P/N 06-237459-001
October 2015

Kidde Fire Systems® Nitrogen Engineered Systems

Design, Installation, Operation and Maintenance Manual

Kidde Fire Systems

FOREWORD

Kidde Fire Systems reserves the right to revise and improve its products as it deems necessary without notification. This publication is intended to describe the state of this product at the time of its publication, and may not reflect the product at all times in the future.

This technical manual provides information regarding the design, installation, operation and maintenance of a Kidde Nitrogen Engineered System. This is a single volume technical manual.

IMPORTANT: Kidde Nitrogen Systems are to be designed, installed, maintained, and tested by qualified, trained personnel, in accordance with the following standards or regulations:

- Instructions and limitations of this manual
- NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems
- NFPA 70, National Electrical Code
- NFPA 72, National Fire Alarm Code
- Storage, handling, transportation, service, and maintenance of cylinder assemblies shall only be by personnel trained in the proper procedures in accordance with Compressed Gas Association (CGA), pamphlets C-1, C-6, G-6, and P-1.
  CGA pamphlets are published by the Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, VA 22202.

Any questions concerning the information presented in this manual should be addressed to the Burr Ridge Office:

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SAFETY SUMMARY

Safety precautions are essential whenever electrical or mechanical equipment is involved. Take precautions when handling, servicing, and charging Nitrogen fire suppression systems cylinders. Using this equipment with the respect and caution demanded will considerably lessen the possibility of personal injury. If safety precautions are overlooked or ignored, personal injury or property damage may occur. The following symbols are used throughout this manual. Always heed these precautions. They are essential to the safe use of the equipment described in this manual.

WARNING The warning symbol identifies immediate hazards and provides specific instructions or procedures which if not correctly followed will result in severe personal injury or death.

CAUTION This caution symbol identifies specific instructions or procedures which if not correctly followed could result in minor personal injury or equipment or property damage.

MATERIAL SAFETY DATA SHEETS

Hard copies of the Material Safety Data Sheets (MSDS) are included with this manual. In addition, the latest version of the MSDS can be found online at the Kidde Fire Systems website (http://www.kidde-fenwal.com). Use the built-in navigation links to view the desired sheet.

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CHAPTER 1
INTRODUCTION

1-1 GENERAL

This technical manual provides the necessary information for the design, installation and maintenance of a Kidde Nitrogen Gas Extinguishing System. The content should enable the reader to understand the operation of a Nitrogen Gas Extinguishing System for Industrial and Offshore applications.

It has been assumed in the preparation of the various sections of this manual that execution of its provisions is entrusted to people appropriately qualified in the specification, design, installation, operation and maintenance of Nitrogen systems and the associated equipment. In addition, this manual does not eliminate the need for system design by trained engineers/ designers nor the use of competent engineering judgement.

The manual does not cover detection and control systems, which are to be designed and installed in accordance with national codes and local requirements.

It is important that the fire protection of a building or plant be considered as a whole. Gaseous extinguishing systems form only a part, though an important part, of the available facilities. It should not be assumed that using a gaseous agent system necessarily removes the need to consider supplementary measures, such as automatic fire detection, the provision of fire extinguishers, other mobile appliances for first aid or emergency use, or to deal with special hazards.

For many years, gaseous extinguishants have been recognized as an effective medium for extinguishing ordinary Class A fires, flammable liquid Class B fires, and electrical Class C fires. However, in the planning of comprehensive hazard protection, it should not be forgotten that there may be hazards for which these agents are not suitable, or that in certain circumstances or situations there may be danger in their use requiring special precautions.

Care should always be taken to thoroughly evaluate and correct any factors that could result in unwanted discharges. It is essential that fire extinguishing equipment be carefully maintained to ensure instant readiness when required and that the owner be given detailed instruction regarding the operation of the systems installed in his building/plant.

1-2 INTRODUCTION

The interest in inert gas blends continues to increase due to the phase out of Halon systems in accordance with the Montreal Protocol and the growing interest in meeting the intent of the Kyoto Protocol.

Kidde's Nitrogen fire extinguishing system utilizes pure Nitrogen. Nitrogen is a naturally occurring substance and present in the atmosphere, and as such, has no ozone depletion potential and no direct global warming risk.

There are no toxicological factors associated with the use of Nitrogen and Nitrogen will not decompose or produce any byproducts when exposed to a flame from a fire condition. However, heat and byproducts of the fire itself can still be substantial and could make the area untenable for human occupancy until the enclosure has been properly vented.

Nitrogen is stored in high-pressure cylinders at a nominal pressure of 2900 psi (200 bar) at 70°F (21.1°C). Safety and exposure guidelines, including concentration levels, as established by NFPA 2001, *Standard for Clean Agent Fire Extinguishing Systems*, should be followed.

1-3 USE AND LIMITATIONS

Nitrogen fire extinguishing systems are primarily used as total flooding systems for protection of self-enclosed equipment or enclosed hazards to contain the extinguishant.

1-3.1 Use

Nitrogen systems operate safely in temperatures from -20°F to 130°F (-29°C to +54°C). Nitrogen will not cause "fogging" during a discharge, a condition caused by the super-cooling of the water content in the air. The density of Nitrogen in air is similar to that of atmospheric air, which greatly improves the holding time after a release compared with other agents.

Nitrogen is electrically nonconductive and therefore suitable for use to extinguish fires in electric and electronic equipment, such as that found at electronic data processing and telecommunication facilities. Nitrogen is also useful for extinguishing fires:

- Involving flammable and combustible liquids and gases
- In subfloors and other concealed spaces
- In tape file storage areas
- involving delicate artifacts and high-value assets
- In places where other extinguishing media could be directly destructive.

Deep-seated fires in solid material require that the Nitrogen atmosphere be maintained for an extended period of time (holding time) to achieve total extinguishment.

Nitrogen does not leave any hazardous substances after a release. Since cleanup after a fire will only involve items damaged in the fire, downtime and secondary damage can therefore be kept to a minimum.

CHAPTER 2
FIRE EXTINGUISHMENT METHODS

Nitrogen systems extinguish fires by the following methods:

2-1 TOTAL FLOODING

Release of Nitrogen into an enclosure (total flooding) means that an inert atmosphere is created within the entire room volume.

2-2 SELECTOR VALVES/DISTRIBUTION SYSTEM

If more than one room or hazard in a building is to be protected, a common Nitrogen cylinder bank may be used. The capacity of the cylinder bank must be calculated for protection of the largest room/ hazard and/or adjoining rooms/hazards that may be involved in a fire simultaneously. In most cases, Nitrogen selector valve systems reduce the cost as compared to individual systems protecting the same hazards.

2-3 MODULAR SYSTEM

In limited space areas where the authority having jurisdiction will allow for a modular system, cylinders located singly or in multiple units within the room may be used. The total quantity of stored agent, the number of nozzles etc., shall be that as required for a central bank system. Cylinders shall be connected either electrically or pneumatically, allowing for simultaneous discharge. Each individual unit shall be treated as a separate system.

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CHAPTER 3
DESIGN GUIDELINES

Design Guidelines for Nitrogen systems are as established in NFPA 2001, *Standard for Clean Agent Fire Extinguishing Systems*. Nitrogen has been designated IG-100 in NFPA 2001 (100% nitrogen).

3-1 DESIGN STANDARDS

A Nitrogen system shall always be designed in accordance with the latest version of applicable design standards, taking into consideration requirements specified by local authorities having jurisdiction.

- NFPA 2001, *Standard for Clean Agent Fire Extinguishing Systems*

Marine Applications:

- Safety Of Life At Sea. SOLAS, Consolidated Edition

3-2 PERSONAL SAFETY

WARNING

When extinguishing a fire using nitrogen, the oxygen level in the protected room is reduced to a level that will not sustain combustion. This could create an imminent risk to personnel occupying the enclosure if the residual oxygen level becomes less than that which can support life. Products of combustion from the fire must also be considered a hazard.

Suitable safeguards shall always be provided to ensure prompt evacuation from and prevent entry into a hazardous atmosphere, and include a safe means for prompt rescue of any trapped personnel. Safety items such as personnel training, warning signs, discharge alarms, self-contained breathing apparatus, evacuation plans and fire drills shall be considered and implemented as required

WARNING

Personnel should be acquainted with the fact that nitrogen presents a noise hazard during discharge and may result in damage to hearing if personnel are present without protection during discharge.

Consideration shall be given to the possibility of migration of Nitrogen to adjacent areas outside of the protected space (pressure relief vent openings, etc.).

Nitrogen systems may be designed for a residual oxygen level of 12% (sea level equivalent) if personnel can vacate the area within five minutes (exposure time of 5 minutes or less), but may be designed to have a residual oxygen level of 10% (sea level equivalent) if personnel can vacate the area within3 minutes (exposure limited to 3 minutes or less).

WARNING

Nitrogen systems designed to reduce oxygen levels to below 12% should only be provided in normally unoccupied areas.

However, in all of situations it is necessary that personnel evacuate the hazard **prior** to system discharge. Hence the need to include both predischarge alarms and time delays into all system designs.

Nitrogen systems designed to concentrations below 42.5% (corresponding to an oxygen concentration of 12% or higher, sea level equivalent of oxygen) shall be permitted, given the following:

- The space is normally occupied.
- Means are provided to limit exposure to no longer than 5 minutes.

Systems designed to concentrations between 42.5 and 52% (corresponding to between 12 and 10% oxygen, sea level equivalent of oxygen) shall be permitted, given the following:

- The space is normally unoccupied.
- Means are provided to limit exposure to no longer than 3 minutes.

Systems designed to concentrations between 52 and 61.7% (corresponding to between 10 and 8% oxygen, sea level equivalent of oxygen) shall be permitted, given the following:

- The space is normally unoccupied.
- Where personnel could possibly be exposed, means are provided to limit the exposure to less than 30 seconds.

Systems designed to concentrations above 61.7% (corresponding to 8% oxygen or below, sea level equivalent of oxygen), shall only be used in unoccupied areas where personnel are not exposed to such oxygen depletion.

3-3 RELEASE TIME

- **Industrial**: NFPA 2001 recommends 95% of the design quantity of Nitrogen be released within 60 seconds.
- **Marine**: SOLAS recommends 85% of the design quantity of Nitrogen be released within 120 seconds. Other countries/authorities may have different requirements than those mentioned above.

3-4 TEMPERATURE CONSIDERATIONS

During a discharge of the agent only, the temperature within the protected enclosure will drop approximately 10 - 20°F (5 - 10°C). After the end of the discharge, the temperature will rise again within approximately 2 - 3 minutes.

3-5 ELECTRICAL CLEARANCE

All system components shall be located to maintain no less than minimum clearance from energized electrical parts. Should a design insulation level not be available and where nominal voltage is used for the design criteria, the highest minimum clearance listed for this group shall be used.

The following references shall be considered as the minimum electrical clearance requirements for the installation of clean agent systems:

- ANSI C2, *National Electrical Safety Code*
- NFPA 70, *National Electrical Code*®
- 29 CFR 1910, Subpart S
- NFPA 2001, *Standard for Clean Agent Fire Extinguishing Systems*

3-6 AUTOMATIC DETECTION AND CONTROL

Detection, actuation and control systems shall be installed, tested and maintained in accordance with the requirements of the authority having jurisdiction.

Automatic detection and actuation (release) is preferred. Selection of the detection devices shall be determined based on an evaluation of the flammables involved, the environment and the response time anticipated.

Means for manual release of the system shall be provided and located, installed and/or suitably protected so that they are not subject to mechanical, chemical or other damage that would render them inoperative.

The control equipment shall supervise the actuating devices and the associated wiring and, as required, cause actuation.

Audible or visual alarms, or both, shall be used to indicate the operation of the system, hazards to personnel or failure of any supervised device. The device type - audible or visual - their number and location shall be such to comply with all local and/or national codes.

Audible and visual predischarge alarms shall be provided within the protected area to give positive warning of impending discharge. The operation shall be continued after discharge until positive action has been taken to acknowledge the alarm and proceed with appropriate action.

The time delay between the predischarge alarm and discharge shall be sufficient to allow personnel to evacuate prior to the discharge. Time delays shall be used only for personnel evacuation or to prepare the hazard area for discharge (closing of doors, vents, shut down of equipment, etc.).

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CHAPTER 4
SYSTEM DESCRIPTION

A Nitrogen system may involve parts as described below.

4-1 CENTRAL CYLINDER BANK

A Nitrogen system normally comprises a bank of cylinders consisting of a sufficient number of cylinders to provide the Nitrogen supply required. Where required, a reserve bank should consist of as many multiples of the primary supply as the authority having jurisdiction considers necessary. Main and reserve supplies may be permanently connected to the distribution piping and arranged for easy change over.

Note: It is recommended that a reserve bank of cylinders always be provided.

The cylinder bank shall not be located where it can be rendered inoperable or unreliable due to mechanical damage, exposure to chemicals or harsh weather conditions, or by any other foreseeable cause. Where exposure to such conditions is unavoidable, then a suitable enclosure or other protective measures shall be employed.

The cylinders in a bank must be securely supported and attached to a wall or a solid structure in a manner that allows for convenient individual inspecting/servicing. Each cylinder valve must be fitted with a pressure gauge. A supervisory pressure switch is provided for remote monitoring.

The cylinders in a bank are each connected to a discharge manifold or series of manifolds via flexible high-pressure hoses. The connection at the manifold includes an in-line check valve. Check valves are provided to prevent agent loss and to ensure personnel safety if the system is operated when any containers are removed for maintenance.

It is permissible to utilize multiple storage container sizes in the cylinder bank.

4-2 SELECTOR VALVE SYSTEM/DISTRIBUTION SYSTEM

Should the system be designed for protection of more than one hazard from a common cylinder bank, the manifold must be equipped with normally closed, pneumatically operated selector valves.

The pressure required to operate the pneumatic actuators on the selector valves is taken from the main distribution manifold, via a pressure regulator. The pressure regulator reduces the operating pressure to between 75 and 120 psi (5 to 8 bar) to safely operate the selector valves, and shall include a relief device in case of overpressurization.

Each selector valve is equipped with its own actuator and solenoid valve assembly, which, when operated, will release Nitrogen into the appropriate hazard area.

A portion of the total number of Nitrogen cylinders may be used for a particular hazard. This is accomplished by utilizing a non-return (check) valve in the cylinder pilot line. The system designer shall specify the location of the valve.

A restrictor is used at the outlet of each selector valve to reduce the pressure going into the distribution piping.

Optional isolation (lockout) valves may be installed upstream of the selector valve. These valves must remain supervised open and may only be closed during system service or routine maintenance.

