to give positive warning of a discharge where hazards to personnel could exist. Such alarms shall function to warn personnel against entry into hazardous areas as long as such hazards exist or until such hazards are properly recognized.

Audible pre-discharge alarms shall be at least 15 dB above ambient noise level or 5 dB above maximum sound level, whichever is greater, measured 5 ft. (1.5 m) above the floor of the occupiable area. Such alarms shall have a maximum sound level of 120 dB at the minimum hearing distance and a minimum sound level of 90 dB at 10' (3 m).

Visual or other methods of indication are also recommended.

3-14.6 Supervision of Controls

Interconnections between the components that are necessary for control of the system and life safety, such as lockout valves and manual bypasses that may be left in the open position shall be supervised. Such supervisory alarms shall be distinctive from alarms indicating system operation or hazardous conditions.

3-14.7 Main and Reserve System Actuation

For systems with a connected reserve agent supply, the Main-to-Reserve Transfer Switch, Part No. 84-802398-000, is used to select the supply to be discharged. Reference Paragraph 4-4.5 for wiring information.

3-15 AUXILIARY EQUIPMENT AND SYSTEMS

A sub-system of components is used to provide auxiliary interlocks that occur at system actuation. Such interlocks may include electrical connections, such as fan or process shutdown, and/or mechanical operations, such as door or vent closure.

Where the continuing operation of equipment associated with a hazard being protected could contribute to sustaining the fire in that hazard, the source of power or fuel shall be automatically shut off.

NOTE *This does not apply to lubricating oil systems associated with large rotating equipment, where an extended discharge system is provided and that is designed to operate for the deceleration/cooldown period.*

All shutdown devices shall be considered integral parts of the system and shall function with the system operation.

3-15.1 Pressure Operated Switches

One or more Pressure Operated Switches (Part No. 81-486536-000 or 81-981332-000) may be used for auxiliary electrical functions such as HVAC shut down, closing motorized dampers, or providing a release signal to the building alarm system. Refer to Paragraph 2-8.1 for additional information.

3-15.2 Pressure Operated Trips

One or more Pressure Operated Trips (Part No. 81-874290-000) may be used for auxiliary mechanical functions such as damper closure, door closure, or mechanical gas valve shutdown. Typical applications of the pressure-operated trip are shown in Figure 3-13. Reference Paragraph 2-8.2 for additional information.

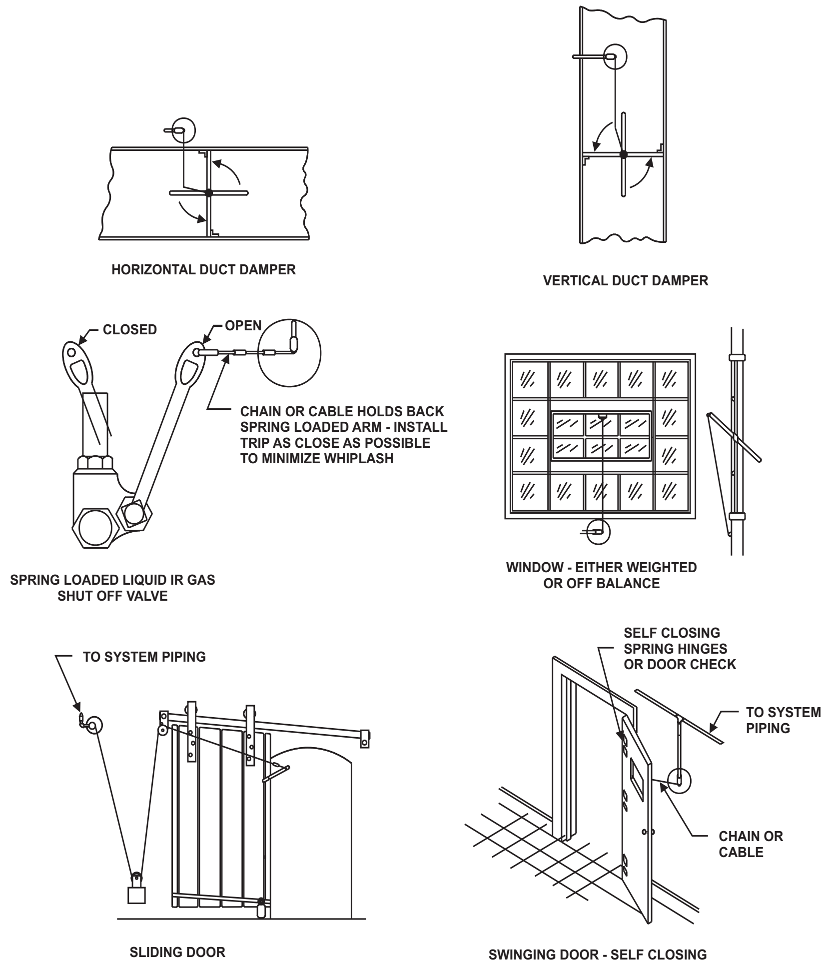


Figure 3-13. Pressure Trip Applications

The Trip shall be installed with the shortest feed pipe possible. However, should it be necessary to install a pressure trip with a considerable length of the branched pipe, the quantity of carbon dioxide required to fill the pipe volume should be added to the minimum design quantity for the system.

3-16 HAND HOSE LINE SYSTEMS

A Hand Hose Line System consists of a hose reel or rack, hose, and a discharge nozzle assembly connected by fixed piping to a supply of carbon dioxide.

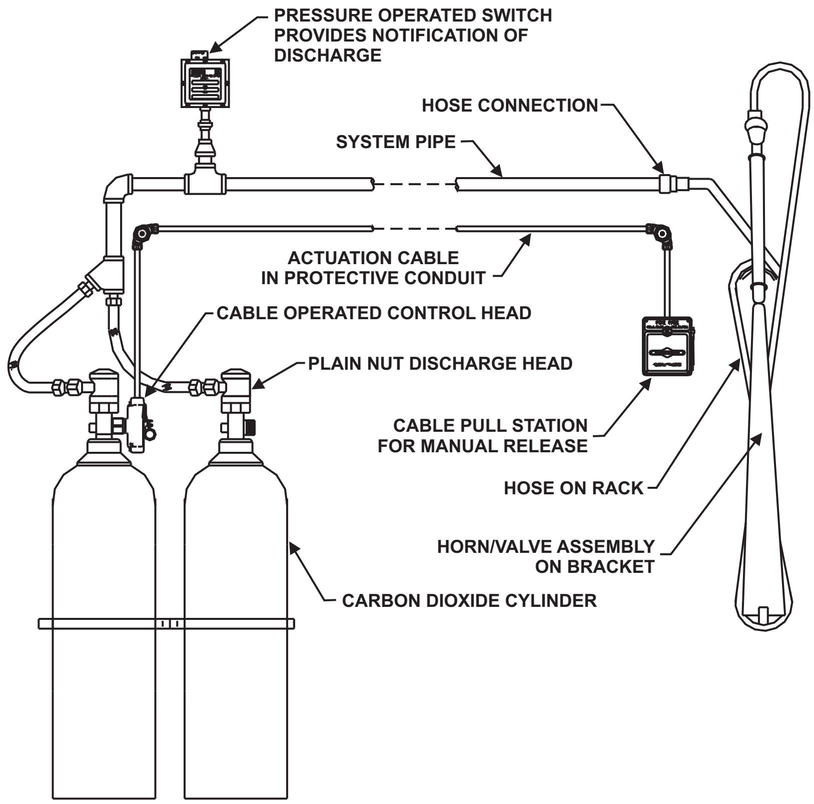


Figure 3-14. Typical Hand Hose Line System with Rack

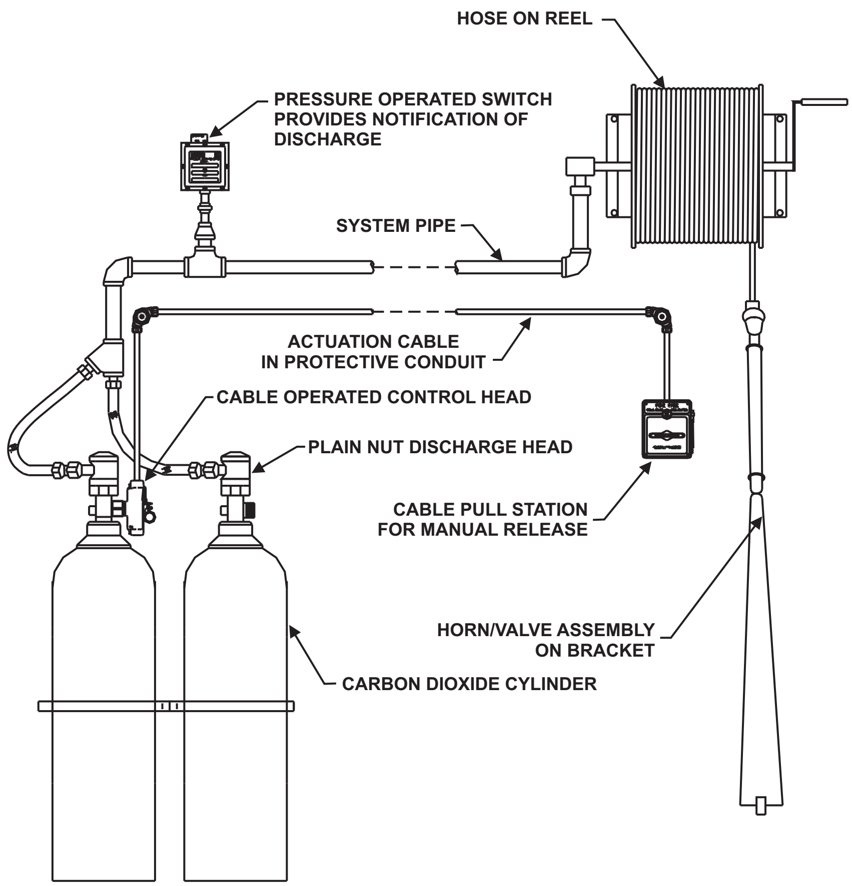


Figure 3-15. Typical Hand Hose Line System with Reel

3-16.1 Uses

Hand hose line systems may be used to supplement fixed fire protection systems or to supplement first response portable fire extinguishers for the protection of specific hazards for which carbon dioxide is the extinguishing agent. These systems shall not be used as a substitute for other fixed carbon dioxide fire-extinguishing systems equipped with fixed nozzles, except where the hazard cannot adequately or economically be protected by a fixed system. Hand hose line systems may be used to combat fires in all hazards covered under Chapter 1, except those that are inaccessible and beyond the scope of manual firefighting. The decision as to whether hose lines are applicable to the particular hazard shall rest with the authority having jurisdiction.

3-16.2 Safety Requirements

Consideration shall be given to the possibility of carbon dioxide migrating and settling into adjacent areas outside the protected space. Consideration shall also be given to where the carbon dioxide can migrate or collect in the event of a discharge from a safety relief device of a storage container. In any use of carbon dioxide, consideration shall be given to the possibility that personnel could be trapped in or enter into an atmosphere made hazardous by a carbon dioxide discharge. Safeguards shall be provided to ensure prompt evacuation, to prevent entry into such atmospheres, and to provide means for prompt rescue of any trapped personnel. Safety training shall be provided to all personnel that work near or in a protected space.

The provisions detailed in Paragraph 1-6.1 shall apply to hand hose line systems.

3-16.3 Location

Hand hose line systems shall be placed such that they are easily accessible and that the hose length is adequate to reach the most distant hazard. In general, they should not be located where they will be exposed to the hazard, nor shall they be located inside any hazard area protected by a total flooding system.

The hose shall be coiled on a Hose Reel, P/N WK-994058-000, or Rack, P/N 81-919842-000, such that it will be ready for immediate use without the necessity of coupling and that it can be uncoiled with a minimum of delay. If installed outdoors, it shall be protected against the weather.

The carbon dioxide supply shall be located as close to the hose reel or rack as possible so that liquid carbon dioxide will be supplied to the hose line with a minimum of delay after actuation.

If multiple hose stations are used, they shall be spaced so that one or more hose lines can cover any area within the hazard.

3-16.4 System Design

The rate and duration of discharge shall be determined by the type and potential size of the hazard. A hand hose line shall have a quantity of carbon dioxide to permit its use for at least 1 minute. The possibility of these hose lines being used by inexperienced personnel shall be considered, and a provision shall be made so that there will be a supply of carbon dioxide to enable personnel to effect extinguishment of the hazards that they are likely to encounter.

3-16.4.1 FLOW RATE

Once a convenient cylinder location, hose location and pipe routing have been determined, a hydraulic calculation shall be performed to determine the nominal flow rate of the system. The equivalent lengths in Table 3-14 and Table 3-15 may be used to calculate pressure loss through the various components. Each equivalent length is given in multiple pipe sizes for convenience. The Horn/Valve Assembly may be modeled as a Code 8.5 Type V nozzle.

Table 3-14. Equivalent Lengths of Hand Hose Line Components (US Units)

P/N	Description	Equivalent Length Nominal Pipe Size				
		1/2 in.		3/4 in.		1 in.
		Sch 80	Sch 40	Sch 80	Sch 40	Sch 80
WK-994058-000	Hose Reel (Swivel Joint)	10	20	7	12	-
81-961966-000	Hose, 1/2 in. x 50 ft.	63	124	312	541	-
81-918435-000	Hose, 3/4 in. x 50 ft.	-	-	37.5	65	143
81-980564-000	Horn and Valve Assembly (Shutoff Valve)	1.5	2.5	-	-	-

Table 3-15. Equivalent Lengths of Hand Hose Line Components (Metric Units)

P/N	Description	Equivalent Length Nominal Pipe Size				
		15 mm		20 mm		25 mm
		Sch 80	Sch 40	Sch 80	Sch 40	Sch 80
WK-994058-000	Hose Reel (Swivel Joint)	3.05	6.10	2.13	3.66	-
81-961966-000	Hose, 15 mm x 15.24 m	19.20	37.80	95.10	164.90	-
81-918435-000	Hose, 20 mm x 15.24 m	-	-	11.43	19.81	43.59
81-980564-000	Horn and Valve Assembly (Shutoff Valve)	0.46	0.76	-	-	-

Note that the equivalent lengths of hoses are given for 50-foot (15.24-meter) lengths of hose. As the actual hose length may vary from 25 ft. to 200 ft. (7.62 m to 60.96 m), the equivalent length for the system hose may be calculated from Equation (36).

(Equation 36)

$$z = z_r \div 50L \text{ (US Units)}$$

or

$$z = z_r \div 15.24L \text{ (Metric Units)}$$

Where:

z = Equivalent length of hose, ft. (m)

z_r = Equivalent length of 50 ft. (15.24 m) hose from Table 3-14 and Table 3-15

L = Actual length of hose, ft. (m)

3-16.4.2 MINIMUM AGENT QUANTITY

A hand hose line system is a local application of agent, and therefore only the liquid portion of the discharge is effective. A vaporization factor of 40% must be applied to the total agent quantity to be supplied.

(Equation 37)

$$W = 1.4 \times q \times t$$

Where:

W = Minimum quantity of agent to be supplied, lb. (kg)

q = Nominal system flow rate from hydraulic calculation, lb./min. (kg/min.)

t = Duration of discharge, minimum 1 min.

3-16.4.3 MULTIPLE STATIONS

Where simultaneous use of two or more hose lines from a single bank of cylinders is possible, a quantity of carbon dioxide shall be available to support the maximum number of hoses that are likely to be used at any one time for at least 1 minute. All supply piping shall be sized for the simultaneous operation of these hoses.

3-16.4.4 CARBON DIOXIDE SUPPLY

A separate carbon dioxide supply can be provided for hand hose line use, or carbon dioxide can be piped from a central storage unit supplying several hose lines or from fixed manual or automatic systems. Where hand hose lines are provided for use on a hazard protected by a fixed system, separate supplies shall be provided unless sufficient carbon dioxide is provided to ensure that the fixed protection for the largest single hazard on which the hose lines can be used will not be jeopardized.

All controls for actuating the system shall be located in the immediate vicinity of the hose reel or rack. Operation of hand hose line systems depends upon manual actuation and manual manipulation of the horn and valve assembly. Therefore, speed and simplicity of operation are essential for successful extinguishment. Refer to Paragraph 3-13 for additional information on actuation systems.

The use of a Grooved Nut Discharge Head, P/N 81-872442-000, with a Lever Operated Control Head, P/N WK-870652-000, allows the operator to actuate only one cylinder at a time in a multiple cylinder bank and to close the cylinder valve without discharging the entire contents of the cylinder.

3-16.4.5 ACTUATION

All controls for actuating the system shall be located in the immediate vicinity of the hose reel or rack. Operation of hand hose line systems depends upon manual actuation and manual manipulation of the horn and valve assembly. Therefore, speed and simplicity of operation are essential for successful extinguishment. Refer to Paragraph 3-13 fir additional information on actuation systems.

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CHAPTER 4
INSTALLATION

4-1 INTRODUCTION

This section contains installation instructions for Kidde Fire Systems fixed carbon dioxide systems as well as hose reel and rack systems.

Equipment installation shall be such that the components are located and arranged to permit inspection, testing, recharging, and any other required maintenance that may be necessary. Components must not be located where they may be subject to severe weather conditions, direct sunlight, mechanical, chemical, or other damage which could render them inoperative.

4-2 GENERAL INSTALLATION REQUIREMENTS

Installation of Kidde Fire Systems fixed carbon dioxide systems shall comply with local and regional standards, be conducted according to accepted practices, and be performed in accordance with the approved installation drawings as well as with the instructions and information contained in this manual.

4-3 INSTALLATION OF SUPPRESSION SYSTEMS

4-3.1 Discharge Pipe and Fittings

Pipe, tubing, and fittings must be installed in strict accordance with the approved installation drawings and acceptable engineering practices. The piping between the cylinders and nozzles must be the shortest route possible, with a minimum of fittings. Any deviations in the routing or number of fittings must be approved by the design engineer prior to installation.

Piping and tubing must be reamed free of burrs and ridges after cutting, welding or threading. Joint compound tape or thread sealant must be applied only to the male threads of the joint, excluding the first two threads. Each pipe section must be swabbed clean, using a nonflammable organic solvent.

All piping must be blown out with nitrogen, carbon dioxide, or dry compressed air prior to installing the discharge nozzles. Dirt traps at least 2-inches (51 mm) in length must be installed 1at the end of each pipe run. The piping system must be securely supported and braced to account for discharge reaction forces in addition to the load from piping deadweight and forces resulting from thermal expansion/contraction. Consideration must be given to thermal expansion/contraction by avoiding rigid restraints (anchors) at both ends of a long pipe run. One end of the pipe run must be supported with an intermediate type pipe hanger (refer to *Pipe Design Handbook, Second Edition* published by Fire Suppression Systems Association, Baltimore, Maryland), in order to avoid structural buckling or pipe joint or support separation due to thermal expansion/contraction. Care must be taken to insure the piping is not subjected to vibration, mechanical, or chemical damage. Refer to Table 4-1 and Table 4-2 for pipe support guidance.

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

(a) Ferrous Piping: Black or galvanized steel pipe shall be either ASTM A-53 seamless or electric welded, Grade A or B, or ASTM A-106, Grade A, B, or C.

ASTM A-120, furnace butt-weld ASTM A-53 and ordinary cast-iron pipe shall not be used.

In systems using high pressure supply, 3/4-inch (DN20) and smaller pipe may be Schedule 40. Pipe 1-inch (DN25) through 4-inches (DN100) shall be a minimum of Schedule 80. Furnace butt weld ASTM-53 pipe shall not be used.

Stainless steel shall be TP304 or TP316 for threaded connections or TP304, TP316, TP304L or TP316L for welded connections.⌖

(b) NFPA 12 does not preclude the use of other piping materials providing an internal pressure of 2,800 PSI (19.3 MPa) which will not exceed the maximum allowable stress value published in the ASME Code for Pressure Piping, B-31.1, an American National Standard.; in other words, the thickness of the pipe wall shall be calculated in accordance with ASME B31.1.

In accordance with NFPA 12, Class 150 and cast-iron fittings shall not be used.⌖

(c) High Pressure Fittings: Class 300 malleable or ductile iron fittings shall be used through 2-inch (DN50) internal pipe size (IPS). Larger internal pipe sizes shall be forged steel fittings. Flanged joints used in open sections of pipe shall be permitted to be Class 300. Flanged joints used in closed sections of pipe shall be Class 600.

Stainless steel fittings shall be type 304 or 316 in accordance with ASTM A 182, Class 3000, threaded or socket weld, for all sizes 1/8-inch (DN6) through 4-inch (DN100).

4-3.2 Pressure Operated Actuation Pipe, Tubing and Fittings

The pressure operated actuation tubing must be 1/4-inch (6 mm) O. D. stainless steel (0.035-inch (1 mm) wall thickness) or 1/4-inch (DN6), schedule 40 or 80 galvanized steel pipe. The pipe or tubing must be routed in the most direct manner, with a minimum of fittings. Tubing fittings can be flared or compression-type. The pipe, tubing and fittings must have a minimum allowable pressure rating of 1800 psig. The pressure/temperature ratings of the fitting manufacturer must not be exceeded.

Piping and tubing must be reamed free of burrs and ridges after cutting, threading, or flaring. Upon assembly, pipe or tubing must be blown out with nitrogen, carbon dioxide, or dry compressed air; and must be securely supported, braced, and isolated from vibration, mechanical, or chemical damage.

Table 4-1. Maximum Horizontal Pipe Hanger and Support Bracing[1]

Pipe Size	Distance Between Supports	Rod Diameter
1/4 in. (DN06)	7 ft. (2.1 m)	3/8 in.
1/2 in. (DN15)	7 ft. (2.1 m)	3/8 in.
3/4 in. (DN20)	7 ft. (2.1 m)	3/8 in.
1 in. (DN25)	7 ft. (2.1 m)	3/8 in.
1-1/4 in. (DN32)	7 ft. (2.1 m)	3/8 in.
1-1/2 in. (DN40)	9 ft. (2.7 m)	3/8 in.
2 in. (DN50)	10 ft. (3 m)	3/8 in.
2-1/2 in. (DN65)	11 ft. (3.4 m)	1/2 in.
3 in. (DN80)	12 ft. (3.7 m)	1/2 in.
4 in. (DN100)	14 ft. (4.3 m)	5/8 in.
5 in. (DN125)	16 ft. (4.9 m)	5/8 in.
6 in. (DN150)	17 ft. (5.2 m)	3/4 in.
8 in. (DN200)	19 ft. (5.8 m)	3/4 in.

[1] Extracted from FSSA Pipe Design handbook, Second Edition, with permission of the publisher, FSSA.

Additional Pipe Hanger and Support Considerations:

- Riser supports shall take into consideration the weight of the entire riser including pipe, valves and other concentrated loads
- Pipe supports shall be located at each change in direction
- Pipe supports shall be located as close as possible to concentrated loads

Table 4-2. Maximum Pipe Hanger and Support Design Load Ratings

Applicable to all pipe support assembly components including pipe attachment, rod, fixtures, clamps, bolts and nuts, and building structure attachments.	
Nominal Pipe Size	**Ratings at Normal Temperature Range***
3/8 in. (DN10)	150 lbs. (65 kg)
1/2 in. (DN15)	150 lbs. (65 kg)
3/4 in. (DN20)	150 lbs. (65 kg)
1 in. (DN25)	150 lbs. (65 kg)
1-1/4 in. (DN32)	150 lbs. (65 kg)
1-1/2 in. (DN40)	150 lbs. (65 kg)
2 in. (DN50)	150 lbs. (65 kg)
2-1/2 in. (DN65)	170 lbs. (75 kg)
3 in. (DN80)	210 lbs. (95 kg)
3-1/2 in. (DN90)	250 lbs. (110 kg)
4 in. (DN100)	300 lbs. (135 kg)
*Normal temperature range is -20° F to 650° F (-29° C to 343° C) for carbon steel.	
Extracted from MSS SP-58, 1993, with permission of the publisher, the Manufacturers Standardization Society.	

4-3.3 Discharge Manifold

Securely support the discharge manifold. The manifold must be installed such that it is level and the inlets are aligned to connect with the cylinder valve discharge head.

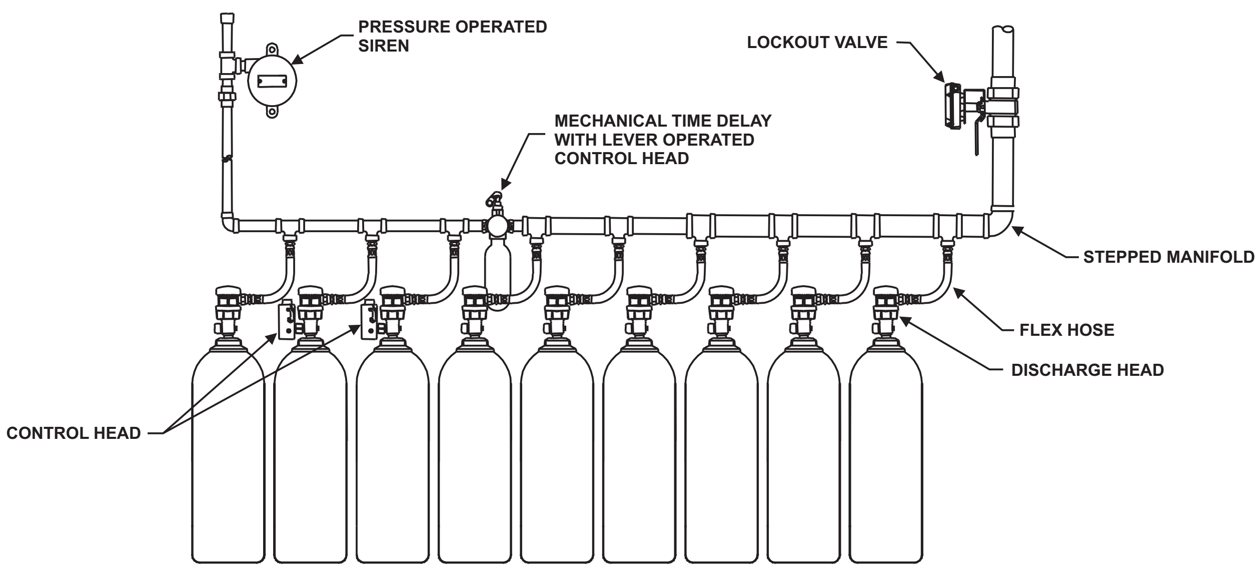


Figure 4-1. Typical Manifold Layout

Note: Not FM Approved.

4-3.4 Manifold "Y" Fitting

When the carbon dioxide system consists of two (2) cylinders this fitting (P/N 207877) may be used to connect the Flex Hoses to the pipe network riser.

Refer to Paragraph 4-3.6 for information on Flex Hose installation.

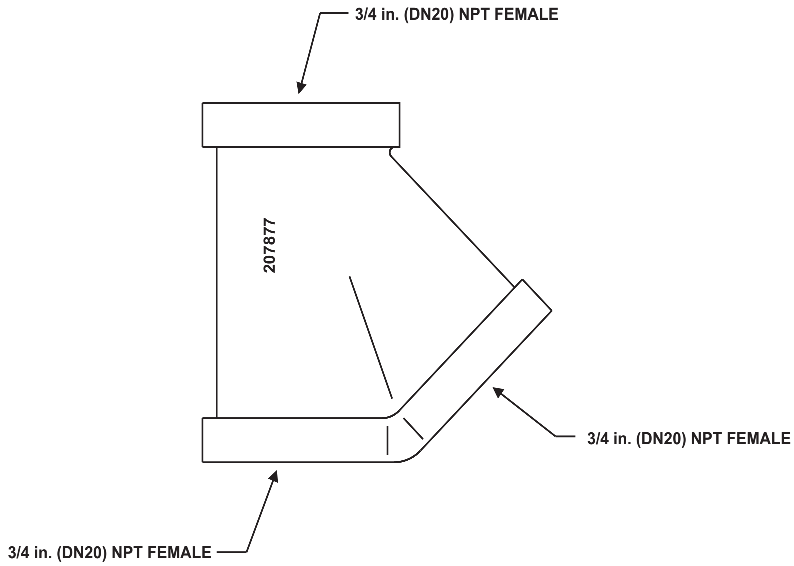


Figure 4-2. Manifold "Y" Fitting

4-3.5 Carbon Dioxide Cylinder Assemblies

The carbon dioxide cylinders must be located as close to the hazard area as possible. The cylinders must be located in an environment protected from the weather and where ambient storage temperatures for, (a) local application systems shall not exceed 120°F (49°C) nor be less than 32°F (0°F); and (b) total flooding systems shall not exceed 130°F (54°C) nor be less than 0°F (-18°C). External heating or cooling may be required to maintain this temperature range.

Orient the cylinders according to the approved installation drawings. Mount the cylinders securely to the structural supports with the straps and/or brackets provided. Elevate the cylinders at least two inches off the floor if moisture is present. Locate the cylinder straps as shown in Figure 4-3 and Figure 4-5. For other strap and bracketing arrangements refer to Figure 4-5 through Figure 4-20.

WARNING

Each cylinder strap and/or bracket must be securely attached to structural supports to absorb the force generated by cylinder discharge.

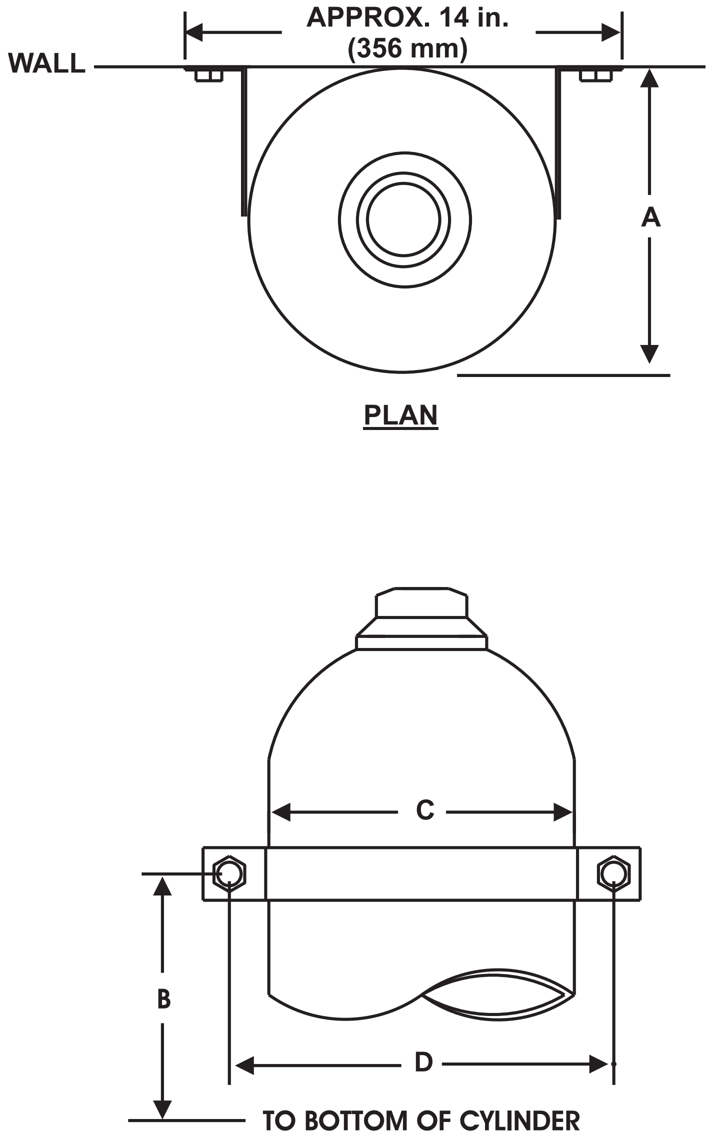
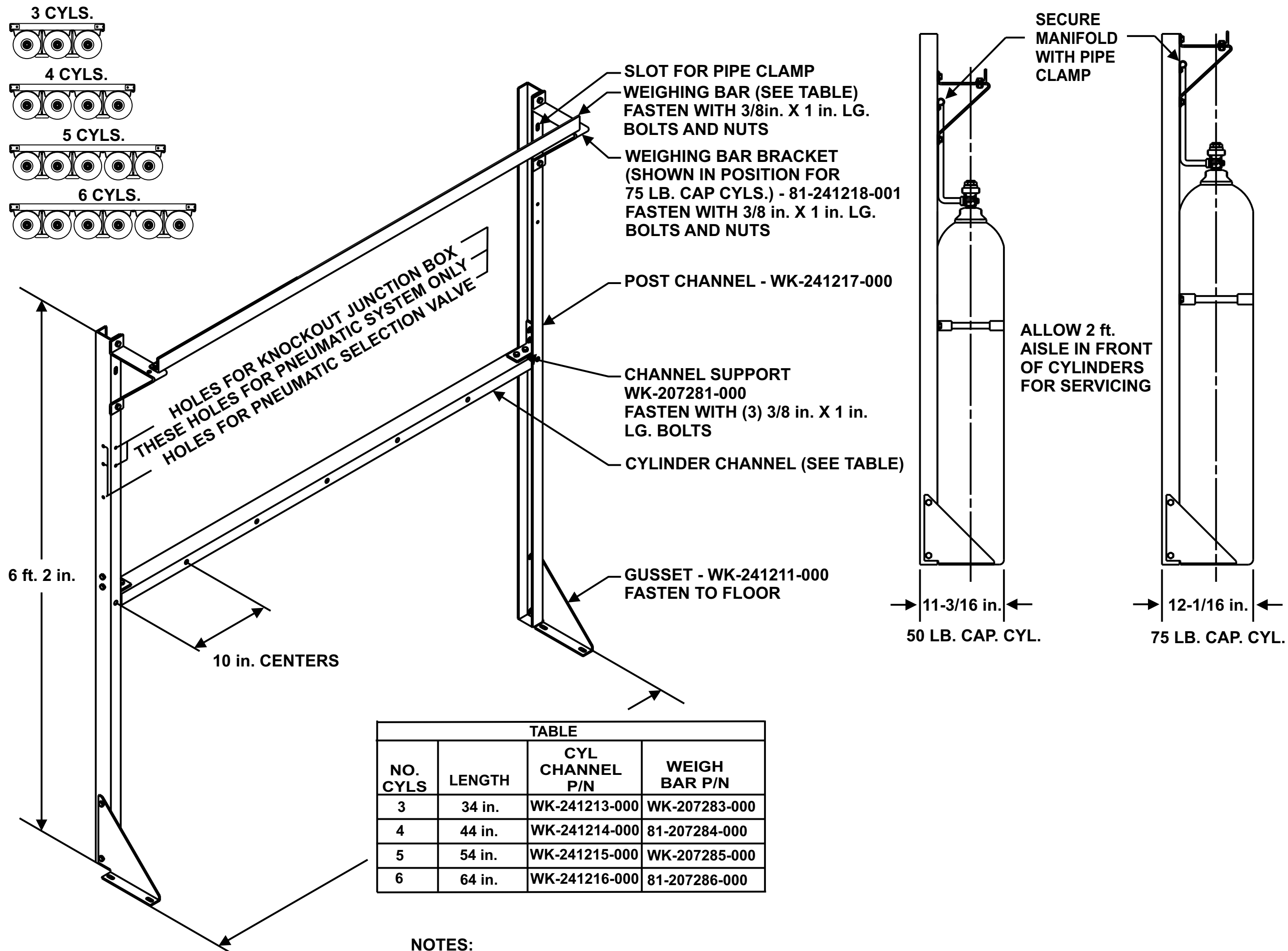


Figure 4-3. Typical Cylinder Strap Location

Table 4-3. Typical Cylinder Strap Location Dimensions

Cylinder Capacity	A	B	C	D
25 lb.	8-3/4 in. (222 mm)	17 in. (431 mm)	8-1/2 in. (216 mm)	10-3/8 in. (264 mm)
35 lb.	8-3/4 in. (222 mm)	23 in. (584 mm)	8-1/2 in. (216 mm)	10-3/8 in. (264 mm)
50 lb.	8-3/4 in. (222 mm)	34 (864 mm)	8-1/2 in. (216 mm)	10-3/8 in. (264 mm)
75 lb.	9-1/2 in. (241 mm)	38 in. (965 mm)	9-1/4 in. (235 mm)	11-1/8 in. (283 mm)
100 lb.	10-3/4 in. (273 mm)	40 in. (1016 mm)	10-9/16 in. (268 mm)	12-3/8 in. (314 mm)



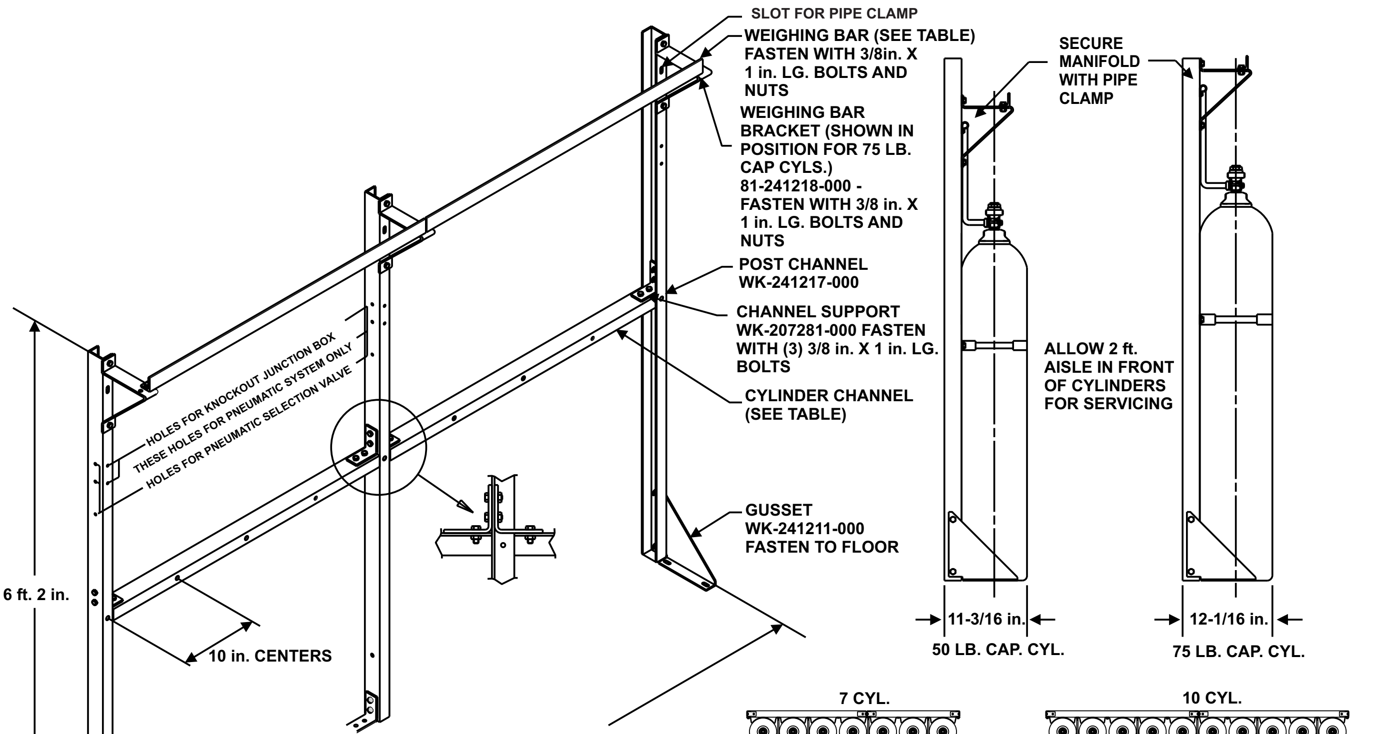
TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
3	34 in.	WK-241213-000	WK-207283-000
4	44 in.	WK-241214-000	81-207284-000
5	54 in.	WK-241215-000	WK-207285-000
6	64 in.	WK-241216-000	81-207286-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

WITH THE ABOVE FRAMEWORK, CYLINDER ASSEMBLIES CAN BE PLACED AGAINST A WALL OR CAN BE FREE STANDING BY FASTENING GUSSETS TO FLOOR

Figure 4-4. Rack Framing - 3 to 6 Cylinders (50 and 75 lb. Capacity), Single Row



TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
7	6 ft. 2 in.	WK-241213-000 WK-241214-000	WK-207283-000 81-207284-000
8	7 ft.	(2) WK-241214-000	(2) 81-207284-000
9	7 ft. 10 in.	WK-241214-000 WK-241215-000	81-207284-000 WK-207285-000
10	8 ft. 8 in.	(2) WK-241215-000	(2) WK-207285-000
11	9 ft. 6 in.	WK-241215-000 WK-241216-000	WK-207285-000 81-207286-000
12	10 ft. 4 in.	(2) WK-241216-000	(2) 81-207286-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

THIS FRAMEWORK TO BE PLACED AGAINST A WALL, BUT CAN ALSO BE INSTALLED FREE STANDING.