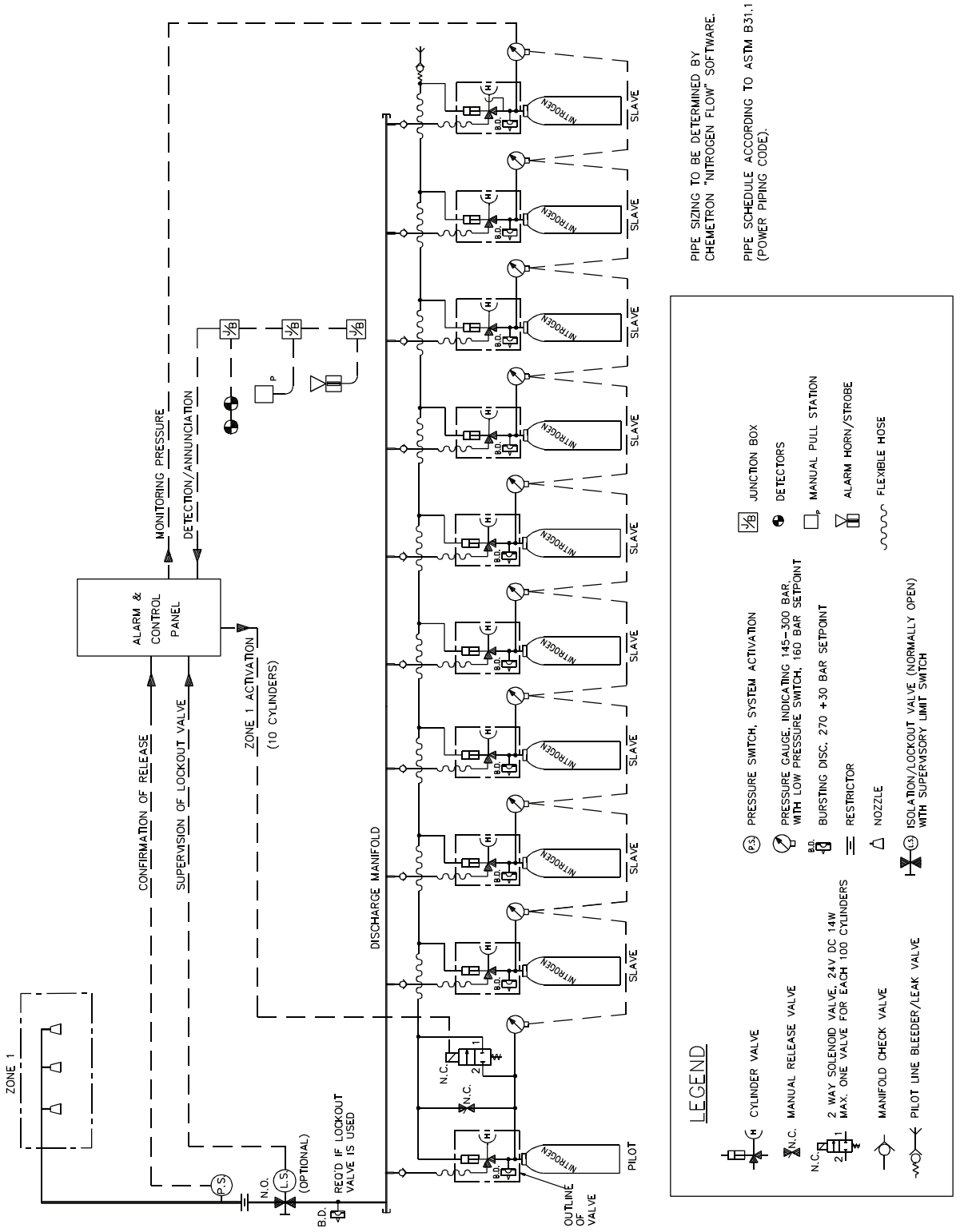

Figure 4-1. Piping and Instrumentation Diagram for Single-Hazard Nitrogen System

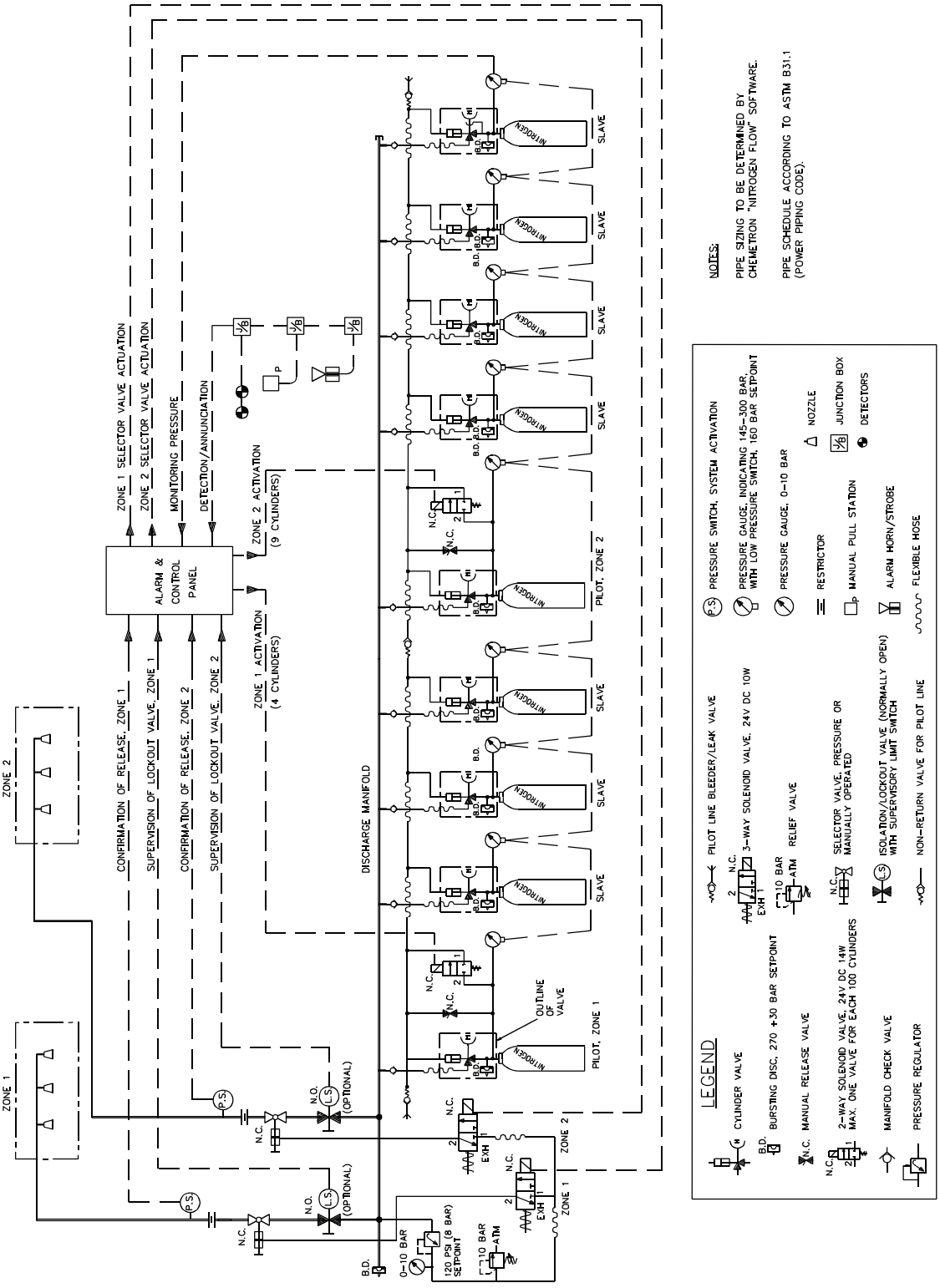

Figure 4-2. Piping and Instrumentation Diagram for Multi-Hazard Nitrogen System (2 hazards shown)

4-3 RESTRICTOR

The purpose of the restrictor is to reduce the pressure of the gas from the cylinder before it enters the piping system. The pressure is reduced from the storage pressure of 2900 psi (200 bar).

Note: The Kidde Fire Systems Nitrogen Flow Calculation Software is required to determine restrictor orifice sizes and pressure up and down stream of the restrictor.

4-4 RELEASE NOTES

The system is capable of electric, pneumatic and manual actuation and can be released by one or more of the following methods:

4-4.1 Automatic Release

When a fire condition is detected and the control panel goes into an alarm state, the panel will annunciate a visual and/or audible alarm, activate the alarm relay and energize the high-pressure solenoid valve on the pilot cylinder. In a selector valve system, the low-pressure solenoid valve at the selector valve is also energized.

4-4.2 Manual Remote Release - Electrical

Remote release is accomplished by actuation of a switch at a manual release station (if required). Once the station has been actuated, the alarm and control panel will operate the system as described above.

4-4.3 Manual Emergency Release

In the unlikely event of total power failure and expiration of the emergency batteries, the system may be activated by pulling the pin and rotating the actuator handle. In a selector valve system, rotate the manual override handle on the selector valve for the desired area.

Note: The green handle on the top of the cylinder valve is **NOT** for manual operation and should **NOT** be used for the operation of the system.

4-5 CYLINDERS

Each cylinder is fitted with a pressure operated Nitrogen cylinder valve. The cylinders has an 80 liter capacity and is filled with Nitrogen at a pressure of 2900 psi (200 bar) at 70°F (21.1°C). The cylinders are provided with a protective cap and grey shoulder markings.

4-5.1 Cylinder Valves

Each valve is to be provided with a pneumatic operator to open the valve; one of the cylinder valves in the bank must be fitted with a manual/pneumatic actuator. A pressure gauge with supervisory pressure switch is provided for local and/or remote monitoring of cylinder pressure.

The pilot cylinder in a bank is provided with a pressure gauge/solenoid valve actuator unit allowing for electrical release. In event of release by the use of pressure through the manual/pneumatic actuators on the slave cylinders, the pilot cylinder will provide pressure for their opening. The interconnection between pilot and slave cylinders is accomplished using high pressure flexible hoses.

After a discharge, the cylinder valve will automatically close when the pressure decreases to approximately 45 psi (3 bar), maintaining a positive pressure as well as preventing moisture from entering the cylinder and thus ensuring corrosion protection of the interior of the cylinder.

4-5.2 Pressure Monitoring

Kidde offers means for remote and local pressure monitoring of the content within the cylinder.

- The local monitoring is by the use of the pressure gauge on each cylinder.
- The remote monitoring is by the use of a pressure gauge with supervisory pressure switch on each cylinder. The switch, which is normally under pressure, consists of one normally open contact that closes to annunciate loss of pressure at approximately 2200 psi (150 bar).

4-6 SELECTOR VALVES

In systems where a common cylinder bank protects more than one hazard, selector valves are utilized. The selector valve is a pneumatically actuated ball valve, sized according to the system requirements.

In systems where remote indication of release into a specific area is required, a discharge pressure switch can be fitted downstream of the selector valve.

The solenoid valve energized by the fire alarm/control panel will provide pressure to the pneumatic actuator on the valve. The solenoid valve will close when de-energized, however the ball valve must be closed manually.

4-7 DISTRIBUTION PIPE NETWORK AND NOZZLES

The distribution pipe network is to be designed and the nozzles selected and positioned to allow an even distribution of the Nitrogen throughout the protected area. The piping and fittings should conform to NFPA 2001, Power Piping Code, and all local codes and standards.

4-8 FLOW CALCULATIONS

Flow calculations are to be based on the design drawings and should be verified prior to installation of the nozzles. Any significant changes should be evaluated, and if necessary, the flow calculation repeated and orifices in restrictor and nozzles replaced to ones suitable for the as-built situation.

All calculations to determine the size of restrictor orifice pipe dimensions and nozzle orifices must be carried out utilizing the approved Nitrogen software.

4-9 PRESSURE RELIEF VENTING

When released, fixed fire extinguishing systems employing compressed gases will create a considerable extra volume of gas within the room due to expansion. To compensate for the overpressure, suitable means of pressure relief venting must be employed. The free area of these openings/vents shall be appropriately sized to avoid structural damage.

Normal rooms will withstand an increase of pressure of approximately 5 millibars (2 in. H2O). Pressure relief vents should be located at a high level on the wall or on the ceiling, clear of any direct nozzle discharge. At the end of the discharge the pressure relief vents shall close in order to maintain the extinguishing concentration for as long as possible.

The fire rating of all pressure vents should be equal to or greater than the rating of the structure.

4-10 SERVICE AND MAINTENANCE

The importance of maintenance cannot be overemphasized. Trained personnel shall regularly service a Nitrogen system. The service engineer shall be proficient in the installation and commissioning of Nitrogen systems as well as have detailed knowledge of the involved components.

At least annually, all systems shall be thoroughly inspected and tested for proper operation. The inspection should include a verification of the integrity of the protected volume and assurance that the protected volume has not increased or decreased. Changes in installed equipment occupying additional or less volume than at the design/installation stage will affect the resulting oxygen concentration after a discharge. A recalculation of the system may be required.

NFPA 2001 requires that if a Nitrogen cylinder shows a loss in pressure (adjusted for temperature) of more than 5% (2750 psi at 70°F or 190 bar at 21.1°C) it shall be refilled or replaced. The cylinder pressure gauge reading shall be compared to a separate calibrated device at least annually.

Refer to Chapter 9 for further service and maintenance procedures.

CHAPTER 5
SYSTEM BASICS

5-1 OVERVIEW

The following list applies to all Kidde Nitrogen systems:

- The cylinders are installed in racks available in single, dual or quadruple row configuration.
- A Nitrogen system may consist of one or more cylinders, connected through a common discharge manifold arrangement (cylinder bank).
- The cylinders in the bank are connected to a common release manifold arrangement via highpressure hoses and a check valve assembly, one for each cylinder. The check valves allow removal of one or more cylinders from the manifold.
- The cylinder valves are constructed to be capable of releasing 80 liters of Nitrgoen at 2900 psi (200 bar) within 1 minute.
- The system can be released manually by removing a safety pin and turning the actuator handle.The manual release unit is mounted on the side of the pilot cylinder valve.

Note: The green handle on the top of the cylinder valve is **NOT** for manual operation and should **NOT** be used for the operation of the system.

- The cylinders are provided with a pressure gauge assembly and the pilot cylinder is also provided with a solenoid valve/manual release/gauge assembly.
- When energized, the solenoid valve will provide pressure for opening all of the cylinder valves.
- The pressure from the pilot cylinder is fed to pneumatic actuators on the slave cylinders.
- The manifold arrangement is further equipped with restrictor(s), which reduce the discharge piping pressure during the discharge.
- Selector valves may be used to divert Nitrogen to the required hazard.
- From the restrictor, Nitrogen is fed through a piping system to the nozzles, which distributes the gas in the room.
- A Nitrogen system is to be monitored and controlled by the building fire alarm and control panel or a local fire alarm and control panel (depending on local approval and/or requirements). Fire detectors for each hazard shall be selected based on the flammables involved, their burning rate and the accepted response time.
- The room should be evacuated before discharge in order to secure both the extinguishing effect, as well as human safety (secure the hazard during and after the release). The control panel may be equipped with a time delay of 10 - 30 seconds (depending on requirements of authorities having jurisdiction). The warning alarm shall start sounding simultaneously with the start of the time delay period.

5-2 EXTINGUISHING EFFECT

When Nitrogen is discharged, an inert atmosphere is created in the protected hazard. Within a short time, the fire will be suffocated as the oxygen content will decrease from the normal 20.9% to 15-10% (depending on the flammables involved).

For most flammable liquids and solid materials, a 15% oxygen level is the lowest limit at which a fire can be sustained; however 30% safety factor requirements result in the 12.5 - 13% oxygen level. A 12% oxygen level is the lowest limit acceptable for personnel occupancy in the protected hazard/room.

Note: In order to achieve extinguishment of some materials, it is necessary to lower the oxygen level below 10%. These systems require special safety precautions.

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CHAPTER 6
SYSTEM COMPONENTS

6-1 CYLINDERS

Nitrogen gas is stored in high pressure cylinders having a filling pressure of 2900 psi (200 bar) and a test pressure of 4830 psi (333 bar).

Table 6-1. 80 Liter Cylinder Assembly (Filled Cylinder and Valve) Specifications

Description		Part Number	Filled Weight		Empty Weight	
			lb.	kg	lb.	kg
2900 psi	Department of Transportation (D.O.T. - US) Transportation Canada (TC)	10980090	312	141.3	273	123.8

The 80 liter cylinders are spaced 12 inches (305 mm) apart and can be installed in single, double, and quadruple row configurations.

Because Nitrogen is stored as a non-liquefied gas, dip tubes are not used, allowing the cylinders to be installed either vertically or horizontally, as required. All rack configurations are for vertical mounting only.

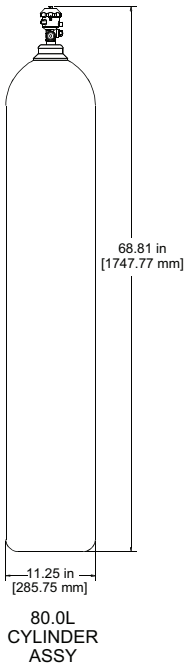


Figure 6-1. Cylinder

6-2 CYLINDER VALVE

Each cylinder is supplied with a pneumatic cylinder valve (discharge valve). The cylinder valve is equipped with a burst disc and must also be equipped with a completer kit that will include a pressure gauge with supervisory pressure switch, hose and connection fittings.

The completer kits allow the valves to be released either electrically, by means of a solenoid, or pneumatically, using the manual release. The valve discharge outlet is connected to the discharge manifold via a high pressure flexible hose and a check valve.

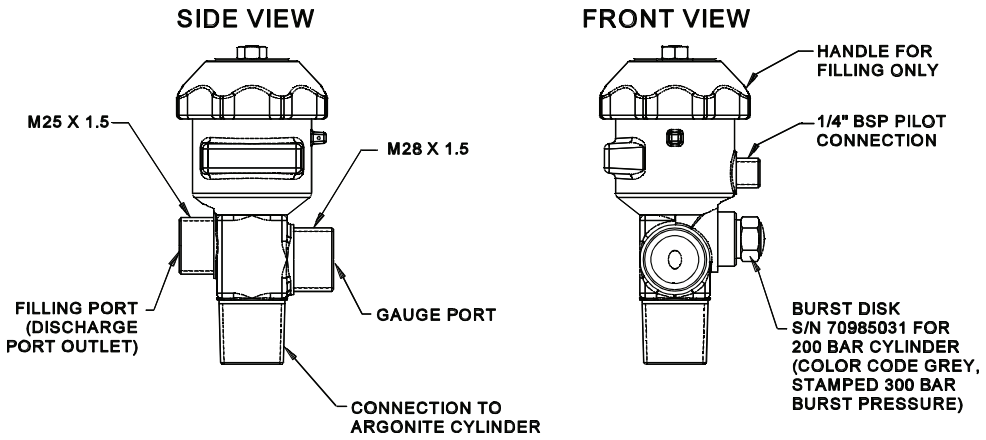


Figure 6-2. Nitrogen Cylinder Valve, P/N 70985015

6-3 CYLINDER RELEASE - COMPLETER KITS

The pressure for activation is taken from the primary/pilot cylinder through the electrical actuator and via high pressure flexible hoses connected to the pneumatic actuator inlet on the pilot cylinder as well as to the actuator inlets on the neighboring slave cylinders. The actuation ports on the cylinders are interconnected by the use of high pressure flexible hoses. The arrangement allows all the cylinders in the cylinder bank to be opened almost simultaneously.

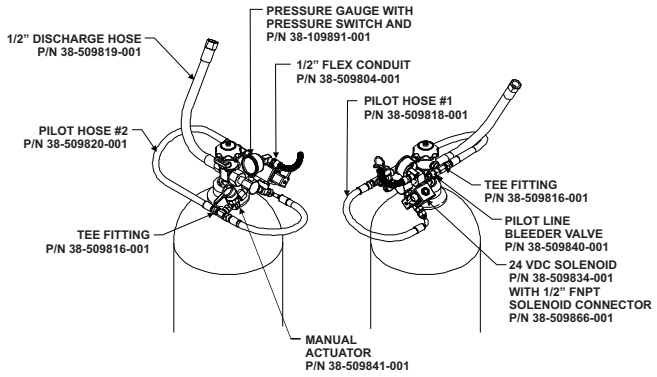


Figure 6-3. Primary Completer Kit

Table 6-2. Primary Completer Kit Information

Rating	Part Number	Completer Kit includes
NEMA 4	38-109802-001	Manual Release Pressure Gauge with Supervisory Pressure Switch, Solenoid, Bleeder Valve, Hoses, Fittings and Emergency Operation Nameplate

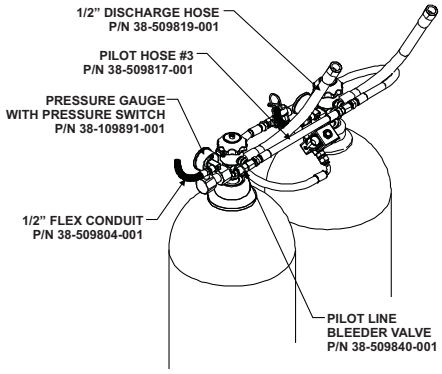


Figure 6-4. Standard Primary and Slave Completer Kit

Table 6-3. Slave Completer Kit Information

Rating	Part Number	Completer Kit includes
NEMA 4	38-109803-001	Pressure Gauge with Supervisory Pressure Switch, Hoses and Fittings

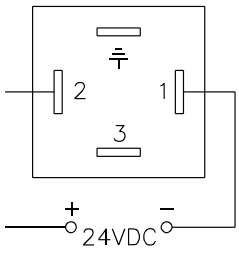


Figure 6-5. Solenoid Wiring Diagram

6-4 ELECTRICAL ACTIVATION

One solenoid valve (primary completer kit) can be used to actuate up to a maximum of 100 cylinders. When the number of system cylinders exceeds 100, two solenoid valves (two primary completer kits) must be used.

6-5 SELECTOR VALVE SYSTEMS

Selector valves are used in multiple hazard systems where Nitrogen may be supplied to different hazards from the same cylinder bank.