Figure 4-5. Rack Framing - 7 to 12 Cylinders (50 and 75 lb. Capacity), Single Row

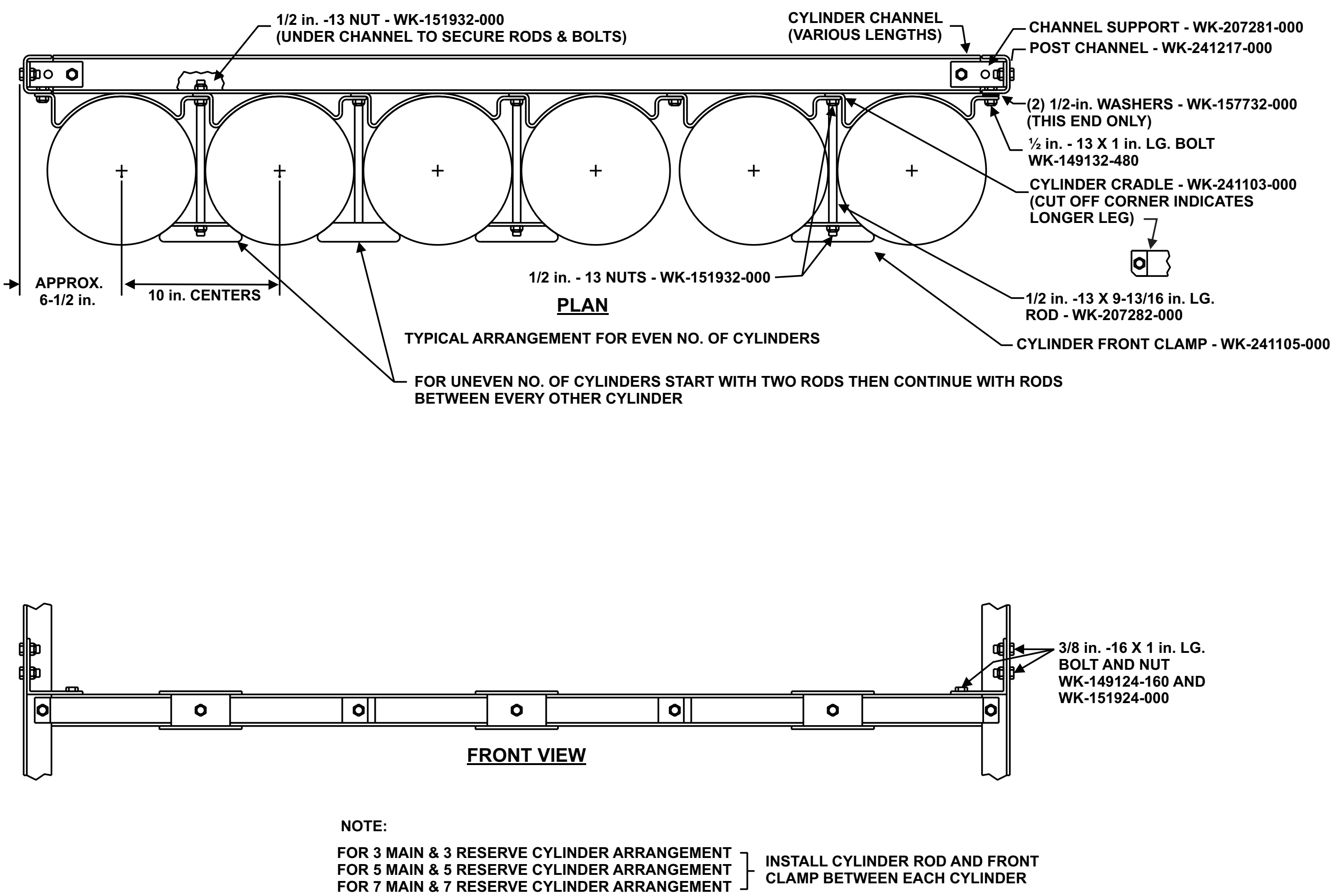
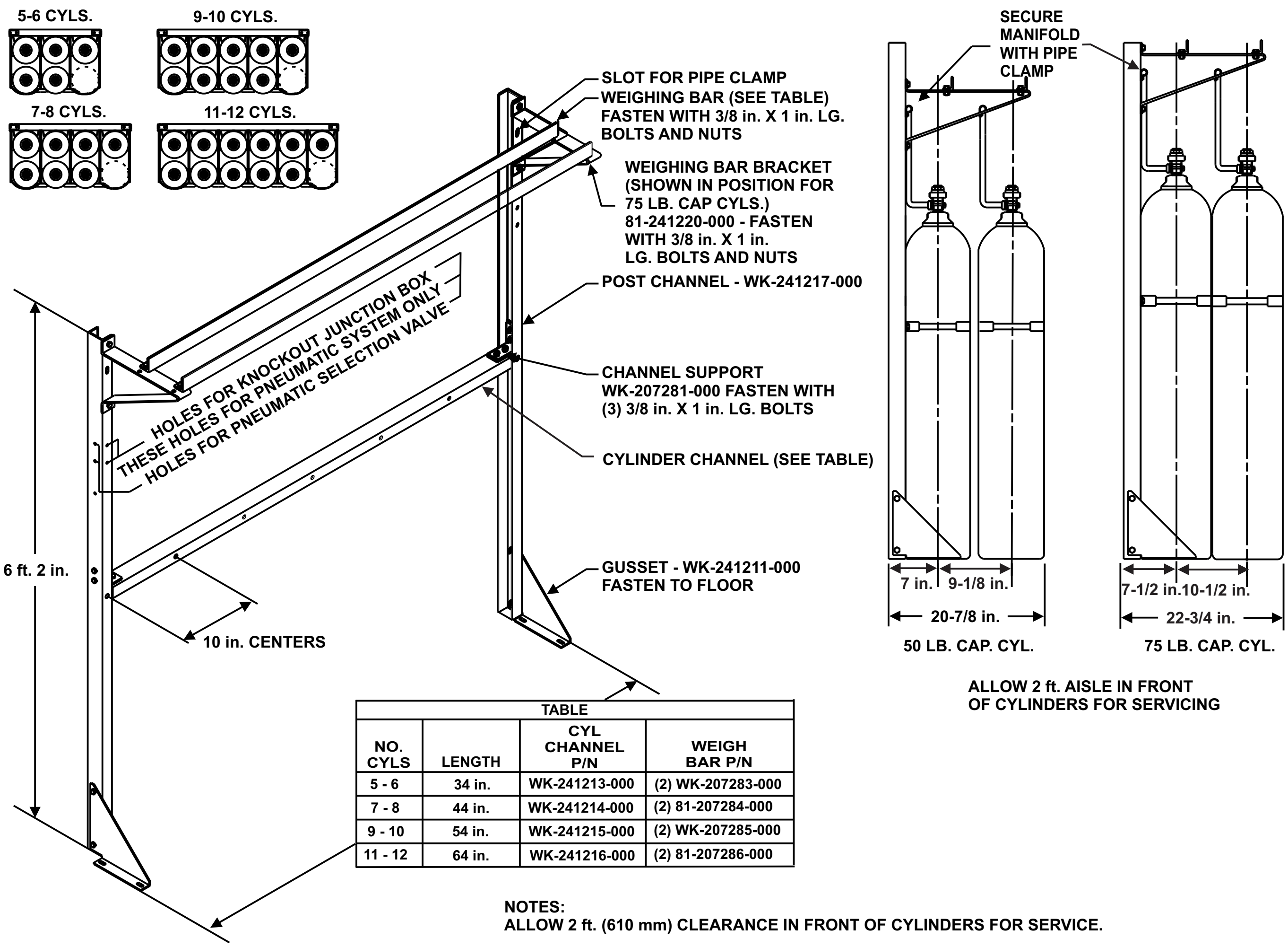


Figure 4-6. Cylinder Racks (50 and 75 lb. Capacity), Single Row



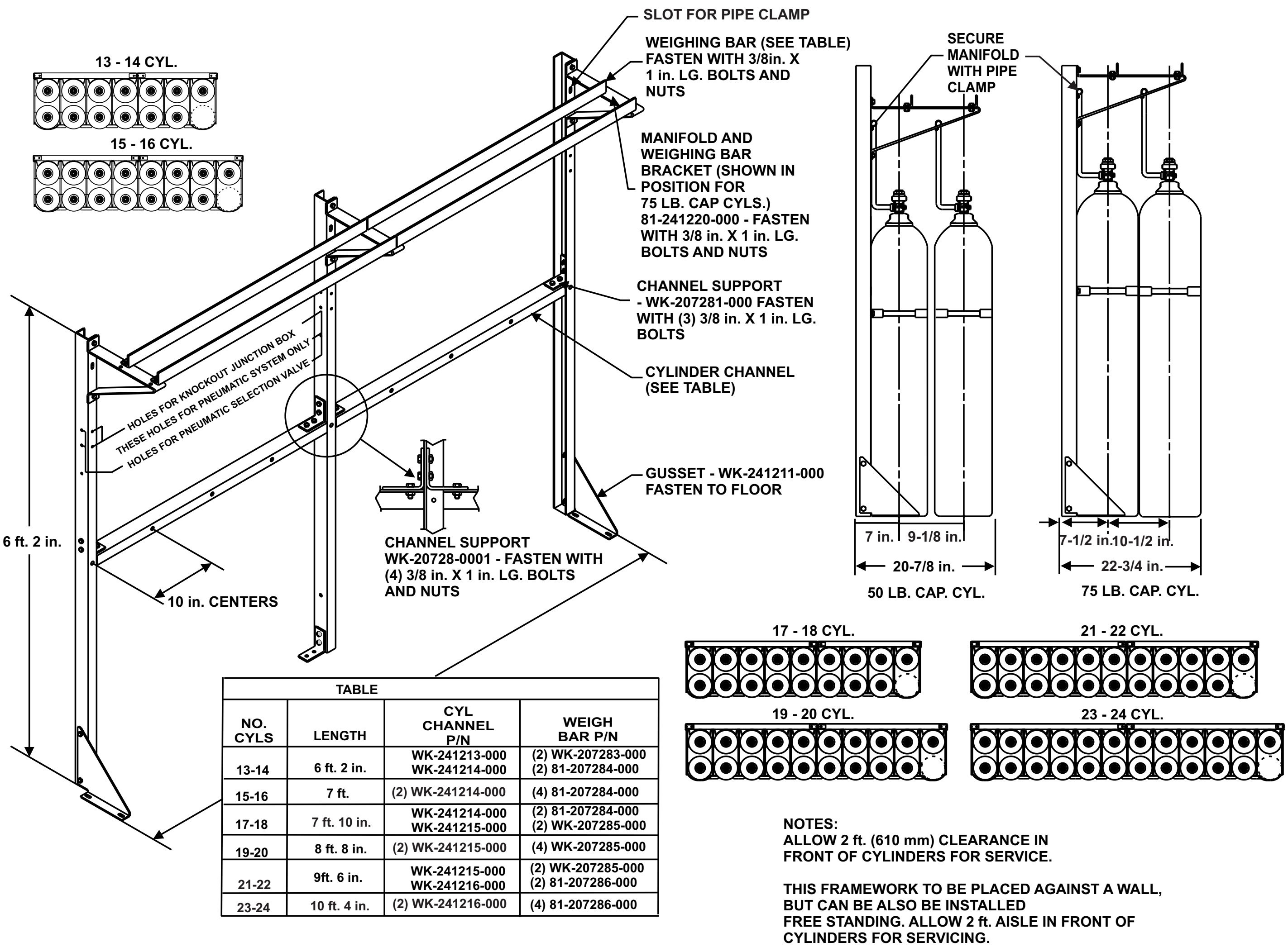
TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
5 - 6	34 in.	WK-241213-000	(2) WK-207283-000
7 - 8	44 in.	WK-241214-000	(2) 81-207284-000
9 - 10	54 in.	WK-241215-000	(2) WK-207285-000
11 - 12	64 in.	WK-241216-000	(2) 81-207286-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

THIS FRAMEWORK, CYLINDER ASSEMBLIES CAN BE
PLACED AGAINST A WALL OR CAN BE FREE STANDING BY
FASTENING GUSSETS TO FLOOR

Figure 4-7. Rack Framing - 5 to 12 Cylinders (50 and 75 lb. Capacity), Double Row (One Side)



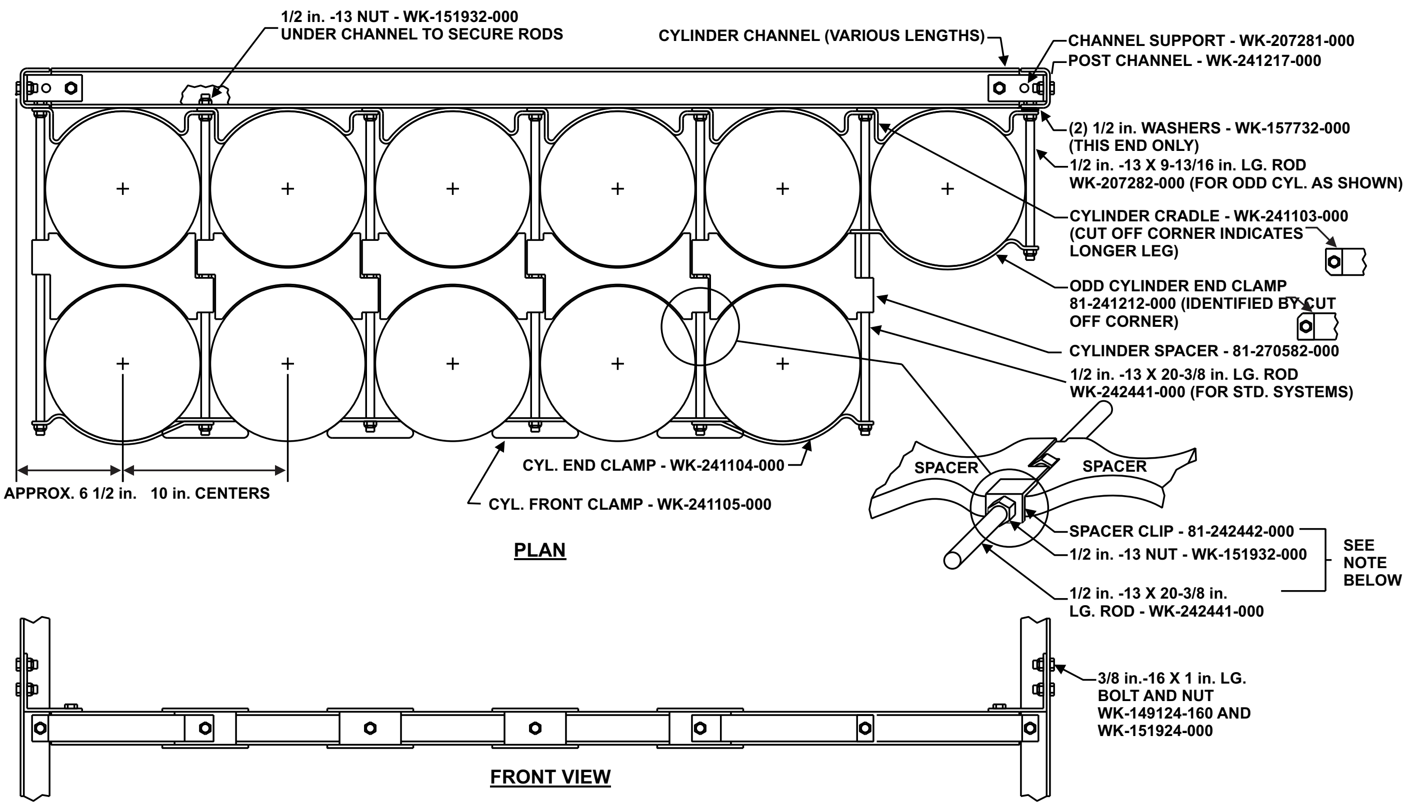
TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
13-14	6 ft. 2 in.	WK-241213-000 WK-241214-000	(2) WK-207283-000 (2) 81-207284-000
15-16	7 ft.	(2) WK-241214-000	(4) 81-207284-000
17-18	7 ft. 10 in.	WK-241214-000 WK-241215-000	(2) 81-207284-000 (2) WK-207285-000
19-20	8 ft. 8 in.	(2) WK-241215-000	(4) WK-207285-000
21-22	9ft. 6 in.	WK-241215-000 WK-241216-000	(2) WK-207285-000 (2) 81-207286-000
23-24	10 ft. 4 in.	(2) WK-241216-000	(4) 81-207286-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

THIS FRAMEWORK TO BE PLACED AGAINST A WALL, BUT CAN BE ALSO BE INSTALLED FREE STANDING. ALLOW 2 ft. AISLE IN FRONT OF CYLINDERS FOR SERVICING.

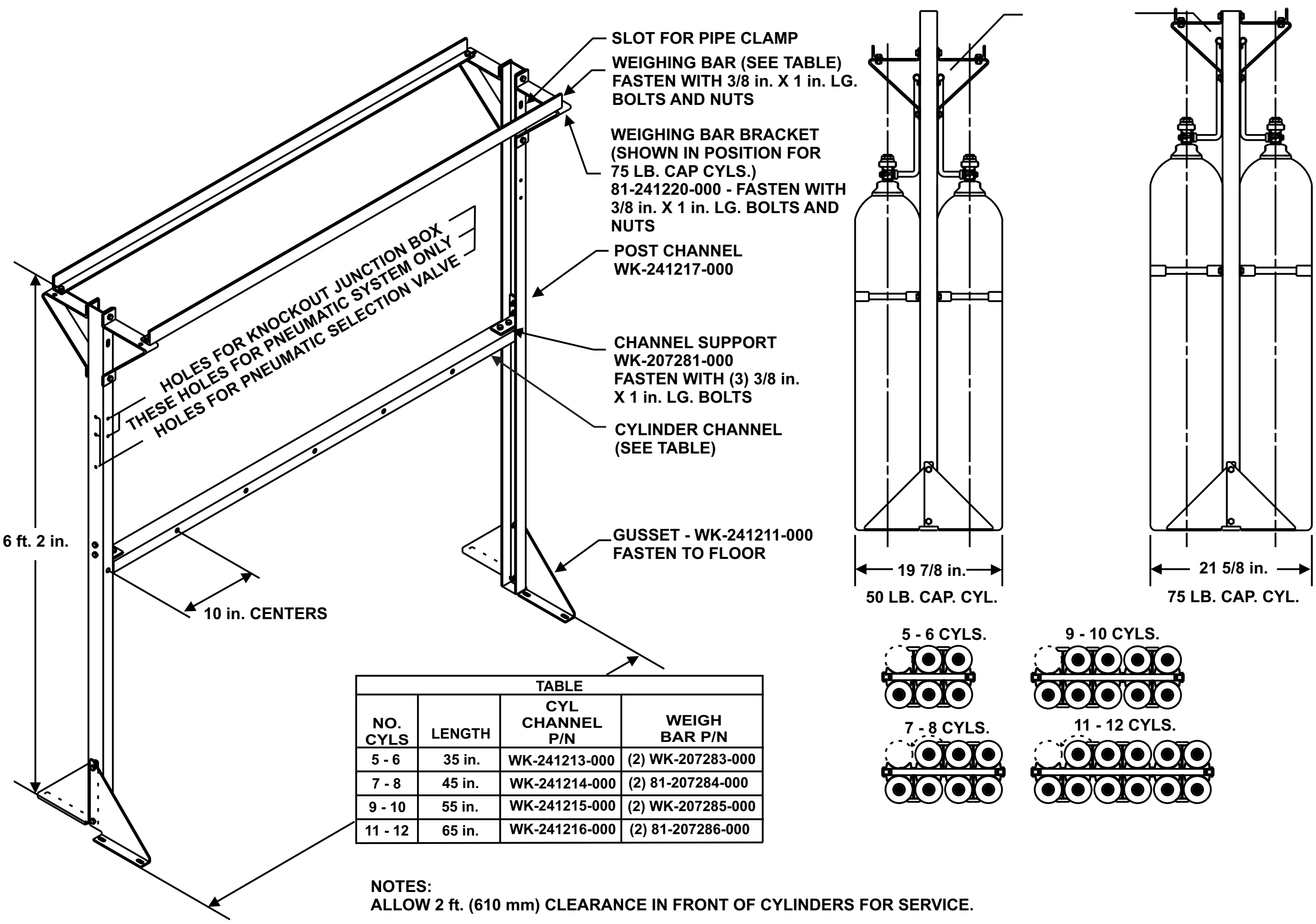
Figure 4-8. Rack Framing - 13 to 24 Cylinders (50 and 75 lb. Capacity), Double Row (One Side)



NOTE:
THESE PARTS WILL BE SUPPLIED FOR "MAIN" & "RESERVE" SYSTEMS ONLY.
THE PARTS WILL SECURE THE REAR ROW "RESERVE" CYLS. WHEN THE FRONT ROW "MAIN" CYLS. ARE REMOVED FOR RECHARGING.
USE ONE SPACER CLIP PER ROD, AND SECURE WITH NUT SUPPLIED.

CAUTION:
BE SURE THE ROD END THREADED FOR 8" IS TOWARDS THE FRONT OF THE FRAMING

Figure 4-9. Cylinder Racks (50 and 75 lb. Capacity), Double Row (One Side)



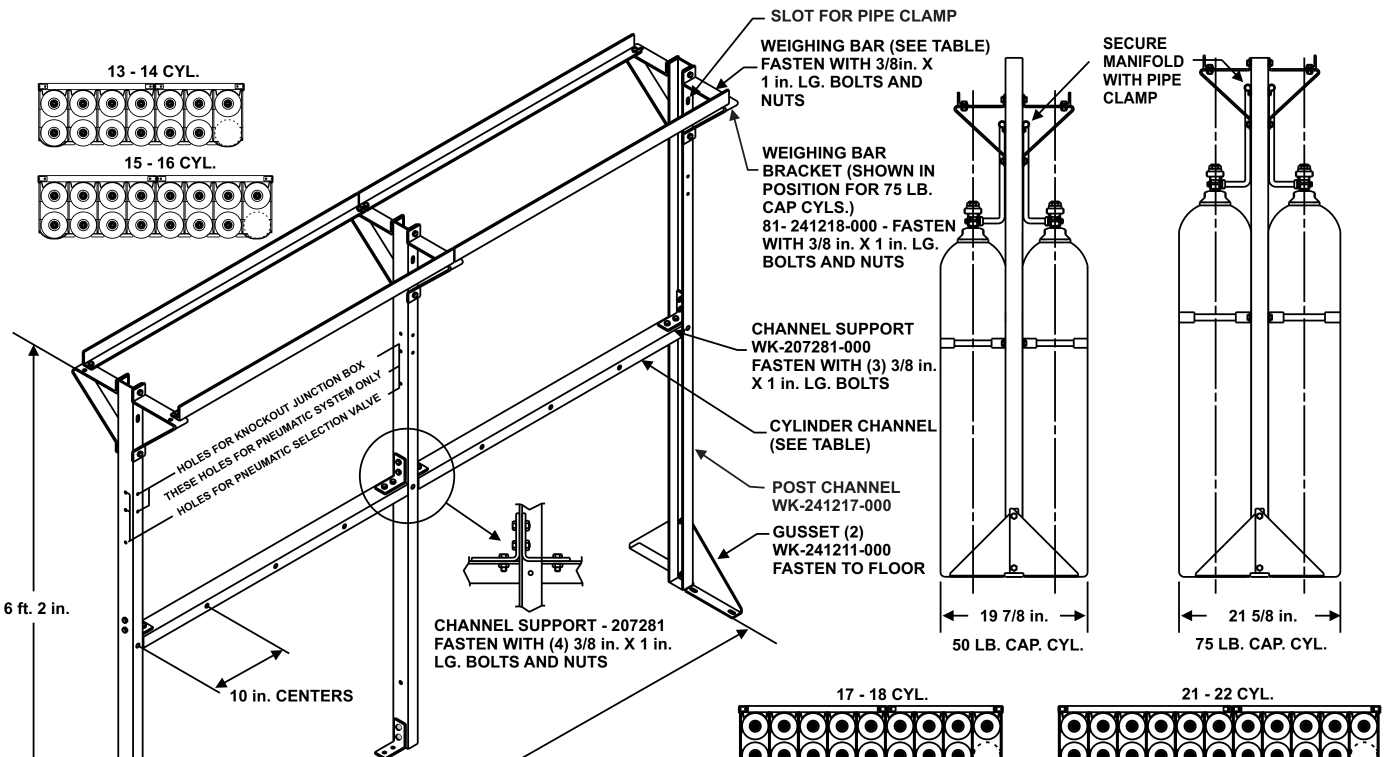
TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
5 - 6	35 in.	WK-241213-000	(2) WK-207283-000
7 - 8	45 in.	WK-241214-000	(2) 81-207284-000
9 - 10	55 in.	WK-241215-000	(2) WK-207285-000
11 - 12	65 in.	WK-241216-000	(2) 81-207286-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

THIS FRAMEWORK IS A FREE STANDING ARRANGEMENT BY FASTENING GUSSETS TO FLOOR. ONE ROW OF CYLINDERS CAN BE REMOVED FROM EACH SIDE FOR SERVICING, THEREFORE A 2 ft. (610 mm) AISLE ON EACH SIDE IS REQUIRED.

Figure 4-10. Rack Framing - 5 to 12 Cylinders (50 and 75 lb. Capacity), Double Row (Two Sides)



TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
13-14	6 ft. 3 in.	WK-241213-000 WK-241214-000	(2) WK-207283-000 (2) 81-207284-000
15-16	7 ft. 1 in.	(2) WK-241214-000	(4) 81-207284-000
17-18	7 ft. 11 in.	WK-241214-000 WK-241215-000	(2) 81-207284-000 (2) WK-207285-000
19-20	8 ft. 9 in.	(2) WK-241215-000	(4) WK-207285-000
21-22	9 ft. 7 in.	WK-241215-000 WK-241216-000	(2) WK-207285-000 (2) 81-207286-000
23-24	10 ft. 5 in.	(2) WK-241216-000	(4) 81-207286-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

THIS FRAMEWORK IS A FREE STANDING ARRANGEMENT BY FASTENING GUSSETS TO FLOOR. ONE ROW OF CYLINDERS CAN BE REMOVED FROM EACH SIDE FOR SERVICING. ALLOW 2 ft. (610 mm) AISLE ON EACH SIDE OF CYLINDERS IS REQUIRED.

Figure 4-11. Rack Framing - 13 to 24 Cylinders (50 and 75 lb. Capacity), Double Row (One Side)

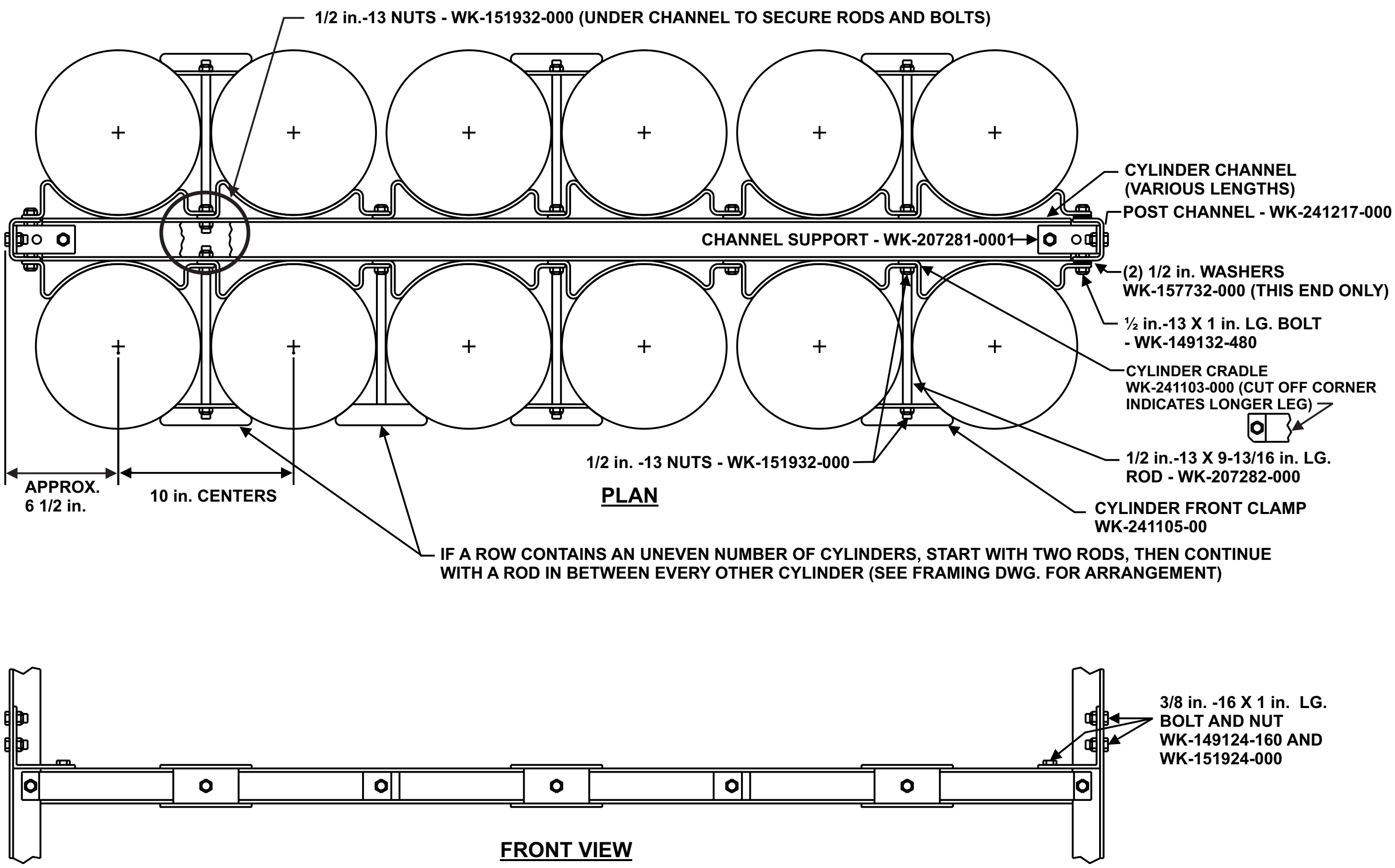
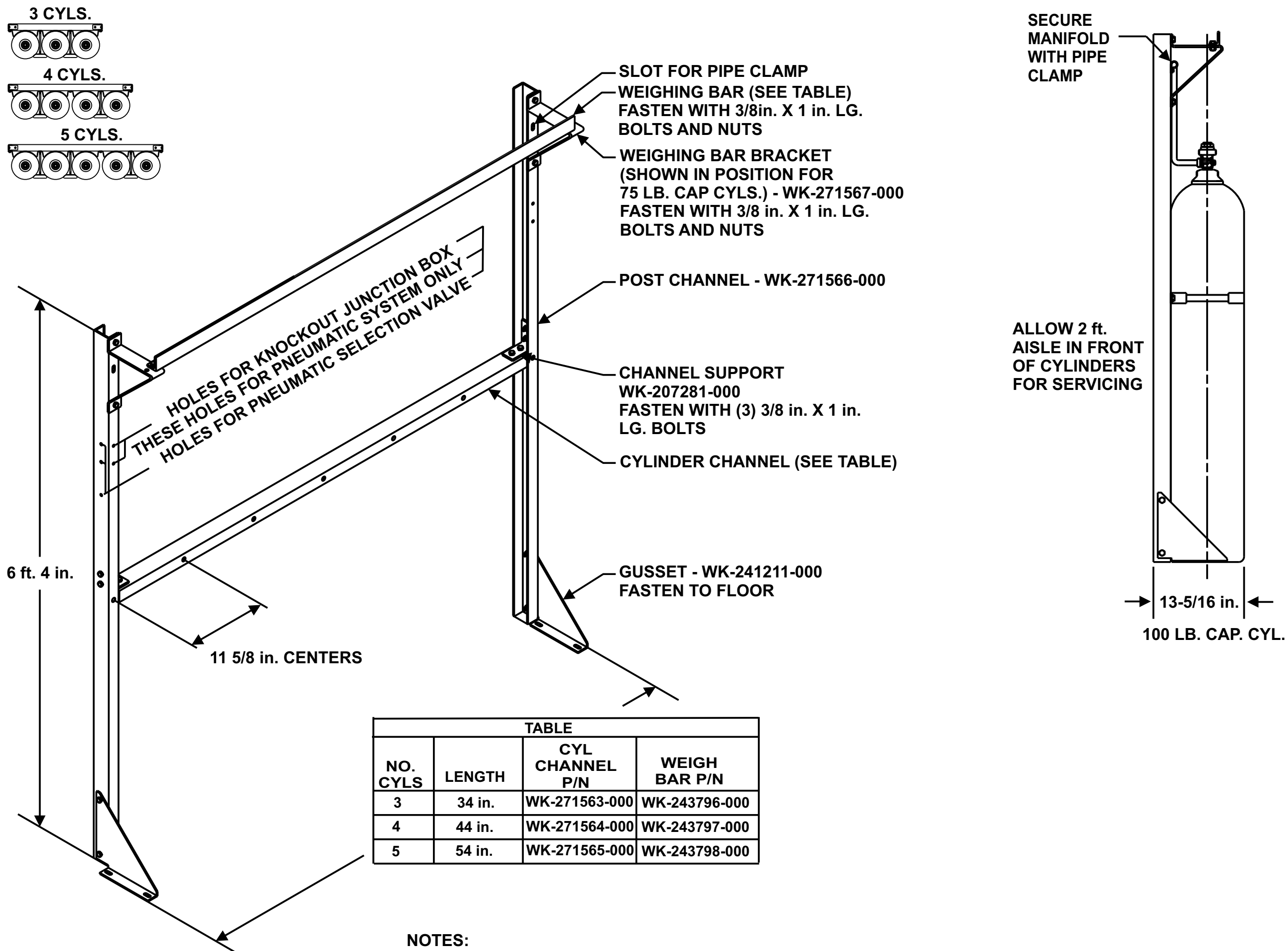


Figure 4-12. Cylinder Racks (50 and 75 lb. Capacity), Double Row (Two Sides)



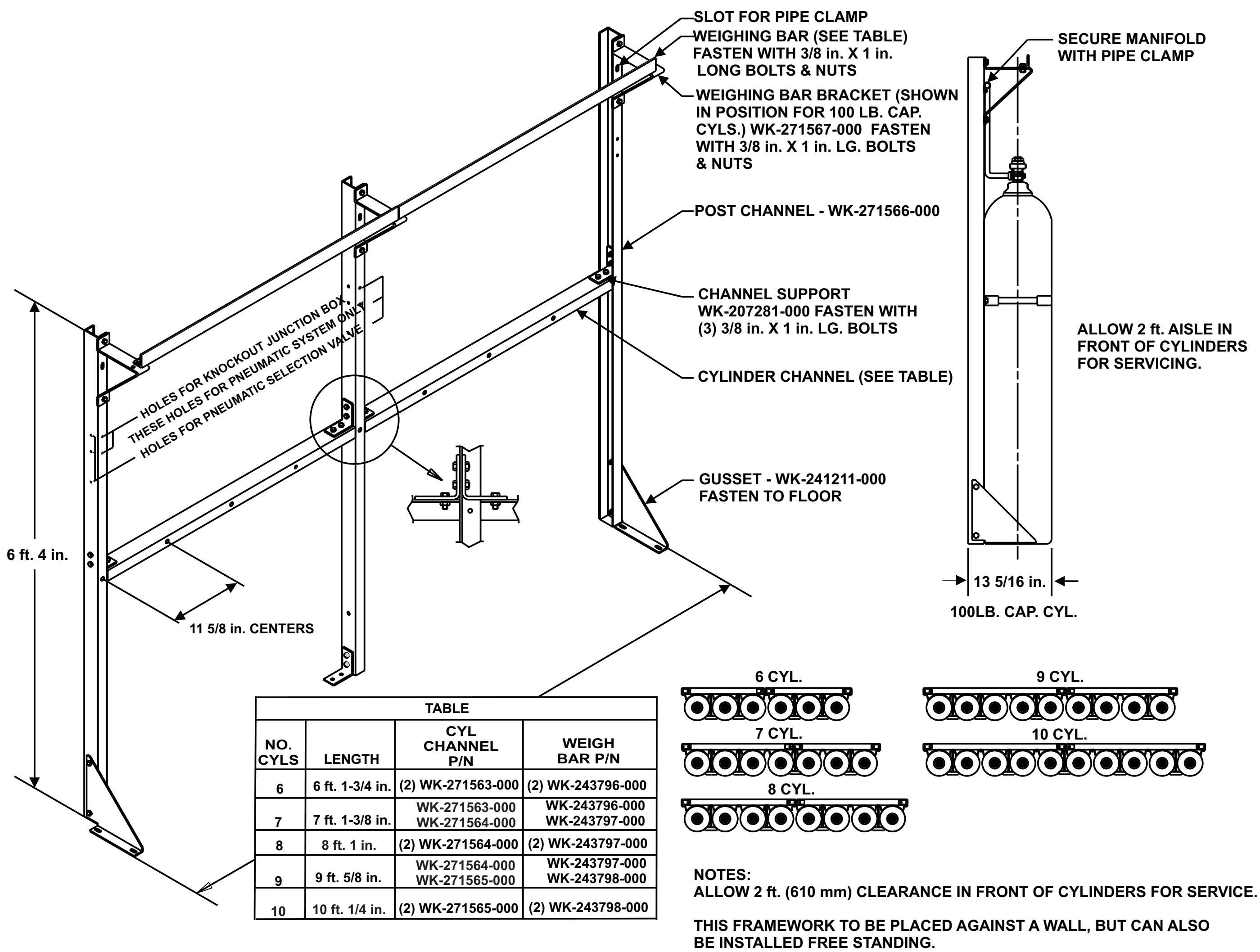
TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
3	34 in.	WK-271563-000	WK-243796-000
4	44 in.	WK-271564-000	WK-243797-000
5	54 in.	WK-271565-000	WK-243798-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

WITH THE ABOVE FRAMEWORK, CYLINDER ASSEMBLIES CAN BE PLACED AGAINST A WALL OR CAN BE FREE STANDING BY FASTENING GUSSETS TO FLOOR

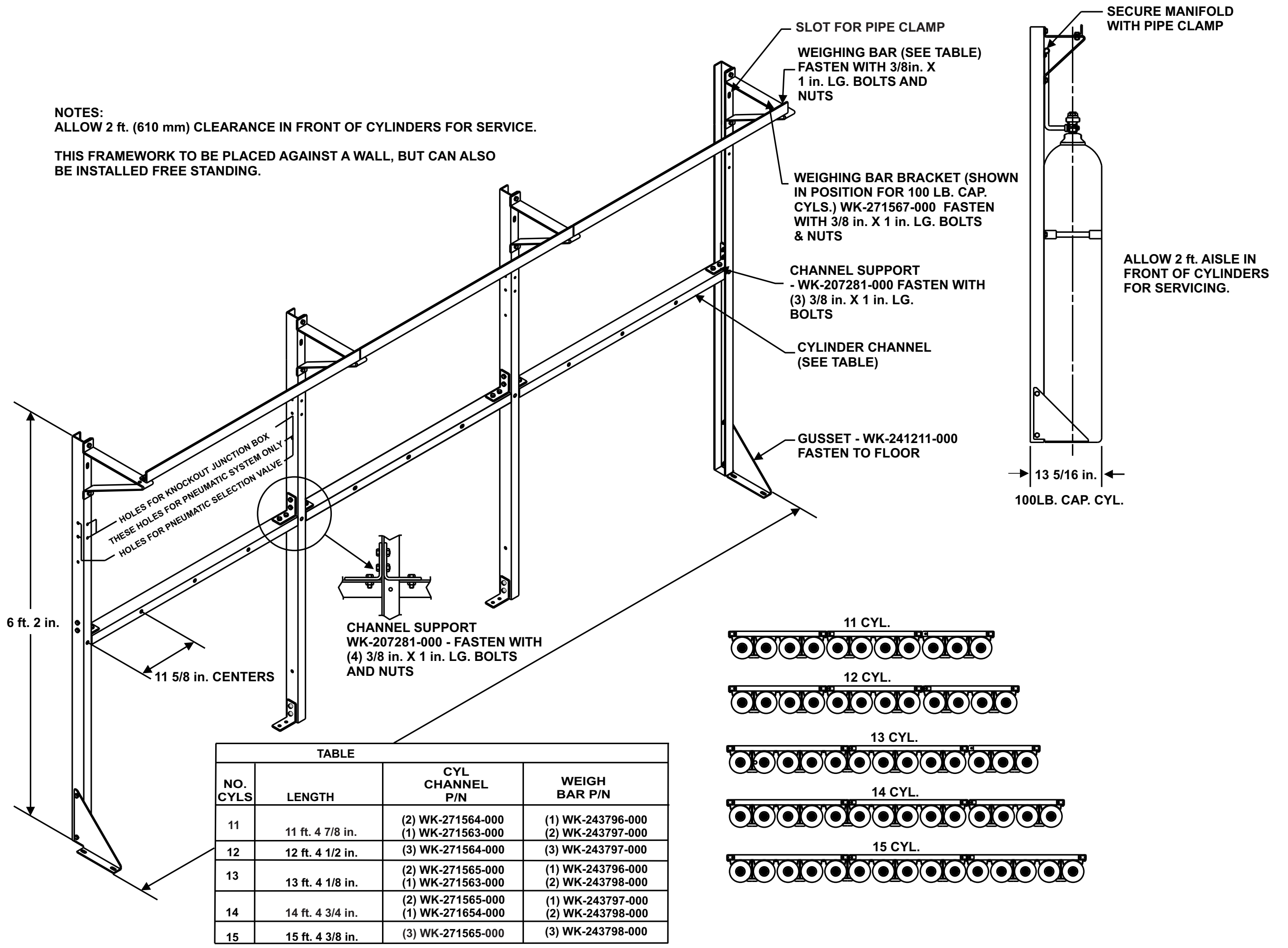
Figure 4-13. Rack Framing -3 to 5 Cylinders (100 lb. Capacity), Single Row



TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
6	6 ft. 1-3/4 in.	(2) WK-271563-000	(2) WK-243796-000
7	7 ft. 1-3/8 in.	WK-271563-000 WK-271564-000	WK-243796-000 WK-243797-000
8	8 ft. 1 in.	(2) WK-271564-000	(2) WK-243797-000
9	9 ft. 5/8 in.	WK-271564-000 WK-271565-000	WK-243797-000 WK-243798-000
10	10 ft. 1/4 in.	(2) WK-271565-000	(2) WK-243798-000

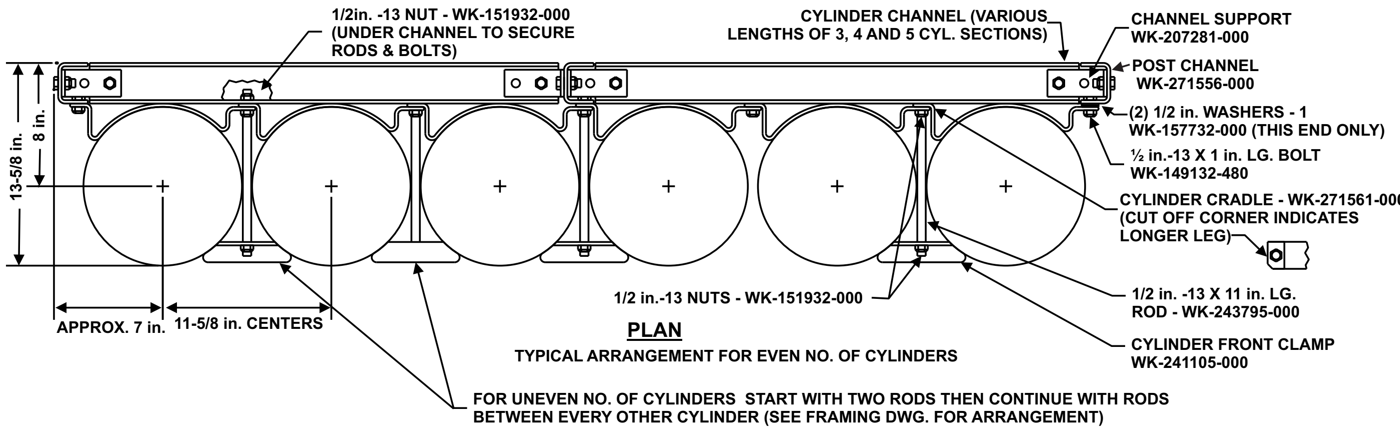
Figure 4-14. Rack Framing - 6 to 10 Cylinders (100 lb. Capacity), Single Row



TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
11	11 ft. 4 7/8 in.	(2) WK-271564-000 (1) WK-271563-000	(1) WK-243796-000 (2) WK-243797-000
12	12 ft. 4 1/2 in.	(3) WK-271564-000	(3) WK-243797-000
13	13 ft. 4 1/8 in.	(2) WK-271565-000 (1) WK-271563-000	(1) WK-243796-000 (2) WK-243798-000
14	14 ft. 4 3/4 in.	(2) WK-271565-000 (1) WK-271654-000	(1) WK-243797-000 (2) WK-243798-000
15	15 ft. 4 3/8 in.	(3) WK-271565-000	(3) WK-243798-000