Systems that utilize differing numbers of cylinders for each hazard **MUST** use a pilot line non-return (check) valve (P/N 70985013). This valve allows for a portion of the pilot line to be used for system activation, as needed. Separate pilot cylinders must be used for each hazard. For example in Figure 4-2 on page 4-3, when the Zone 1 pilot cylinder is activated, only 4 cylinders will discharge into the manifold. When the Zone 2 pilot cylinder is activated, all nine cylinders will discharge. The pilot line non-return valve (Figure 6-6) allows for the proper amount of Nitrogen to be discharged into each hazard.

Using the standard primary completer kit assembly(s), the cylinders to be released are discharged into the discharge manifold(s). At the end of the discharge manifold, customer supplied fittings and/or a selector manifold is used to contain the Nitrogen pressure until the proper selector valve is operated to release Nitrogen into the hazard area. The selector valves operate pneumatically or manually. discharge manifold, customer supplied fittings and/or a selector manifold is used to contain the Nitrogen pressure until the proper selector valve is operated to release Nitrogen into the hazard area. The selector valves operate pneumatically or manually.

Each selector valve is equipped with its own actuator and is supplied with a 24 VDC 3-way solenoid. When actuated, the solenoid will route pressure to the actuator to open the selector valve. Once opened, the selector valve will remain open until manually closed

Restrictors for each hazard area are to be installed downstream of their respective selector valves.

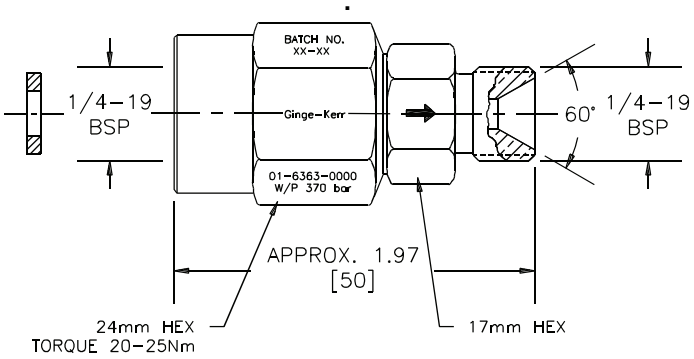


Figure 6-6. Non-Return Check Valve for Pilot Lines, P/N 70985013

Note: All discharge piping upstream of the restrictors, including the selector valve manifold, must be Schedule 160 or stronger.

The selector valve manifold or piping configuration is supplied by others (not Kidde) and must include a 3/4" relief valve (P/N 70985027) and a 1/4" NPT fitting for connection of the pressure regulator. The relief valve and regulator are supplied as part of the pressure regulator kit (P/N 38-509803-001).

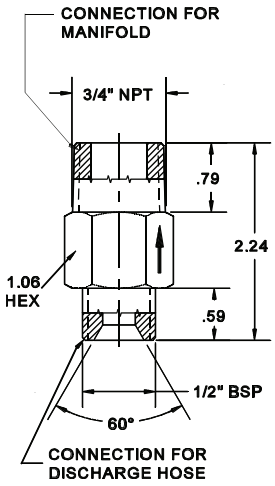


Figure 6-7. Check Valve, P/N 70985014

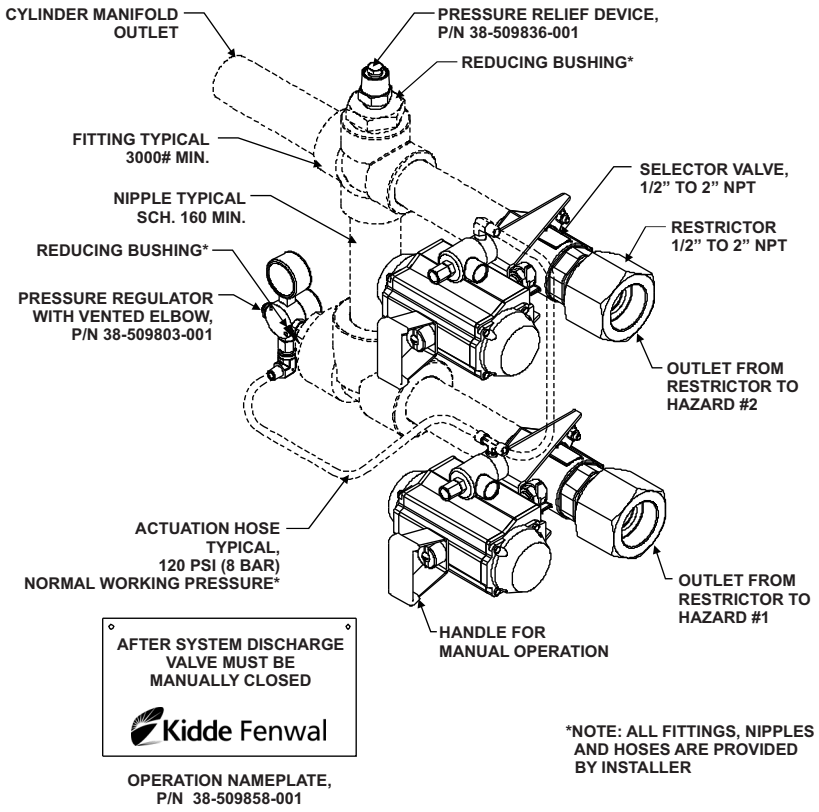


Figure 6-8. Typical Selector Valve Arrangement

6-5.1 Pressure Regulator Kit (P/N 38-509803-001)

The pre-assembled pressure regulator kit consists of:

Table 6-4. Pressure Regulator Kit Data

Item	Part Number	Qty	Description
1	38-509830-001	1	Pressure regulator preset at 120 psi (8.3 bar) with gauge and
2	38-509825-001	2	Gauge adapters (converts threads from BSP to NPT)
3	38-809826-001	2	Gauge adapter gaskets
4	38-509867-001	1	Vented elbow, 1/4" NPT
5	38-509836-001	1	3/4" Pressure relief valve 4350 psi (300 bar)

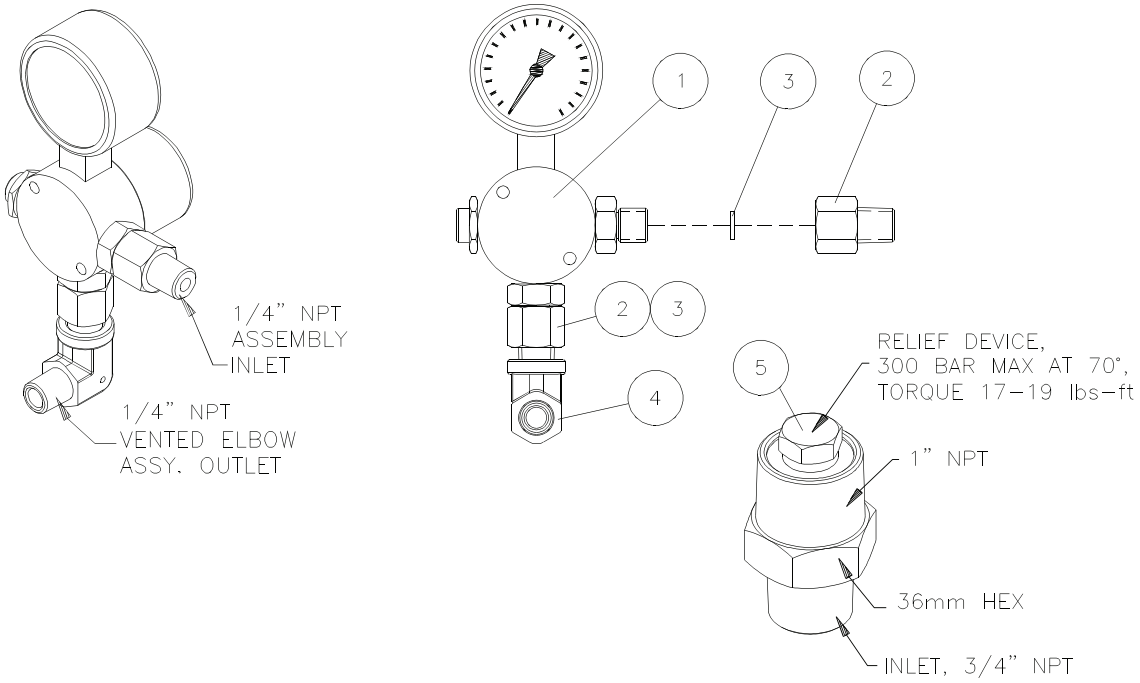


Figure 6-9. Selector Valve Pressure Regulator Kit, P/N 38-509803-001

6-5.2 Selector Valve Assemblies

Each selector valve assembly consists of the selector valve (in various sizes from 1/2" up to 2") with actuator and reset handle. It will also include the 24 VDC 3-way actuation solenoid (choice of weatherproof or explosion-proof), and the nipple connector to assemble the unit.

The selector valves will operate pneumatically by actuating the solenoid, but because of the design of the unit, the valves must be closed manually after the discharge. An operation nameplate is also provided to be mounted near the associated selector valve assemblies

All selector valves have a working pressure of 2900 psi (200 bar).

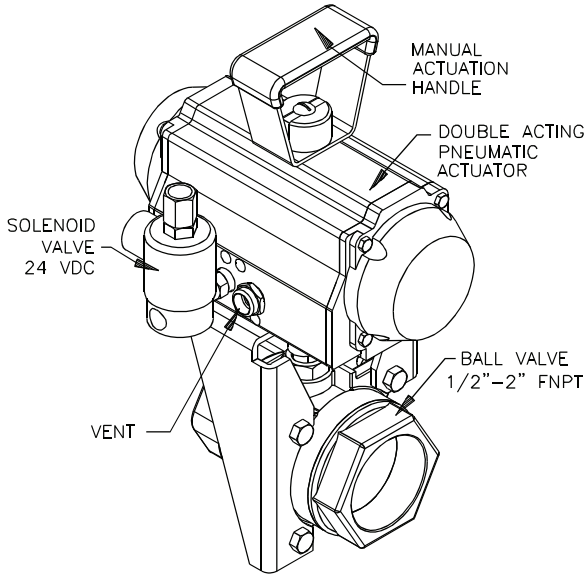


Figure 6-10. Selector Valve (Typical)

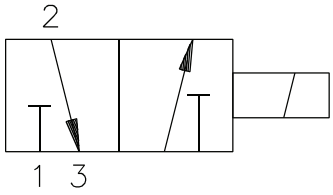
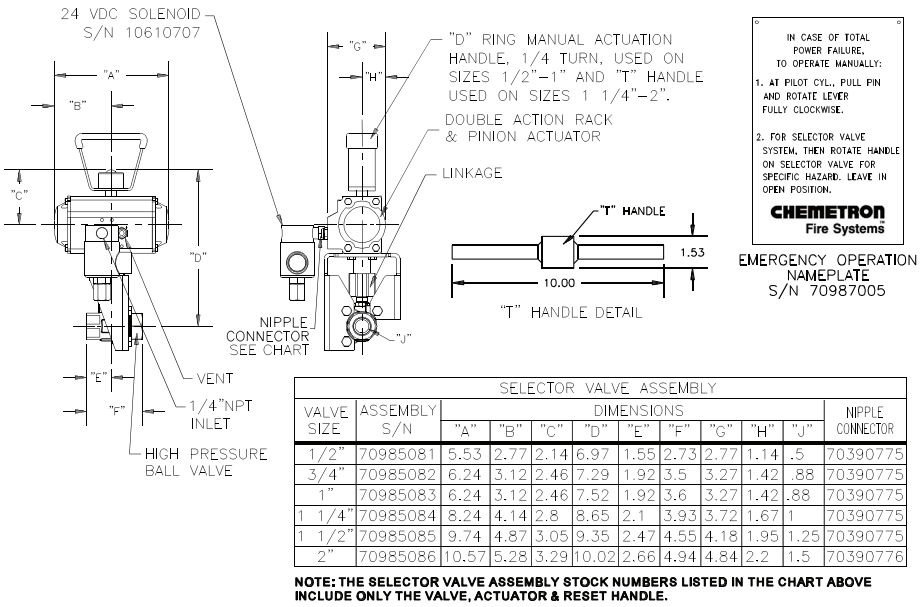


Figure 6-11. Selector Valve Solenoid Wiring Schematic



SELECTOR VALVE ASSEMBLY

VALVE SIZE	ASSEMBLY S/N	DIMENSIONS "A"	"B"	"C"	"D"	"E"	"F"	"G"	"H"	"J"	NIPPLE CONNECTOR
1/2"	70985081	5.53	2.77	2.14	6.97	1.55	2.73	2.77	1.14	.5	70390775
3/4"	70985082	6.24	3.12	2.46	7.29	1.92	3.5	3.27	1.42	.88	70390775
1"	70985083	6.24	3.12	2.46	7.52	1.92	3.6	3.27	1.42	.88	70390775
1 1/4"	70985084	8.24	4.14	2.8	8.65	2.1	3.93	3.72	1.67	1	70390775
1 1/2"	70985085	9.74	4.87	3.05	9.35	2.47	4.55	4.18	1.95	1.25	70390775
2"	70985086	10.57	5.28	3.29	10.02	2.66	4.94	4.84	2.2	1.5	70390776

NOTE: THE SELECTOR VALVE ASSEMBLY STOCK NUMBERS LISTED IN THE CHART ABOVE INCLUDE ONLY THE VALVE, ACTUATOR & RESET HANDLE.

Figure 6-12. Detail - Selector Valve Assembly (Typical)

Table 6-5. Selector Valve Assemblies

With 24 VDC 3-Way Solenoid (weatherproof), Actuator, Reset Handle, Connector, and Operation Nameplate		**With 24 VDC 3-Way Solenoid (explosion proof), Actuator, Reset Handle, Connector, and Operation Nameplate**	
P/N	**Description**	**P/N**	**Description**
20980096	1/2" (15 mm) NPT selector valve assy	20980102	1/2" (15 mm) NPT selector valve assy
20980097	3/4" (20 mm) NPT selector valve assy	20980103	3/4" (20 mm) NPT selector valve assy
20980098	1" (25 mm) NPT selector valve assy	20980104	1" (25 mm) NPT selector valve assy
20980099	1-1/4" (32 mm) NPT selector valve assy	20980105	1-1/4" (32 mm) NPT selector valve assy
20980100	1-1/2" (40 mm) NPT selector valve assy	20980106	1-1/2" (40 mm) NPT selector valve assy
20980101	2" (50 mm) NPT selector valve assy	20980107	2" (50 mm) NPT selector valve assy
NOTE: Explosion-proof rating - Class I, Groups C & D; Class II, Groups E, F, & G; Divisions 1 & 2			
Selector Valve Assembly Replacement Parts			
P/N	**Description**	**P/N**	**Description**
70985081	1/2" Valve, actuator & reset handle only	10610707	Solenoid, 24 VDC, 3-Way, weatherproof
70985082	3/4" Valve, actuator & reset handle only	70610412	Solenoid, 24 VDC, 3-Way, explosion proof
70985083	1" Valve, actuator & reset handle only	70390775	Nipple connector 1/8" x 1/4" NPT (1/2" to 1-1/2" valves)
70985084	1-1/4" Valve, actuator & reset handle only	70390776	Nipple connector 1/4" x 1/4" NPT (2" valves only)
70985085	1-1/2" Valve, actuator & reset handle only	70360699	Reset nameplate
70985086	2" Valve, actuator & reset handle only	20987005	Emergency operation nameplate

6-5.3 Isolation (Lockout) Valve Assemblies

Isolation (lockout) valves may be installed for maintenance/service reasons; for multi-hazard systems they are typically installed upstream of the selector valve as illustrated in Figure 4-2 on page 4-3. For single hazard systems, the isolation valves shall be located upstream of the restrictor. These devices **MUST** be locked in the OPEN position whenever the Nitrogen System is in operational/standby condition. When the discharge piping is being serviced, these valves **MUST** be locked in the CLOSED position.

Isolation valve assemblies include a high visibility indicator and limit switch (weatherproof or explosion proof). The limit switch shall initiate a "Trouble" signal at the control panel when the ball valve is in the closed position. All ball valves have a working pressure of 2900 psi (200 bar). When using isolation valves, a pressure relief valve should also be installed wherever pressure could be trapped in closed sections of pipe

Table 6-6. Isolation (Lockout) Valve Assemblies

NEMA 4 & 4X with Limit Switch, 2-SPDT		**Explosion Proof, NEMA 4, 4X, &9 with Limit Switch, 2-SPDT**	
Part Number	**Size**	**Part Number**	**Size**
70985020	1/2 in.	70985069	1/2 in.
70985021	3/4 in.	70985070	3/4 in.
70985022	1 in.	70985071	1 in.
70985023	1-1/4 in.	70985072	1-1/4 in.
70985024	1-1/2 in.	70985073	1-1/2 in.
70985025	2 in.	70985074	2 in.
NOTE: Explosion Proof rating- Class I, Groups C & D; Class II, Groups E, F, & G; Divisions 1 & 2			

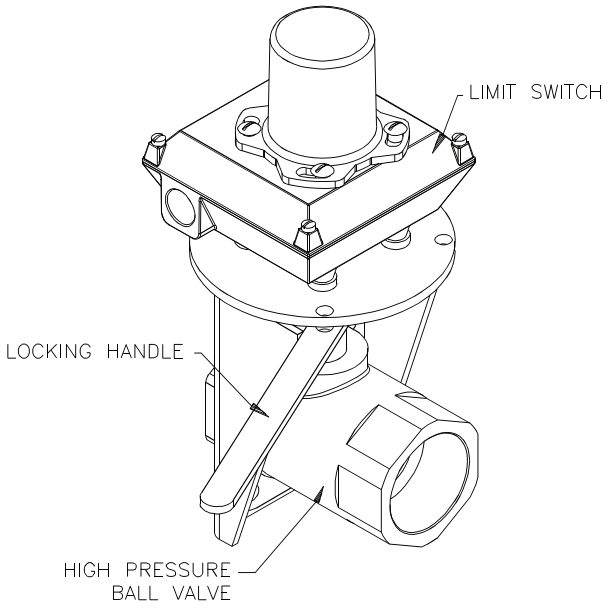


Figure 6-13. Isolation Lockout Valve (Typical)

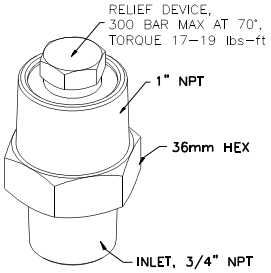


Figure 6-14. Pressure Relief Valve, P/N 70985027

6-6 RESTRICTOR/ORIFICE

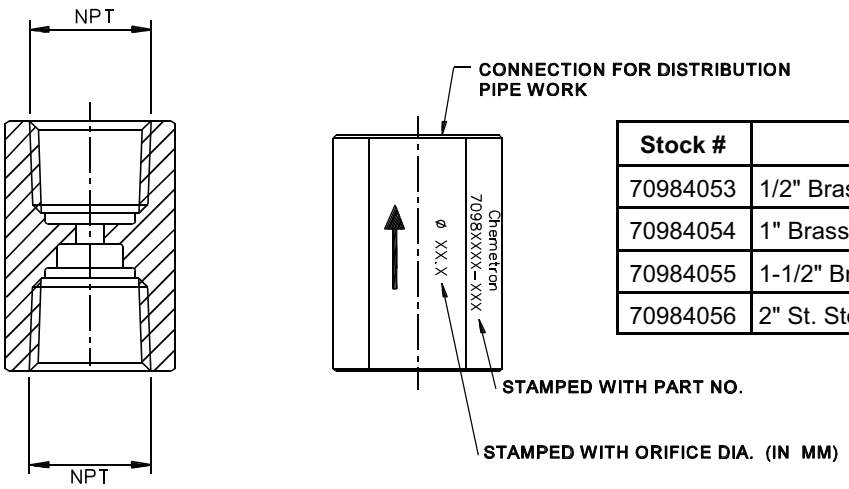
The high-pressure 2900 psi (200 bar) Nitrogen is discharged into the distribution pipe network through a restrictor assembly. During agent flow, the restrictor reduces the initial manifold pressure before the agent enters the distribution piping. The size of the orifice is calculated based on the required discharge time and the required flow.

The restrictors are normally fitted onto the discharge manifolds; however, in certain cases - for example, single cylinder systems - the restrictor is installed directly at the beginning of the discharge piping. Discharge pipe/manifold pipe type restrictors are female NPT to female NPT, threaded.

The restrictor assures that the Nitrogen will be delivered to the distribution pipe network and discharge nozzles at the proper predetermined pressure. Restrictors are available in 1/2", 1", 1-1/2" or 2" NPT. Larger 2-1/2", 3" and 4" flange type orifice plate restrictors are also available.

6-6.1 Threaded Flow Restrictors

Size 1/2", 1" and 1-1/2" restrictors are brass; 2" restrictor is stainless steel. See Figure 6-15.



Stock #	Description
70984053	1/2" Brass Restrictor Code 3.5 to 7.5
70984054	1" Brass Restrictor Code 5.0 to 13.0
70984055	1-1/2" Brass Restrictor Code 8.5 to 22.0
70984056	2" St. Steel Restrictor Code 11.5 to 27.0

Figure 6-15. Threaded Restrictor

6-6.2 Orifice Plate Restrictor Assemblies

For large systems with 2-1/2, 3, or 4 inch pipe, use a Class 1500# flange. Only the orifice plate will be provided by Kidde Fire Systems. The flange nuts must be torqued to at least the minimum required by the flange manufacturer. See Figure 6-16.

Stock #	Description
30980007	2-1/2" Orifice plate restrictor, Code 13.5 to 35.0
30980008	3" Orifice plate restrictor, Code 18.0 to 43.0
30980009	4" Orifice plate restrictor, Code 25.0 to 56.0

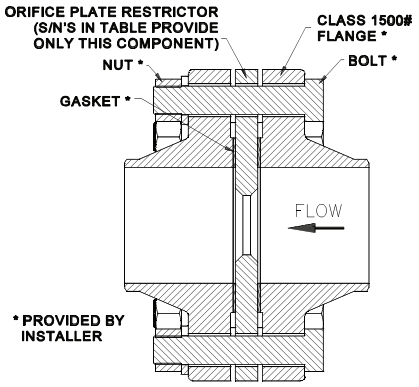


Figure 6-16. Orifice Plate Restrictor and Flanged Assembly

6-7 NOZZLES

Discharge nozzles are available in sizes from 1/2” to 1-1/2”. Each nozzle is available with a variety of orifices. The nozzles are to be installed in a position where the agent release will be most effective, allowing for unobstructed flow of the discharge stream. The nozzles shall be installed in a manner so that they will not potentially cause injury to personnel. When discharged from the nozzle, the agent should not directly impinge on areas where personnel might be found in the normal work area. The agent shall not impinge on any loose objects on shelves, cabinet tops, or similar surfaces where loose objects could be present and become missiles. Normally, the nozzles are located at ceiling level.

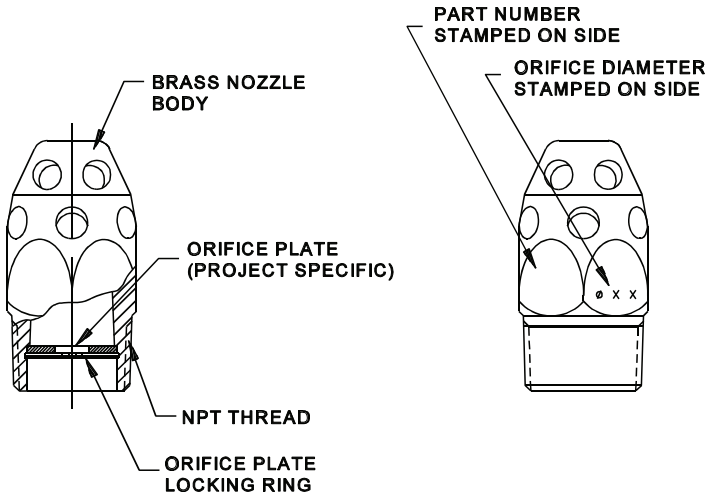


Figure 6-17. Discharge Nozzle

Table 6-7. Nozzle Part Numbers and Descriptions

Part Number	Description
70984041	1/2" Nozzle (NPT) available in codes 3.0 to 10.0
70984042	3/4” Nozzle (NPT) available in codes 4.0 to 13.5
70984043	1" Nozzle (NPT) available in codes 5.0 to 17.0
70984044	1-1/2" Nozzle (NPT) available in codes 8.0 to 26.0
Note: When ordering, specify an 11 digit hyphenated Part Number - the nozzle assembly Part Number plus the 3 digit orifice code; i.e., 70984043-150, to order a 1" nozzle, orifice code 15.0.	

6-8 CYLINDER RACKS

6-8.1 Wall Mount Bracket for 80L Cylinders with Manifold Mounting Brackets

Each kit consists of unistrut steel mounting rails, threaded rods and straps, and hardware for 1 to 12 cylinders. Manifold mounting brackets are not included and must be ordered separately.

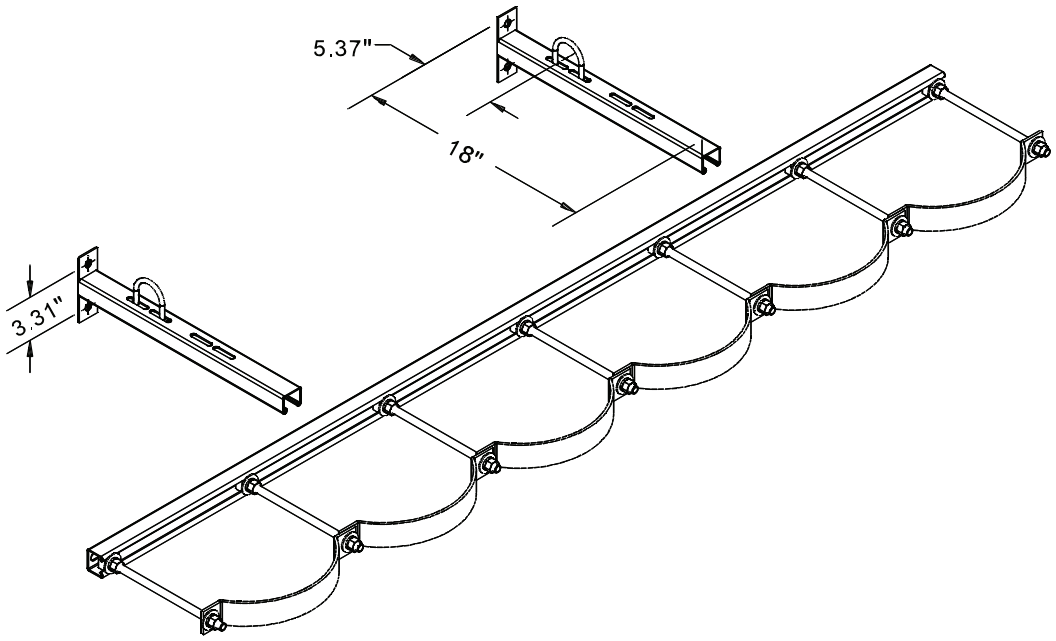


Figure 6-18. 80L Cylinder Wall Mount Rack Kit and Wall Mount Brackets for Manifold

Table 6-8. Wall Mount 1-Row Rack Kit Ordering Information

Number of Cylinders	Part Number
1	38-109879-001
2	38-109880-001
3	38-109881-001
4	38-109882-001
5	38-109883-001
6	38-109884-001
7	38-109885-001
8	38-109886-001
9	38-109887-001
10	38-109888-001
11	38-109889-001
12	38-109890-001

Table 6-9. Wall Mount Brackets for Discharge Manifold- Ordering Information
(All are 18 in. long and 5-3/8 in. to center line)

Manifold Clamp Size	Part Number	Manifold Note
1 in.	38-503073-001	A 1 in. manifold will typically flow from 2 to 6 cylinders
1-1/2 in.	38-503073-002	7 to 10 cylinder arrangements will most often require a 1-1/2 in. manifold
2 in.	38-503073-003	When flowing 11 or 12 cylinders, a 2 in. manifold is usually required
A minimum of 2 brackets is required.		

6-8.2 Cylinder Rack Assemblies - Free-Standing Racks

The cylinder racks are available in four basic styles:

- One row/one side
- One row/two sides
- Two rows/one side
- Two rows/two sides

The cylinder racks are shipped disassembled and must be field assembled. When assembled, the rack should be aligned so that the vertical upright sections are parallel. It is desirable and recommended to have the rack bolted to the floor and a wall or other vertical surface.

Mount the discharge manifold to the rack uprights by means of the U-bolts supplied. Do not tighten the U-bolts until the cylinders and hosing have been connected. Some minor height adjustments may be required.

6-8.2.1 One-Row/One-Side Cylinder Racks

Table 6-10. Rack Sizes and Part Numbers

Rack Size	Part Number
2 cylinders	38-109809-001
3 cylinders	38-109810-001
4 cylinders	38-109811-001
5 cylinders	38-109812-001
6 cylinders	38-109813-001
7 cylinders	38-109814-001
8 cylinders	38-109815-001
9 cylinders	38-109816-001
10 cylinders	38-109817-001
11 cylinders	38-109818-001
12 cylinders	38-109819-001

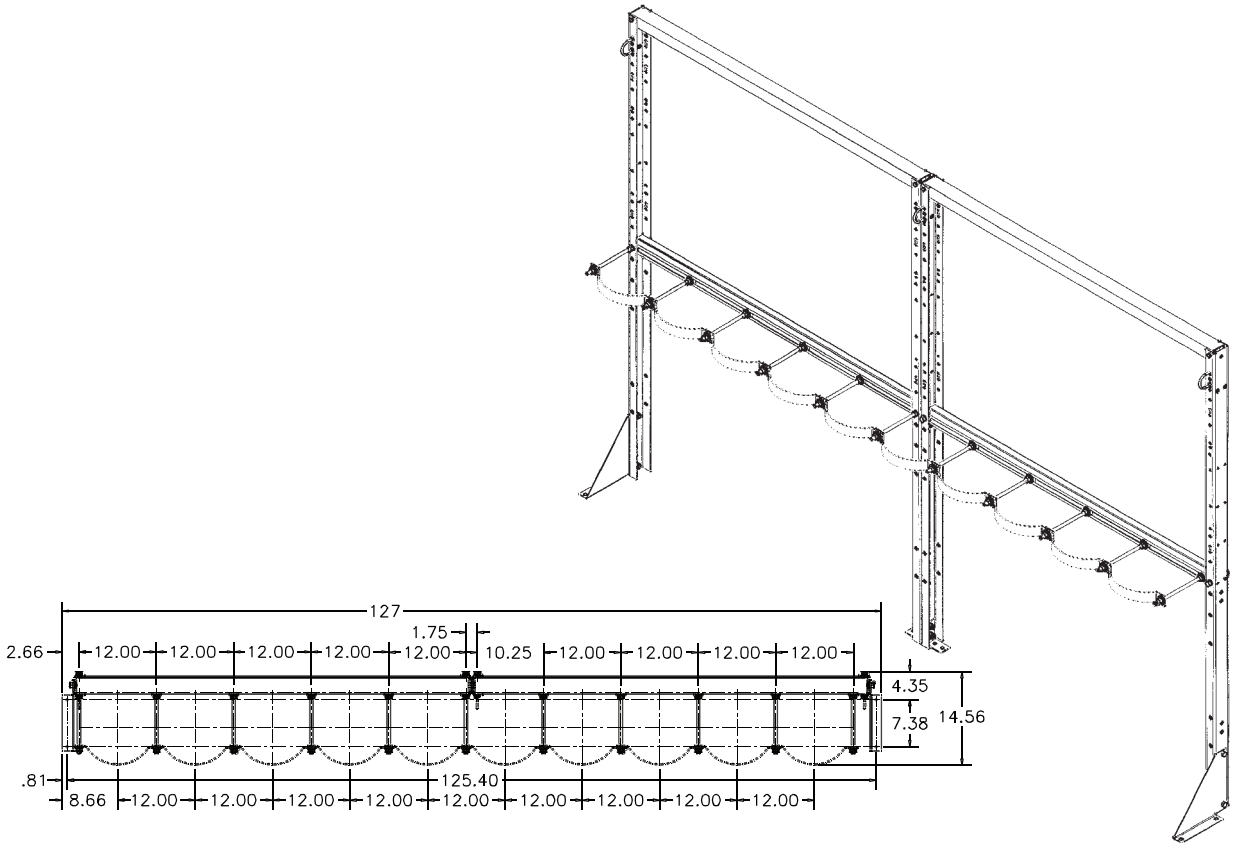


Figure 6-19. One-Row, One-Side Cylinder Rack - 10 Cylinder Rack Assembly Shown

Table 6-11. Cylinder Rack Kits, One Row/One Side, 2 through 5 Cylinders

Item #	Description	2 Cylinder P/N 38-109809-001		3 Cylinder P/N 38-109810-001		4 Cylinder P/N 38-109811-001		5 Cylinder P/N 38-109812-001	
		Qty.	Part Number	Qty.	Part Number	Qty.	Part Number	Qty.	Part Number
1	Header	1	38-503075-001	1	38-503075-002	1	38-503075-003	1	38-503075-004
2	3/8 in. - 16 in. x 1 in. HHDCS	2	38-503076-001	2	38-503076-001	2	38-503076-001	2	38-503076-001
3	3/8 in. Lockwasher	2	38-503077-001	2	38-503077-001	2	38-503077-001	2	38-503077-001
4	3/8 in. - 16 HEX Nut	2	38-503078-001	2	38-503078-001	2	38-503078-001	2	38-503078-001
5	U-Bolt	2	38-503079-003	2	38-503079-003	2	38-503079-003	2	38-503079-003
6	U-Bolt Lockwasher	4	38-503080-001	4	38-503080-001	4	38-503080-001	4	38-503080-001
7	Upright	2	38-503081-001	2	38-503081-001	2	38-503081-001	2	38-503081-001
8	Rail	1	38-503074-001	1	38-503074-002	1	38-503074-003	1	38-503074-004
9	1/2 in. -13 Channel Nut	5	38-503082-001	6	38-503082-001	7	38-503082-001	8	38-503082-001
10	1/2 in. Lockwasher	12	38-503083-001	14	38-503083-001	16	38-503083-001	18	38-503083-001
11	Stud (Threaded Rod)	3	38-503084-001	4	38-503084-001	5	38-503084-001	6	38-503084-001
12	1/2 in. Flat Washer	4	38-503085-001	6	38-503085-001	8	38-503085-001	10	38-503085-001
13	1/2 in. - 13 HEX Nut	10	38-503086-001	12	38-503086-001	14	38-503086-001	16	38-503086-001
14	Cylinder Strap	2	38-503087-001	3	38-503087-001	4	38-503087-001	5	38-503087-001
15	Brace, Left Side	1	38-503088-001	1	38-503088-001	1	38-503088-001	1	38-503088-001
16	Brace, Right Side	1	38-503089-001	1	38-503089-001	1	38-503089-001	1	38-503089-001
17	1/2 in. -13 x 1 in. HHDCS	6	38-503090-001	6	38-503090-001	6	38-503090-001	6	38-503090-001
18	1/2 in. -13 x 1½ in. HHDCS	–	–	–	–	–	–	–	–
19	Rail Support	–	–	–	–	–	–	–	–
20	Rail	–	–	–	–	–	–	–	–
21	Header	–	–	–	–	–	–	–	–

Table 6-12. Cylinder Rack Kits, One Row/One Side, 6 through 9 Cylinders

Item #	Description	6 Cylinder P/N 38-109813-001		7 Cylinder P/N 38-109814-001		8 Cylinder P/N 38-109815-001		9 Cylinder P/N 38-109816-001	
		Qty.	Part Number	Qty.	Part Number	Qty.	Part Number	Qty.	Part Number
1	Header	1	38-503075-005	1	38-503075-002	2	38-503075-003	1	38-503075-003
2	3/8 in. - 16 in. x 1 in. HHDCS	2	38-503076-001	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in. Lockwasher	2	38-503077-001	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 HEX Nut	2	38-503078-001	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	2	38-503079-003	3	38-503079-002	3	38-503079-002	3	38-503079-002
6	U-Bolt Lockwasher	4	38-503080-001	6	38-503080-002	6	38-503080-002	6	38-503080-002
7	Upright	2	38-503081-001	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	1	38-503074-005	1	38-503074-003	2	38-503074-003	1	38-503074-003
9	1/2 in. -13 Channel Nut	9	38-503082-001	15	38-503082-001	15	38-503082-001	16	38-503082-001
10	1/2 in. Lockwasher	20	38-503083-001	30	38-503083-001	32	38-503083-001	34	38-503083-001
11	Stud (Threaded Rod)	7	38-503084-001	9	38-503084-001	9	38-503084-001	10	38-503084-001
12	1/2 in. Flat Washer	12	38-503085-001	14	38-503085-001	16	38-503085-001	18	38-503085-001
13	1/2 in. - 13 HEX Nut	18	38-503086-001	26	38-503086-001	28	38-503086-001	30	38-503086-001
14	Cylinder Strap	6	38-503087-001	7	38-503087-001	8	38-503087-001	9	38-503087-001
15	Brace, Left Side	1	38-503088-001	1	38-503088-001	1	38-503088-001	1	38-503088-001
16	Brace, Right Side	1	38-503089-001	1	38-503089-001	1	38-503089-001	1	38-503089-001
17	1/2 in. -13 x 1 in. HHDCS	6	38-503090-001	13	38-503090-001	12	38-503090-001	12	38-503090-001
18	1/2 in. -13 x 1½ in. HHDCS	–	–	2	38-503091-001	2	38-503091-001	2	38-503091-001
19	Rail Support	–	–	2	38-503092-001	2	38-503092-001	2	38-503092-001
20	Rail	–	–	1	38-503074-002	–	–	1	38-503074-004
21	Header	–	–	1	38-503075-003	–	–	1	38-503075-004