Figure 4-15. Rack Framing - 11 to 15 Cylinders (100 lb. Capacity), Single Row



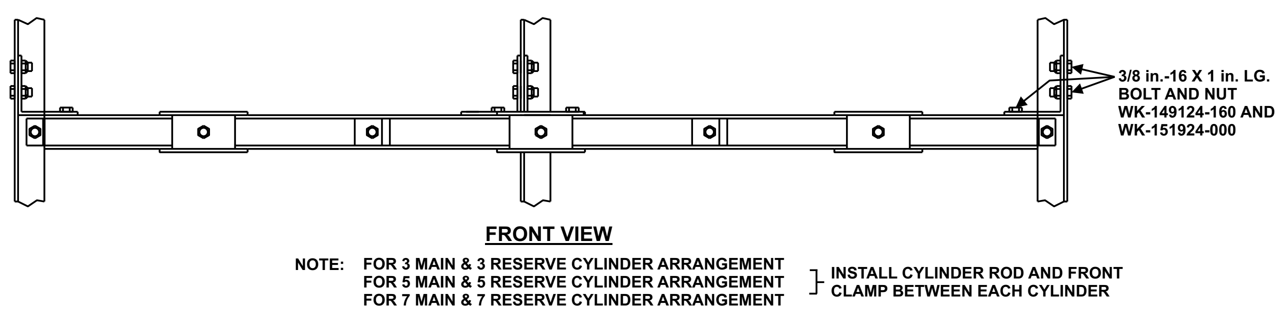
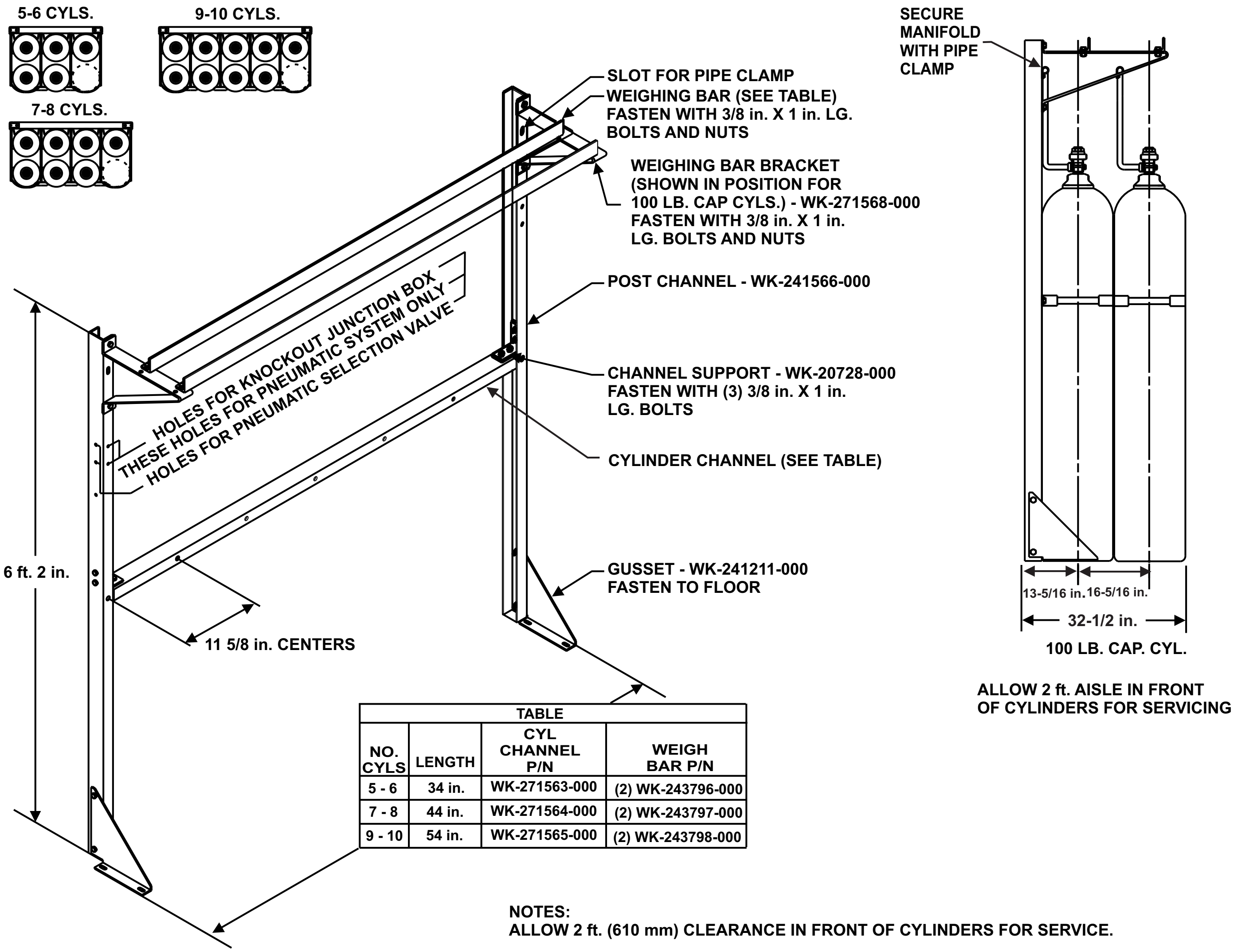


Figure 4-16. Cylinder Racks (100 lb. Capacity), Single Row



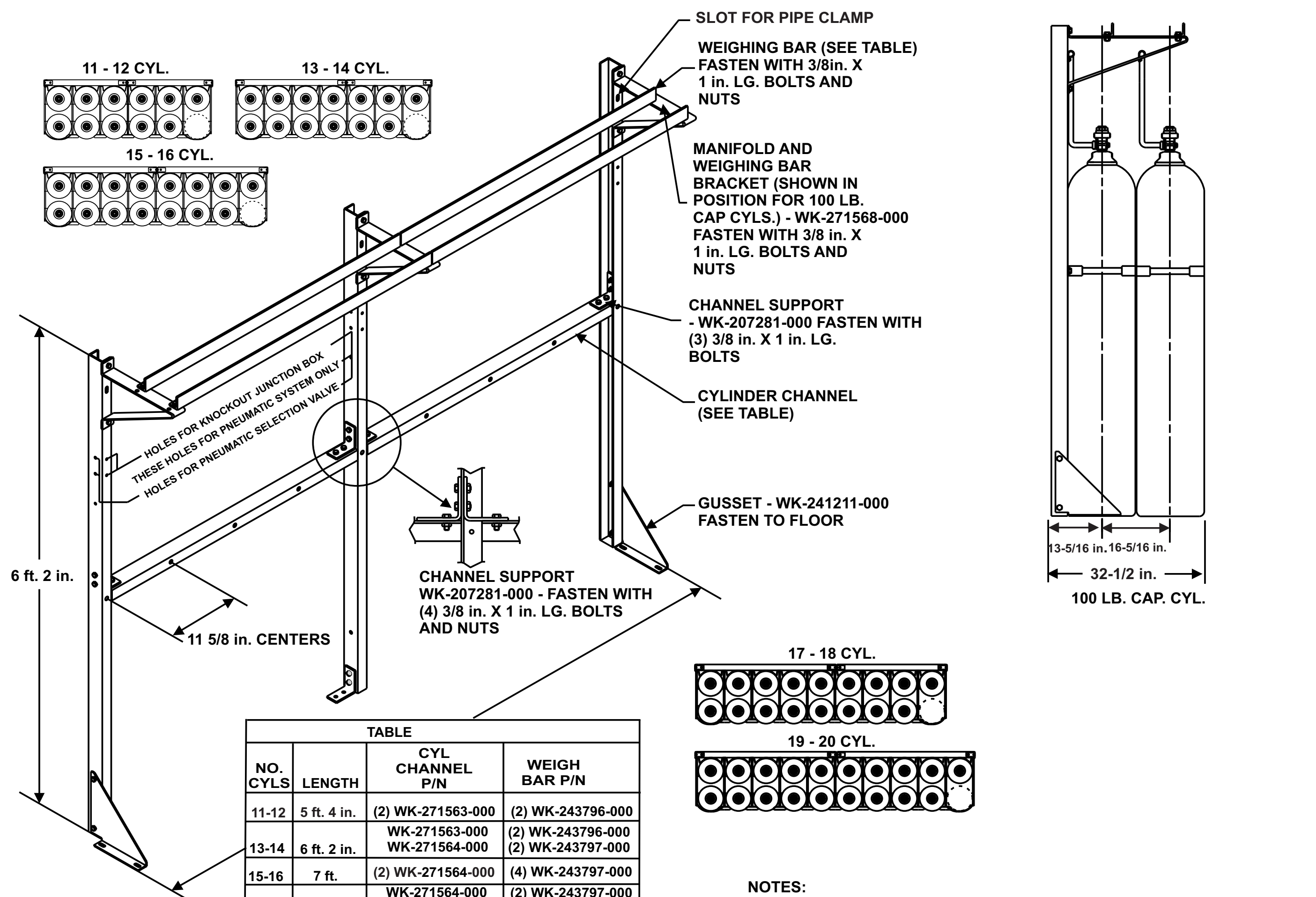
TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
5 - 6	34 in.	WK-271563-000	(2) WK-243796-000
7 - 8	44 in.	WK-271564-000	(2) WK-243797-000
9 - 10	54 in.	WK-271565-000	(2) WK-243798-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

THIS FRAMEWORK, CYLINDER ASSEMBLIES CAN BE
PLACED AGAINST A WALL OR CAN BE FREE STANDING BY
FASTENING GUSSETS TO FLOOR

Figure 4-17. Rack Framing - 5 to 10 Cylinders (100 lb. Capacity), Double Row (One Side)



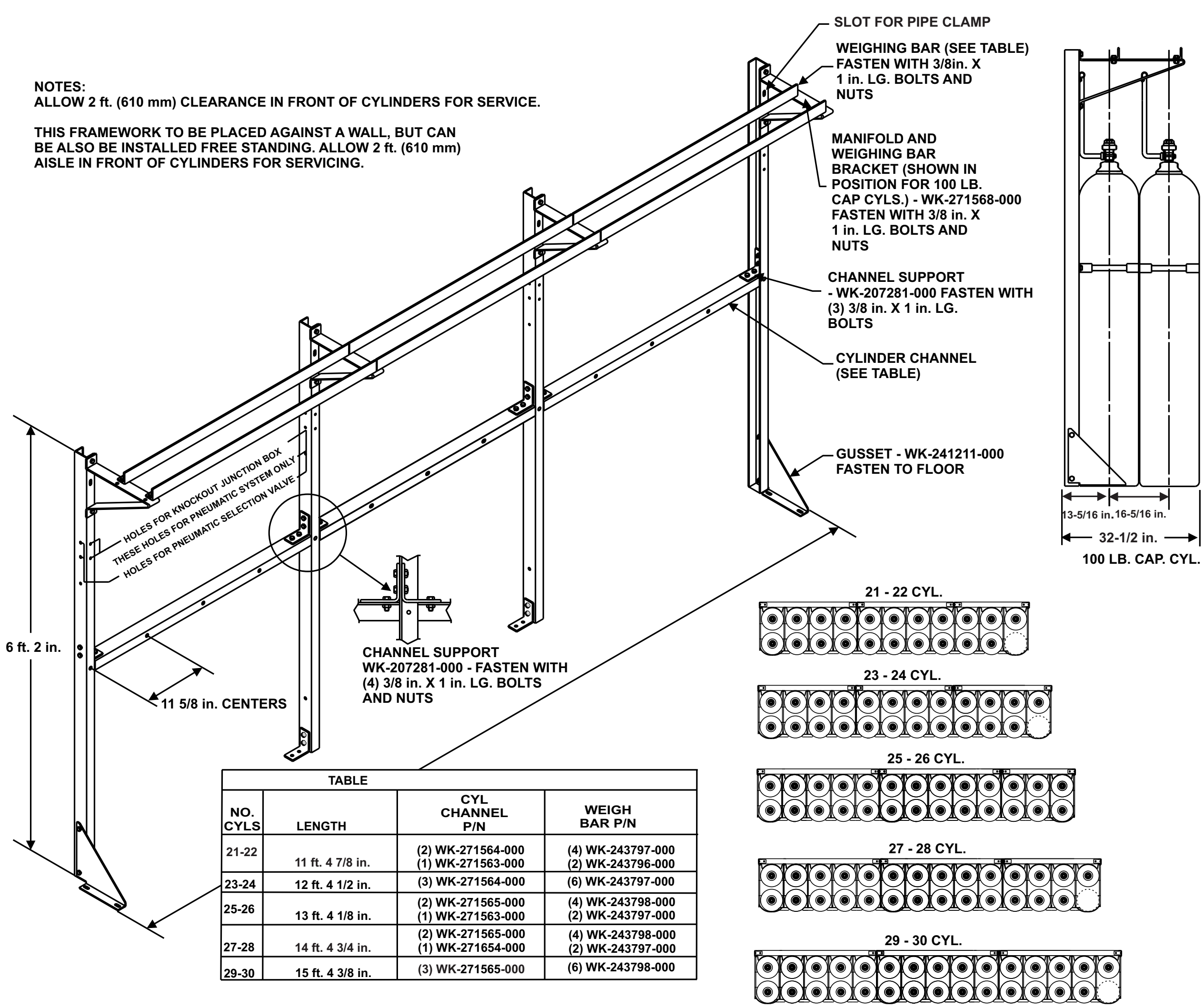
TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
11-12	5 ft. 4 in.	(2) WK-271563-000	(2) WK-243796-000
13-14	6 ft. 2 in.	WK-271563-000 WK-271564-000	(2) WK-243796-000 (2) WK-243797-000
15-16	7 ft.	(2) WK-271564-000	(4) WK-243797-000
17-18	7 ft. 10 in.	WK-271564-000 WK-271565-000	(2) WK-243797-000 (2) WK-243798-000
19-20	8 ft. 8 in.	(2) WK-271565-000	(4) WK-243798-000

NOTES:
ALLOW 2 ft. (610 mm) CLEARANCE IN FRONT OF CYLINDERS FOR SERVICE.

THIS FRAMEWORK TO BE PLACED AGAINST A WALL, BUT CAN BE ALSO BE INSTALLED FREE STANDING. ALLOW 2 ft. (610 mm) AISLE IN FRONT OF CYLINDERS FOR SERVICING.

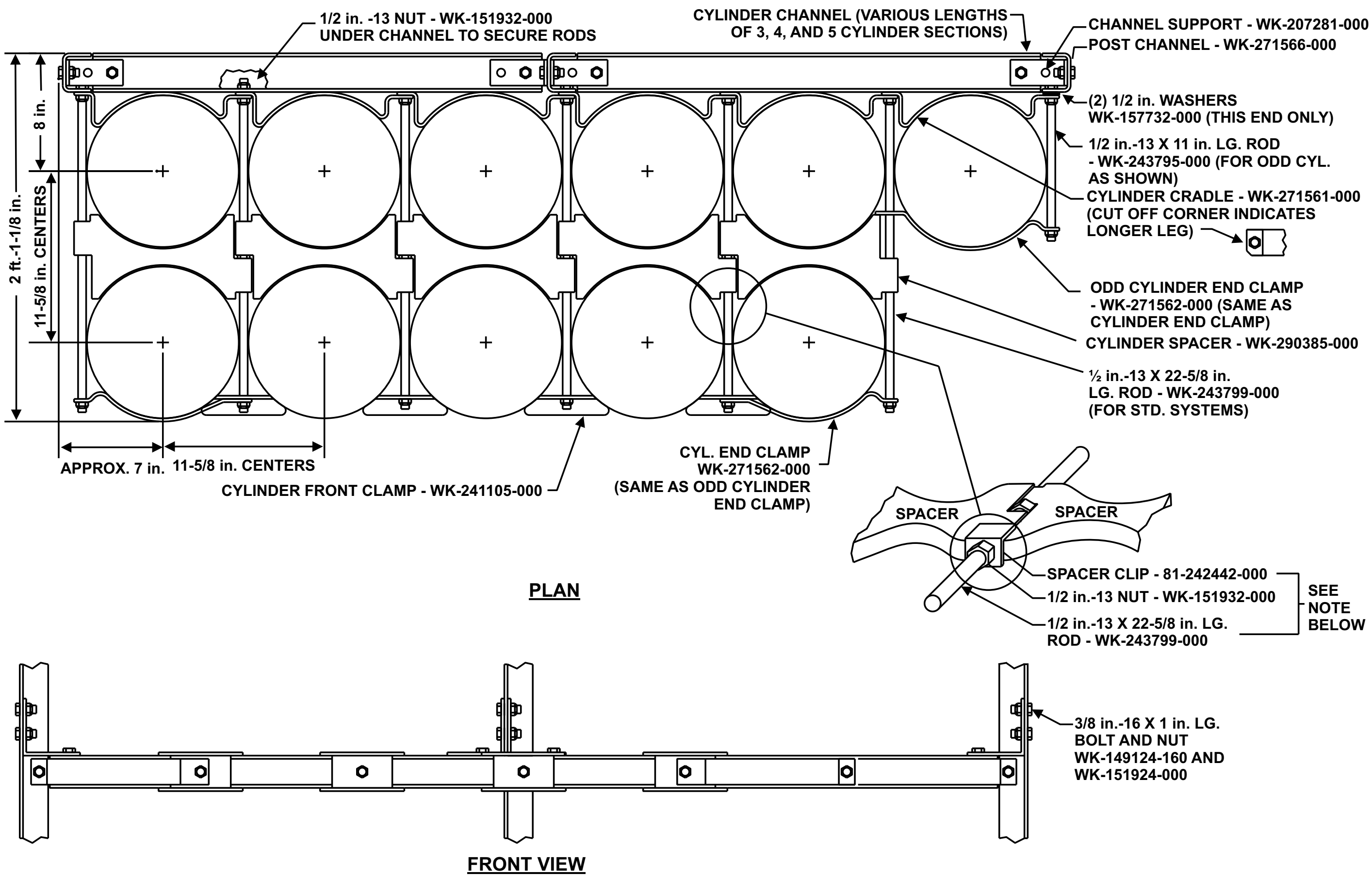
Figure 4-18. Rack Framing - 11 to 20 Cylinders (100 lb. Capacity), Double Row (One Side)



TABLE

NO. CYLS	LENGTH	CYL CHANNEL P/N	WEIGH BAR P/N
21-22	11 ft. 4 7/8 in.	(2) WK-271564-000 (1) WK-271563-000	(4) WK-243797-000 (2) WK-243796-000
23-24	12 ft. 4 1/2 in.	(3) WK-271564-000	(6) WK-243797-000
25-26	13 ft. 4 1/8 in.	(2) WK-271565-000 (1) WK-271563-000	(4) WK-243798-000 (2) WK-243797-000
27-28	14 ft. 4 3/4 in.	(2) WK-271565-000 (1) WK-271654-000	(4) WK-243798-000 (2) WK-243797-000
29-30	15 ft. 4 3/8 in.	(3) WK-271565-000	(6) WK-243798-000

Figure 4-19. Rack Framing - 21 to 30 Cylinders (100 lb. Capacity), Double Row (One Side)



NOTE: THESE PARTS WILL BE SUPPLIED FOR "MAIN" AND "RESERVE" SYSTEMS ONLY.
THE PARTS WILL SECURE THE REAR ROW "RESERVE" CYLS. WHEN THE FRONT ROW "MAIN" CYLINDERS ARE REMOVED FOR RECHARGING.
USE ONE SPACER CLIP PER ROD, AND SECURE WITH NUT SUPPLIED.

CAUTON: BE SURE THE ROD END THREADED FOR 9 in. (229 mm) IS TOWARDS THE FRONT OF THE FRAMING

Figure 4-20. Cylinder Racks (100 lb. Capacity), Double Row (One Side)

4-3.6 Flexible Discharge Hose to Piping

Use the following steps to connect the cylinder(s) to the system piping or manifold using the flex hose.

1. Inspect hose to verify the thread connections and hose are not damaged.
2. Apply Teflon tape or pipe dope to the threaded male end and connect to the system piping or manifold.
3. Connect the swivel female end to the male discharge head.
4. The hose may be installed horizontally or in a 90 degree up position.
5. Verify that the discharge hose does not flatten when installed and does not kink.

WARNING **Flexible hoses must always be connected to the system piping and to the discharge heads before attaching the discharge heads to the cylinder valves, in order to prevent injury in the event of inadvertent carbon dioxide discharge.**

4-3.7 Swivel Adapter to Piping

Do not use the swivel adapter to connect more than one cylinder or more than one main and reserve cylinder. Connect the cylinder to the system piping using the swivel adapter, by following the steps listed below:

1. Disassemble the swivel adapter and inspect the thread connections, O-ring and union for damage.
2. Apply Teflon tape or pipe dope to the male threads on the system piping and attach the swivel nut piece to the system piping.
3. Connect the swivel union (1/2 in. NPT) (DN15) to the system piping.
4. Connect the other end (3/4 in. NPT) (DN20) to the discharge head.

WARNING **The swivel adapter must always be connected to the system piping and to the discharge head before attaching the discharge head to the cylinder valve, in order to prevent injury in the event of inadvertent carbon dioxide discharge.**

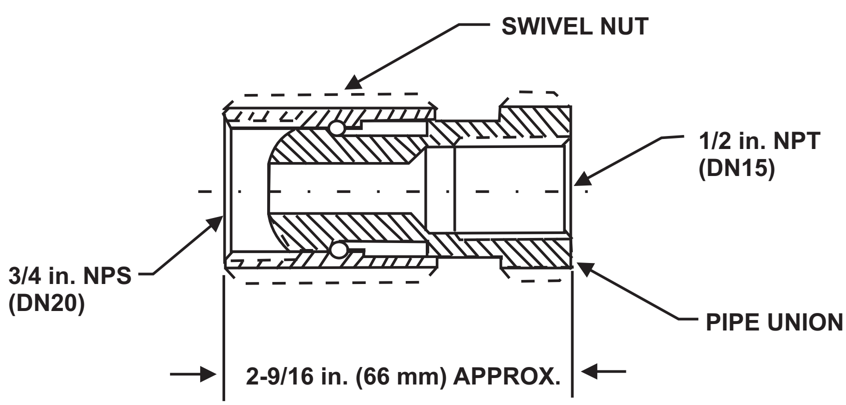


Figure 4-21. Swivel Adapter to Piping

4-3.8 Discharge Head to Cylinder Valve

Install the discharge head as follows:

1. Wipe off cylinder valve sealing surface.
2. Verify that both O-rings within the discharge head are installed in the mating surface grooves at the bottom of the swivel nut cavity. O-rings must be free of dirt or other contaminants. The O-rings have been lightly greased at the factory and should not require further greasing.
3. Make certain the pilot orifice located between the inner and outer O-ring is unobstructed.
4. Make certain the discharge port is clean and unobstructed.
5. Install discharge head on cylinder valve. Tighten securely.

WARNING **The discharge head must be securely connected into the system piping. Never attach the discharge heads to the cylinder valves until the cylinders are secured in brackets or racking. Under no circumstances is the discharge head to remain attached to the cylinder valve after removal from service, handling, storage, or during shipment. Failure to follow these instructions could result in serious bodily injury, death, or property damage.**

4-3.9 Check Valves and Directional (Stop) Valves

4-3.9.1 2-inch AND SMALLER CHECK VALVES AND DIRECTIONAL (STOP) VALVES

Install the 2-inch (DN50) or smaller diameter directional (stop) valves or check valves by following the steps listed below:

1. Inspect the valves to verify the threads are not damaged.
2. Use high pressure air, nitrogen, or CO_2 to verify the valves allow flow in the direction shown by the arrow on the valve body.
3. Kidde recommends installing union fittings before and after the valves to facilitate future service work.
4. Apply Teflon tape or pipe dope to the piping male threads.
5. Valves can be installed horizontally or vertically.
6. Ensure the piping is properly supported with pipe hangers prior to installing the valves.

CAUTION **All valves must be installed with the arrow on the valve body pointing in the direction of flow.**

4-3.9.2 2-1/2 inch AND LARGER CHECK VALVES AND DIRECTIONAL (STOP) VALVES

Install the 2-1/2 inch (DN65) and larger diameter direction (stop) valves and check valves by following the steps listed below:

1. Inspect the gaskets and valve assemblies for damage.
2. Use high pressure air, nitrogen, or CO_2 to verify the valves allow flow in the direction shown by the arrow on the valve body.
3. Weld the flange connections to the piping in accordance with the ASME B31 Boiler & Pressure Vessel Code.
4. Align the valve body with the flanges, insert gaskets between the valve body and each flange and insert the bolts through the bolt holes.
5. Tighten the hex nuts.
   a. Valves can be installed horizontally or vertically.

b. All valves must be checked to ensure installation in the proper flow direction.

c. Ensure the piping is properly supported with pipe hangers prior to installing the valves.

CAUTION **All valves must be installed with the arrow on the valve body pointing in the direction of flow.**

4-3.10 Lockout Valves

The lockout valve with limit switch must be installed in the discharge pipe network, downstream of all cylinders, check valves, and selector valves. All valves should be easily accessible. Lockout valves can be installed in either the vertical or horizontal position using good pipe fitting practices. Place two to three wraps of Teflon tape on male threads of pipe. A union is recommended after the valve to facilitate future service work. The valve should be locked in the “open” position using a padlock. All valves must be electrically supervised.

Figure 4-22 shows the lockout valve wiring diagram when the ball valve is in the fully open position.

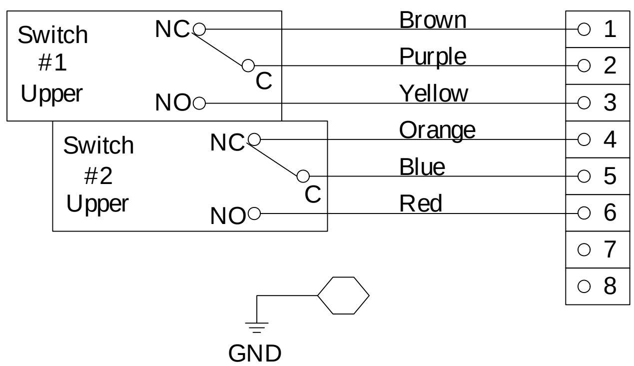


Figure 4-22. Wiring Diagram for Lockout Valve when Ball Valve is in Fully Open Position

4-3.11 Pneumatic Discharge Delay

The discharge delay shall be installed with the arrow stamped on the unit pointing in the direction of flow. The unit may be installed at any angle below horizontal. Install the discharge delay by following the steps listed below:

1. Inspect the threads and the discharge delay for any damage.
2. Kidde recommends installing union fittings before and after the discharge delay to facilitate future service work.
3. Ensure the piping is properly supported with pipe hangers prior to installing the discharge delay.
4. Bushings or bell reducer fittings may be used to connect to 1/2-inch (DN15) piping. The discharge delay connections are 3/4-inch (DN20).
5. Install the discharge delay with arrow stamped on the unit pointing in the direction of flow. The unit may be installed at any angle below horizontal. Kidde prefers to always install the discharge delay in the fully pendent position.
6. Provide sufficient clearance around the discharge delay to allow operation of the lever operated or other control head provided.
7. Verify the control head is in the "SET" position.

a. Any bypass of the discharge delay must be supervised.

b. The discharge delay may be installed in the discharge piping or the actuation line.

Note: The discharge delay period is preset at the factory; however, the actual discharge delay period may vary up to 100% depending on the ambient conditions and/or variations in installation.

4-3.12 Discharge Nozzles

After the system piping has been blown free of debris, install the discharge nozzles in strict accordance with the approved installation drawings and acceptable engineering practices. Make certain the correct nozzle type, part number, and orifice size are installed in the proper locations. Ensure that the nozzles are securely tightened to the piping.

4-4 ACTUATION SYSTEMS

4-4.1 Lever Operated Control Head

Install the lever operated control head by following the steps listed below:

1. Inspect the threads and control head for damage. Ensure the locking pin and seal wire are intact.
2. Remove the protection cap from the appropriate control port.
3. Using a suitable wrench, tighten the swivel nut securely to the control port.
4. Provide suitable clearance around the control head to allow operation.

4-4.2 Cable Operated Actuation System Components

Kidde CO_2 cable operated devices must use 1/16-inch stainless steel cable run in 3/8-inch NPT galvanized pipe or 1/2-inch conduit. Do not run more than one cable in each pipe/conduit run. At each change in direction, use either the 3/8-inch NPT corner pulley or the 1/2-inch EMT corner pulley for conduit as required. Do not bend the pipe or conduit.

To install a cable operated control system, affix the pull boxes to an appropriate structure at the locations noted on the installation plan. Connect the pipe/conduit to the pull boxes and install the necessary pipe/conduit sections, corner pulleys and cable devices (i.e., dual pull mechanism, tee pulley, dual pull equalizer, etc.) to terminate at the cable operated control head(s). Do not exceed the allowable corner pulley quantities and cable lengths as noted in Table 4-4. Remove all the corner pulley covers. Run the cable from the pull boxes through the pipe/conduit, corner pulleys and other cable devices. Reattach the corner pulley covers.

After completing the cabling, test each pull box for pull length and pull force. Ensure the cable controls do not require more than 40 lb. (178 N) and 14 inches (356 mm) of pull length.

The following sections will detail the specific installation requirements for all the components necessary to complete the cabling.

Table 4-4. Corner Pulley and Cable Limitations

Control Head Type	Part Number	Maximum Corner Pulleys		Max. Cable Length
		Part No. 803808	Part No. 844648	
Cable Operated	81-979469-000	15	30	100 ft. (30 m)
Electric/Cable	81-895630-000	6	30	100 ft. (30 m)
Electric/Cable, XP	WK-897494-000	6	30	100 ft. (30 m)
Pneumatic	All	6	30	100 ft. (30 m)

4-4.3 Cable Operated Control Head

The following procedures must be performed before attaching control head to cylinder valve (refer to Figure 4-25):

1. Remove protection cap from CO_2 cylinder valve pilot control port.
2. Remove cover from control head and take out wheel assembly, cable pipe locknut, and closure disc.
3. Ensure plunger is below surface of control head body. Position control head at valve pilot control port with arrow pointing in direction of pull.
4. Assemble cable pipe locknut to cable pipe and place locknut in position in the control head body.
5. Slide wheel assembly on control cable to proper "SET" position. Tighten set screws securely. Ensure wheel assembly is at start of stroke.
6. Cut off excess cable close to wheel assembly.
7. Insert closure disc and replace cover on control head. Control head is now armed!

CAUTION **To ensure that the manual lever does not snag or trap the pull cable, make sure the local manual release lever is in the “SET” position, with locking pin and seal wire installed, before assembling control head cover to body.**

8. Assemble control head to cylinder valve or stop valve pilot control port. Tighten swivel nut securely.

4-4.4 Pull Boxes

Install the Kidde cable pull boxes following the steps listed below:

1. If mounting the pull box directly to the mounting surface, use the pull box as a template to drill the necessary bolt holes at the appropriate height and location per the installation plan.
2. If mounting the break glass (P/N 81-871403-000) pull station to the Z bracket (P/N 81-60532-000), use the Z bracket as a template to drill the necessary bolt holes at the appropriate height and location per the installation plan.
3. If using conduit, connect the conduit adapter (P/N WK-843837-000) to the pipe connection on the back of the pull box, prior to attaching the pull box as required to the mounting surface.
4. Insert 1/16-inch cable into the cable fastener.

4-4.5 Main to Reserve Transfer Switch

The main to reserve transfer switch is used in the system to toggle the connection between the electrical control heads installed on the main or reserved cylinders with a suppression control unit. For electrical wiring with a single electrical control head, refer to Figure 4-23 and for two electrical control heads, refer to Figure 4-24. The transfer switch is generally installed at the cylinder bank.

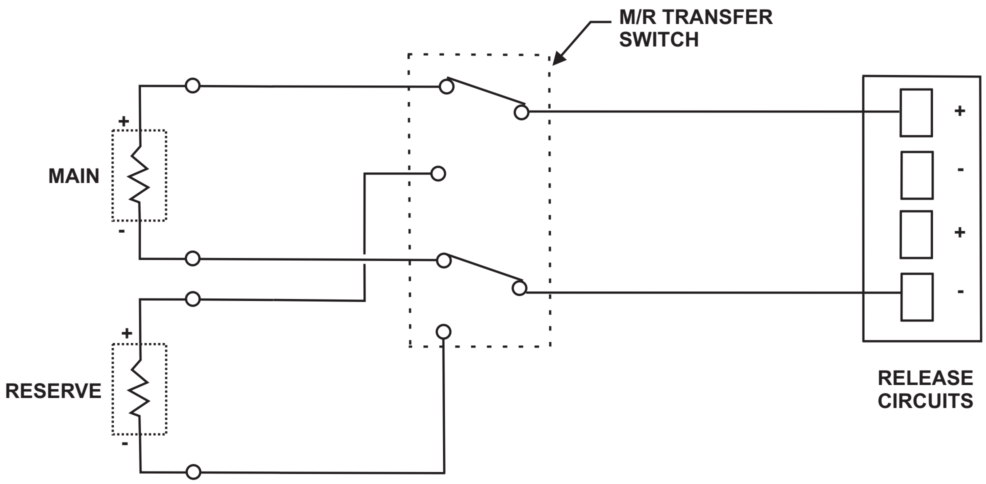


Figure 4-23. Wiring Diagram with Single Solenoid (Main and Reserve)

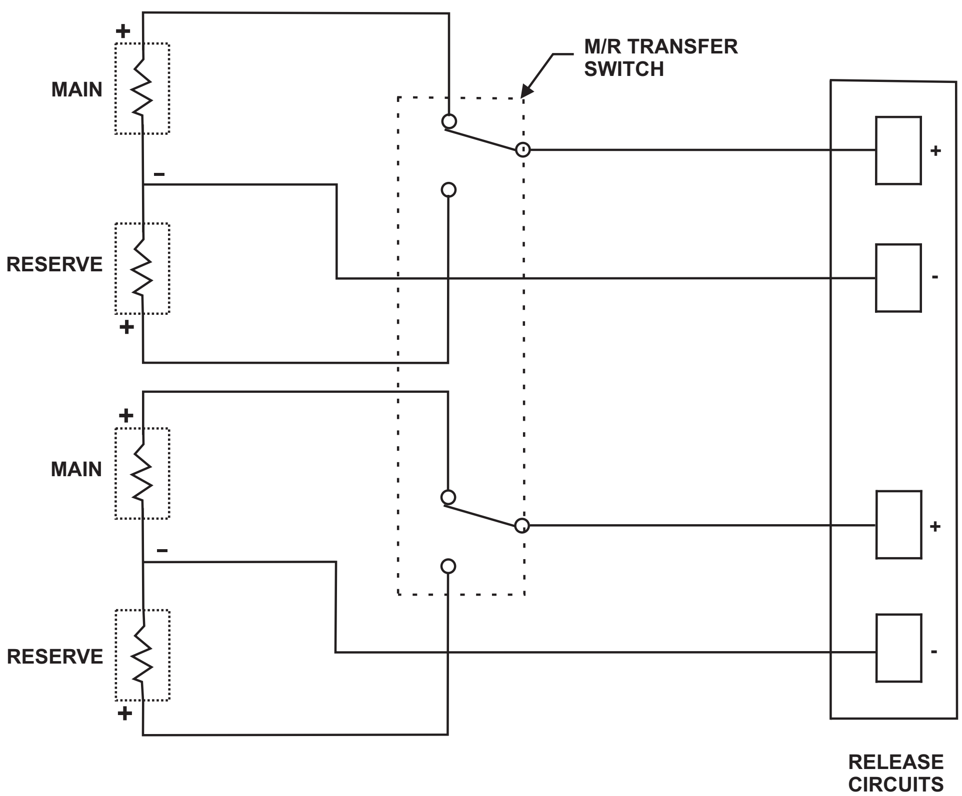


Figure 4-24. Wiring Diagram with Dual Solenoid (Main and Reserve)

4-4.6 Tandem Control Head

1. Install first control head as described in Paragraph 4-4.3, steps 1 through 7 above, except that in step 7 the closure disk is omitted and cable is not to be cut until the second head is installed.
2. Repeat steps 1, 2, 3 for second control head.
3. Assemble second cable pipe locknut to cable housing. Slide cable housing over free end of control cable. Place cable housing into proper slots in both control heads. Adjust as required to obtain proper spacing.
4. Repeat steps 5, 6, 7 and 8 for the second control head.

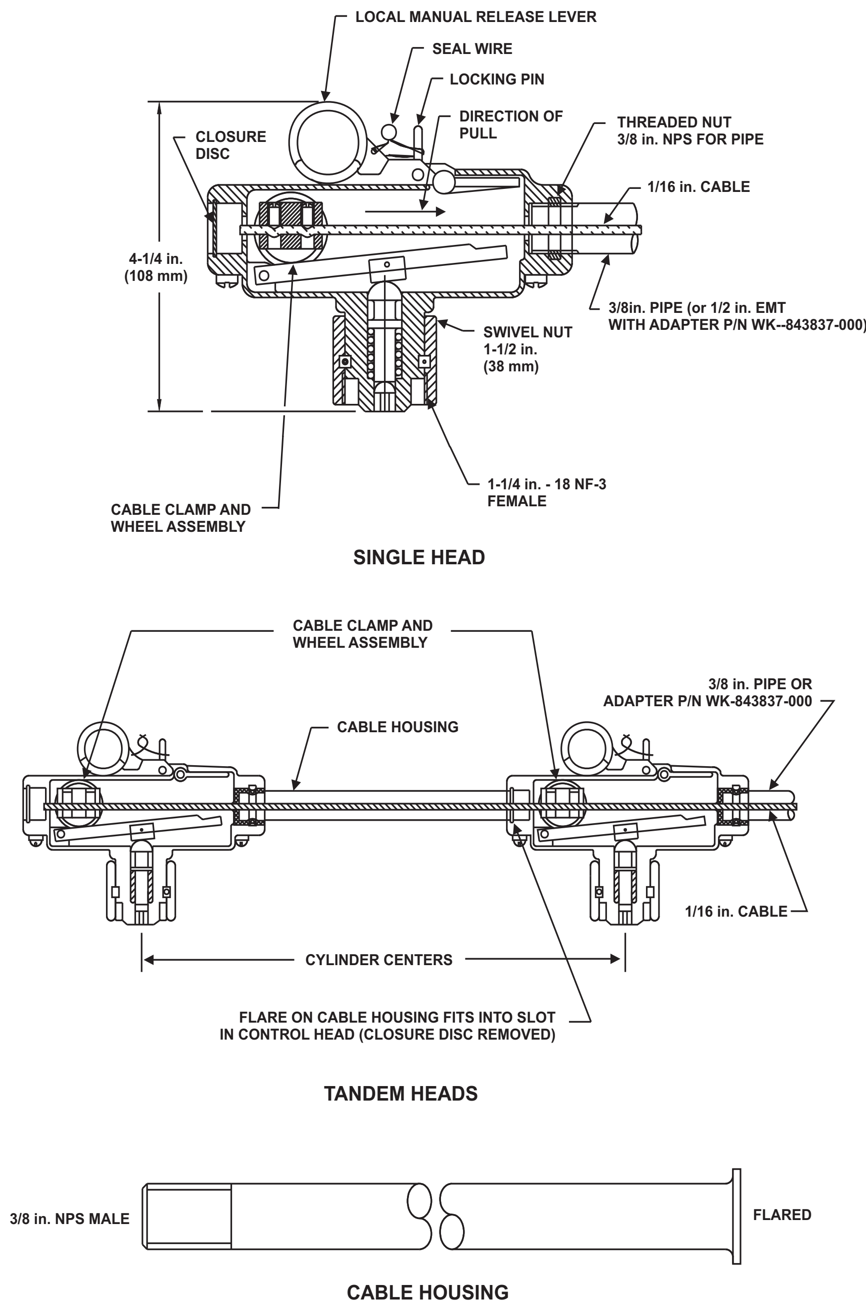


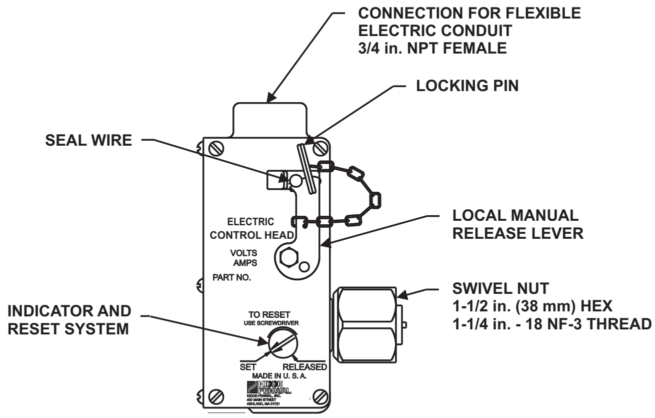
Figure 4-25. Cable Operated Control Heads

4-4.7 Electric Control Heads

WARNING **Before installing control head on the carbon dioxide cylinder valve, ensure that the control head is in "Set" position (actuating pin is in the fully retracted or "Set position). Failure to position control head in the "Set" position will result in accidental carbon dioxide cylinder discharge when the control head is installed on the cylinder valve.**

For electrical connections to the same control head, install the electric control head as follows (refer to Figure 4-26):

1. Remove protective cap from CO_2 cylinder valve or stop valve pilot control port. Ensure control head is in "SET" position.
2. Make all electrical connections.
3. Install electric control head on pilot control port. Tighten swivel nut.



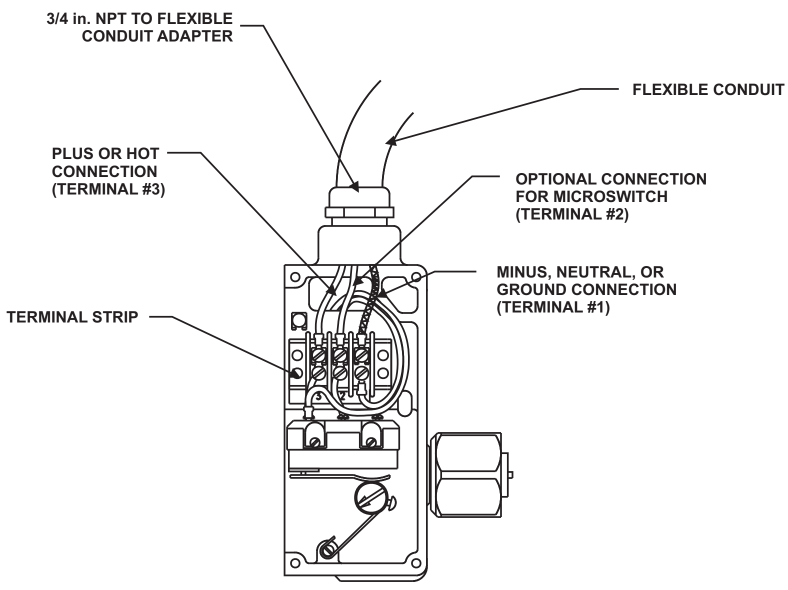


Figure 4-26. Electric Control Heads

4-4.8 Electric and Cable Operated Control Heads

WARNING

Before installing control head on the carbon dioxide cylinder valve, ensure that the control head is in the "SET" position (actuating pin is in the fully retracted or "SET" position). Failure to position control head in the "SET" position will result in accidental carbon dioxide cylinder discharge when the control head is installed on the cylinder.

The following procedures are to be performed before attaching control head to the cylinder valve or stop valve (refer to Figure 4-27):

1. Remove four screws holding cable housing cover on control head. Remove cover.
2. Position control head in the approximate installed position at the carbon dioxide cylinder valve or stop valve pilot control port, but do not assemble onto the pilot control port.
3. Check that the control head is in the "SET" position.
4. Assemble the pull cable conduit to the conduit connection on the control head.

Note: The corner pulley installation should allow flexibility for installation and removal of the control head from pilot control port.

5. Feed cable into control head through the hole in the operating lever.
6. Feed cable through the cable clamp. Pull cable taut, allowing approximately 1/4-inch to 1/2-inch clearance between the cable clamp and the operating lever. Tighten set screws in cable clamp to secure cable to clamp.
7. Cut off excess cable.
8. Verify manual remote cable operation to ensure control head actuates and all cable clamps are tight.
9. Pull cable back to its normal set (un-operated) position.
10. Reset control head.
11. Replace control head cover.
12. Examine seal wire at locking pin. Ensure it is intact.
13. Make electrical connections.
14. Assemble control head to cylinder or stop valve pilot control port. Tighten swivel nut securely.

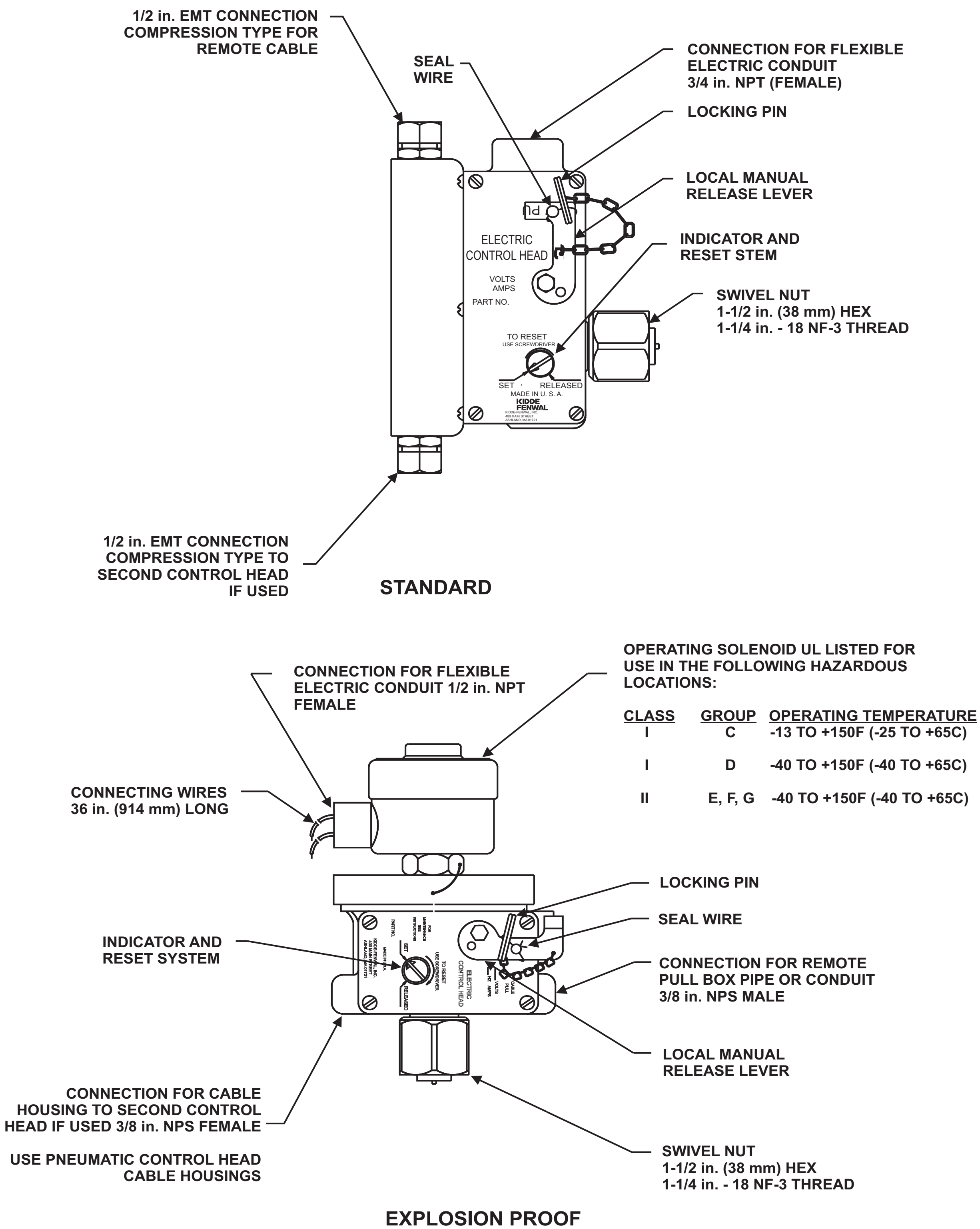


Figure 4-27. Electric and Cable Operated Control Heads

4-4.9 Pneumatic Heat Actuated Detection (HAD) System Components

4-4.9.1 HAD

HADs (Figure 4-28) are to be installed in an anticipated path of convective heat flow from the fire and spaced at a maximum on-center distance of 20 feet (15 feet-10 inches for FM applications) for ceiling heights up to 12 feet. Consult NFPA 72 for reduction in spacing for ceiling heights greater than 12 feet, and for spacing guidelines when different ceiling configurations are encountered. Ensure that no HAD is mounted at a location where normal process conditions can cause temperature increases to occur at rates faster than 20^{o}F per minute.

The pneumatic heat actuated detector (HAD) is attached to a mounting bracket for ease of installation in industrial applications. Depending upon the size of the area being protected, the number of HADs used can range from a minimum of 1 to a maximum of 15. When up to 5 HADs are required, they are parallel branched by means of tee connections from a common tubing line, and the tubing is connected directly to the control head. When more than 5 HADs are required, they are evenly distributed on separate tubing lines and the individual tubing lines are connected directly to the control heads. Therefore, for 15 HADs, three (3) control heads should be installed.

CAUTION

Pneumatic detectors shall be installed on the ceiling and not on the underside of beams. Refer to the approved installation drawings for quantity and location of detectors.

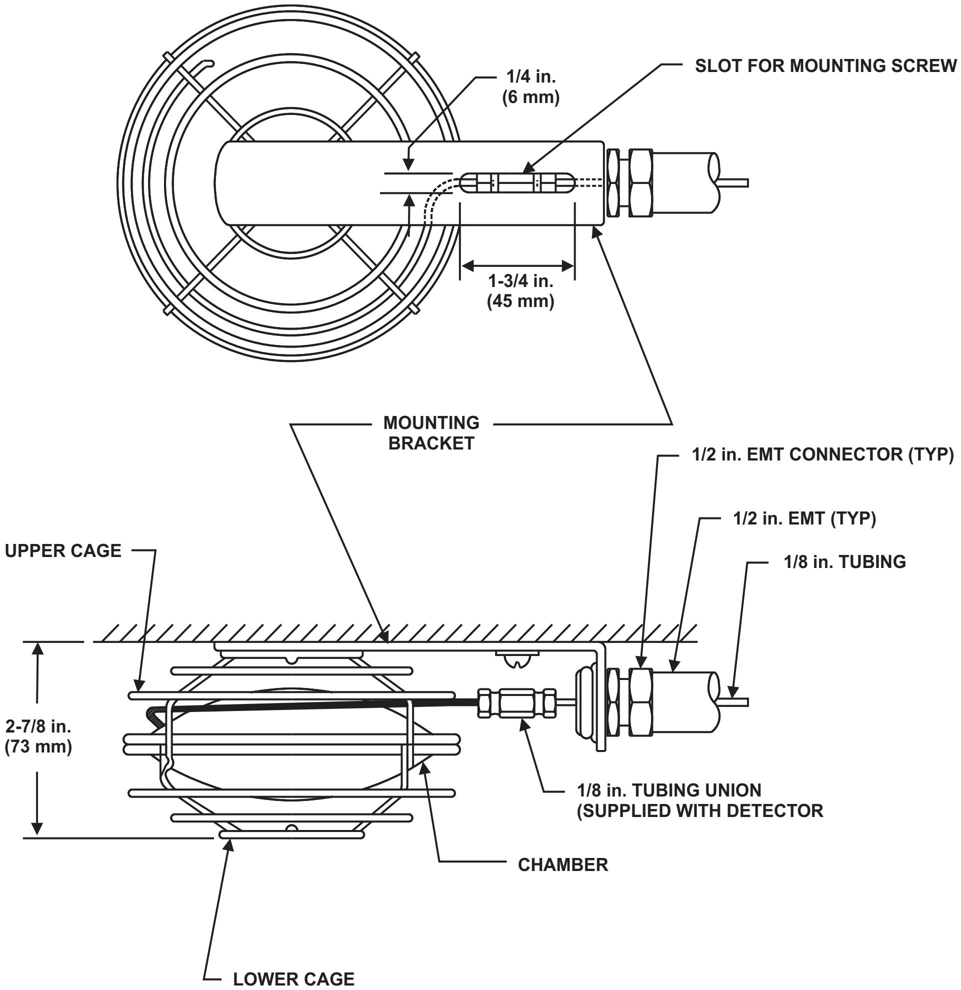


Figure 4-28. Pneumatic Detector (HAD)

4-4.9.2 TUBING

The response time of a pneumatic detection system is dependent upon a number of factors, such as:

a. fire intensity
b. HAD spacing and location
c. control head setting and vent size
d. volume of copper tubing

It is important to remember that the system will actuate when the **entire sensing volume** (HADs, copper tubing, and pneumatic-control-head sensing chamber) is pressurized to a level equal to the control-head setting (e.g. 4 inches of water). To ensure a fast response to rapidly progressing or intense fires, the tubing system must be limited to a total length of 200 feet or less of 1/8-inch O.D. copper tubing for a single-line system, or a total length of 200 feet or less of 1/8-inch O.D. copper tubing for each line of a multiple control head system.

1/8-inch copper tubing is used in industrial systems to interconnect the HADs to the pneumatic control head(s) or a pneumatic main-reserve transfer valve.

Note: The final leg of the copper tubing system connects to the pneumatic control head by means of 3/16-inch O.D. heavy wall copper tubing provided by Kidde Fire Systems.

The 1/8-inch copper tubing to the HADs must be protected by 1/2-inch EMT. Water which collects in the conduit line and freezes may damage the tubing. This necessitates the draining of all low points in tubing conduit which are subject to freezing. If necessary, drill a small hole in the conduit or fitting at the low point.

CAUTION **Do not damage or drill through tubing.**

Install the pneumatic detectors on the ceiling of the protected space. Connect each detector on a detection system branch line to 1/2-inch conduit. Terminate single branch line conduit at a junction box near the pneumatic control head. Conduit bends must be rounded smoothly. Fasten and securely brace the conduit. Use standard junction boxes where required to make connections.

Run 1/8-inch copper tubing through the conduit, checking each section of tubing for obstructions with a manometer prior to installation and prior to making connections, as shown in Figure 4-29. Connect the tubing sections by means of flared fittings and connect each detector as shown.

Terminate the 1/8-inch tubing for single branch line systems at the junction box near the control head. Connect the 1/8-inch tubing to 3/16-inch tubing in the junction box by means of a reducing union, and then route 3/16-inch tubing from the junction box to the pneumatic control head.

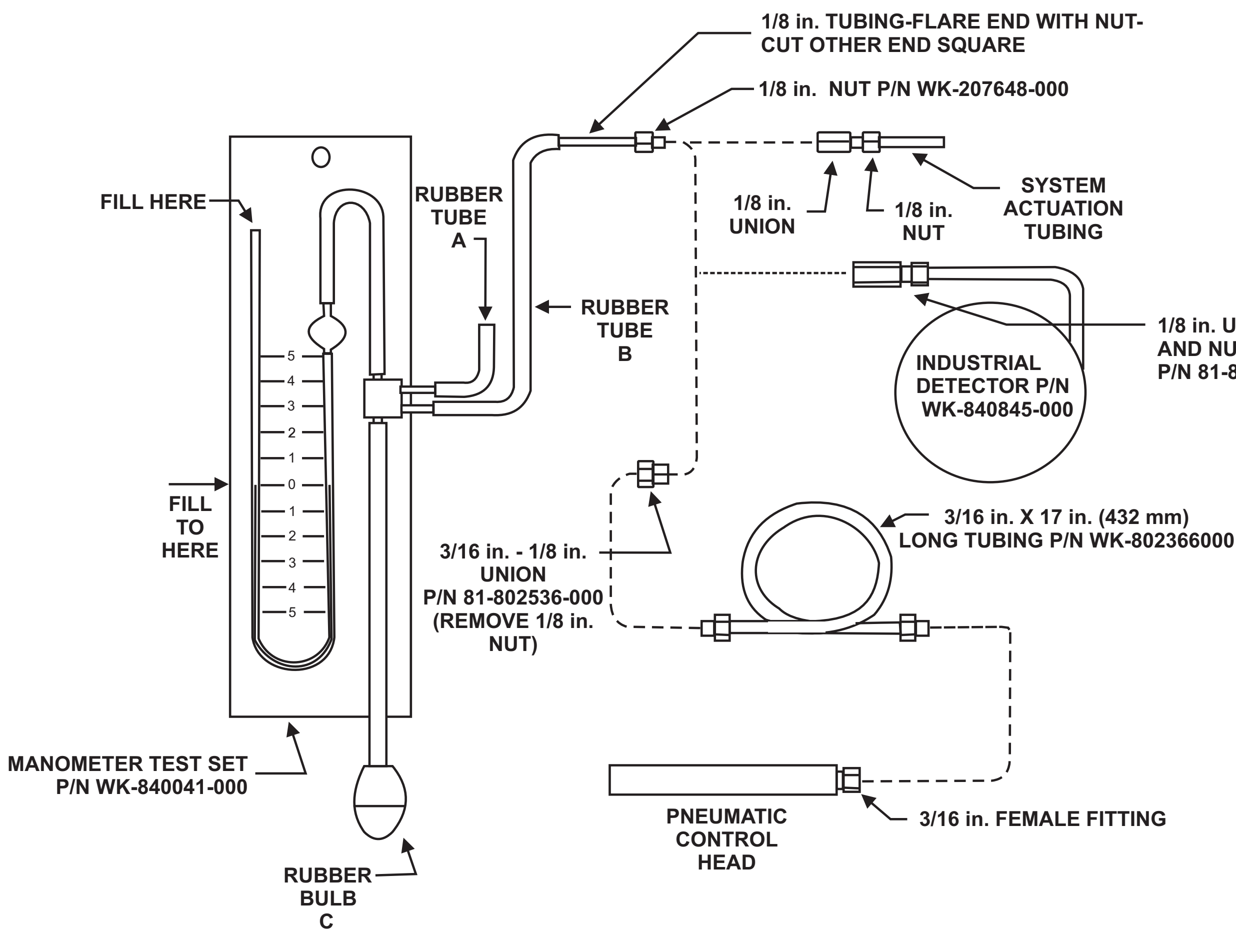


Figure 4-29. Manometer Pneumatic Detection

4-4.9.3 MANOMETER TEST PROCEDURE

Fill manometer glass tube at point marked “FILL HERE” (see Figure 4-29). "Rock" water level back and forth by squeezing rubber bulb to eliminate air bubbles. Add or pour out water until level is at fill point marked “FILL TO HERE” (see Figure 4-29).

1. Connect the test fitting of the manometer test set to the diaphragm chamber of the control head.
2. Make certain sufficient clearance is provided at swivel mounting nut so control head will not be damaged upon operation.
3. If control head has been operated, reset by placing screwdriver in reset stem and turning clockwise until stem locks in position (with arrow on reset stem lined up with "Set" arrow on nameplate).

Note: Slight resistance will be met just before stem locks.

4. Close off the rubber tube "A" by squeezing tightly with the fingers or use a crimp clamp and then apply pressure by gradually squeezing the rubber bulb "C". The control head should operate at the factory pressure setting ± the 10% tolerance allowed. The pressure required to operate the control head is the difference, in inches on the manometer, between the water levels in the two tubes, and is equal to twice the reading of either tube, for example, 3 inches both tubes or 1-1/2 inches one tube.

CAUTION

After the control head has operated, be sure to release rubber tube "A" first before allowing the rubber bulb "C" to expand to normal; otherwise water may be sucked into the tubing and control head, causing serious problems.

4-4.9.4 CONTROL HEAD VENT TEST

Before disconnecting the manometer from the control head, the vent must be tested. To test the vent for correct calibration, perform the following:

1. Squeeze rubber bulb "C" about halfway or enough to achieve sufficient vacuum for test, then close tube "A" by pinching with fingers or crimp clamp.
2. Let bulb expand gradually to its normal shape. This creates a partial vacuum, causing the water level to change, indicating inches of vacuum applied to the control head (the vacuum must be more than minimum of 3 inches in order to observe drop from 3 inches to 1 inch).
3. The water column will recede to "0" level as air passes through the vent. The time required (number of seconds) for the water column to recede 2 inches reading from 3 inches to 1 inch on both legs or 1-1/2 inches to 1/2 inch on either leg is the number of the vent (the calibrated rate of flow). For example, if the time required to pass the above amount of water is 5 seconds the control head vent is "No. 5". When vents are tested in control heads, the time will vary due to the control head diaphragm volume and a No. 5 vent will test 5-7 seconds, which is acceptable. If a vent reads much higher, it will increase system sensitivity; if a vent reads much lower, it will decrease system sensitivity and may not be acceptable.
4. Repeat above procedure for testing tandem control head (if installed). Since there is no vent in the tandem control head, the vacuum should hold (same as tubing tightness test).
5. Disconnect manometer test set from the control head (test fitting "A"). Reset the control head by turning the reset stem to its "SET" position.

4-4.9.4.1 To Test Pneumatic Detectors And/or System Tubing For Tightness

Connect manometer system tubing as shown on Figure 4-29. Squeeze rubber bulb "C", then close off rubber tube "A". Allowing rubber bulb "C" to expand gradually will cause water level in manometer to change, and then hold steady. If detector(s) and/or system tubing is tight, water level will not drop when observed for at least one minute. Relieve vacuum by opening rubber tube "A". Hold a minimum of 8 inches vacuum (difference between 2 sides of "U" tube, or 4 inches on each side of "U" tube).

CAUTION

When making tests with manometer, do not allow water to enter rubber tubing, control head, detector, or system tubing.

Do not blow through system tubing as moisture from breath will impair system operation.

4-4.9.4.2 Other Use For Manometer

Test tubing for freedom from obstructions before installation.

4-4.9.5 HEAT COLLECTOR

Mount heat collector (Figure 4-30) in designated location (see the approved installation drawings). Install pneumatic detector in center of heat collector.

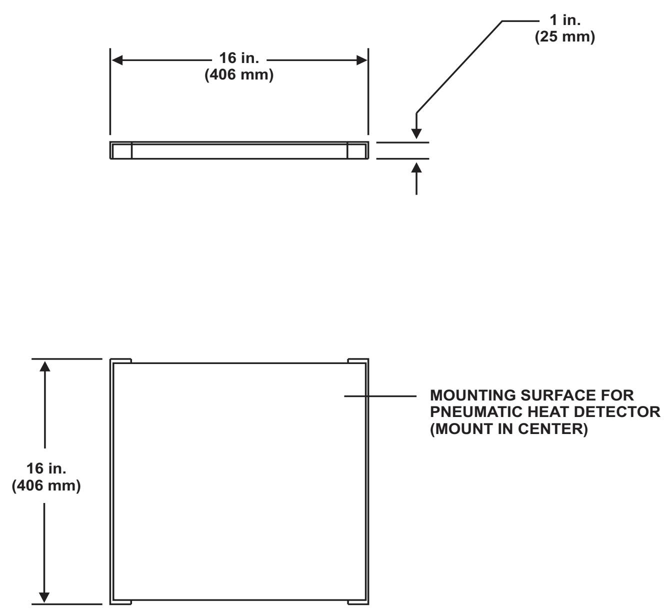


Figure 4-30. Heat Collector

4-4.10 Pneumatic Control Head

The following procedures are to be performed before attaching control head to cylinder valve (refer to Figure 4-31):

1. Remove pilot port outlet protection cap from valve of cylinder to be equipped with control head.
2. Be sure control head is in "SET" position.
3. Arrow on reset stem should line up with "SET" arrow on nameplate.
4. Connect heat detector tubing securely to diaphragm chamber of control head as follows:

   Install a 3/16-inch tubing nut at the termination of the pneumatic detection tubing. Attach the 3/16-inch tubing nut to the diaphragm connection on the pneumatic control head. Although the tubing for an HAD detection system is 1/8-inch O.D. copper tubing, the connection to the pneumatic control head is 3/16-inch O.D. copper tubing. The transition from 1/8-inch O.D. copper tubing to 3/16-inch O.D. copper tubing is made by means of a 3/16-inch to 1/8-inch tubing reducing union.
5. If a Tandem Pneumatic Control Head (Figure 4-32) is required, both heads must be connected using 3/16-inch O.D. pneumatic tubing (Part No. WK-802366-000) provided by Kidde Fire Systems.

Note: If a mechanical pullbox is supplied, proceed with steps 6 through 8.

6. Connect control cable conduit to control head. Remove control head nameplate exposing manual release chamber.
7. Loosen screws on cable clamp and feed cable through hole. Tighten the set screws securely, allowing the cable to sag a little. Do not pull the cable taut. Cut off excess cable.
8. Make certain locking pin and seal wire have been assembled to nameplate. Local control lever should be parallel with nameplate. Assemble nameplate to control head, being sure to fit the small shaft into the cover bearing and the large pin under the trip lever.

WARNING

Before installing control head on the carbon dioxide cylinder valve, ensure that the control head is in the “Set” position (actuating pin in the fully retracted or “Set” position). Failure to position control head in the “Set” position will result in accidental carbon dioxide cylinder discharge when the control head is installed on the cylinder valve.

9. Assemble control head to pilot control port. Tighten swivel coupling nut securely.

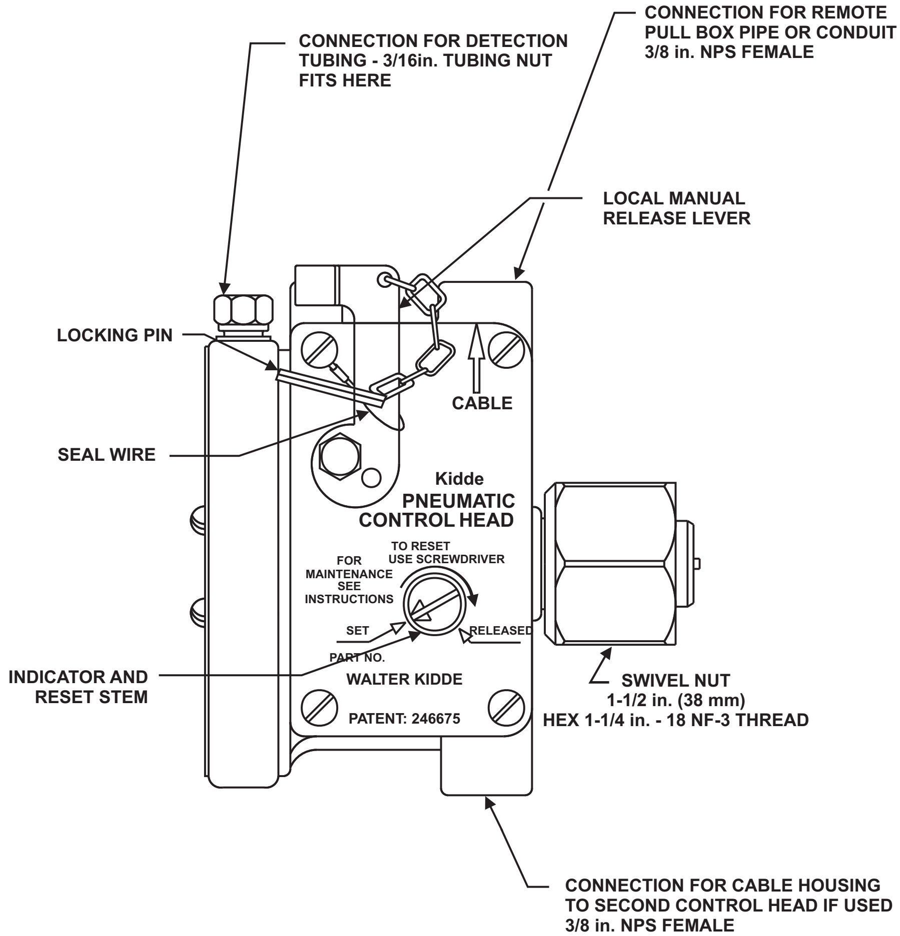


Figure 4-31. Pneumatic Control Head

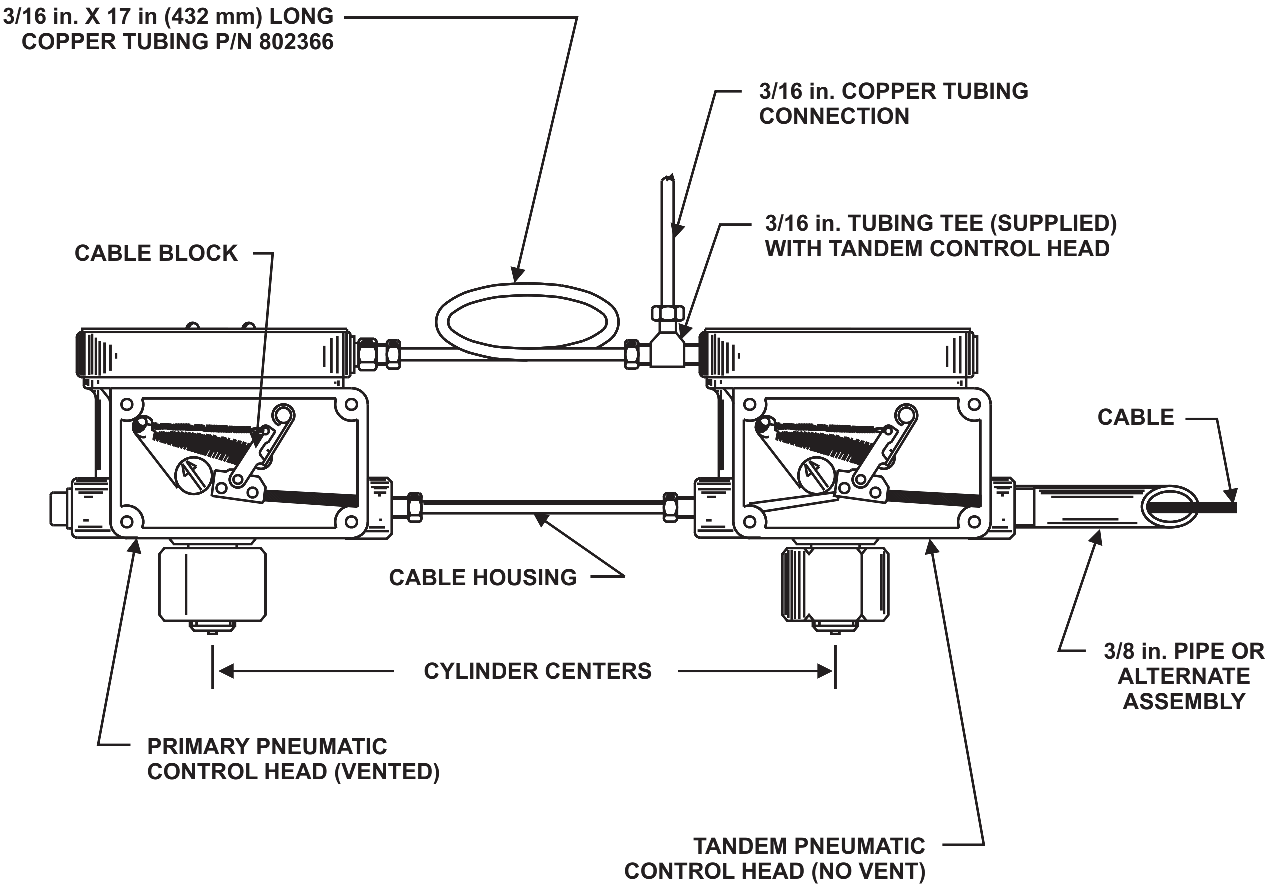


Figure 4-32. Tandem Pneumatic Control Head

4-4.11 Nitrogen Actuation Station

4-4.11.1 INSTALLATION OF NITROGEN CYLINDER, P/N WK-877940-000, AND MOUNTING BRACKET, P/N WK-877845-000

1. Locate the nitrogen cylinder mounting bracket in an area where the cylinder valve assembly and control head will be protected from inclement weather by a suitable total or partial enclosure.
2. Install the mounting bracket clamps and hardware. Install the nitrogen cylinder in position in a mounting bracket; tighten sufficiently to hold the cylinder in place while allowing the cylinder enough free play to be rotated.
3. Turn the cylinder until the cylinder valve discharge outlet is in the desired position. The nitrogen cylinder must be positioned so that control head is readily accessible during manual operation.
4. Securely tighten the mounting bracket clamps and hardware.
5. If the cylinder is being used to drive a pressure operated siren, P/N 90-981574-001, then the add-on label P/N 06-231866-518 (supplied with the cylinder) should be affixed over the area at the center of the cylinder main label (bounded by a dotted line). This ensures the cylinder function is adequately indicated.

4-4.11.2 NITROGEN PILOT CYLINDER INSTALLATION, 1040 CU. IN. AND 2300 CU. IN., P/NS 90-101040-000 AND 90-102300-100

WARNING **Nitrogen cylinders must not be moved unless the discharge and control heads have been removed and the protection caps are installed. Failure to follow these instructions could result in inadvertent discharge, serious bodily injury, death or property damage.**

The nitrogen pilot cylinders must be located as close to the hazard area as possible. The storage location must be protected from the elements and maintained at a temperature between 32°F (0°C) and 130°F (54°C). External heating and/or cooling may be required to maintain this temperature range. Cylinders should be raised at least 2 in. (50 mm) from the deck using a suitable bracket or blocks if the area is regularly washed down or is subject to environmental wetting.

Single cylinders should be installed using two straps, P/N WK-270014-000, installed at the heights shown in Figure 4-33. See Table 4-5 for strap dimensions. Where two cylinders are installed, two double straps, P/N WK-241219-000 can be used. Install at the same heights defined for single cylinder straps.

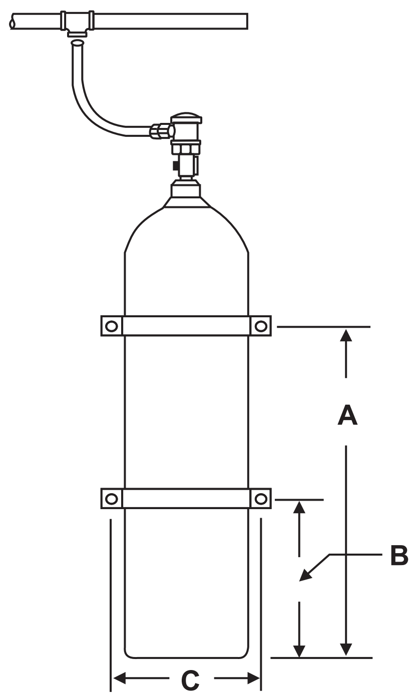


Figure 4-33. Typical 1040 and 2300 cu. in. Pilot (Driver) Cylinder Strap Installation (P/N 90-101040-000 and 90-102300-100)

Table 4-5. 1040 and 2300 cu. in. Nitrogen Pilot (Driver) Cylinder Strap Installation

Part Number	Description	A		B		C	
		in.	mm	in.	mm	in.	mm
90-101040-000	1040 cu. in.	21 to 22	533 to 559	6 to 8	152 to 203	10.4	263
90-102300-100	2300 cu. in.	42 to 44	1067 to 1118	12 to 14	305 to 356	10.4	263

Before connecting cylinders into the discharge pipework, tighten straps until there is clearance enough to allow the cylinders to be rotated in place if required. Tighten fully when all components are correctly positioned.

4-4.12 Pressure Operated Control Heads

1. Refer to Figure 4-34 and remove protection cap from cylinder valve or stop valve pilot control port.
2. Connect flexible actuation hose to pressure operated control head.
3. Apply Teflon tape to the threads of pressure operated control head.
4. Using a suitable wrench, assemble control head to cylinder valve or stop valve pilot control port. Tighten swivel nut securely.

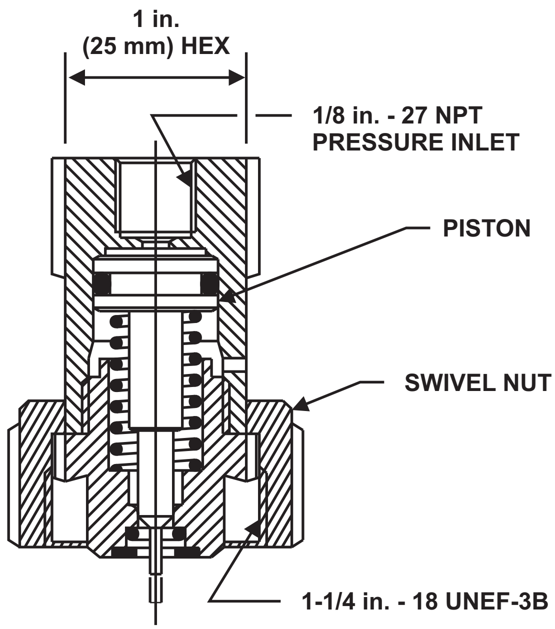


Figure 4-34. Pressure Operated Control Heads

4-4.13 Lever and Pressure Operated Control Heads

1. Refer to Figure 4-35 and ensure the control head is in the “Set” position with locking pin and seal wire intact.
2. Remove protection cap from cylinder valve or stop valve pilot control port.
3. Connect flexible actuation hose to pressure operated control head.
4. Apply Teflon tape to the threads of lever and pressure operated control head.
5. Using a suitable wrench, assemble control head to cylinder valve or stop valve pilot control port. Tighten swivel nut securely.

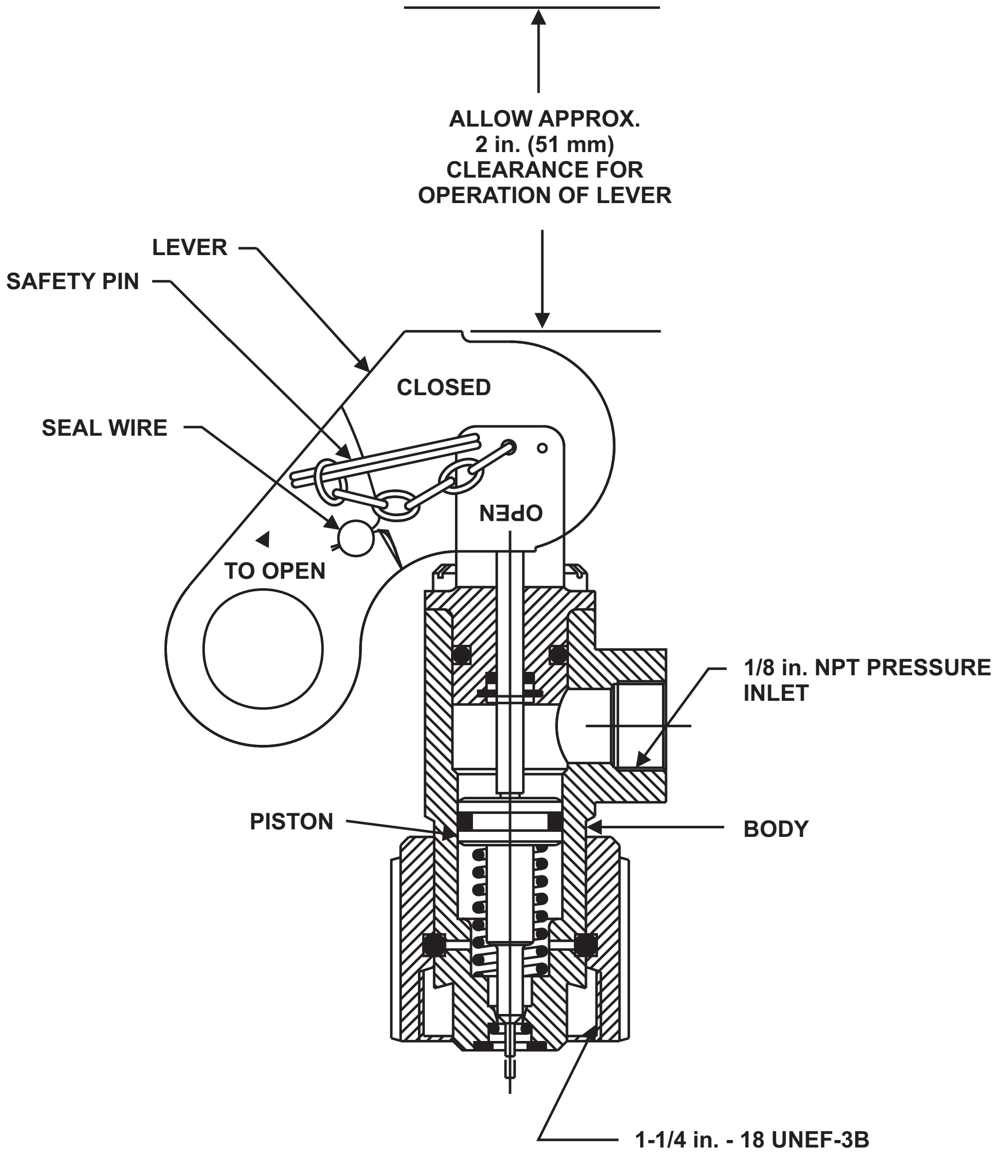


Figure 4-35. Lever and Pressure Operated Control Heads

4-5 AUXILIARY COMPONENTS

4-5.1 Pressure Operated Switches

Pressure operated switches must be connected to the pilot piping or discharge manifolds as shown in Figure 4-36 and Figure 4-37. The preferred mounting position is upright. Both the standard and explosion-proof pressure switches have 1/2-inch NPT pressure inlets to connect to the piping. The electrical connections are either 1/2-inch conduit knockouts or 1-inch NPT fittings. The minimum operating pressure required is 50 PSI.

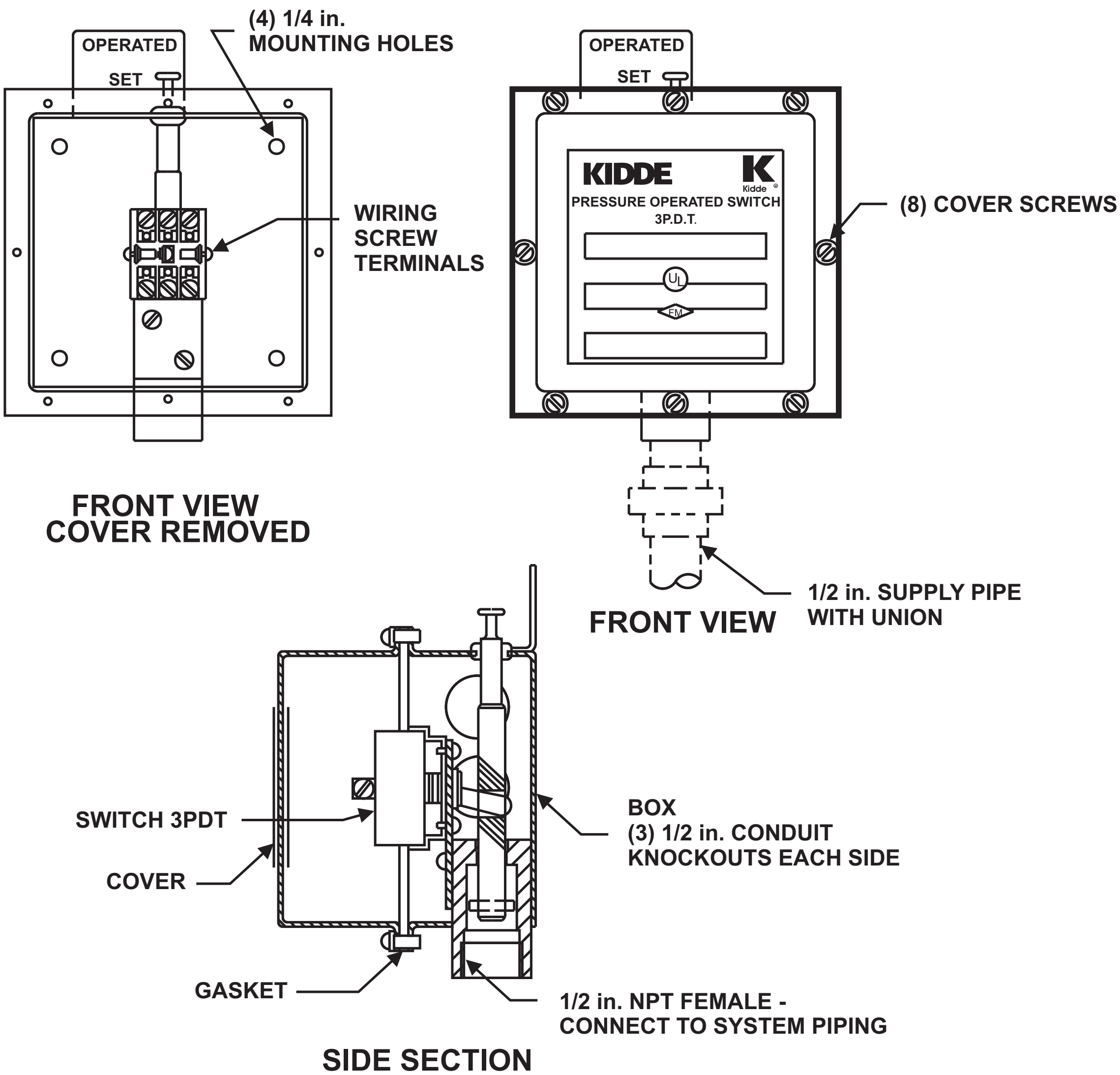


Figure 4-36. Pressure-Operated Switches

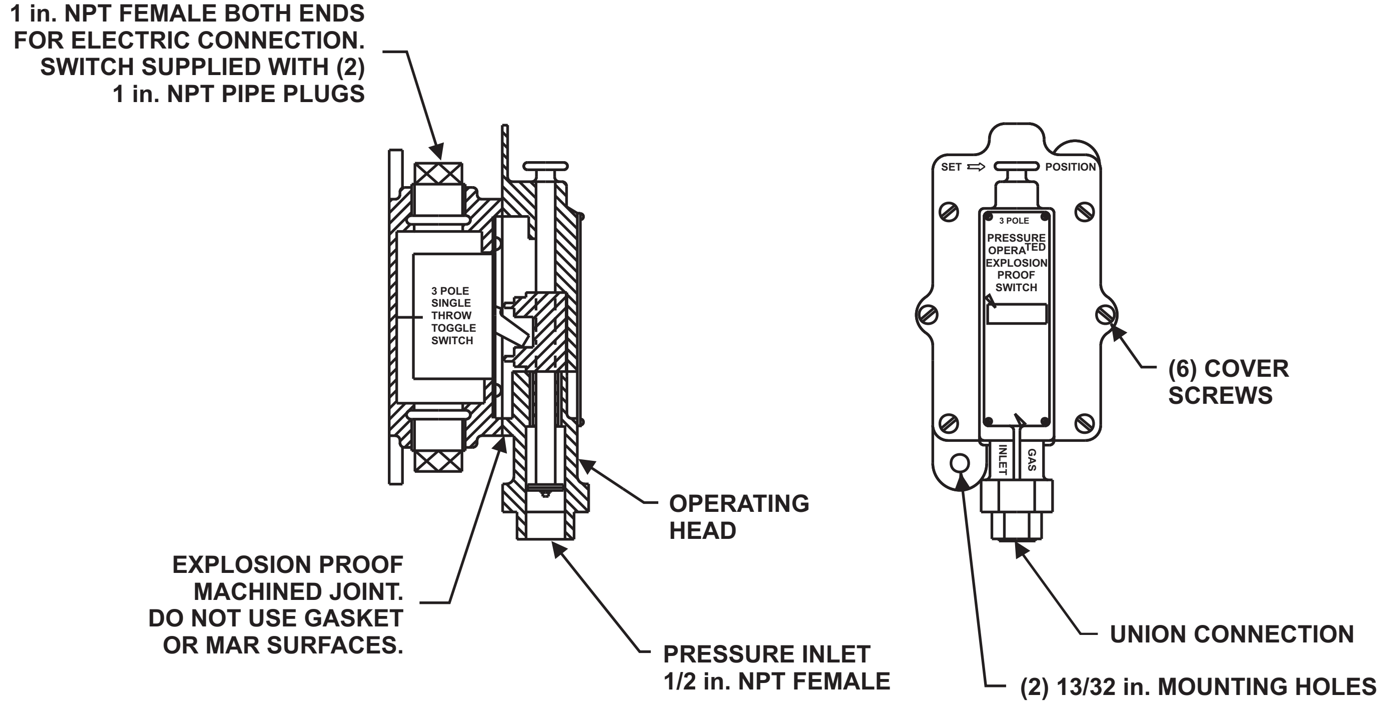


Figure 4-37. Pressure Operated Switches, Explosion Proof

4-5.2 Pressure Operated Trip

Install the pressure operated trip as shown in Figure 4-38. Connect the trip to the discharge piping with 1/2-inch schedule 40 pipe. The minimum operating pressure required is 50 PSI. The maximum load on the retaining ring is 100 pounds.