Table 6-13. Cylinder Rack Kits, One Row/One Side, 10 through12 Cylinders

Item #	Description	10 Cylinder P/N 20980016		11 Cylinder P/N 20980018		12 Cylinder P/N 20980019	
		Qty	P/N	Qty	P/N	Qty	P/N
1	Header	2	38-503075-004	1	38-503075-004	2	38-503075-005
2	3/8 in. -16 x 1 in. HHDCS	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in Lockwasher	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 Hex Nut	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	3	38-503079-002	3	38-503079-001	3	38-503079-001
6	U-Bolt Lockwasher	6	38-503080-002	6	38-503080-002	6	38-503080-002
7	Upright	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	2	38-503074-004	1	38-503074-004	2	38-503074-005
9	1/2 in. - 13 Channel Nut	17	38-503082-001	18	38-503082-001	19	38-503082-001
10	1/2 in. Lockwasher	36	38-503083-001	38	38-503083-001	40	38-503083-001
11	Stud (Threaded Rod)	11	38-503084-001	12	38-503084-001	13	38-503084-001
12	1/2 in. Flat Washer	20	38-503085-001	22	38-503085-001	24	38-503085-001
13	1/2 in- 13 Hex Nut	32	38-503086-001	34	38-503086-001	36	38-503086-001
14	Cylinder Strap	10	38-503087-001	11	38-503087-001	12	38-503087-001
15	Brace Left Side	1	38-503088-001	1	38-503088-001	1	38-503088-001
16	Brace Right Side	1	38-503089-001	1	38-503089-001	1	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	12	38-503090-001	12	38-503090-001	12	38-503090-001
18	1/2 in. - 13 x 1-1/2 in. HHDCS	2	38-503091-001	2	38-503091-001	2	38-503091-001
19	Rail Support	2	38-503092-001	2	38-503092-001	2	38-503092-001
20	Rail	–	–	1	38-503074-005	–	–
21	Header	–	–	1	38-503075-005	–	–

6-8.2.2 One Row/Two Sides Cylinder Racks

Table 6-14. Rack Sizes and Part Numbers

Rack Size	Part Number
3 or 4 cylinders	38-109820-001
5 or 6 cylinders	38-109821-001
7 or 8 cylinders	38-109822-001
9 or 10 cylinders	38-109823-001
11 or 12 cylinders	38-109824-001
13 or 14 cylinders	38-109825-001
15 or 16 cylinders	38-109826-001
17 or 18 cylinders	38-109827-001
19 or 20 cylinders	38-109828-001
21 or 22 cylinders	38-109829-001
23 or 24 cylinders	38-109830-001

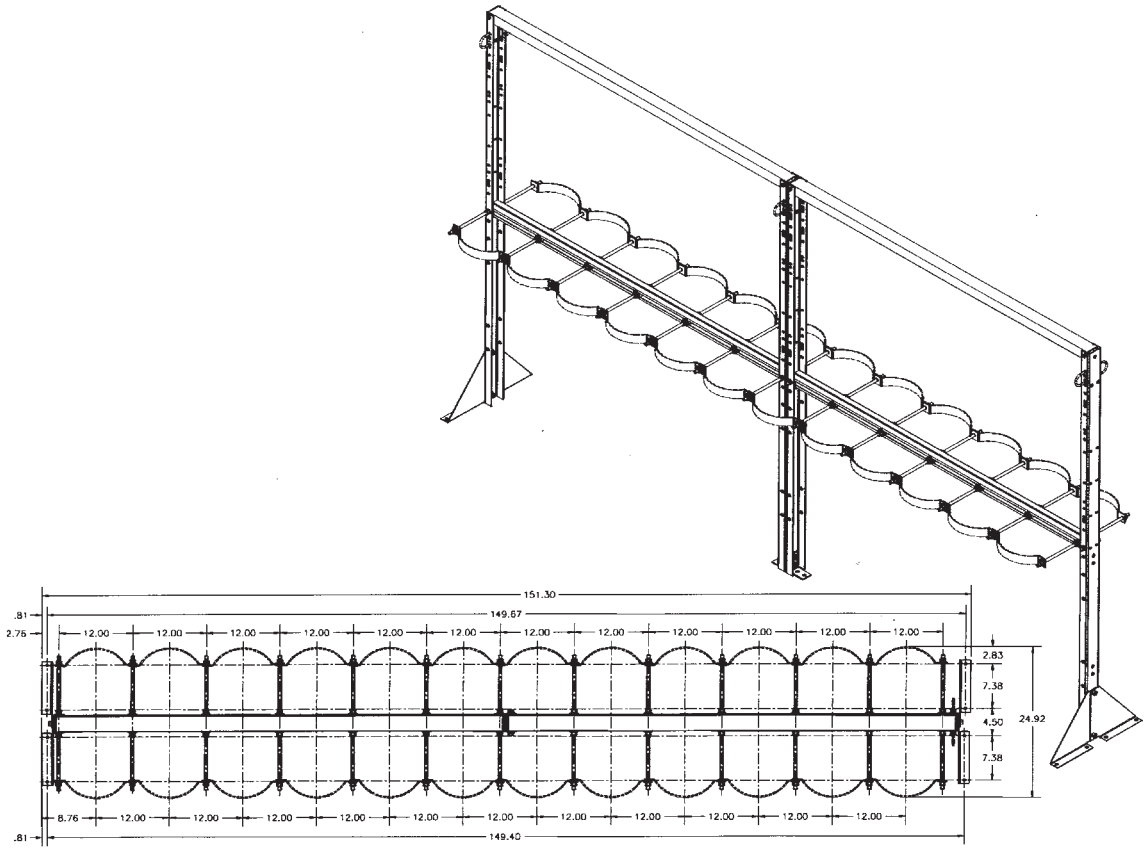


Figure 6-20. One Row/Two Sides Cylinder Rack- 24 Cylinder Rack Assembly Shown

Table 6-15. Cylinder Rack Kits- One Row/Two Sides, 3 through 10 Cylinders

Item #	Description	3 or 4 Cylinders P/N 38-109820-001		5 or 6 Cylinders P/N 38-109821-001		7 or 8 Cylinders P/N 38-109822-001		9 or 10 Cylinders P/N 38-109823-001	
		Qty	P/N	Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-001	1	38-503075-002	1	38-503075-003	1	38-503075-004
2	3/8 in. -16 x 1 in. HHDCS	2	38-503076-001	2	38-503076-001	2	38-503076-001	2	38-503076-001
3	3/8 in Lockwasher	2	38-503077-001	2	38-503077-001	2	38-503077-001	2	38-503077-001
4	3/8 in. - 16 Hex Nut	2	38-503078-001	2	38-503078-001	2	38-503078-001	2	38-503078-001
5	U-Bolt	4	38-503079-003	4	38-503079-003	4	38-503079-003	4	38-503079-003
6	U-Bolt Lockwasher	8	38-503080-001	8	38-503080-001	8	38-503080-001	8	38-503080-001
7	Upright	2	38-503081-001	2	38-503081-001	2	38-503081-001	2	38-503081-001
8	Rail	1	38-503074-001	1	38-503074-002	1	38-503074-003	1	38-503074-004
9	1/2 in. - 13 Channel Nut	6	38-503082-001	8	38-503082-001	10	38-503082-001	12	38-503082-001
10	1/2 in. Lockwasher	16	38-503083-001	20	38-503083-001	24	38-503083-001	28	38-503083-001
11	Stud (Threaded Rod)	6	38-503084-001	8	38-503084-001	10	38-503084-001	12	38-503084-001
12	1/2 in. Flat Washer	8	38-503085-001	12	38-503085-001	16	38-503085-001	20	38-503085-001
13	1/2 in- 13 Hex Nut	16	38-503086-001	20	38-503086-001	24	38-503086-001	28	38-503086-001
14	Cylinder Strap	4	38-503087-001	6	38-503087-001	8	38-503087-001	10	38-503087-001
15	Brace Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	4	38-503090-001	4	38-503090-001	4	38-503090-001	4	38-503090-001
18	1/2 in. - 13 x 1-1/2 in. HHDCS	-	-	-	-	-	-	-	-
19	Rail Support	-	-	-	-	-	-	-	-
20	Rail	-	-	-	-	-	-	-	-
21	Header	-	-	-	-	-	-	-	-

Table 6-16. Cylinder Rack Kits- One Row/Two Sides, 11 through 18 Cylinders

Item #	Description	11 or 12 Cylinders P/N 38-109824-001		13 or 14 Cylinders P/N 38-109825-001		15 or 16 Cylinders P/N 38-109826-001		17 or 18 Cylinders P/N 38-109827-001	
		Qty	P/N	Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-005	1	38-503075-002	2	38-503075-003	1	38-503075-003
2	3/8 in. -16 x 1 in. HHDCS	2	38-503076-001	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in Lockwasher	2	38-503077-001	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 Hex Nut	2	38-503078-001	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	4	38-503079-003	6	38-503079-002	6	38-503079-002	6	38-503079-002
6	U-Bolt Lockwasher	8	38-503080-001	12	38-503080-002	12	38-503080-002	12	38-503080-002
7	Upright	2	38-503081-001	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	1	38-503074-005	1	38-503074-003	2	38-503074-003	1	38-503074-003
9	1/2 in. - 13 Channel Nut	14	38-503082-001	20	38-503082-001	22	38-503082-001	24	38-503082-001
10	1/2 in. Lockwasher	32	38-503083-001	46	38-503083-001	50	38-503083-001	52	38-503083-001
11	Stud (Threaded Rod)	14	38-503084-001	16	38-503084-001	9	38-503084-001	20	38-503084-001
12	1/2 in. Flat Washer	24	38-503085-001	30	38-503085-001	34	38-503085-001	36	38-503085-001
13	1/2 in- 13 Hex Nut	32	38-503086-001	46	38-503086-001	44	38-503086-001	48	38-503086-001
14	Cylinder Strap	12	38-503087-001	14	38-503087-001	16	38-503087-001	18	38-503087-001
15	Brace Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	4	38-503090-001	4	38-503090-001	12	38-503090-001	12	38-503090-001
18	1/2 in. - 13 x 1-1/2 in. HHDCS	-	-	4	38-503091-001	2	38-503091-001	2	38-503091-001
19	Rail Support	-	-	2	38-503092-001	2	38-503092-001	2	38-503092-001
20	Rail	-	-		38-503074-002	-	-	1	38-503074-004
21	Header	-	-	1	38-503075-003	-	-	1	38-503075-004

Table 6-17. Cylinder Rack Kits- One Row/Two Sides, 19 through 24 Cylinders

Item #	Description	19 or 20 Cylinders P/N 38-109828-001		21 or 22 Cylinders P/N 38-109829-001		23 or 24 Cylinders P/N 38-109830-001	
		Qty	P/N	Qty	P/N	Qty	P/N
1	Header	2	38-503075-004	1	38-503075-004	2	38-503075-005
2	3/8 in. -16 x 1 in. HHDCS	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in Lockwasher	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 Hex Nut	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	6	38-503079-002	6	38-503079-001	6	38-503079-001
6	U-Bolt Lockwasher	12	38-503080-002	12	38-503080-001	12	38-503080-001
7	Upright	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	2	38-503074-004	1	38-503074-004	2	38-503074-005
9	1/2 in. - 13 Channel Nut	26	38-503082-001	28	38-503082-001	30	38-503082-001
10	1/2 in. Lockwasher	56	38-503083-001	62	38-503083-001	64	38-503083-001
11	Stud (Threaded Rod)	22	38-503084-001	24	38-503084-001	26	38-503084-001
12	1/2 in. Flat Washer	40	38-503085-001	46	38-503085-001	48	38-503085-001
13	1/2 in- 13 Hex Nut	52	38-503086-001	56	38-503086-001	60	38-503086-001
14	Cylinder Strap	20	38-503087-001	22	38-503087-001	24	38-503087-001
15	Brace Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	12	38-503090-001	12	38-503090-001	12	38-503090-001
18	1/2 in. - 13 x 1-1/2 in. HHDCS	2	38-503091-001	2	38-503091-001	2	38-503091-001
19	Rail Support	2	38-503092-001	2	38-503092-001	2	38-503092-001
20	Rail	-	–	1	38-503074-005	-	–
21	Header	-	–	1	38-503075-005	-	–

6-8.2.3 Two Rows/One Side Cylinder Racks

Table 6-18. Rack Sizes and Part Numbers

Rack Size	Part Number
3 or 4 cylinders	38-109831-001
5 or 6 cylinders	38-109832-001
7 or 8 cylinders	38-109833-001
9 or 10 cylinders	38-109834-001
11 or 12 cylinders	38-109835-001
13 or 14 cylinders	38-109836-001
15 or 16 cylinders	38-109837-001
17 or 18 cylinders	38-109838-001
19 or 20 cylinders	38-109839-001
21 or 22 cylinders	38-109840-001
23 or 24 cylinders	38-109841-001

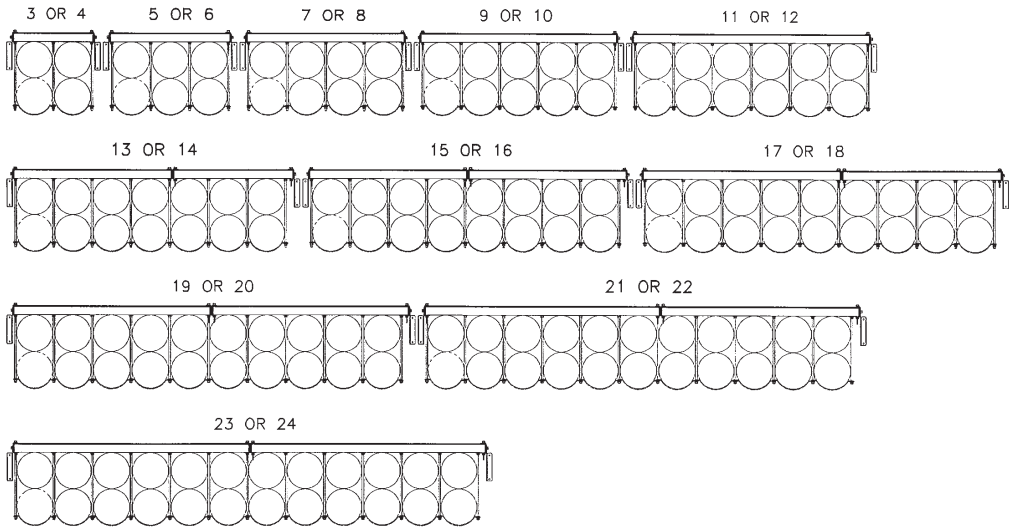


Figure 6-21. Two Rows/One Side Cylinder Racks

Table 6-19. Cylinder Rack Kits- Two Rows/One Side, 3 through 10 Cylinders

Item #	Description	3 or 4 Cylinders P/N 38-109831-001		5 or 6 Cylinders P/N 38-109832-001		7 or 8 Cylinders P/N 38-109833-001		9 or 10 Cylinders P/N 38-109834-001	
		Qty	P/N	Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-001	1	38-503075-002	1	38-503075-003	1	38-503075-004
2	3/8 in. -16 x 1 in. HHDCS	2	38-503076-001	2	38-503076-001	2	38-503076-001	2	38-503076-001
3	3/8 in Lockwasher	2	38-503077-001	2	38-503077-001	2	38-503077-001	2	38-503077-001
4	3/8 in. - 16 Hex Nut	2	38-503078-001	2	38-503078-001	2	38-503078-001	2	38-503078-001
5	U-Bolt	2	38-503079-003	2	38-503079-002	2	38-503079-002	2	38-503079-002
6	U-Bolt Lockwasher	2	38-503080-001	4	38-503080-002	4	38-503080-002	4	38-503080-002
7	Upright	2	38-503081-001	2	38-503081-001	2	38-503081-001	2	38-503081-001
8	Rail	1	38-503074-001	1	38-503074-002	1	38-503074-003	1	38-503074-004
9	1/2 in. - 13 Channel Nut	5	38-503082-001	6	38-503082-001	7	38-503082-001	8	38-503082-001
10	1/2 in. Lockwasher	17	38-503083-001	19	38-503083-001	21	38-503083-001	23	38-503083-001
11	Stud (Threaded Rod)	3	38-503084-002	4	38-503084-002	5	38-503084-002	6	38-503084-002
12	1/2 in. Flat Washer	5	38-503085-001	7	38-503085-001	9	38-503085-001	11	38-503085-001
13	1/2 in- 13 Hex Nut	15	38-503086-001	17	38-503086-001	19	38-503086-001	21	38-503086-001
14	Cylinder Strap	2	38-503087-001	3	38-503087-001	4	38-503087-001	5	38-503087-001
15	Brace Left Side	1	38-503088-001	1	38-503088-001	1	38-503088-001	1	38-503088-001
16	Brace Right Side	1	38-503089-001	1	38-503089-001	1	38-503089-001	1	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	10	38-503090-001	10	38-503090-001	10	38-503090-001	10	38-503090-001
18	Manifold Mounting Bracket	2	38-503093-001	2	38-503093-001	2	38-503093-001	2	38-503093-001
19	Stud (Short Rod)	1	38-503084-001	1	38-503084-001	1	38-503084-001	1	38-503084-001