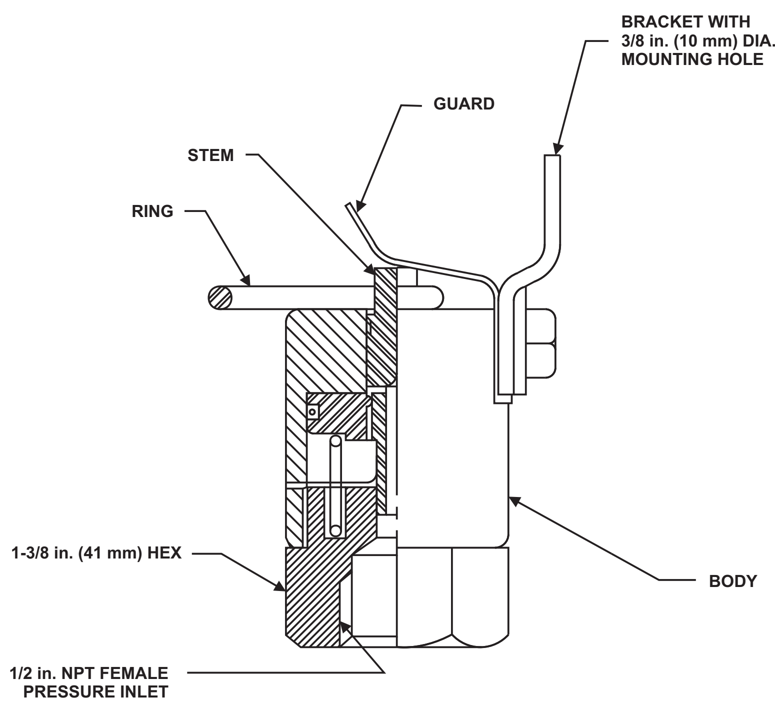


Figure 4-38. Pressure Operated Trip

4-5.3 Pressure Operated Sirens

Either CO_2 pressure operated sirens or Nitrogen pressure operated sirens may be used with the CO_2 suppression system. However, the installation requirements for each siren style are unique. Refer to the following sections for proper installation guidance for each style.

4-5.3.1 CO_2 PRESSURE OPERATED SIREN

The CO_2 pressure operated siren (Figure 4-39) shall be located in accordance with the installation plan. Connect the CO_2 siren to the pilot piping with 1/2-inch schedule 40 pipe.

- When used with a CO2 discharge delay, the siren supply line shall be installed upstream of the CO2 discharge delay.
- Typically located inside the protected space.
- Install a dirt trap and union as shown in Figure 4-39.
- Maximum 250 feet of 1/2-inch pipe between the Siren and the manifold.

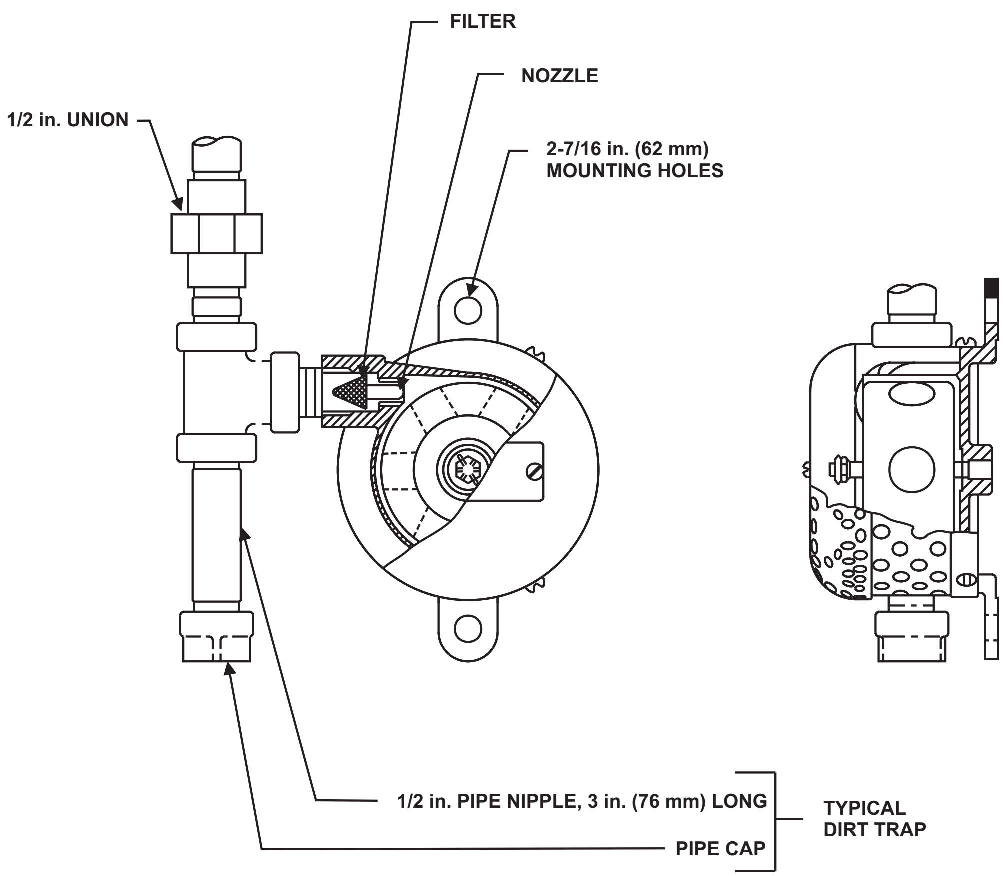


Figure 4-39. Pressure Operated Siren

4-5.3.2 N_2 PRESSURE OPERATED SIREN

The N_2 pressure operated siren (Figure 4-39) shall be located in accordance with the installation plan. Connect the N_2 siren in accordance with requirements corresponding to the siren driver cylinder noted in Table 4-6:

Table 4-6. Siren Driver Cylinder Actuation Limits

Pilot Cylinder Size	Siren Part Number	Number of Sirens per Siren Driver	Maximum Length of 1/4 in. Sch. 80 Pipe	Maximum Length of 1/4 in. Sch. 40 Pipe	Maximum Length of 5/16 in. x 0.032 in. Wall Tubing
108 cu. in.	90-981574-001	1	90 ft.	90 ft.	90 ft.
1040 cu. in.	90-981574-001	4	500 ft.	500 ft.	500 ft.
2300 cu. in.	90-981574-001	10	500 ft.	500 ft.	500 ft.
2 x 2300 cu. in.	90-981574-001	20	500 ft.	500 ft.	500 ft.

- Never connect a pipe supplying CO_2 to the N_2 pressure operated siren.
- The N_2 siren supply line shall start from a dedicated siren driver cylinder, which is separate from the system nitrogen pilot cylinder.
- Typically located inside the protected space.
- Install a dirt trap and union as shown in Figure 4-39.

4-5.4 Odorizer

When used, odorizer assemblies should be located immediately downstream of each selector valve. For systems protecting a single hazard, a single odorizer assemble can be located immediately downstream of the discharge manifold.

The odorizer assembly shall be installed upstream of the lock-out valve. In the event a safety outlet ruptures in a locked-out system, the scent from the odorizer will provide a warning that carbon dioxide has vented into the area by the safety outlet.

Odorizer assemblies must be attached to the discharge piping in the upright position. The odorizer assembly requires approximately 9” of clearance. Odorizer assemblies connect to a 3/4” NPT fitting.

1. Install the 3/4” NPT fitting where the odorizer assembly will be located.
2. Screw the odorizer assembly to the 3/4” NPT fitting.

CAUTION

To prevent damaging the odorizer assembly during testing, it is recommended that the odorizer assembly not be installed until after system testing of the discharge piping is complete. For periodic maintenance after the system has been installed and in use, remove the odorizer assembly prior to any testing of the discharge piping.

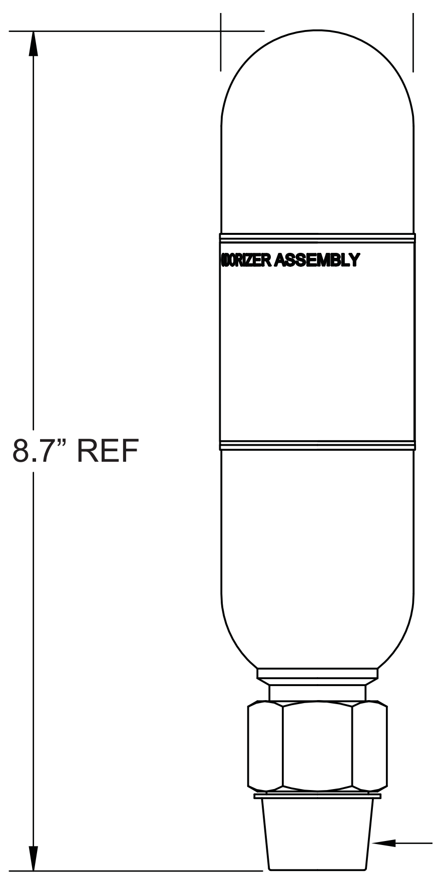


Figure 4-40. Odorizer Installation

4-5.5 Safety Outlet

NFPA 12 requires a pressure relief device to be installed in sections of closed piping. These "closed sections of pipe" are normally located between the carbon dioxide cylinders and Directional (Stop) Valves or lock-out valves. In order to prevent over pressurization of this closed section of pipe when carbon dioxide is trapped and in the event of high temperature exposure, a pressure relief device (Safety Outlet) is required.

1. Locate the Safety Outlet in an area where the carbon dioxide can be safely discharged without exposing personnel.
2. Ensure that the maximum allowable working pressure of the closed section of pipe is equal to or greater than the maximum operating pressure of the Safety Outlet, which is 2,800 psig for part number 81-803242-000.
3. The Safety Outlet (Figure 4-41) must be installed upstream of any stop valve. Connection to the piping is made with a 3/4-inch NPT fitting. Attach the wrench to the body of the safety outlet. Do not tighten or loosen the retaining nut containing the safety disc.

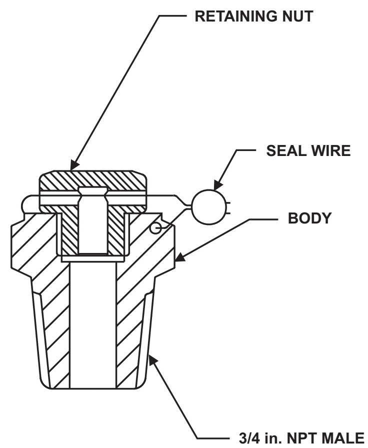


Figure 4-41. Safety Outlet

4-5.6 Discharge Indicator

The discharge indicator (Figure 4-42) must be installed on the discharge manifold in either a horizontal or vertical position. The indicator has a 3/4-inch NPT male connection. Make certain the indicator stem is in the normal position.

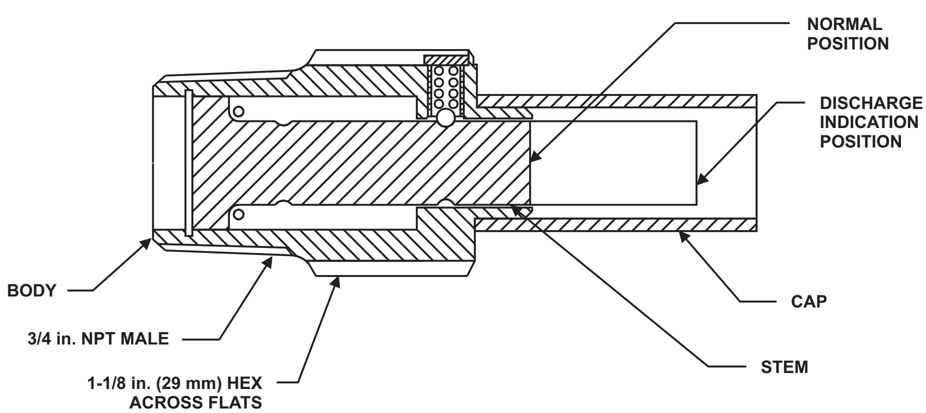


Figure 4-42. Discharge indicator

4-6 HOSE REEL / RACK

Hose reel (Figure 4-43) or rack (Figure 4-44) must be installed in a location where access to the hose and discharge horn is unobstructed. In addition, the hose reel or rack location must allow firefighting personnel to reach all hazard areas protected by the system, such as fuel pumps, electrical apparatus, etc. with the hose.

Install the hand hose line system as follows:

1. Install the cylinder support equipment, discharge piping, safety equipment and actuation system in accordance with the applicable sections of this manual.
2. Mount the hose rack or reel and attach the hose to the piping as shown in Figure 4-43 or Figure 4-44.

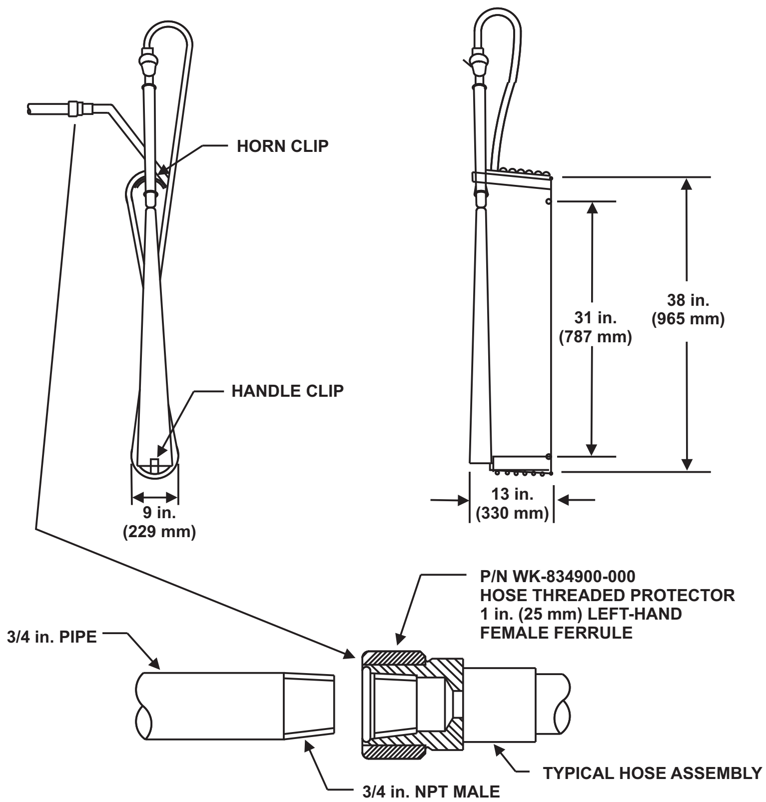


Figure 4-43. Hose Reel Installation

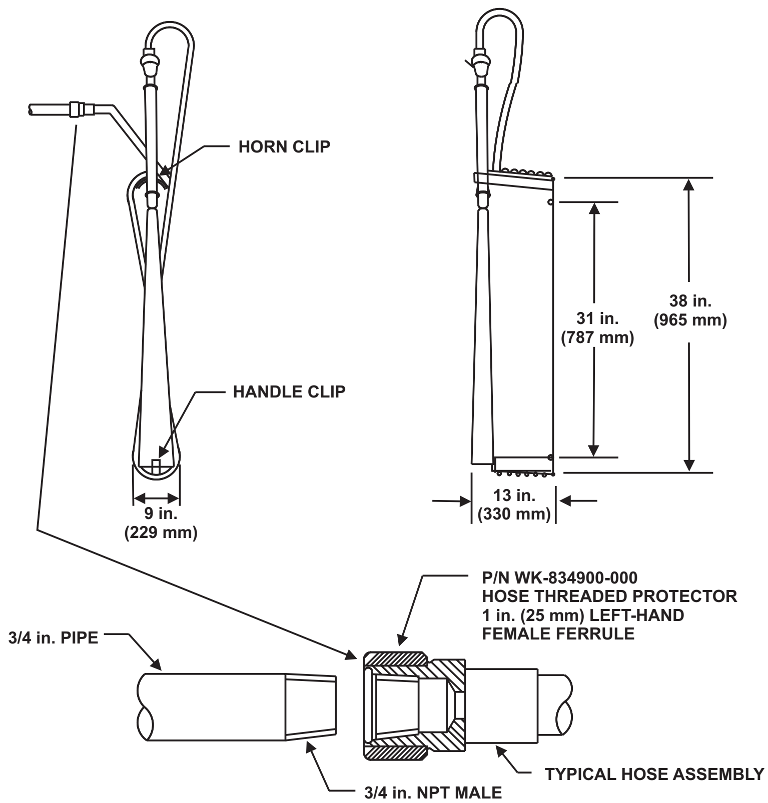


Figure 4-44. Hose Rack Installation

3. Connect multiple hoses in accordance with Figure 4-45 to achieve the desired total length.

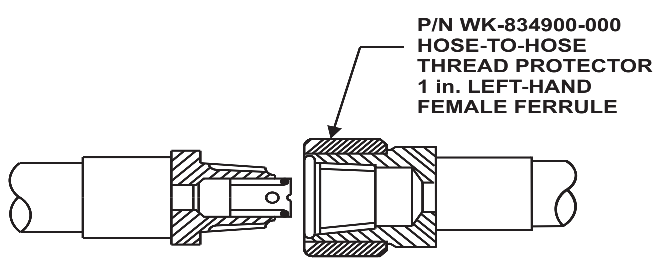


Figure 4-45. Hose Assembly

4. Connect the horn/valve assembly securely to the hose in accordance with Figure 4-46. The temporary shut-off on the horn must be in the CLOSED position.

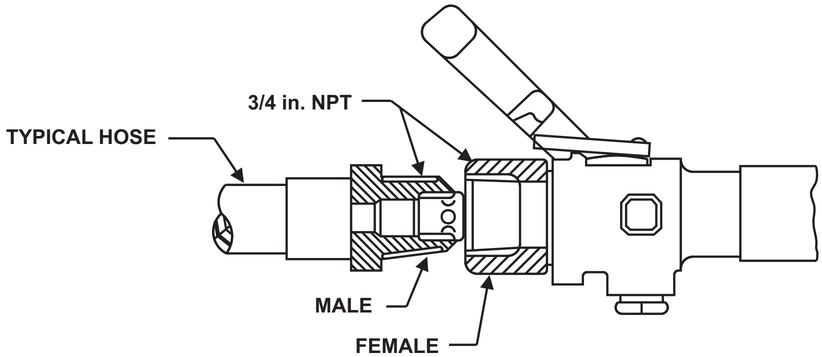


Figure 4-46. Horn and Valve Assembly

5. Mount the Handle and Horn Clips to the wall and place the horn/valve assembly in the mounting clips provided.

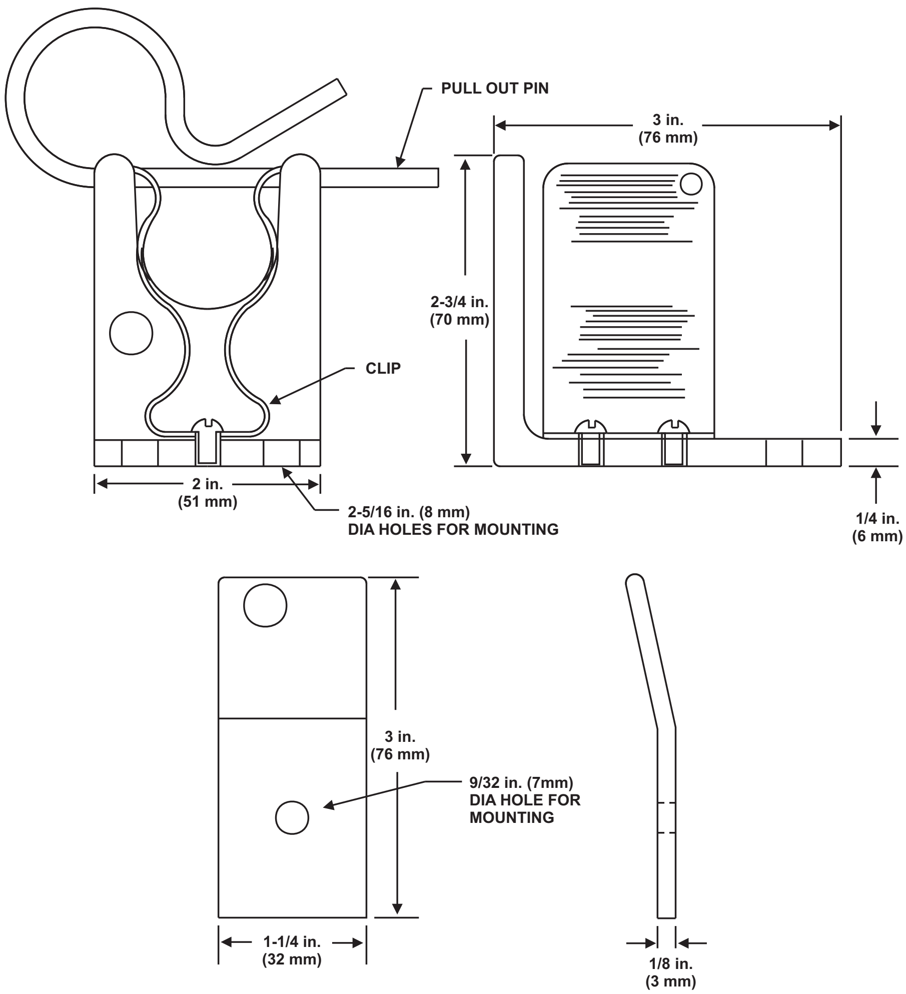


Figure 4-47. Handle and Horn Clips

6. Install the carbon dioxide cylinders in accordance with Paragraph 6-9.1.

WARNING **Lever operated or cable operated control head must be in the "Set" position before installing on the cylinder valve. Control head in the released position will result in accidental discharge of carbon dioxide when installed on the cylinder valve.**

4-7 COMMISSIONING THE CARBON DIOXIDE SYSTEM

Note: The following procedure in part is based on language from NFPA 12, Standard on Carbon Dioxide Extinguishing Systems 2005 Edition, NFPA 72, National Fire Alarm Code 2002 Edition, and the NFPA Fire Protection Systems Inspection, Test and Maintenance Manual, Third Edition published in 2000.

The completed carbon dioxide system shall be inspected, tested, and documented by qualified personnel, in accordance with the NFPA 12 Standard. The objective is to assure that the installation of all required safety features is verified and that expert judgments can be made as to the compliance with the specifications, the system design documents, this manual, the requirements of the AHJ and good practice.

The system must be commissioned prior to being put into service. The goal of the commissioning procedure is to verify that the system installation is operable in accordance with all documented requirements.

Note: The following procedures are inclusive of all components, or component groups (i.e. control heads), in the Kidde carbon dioxide product offering. These instructions must be followed except where they do not apply to the installed system.

4-7.1 Pre-Commission Inspection

Review the system specifications including the hazard description, carbon dioxide agent quantity calculations, plans of the protected area, system piping drawings, variances from the current NFPA 12 Standard and requirements of the Authority Having Jurisdiction (AHJ).

The AHJ shall approve the type and extent of the approval testing to be performed. This approval shall be documented before completion of the commissioning of the carbon dioxide system and issuance of the commissioning certificate.

WARNING **A personnel-training program must be conducted before commissioning the carbon dioxide system. This is to communicate to all necessary personnel the steps and safeguards required to safeguard against injury or death in areas where atmospheres will be made hazardous by the discharge of carbon dioxide.**

4-7.2 Commissioning Procedure

Prior to commencing with the commissioning procedure, ensure that the availability of the following documents is verified and reviewed for a full understanding. Request clarifications from the AHJ and/or the system design engineer if required:

- Carbon dioxide system specifications
- System drawings/plans
- Kidde Engineered Carbon Dioxide (CO_2) Fire Suppression Systems DIOM Manual, P/N 81-CO2MAN-001
- Requirements of the AHJ

Request the approval to proceed from all appropriate authorities (owner, insurance underwriter(s), fire department, etc.) before the system is inspected and tested.

WARNING

Ensure that the system is disarmed, in order to prevent an accidental discharge of carbon dioxide.

Before start of the inspection, ensure that the release outputs from the control unit are isolated and that all control heads and discharge heads have been removed from the carbon dioxide cylinders.

4-7.3 Enclosure Inspection

1. Inspect the protected enclosure to assure that all openings are sealed or provided with automatic closing devices.
2. If the unsealed openings are to remain (i.e. for pressure relief), ensure that the quantity of carbon dioxide includes additional agent to account for the loss through the openings.
3. For local application systems, verify the structure being protected is the same as that which is specified by the drawing.

4-7.4 System Inspection

1. Verify that only listed and/or approved (refer to NFPA 12 Definitions) components have been installed in accordance with the approved drawings. Use the bill of material of the system drawing as a checklist.
2. Conduct a thorough visual inspection of the installed system and hazard area (reference NFPA 12).
   a. The piping, operational equipment and discharge nozzles shall be inspected for proper size and location; also, inspect the aiming point of the discharge nozzles.
   b. Identify the locations of all heat detectors, smoke detectors, alarms, and manual emergency releases in accordance with the approved system drawing.
   c. Confirm that the control unit to which the detectors and manual releases are connected is in the normal operating condition except for the isolated release circuits.
   d. Compare the actual hazard configuration with the original specifications and system drawings; record deviations; As-Installed system design verification may be required because of these deviations.
   e. Inspect the hazard for unclosable openings and other sources of agent loss that have not been identified on the system design specifications and drawings. Record any discrepancies.
   f. Inspect the cylinders to assure that they are properly supported and are not damaged.
   g. In accordance with NFPA 72, verify availability of the Fire Alarm System Record Of Completion.

4-7.5 Labeling

1. Verify the labeling of devices for proper designations and instructions.
2. Compare the nameplate data on the carbon dioxide cylinders with the system specifications.
3. Check the hydrostatic test date stamped on the cylinder(s).

4-7.6 Operational Tests of the Individual Components

1. Conduct nondestructive, operational tests on all devices necessary for functioning of the system, including detection and actuating devices.

Note: Some system components, such as the (pressure operated switches,) may only be tested during the full system discharge. Verification that all interlock functions properly operate such as, damper closure, equipment power supply shut down, etc. is required and must be documented.

2. Notify all appropriate authorities (owner, fire department, insurance underwriter, etc.) when the carbon dioxide fire protection system will be tested, in accordance with the approved schedule of work.
3. De-isolate the outputs from the control unit and assure that the carbon dioxide cylinders remain disconnected from their associated discharge heads.
4. Operate all initiating devices such as heat detectors, smoke detectors and manual releases, and verify proper receipt of all alarm initiating signals at the control unit.
5. Ensure that all control unit outputs (including the control heads) activate according to the approved sequence of operations.
6. If any required function fails to occur, have it repaired, modified, or reprogrammed.
7. Reset the control heads after each activation.
8. Repeat steps 4 through 7 until all operating devices have been tested and the approved operating sequence has been confirmed.
9. Verify the operability of all pre-discharge notification appliances and discharge time delay devices.
10. For all occupiable enclosures, verify that the following safety features have been installed and operate properly (where applicable):
    a. Signage (per Standard NFPA 12)
    b. Pneumatic pre-discharge alarm*
    c. Pneumatic Discharge delay*
    d. Odor additive* to the carbon dioxide discharge, or carbon dioxide detector, or establishment and enforcement of confined space entry procedures.

Note: The operation of all pneumatic devices will be verified during the full system discharge test.

11. Operate the electrical output from the control unit to the electrical control heads, ensuring that the actuation pin is released.
12. Verify Check that all electrical signaling devices operate.
13. Verify Check that all auxiliary equipment responds as specified.
14. Verify Check pressure operated control heads manually during the full discharge test.
15. Test the control panel and its circuitry to assure compliance with NFPA 72.
16. Verify that all control panel circuits are electrically supervised for open circuit, short circuit, and ground fault conditions to within 3 feet (.9 m) of any equipment being controlled, such as air-handler shutdown.
17. Re-isolate the release outputs from the control unit.
18. Reset the electrical control heads.

4-7.7 Full Discharge Test

A full discharge test shall be performed on all systems.

1. Notify all personnel in the protected area, and all areas where carbon dioxide can migrate, of the impending carbon dioxide system discharge test.
2. Arm the system by first installing the control head(s) onto the pilot cylinder(s), connecting the discharge heads to all cylinders, and then de-isolating the release outputs from the control unit after ensuring that no alarm conditions exist in the system.
3. Operate any initiating device or combination of initiating devices (as appropriate) to actuate the extinguishing system.
4. Check operation of the pneumatic siren, time delays, damper closures, and equipment shut downs.
5. Verify that carbon dioxide is discharged from all nozzles in accordance with the design requirements for local-application systems. Confirm that the carbon-dioxide extinguishing concentration is attained and maintained for the required period of time for total-flooding systems.

4-7.8 Commissioning the System

Upon successful completion of the system inspection and test procedure, the system shall be commissioned in accordance with the following procedure.

- Successfully perform the discharge tests in accordance with the specifications and to the approval of the authority having jurisdiction, as previously detailed.
- Verify and document the details of the discharge test(s) and personnel-training program. Fire fighting techniques with Hand Hose Line Systems and/or portable extinguishers must be part of this program.
- Recharge all discharged cylinders after checking the last hydrostatic test date and retesting the cylinders per applicable Department of Transportation (DOT)/Transport Canada (TC) procedures. Begin to arm the system by reconnecting the cylinder(s) to the mounting rack, installing the control head(s) onto the pilot cylinder(s), and connecting the discharge heads to all cylinders. Return all parts of the system to full service.
- Verify and document the details of the personnel-training program. Fire fighting techniques with Hand-Held Hose Lines and/or portable extinguishers must be part of this program.
- De-isolate the release outputs from the control unit after confirming that no automatic or manual initiating devices are in an alarm state. This will make the system operability effective.
- Notify all appropriate authorities (owner, insurance underwriter(s), fire department, etc.) in writing that the carbon dioxide fire protection system is now armed and fully operational.

6. Submit a Certificate of Commissioning to the Owner.

4-7.9 References and Checklists

- For a definition of Control Unit and an explanation of the "*Fire Alarm System Record Of Completion*" reference NFPA 72, National Fire Alarm Code Handbook.
- For information on inspection, test, and maintenance checklists reference the "*Fire Protection Systems: Inspection, Test and Maintenance Manual, Third Edition*" published by the National Fire Protection Association.

CHAPTER 5
OPERATION

5-1 INTRODUCTION

The following operation procedures are based on the CO_2 system being used in normally occupied areas or where occupancy is possible. In these instances a pressure operated time delay and a pressure operated siren are required, to ensure that personnel are alerted and afforded the time to evacuate the hazard area prior to system discharge, regardless of the actuation mode.

In all cases the pressure operated time delay shall be equipped with a supervised manual bypass.

5-2 AUTOMATIC OPERATION

When a system is operated automatically by the electric or pneumatic detection system, proceed as follows:

1. All personnel must evacuate the hazard area promptly. Close all doors.

WARNING **If the pressure operated time delay fails to operate, operate the manual bypass installed on the time delay to immediately discharge the system.**

2. Call the fire department immediately.
3. If the system is provided with a reserve cylinder(s), see Paragraph 5-6.
4. Contact a Kidde Fire Systems distributor for service.

5-3 MANUAL OPERATION

5-3.1 Cable Operated Systems

Operate the system using the controls as follows:

1. Immediately evacuate all personnel from the hazard area. Close all doors.
2. Proceed to cable pull station for appropriate hazard.
3. Operate the control head cable pull station to actuate the CO_2 cylinders
4. For multiple hazard systems operate the cable pull station for the appropriate stop valve.

WARNING **If the pressure operated time delay fails to operate, operate the manual bypass installed on the time delay to immediately discharge the system.**

5. Call the fire department immediately.
6. If the system is provided with a reserve cylinder(s), see Paragraph 5-6.
7. Contact a Kidde Fire Systems distributor for service.

5-3.2 Electric Systems

Operate electric systems as follows:

Proceed to the manual electric station for the hazard.

1. Immediately evacuate all personnel from the hazard area. Close all doors.
2. Operate the manual electric station.

WARNING **If the pressure operated time delay fails to operate, operate the manual bypass installed on the time delay to immediately discharge the system.**

3. Call the fire department immediately.
4. If the system is provided with a reserve cylinder(s), see Paragraph 5-6.
5. Contact a Kidde Fire Systems distributor for service.

5-3.3 Systems Equipped with Remote Nitrogen Actuator

1. Immediately evacuate all personnel from the hazard area. Close all doors.
2. Proceed to remote nitrogen actuator station for the appropriate hazard.
3. Operate the control head mounted on the nitrogen actuation cylinder.
4. Move the ball valve, installed in the actuation piping downstream of the nitrogen cylinder to the OPEN position.

WARNING **If the pressure operated time delay fails to operate, operate the manual bypass installed on the time delay to immediately discharge the system.**

5. Call the fire department immediately.
6. If the system is provided with a reserve cylinder(s), see Paragraph 5-6.
7. Contact a Kidde Fire Systems distributor for service.

5-4 EMERGENCY OPERATION

5-4.1 Local Manual Operation - All Systems

CAUTION **This manual control is not part of the normal system actuation mode and should only be used in a last resort, emergency condition.**

1. Immediately evacuate the hazard area. Close all doors.
2. Proceed to the cylinder(s) for the hazard.
3. Remove the locking pin from the cylinder control head(s).
4. Rotate the local manual release lever to the “released” or “open” position.
5. Proceed to hazard area stop (directional) valve if one is installed. Remove the locking pin from the stop (directional) valve control head. Rotate the local manual release lever to the “released” or “open” position.

WARNING **If the pressure operated time delay fails to operate, operate the manual bypass installed on the time delay to immediately discharge the system.**

5-5 HOSE REEL OR RACK SYSTEMS

Hose line systems must be used by trained personnel only. It is the owner's responsibility to ensure that personnel have been properly trained and are aware of all safety provisions.

5-5.1 Remote Manual Operation

If system is equipped with a remote cable pull station, operate system as follows:

1. Unwind hose from reel or rack.
2. Proceed to cable pull station. Break glass using attached hammer.
3. Pull handle to operate cylinder control head.
4. Approach fire carefully. Do not allow hose to lie in the path of the flames. Point horn at hazard. Open horn valve by pushing stirrup handle forward.
5. Direct carbon dioxide discharge at base of the flames. As flames recede, follow slowly.

Follow detailed instructions below.

Surface Fires:

a. Direct carbon dioxide discharge close to the edge of the fire nearest you. DO NOT point the horn at the center of the flame. If the hose horn must be aimed into an inaccessible fire, the horn must be in the OPEN position.
b. Sweep the horn slowly back and forth across the base of the flames. Chase flames slowly as the fire is extinguished. For vertical fires, direct the discharge at the bottom and gradually work upward as the fire recedes.
c. Continue discharging carbon dioxide until all smoldering material is covered with carbon dioxide "snow".

Electrical Fires - Switchboards, Motors, Etc.

a. Discharge carbon dioxide into all openings on burning substances.
b. Continue to discharge carbon dioxide until flames have been extinguished and the burned material is coated with carbon dioxide "snow". This will prevent any incandescent material from re-igniting.

CAUTION **While it is not necessary to de-energize equipment before discharging carbon dioxide onto electrical fires, equipment must be de-energized as soon as possible after system discharge to prevent the fire from spreading.**

6. After the fire has been extinguished, leave the horn valve open to relieve all pressure from the hose.

WARNING **Except when in use, pressure shall not be permitted to remain in the hose line.**

7. Perform post fire maintenance. Refer to Chapter 7 for details.

5-5.2 Local Manual Operation

1. Unwind hose from reel or rack. Verify that the horn valve is in the "closed" position.

Note: If a reel is used, it is not necessary to remove or unwind the entire length of hose. However, if a rack is used, the hose must be completely removed before charging the line.

2. Proceed to carbon dioxide cylinder(s).
3. Remove the locking pin from the cylinder control head, and rotate the local manual release lever to the “released” or “open” position.

WARNING **Except when in use, pressure shall not be permitted to remain in the hose line.**

4. Approach fire carefully. Do not allow hose to lie in the path of the flames. Point horn at hazard. Open horn valve by pushing stirrup handle forward.
5. Direct carbon dioxide discharge at base of the flames. As flames recede, follow slowly.

Follow detailed instructions below.

Surface Fires:

a. Direct carbon dioxide discharge close to the edge of the fire nearest you. DO NOT point the horn at the center of the flame. If the hose horn must be aimed into an inaccessible fire, the horn must be in the OPEN position.

b. Sweep the horn slowly back and forth across the base of the flames. Chase flames slowly as the fire is extinguished. For vertical fires, direct the discharge at the bottom and gradually work upward as the fire recedes.

c. Continue discharging carbon dioxide until all smoldering material is covered with carbon dioxide "snow".

Electrical Fires - Switchboards, Motors, Etc.

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CAUTION **While it is not necessary to de-energize equipment before discharging carbon dioxide onto electrical fires, equipment must be de-energized as soon as possible after system discharge to prevent the fire from spreading.**

6. After the fire has been extinguished, leave the horn valve open to relieve all pressure from the hose.

WARNING **Except when in use, pressure shall not be permitted to remain in the hose line.**

7. Perform post fire maintenance. Refer to Chapter 7 for details.

5-6 MAIN AND RESERVE SYSTEMS

WARNING **The following procedures can be applied only when the reserve system has not been previously discharged.**

After operating the “main” system as described above, place the “reserve” system in standby mode as follows:

1. Reset all manually operated control heads, pressure operated trips, discharge indicators, manual operation stations, and pressure operated switches. Ensure that the control panel and all detectors are reset.
2. Ensure that the manual lever on the pneumatic Discharge delay is in the “closed” position with the locking pin and seal wire installed.
3. If the system uses stop (directional) valves, reset control head on the valve.

WARNING **When pneumatic main/reserve transfer switch, Part No. 81-871364-000, is installed, wait at least 15 minutes before moving lever to the “reserve” position. This allows any remaining pressure in the pneumatic system to vent to atmosphere. Failure to follow these instructions may accidentally discharge the reserve system when the transfer switch is moved.**

4. Proceed to the main/reserve transfer switch. Move switch lever to the RESERVE position.
5. Immediately contact a Kidde Fire Systems distributor for service.

5-7 LOCKOUT VALVES

When it is necessary to perform maintenance on the CO_2 system or need to perform work that could cause false alarms and discharge, it is essential to lockout the CO_2 system. The following steps must be observed.

1. Unlock the valve and place it in the Closed position.
2. Lock the valve.
3. Verify that a Trouble indicator appears on the control unit.
4. When maintenance or test is complete, unlock the valve and place it in the Open position.
5. Lock the valve.
6. Verify the Trouble indicator is clear on the control unit.

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CHAPTER 6
MAINTENANCE

WARNING

CO_2 and nitrogen cylinder assemblies must be stored, handled, transported, serviced, maintained, tested, and installed only by trained personnel in accordance with the instructions contained in this manual, NFPA-12, and CGA pamphlets C-1, C-6, G-6, G-6.3 and P-1. CGA pamphlets may be obtained from the Compressed Gas Association, 1725 Jefferson Davis Highway, Arlington, VA 22202-4102.

Before performing maintenance procedures, refer to the material safety data sheets and safety bulletins at: http://www.kiddefiresystems.com.

WARNING

All actuation devices (control heads, discharge heads, etc.) must be removed from the system cylinders prior to performing system maintenance. Observe all safety precautions applicable to handling pressurized equipment. Recharge of CO_2 and nitrogen cylinder assemblies must be performed by personnel trained in Kidde Fire Systems CO_2 systems equipment. See the "Safety Summary" on page iii for additional information.

CAUTION

To prevent operation of the Odorizer or damaging the Odorizer Cartridge, remove the Odorizing cartridge(s) from all odorizer Assemblies prior to testing the discharge piping or performing any system test.

6-1 GENERAL

Fire suppression systems require proper care to ensure normal operation at all times. Periodic inspections must be made to determine the exact condition of the system equipment.

A regular program of systematic maintenance is essential for proper operation of the carbon dioxide system. A periodic maintenance schedule must be followed and an inspection log maintained for ready reference. As a minimum, the log should record inspection interval, inspection procedure performed, maintenance performed, if any, as a result of inspection, and name of inspector performing task. If inspection indicates areas of rust or corrosion, immediately clean and repaint the area.

6-2 PREVENTIVE MAINTENANCE

Perform preventive maintenance in accordance with Table 6-1. The inspection procedures and intervals are recommended and can be modified to fit into normal facility schedules providing the intervals do not exceed the time periods shown in the table.

Table 6-1. Preventive Maintenance Schedule

Schedule	Requirement	Reference Paragraph
Monthly	Inspect hazard area system components	Paragraph 6-3
	Check nitrogen cylinder pressure	Paragraph 6-3
Semi-Annually	Check CO_2 cylinder weight	Paragraph 6-4
	Test electric control head	Paragraph 6-4.3
	Test pressure switch	Paragraph 6-4.4
	Verify odorizer cartridge	Paragraph 6-4.5
Annually	Check nitrogen cylinder pressure	Paragraph 6-5.1
	Check CO_2 cylinder weight	Paragraph 6-5.1
	Blow out distribution piping	Paragraph 6-5.2
	Perform complete system function	Paragraph 6-5.3
	Test pneumatic detection system	Paragraph 6-5.4
Every 5 years	Hydrostatic test all CO_2 and nitrogen system hoses and flexible connectors.	Paragraph 6-6
Every 5 or 12 years	CO_2 cylinder hydrostatic test	Paragraph 6-6.1
	N_2 cylinder hydrostatic test	Paragraph 6-6.1

6-3 INSPECTION PROCEDURES - MONTHLY

1. Make a general inspection survey of all cylinders and equipment for damaged or missing parts. If any equipment requires replacement, refer to Paragraph 6-7.
2. Ensure that access to hazard areas, remote nitrogen or cable pull stations, discharge nozzles, and cylinders are unobstructed and there are no obstructions to the operation of the equipment or distribution of carbon dioxide.
3. Inspect flexible actuation hoses for loose fittings, damaged threads, cracks, distortion, cuts, dirt and frayed wire braid. Tighten loose fittings. Replace hoses having stripped threads or other damage. If necessary, clean parts as directed in Paragraph 6-6.3. Inspect flexible actuation hose adapters for stripped threads and damage. Replace damaged adapters. Inspect couplings and tees for tightness. Tighten if necessary. Replace damaged parts.
4. Inspect control heads attached to CO_2 cylinders, nitrogen cylinders, stop valves and time delays for physical damage, deterioration, corrosion, distortion, cracks, dirt, and loose couplings. Tighten loose couplings. Replace damaged or missing caps. Replace control head if damage is found. If necessary, clean as directed in Paragraph 6-6.3. Ensure that all control heads, actuation devices, etc. are all in the “set” or “closed” position with the locking pin installed and seal wire intact.
5. Inspect carbon dioxide cylinder and valve assembly for leakage, physical damage such as cracks, dents, distortion, and worn parts. Check safety disc for damage, and replace if necessary. If necessary, clean cylinder and associated parts as described in Paragraph 6-6.3.
6. Inspect cylinder straps, cradles, and attaching hardware for loose, damaged, or broken parts. Check straps and associated parts for corrosion, oil, grease, grime, etc. Tighten loose hardware. Replace damaged parts. If necessary, clean as directed in Paragraph 6-6.3.

7. Inspect CO_2 system discharge heads for cracks, corrosion, grime, etc. Ensure that discharge heads are tightly secured to each CO_2 cylinder valve and connected to the discharge manifold with a flexible discharge hose or swivel adapter.
8. Inspect flexible discharge hoses for loose fittings, damaged threads, cracks, rust, kinks, distortion, dirt, and frayed wire braid. Tighten loose fittings, and replace hoses which have stripped threads. If necessary, clean as directed in Paragraph 6-6.3.
9. Inspect discharge manifold for physical damage, corrosion, and dirt. Inspect manifold support brackets and clamps for looseness and damage. Inspect check and stop valves, where applicable, for deformation, leakage, cracks, wear, corrosion, and dirt. Secure loose parts. Replace damaged parts. If necessary, clean as directed in Paragraph 6-6.3.
10. Inspect discharge nozzles for dirt and physical damage. Replace damaged nozzles. If nozzles are dirty or clogged, refer to Paragraph 6-6.4. Where frangible discs are used, ensure they are intact and clean. Look for holes or cuts. Broken discs will allow vapors, oils, etc. from the hazard to enter into the nozzles and system piping and seriously effect or block system discharge.

CAUTION

Do not paint nozzle orifices. The part number of each nozzle is stamped on the nozzle. Nozzles must be replaced by nozzles of the same part number. Nozzles must never be interchanged, since random interchanging of nozzles will adversely affect proper CO_2 distribution within a hazard area.

11. Inspect pressure switches for deformations, cracks, dirt or other damage. Replace switch if damage is found.
12. Check nitrogen cylinder pressure gauge for proper operating pressure. If pressure loss (adjusted for temperature) exceeds 10%, recharge with nitrogen to 1800 PSIG at 70°F. See Figure 6-1 for pressure-temperature relationship.
13. Inspect lock-out valve (if installed). Valve must be secured and locked in the “open” position.
14. Visually inspect Control Panel/Detection system. Ensure that system is “normal” and free from any “alarm” or “trouble” signals.
15. If any defects are found during the monthly inspection, immediately contact a Kidde Fire Systems Distributor to service the systems.

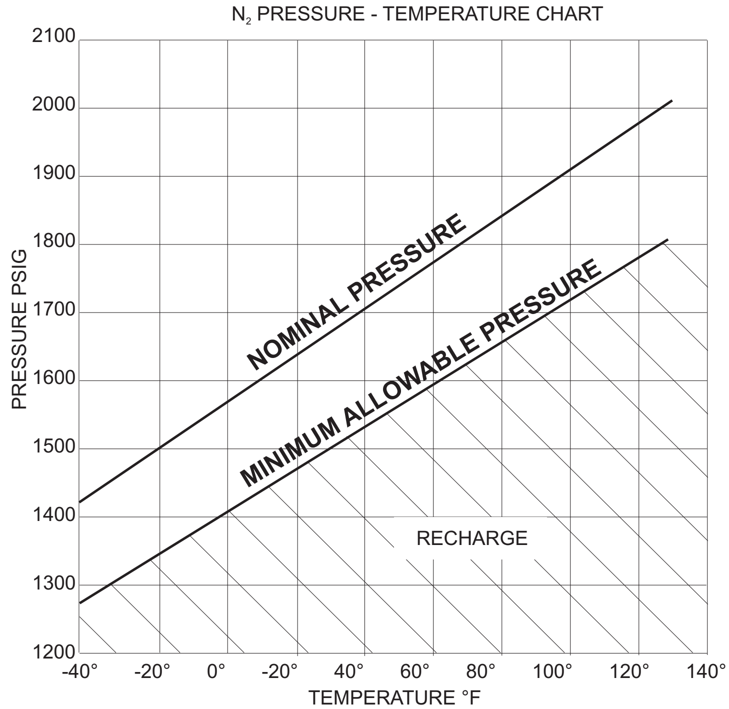


Figure 6-1. Nitrogen Temperature vs. Pressure Data

6-4 SEMI-ANNUAL WEIGHING OF CO_2 CYLINDERS

WARNING

The CO_2 cylinders are equipped with a high flow rate discharge valve, which when actuated, will open, remain open, and can not be closed. Accidental actuation of the discharge valve on an unsecured, disconnected cylinder will result in a discharge thrust capable to causing severe property damage and bodily injury.

It is therefore extremely important that the exact sequence of cylinder removal and installation always be followed. Cylinder removal or cylinder installation must always be supervised to assure full compliance with the instructions in this manual.

6-4.1 Weighing (using Kidde Fire Systems Weigh Scale)

Use the following steps to weigh the cylinder by using the weighing scale (P/N 81-982505-000).

1. Remove control head(s) at the coupling nut only. When tandem heads are used, back off each head at the same time before attempting to completely remove both heads from the cylinders.

   The flexible hose must remain connected to the discharge head.

2. Loosen the cylinder from the framing, leaving the framing components connected to each other while allowing free vertical movement of the cylinder.
3. Hook scale on weighing angle, and slip yoke under discharge head. Adjust as shown on Figure 6-2.

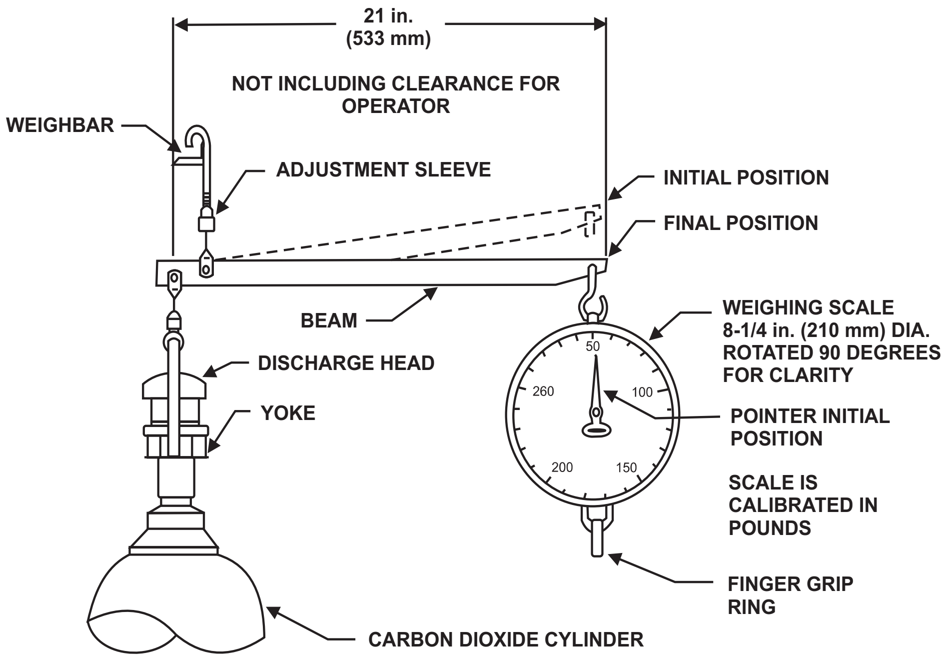


Figure 6-2. Carbon Dioxide Cylinder Weighing Scale

4. Use the adjustment sleeve of the weighing scale assembly to bring the beam to the initial position. The initial position must be determined to allow the cylinder to be suspended freely when the beam is pulled down towards the horizontal position. Free suspension should move the cylinder just free from its supporting surface when the beam is pulled down using the finger grip ring.
5. Pull down on finger grip until cylinder is just clear of floor and lever is horizontal.
6. Read the weighing scale. One division between two lines represents 10 lb. (4.5 kg) of weight. The weighing scale measures weights between 50 and 300 lbs. (23 and 136 kg). The scale is calibrated to compensate for leverage. The empty cylinder weight is stamped on the cylinder valve body.
7. From the scale reading, deduct the empty cylinder weight and deduct the discharge head weight of 3.75 lbs. (1.7 kg). The resulting weight is the amount of carbon dioxide (charge weight) within the cylinder.
8. The charge weight shall not deviate more than 10 percent (10%) from the net content of the cylinder. For example, the weight of a cylinder filled with 100 lb. (45 kg) of carbon dioxide shall not deviate more than 10 lb. (4.5 kg) (after subtraction of the weight of the discharge head) from the full weight stamped on the valve body.
9. If the CO_2 weight loss exceeds 10%, forward charged cylinder with discharge and control heads removed and safety cap and cylinder protection cap installed, to a Kidde Fire Systems distributor for recharge.
10. After all cylinders have been weighed, tighten clamps, and reinstall control heads on cylinders. Tighten control head coupling nuts securely.

6-4.2 Weighing (without Kidde Fire Systems Weigh Scale)

1. Remove CO_2 cylinders following procedures detailed in Paragraph 6-8.
2. Weigh cylinder(s) on platform scale. Empty cylinder weight is stamped on cylinder valve body. Remove the cylinder protection cap only during weighing. This cap is not included in the empty weight of the cylinder.
3. If CO_2 weight loss exceeds 10% forward charged cylinder, with cylinder protection cap and valve protection caps installed, to a Kidde Fire Systems distributor for recharge.

4. After all cylinders have been weighed, or recharged as may be required, reinstall into the system following procedures detailed in Paragraph 6-9.

6-4.3 Electric Control Head Test

The electric control head must be tested semi-annually for proper operation. This test can be performed without discharging the carbon dioxide cylinders. Test one hazard area at a time before proceeding to the next hazard area as follows:

CAUTION **All electric control heads must be removed from carbon dioxide and nitrogen pilot cylinders prior to testing to prevent accidental cylinder discharge.**

1. Remove electric control heads from all master carbon dioxide cylinders and nitrogen pilot cylinders within the hazard area being tested. Let the electric control head(s) hang freely from the flexible electric conduit connections. Leave all pressure operated control heads, discharge heads and actuation hoses attached to the cylinders.
2. Operate carbon dioxide system electrically. This can be accomplished by actuation at the system control panel or by manual operation of an electric pull station.
3. Ensure that each electric control head has operated. Observe that the actuating pin has moved to its fully “released” position. If any control heads have not operated, check circuit for electric continuity to these particular heads and repeat test. Replace all damaged heads. Repeat test if any control heads have been replaced.

CAUTION **Electric control heads must be reset manually before reconnecting to the cylinder valves, to prevent accidental carbon dioxide discharge.**

4. Replace any damaged head which fails to reset properly. Make certain electric control heads are in the SET position before reconnecting to the system cylinders. Reattach all electric control heads to threaded port on cylinder valves. Tighten swivel nuts securely. Failure to follow this procedure will result in an accidental carbon dioxide discharge.

6-4.4 Pressure Switch Test

Perform pressure switch test as follows:

WARNING **If the pressure switch is connected to an electrical release, disconnect the circuit prior to performing the test.**

1. Contact appropriate personnel and obtain authorization for shutdown.
2. Check that hazard area operations controlled by pressure switch are operative.
3. Manually operate switch by pulling up on plunger.
4. Verify that hazard area operations, controlled by the pressure switch, shut down.
5. Return pressure switch to SET position.
6. Reactivate all systems shut down by pressure switch; this includes power and ventilation systems, compressors, etc.
7. Re-connect any circuits that were disconnected.

6-4.5 Verify Odorizer Cartridge

Verify the odorizer assembly as follows:

1. Remove the odorizer assembly.
2. Check to make sure the burst disc is intact.
3. Reattach the odorizer assembly. If the burst disc has ruptured, replace the odorizer assembly.

6-5 ANNUAL MAINTENANCE

6-5.1 Equipment Inspection

Perform the procedures described in:

- Paragraph 6-3
- Paragraph 6-4

6-5.2 Distribution Piping Blow Out

Before blowing out system, remove pipe caps from the ends of the distribution piping to allow any foreign matter to blow clear. In addition, remove any frangible discs from vent or flanged nozzles (if installed). Blow out all distribution piping with dry air or CO_2 to make sure there are no obstructions.

WARNING

Do not use water or oxygen to blow out pipe lines. The use of oxygen is especially dangerous as the possible presence of even a minute quantity of oil may cause an explosion.

1. Remove all discharge heads from the carbon dioxide cylinders.
2. Remove all pipe caps on dirt traps from distribution piping to allow any foreign matter to blow clear.
3. Remove all frangible discs (if installed).

WARNING

Do not disconnect discharge head(s) from flexible hose(s). Discharge of CO_2 system will cause flexible hose, without discharge head attached, to flail violently, resulting in possible equipment damage and severe bodily injury to personnel.

4. Discharge test cylinder into system manifold. Use of CO_2 or dry air is acceptable. Discharge duration is to be of sufficient length to insure that all piping is blown clear.
5. Reinstall all pipe caps and frangible discs as required.
6. Reconnect all discharge heads to CO_2 cylinder valves.

6-5.3 Complete System Inspection

Perform complete system inspection and test in accordance with NFPA-12. Full system functional tests are to be performed without the need to discharge the carbon dioxide cylinders. The full functional tests are to be conducted with all of the electric, mechanical, pressure operated or pneumatic control heads removed from the CO_2 cylinders and/or nitrogen pilot cylinders, as described in Paragraph 6-4.3, Paragraph 6-4.4 and Paragraph 6-5.4.

6-5.4 Pneumatic Detection System Tests

CAUTION

Before conducting any of the tests outlined below first remove the discharge heads from the cylinders equipped with pneumatic control heads. Then remove the pneumatic control heads from the cylinder valves. This will prevent discharge of the system upon accidental operation of a control head. When tandem heads are used, back-off each head at the same time before attempting to remove either head from the cylinder valves. Do not allow the control heads to rotate out of position.

6-5.4.1 PNEUMATIC CONTROL HEAD TEST - PRESSURE SETTING

Note: The tests to be performed using Manometer Test Set Kidde Fire Systems Part No. 81-840041-000.

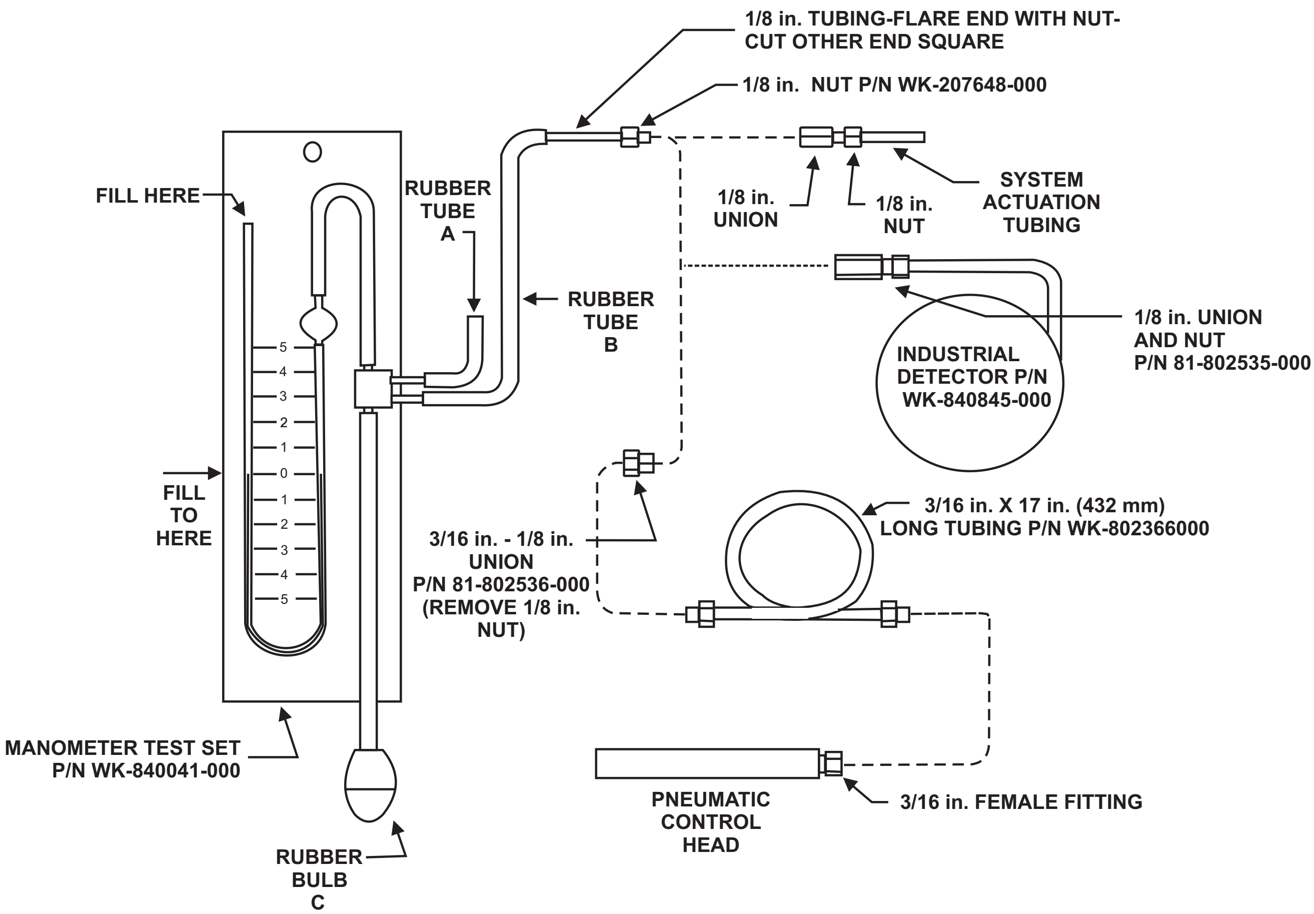


Figure 6-3. Manometer Pneumatic Detection

1. Connect the test fitting of the manometer test set to the diaphragm chamber of the control head.
2. Make certain sufficient clearance is provided at mounting nut so control head will not be damaged upon operation.
3. If control head has been operated, reset by placing screwdriver in reset stem and turning clockwise until stem locks in position. This occurs when the arrow on the reset stem is lined up with the “SET” arrow on the nameplate.

4. Slight resistance will be met just before stem locks.
5. Use manometer test set Part No. 81-840041-000, and pour water into the open glass tube until the water level in both tubes is exactly at the zero mark.
6. Close off the rubber tube “A” by squeezing tightly with the fingers or use a crimp clamp. Apply pressure by gradually squeezing the rubber bulb "C". The control head should operate at the factory pressure setting with +/- 10% tolerance allowed. The pressure required to operate the control head is the difference, in inches, between the water levels in the two tubes, and is equal to twice the reading of either tube.

CAUTION **After the control head has operated, be sure to release rubber tube "A" first before allowing the rubber bulb "C" to expand to normal; otherwise, water may be drawn into the tubing and control head, causing serious problems.**

6-5.4.2 CONTROL HEAD VENT TEST

Before disconnecting manometer from the control head, the vent must be tested. To test the vent for correct calibration, perform the following steps:

1. Squeeze rubber bulb "C" about halfway or enough to achieve sufficient vacuum for test. Then close tube "A" by pinching with fingers or crimp clamp.
2. Let bulb expand gradually to its normal shape. This creates a partial vacuum, causing the manometer water level to change, indicating inches of vacuum applied to the control head. The vacuum must be more than a minimum of 3 inches in order to observe a drop from 3 inches to 1 inch.
3. The water column will recede to "0" level as air passes through the vent. The vent setting is the time required (in seconds) for the water column to drop 2 inches from a level of 3 inches to 1 inch on both legs (or from 1-1/2 inches to 1/2 inch on each leg) of the U-Tube manometer. This is also known as the calibrated rate of flow. For example, if the time required to pass the above amount of water is 5 seconds, the control head vent is "No. 5". When vents are tested in control heads, the time will vary due to the added volume in the control head diaphragm chamber, and a No. 5 vent will test 5-7 seconds, which is acceptable. If a vent time reads much higher, it will increase system sensitivity; if a vent time reads much lower, it will decrease system sensitivity and may not be acceptable. Repeat above procedure for testing tandem control head, if installed. Since there is no vent in the tandem control head, the vacuum should hold.
4. Disconnect manometer test set from the control head, test fitting "A". Reset the control head by turning the reset stem to its “SET” position.

Note: For accuracy, Kidde Fire Systems test set Part No. 81-840041-000 must be used.

6-5.4.3 TEST FOR LEAKAGE OF SYSTEM TUBING AND DETECTORS

1. Connect the test fitting of the manometer to the pneumatic detector tubing at the control head connection nut.
2. Squeeze the rubber bulb "C" fully. Close off the open rubber tube "A". Very gradually, release the rubber bulb to its normal shape. This will cause the water level in the two tubes to change, and a maximum vacuum will develop. Hold a minimum of 8 inches vacuum, the difference between the two sides of the "U" tube, or 4 inches on each side of the "U" tube.
3. If all connections are absolutely tight, the water level will remain in the position taken in paragraph 2 above and will not change as long as the rubber tube "A" is held closed. Observe the level of the water for at least one minute, and then release the rubber tube "A". It is absolutely essential the water level remain the same as long as the rubber tube is held closed. Even a slow, steady fall of the water level is serious, for it indicates a leak which may prevent automatic operation of the system. Disconnect the test set from the detector tubing. After tests have been completed, reset the control heads.

WARNING **When using hot or boiling water, exercise care when immersing the Pneumatic Detector Actuating Chamber. Do not stand directly beneath the water container.**

4. Functional Test of the Detection System. Hold a container of hot or boiling water under the heat detector, immersing the actuating chamber in the water. At least 50% of the detector should be immersed. The water must be at least 100°F above the ambient temperature. Note the time between the application of the hot water to the detector and the operation of the control head. The control head should operate in approximately 15 seconds. Do not apply heat for more than 15 seconds. The detector is not functioning if the control head has not operated within this time.

   When testing two control heads connected in tandem, both may not operate simultaneously. Both control heads should operate within 30 seconds if the heat is sustained.
5. The heat test should be performed on each heat detector. Between each test, wait about ten minutes for the system to return to normal, and then reset the control head(s). To reset, insert screwdriver in reset stem and turn clockwise until the stem locks in position with the arrow on reset stem lining up with the "Set" arrow on the nameplate. (Slight resistance will be met just before the stem locks.)
6. If the application of heat does not cause the control head to operate within 15 seconds, remove the container of water and investigate the cause.

6-5.4.4 TROUBLESHOOTING OF PNEUMATIC DETECTION SYSTEM

Failure of the pneumatic detection system to operate when applying heat to the detectors may be caused by:

- Insufficient heat applied to the detector
- Leakage in the tubing system (tubing connections not tight).
- Obstruction in the tubing.

The manometer can be used to assist in trouble shooting the system as follows:

1. Install manometer in system tubing at pneumatic control head connection. Replace union connection with a control head "T." Connect manometer tube B to the "T" fitting. Close open tube A of the manometer with a crimp clamp. The manometer is now an integral part of the system and provides a visual record of pressure to which system is subjected by heat or cold at the detector.
2. The installation of the manometer as described above provides a visual indication of the pressure build-up within the system and will assist in determining if there is sufficient or insufficient pressure build-up during the test of the system.

6-6 5 YEAR AND 12 YEAR INSPECTION AND TEST GUIDELINES

6-6.1 Carbon Dioxide and Nitrogen Cylinders

The United States' Code of Federal Regulations (CFR) Title 49 - Transportation and Canada's Transport Canada (TC) Transport of Dangerous Goods Act (TDG) Part 5 govern the design, fabrication, testing and stamping of hazardous goods transported over all public ways (roads, rail, boat, etc.). When filled, CFR49/TDG classify Kidde cylinders as hazardous goods. In any case of information within this section conflicting with CFR49/TDG, the requirements of CFR49/TDG take precedence over the instructions provided within this section.

All Kidde cylinders are designed, fabricated, tested and stamped in compliance with CFR49/TDG.

6-6.1.1 CARBON DIOXIDE CYLINDERS

Kidde CO2 cylinders shall comply with CFR49/TDG requirements while in transit and shall comply with NPFA 12 requirements while installed.

All Kidde CO2 cylinders shall be qualified for use over public ways in accordance with CFR49/TDG as applicable. Per CFR49/TDG, qualified cylinders shall not have a hydrostatic test date stamp that is more than five (5) years old. Cylinders with a date stamp more than 5 years old shall be re-qualified in accordance with CFR49/TDG prior to shipment.

While installed, NPFA 12 allows CO2 cylinders to remain in service for a maximum of twelve (12) years from the last stamped hydrostatic test date. At the end of the 12 year period, cylinders shall be removed from service, vented (emptied) and re-qualified in accordance with CFR49/TDG before returning to service. The applicable sections of this manual shall be followed when removing, venting or reconnecting cylinders to service.

6-6.1.2 NITROGEN CYLINDERS

Kidde N2 cylinders shall comply with CFR49/TDG requirements while in transit and shall comply with NPFA 12 requirements while installed.

All Kidde N2 cylinders shall be qualified for use over public ways in accordance with CFR49/TDG as applicable. Per CFR49/TDG, qualified cylinders shall not have a hydrostatic test date stamp that is more than allowed period of time. CFR49/TDG define the allowed period of time as ten (10) years for 3AA cylinders with a water capacity of 125-lbm (3,467 cu. in.) or less. CFR49/TDG define the allowed period of time as five (5) years for 3AA cylinders with a water capacity greater than 125-lbm (3,467 cu. in.). Cylinders with a date stamp older than the allowed period of time shall be re-qualified in accordance with CFR49/TDG prior to shipment.

While installed, NPFA 12 allows N2 cylinders to remain in service indefinitely.

Any cylinder (CO2/N2/Other) shall be re-qualified immediately if the cylinder shows evidence of distortion, damage, cracks, corrosion or mechanical damage. Any cylinder failing requalification shall be destroyed. The applicable sections of this manual shall be followed when removing, venting or reconnecting cylinders to service.

6-6.2 Flexible Hoses

Flexible hoses must be hydrostatic pressure tested every five years in accordance with the requirements in NFPA 12.

6-6.3 Cleaning

Remove dirt from metallic parts using a lint-free cloth moistened with dry cleaning solvent. Dry parts with clean, dry, lint-free cloth or air blow dry. Wipe non-metallic parts with clean, dry lint-free cloth. Clean and paint steel parts as required.

6-6.4 Nozzle Service

Service nozzles after use as follows:

1. Clean outside of nozzles with rag or soft brush.
2. Examine discharge orifices for damage or blockage. If nozzles appear to be blocked, unscrew nozzles and clean by immersing in dry cleaning solvent and drying thoroughly with lint-free cloth. Replace damaged nozzles. Nozzles must be replaced with same part number. Clean and paint steel nozzle bowls as required.
3. Examine nozzle frangible discs (if installed). Replace damaged or ruptured frangible discs.

6-7 REPAIRS

Replace all damaged parts during inspection. Installation and removal procedures for CO_2 system cylinders are provided below. Since replacement of other system components are simple, refer to installation drawings and component drawings noted in Chapter 2 for guidance. Part numbers of the components are provided in Chapter 8 and may be used to procure replacement parts as required.

6-8 REMOVAL OF CYLINDERS

6-8.1 CO_2 Cylinders

WARNING **When removing charged cylinders, always disconnect the discharge heads first. This will minimize the possibility of accidentally discharging the CO_2 system, which could result in possible equipment or property damage or injury to personnel.**

These instructions must be carefully followed in the exact sequence given when any cylinder or group of cylinders are to be removed at any time.

1. Remove discharge head(s) from all cylinder valves by loosening mounting nut (right hand thread). On multiple cylinder installations, swing discharge head and hose away from cylinder and allow to hang.

WARNING **Discharge head(s) must be left connected to the discharge hose and system piping to prevent injury in the event of system discharge.**

2. Remove all control heads from the cylinder valves by loosening mounting nut (right hand thread).
3. Install large top protection cap over threads on top of cylinder valve. Cap control head outlet by screwing on side protection cap.
4. Install valve protection cap on cylinder.

WARNING **Do not remove cylinder(s) from the bracketing if the valve protection cap is missing. Obtain a new protection cap from Kidde Fire Systems or a distributor of Kidde Fire Systems products.**

5. Remove cylinder bracketing.
6. Remove cylinder(s).

6-8.2 Nitrogen Pilot Cylinders

1. Remove control head from nitrogen cylinder valve.
2. Install protection cap on nitrogen cylinder actuation port.
3. Loosen flexible actuation hose and remove adapter (Part No. WK-699205-010) from the cylinder valve outlet.
4. Open bracket strap and remove nitrogen cylinder from bracket.

6-9 INSTALLATION OF CYLINDERS

6-9.1 CO_2 Cylinders

WARNING **When installing charged cylinders, always install the discharge heads last. This will minimize the possibility of accidentally discharging the CO_2 system, which could result in possible injury to personnel, or damage to equipment or property.**

These instructions must be carefully followed in the exact sequence given below when any cylinder or group of cylinders are to be installed at any time.

1. Place fully charged cylinder in cylinder rack before removing the cylinder protection cap.
2. Install the cylinder rack and tighten bolts only enough to allow for turning of cylinder as may be required later.
3. Remove the cylinder protection cap and top protection cap from the cylinder valve. Remove the side protection cap only from the cylinder valve(s) to be equipped with control head(s). Return all caps to the storeroom.
4. Turn cylinder so that the cylinder valve control head port points in the proper direction; tighten bolts of the cylinder rack securely.
5. Make certain that all control head(s) are in the “set” or “closed” position, (actuator plunger should fully recede into the control head body). Ensure that the locking pin and seal wire are intact.

WARNING **Control heads must be in the “set” or “closed” position before attaching to the cylinder valves to prevent accidental carbon dioxide discharge.**

6. Install control head(s) onto cylinder valve(s). Tighten securely.
7. Assemble discharge head(s) to cylinder valve(s) and tighten mounting nut.

6-9.2 Nitrogen Pilot Cylinders

1. Install nitrogen cylinder in mounting bracket. Rotate cylinder until valve outlet is in desired position.
2. Tighten mounting bracket strap.
3. Remove pipe plug and connect adapter (Part No. WK-699205-010) to cylinder valve outlet port. Attach flexible actuation hose to outlet port adapter.
4. Remove protection cap from cylinder valve control head port.

WARNING

Control head must be in the “set” or “closed” position before attaching to the cylinder valve, which will prevent:

- **an accidental discharge of the nitrogen cylinder and any corresponding suppression agent**
- **a nitrogen leake during actuation**

Failure to properly set the control head may cause damage to the unit and could result in one of the aforementioned concerns.

5. Install control head to cylinder valve.
6. Tighten the control head to the valve. Tightening the control head to the valve requires that a wrench be used to hold the valve while the control head hex nut is tightened. The

outlet fitting (1/8 NPT to 5/16 tube connector) must be removed to expose the two flats on the valve body (new cylinders are supplied with plastic shipping plug in this outlet).

7. Both the valve body and the control head hex nut are 1-1/2” across the flats. Hold the valve body using a 1-1/2” wrench (preferred) or a suitable smooth jawed adjustable wrench.
8. Position the control head in the desired orientation and hand tighten the hex-nut. Using a torque wrench[1] fitted with a 1-1/2" crowfoot wrench, tighten to a minimum torque of 60 ft. lb.[2].
9. Reinstall outlet fitting and connect to system hose, tubing or pipe (as appropriate).

[1] Recommended 10-100 ft. lb. 1/2” drive torque wrench. Other ranges are acceptable provided 40-60 ft. lb. is within optimum tolerance for the tool.

[2] Set wrench to a minimum setting of 55 ft. lb. (most styles of crowfoot will increase the actual torque value by approximately 10% since a typical 1-1/2" crowfoot wrench has a center-to-center dimension of 2”. Actual minimum torque value is 60 ft. lb. Calculate effect of crowfoot using tool manufacturer’s data.

CHAPTER 7
POST-DISCHARGE MAINTENANCE

WARNING

CO_2 and nitrogen cylinder assemblies must be stored, handled, transported, serviced, maintained, tested, and installed only by trained personnel in accordance with the instructions contained in this manual, NFPA 12, and CGA pamphlets C-1, C-6, G-6, G-6.3 and P-1. CGA pamphlets may be obtained from the Compressed Gas Association, 1725 Jefferson Davis Highway, Arlington, VA 22202-4102.

Before performing maintenance procedures, refer to the material safety data sheets and safety bulletins at: http://www.kiddefiresystems.com.

WARNING

All actuation devices (control heads, discharge heads, etc.) must be removed from the system cylinders prior to performing system maintenance. Observe all safety precautions applicable to handling pressurized equipment. Recharge of CO_2 and nitrogen cylinder assemblies must be performed by personnel trained in Kidde Fire Systems CO_2 systems equipment. See pages i and ii of this manual for additional information.

7-1 GENERAL

Fire suppression systems require proper care to ensure normal operation at all times. Periodic inspections must be made to determine the exact condition of the system equipment.

A regular program of systematic maintenance is essential for proper operation of the carbon dioxide system. A periodic maintenance schedule must be followed and a inspection log maintained for ready reference. As a minimum, the log should record inspection interval, inspection procedure performed, maintenance performed, if any, as a result of inspection, and name of inspector performing task. If inspection indicates areas of rust or corrosion, immediately clean and repaint the area.

7-2 POST FIRE MAINTENANCE

After a CO_2 system discharge, qualified fire suppression system personnel must perform post fire maintenance as directed in this section. Observe all warnings, especially those pertaining to the length of elapsed time before entering the hazard area following discharge.

WARNING

Do not enter the hazard with an open flame or lighted cigarette. The possible presence of flammable vapors may cause re-ignition or explosion. For deep seated hazards, the space must be kept tightly closed for 30 to 60 minutes after system discharge. Ensure that fire is completely extinguished before ventilating the area. Before permitting anyone to enter the hazard, vent area thoroughly or use self-contained breathing apparatus.

1. Return all cylinders to a Kidde Fire Systems distributor for recharge and retest (if required).
2. Recharge carbon dioxide and nitrogen cylinders in accordance with procedures outlined in this manual.

3. Reset all control heads on cylinders; and stop (directional) valves on multi-hazard systems. Replace any control head that fails to reset properly. Reinstall locking pins. Replace seal wires.

WARNING **Control head(s) must be in the “set” or “closed” position before attaching to the cylinder valve, to prevent accidental discharge of the carbon dioxide system.**

CAUTION **Before resetting a control head fitted to a nitrogen cylinder, all pressure must be relieved from the downstream actuation piping. Failure to follow this procedure can cause the control head to not be operationally ready after reset.**

4. If pneumatic transmitter is installed, reset as follows:

CAUTION **Pneumatic control head, attached to the pneumatic transmitter, must be reset before resetting the transmitter.**

   a. Unscrew the slotted indicator cap.
   b. Reverse cap and screw onto plunger.
   c. Pull plunger out until it clicks into position.
   d. Unscrew cap and reinstall over plunger. Green indicator showing through slots in cap indicates transmitter is in "SET" position.

5. If system was operated using a nitrogen pilot cylinder, remove the control head from the nitrogen cylinder. This will vent nitrogen pressure from the actuation piping and reset the pressure operated control heads on the carbon dioxide cylinders.
6. If system was operated using a manual pull station, reset manual pull station.
7. If time delay was manually overridden, reset manual control lever on pneumatic Discharge delay. Reinstall locking pin. Replace seal wire.
8. Replace all discharged odorizer assemblies.

7-3 CYLINDER RECHARGE

CAUTION **CO_2 and nitrogen cylinders must not be recharged without a retest if more than five (5) years have elapsed from the date of last test. Retest shall be in accordance with the requirements of CFR 49. After retest, interior of cylinders must be thoroughly dried and free of residue.**

WARNING **Under no circumstances while performing either cylinder recharge or leak test should a CO_2 cylinder have a discharge head or control head attached to the cylinder valve. When handling carbon dioxide cylinders, observe the following:**

a. Each cylinder is factory equipped with a valve protection cap threaded securely over the valve assembly. This device is a safety feature and provides protection during handling.

b. This protection cap must be installed at all times, except when the cylinder is connected into the system piping, being filled, or leak tested.

c. The valve protection cap must be stored in a secure space and made readily available for use. Do not move or handle cylinders without the cap installed.

7-3.1 Carbon Dioxide Agent

Carbon dioxide should be of excellent grade, pure and dry. The agent shall have the following minimum properties:

a. The vapor phase shall be not less than 99.5 percent carbon dioxide.

b. The water content of the liquid phase shall comply with CGA G6.2. The water content should be below 0.03 percent (32 ppm) by weight.

c. Oil content shall be not more than 10 ppm by weight.

7-3.2 CO_2 Cylinders

Note: CO_2 cylinders are filled by weight only, not by pressure.

CAUTION

CO_2 cylinders should be filled using an approved transfer pump. DO NOT use dry ice converters as this may allow water vapor to enter the cylinder, causing internal corrosion.

Recharge of Kidde Fire Systems CO_2 cylinders should only be performed by a Kidde Fire Systems distributor. CO_2 cylinder recharge shall be in accordance with the following instructions. Where applicable, refer to Figure 7-1 and Figure 7-2 during performance of the following procedure.

1. Secure CO_2 cylinder to vise or bracket and relieve any remaining cylinder pressure. This can be accomplished by utilizing the Kidde Fire Systems blow-off fixture, Part No. 81-930117-000.
2. Remove valve from cylinder (if necessary).
3. Remove valve seat.
4. Remove copper sealing gasket.
5. Remove main check assembly and spring.
6. Remove sleeve retainer, brass sleeve and pilot check assembly.
7. Kidde Fire Systems recommends replacing the safety burst disc. Remove the safety outlet nut and reattach with a maximum torque of 350 in./lbs.
8. Examine rubber portions of main check, Part No. WK-932636000 (for 1/2-inch valve) and Part No. WK-800760-000 (for 5/8-inch valve), and the pilot check Part No. WK-923066-000 (for both 1/2-inch and 5/8-inch valve) for the following conditions: nicks, voids, tool marks, bubbles, swelling, chips, grease, dirt, and foreign matter.
9. If any of these conditions exist, the checks should be replaced with new parts before the cylinder and valve assembly are refilled.
10. Assemble the valve in the following order:
    a. Pilot check assembly, Part No. WK-923066-000
    b. Brass sleeve, Part No. WK-202805-000
    c. Sleeve retainer, Part No. WK-202804-000
    d. Spring, Part No. WK-326410-000)
    e. Main check assembly, Part No. WK-932636-000 (for 1/2-inch valve) and Part No. WK-800760-000 (for 5/8-inch valve)
    f. Copper gasket, Part No. WK-326420-000
    g. Valve seat, Part No. WK-202490-000
11. Install valve into cylinder using Teflon tape on valve threads.

Note: The main check assembly is installed with rubber seat facing up.

Note: The copper sealing gasket <u>MUST</u> be replaced once the valve seat is removed.

Note: The tightening torque on the valve seat is 2200 in./lb.

12. Place CO_2 cylinder on weigh scale and secure to prevent movement of cylinder during recharge.
13. Install recharge adapter, Part No. WK-933537-000, to the valve control port.
14. Fill cylinder with required weight of CO_2.
15. After cylinder is full remove recharge adapter, ensure that all CO_2 fill valves are closed and check cylinder for leakage. Allow time for cylinder to return to room temperature before conducting the leak test. The areas that should closely be examined are the pilot port, the discharge port, the safety outlet and the valve to cylinder threads.

    If leakage is discovered at the pilot or discharge port:

    a. Empty the cylinder and valve assembly of CO_2.
    b. Replace the main check and the pilot check assemblies (if not already replaced from step 7).
    c. Repeat steps 8 through 12.

    If leakage is detected at the safety outlet, check torque on nut (350 in./lb. maximum).

    If leakage persists at safety outlet:

    a. Empty cylinder and valve assembly of CO_2.
    b. Remove safety outlet nut.
    c. Replace safety disc and washer (white disc Part No. 81-902048-000 for 1/2-inch valve, and red disc Part No. 81-903684-000 for 5/8-inch valve).
    d. Install safety outlet nut and tighten to maximum torque of 350 in./lb.
    e. Repeat steps 9 through 12.

Note: The Compressed Gas Association recommends that the safety disc and washer be replaced when the cylinder is hydrotested.

WARNING

The red safety disc is set to rupture at a higher pressure than the white disc. The red disc is designed for use on the 75 lb. and 100 lb. cylinders only. Use of the red disc on the 25, 35 or 50 lb. CO_2 cylinders will pose a safety hazard to personnel and property.

If leakage is discovered at the valve threads make sure the valve is tightened into cylinder.

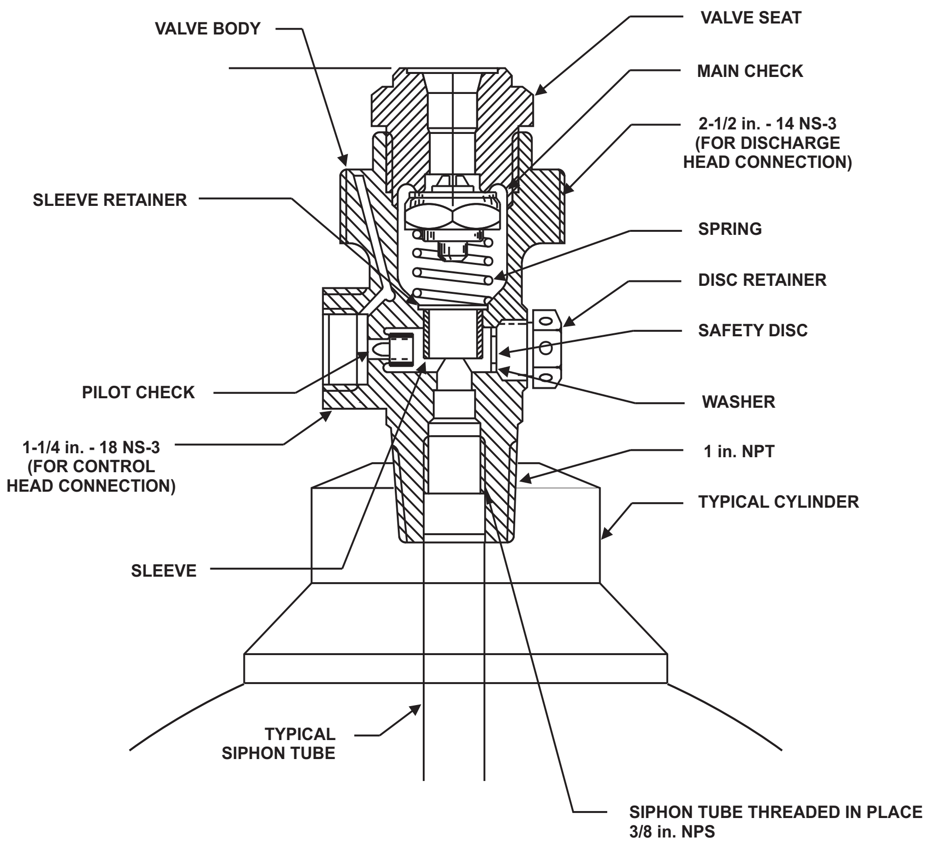
If leakage continues from the threads:

a. Empty cylinder and valve assembly of CO_2.
b. Remove valve.
c. Examine threads of valve and cylinder; if threads are damaged replace valve.
d. Clean threads of valve and cylinder and re-tape valve threads with Teflon tape.
e. Install valve into cylinder.
f. Repeat steps 9 through 12.

If any leaks persist, replacement of the valve is necessary.

7-3.2.1 CO_2 CYLINDER LEAK TEST

1. Leak test cylinder either by immersing in water using a bell jar over the valve to check for leaks. Water temperature should not exceed 100°F (38°C), or apply a soap solution to all pressure connection(s) and observe for bubble leaks.