Table 6-20. Cylinder Rack Kits- Two Rows/One Side, 11 through 18 Cylinders

Item #	Description	11 or 12 Cylinders P/N 38-109835-001		13 or 14 Cylinders P/N 38-109836-001		15 or 16 Cylinders P/N 38-109837-001		17 or 18 Cylinders P/N 38-109838-001	
		Qty	P/N	Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-005	1	38-503075-002	2	38-503075-003	1	38-503075-003
2	3/8 in. -16 x 1 in. HHDCS	2	38-503076-001	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in Lockwasher	2	38-503077-001	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 Hex Nut	2	38-503078-001	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	2	38-503079-001	3	38-503079-001	3	38-503079-001	3	38-503079-001
6	U-Bolt Lockwasher	4	38-503080-002	6	38-503080-002	6	38-503080-002	6	38-503080-002
7	Upright	2	38-503081-001	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	1	38-503074-005	1	38-503074-003	2	38-503074-003	1	38-503074-003
9	1/2 in. - 13 Channel Nut	9	38-503082-001	14	38-503082-001	15	38-503082-001	16	38-503082-001
10	1/2 in. Lockwasher	25	38-503083-001	37	38-503083-001	39	38-503083-001	41	38-503083-001
11	Stud (Threaded Rod)	7	38-503084-002	8	38-503084-002	9	38-503084-002	10	38-503084-002
12	1/2 in. Flat Washer	13	38-503085-001	15	38-503085-001	17	38-503085-001	19	38-503085-001
13	1/2 in- 13 Hex Nut	23	38-503086-001	31	38-503086-001	33	38-503086-001	35	38-503086-001
14	Cylinder Strap	6	38-503087-001	7	38-503087-001	8	38-503087-001	9	38-503087-001
15	Brace Left Side	1	38-503088-001	1	38-503088-001	1	38-503088-001	1	38-503088-001
16	Brace Right Side	1	38-503089-001	1	38-503089-001	1	38-503089-001	1	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	10	38-503090-001	18	38-503090-001	18	38-503090-001	18	38-503090-001
18	Manifold Mounting Bracket	2	38-503093-001	3	38-503093-001	3	38-503093-001	3	38-503093-001
19	Stud (Short Rod)	1	38-503084-001	1	38-503084-001	1	38-503084-001	1	38-503084-001
20	1/2 in. -13 x 1½ in. HHDCS	-	-	2	38-503091-001	2	38-503091-001	2	38-503091-001
21	Rail Support	-	-	2	38-503092-001	2	38-503092-001	2	38-503092-001
22	Rail	-	-	1	38-503074-002	–	–	1	38-503074-004
23	Header	-	-	1	38-503075-003	–	–	1	38-503075-004

Table 6-21. Cylinder Rack Kits- Two Rows/One Side, 19 through 24 Cylinders

Item #	Description	19 or 20 Cylinders P/N 38-109839-001		21 or 22 Cylinders P/N 38-109840-001		23 or 24 Cylinders P/N 38-109841-001	
		Qty	P/N	Qty	P/N	Qty	P/N
1	Header	2	38-503075-004	1	38-503075-004	2	38-503075-005
2	3/8 in. -16 x 1 in. HHDCS	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in Lockwasher	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 Hex Nut	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	3	38-503079-001	3	38-503079-001	3	38-503079-001
6	U-Bolt Lockwasher	6	38-503080-002	6	38-503080-002	6	38-503080-002
7	Upright	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	2	38-503074-004	1	38-503074-004	2	38-503074-005
9	1/2 in. - 13 Channel Nut	17	38-503082-001	18	38-503082-001	19	38-503082-001
10	1/2 in. Lockwasher	43	38-503083-001	45	38-503083-001	47	38-503083-001
11	Stud (Threaded Rod)	11	38-503084-002	12	38-503084-002	13	38-503084-002
12	1/2 in. Flat Washer	21	38-503085-001	23	38-503085-001	25	38-503085-001
13	1/2 in- 13 Hex Nut	37	38-503086-001	39	38-503086-001	41	38-503086-001
14	Cylinder Strap	10	38-503087-001	11	38-503087-001	12	38-503087-001
15	Brace Left Side	1	38-503088-001	1	38-503088-001	1	38-503088-001
16	Brace Right Side	1	38-503089-001	1	38-503089-001	1	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	18	38-503090-001	18	38-503090-001	18	38-503090-001
18	1/2 in. - 13 x 1-1/2 in. HHDCS	3	38-503093-001	3	38-503093-001	3	38-503093-001
19	Rail Support	1	38-503084-001	1	38-503084-001	1	38-503084-001
20	1/2 in. -13 x 1½ in. HHDCS	2	38-503091-001	2	38-503091-001	2	38-503091-001
21	Rail Support	2	38-503092-001	2	38-503092-001	2	38-503092-001
22	Rail	–	–	1	38-503074-005	–	–
23	Header	–	–	1	38-503075-005	–	–

6-8.2.4 Two Rows/Two Sides Cylinder Racks

Table 6-22. Rack Sizes and Part Numbers

Rack Size	Part Number
11 or 12 cylinders	38-109842-001
13 or 14 cylinders	38-109843-001
15 or 16 cylinders	38-109844-001
17 or 18 cylinders	38-109845-001
19 or 20 cylinders	38-109846-001
21 or 22 cylinders	38-109847-001
23 or 24 cylinders	38-109848-001
25 or 26 cylinders	38-109849-001
27 or 28 cylinders	38-109850-001
29 or 30 cylinders	38-109851-001
31 or 32 cylinders	38-109852-001
33 or 34 cylinders	38-109853-001
35 or 36 cylinders	38-109854-001
37 or 38 cylinders	38-109855-001
39 or 40 cylinders	38-109856-001
41 or 42 cylinders	38-109857-001
43 or 44 cylinders	38-109858-001
45 or 46 cylinders	38-109859-001
47 or 48 cylinders	38-109860-001

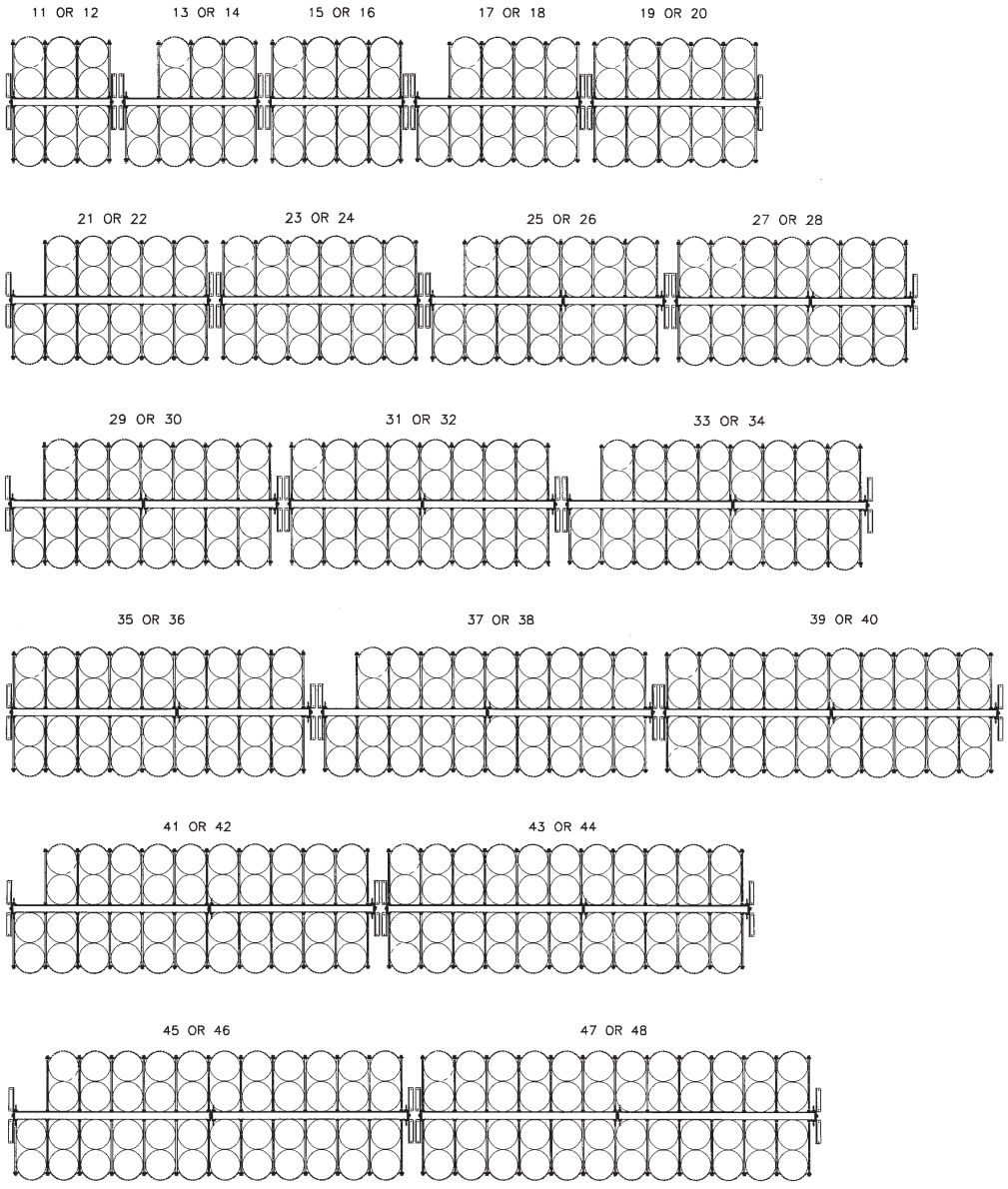


Figure 6-22. Two Rows/Two Sides Cylinder Rack

Table 6-23. Cylinder Rack Kits- Two Rows/Two Sides, 11 through 16 Cylinders

Item #	Description	11 or 12 Cylinders P/N 38-109842-001		13 or 14 Cylinders P/N 38-109843-001		15 or 16 Cylinders P/N 38-109844-001	
		Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-002	1	38-503075-003	1	38-503075-003
2	3/8 in. -16 x 1 in. HHDCS	2	38-503076-001	2	38-503076-001	2	38-503076-001
3	3/8 in Lockwasher	2	38-503077-001	2	38-503077-001	2	38-503077-001
4	3/8 in. - 16 Hex Nut	2	38-503078-001	2	38-503078-001	2	38-503078-001
5	U-Bolt	4	38-503079-001	4	38-503079-001	4	38-503079-001
6	U-Bolt Lockwasher	8	38-503080-002	8	38-503080-002	8	38-503080-002
7	Upright	2	38-503081-001	2	38-503081-001	2	38-503081-001
8	Rail	1	38-503074-002	1	38-503074-003	1	38-503074-003
9	1/2 in. - 13 Channel Nut	8	38-503082-001	10	38-503082-001	10	38-503082-001
10	1/2 in. Lockwasher	12	38-503083-001	33	38-503083-001	33	38-503083-001
11	Stud (Threaded Rod)	8	38-503084-002	10	38-503084-002	10	38-503084-002
12	1/2 in. Flat Washer	13	38-503085-001	15	38-503085-001	17	38-503085-001
13	1/2 in- 13 Hex Nut	29	38-503086-001	33	38-503086-001	33	38-503086-001
14	Cylinder Strap	6	38-503087-001	7	38-503087-001	8	38-503087-001
15	Brace Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	12	38-503090-001	12	38-503090-001	12	38-503090-001
18	Manifold Mounting Bracket	4	38-503093-001	4	38-503093-001	4	38-503093-001
19	Stud (Short Rod)	1	38-503084-001	1	38-503084-001	1	38-503084-001

Table 6-24. Cylinder Rack Kits- Two Rows/Two Sides, 17 through 22 Cylinders

Item #	Description	17 or 18 Cylinders P/N 38-109845-001		19 or 20 Cylinders P/N 38-109846-001		21 or 22 Cylinders P/N 38-109847-001	
		Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-004	1	38-503075-004	1	38-503075-005
2	3/8 in. -16 x 1 in. HHDCS	2	38-503076-001	2	38-503076-001	2	38-503076-001
3	3/8 in Lockwasher	2	38-503077-001	2	38-503077-001	2	38-503077-001
4	3/8 in. - 16 Hex Nut	2	38-503078-001	2	38-503078-001	2	38-503078-001
5	U-Bolt	4	38-503079-001	4	38-503079-001	4	38-503079-001
6	U-Bolt Lockwasher	8	38-503080-002	8	38-503080-002	8	38-503080-002
7	Upright	2	38-503081-001	2	38-503081-001	2	38-503081-001
8	Rail	1	38-503074-004	1	38-503074-004	1	38-503074-005
9	1/2 in. - 13 Channel Nut	12	38-503082-001	12	38-503082-001	14	38-503082-001
10	1/2 in. Lockwasher	36	38-503083-001	37	38-503083-001	40	38-503083-001
11	Stud (Threaded Rod)	11	38-503084-002	12	38-503084-002	13	38-503084-002
12	1/2 in. Flat Washer	20	38-503085-001	21	38-503085-001	24	38-503085-001
13	1/2 in- 13 Hex Nut	36	38-503086-001	37	38-503086-001	39	38-503086-001
14	Cylinder Strap	9	38-503087-001	10	38-503087-001	11	38-503087-001
15	Brace Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. - 13 x 1 in. HHDCS	12	38-503090-001	12	38-503090-001	12	38-503090-001
18	Manifold Mounting Bracket	4	38-503093-001	4	38-503093-001	4	38-503093-001
19	Stud (Short Rod)	1	38-503084-001	1	38-503084-001	1	38-503084-001

Table 6-25. Cylinder Rack Kits- Two Rows/Two Sides, 23 through 28 Cylinders

Item #	Description	23 or 24 Cylinders P/N 38-109848-001		25 or 26 Cylinders P/N 38-109849-001		27 or 28 Cylinders P/N 38-109850-001	
		Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-005	1	38-503075-003	1	38-503075-003
2	3/8 in. - 16 in. x 1 in. HHDCS	2	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in. Lockwasher	2	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 HEX Nut	2	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	4	38-503079-001	6	38-503079-001	6	38-503079-001
6	U-Bolt Lockwasher	8	38-503080-002	12	38-503080-002	12	38-503080-002
7	Upright	2	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	2	38-503074-005	1	38-503074-003	1	38-503074-003
9	1/2 in. -13 Channel Nut	14	38-503082-001	20	38-503082-001	20	38-503082-001
10	1/2 in. Lockwasher	39	38-503083-001	51	38-503083-001	57	38-503083-001
11	Stud (Threaded Rod)	14	38-503084-002	15	38-503084-002	16	38-503084-002
12	1/2 in. Flat Washer	22	38-503085-001	28	38-503085-001	29	38-503085-001
13	1/2 in. - 13 HEX Nut	39	38-503086-001	51	38-503086-001	53	38-503086-001
14	Cylinder Strap	12	38-503087-001	13	38-503087-001	14	38-503087-001
15	Brace, Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace, Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. -13 x 1 in. HHDCS	12	38-503090-001	16	38-503090-001	22	38-503090-001
18	Manifold Mounting Bracket	4	38-503093-001	6	38-503093-001	6	38-503093-001
19	1/2 in. -13 x 1½" HHDCS	–	–	2	38-503091-001	2	38-503091-001
20	Rail Support	–	–	2	38-503092-001	2	38-503092-001
21	Rail	–	–	1	38-503074-002	1	38-503074-002
22	Header	–	–	1	38-503075-002	1	38-503075-002
23	Stud	1	38-503084-001	1	38-503084-001	1	38-503084-001

Table 6-26. Cylinder Rack Kits- Two Rows/Two Sides, 29 through 34 Cylinders

Item #	Description	29 or 30 Cylinders P/N 38-109851-001		31 or 32 Cylinders P/N 38-109852-001		33 or 34 Cylinders P/N 38-109853-001	
		Qty	P/N	Qty	P/N	Qty	P/N
1	Header	2	38-503075-003	2	38-503075-003	1	38-503075-004
2	3/8 in. - 16 in. x 1 in. HHDCS	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in. Lockwasher	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 HEX Nut	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	6	38-503079-001	6	38-503079-001	6	38-503079-001
6	U-Bolt Lockwasher	12	38-503080-002	12	38-503080-002	12	38-503080-002
7	Upright	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	2	38-503074-003	2	38-503074-003	1	38-503074-004
9	1/2 in. -13 Channel Nut	22	38-503082-001	22	38-503082-001	24	38-503082-001
10	1/2 in. Lockwasher	60	38-503083-001	59	38-503083-001	63	38-503083-001
11	Stud (Threaded Rod)	17	38-503084-002	18	38-503084-002	19	38-503084-002
12	1/2 in. Flat Washer	32	38-503085-001	33	38-503085-001	35	38-503085-001
13	1/2 in. - 13 HEX Nut	55	38-503086-001	57	38-503086-001	58	38-503086-001
14	Cylinder Strap	15	38-503087-001	16	38-503087-001	17	38-503087-001
15	Brace, Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace, Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. -13 x 1 in. HHDCS	23	38-503090-001	22	38-503090-001	23	38-503090-001
18	Manifold Mounting Bracket	6	38-503093-001	6	38-503093-001	6	38-503093-001
19	1/2 in. -13 x 1½" HHDCS	2	38-503091-001	2	38-503091-001	2	38-503091-001
20	Rail Support	2	38-503092-001	2	38-503092-001	2	38-503092-001
21	Rail	–	–	–	–	1	38-503074-003
22	Header	–	–	–	–	1	38-503075-003
23	Stud	1	38-503084-001	1	38-503084-001	1	38-503084-001