MATERIALS

VALVE BODY:	BRASS
VALVE SEAT:	BRASS
SLEEVE:	BRASS
SLEEVE RETAINER:	BRASS
MAIN CHECK:	BRASS WITH RUBBER SEAT
PILOT CHECK:	STAINLESS STEEL WITH RUBBER SEAT

Figure 7-1. 1/2-inch Type “I” Cylinder Valve

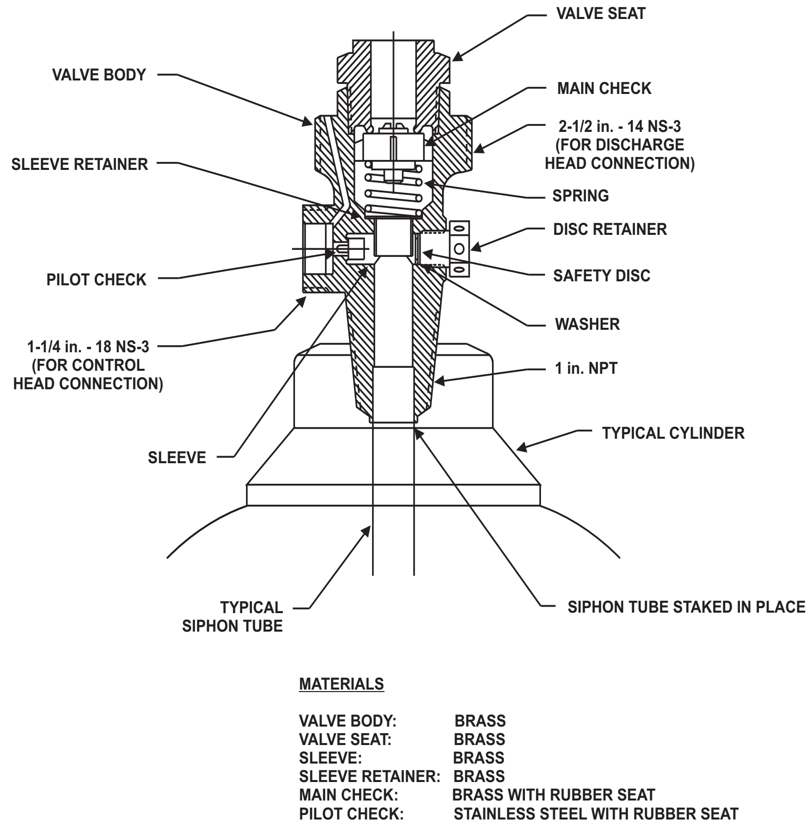


Figure 7-2. 5/8-inch Type “I” Cylinder Valve

7-4 NITROGEN PILOT CYLINDER, 108 CU. IN., SERVICE AND MAINTENANCE

WARNING

Any area in which nitrogen is used or stored must be properly ventilated. A person working in an area where air has become enriched with nitrogen can become unconscious without sensing the lack of oxygen. Remove the victim to fresh air. Administer artificial respiration if necessary and summon a physician. Never dispose of liquefied nitrogen in an indoor work or storage area.

7-4.1 Nitrogen Cylinder Replacement

WARNING

When removing a pressurized cylinder due to pressure loss, the control head must be in the SET position with the safety pull pin installed. A control head in the released position will cause the remaining contents of cylinder to discharge resulting in a system activation which may damage property and cause bodily injury.

Replace the nitrogen cylinder when expended or when loss of pressure occurs, as follows:

1. Remove the control head from the nitrogen cylinder valve.
2. Immediately install the protection cap on the nitrogen cylinder actuation port.
3. Remove the flexible actuation hose or tubing and adapter (P/N WK-699205-010) from the cylinder valve outlet.
4. Remove the clamps and hardware that secure the nitrogen cylinder to the mounting bracket.

7-4.2 Nitrogen Cylinder Recharge

Nitrogen cylinders must be recharged when the cylinder pressure gauge indicates pressure is below normal (1800 PSIG at 70°F [124 bar gauge at 21°C] or as adjusted for temperature) or immediately after discharge. Nitrogen used for charging must comply with Federal Specification BB-N-411C, Grade A, Type 1. Copies of this specification may be obtained from: Global Engineering Documents, 2625 S. Hickory St., Santa Ana, CA 92707.

WARNING

Before recharging, the cylinder must be firmly secured by chains, clamps or other devices to an immovable object such as a wall, structural I-beam or permanently mounted holding rack.

Recharge the nitrogen cylinders as follows:

1. Remove the protection cap from the cylinder valve actuation port.
2. Install the nitrogen cylinder recharge adapter (P/N WK-933537-000) to the cylinder valve actuation port and plug valve outlet port with 1/8" NPT pipe plug.
3. Connect the nitrogen recharging supply hose to the adapter. Tighten securely.
4. Open the nitrogen recharging control valve slowly until full nitrogen flow is obtained.
5. Monitor the recharging supply pressure gauge. Close the charging control valve when the gauge indicates the proper cylinder pressure (1800 PSIG at 70°F [124 bar gauge at 21°C]).
6. Allow the cylinder to cool to ambient temperature and recheck the nitrogen cylinder pressure.
7. Open the valve and add additional nitrogen as necessary to obtain a full cylinder charge at ambient temperature (1800 PSIG at 70°F [124 bar gauge at 21°C]).
8. Close the valve and remove the supply hose and charging adapter from the nitrogen cylinder.
9. Using a soap solution, thoroughly check the nitrogen cylinder valve for leakage. Bubbles in the soap solution indicate leakage and shall be cause for rejection of the cylinder.
10. At the completion of the leak test, thoroughly clean and dry the cylinder valve.
11. Ensure the cylinder valve control head port is clean and dry.
12. Immediately install the protective cap to the actuation port of the cylinder valve.
13. Install the charged cylinder as described below.

7-4.3 Nitrogen Cylinder Installation

1. Install the nitrogen cylinder in position in the mounting bracket.
2. Tighten sufficiently to hold cylinder in place while allowing cylinder enough free play to be manually rotated.
3. Turn the cylinder until the cylinder valve discharge outlet is in the desired position.

CAUTION

The nitrogen cylinder must be positioned so that the control head, when installed, is readily accessible and cannot be obstructed during manual operation.

4. Securely tighten the mounting bracket clamps and hardware.
5. Remove the pipe plug, reconnect the adapter (P/N WK-699205-010) and flexible actuation hose or tubing to the cylinder valve outlet port.
6. Remove the protective cap from the cylinder valve actuation port.

WARNING **Ensure the control head is in the SET position (that is, the actuating pin is in the fully retracted or SET position). Failure to do so will cause the nitrogen cylinder to discharge when the control head is installed.**

7. Install the control head to the cylinder valve and tighten securely.

7-5 HOSE REEL OR RACK SYSTEM

1. Reset the control head. Reinstall locking pin. Replace seal wire.
2. Verify the hose horn valve is in the OPEN position to relieve all pressure from the hose.
3. Close horn valve.
4. Inspect hose and horn valve for fire damage. Replace if damage is found.
5. Rewind hose on rack or reel. Place horn in clip with horn facing down.
6. If hose reel or rack system was operated using a cable pull station, replace broken pull station glass.
7. Remove empty cylinder(s). Reinstall charged cylinders as instructed in Paragraph 7-3.

CHAPTER 8
PARTS LIST

8-1 PARTS LIST

This chapter identifies the parts comprising the Kidde Fire Systems carbon dioxide fire suppression system. The information is grouped as follows:

- Cylinders and Associated Equipment (Table 8-1)
- Manual and Pressure Control Equipment (Table 8-2)
- Electric Control Equipment (Table 8-3)
- Remote Control Equipment, Cable (Table 8-4)
- Pneumatic Control Equipment (Table 8-5)
- Check Valves (Table 8-6)
- Directional (Stop) Valves (Table 8-7)
- Lockout Valves (Table 8-8)
- Hose Equipment (Table 8-9)
- Auxiliary Equipment (Table 8-10)
- Carbon Dioxide Computer Program (Table 8-11)
- Manuals (Table 8-12)
- Maintenance and Repair Parts (Table 8-13)
- Carbon Dioxide Nozzles (Table 8-14)
- Nozzle Identification (Table 8-15)
- Carbon Dioxide Nozzles, Accessories (Table 8-16)
- CO_2 Valves Maintenance, Repair and Spare Parts (Table 8-17)
- Cylinder Rack and Framing Components (Table 8-18)
- Framing Kits - One Row, 3 through 15 Cylinders (Table 8-19)
- Framing Kits - Two Rows (One Side), 5 through 17 Cylinders (Table 8-20)
- Framing Kits - Two Rows (One Side), 18 through 30 Cylinders (Table 8-21)

Table 8-1. Cylinders and Associated Equipment

Part No.	Description
81-870486-000	25 lb. (11.3 kg) Cylinder & Valve Assembly, Bent Siphon
81-982547-000	35 lb. (15.9 kg) Cylinder & Valve Assembly, Bent Siphon
81-982548-000	50 lb. (22.7 kg) Cylinder & Valve Assembly, Bent Siphon
81-870287-000	75 lb. (34.0 kg) Cylinder & Valve Assembly, Straight Siphon
81-870269-000	100 lb. (45.4 kg) Cylinder & Valve Assembly, Straight Siphon
81-872450-000	Discharge Head, Plain Nut
81-872442-000	Discharge Head, Grooved Nut
WK-251821-000	Flexible Hose, 3/4-inch Outlet
81-252184-000	Flexible Hose, 1/2-inch Outlet
81-207877-000	Manifold “Y” Fitting
WK-934208-000	Swivel Adapter, 1/2-inch NPT

Table 8-2. Manual and Pressure Control Equipment

Part No.	Description
WK-870652-000	Lever Operated Control Head
82-878751-000	Lever and Pressure Operated Control Head
82-878737-000	Pressure Operated Control Head
82-878750-000	Pressure Operated Control Head, Stackable
WK-264987-000	Actuation Hose, 22-inch
WK-699205-050	Male Branch Tee, 5/16-inch Flare x 1/8-inch NPT
WK-699205-030	Male Elbow, 5/16-inch Flare x 1/8-inch NPT
WK-699205-010	Male Connector, 5/16-inch Flare x 1/8-inch NPT
81-979469-000	Cable Operated Control Head
WK-331570-000	Cable Housing, 25 and 35 lb. Cylinders
WK-202355-000	Cable Housing, 50 and 75 lb. Cylinders
WK-200822-000	Cable Housing, 100 lb. Cylinders
WK-877940-000	Nitrogen Pilot Cylinder, 108 in.^{3} (1770 cc), no pressure switch
06-129773-001	Nitrogen Pilot Cylinder, 108 in.^{3} (1770 cc) With Supervisory Pressure Switch, Normally Open Under Pressure
06-129773-002	Nitrogen Pilot Cylinder, 108 in.^{3} (1770 cc) With Supervisory Pressure Switch, Normally Closed Under Pressure
81-87745-000	Mounting Bracket, Nitrogen Pilot Cylinder
WK-283888-000	Ball Valve, 1/4-inch, Marine

Table 8-3. Electric Control Equipment

Part No.	Description
WK-890181-000	Electric Control Head, 24 Vdc
81-895630-000	Electric and Cable Operated Control Head, 24 Vdc
WK-897494-000	Electric and Cable Operated Control Head, 24 Vdc (Ex. Proof)

Table 8-4. Remote Control Equipment, Cable

Part No.	Description
81-840098-000	Pull Box, Flush, 3/8-inch Pipe (Yacht Type)
81-871403-000	Pull Box, Surface 3/8-inch Pipe (Break Glass)
81-870087-000	Pull Box, Surface, 3/8-inch Pipe (Water Tight)
81-605320-000	Pull Box Bracket (81-871403-000)
81-803808-000	Corner Pulley, 3/8-inch Pipe (Water Tight)
WK-843837-000	Adapter, 1/2-inch EMT (F) x 3/8-inch Pipe (M)
WK-844648-000	Corner Pulley, 1/2-inch EMT
83-843791-000	Tee Pulley, 1/2-inch EMT
81-840058-000	Dual Pull Mechanism, 3/8-inch Pipe

Table 8-4. Remote Control Equipment, Cable (Continued)

81-840051-000	Dual Pull Equalizer, 3/8-inch Pipe (1/16-inch Cable Only)
06-118316-100	1/16-inch Cable 100 ft. Roll
WK-219649-000	1/16-inch Cable 500 ft. Roll

Table 8-5. Pneumatic Control Equipment

Part No.	Description
81-872318-000	Pneumatic Control Head, 1-inch 40 seconds
81-872335-000	Pneumatic Control Head, 3-inch 5 seconds
81-872365-000	Pneumatic Control Head, 6-inch 5 seconds
81-872362-000	Pneumatic Control Head, 6-inch 2 seconds
81-872310-000	Pneumatic Control Head, Tandem 1-inch
81-872330-000	Pneumatic Control Head, Tandem 3-inch
81-872360-000	Pneumatic Control Head, Tandem 6-inch
WK-840845-000	Pneumatic Heat Detector (1/8-inch Tubing, Industrial)
WK-841241-000	Pneumatic Heat Detector (3/16-inch Tubing, Marine)
WK-312720-000	Heat Collector, 16-inch x 16-inch (406 mm x 406 mm)
81-840044-000	Cable Housing, 25 and 35 lb. Cylinders
81-840398-000	Cable Housing, 50 and 75 lb. Cylinders
81-841739-000	Cable Housing, 100 lb. Cylinders
81-871364-000	Pneumatic Main-To-Reserve Valve
WK-207825-000	Rubber Grommet
WK-802366-000	Tubing, 3/16-inch x 17-inch (432 mm)
81-802367-000	Tubing, 3/16-inch x 46-inch (1168 mm)
WK-802486-000	Tubing, 3/16-inch x 12 feet (3.7 m)
WK-802555-000	Tubing, 1/8-inch x 50 feet (15.2 m)
WK-802556-000	Tubing, 1/8-inch x 100 feet (30.5 m)
WK-207809-000	Tubing, 1/8-inch x 250 feet (75.2 m)
WK-207648-000	Tubing Nut 1/8-inch
81-802537-000	Tee, 1/8-inch with Nuts
81-802535-000	Union, 1/8-inch with Nuts
81-802536-000	Union, 1/8-inch x 3/16-inch, with 1/8-inch Nut
WF-528103-000	Tubing Nut, 3/16-inch (Marine)
WK-528103-700	Tee, 3/16-inch without Nuts (Marine)
WK-528103-600	Union, 3/16-inch without Nuts (Marine)
WK-150530-000	Tubing Clip (Marine)
WK-802742-000	Vent, 2 Second
81-802743-000	Vent, 3 Second
WK-802745-000	Vent, 5 Second
WK-802746-000	Vent, 10 Second

Table 8-5. Pneumatic Control Equipment (Continued)

Part No.	Description
WK-200370-000	Vent Plug
WK-209145-000	Wrench, Vent Plug
WK-207875-000	Flaring Tool, 1/8-inch Tubing

Table 8-6. Check Valves

Part No.	Description
WK-264985-000	1/4-inch Check Valve
WK-261193-000	3/8-inch Check Valve
81-800327-000	1/2-inch Check Valve
81-800266-000	3/4-inch Check Valve
WK-800443-000	1-inch Check Valve
81-800444-000	1-1/4-inch Check Valve
81-870152-000	1-1/2-inch Check Valve
81-870151-000	2-inch Check Valve
81-870100-000	3-inch Flanged Check Valve, Less Flanges

Table 8-7. Directional (Stop) Valves

Part No.	Description
81-870023-000	1/2-inch Stop Valve
81-870022-000	3/4-inch Stop Valve
81-870122-000	1-inch Stop Valve
81-870032-000	1-1/4-inch Stop Valve
81-870123-000	1-1/2-inch Stop Valve
81-870049-000	2-inch Stop Valve
81-890010-000	3-inch Flanged Stop Valve, Less Flanges
81-890208-000	4-inch Flanged Stop Valve, Less Flanges
WK-263716-000	2-1/2-inch Flange (For Welding Pipe)
WK-681012-000	3-inch Flange (For Welding Pipe)
WK-200973-000	Gasket for 2-1/2-inch and 3-inch Flanges
WK-196648-720	Bolt, 3/4-inch x 4-1/2-inch Hex, for use with 2-1/2-inch and 3-inch Flanges
WK-152348-000	Nut, 3/4-inch Hex, for 2-1/2-inch and 3-inch Flanges
WK-681016-000	4-inch Flange (For Welding Pipe)
WK-200150-000	Gasket for 4-inch Flange
WK-196656-800	Bolt, 7/8-inch x 5-inch Hex, for use with 4-inch Flanges
WK-152356-000	Nut, 7/8-inch Hex, for 4-inch Flanges

Table 8-8. Lockout Valves

Part No.	Description
10611105	Lock-Out Valve, 1/4"
70985075	Lock-Out Valve, 1/2"
70985076	Lock-Out Valve, 3/4"
70985077	Lock-Out Valve, 1"
70985078	Lock-Out Valve, 1-1/4"
70985079	Lock-Out Valve, 1-1/2"
70985080	Lock-Out Valve, 2"
70985018	Lock-Out Valve, 1/4" (w/limit switch & Indicator)
70985020	Lock-Out Valve, 1/2" (w/limit switch & Indicator)
70985021	Lock-Out Valve, 3/4" (w/limit switch & Indicator)
70985022	Lock-Out Valve, 1" (w/limit switch & Indicator)
70985023	Lock-Out Valve, 1-1/4" (w/limit switch & Indicator)
70985024	Lock-Out Valve, 1-1/2" (w/limit switch & Indicator)
70985025	Lock-Out Valve, 2" (w/limit switch & Indicator)
70985090	Lock-Out Valve, 1/4" (w/XP&WP limit switch & Indicator)
70985069	Lock-Out Valve, 1/2" (w/XP&WP limit switch & Indicator)
70985070	Lock-Out Valve, 3/4" (w/XP&WP limit switch & Indicator)
70985071	Lock-Out Valve, 1" (w/XP&WP limit switch & Indicator)
70985072	Lock-Out Valve, 1-1/4" (w/XP&WP limit switch & Indicator)
70985073	Lock-Out Valve, 1-1/2" (w/XP&WP limit switch & Indicator)
70985074	Lock-Out Valve, 2" (w/XP&WP limit switch & Indicator)
10611104	SS Lock-Out Valve, 1/4"
10611100	SS Lock-Out Valve, 1/2"
10611101	SS Lock-Out Valve, 3/4"
10611099	SS Lock-Out Valve, 1"
10611102	SS Lock-Out Valve, 1-1/4"
10611098	SS Lock-Out Valve, 1-1/2"
10611103	SS Lock-Out Valve, 2"
10611106	SS Lock-Out Valve, 1/4" (w/limit switch & Indicator)
10611107	SS Lock-Out Valve, 1/2" (w/limit switch & Indicator)
10611108	SS Lock-Out Valve, 3/4" (w/limit switch & Indicator)
10611109	SS Lock-Out Valve, 1" (w/limit switch & Indicator)
10611110	SS Lock-Out Valve, 1-1/4" (w/limit switch & Indicator)
10611111	SS Lock-Out Valve, 1-1/2" (w/limit switch & Indicator)
10611112	SS Lock-Out Valve, 2" (w/limit switch & Indicator)
10611113	SS Lock-Out Valve, 1/4" (w/XP&WP limit switch & Indicator)
10611114	SS Lock-Out Valve, 1/2" (w/XP&WP limit switch & Indicator)
10611115	SS Lock-Out Valve, 3/4" (w/XP&WP limit switch & Indicator)

Table 8-8. Lockout Valves (Continued)

Part No.	Description
10611116	SS Lock-Out Valve, 1" (w/XP&WP limit switch & Indicator)
10611117	SS Lock-Out Valve, 1-1/4" (w/XP&WP limit switch & Indicator)
10611118	SS Lock-Out Valve, 1-1/2" (w/XP&WP limit switch & Indicator)
10611119	SS Lock-Out Valve, 2" (w/XP&WP limit switch & Indicator)
06-231867-379	CO_2 System Lockout Valve Operational Sign

Table 8-9. Hose Equipment

Part No.	Description
WK-994058-000	Reel - Standard Paint - Red Enamel
WK-909000-000	Coupling Nut, Hose Reel (Required for 994058)
81-919842-000	Rack
81-907757-000	Hose, 1/2-inch x 25 feet (7.5 m)
81-961966-000	Hose, 1/2-inch x 50 feet (15 m)
81-918990-000	Hose, 3/4-inch x 25 feet (7.5 m)
81-918435-000	Hose, 3/4-inch x 50 feet (15 m)
WK-834900-000	Hose to Hose Thread protector (Ferrule)
WK-980564-000	Horn/Valve Assembly
81-960099-000	Clip, Handle
81-939000-000	Clip Horn
WK-282386-000	Instruction Plate, Model HR-1
WK-405710-000	Instruction Manual

Table 8-10. Auxiliary Equipment

Part No.	Description
81-486536-000	Pressure Switch, 3 Pole Double Throw
81-981332-000	Pressure Switch, 3 Pole Single Throw (Ex. Proof)
81-874290-000	Pressure Trip
81-871071-000	CO2 Discharge Delay, 30 Second (Not FM Approved)
81-897636-000	CO2 Discharge Delay, 60 Second (Not FM Approved)
81-981574-000	CO2 Siren, Pressure Operated
81-871072-001	N2 Discharge Delay, 30 Second (For Use w/108-cuin N2 Cylinder Only)
81-871072-002	N2 Discharge Delay, 60 Second (For Use w/108-cuin N2 Cylinder Only)
90-101040-000	1040 cu. in. Nitrogen Cylinder (Pilot, Siren Driver)
90-102300-100	2300 cu. in. Nitrogen Siren Driver Cylinder
90-981574-001	N2 Siren, Pressure Operated (For Use with 108/1040/2300-cuin N2 Cylinders Only)
81-803242-000	Safety Outlet, 3/4-inch NPT 2400-2800 PSI (165-193 bars)
81-967082-000	Discharge Indicator, 3/4-inch NPT (Brass)

Table 8-10. Auxiliary Equipment (Continued)

Part No.	Description
WK-31033-000	Nameplate, "Main"
WK-310340-000	Nameplate, "Reserve"
WK-404070-000	Record Card
WK-281704-000	Operating Instructions Plate, without Stop Valve
WK-281705-000	Operating Instructions Plate, with Stop Valve
81-897600-000	Odorizer Assembly
06-231866-851	Vacate Warning Sign
06-231866-852	Do Not Enter Warning Sign
06-231866-853	Odorizer Warning Sign
06-231866-854	Migration Warning Sign
06-231866-855	Storage Warning Sign
06-231866-856	Actuation Warning Sign

Table 8-11. Carbon Dioxide Computer Program

Part No.	Description
81-190001-XXX	CO_2 Flow Calculation software with User's Manual & Hardware Key. Call for current Part Number and Version.

Table 8-12. Manuals

Part No.	Description
81-CO2MAN-001	Engineered Carbon Dioxide (CO_2) Fire Suppression Systems Design, Installation, Operation, and Maintenance Manual
81-220610-000	CO_2 Marine Design Manual
06-236177-001	CO_2 Carbon Dioxide Fire Suppression System Owner’s Manual

Table 8-13. Maintenance and Repair Parts

Part No.	Description
WK-32957-000	Gasket, Discharge Head (Perforated)
WF-242466-000	O-ring, Outer, Discharge Head
WF-242467-000	O-ring, Inner, Discharge Head
WF-152620-000	Seal Wire
WK-907042-000	Replacement Hammer, Clip & Chain, Pull Box 870087
WK-802394-000	Handle, Pull Box 871403
WK-200863-000	Breakable Cover, Pull Box 840098
WK-928103-000	Replacement Glass, Pull Box 871403
WK-313020-000	Replacement Glass, Pull Box 870087
WK-312950-000	Handle, Pull Box 870087
WK-312960-000	Latch, Pull Box 870087

Table 8-13. Maintenance and Repair Parts (Continued)

Part No.	Description
WK-318190-000	Groove-Pin, Pull Box 870087
WK-662890-000	Beam, Pull Box 870087
WK-933073-000	Protective Cap, Vented
WK-290001-000	Upper Body, Type L Nozzle
WK-290002-000	Lower Body, Type L Nozzle
81-982505-000	Weigh Scale
WK-933537-000	Recharge Adapter
81-930117-000	Blow off Fixture
WK-840041-000	Manometer Test Set

Table 8-14. Carbon Dioxide Nozzles

Part No.	Description
*	Multijet, Type S, 1/2-inch NPT
*	Multijet, Type S, Zinc plated, 1/2-inch NPT
*	Multijet, Type S, Flanged, 1/2-inch NPT
*	Multijet, Type M, 3/4-inch NPT
*	Vent, Type V, 1/2-inch NPT
*	Multijet, Type L, 1/2-inch NPT
* See Table 8-15 for part numbers.	

Table 8-15. Nozzle Identification

Size	S	S-Zinc	S-Flanged	M	V	V-Stainless	L
1	X	X	X	X	930066**	81098656	X
1+	X	X	X	X	930067	81098657	X
2	803381	803397	802990	X	919309	81098658	X
2+	803365	803881	802974	X	803327	81098659	X
3	803367	803882	802975	X	929242	81098660	842334
3+	803367	803883	802976	X	803328	81098661	842335
4	803368	803884	802977	842319	915876	81098662	842336
4+	803369	803885	802978	842320	803329	81098663	842337
5	803370	803886	802979	842321	214721	81098664	842338
5+	803371	803887	802980	842322	214722	81098665	842339
6	803372	803888	802981	842323	214723	81098666	842340
6+	803373	803889	802982	842324	214724	81098667	842341
7	803374	803890	802983	842325	214725	81098668	842342
7+	803375	803891	802984	X	214726	81098669	842343
8	803376	803892	802985	842326	214727	81098670	842344
8+	803877	803893	802986	X	214728	81098671	842345

Table 8-15. Nozzle Identification (Continued)

Size	S	S-Zinc	S-Flanged	M	V	V-Stainless	L
9	803378	803894	802987	842327	214729	81098672	842346
9+	803379	803895	802988	X	X	X	842347
10	803380	803896	802989	842328	X	X	X
11	X	X	X	842329	X	X	X
12	X	X	X	842330	X	X	X
13	X	X	X	842331	X	X	X
14	X	X	X	842332	X	X	X
15	X	X	X	842333	X	X	X

Table 8-16. Carbon Dioxide Nozzles, Accessories

Part No.	Description
81-803330-000	Flanged Mounting Kit, Type S Nozzle
WK-310020-000	Aluminum Disc for Flanged Type S Nozzle
81-220299-000	Stainless Steel Disc for Flanged Type S Nozzle
WK-201004-000	Disc Gasket for Flanged Type S Nozzle
81-844492-000	Flange and Cover Assembly, Type V Nozzle
WK-260884-000	Washer, for the Type V Nozzle
WK-260885-000	Disc, for the Type V Nozzle

Table 8-17. CO_2 Valves Maintenance, Repair and Spare Parts

WK-981372-000	1/2-inch "I" Valve, 25, 35 & 50 lb. Cylinders
WK-840253-000	5/8-inch "I" Valve, 75 & 100 lb. Cylinders
81-902048-000	Safety Disc (White) and Washer, 25, 35 & 50 lb. Cylinders
81-903684-000	Safety Disc (Red) and Washer, 75 & 100 lb. Cylinders
WK-295500-000	Nut - Safety Disc
WK-923066-000	Pilot Check
WK-932636-000	Main Check, 1/2-inch "I" Valve
WK-800760-000	Main Check, 5/8-inch "I" Valve
WK-326420-000	Gasket
WK-326410-000	Spring
WK-202805-000	Sleeve
WK-202804-000	Retainer, Sleeve
WK-202490-000	Valve Seat
WK-203874-000	Siphon Tube, 25 lb. Cylinder
WK-346050-000	Siphon Tube, 35 lb. Cylinder
WK-346060-000	Siphon Tube, 50 lb. Cylinder
WK-202497-000	Siphon Tube, 75 lb. Cylinder

Table 8-17. CO_2 Valves Maintenance, Repair and Spare Parts (Continued)

WK-202332-000	Siphon Tube, 100 lb. Cylinder

Table 8-18. Cylinder Rack and Framing Components

Part No.	Description
25 AND 35 lb. CYLINDER FRAMING	
WK-270014-000	25 and 35 lb. Cylinder Strap
50 AND 75 lb. CYLINDER FRAMING	
WK-241217-000	Post
WK-241211-000	Gusset
WK-207281-000	Channel Support
WK-241213-000	3 Cylinder Channel
WK-241214-000	4 Cylinder Channel
WK-241215-000	5 Cylinder Channel
WK-241216-000	6 Cylinder Channel
WK-241103-000	Cradle
WK-207282-000	Rack Rod, 1 Row
WK-241105-000	Front Clamp
WK-242441-000	Rack Rod, 2 Row
81-270582-000	Spacer
81-242442-000	Spacer Clip
WK-241104-000	End Clamp
81-241212-000	Odd Cylinder End Clamp
81-241218-000	Weigh Bar Bracket, 1 Row
81-241220-000	Weigh Bar Bracket, 2 Row
81-207283-000	3 Cylinder Weigh Bar
WK-207284-000	4 Cylinder Weigh Bar
81-207285-000	5 Cylinder Weigh Bar
WK-207286-000	6 Cylinder Weigh Bar
WK-270014-000	1 Cylinder Strap, 50 lb.
81-626690-000	1 Cylinder Strap, 75 lb.
WK-241219-000	2 Cylinder Strap, 50 & 75 lb.
100 lb. CYLINDER FRAMING	
WK-271566-000	Post
WK-241211-000	Gusset
WK-207281-000	Channel Support
WK-271563-000	3 Cylinder Channel
WK-271564-000	4 Cylinder Channel
WK-271565-000	5 Cylinder Channel

Table 8-18. Cylinder Rack and Framing Components (Continued)

Part No.	Description
WK-271561-000	Cradle
WK-243795-000	Rack Rod, 1 Row
WK-241105-000	Front Clamp
WK-243799-000	Rack Rod, 2 Row
81-290385-000	Spacer
WK-242442-000	Spacer Clip
WK-271562-000	End Clamp
WK-271567-000	Weigh Bar Bracket, 1 Row
WK-271568-000	Weigh Bar Bracket, 2 Row
WK-243796-000	3 Cylinder Weigh Bar
WK-243797-000	4 Cylinder Weigh Bar
WK-243798-000	5 Cylinder Weigh Bar
WK-270157-000	1 Cylinder Strap, 100 lb.
WK-241254-000	2 Cylinder Strap, 100 lb.
100 lb. CYLINDER RACK AND FRAMING KITS	
ONE ROW	
81-010001-003	3 Cylinders
81-010001-004	4 Cylinders
81-010001-005	5 Cylinders
81-010001-006	6 Cylinders
81-010001-007	7 Cylinders
81-010001-008	8 Cylinders
81-010001-009	9 Cylinders
81-010001-010	10 Cylinders
81-010001-011	11 Cylinders
81-010001-012	12 Cylinders
81-010001-013	13 Cylinders
81-010001-014	14 Cylinders
81-010001-015	15 Cylinders
TWO ROW ONE SIDE	
81-010021-005	5 Cylinders
81-010021-006	6 Cylinders
81-010021-007	7 Cylinders
81-010021-008	8 Cylinders
81-010021-009	9 Cylinders
81-010021-010	10 Cylinders
81-010021-011	11 Cylinders
81-010021-012	12 Cylinders

Table 8-18. Cylinder Rack and Framing Components (Continued)

Part No.	Description
81-010021-013	13 Cylinders
81-010021-014	14 Cylinders
81-010021-015	15 Cylinders
81-010021-016	16 Cylinders
81-010021-017	17 Cylinders
81-010021-018	18 Cylinders
81-010021-019	19 Cylinders
81-010021-020	20 Cylinders
81-010021-021	21 Cylinders
81-010021-022	22 Cylinders
81-010021-023	23 Cylinders
81-010021-024	24 Cylinders
81-010021-025	25 Cylinders
81-010021-026	26 Cylinders
81-010021-027	27 Cylinders
81-010021-028	28 Cylinders
81-010021-029	29 Cylinders
81-010021-030	30 Cylinders

Table 8-19. Framing Kits - One Row, 3 through 15 Cylinders

Number of Cylinders		3	4	5	6	7	8	9	10	11	12	13	14	15
Kit Number 81-010001-XXX		**-003**	**-004**	**-005**	**-006**	**-007**	**-008**	**-009**	**-010**	**-011**	**-012**	**-013**	**-014**	**-015**
Part No.	**Description**	**Quantity Supplied in Kit**												
WK-271566-000	Post	2	2	2	3	3	3	3	3	4	4	4	4	4
WK-241211-000	Gusset	2	2	2	2	2	2	2	2	2	2	2	2	2
WK-207281-000	Channel Support	2	2	2	5	5	5	5	5	7	7	7	7	7
WK-271563-000	3 Cylinder Channel	1	—	—	2	1	—	—	—	1	—	—	—	—
WK-271564-000	4 Cylinder Channel	—	1	—	—	1	2	1	—	2	3	2	1	—
WK-271565-000	5 Cylinder Channel	—	—	1	—	—	—	1	2	—	—	1	2	3
WK-271561-000	CRADLE	3	4	5	6	7	8	9	10	11	12	13	14	15
WK-271567-000	1 Row Weigh Bar Bracket	2	2	2	3	3	3	3	3	4	4	4	4	4
WK-243796-000	3 Cylinder Weigh Bar	1	—	—	2	1	—	—	—	1	—	—	—	—
WK-243797-000	4 Cylinder Weigh Bar	—	1	—	—	1	2	1	—	2	3	2	1	—
WK-243798-000	5 Cylinder Weigh Bar	—	—	1	—	—	—	1	2	—	—	1	2	3
WK-241105-000	Front Clamp	2	2	3	3	4	4	5	5	6	6	7	7	8
WK-243795-000	Rack Rod 1 Row	2	2	3	3	4	4	5	5	6	6	7	7	8
ADDITIONAL PARTS TO ORDER FOR MAIN & RESERVE - NOT INCLUDED IN KITS														
WK-241105-000	Front Clamp	—	2	—	4	—	4	—	6	—	6	—	8	—
WK-243795-000	Rack Rod 1 Row	—	2	—	4	—	4	—	6	—	6	—	8	—
HARDWARE - NOT SUPPLIED BY KIDDE FIRE SYSTEMS														
—	3/8-inch - 16 x 1-inch Long Bolt	16	16	16	26	26	26	26	26	36	36	36	36	36
—	3/8-inch -16 Nut	16	16	16	26	26	26	26	26	36	36	36	36	36
Main	1/2-inch -13 x 1-inch Long Bolt	2	3	3	4	4	5	5	6	6	7	7	8	8
M & R	1/2-inch -13 x 1-inch Long Bolt	—	3	—	3	—	5	—	5	—	7	—	7	—
Main	1/2-inch -13 Nut	8	9	12	13	16	17	20	21	24	25	28	29	32
M & R	1/2-inch -13 Nut	—	9	—	15	—	17	—	23	—	25	—	31	—
—	1/2-inch Washer	2	2	2	2	2	2	2	2	2	2	2	2	2
Note: No hardware listed for fastening framing to floor or wall.														

Table 8-20. Framing Kits - Two Rows (One Side), 5 through 17 Cylinders

Number of Cylinders		**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Kit Number 81-010021-XXX		**-005**	**-006**	**-007**	**-008**	**-009**	**-010**	**-011**	**-012**	**-013**	**-014**	**-015**	**-016**	**-017**
Part No.	**Description**	**Quantity Supplied in Kit**												
WK-271566-000	Post	2	2	2	2	2	2	3	3	3	3	3	3	3
WK-241211-000	Gusset	2	2	2	2	2	2	2	2	2	2	2	2	2
WK-207281-000	Channel Support	2	2	2	2	2	2	5	5	5	5	5	5	5
WK-271563-000	3 Cylinder Channel	1	1	—	—	—	—	2	2	1	1	—	—	—
WK-271564-000	4 Cylinder Channel	—	—	1	1	—	—	—	—	1	1	2	2	1
WK-271565-000	5 Cylinder Channel	—	—	—	—	1	1	—	—	—	—	—	—	1
WK-271561-000	Cradle	3	3	4	4	5	5	6	6	7	7	8	8	9
WK-241105-000	Front Clamp	1	2	2	3	3	4	4	5	5	6	6	7	7
WK-271562-000	End Clamp	3	2	3	2	3	2	3	2	3	2	3	2	3
WK-243795-000	Rack Rod 1 Row	1	—	1	—	1	—	1	—	1	—	1	—	1
WK-243799-000	Rack Rod 2 Rows	3	4	4	5	5	6	6	7	7	8	8	9	9
WK-271568-000	2 Row Weigh Bar Bracket	2	2	2	2	2	2	3	3	3	3	3	3	3
WK-243796-000	3 Cylinder Weigh Bar	2	2	—	—	—	—	4	4	2	2	—	—	—
WK-243797-000	4 Cylinder Weigh Bar	—	—	2	2	—	—	—	—	2	2	4	4	2
WK-243798-000	5 Cylinder Weigh Bar	—	—	—	—	2	2	—	—	—	—	—	—	2
WK-290385-000	Cylinder Spacer	2	3	3	4	4	5	5	6	6	7	7	8	8
ADDITIONAL PARTS TO ORDER FOR MAIN & RESERVE - NOT INCLUDED IN KITS														
81-242442-000	Spacer Clip	—	2	—	3	—	4	—	5	—	6	—	7	—
HARDWARE - NOT SUPPLIED BY KIDDE FIRE SYSTEMS														
—	3/8-inch - 16 x 1-inch Long Bolt	18	18	18	18	18	18	30	30	30	30	30	30	30
—	3/8-inch -16 Nut	18	18	18	18	18	18	30	30	30	30	30	30	30
MAIN	1/2-inch -13 Nut	12	12	15	15	18	18	21	21	24	24	27	27	30
M & R	1/2-inch -13 Nut	—	14	—	18	—	22	—	26	—	30	—	34	—
—	1/2-inch Washer	2	2	2	2	2	2	2	2	2	2	2	2	2
Note: No hardware listed for fastening framing to floor or wall.														

Table 8-21. Framing Kits - Two Rows (One Side), 18 through 30 Cylinders

Number of Cylinders		18	19	20	21	22	23	24	25	26	27	28	29	30
Kit Number 81-010021-XXX		**-018**	**-019**	**-020**	**-021**	**-022**	**-023**	**-024**	**-025**	**-026**	**-027**	**-028**	**-029**	**-030**
Part No.	**Description**	**Quantity Supplied in Kit**												
WK-271566-000	Post	3	3	3	4	4	4	4	4	4	4	4	4	4
WK-241211-000	Gusset	2	2	2	2	2	2	2	2	2	2	2	2	2
WK-207281-000	Channel Support	5	5	5	8	8	8	8	8	8	8	8	8	8
WK-271563-000	3 Cylinder Channel	—	—	—	1	1	1	1	1	1	—	—	—	—
WK-271564-000	4 Cylinder Channel	1	—	—	2	2	1	1	—	—	1	1	—	—
WK-271565-000	5 Cylinder Channel	1	2	2	—	—	1	1	2	2	2	2	3	3
WK-271561-000	Cradle	9	10	10	11	11	12	12	13	13	14	14	15	15
WK-241105-000	Front Clamp	8	8	9	9	10	10	11	11	12	12	13	13	14
WK-271562-000	End Clamp	2	3	2	3	2	3	2	3	2	3	2	3	2
WK-243795-000	Rack Rod 1 Row	—	1	—	1	—	1	—	1	—	1	—	1	—
WK-243799-000	Rack Rod 2 Rows	10	10	11	11	12	12	13	13	14	14	15	15	16
WK-271568-000	2 Row Weigh Bar Bracket	3	3	3	4	4	4	4	4	4	4	4	4	4
WK-243796-000	3 Cylinder Weigh Bar	—	—	—	2	2	2	2	2	2	—	—	—	—
WK-243797-000	4 Cylinder Weigh Bar	2	—	—	4	4	2	2	—	—	2	2	—	—
WK-243798-000	5 Cylinder Weigh Bar	2	4	4	—	—	2	2	4	4	4	4	6	6
WK-290385-000	Cylinder Spacer	9	9	10	10	11	11	12	12	13	13	14	14	15
ADDITIONAL PARTS TO ORDER FOR MAIN & RESERVE - NOT INCLUDED IN KITS														
81-242442-000	Spacer Clip	8	—	9	—	10	—	11	—	12	—	13	—	14
HARDWARE - NOT SUPPLIED BY KIDDE FIRE SYSTEMS														
—	3/8-inch - 16 x 1-inch Long Bolt	30	30	30	42	42	42	42	42	42	42	42	42	42
—	3/8-inch -16 Nut	30	30	30	42	42	42	42	42	42	42	42	42	42
MAIN	1/2-inch -13 Nut	30	33	33	36	36	39	39	42	42	45	45	48	48
M & R	1/2-inch -13 Nut	38	—	42	—	46	—	50	—	54	—	58	—	62
—	1/2-inch Washer	2	2	2	2	2	2	2	2	2	2	2	2	2
Note: No hardware listed for fastening framing to floor or wall.														

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APPENDIX A
FORMULA DERIVATIONS

A-1 THEORETICAL CO_2 EXTINGUISHING CONCENTRATION FOR A TOTAL FLOODING SYSTEM

If maximum residual oxygen values are known, the theoretical carbon dioxide extinguishing concentration can be calculated from the following formula.

Equation A.1

$$\%CO_2 = \frac{(21 - O_2)}{21} \times 100$$

Where: O_2 = maximum residual oxygen

Diffusion flame fires in most flammable liquids will be extinguished if the oxygen concentration in the atmosphere is reduced to 15 percent. The theoretical carbon dioxide extinguishing concentration for most flammable liquids can then be calculated from Equation A.1

$$\%CO_2 = \frac{(21 - 15)}{21} \times 100 = 28.6\%$$

A safety factor of 20 percent is then added for fire extinguishing systems. This yields the following design concentration for most carbon dioxide extinguishing systems.

$$\%CO_2 = 28.6\% \times 1.2 = 34.3\%$$

Therefore, a minimum carbon dioxide concentration of 34 percent by volume is required for all total-flooding fire extinguishing systems.

The most complete list of theoretical carbon-dioxide extinguishing concentrations and the suggested minimum design concentration are contained in Table 3-1.

A-2 QUANTITY OF CO_2 REQUIRED FOR A TOTAL FLOODING SYSTEM UNDER A FREE EFFLUX FLOODING CONDITION

The formula for calculating the quantity of carbon dioxide required to achieve a given extinguishing concentration under free efflux flooding conditions is.

Equation A.2

$$W = \frac{V}{S}\ln(1/1 - C)$$

Where:

W = weight of carbon dioxide, lb.
V = enclosure volume, ft.^{3}
S = specific volume of superheated carbon dioxide vapor; 9 ft.^{3}/lb.
C = design concentration
$\ln$ = natural logarithm

The equation assumes instantaneous mixing of the discharged carbon dioxide with the enclosure atmosphere.

Example

Determine the weight of carbon dioxide per unit enclosure volume required to create a 34% concentration.

From Equation A.2

$$\frac{W}{V} = \frac{1}{S}\ln[1/(1-C)] = \frac{1}{9}\ln[1/(1-.34)] = (0.111)(0.4155) = 0.0461 \text{ lb./ft.}^3$$

Equation A.2 represents the idealized situation where the amount of carbon dioxide lost upon discharge through openings or vents is only the amount necessary to displace the required atmosphere while maintaining a constant pressure in the enclosure. In general, such a situation exists only in the limit of very large volumes.

A-3 DERIVATION OF THE MATERIAL CONVERSION FACTOR (MCF)

Equation A.3

$$MCF = \frac{\ln(1-C2)}{\ln(1-C1)}$$

Where:

MCF = material conversion factor

$C2$ = higher design concentration

$C1$ = reference design concentration, 0.34

$\ln$ = natural logarithm

Example

A chemical storage room is known to contain Butadiene. Determine the material conversion factor for carbon dioxide protection.

The recommended minimum design concentration for Butadiene is 41% (from Table 3-1). Using Equation A.3:

$$MCF = \frac{\ln(1-.41)}{\ln(1-C1.34)} = \frac{-0.527}{-0.415} = 1.27$$

A-4 RATE OF CARBON DIOXIDE LOSS THROUGH AN OPENING IN AN ENCLOSURE

The following equation can be used to calculate the rate of carbon dioxide loss through an opening in an enclosure, assuming the conditions in the previous paragraph are true:

Equation A.4

$$R = 60CpA\sqrt{\frac{2g(p_1-p_2)h}{p_1}}$$

Where:

R = Rate of CO_2 in lbs./min.

	C	= CO_2 concentration fraction
p		= Density of CO_2 vapor in lbs./ft.^{3}
A		= Area of opening in ft.^{2} (flow coefficient included)
g		= Gravitational constant, 32.2 ft./sec.^{2}
p_1		= Density of atmosphere in lbs./ft.^{3}
p_2		= Density of surrounding air in lbs./ft.^{3}
h		= Static head between opening and top of enclosure in ft.

Example

Determine the loss rate through a 1 foot by 1 foot opening in an enclosure. The midpoint of the opening is 5 feet below the ceiling, and the system is designed to achieve a 34 percent concentration.

A number of factors must be calculated prior to applying Equation A.4

The density of air at 70°F is 0.075 lb./ft.^{3}

The density of carbon dioxide vapor at 70°F can be calculated from its molecular weight (44) and the molecular weight of air (29)

0.075 lb./ft.^{3} X (44/29) = 0.114 lb./ft.^{3}

The density of a carbon dioxide/air mixture containing 34 percent by volume of carbon dioxide is:

0.114 lb./ft.^{3} X 0.34 + 0.075 lb./ft.^{3} X 0.66 = 0.089 lb./ft.^{3}

The effective area of the opening can be reduced by a factor of 2 since there are no known openings above this opening. The opening area for calculation purposes is thus:

1ft. X 1ft./2 = 0.5 ft.^{2}

The carbon dioxide loss rate through the opening is:

$$R = (60)(0.34)(0.114)(0.\dot{5})\frac{(2)(32.2)(0.089-0.075)(5)''''}{0.089} = (1.16)(7.11)$$

$$R = 8.2 \text{ lb./min.}$$

A-5 DISCHARGE RATES FOR DEEP SEATED FIRES

The discharge rate required to satisfy the two minute constraint in the preceding paragraph can be obtained. From Equation A.2, the quantity of carbon dioxide per cubic foot required to create a 30 percent concentration is:

Equation A.5

$$\frac{W}{V} = \frac{1}{9}\ln\frac{(1)}{1-0.3} = 0.0396 \text{ lb./ft.}^3$$

An 8% safety factor is usually applied to the quantity calculated in Equation A.5, and thus the required flooding factor to create a 30 percent concentration is:

$$\frac{W}{V} = (1.08)(0.0396 \text{ lb./ft.}^3) = 0.0428 \text{ lb./ft.}^3$$

The quantity (per cubic foot) calculated in Equation A.5 must be delivered within two minutes, so the system discharge rate is obtained by dividing this quantity by 2. Thus the discharge rate required to attain a 30 percent carbon dioxide concentration within two minutes is:

Equation A.6

$$R = 0.0428 \text{ lb./ft.}^3/2 \text{ minutes} = 0.0214 \text{ lb./ft.}^3\text{min}$$

The rate calculated in A.6 must be checked to ensure that it is high enough to attain the design concentration is seven minutes. In general, the seven minute constraint will be satisfied if the rate calculated in Equation A.6 is high enough to discharge at least 28.6 percent (2/7) of the required quantity of carbon dioxide in the first two minutes. The maximum carbon dioxide concentration that can be attained in seven minutes by a total flooding system discharging at the rate calculated in Equation A.6 can be calculated by the following formula.

Equation A.7

$$\frac{\ln(1 - C_1)}{\ln(1 - C_2)} = 0.286$$

Where:

C_1 = minimum concentration at two minutes, 0.30

C_2 = maximum concentration at seven minutes

$\ln$ = natural logarithm

Solving Equation A.7 for C_2

Equation A.8

$$C_2 = 1 = EXP(\ln(1 - C_1)/(0.286))$$

Where:

EXP = exponential function

C_2 = 1 - EXP (ln (1-0.3)/(0.286) = 1 - 0.287 = 0.713 or 71.3%

Thus the discharge rate calculated in Equation A.6 will be adequate to attain all design concentration less than 71.3 percent within seven minutes after the start of carbon dioxide discharge. This rate will be insufficient to attain design concentrations in excess of 71.3 percent within seven minutes, and thus the required discharge rates for these systems shall be calculated by dividing the required quantity of carbon dioxide by seven minutes.

APPENDIX B
OBSOLETE EQUIPMENT

B-1 INTRODUCTION

This appendix contains information concerning equipment and components that were previously provided as part of the system or as an option for the system but are no longer available for procurement.

B-2 OBSOLETE EQUIPMENT

The obsolete items contained in this appendix are:

- Mercury Check
- Pneumatic Transmitter
- Pneumatic Control Head, 1-inch, 40-second
- Pneumatic Main-to-Reserve Valve
- Lockout Valves
- Odorizer, 1.5" NPT Housing and Glass Cartridge

B-3 MERCURY CHECK

B-3.1 Description

The mercury check, Part No. 871346 (Figure B-1 and Figure B-2) is used for pneumatic systems having more than five heat actuated detectors, or for applications where it is necessary to isolate HADs subject to varying environmental and/or process conditions.

The mercury check can accept a detection signal from up to three separate detector branch lines. It consists of three detection chambers manifolded together to a common outlet port, and three interconnected wells filled with mercury. Each detection chamber is individually vented by an appropriately-sized vent, and the level of the mercury can be adjusted to provide the degree of sensitivity required for each tubing branch line and its associated HADs. The mercury isolates the detection chambers from each other and its level above the manifold outlet determines the pressure setting of the system in inches of water column.

Refer to Paragraph 2-3.6.4 for detailed vent information.

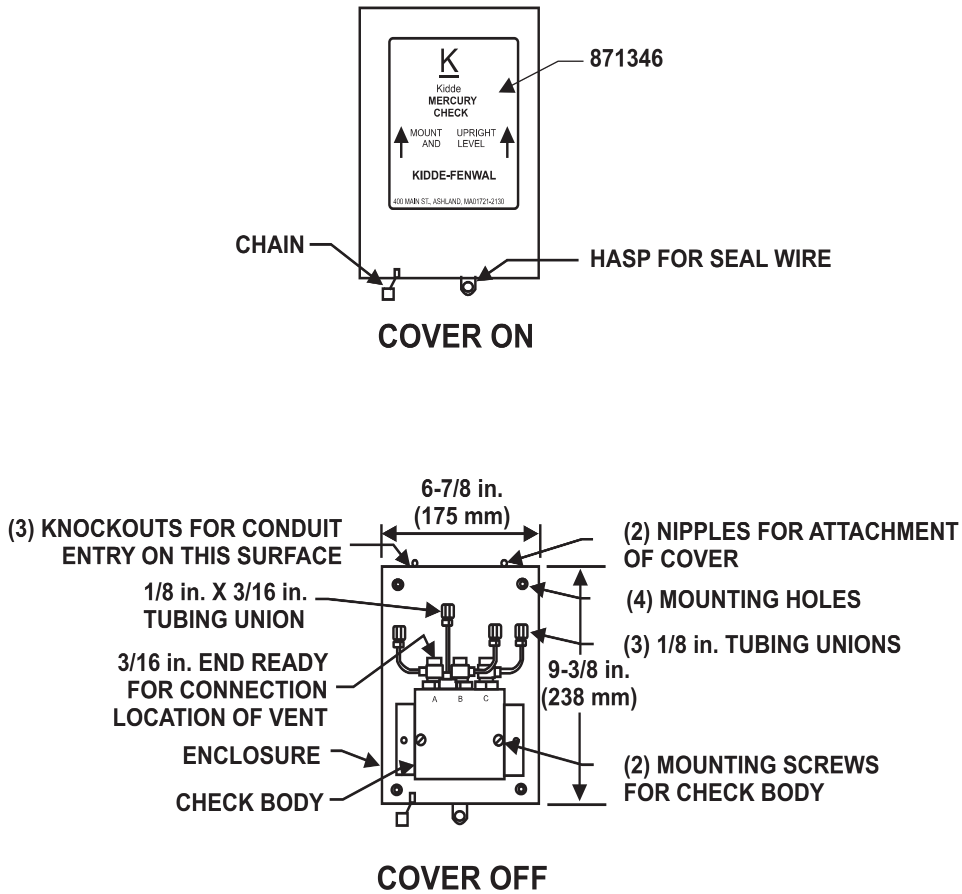

Figure B-1. 3-Well Mercury Check

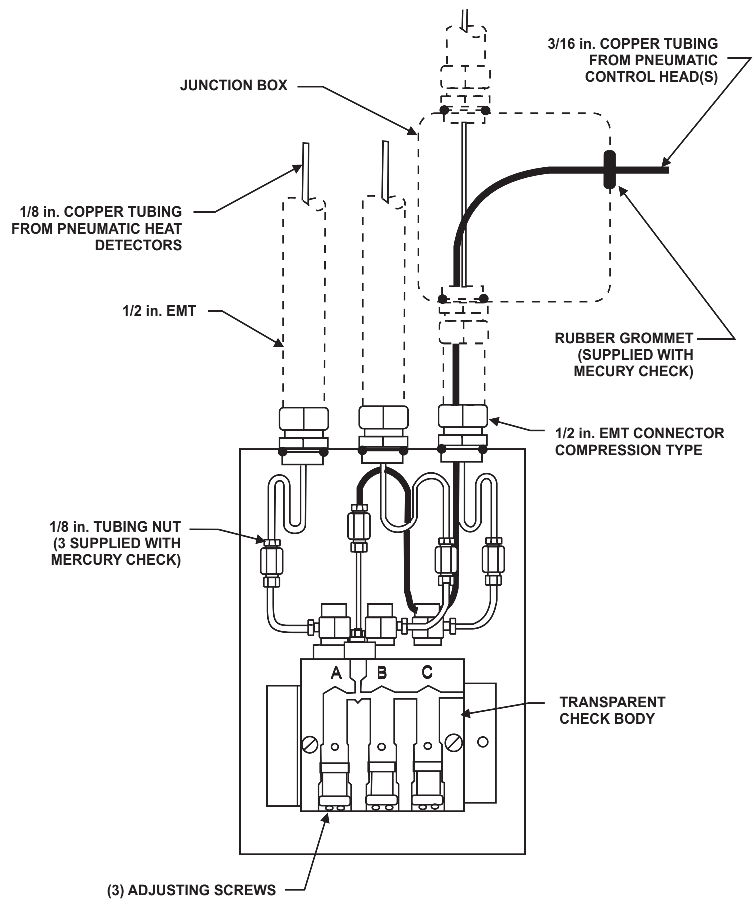

Figure B-2. 3-Well Mercury Check - Installation Detail

B-3.2 Installation

The mercury check is required for applications that use more than five HAD detectors.

The installation procedure for the mercury check is as follows:

1. Remove seal wire.
2. Remove the cover from the enclosure.
3. Route tubing from the pneumatic detectors into the mercury check box. Secure box to the installation area using suitable attaching hardware. Ensure that the box is upright and level.
4. Secure conduits to the box using conduit nuts.
5. Route the 3/16-inch tubing from the pneumatic control head through a grommet into the mercury check box.
6. Fill mercury wells as follows:
7. The proper vent size and well setting is predetermined for each installation and can be found on the layout drawing supplied with each system installation.
8. Unscrew two mounting screws and remove the transparent plastic body from the box.
9. Remove plastic caps from vent ports. Insert funnel Part No. 207635 (supplied), and slowly fill each well with the full contents of a single vial of mercury. Make certain no mercury enters tubing.

WARNING **Wear rubber gloves when filling mercury wells. Flush gloves with water and wash hands thoroughly after filling procedure has been completed. Avoid touching hands to mouth or eyes. Contact a physician immediately if irritation develops.**

1. Remove funnel. Make certain the flat rubber gasket is in place at bottom of the vent port. Install vent plug assembly. Tighten securely with Kidde Fire Systems tool Part No. 209145 while holding hex of vent housing with a wrench.
2. Keep mercury check upright at all times to prevent mercury from spilling out of wells.
3. Sequentially connect a manometer test set, Part No. 840041, to each well inlet using the conversion coupling supplied with the test set to make connection. Close off tube “B” (noted on manometer instructions) and gently squeeze the rubber bulb until a slight pulsing is felt in the bulb. This can be visually observed as a dropping off of the reading, followed by a steady reading as continued pressure is applied to the rubber bulb of manometer. The sum of the readings of both legs of the manometer is the setting of the well under test. The setting is obtained by turning the adjustment screw under each well in either and upward or downward position. Turing the screw upward increases the setting; turning the screw downward decreases the setting. Repeat this adjustment for each additional well.
4. Attach the 1/8-inch tubing to a check union, as applicable, and secure in place using a tubing nut.
5. Upon completion of the adjustments and assembly of the tubing to the unions, close the box cover and assemble the seal wire. Crimp the lead seal with pliers or a crimping tool.

B-4 PNEUMATIC TRANSMITTER

B-4.1 Description

The pneumatic transmitter, Part No. 890176 (Figure B-3), is an intermediary actuation device used for pneumatic systems that employ directional (stop) valves. It is always used in conjunction with a pneumatic control head. The function of the pneumatic transmitter is to engage the pilot check on the directional (stop) valve and to retransmit the pneumatic actuation signal to the pilot cylinders controlling the discharge of the suppression system.

The pneumatic transmitter consists of a metal body to which a bellows housing is attached. The body contains an actuator rod to engage the pilot check of a directional (or stop) valve and a spring loaded bellows assembly located in the attached housing. The associated pneumatic control head mounts to the pilot port on the body. Activation of the control head displaces the actuator rod to open the pilot check on the directional valve and to release the spring loaded bellows assembly. The compressed air is transmitted via copper tubing to the pilot CO_2 cylinders controlling the actuation of the suppression system. The pneumatic transmitter is connected to the system's 1/8-inch copper tubing network via a short segment of 3/16-inch tubing and has a normally open micro switch contact that closes upon actuation. A visual indicator shows when the transmitter is in its set position. The pneumatic transmitter requires manual reset after actuation.

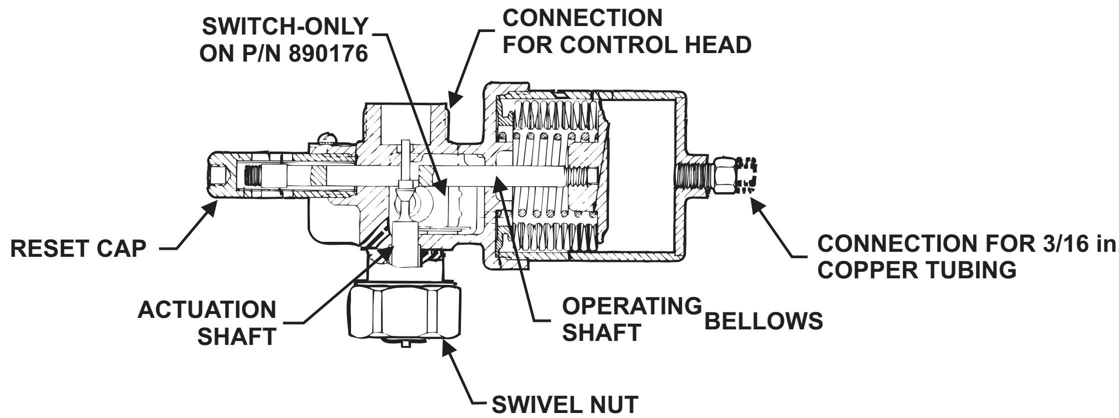

Figure B-3. Pneumatic Transmitter

B-4.2 Installation

WARNING

Pneumatic transmitter must be in the "Set" position (green indicator visible through slots in cap) before installing on the stop valve. Pneumatic transmitter left in the "Actuated" position will allow inadvertent discharge of carbon dioxide into the hazard if the CO_2 cylinders are actuated.

1. Refer to Figure B-3 and remove protection cap from pilot control port of the stop valve.
2. Position pneumatic transmitter on stop valve pilot control port.
3. Run 3/16-inch copper tubing from the pneumatic transmitter to a junction box located adjacent to the transmitter.
4. Using reducing union Part No. 81-802536-000, connect the 3/16-inch O.D. tubing to the 1/8-inch tubing going to the pneumatic control heads on the pilot cylinders.
5. Make electrical connections.

Note: When the pneumatic transmitter is installed on main and reserve systems and the reserve system has not been previously discharged, reset the pneumatic transmitter on the directional (stop) valve.

WARNING

Do not test or actuate the pneumatic transmitter with the pneumatic control heads attached to the pilot CO_2 cylinders. Actuation of the pneumatic transmitter will cause the control heads to operate and result in CO_2 system discharge.

B-5 PNEUMATIC CONTROL HEAD (1-inch, 40-SECOND)

B-5.1 Description

The 1-inch, 40-second control head P/N 872318, is never connected directly to a HAD, only indirectly through an intervening device such as a mercury check or a pneumatic transmitter. The combination of diaphragm and vent settings for the pneumatic control head is shown in Table B-1.

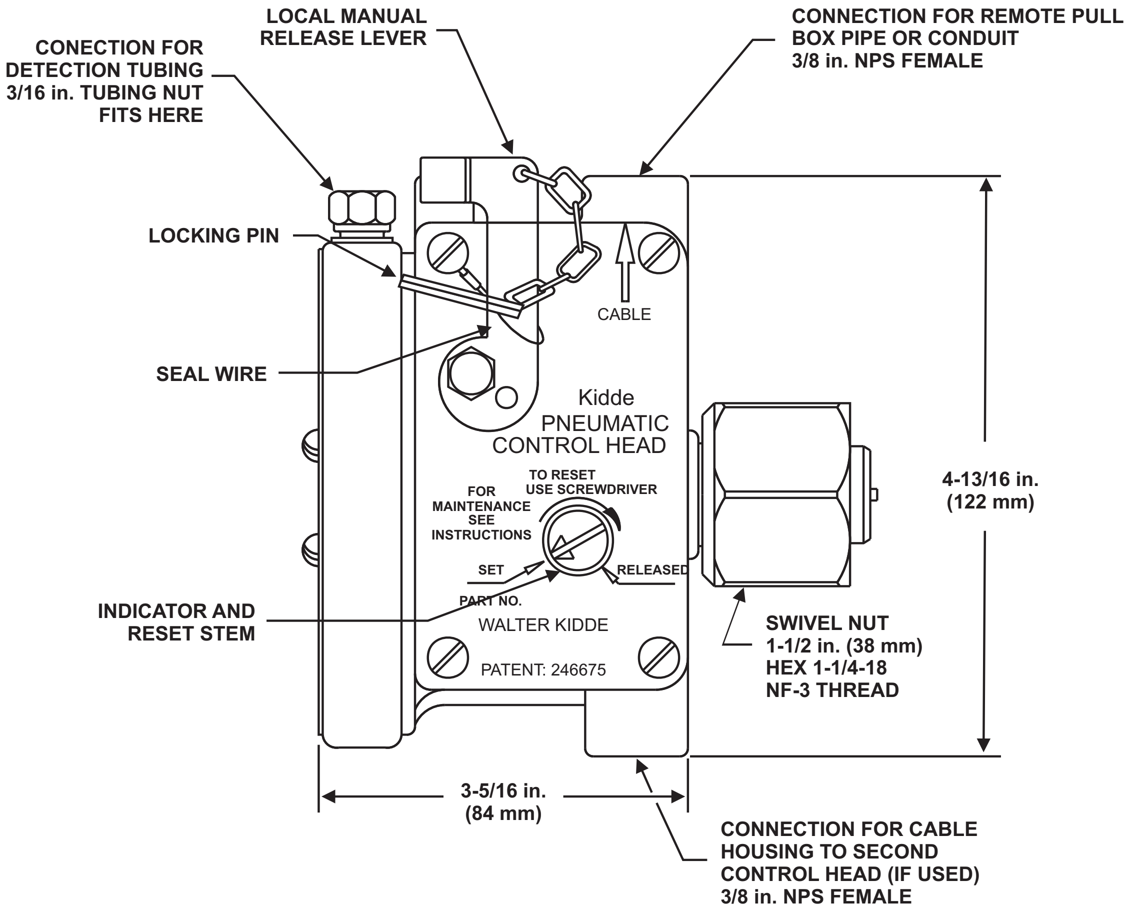

Figure B-4. Pneumatic Control Head (1-inch, 40-second)

Table B-1. Pneumatic Control Head (1-inch, 40-second), Settings

Setting	Control Head Part Number
1-inch, 40-second vent	872318

B-5.2 Installation

Refer to Paragraph 4-4.10 for installation instructions.

B-6 PNEUMATIC MAIN-TO-RESERVE VALVE

The pneumatic main-to-reserve transfer valve, Part No. 871364 (Figure B-5), is installed in pneumatically-actuated systems having a connected main and reserve supply of carbon dioxide, and is used to direct the pneumatic actuation signal to either the main or the reserve pilot cylinders.

The valve contains an inlet port which is connected to two outlet ports. A toggle switch controls a lever that transfers the pneumatic signal to one of the two outlet ports while blocking its passage to the other. The toggle switch is normally placed in the "main" position. In the event that the main suppression system discharges, the switch is placed in the "reserve" position to provide uninterrupted fire protection while the main system is being recharged.

CAUTION **Never move the main-to-reserve transfer valve to the "reserve" position, following a main suppression system actuation, unless the activating detector(s) has/have cooled down.**

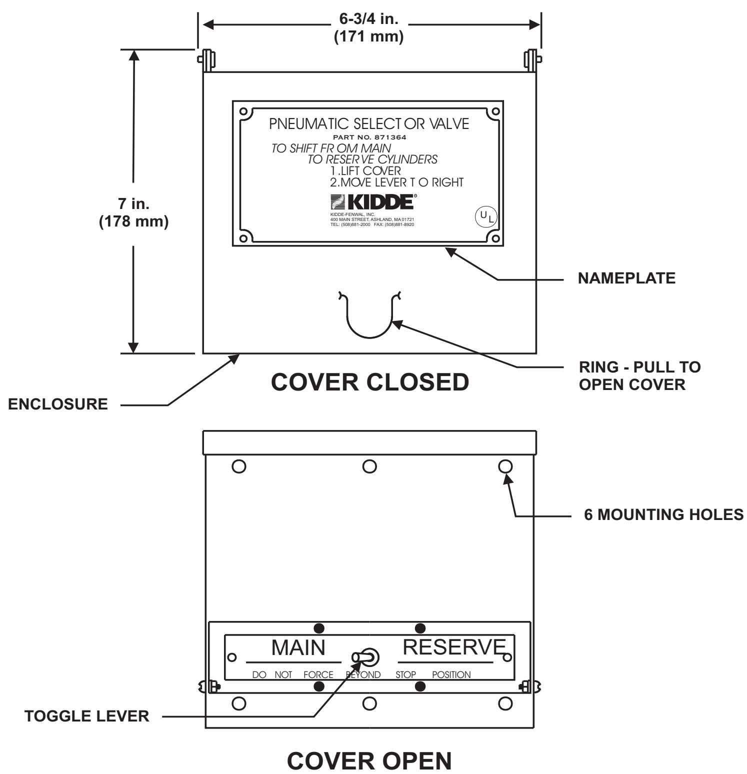

Figure B-5. Pneumatic Main-to-Reserve Valve

B-7 LOCKOUT VALVES

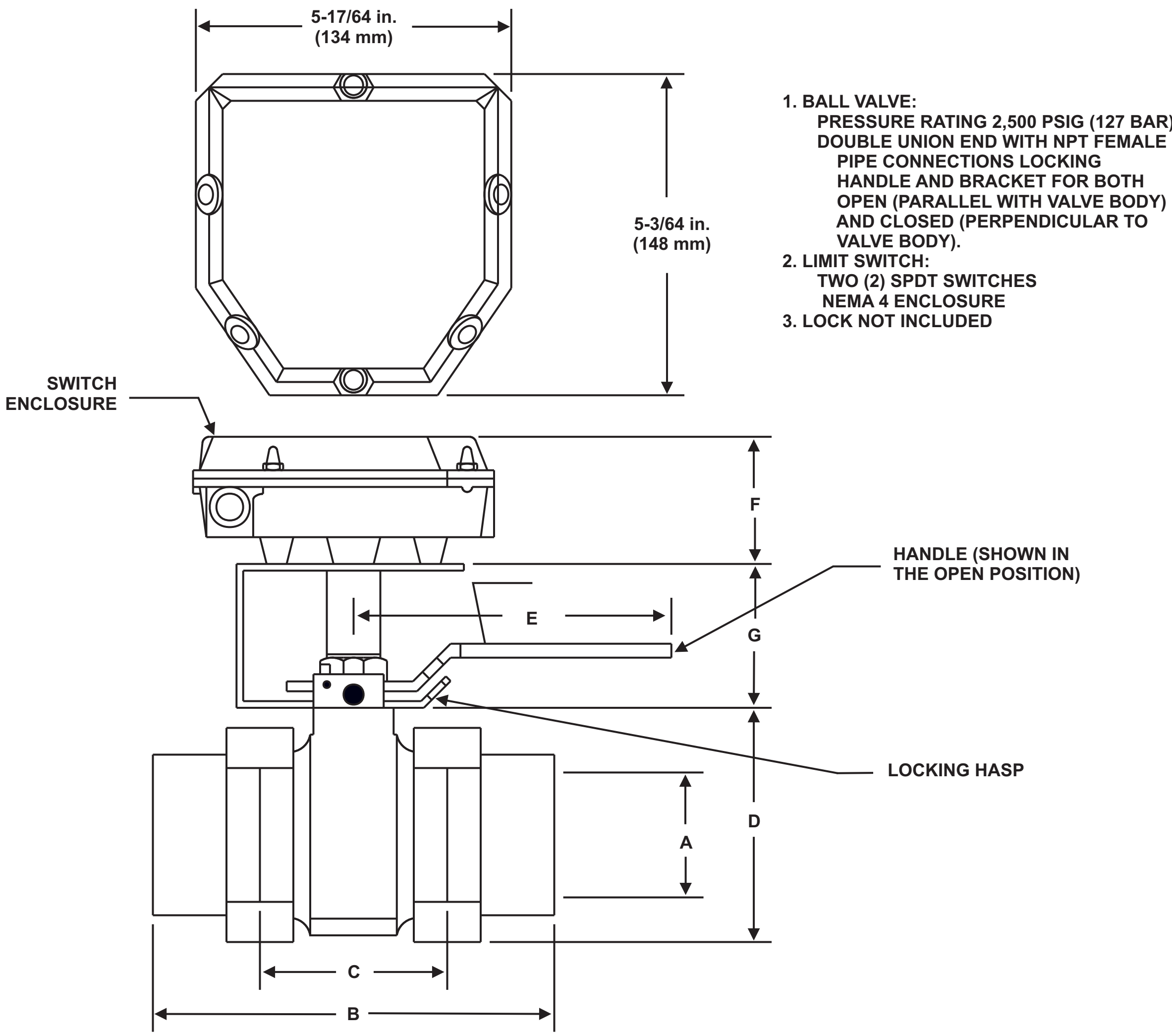

Figure B-6. CO_2 Lockout Valve with Limit Switch

A lockout valve is a manually operated valve installed between the carbon dioxide manifold and the discharge pipe to the protected area. The lockout valve can be locked in the closed position to prevent carbon dioxide from discharging into the protected area. The lockout valve shall be installed at the end of the carbon dioxide manifold or, if a common manifold protects multiple hazards, after each directional (stop) valve.

The lockout valve consists of a stainless steel ball valve with union ends. The ball valve has a 2,500 PSIG pressure rating. A NEMA4 enclosure, housing two SPDT limit switches with a 15A rating, sits atop the valve. Limit Switch No.2 shall be wired in series with the electric control head in the releasing circuit. Limit Switch No.1 may be wired to provide positive indication that the valve is fully closed.

Table B-2 lists the lockout valve with limit switch specifications.

Note: The CO_2 Lockout Valve is not a UL listed item.

Table B-2. CO_2 Lockout Valve with Limit Switch Specifications

	General Dimensions							
Assembly Part Number	**Size**	**A**	**B**	**C**	**D**	**E**	**F**	**G**
81-934711-000	1/2 in. (DN15)	21/32 in. (17 mm)	3-15/19 in. (100 mm)	1-15/16 in. (49 mm)	2-1/4 in. (57 mm)	5-1/2 in. (140 mm)	2-51/64 in. (71 mm)	2-1/2 in. (64 mm)
81-934712-000	3/4 in. (DN20)	13/16 in. (21 mm)	4-1/2 in. (114 mm)	2-3/16 in. (56 mm)	2-39/64 in. (66 mm)	5-1/2 in. (140 mm)	2-51/64 in. (71 mm)	2-1/2 in. (64 mm)
81-934713-000	1 in. (DN25)	1 in. (25 mm)	4-15/16 in. (125 mm)	2-3/8 in. (60 mm)	2-63/64 in. (76 mm)	6-1/2 in. (165 mm)	2-51/64 in. (71 mm)	2-1/2 in. (64 mm)
81-934714-000	1-1/2 in. (DN40)	1-7/16 in. (37 mm)	5-7/8 in. (149 mm)	2-3/4 in. (70 mm)	3-7/8 in. (98 mm)	8-1/2 in. (216 mm)	2-51/64 in. (71 mm)	2-3/4 in. (70 mm)
81-934715-000	2 in. (DN50)	1-23/32 in. (44 mm)	6-7/8 in. (175 mm)	3-3/8 in. (86 mm)	4-1/2 in. (114 mm)	8-1/2 in. (216 mm)	2-51/64 in. (71 mm)	2-3/4 in. (70 mm)

B-7.1 Lockout Valve Installation

The construction of the two-way union end ball valve product design helps make installation and maintenance easy. This product has the "free floating" ball principle. The ball is not fixed and is free to align under line pressure. The resulting benefit from this feature of the valve design is a tight shut-off with the flow in either direction, regardless of the position of the valve in the pipeline. In order to facilitate maintenance, the assembly consists of a union on each side of the valve body.

The lockout valve with limit switch must be installed in the discharge pipe network, downstream of all cylinders, check valves, and directional/stop valves. Lockout valves can be installed in either the vertical or horizontal position using good pipe fitting practices. Place two to three wraps of Teflon tape on male threads of pipe. Attach lockout valve unions to pipe, but do not fully tighten at this time. Rotate the valve body into position, then tighten both unions.

1. Use Teflon tape or paste on male threads.
2. Can be installed vertically and horizontally.
3. Should be locked in the "open" position using a padlock.
4. Must be located downstream of ALL cylinders and should be easily accessible.
5. Must be electrically supervised.

B-7.1.1 STEM SEAL ADJUSTMENT

If leakage is evident in the stem packing area, tighten the adjusting nut (the nut beneath the handle) 1/8 turn. If the leak persists, repeat the above.

Note: The switches and the corresponding cams are preset by the valve assembly supplier to the configurations indicated below. No adjustment to the cams is required. When the cam is engaged with the switch, the switch contacts are closed, thus closing the normally open contacts. Terminals 1 through 6 are used with the microswitches. Terminals 7 and 8 are for optional equipment not part of this assembly.

- Switch 1 can also be wired to provide positive (LED, strobe, bell etc.) indication that the valve is fully closed.
- Switch 2 must always be wired in series with the electric control head in the releasing circuit.

Note: The limit switch assembly consists of two (2) single pole, double throw (SPDT) mechanical switches, which are rated to 15 amps.

B-7.1.2 WIRING DIAGRAM

1. With the ball valve in the fully open position (normal operating mode).

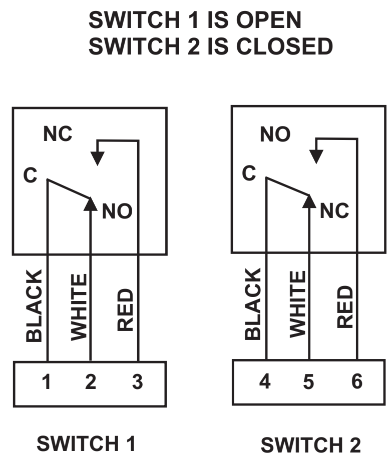

Figure B-7. Switch When Ball Valve is in Fully Open Position

2. With the ball valve in the fully closed position (service/maintenance mode).

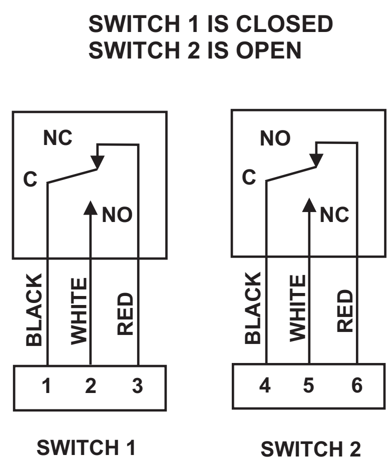

Figure B-8. Switch When Ball Valve is in Fully Closed Position

B-7.2 Lockout Valves Maintenance

When it is necessary to perform maintenance on the CO_2 system or need to perform work that could cause false alarms and discharge, it is essential to lockout the CO_2 system. The following steps must be observed.

1. Unlock the valve and place it in the Closed position.
2. Lock the valve.
3. Verify that a Trouble indicator appears on the control unit.
4. When maintenance or test is complete, unlock the valve and place it in the Open position.
5. Lock the valve.
6. Verify the Trouble indicator is clear on the control unit.

B-8 ODORIZER, 1.5" NPT HOUSING AND GLASS CARTRIDGE

The odorizer assembly injects a scent into the carbon dioxide during a discharge to warn personnel in the vicinity of the area protected by the fire suppression system that carbon dioxide gas is present. The odorizer assembly consists of a protective housing and the odorizer cartridge. This odorizer assembly was replaced by P/N 81-897600-000.

B-8.1 Odorizer Protective Housing

The protective housing, Part No. 81-897637-000 (Figure B-9), safely and securely attaches the odorizer cartridge to the manifold. The stainless steel housing protects the odorizer cartridge from inadvertent rupture.

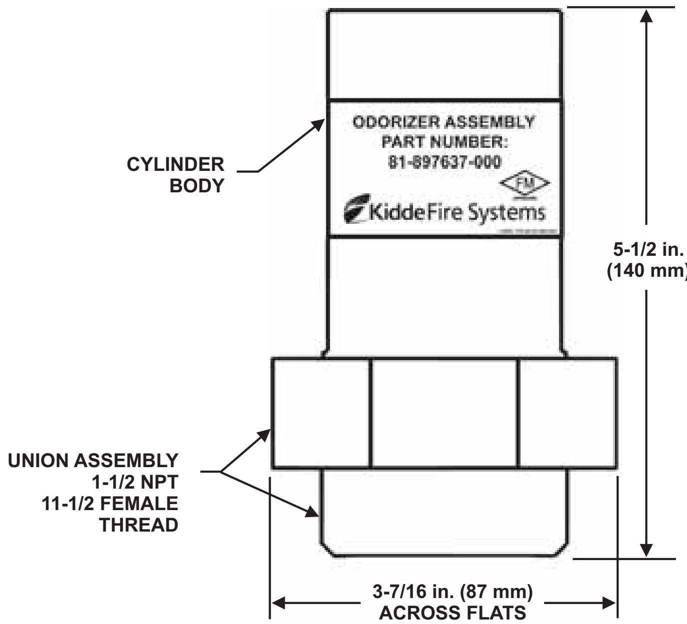

Figure B-9. Odorizer Protective Housing

B-8.2 Odorizer Cartridge

The odorizer cartridge, Part No. 10030080 (Figure B-10), is a 50cc glass vial filled with oil of wintergreen, which provides the scent to the carbon dioxide. Upon discharge, the carbon dioxide pressure ruptures the vial against the protective housing to release the oil of wintergreen.

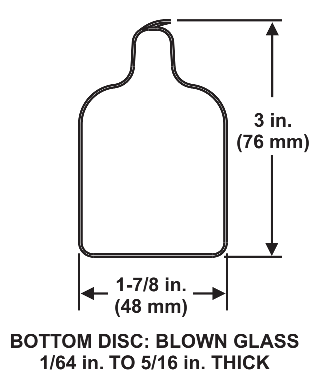

Figure B-10. Odorizer Cartridge

B-8.3 Odorizer Installation

When used, odorizers should be located immediately downstream of each selector valve. For systems protecting a single hazard, a single odorizer can be located immediately downstream of the discharge manifold.

Note: An odorizer assembly, Part Nos. 81-897637-000 and 10030080, shall be installed upstream of the lock-out valve. In the event a safety outlet ruptures in a locked-out system, the scent from the odorizer will provide a warning that carbon dioxide has vented into the area by the safety outlet.

Odorizers must be attached to the discharge piping in the upright position using a 1-1/2 inch standard galvanized close nipple. When a welded connection is required, use a 1-1/2 inch standard pipe, 1-3/4 inches long, threaded on one end. Install odorizer assembly after welding.

1. Attach the odorizer assembly to the piping.
2. Remove the union nut and cylinder body from the odorizer assembly, leaving just the union headpiece attached to the piping.
3. Use a small pick or slotted screwdriver to remove the spiral retaining ring and the circular screen.
4. **Carefully** insert the odorizing cartridge into the cylinder body. This is most easily done by holding the cylinder body on its side. The narrow tip end of the odorizing cartridge should go into the cylinder body first. **DO NOT** drop the odorizing cartridge into the cylinder body, as this will most likely break the odorizing cartridge.
5. Replace the screen and secure with the spiral retaining ring. Make sure the o-ring is still in its groove before placing the cylinder body back onto the union head piece. A small amount of o-ring lubricant can be used to help keep the o-ring in place.
6. Thread the union nut back onto the odorizer assembly and tighten the assembly.

CAUTION

To prevent damaging the odorizing cartridge during testing, it is recommended that the odorizing cartridges not be installed until after system testing of the discharge piping is complete. For periodic maintenance after the system has been installed and in use, remove the odorizing cartridge prior to any testing of the discharge piping.

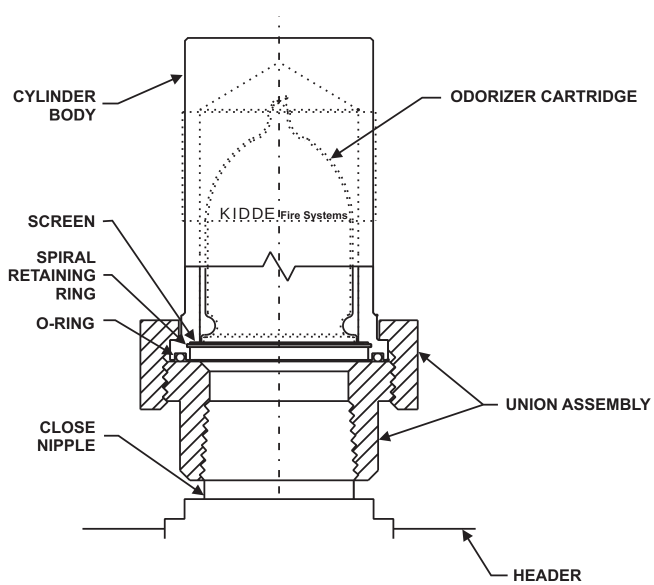

Figure B-11. Odorizer Installation

B-8.4 Semi-annual Maintenance for Odorizer Cartridge

For systems using the odorizer cartridge, Part No. 10030080, disassemble the odorizer and verify that the odorizing cartridge is still intact on a semi-annual basis.

B-8.5 Post Discharge Odorizer Maintenance

1. Remove the union nut and cylinder body from the odorizer assembly, leaving just the union headpiece attached to the piping.
2. Use a small pick or slotted screwdriver to remove the spiral retaining ring and the circular screen. Remove all glass particles.
3. **Carefully** insert the odorizing cartridge into the cylinder body. This is most easily done by holding the cylinder body on its side. The narrow tip end of the odorizing cartridge should go into the cylinder body first. **DO NOT** drop the odorizing cartridge into the cylinder body, as this will most likely break the odorizing cartridge.
4. Replace the screen and secure with the spiral retaining ring. Make sure the o-ring is still in its groove before placing the cylinder body back onto the union head piece. A small amount of o-ring lubricant can be used to help keep the o-ring in place.
5. Thread the union nut back onto the odorizer assembly and tighten the assembly.

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APPENDIX C
EUROPEAN EQUIPMENT

C-1 INTRODUCTION

Kidde Fire Systems CO_2 equipment sold into the European Union must comply with Pressure Equipment Directive (PED) 97/23/EC and Transportable Pressure Equipment Directive (TPED) 1999/36/EC. Refer to Table C-1 for a list of equipment.

Equipment, such as discharge heads, flex hoses, check valves, etc., that will be exposed to pressure during a discharge shall be PED approved. PED approval is indicated by the CE mark affixed to these components.

Equipment, such as cylinders and discharge valves, that retain pressure while during transport, shall be TPED approved. TPED approval is indicated by the PI mark affixed to these components.

Table C-1. TPED and PED Approved Equipment for European Community Only*

Part No.	Description
81-870287-002	75 lb. CO_2 Cylinder and Valve Assembly- "Pi" marked and CE approved
81-870269-002	100 lb. CO_2 Cylinder and Valve Assembly - "Pi" marked and CE approved
WK-981372-002	1/2-inch I-Valve - TPED Approved
WK-840253-002	5/8-inch I-Valve - TPED Approved
81-897494-001	Electric/Cable Control Head, 24 VDC **ATEX/CE** (NOT UL/FM)
81-100000-001	Explosion Proof Electric Control Head, Stackable, 24 VDC, **ATEX** Approved
*** Component Equipment Only**	

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APPENDIX D
EQUIVALENT LENGTH

D-1 VALVE AND DELAY EQUIVALENT LENGTH

The following table provides equivalent length information:

Part Name	Part No.	Nominal Pipe Size, in.	Equivalent Length, ft	
			Sched 40	Sched 80
Directional (Stop) Valve	81-870023-000	1/2	11	-
	81-870022-000	3/4	17	-
	81-870122-000	1	21	13
	81-870032-000	1 1/4	52	35
	81-870123-000	1 1/2	34	24
	81-870049-000	2	76	55
	81-890010-000 w/ WK-236716-000	2 1/2	69	50
	81-890010-000	3	216	159
	81-890208-000	4	206	157
Check Valve	81-800327-000	1/2	7	4
	81-800266-000	3/4	17	10
	WK-800443-000	1	12	8
	81-800444-000	1 1/4	51	34
	81-870152-000	1 1/2	-	40
	81-870151-000	2	-	120
	81-870100-000	3	-	600
CO2 Discharge Delay	81-871071-000 or 81-897636-000	3/4	15	-
Cylinder Valve Assembly. For 25, 35, 50 lb (5, 7, 9, 11, 16, 23 kg) sizes. Includes dip tube, valve, discharge head 872450 or 872442 and flexible hose.				
		1/2	73	37
Cylinder Valve Assembly. For 50, 75, 100 lb (23, 34, 45 kg) sizes. Includes dip tube, valve 840253, head 872450 or 872442 and flexible hose.				
		3/4	31	16

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