Table 6-27. Cylinder Rack Kits- Two Rows/Two Sides, 35 through 40 Cylinders

Item #	Description	35 or 36 Cylinders P/N 38-109854-001		37 or 38 Cylinders P/N 38-109855-001		39 or 40 Cylinders P/N 38-109856-001	
		Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-004	2	38-503075-004	2	38-503075-004
2	3/8 in. - 16 in. x 1 in. HHDCS	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in. Lockwasher	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 HEX Nut	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	6	38-503079-001	6	38-503079-001	6	38-503079-001
6	U-Bolt Lockwasher	12	38-503080-002	12	38-503080-002	12	38-503080-002
7	Upright	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	1	38-503074-004	2	38-503074-004	2	38-503074-004
9	1/2 in. -13 Channel Nut	24	38-503082-001	26	38-503082-001	26	38-503082-001
10	1/2 in. Lockwasher	64	38-503083-001	67	38-503083-001	68	38-503083-001
11	Stud (Threaded Rod)	20	38-503084-002	21	38-503084-002	22	38-503084-002
12	1/2 in. Flat Washer	36	38-503085-001	39	38-503085-001	40	38-503085-001
13	1/2 in. - 13 HEX Nut	60	38-503086-001	62	38-503086-001	64	38-503086-001
14	Cylinder Strap	18	38-503087-001	19	38-503087-001	20	38-503087-001
15	Brace, Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace, Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. -13 x 1 in. HHDCS	22	38-503090-001	23	38-503090-001	22	38-503090-001
18	Manifold Mounting Bracket	6	38-503093-001	6	38-503093-001	6	38-503093-001
19	1/2 in. -13 x 1½" HHDCS	2	38-503091-001	2	38-503091-001	2	38-503091-001
20	Rail Support	2	38-503092-001	2	38-503092-001	2	38-503092-001
21	Rail	1	38-503074-003	–	–	–	–
22	Header	1	38-503075-003	–	–	–	–
23	Stud	1	38-503084-001	1	38-503084-001	1	38-503084-001

Table 6-28. Cylinder Rack Kits- Two Rows/Two Sides, 41 through 48 Cylinders

Item #	Description	41 or 42 Cylinders P/N 38-109857-001		43 or 44 Cylinders P/N 38-109858-001		45 or 46 Cylinders P/N 38-109859-001		47 or 48 Cylinders P/N 38-109860-001	
		Qty	P/N	Qty	P/N	Qty	P/N	Qty	P/N
1	Header	1	38-503075-005	1	38-503075-005	2	38-503075-005	2	38-503075-005
2	3/8 in. - 16 in. x 1 in. HHDCS	4	38-503076-001	4	38-503076-001	4	38-503076-001	4	38-503076-001
3	3/8 in. Lockwasher	4	38-503077-001	4	38-503077-001	4	38-503077-001	4	38-503077-001
4	3/8 in. - 16 HEX Nut	4	38-503078-001	4	38-503078-001	4	38-503078-001	4	38-503078-001
5	U-Bolt	6	38-503079-001	6	38-503079-001	6	38-503079-001	6	38-503079-001
6	U-Bolt Lockwasher	12	38-503080-002	12	38-503080-002	12	38-503080-002	12	38-503080-002
7	Upright	4	38-503081-001	4	38-503081-001	4	38-503081-001	4	38-503081-001
8	Rail	2	38-503074-005	1	38-503074-005	2	38-503074-005	2	38-503074-005
9	1/2 in. -13 Channel Nut	28	38-503082-001	28	38-503082-001	30	38-503082-001	30	38-503082-001
10	1/2 in. Lockwasher	71	38-503083-001	72	38-503083-001	75	38-503083-001	76	38-503083-001
11	Stud (Threaded Rod)	23	38-503084-002	24	38-503084-002	25	38-503084-002	26	38-503084-002
12	1/2 in. Flat Washer	43	38-503085-001	44	38-503085-001	47	38-503085-001	48	38-503085-001
13	1/2 in. - 13 HEX Nut	68	38-503086-001	68	38-503086-001	70	38-503086-001	72	38-503086-001
14	Cylinder Strap	21	38-503087-001	22	38-503087-001	23	38-503087-001	24	38-503087-001
15	Brace, Left Side	2	38-503088-001	2	38-503088-001	2	38-503088-001	2	38-503088-001
16	Brace, Right Side	2	38-503089-001	2	38-503089-001	2	38-503089-001	2	38-503089-001
17	1/2 in. -13 x 1 in. HHDCS	23	38-503090-001	22	38-503090-001	23	38-503090-001	22	38-503090-001
18	Manifold Mounting Bracket	6	38-503093-001	6	38-503093-001	6	38-503093-001	6	38-503093-001
19	1/2 in. -13 x 1½" HHDCS	2	38-503091-001	2	38-503091-001	2	38-503091-001	2	38-503091-001
20	Rail Support	2	38-503092-001	2	38-503092-001	2	38-503092-001	2	38-503092-001
21	Rail	1	38-503074-004	1	38-503074-004	–	–	–	–
22	Header	1	38-503075-004	1	38-503075-004	–	–	–	–
23	Stud	1	38-503084-001	1	38-503084-001	1	38-503084-001	1	38-503084-001

CHAPTER 7
SYSTEM DESIGN

The purpose of this chapter is to provide the minimum design requirements for Nitrogen fire extinguishing systems based upon sound engineering principles, current international standards, test data and field experiences. General requirements and design criteria are based on NFPA 2001.

Nothing within this chapter intends to restrict new technologies or findings, providing that the level of safety prescribed is not reduced. This chapter does not cover general requirements and design criteria for fire detection and control systems. Reference should be made to local requirements.

7-1 GENERAL

The Kidde Nitrogen Fire Extinguishing System employs high-purity nitrogen gas as the fire extinguishing agent. (See MSDS in Chapter 8.) This manual addresses the use of Nitrogen Fire Extinguishing Systems in total flooding applications. Individual system designs depend on the characteristics of the protected hazard space and the flammable material involved.

7-2 PHYSICAL PROPERTIES OF NITROGEN

Table 7-1. Physical Properties of Nitrogen

Property	Units	Value
Chemical Formula	N2	
Molecular Weight	g/mol	28.0
Gas Density at 70°F (21.1°C)	lb/ft^3 (kg/m^3)	0.0724 (1.161)
Boiling Point at 14.7 psi	°F (°C)	-320.4 (-195.8)
Critical Temperature	°F (°C)	-147.0
Critical Pressure	psi (kPa)	492.9 (3,399)

7-2.1 Nitrogen Purity

Note: Nitrogen >99.9 vol. %: water < 5 ppm; oxygen < 1 ppm

7-3 EVALUATION OF HAZARD/RISK

The design and installation of a Kidde Nitrogen Fire Extinguishing System requires a thorough evaluation of the hazard to be protected. The hazard to be protected shall be inspected or relevant information and detailed drawings studied.

The following should be considered:

- Integrity of the enclosure.
- Unclosable ventilation and exhaust openings, as their size and location could jeopardize the agent holding time and require additional agent to be discharged over time (extended discharge).
- Volume of unclosable air intake and exhaust ducts.
- Volume of recirculating air-handling equipment including air intake and exhaust ducts.
- Automatic shutdown of forced ventilation upon fire detection. Spring operated fire damper(s) may be taken into consideration when calculating the required pressure relief vent opening.
- A characterization of the type of flammables in the protected enclosure. The fuel having the highest extinguishing concentration shall govern.
- Quantity of flammables expected to be in the enclosure.
- Automatic shutdown of liquid supply systems at fire detection.
- Location of the most probable place for a fire to start.
- Location and volume of open fuel reservoirs. Nozzles should be positioned to avoid a direct discharge onto the fuel surface, which could cause the fuel to splash and spread the fire.
- Evaluation of the worst possible fire scenario
- Possibility of a liquid spill spreading into adjoining hazards?
- Hot surfaces that might cause re-ignition after the holding time and the time required to cool to below the ignition temperature of flammable vapors that could be present.
- Shutdown of electrical equipment prior to agent release.
- Suspended ceiling and/or elevated floor spaces - volume, discharge nozzles.
- Provision for closing doors and windows upon fire detection.
- Adequate pressure relief venting to accommodate the resulting pressure increase caused by discharge of the inert gas agent.
- Planned escape routes.
- Fire detectors, selected based on the type of fire anticipated (response time).
- Audible/visual alarms required.

WARNING **Under certain conditions, it can be dangerous to extinguish a gas jet fire. Provision must be made to cut off the gas supply before agent discharge begins.**

As a general guideline, an extended discharge is not required in a normal, relatively tight enclosure, i.e., EDP rooms with automatic ventilation systems that shut down upon fire detection. However, if the enclosure is too tight, the increased pressure inside the enclosure during/after a discharge will be relatively high.

In order to avoid structural damage due to excessive pressure, pressure relief vents should be provided. The optimal solution would be to have spring operated vents/fire dampers, which will be forced open when the pressure builds up at the beginning/during the discharge and close automatically after the discharge when the pressure dissipates. Enclosure integrity procedures are provided in NFPA 2001, Appendix C.

7-4 EVALUATION OF CYLINDER STORAGE SPACE

The following items must be considered when evaluating the cylinder storage spaces:

- A standard Nitrogen system will operate within a temperature range of -20°F to 130°F (-29° C to +54°C).
- If closed pipe sections are involved, safety reliefs are required for all closed sections of pipe.
- Pressure relief venting.
- Cylinder storage room equipped with proper exhaust ventilation.
- Cylinder storage space.
- Allowance for proper access to cylinders during installation and service/maintenance.
- Floor capable of carrying the load.
- Wall/structure strong enough for mounting wall brackets supports.
- Storage room should not be used for other purposes that could result in fire exposure to cylinders.

7-5 INERTING

Inerting concentrations shall be used where conditions for subsequent re-flash or explosion could exist. These conditions exist when:

- The quantity of fuel expected to be in the enclosure is sufficient to develop a concentration equal to or greater than one-half of the lower flammable limit throughout the enclosure, **and** the volatility of the fuel, before the onset of fire, is sufficient to reach the lower flammable limit in air (maximum ambient temperature or fuel temperature exceeds the closed cup flash point temperature), **or**
- The system cannot respond quickly enough to detect and extinguish the fire before the volatility of the fuel is increased to a dangerous level because of the fire.

The minimum design concentration used to inert atmospheres involving flammable liquids and gasses shall be the inerting concentration times a safety factor of 1.1.

7-6 AGENT CONCENTRATION AND QUANTITY

7-6.1 Minimum Extinguishing Concentration (MEC) and Minimum Design Concentration (MDC)

The primary function of a Kidde Nitrogen Fire Extinguishing System is to extinguish a fire that has been detected within a protected enclosure. This function is satisfied when:

- A sufficient quantity of nitrogen agent is discharged, in a timely manner, into the protected enclosure (also called the "hazard space") to create a fire extinguishing atmosphere, and
- Retain the fire extinguishing atmosphere for a time (the "hold" time) sufficient to allow response by trained personnel.

This section addresses the method of determining the agent quantity required to perform the fire extinguishing function.

NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems (and similar standards such as those based on *ISO 14520 Gaseous fire-extinguishing systems - Physical properties and system design - Part 1:General requirements)* requires that the concentration of extinguishing agent gas be at least "minimum extinguishing concentration" (MEC) times a "safety factor," that depends on the class of fire hazard, which is based on the type of combustible material within the hazard space.

Class B: Fires that involve flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases

Class A: Ordinary solid combustibles such as wood, cloth, paper, rubber, and many plastics

Class C: A fire that involves energized electrical equipment.

7-6.2 Minimum Design Concentration Criteria

The minimum design concentration (MDC) of a gaseous fire extinguishing agent is determined in accordance with the requirements of NFPA 2001 (2015 edition), section 5.4.2 as follows:

Class B: 5.4.2.3 The minimum design concentration for a Class B fuel hazard shall be the extinguishing concentration, as determined in 5.4.2.1*, times a safety factor of 1.3.

Class A: 5.4.2.4 The minimum design concentration for a Class A surface-fire hazard shall be determined by the greater of the following: (1) The extinguishing concentration, as determined in 5.4.2.2**, times a safety factor of 1.2; (2) Equal to the minimum extinguishing concentration for heptane as determined from 5.4.2.1.

Class C: 5.4.2.5 The minimum design concentration for a Class C hazard shall be the extinguishing concentration, as determined in 5.4.2.2, times a safety factor of 1.35.

*Note: The method referenced in NFPA 2001, 5.4.2.1 is the "cup burner" method, which is described in detail in NFPA 2001, Annex B.

**Note: NFPA 2001, 5.4.2.2 states "The flame extinguishing concentration for Class A fuels shall be determined by test as part of a listing program. As a minimum, the listing program shall conform to ANSI/UL 2127 or ANSI/UL 2166 or equivalent."

7-6.3 MEC and MDC Values: NFPA 2001

The values of MEC and MDC for nitrogen agent used in the Kidde Nitrogen Fire Extinguishing System for the three fire types are as follows:

Class B: MEC = 32.2 vol. % (heptane); MDC = 41.9 vol. %*

*Note: MDC for other Class B combustibles is its MEC x 1.3, but not less than 41.9 vol. %.

Class A: MEC = 30 vol. %; MDC = 36 vol. %

Class C: MEC = 30 vol. %; MDC = 40.5 vol. %

7-6.4 MEC and MDC Values: ISO 14520-13 (for agent IG-100 / nitrogen)

The values of MEC and MDC for nitrogen agent used in the Kidde Nitrogen Fire Extinguishing System for the three fire types are as follows:

Class B: MEC = 33.6 vol. % (heptane); MDC = 43.7 vol. %*

*Note: MDC for other Class B combustibles is its MEC x 1.3, but not less than 43.7 vol. %.

Class A: MEC = 31 vol. %; MDC = 40.3 vol. %

High-hazard Class A: MDC = 41.5 vol. %

7-6.5 Determination of Nitrogen Agent Quantity

The quantity of an inert gas agent required for an enclosure at sea level and at a temperature "t" to achieve a concentration "C" can be calculated using one of the following equations.

Use either form of the equation below to calculate the volume of inert gas volume per unit volume of the protected enclosure.

$X = 2.303 * (so/s) * \log10[100/(100-C)]$

$= (so/s) * \ln[100/(100-C)]$

where

C Design concentration of nitrogen inert gas agent in the protected volume, vol. %

s Specific volume of nitrogen at the lowest temperature of the hazard space

so Specific volume of nitrogen at reference temperature, to, and 14.7 psi (1.013 bar)

where s = k1 + k2*t and the values of k1 + k2* depend on the system of units used. See Table 7-2.

t Temperature within the hazard (in °F or °C, see table below)

X Volume of inert gas agent per unit volume of the protected hazard to achieve agent concentration C.

Table 7-2. Specific Volume of nitrogen at reference temperature

U.S. Units		SI Units	
k_1 ft^3/lb	k_2 ft^3/lb-°F	k_1 m^3/kg	k_2 m^3/kg-°C
11.976	0.02606	0.79968	0.00293
Ref. temp. t_o = 70 °F		Ref. temp. t_o = 20 °C	
s_o = 13.80 ft^3/lb		s_o = 0.8615 m^3/kg	

The mass (m) of nitrogen inert gas agent required for a hazard with volume V is given by:

$m = X * V / s$

Alternatively, the mass (m) of nitrogen agent required can be calculated directly using either of the following equations.

$m = 2.303 * (V/s) * \log10[100/(100-C)]$

$= (V/s) * \ln[100/(100-C)]$

where consistent units are used as shown in Table 7-3:

Table 7-3. Units for Mass of Nitrogen Calculation

	US Units	SI Units
m	lb	kg
V	ft^3	m^3
t	F	C
s	ft^3/lb	m^3/kg

Table 7-4 and Table 7-5 contain flooding factors (agent quantity per unit volume of the protected hazard as a function of temperature and at several design concentrations.

Table 7-4. Total Flooding Quantities - Volume Requirements of Nitrogen -Metric - M (Kg/M^3)

Temp (°C)	Design Concentration (% by Volume)						
	34	36	38	40	42	44	48
-30	0.5010	0.5381	0.5764	0.6160	0.6568	0.6992	0.7885
-25	0.4909	0.5273	0.5648	0.6035	0.6436	0.6851	0.7726
-20	0.4812	0.5169	0.5536	0.5916	0.6309	0.6715	0.7573
-15	0.4719	0.5068	0.5429	0.5801	0.6186	0.6585	0.7427
-10	0.4629	0.4972	0.5326	0.5691	0.6069	0.6460	0.7285
-5	0.4543	0.4879	0.5226	0.5585	0.5956	0.6339	0.7149
0	0.4460	0.4790	0.5131	0.5483	0.5846	0.6223	0.7018
5	0.4379	0.4704	0.5038	0.5384	0.5741	0.6111	0.6892
10	0.4302	0.4621	0.4949	0.5289	0.5640	0.6003	0.6770
15	0.4227	0.4540	0.4863	0.5197	0.5542	0.5899	0.6653
20	0.4155	0.4463	0.4780	0.5108	0.5447	0.5798	0.6539
25	0.4085	0.4388	0.4700	0.5023	0.5356	0.5701	0.6430
30	0.4018	0.4316	0.4623	0.4940	0.5267	0.5607	0.6323
35	0.3953	0.4245	0.4547	0.4859	0.5182	0.5516	0.6221
40	0.3890	0.4178	0.4475	0.4782	0.5099	0.5428	0.6121
45	0.3828	0.4112	0.4404	0.4707	0.5019	0.5342	0.6025
50	0.3769	0.4048	0.4336	0.4634	0.4941	0.5260	0.5932
55	0.3712	0.3987	0.4270	0.4563	0.4866	0.5179	0.5841
60	0.3656	0.3927	0.4206	0.4495	0.4793	0.5102	0.5754
65	0.3602	0.3869	0.4144	0.4428	0.4722	0.5026	0.5668
70	0.3549	0.3812	0.4083	0.4363	0.4653	0.4953	0.5586

Table 7-5. Total Flooding Quantities - Volume Requirements of Nitrogen - US Standard-M (Kg/Ft^3)

Temp (°F)	Design Concentration (% by Volume)						
	34	36	38	40	42	44	48
-30	0.5122	0.5502	0.5893	0.6297	0.6715	0.7148	0.8062
-20	0.5006	0.5377	0.5759	0.6154	0.6563	0.6985	0.7878
-10	0.4895	0.5257	0.5631	0.6017	0.6417	0.6830	0.7703
0	0.4788	0.5143	0.5509	0.5886	0.6277	0.6681	0.7535
10	0.4686	0.5033	0.5391	0.5761	0.6143	0.6539	0.7375
20	0.4588	0.4928	0.5279	0.5641	0.6015	0.6403	0.7221
30	0.4495	0.4828	0.5171	0.5526	0.5892	0.6272	0.7074
40	0.4405	0.4731	0.5067	0.5415	0.5774	0.6146	0.6932
50	0.4318	0.4638	0.4968	0.5309	0.5661	0.6026	0.6796
60	0.4235	0.4549	0.4872	0.5207	0.5552	0.5910	0.6665
70	0.4155	0.4463	0.4780	0.5108	0.5447	0.5798	0.6539
80	0.4078	0.4380	0.4692	0.5014	0.5346	0.5691	0.6418
90	0.4004	0.4300	0.4606	0.4922	0.5249	0.5587	0.6301
100	0.3932	0.4224	0.4524	0.4834	0.5155	0.5487	0.6189
110	0.3863	0.4149	0.4445	0.4750	0.5065	0.5391	0.6080
120	0.3797	0.4078	0.4368	0.4668	0.4977	0.5298	0.5975
130	0.3732	0.4009	0.4294	0.4588	0.4893	0.5208	0.5874
140	0.3670	0.3942	0.4222	0.4512	0.4811	0.5121	0.5776
150	0.3610	0.3877	0.4153	0.4438	0.4732	0.5037	0.5681
160	0.3552	0.3815	0.4086	0.4366	0.4656	0.4956	0.5589
180	0.3440	0.3695	0.3958	0.4230	0.4510	0.4801	0.5415

7-7 DESIGN CONCENTRATIONS

7-7.1 NFPA Design Concentrations

- **Class A**: The minimum design concentration for a Class A surface fire hazard shall be the Class A extinguishing concentration times a safety factor of 1.2.
- **Class B**: The minimum design concentration for a Class B fuel hazard or a manual-only actuated system shall be the extinguishing concentration times a safety factor of 1.3.
- **Class C**: The minimum design concentration for Class C hazards shall be the Class A extinguishing concentration times a safety factor of 1.35.

7-7.2 ISO Design Concentrations

In jurisdictions governed by standards based on ISO 14520-1 and ISO-14520-13 (specific to agent IG-100) the minimum design concentrations of nitrogen extinguishing agent are as follows:

- **Class A**: The minimum design concentration for a Class A surface fire hazard shall be the Class A extinguishing concentration times a safety factor of 1.3. The nitrogen Class A MEC is 31%, therefore the Class A minimum design concentration is 40.3 vol. %.
- **Class B**: The minimum design concentration for a Class B fuel hazard shall be the Class B extinguishing concentration times a safety factor of 1.3. The nitrogen Class B MEC (heptane) is 33.6%, therefore the Class B minimum design concentration is 43.7 vol. %.
- **High-Hazard Class A**: The nitrogen minimum design concentration for high-hazard Class A applications (see ISO 145201-1, 7.5.1.3) is 41.5 vol. %.

7-8 DESIGN FACTORS

In addition to the concentration requirement, additional nitrogen agent may be required due to special conditions that would affect the extinguishing efficiency, such as unclosable openings and their effect on distribution and maintaining concentration; re-ignition from heated surfaces; enclosure geometry; and obstructions and their effect on distribution.

7-8.1 Effects of Altitude

At elevations above sea level, Nitrogen expands to a greater specific vapor. A system designed for sea level will develop a greater concentration level at an elevation above sea level. To correct for the effects of a higher elevation, the quantity of agent used should be reduced. The correction factors are listed in Table 7-6

Table 7-6. Elevation Correction Factors

Altitude		Enclosure Pressure		Correction Factor	Altitude		Enclosure Pressure		Correction Factor
feet	meters	psi	cm Hg		feet	meters	psi	cm Hg	
-3,000	-920	16.25	84.0	1.11	4,000	1,220	12.58	65.0	0.86
-2,000	-610	15.71	81.2	1.07	5,000	1,520	12.04	62.2	0.82
-1,000	-300	15.23	78.7	1.04	6,000	1,830	11.53	59.6	0.78
0	0	14.71	76.0	1.00	7,000	2,130	11.03	57.0	0.75
1,000	300	14.18	73.3	0.96	8,000	2,440	10.64	55.0	0.72
2,000	610	13.64	70.5	0.93	9,000	2,740	10.22	52.8	0.69
3,000	920	13.12	67.8	0.89	10,000	3,050	9.77	50.5	0.66

Note: Multiply the correction factor by the sea level design quantity of nitrogen agent to obtain the correct quantity for a given altitude.

7-9 DESIGN CONSIDERATIONS

7-9.1 Electrical Clearance

All system components shall be located so as to maintain minimum clearances from electrically energized equipment, as shown in Table 7-7. As used in this manual, "clearance" shall be the air distance between equipment, including piping and nozzles, and unenclosed or uninsulated live electrical components at other than ground potential.

The clearances in Table 7-7 are for altitudes of 3,300 feet (1,000 m) or less. At altitudes in excess of 3,300 feet (1,000 m) the clearance shall be increased at the rate of 1 percent for each 330-foot (100-m) increase in altitude above 3,300 feet (1,000 m).

Where the design BIL is not available and where nominal voltage is used for the design criteria, the highest minimum clearance listed for this group shall be used.

Table 7-7. Minimum Electrical Clearance

Nominal System Voltage (kV)	Maximum System Voltage (kV)	Design BIL (2) (kV)	Minimum Clearance (1)	
			inches	millimeters
13.8	14.5	110	7	178
23	24.3	150	10	254
34.5	36.5	200	13	330
46	48.3	250	17	432
69	72.5	350	25	635
115	121	550	42	1067
138	145	650	50	1270
161	169	750	58	1473
230	242	900	76	1930
		1050	84	2134
345	362	1050	84	2134
		1300	104	2642
500	550	1500	124	3150
		1800	144	3658
765	800	2050	167	4242

(1) For voltages up to 161 kV, the clearances are taken from NFPA 70, *National Electrical Code*. For voltages 230 kV and above, the clearances are taken from Table 124 of ANSI C2, *National Electrical Safety Code.*

(2) BIL values are expressed as kilovolts (kV), the number being the crest value of the full wave impulse test that the electrical equipment is designed to withstand. For BIL values that are not listed in the table, clearances may be found by interpolation.

7-9.2 Leakage

It important that the nitrogen agent design concentration be achieved within the prescribed discharge time. It is also important that the extinguishing concentration be maintained for the specified period of time to allow effective emergency action by trained personnel. This is equally important in all hazard classifications (A, B, C) since a persistent ignition source (e.g. an arc, thermal heat source, oxyacetylene torch, or deep-seated fire) can lead to a re-ignition of the fire once the nitrogen agent has dissipated. It is necessary to insure that the agent leakage does not occur during discharge and that the required concentration levels can be maintained for the entire holding period. Guidelines as established by NFPA 2001 should be followed.

7-9.3 Temperature Considerations

During discharge the temperature within the protected enclosure will drop approximately 10 to 20°F (5 to 10°C). The temperature will rise again after approximately two to three (2-3) minutes.

7-9.4 Flow Calculation

Flow-calculation software is used to design a Kidde Nitrogen Fire Extinguishing System. Refer to *Flow Calculation Software User's Manual* #30000063 for details on the flow calculation program used by Kidde Fire Systems. The software makes calculations based on several parameters including the following:

- Nitrogen agent cylinder pressure at storage temperature
- Hazard enclosure temperature
- Volumes of hazard enclosure, raised floor, and suspended ceiling, as applicable
- Specific nitrogen agent quantity
- Nitrogen agent design concentration
- Cylinder size
- Number of cylinders
- Discharge time
- Minimum and maximum temperatures of the hazard
- Number of nozzles selected
- Piping size, length, and schedule
- Maximum pressure the enclosure/building structure can withstand

The program calculates:

- Nozzle orifice diameters
- Flow-restrictor orifice diameter (where applicable)
- Pipe sizes and required pipe schedule
- Maximum pressure in distribution pipe network
- Orifice diameter for each individual discharge nozzle
- Estimated size of pressure relief vent opening
- Final nitrogen agent concentration for each protected hazard
- Discharge time (at 95% of design concentration)

7-9.5 Calculation of Room Volume

The volume to be used in calculating the required amount of nitrogen agent shall be the gross enclosure volume less the volume of any internal building structures, such as columns. The volume shall include ventilation ducts and other related volumes.

7-9.6 Quantity of Agent Calculation

The nitrogen agent fire extinguishing or inerting concentrations shall be used in determining the nitrogen agent design concentration for a particular flammable material. Where a hazard contains multiple flammable materials, the extinguishing or inerting value for the flammable material requiring the greatest concentration shall be used.

The design quantity of nitrogen agent is based on the lowest anticipated temperature of the enclosed hazard space.

Where the Kidde Nitrogen Fire Extinguishing System is intended to simultaneously protect multiple hazard spaces, the nitrogen agent quantity is calculated based on the combined volume of the protected spaces.

Where a Kidde Nitrogen Fire Extinguishing System uses one or more selector valves to direct nitrogen agent to two or more individual protected spaces, the nitrogen agent quantity is calculated based on the greater of:

a. the volume of the largest single protected space, or
b. the combined volume of simultaneously protected spaces.

It is the system design engineer's responsibility to base the design of a Kidde Nitrogen Fire Extinguishing System on consideration of the following:

- Types of combustible materials within the protected hazard space
- Design concentration equal to or higher than required by the most demanding flammable
- Volume of the protected enclosed space
- Lowest anticipated temperature of the protected enclosure
- Elevation above sea level of the hazard location
- Integrity of the room, unclosable openings, unstoppable extraction ventilating, etc.
- Quantity of flammables permitted in the enclosure
- Ventilation conditions
- Personnel egress routes
- Personal safety in general

7-9.7 Cylinder Content

Nitrogen agent cylinders are filed to a pressure of 2900 psi (200 bar) at 70°F (21.1°C), standard cylinders contain the following:

Table 7-8. Cylinder Content

Cylinder Volume - Liters	Nominal Filling 2900 psi (200 bar)	Gas Used During Release	Gas Remaining After Release
80.0	38.5 lb 17.5 kg	38.1 lb 17.3 kg	0.44 lb 0.2 kg

7-9.8 Cylinder/Volume Ratio - Class A and Class C Fires

Each 80 liter cylinder discharges 38.1 lb (17.3 kg) of nitrogen agent when pressurized to 2900 psig (200 bar). Recalling that each class of fire hazard has a minimum design concentration, a single 80-liter cylinder of nitrogen agent is able to protect a maximum volume as indicated in the Table 7-9 assuming sea-level installation at 70°F (or 20°C).

NFPA 2001 Class A, B, or C applications

ISO 14520 Class A, B, and High-Hazard Class A applications indicated below.

Table 7-9. Cylinder/Volume Ratio - Class A and Class C Fires

Hazard Classification	Nominal Protected Volume per 80-liter Cylinder			
	NFPA 2001		ISO 14520-13	
	m^3	ft^3	m^3	ft^3
Class B	27.4	968	25.8	912
Class A	33.4	1178	28.8	1016
Class C	28.7	1013	n/a	n/a
High-Hazard Class A	n/a	n/a	27.7	978

7-10 CYLINDER BANK INSTALLATION LOCATION

The cylinders and accompanying hardware shall be placed and installed according to the relevant cylinder bank assembly layout.

Note: As each 2900 psi (200 bar) - 80L cylinder has a weight of approximately 300 lb (138 kg), it is important to ensure that the floor is rated to bear the resulting load.

7-11 NOZZLES

7-11.1 Selecting Number of Nozzles

The nozzles are designed for 360° coverage. The maximum coverage of a single nozzle is 1,254 ft^2 (116.5 m^2).

A 360° nozzle must not be mounted in a corner or against a wall. The maximum nozzle discharge radius is 25 feet (7.6 m), with the longest side not to exceed 35' 5" (10.8 m). Nozzles should be symmetrically centered in the area of protection when multiple nozzles are used in a single hazard space.

The height of the room shall range between 1 foot (0.3 m) and 16 feet (4.88 m) from floor to ceiling. The nozzle should be placed as close or near to the containers as possible to minimize system piping. The ceiling tiles in the hazard area must be clipped to hold them in place during a discharge in order to prevent them from being dislodged.

As a general rule, the maximum volume that one nozzle can cover is 5700 ft^3 (161.6 m^3). At the maximum height of 16 feet (4.88 m) the area such a nozzle can cover is 356 ft^2 (33.2 m^2) corresponding to a space approximately 18.9 ft (5.76 m) square.

Note: The maximum enclosure height that may be flooded by a single tier of nozzles is 16 feet (4.88 m). For enclosures with ceiling heights above 16’ (4.88 m), nozzles shall be placed at multiple levels/elevations to a maximum height per elevation of 16 feet (4.88 m).

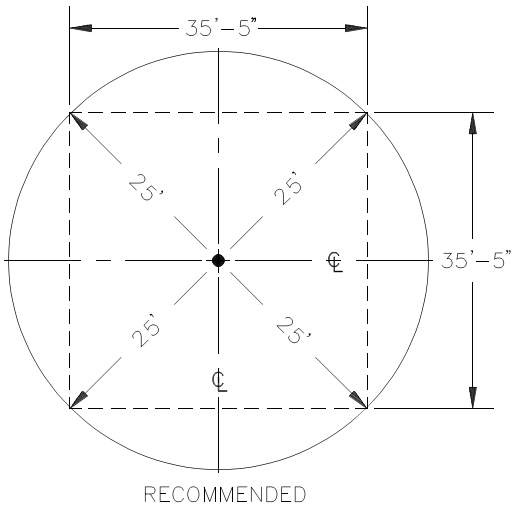


Figure 7-1. 360° Nozzle Determination

The number of nozzles, their size and location in the distribution piping network shall be such that the desired design concentration will be established within the specified discharge time in all parts of the protected enclosure, and such that the discharge will not unduly splash flammable liquids or create dust clouds that could extend the fire, create an explosion, harm any personnel occupying the enclosure or otherwise adversely affect the contents or integrity of the enclosure.

Kidde Fire Systems supplies nozzles ranging in size from 1/2" to 1-1/2", with flow-limiting internal orifices ranging in size from 3 mm to 26 mm. The quantity of nitrogen agent that is discharged from a nozzle depends on the nozzle pressure and orifice size.

In a Kidde Nitrogen Fire Extinguishing System pipe diameters, nozzle sizes, nozzle orifices sizes, and restrictor sizes shall be verified by application of the approved flow calculation software.

When determining the number of nozzles to be used in a system, the shape of the enclosure (area and volume) as well as the shape of any protected voids (raised floor, suspended ceiling) must be taken into account. Other important considerations include: installed equipment in the enclosure/void (chimney effect); pressure in the pipe (pipe wall thickness); obstructions that may affect the distribution of the discharged Nitrogen; and architectural considerations, i.e., a warehouse may allow for the use of a 1-1/2" nozzle whereas an office environment may require a number of smaller nozzles.

In hazards with suspended ceilings, room nozzles shall be installed in such a way that the jets from the nozzles do not damage the ceiling tiles excessively during discharge. For lightweight ceiling tiles, it is recommended that the tiles be securely anchored around each discharge nozzle. In addition, consideration shall also be given to having nozzles installed above the ceiling (simultaneous discharge) in order to equalize the pressure during discharge, thus reducing the risk of unnecessarily damaging ceiling tiles.

7-11.2 Underfloor Nozzles

The maximum area of coverage for a single nozzle in an underfloor is 35' 5" x 35' 5" (10.8 m x 10.8 m), or 1,254 ft^2 (116.5 m^2), with the same limitations on height and positioning noted in the preceding paragraphs. The **MINIMUM** height of an underfloor that may be protected is 12 inches (30.5 cm). The coverage possible in an underfloor is dependent upon the density of cables, runways, and other equipment that might be present in the underfloor space. The maximum figures should be used only in an underfloor that is relatively uncluttered. This requires some judgment on the part of the designer, but in general, if the horizontal line of sight is more than 70% obstructed in an underfloor, these maximum figures should be reduced by 50%.

In a protected hazard with an underfloor that is not protected and not gas tight, consideration shall be given to having nozzles installed below the floor (simultaneous discharge) in order to equalize the pressure and achieve the extinguishing concentration below the floor.

7-11.3 Nozzle Location

The nozzle(s) may be positioned flush with the ceiling or within 21 inches (53 cm) of the ceiling with the design radius covering the required area.

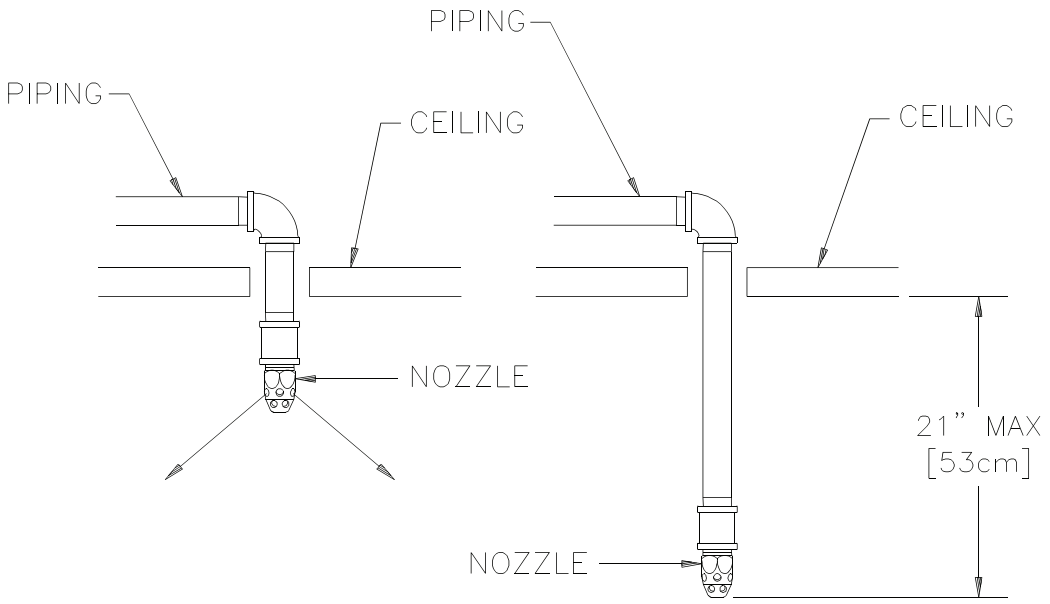


Figure 7-2. Nozzle Location

7-12 DISTRIBUTION PIPING

The piping system shall conform to the requirements of NFPA 2001. In addition, the system shall be securely supported with allowances made for agent thrust forces and thermal expansion/ contraction, and should not be subjected to mechanical, chemical, vibration, corrosion or other damages.

Where explosions are likely, the piping shall be attached to supports that are least likely to be displaced. Although nitrogen agent piping systems are not under continuous pressure, provisions should be made to ensure that the type of piping installed can withstand the maximum stress at maximum storage temperatures.

If black pipe is used, insure that no rust flakes or particles remain inside the pipe as this would ruin ceiling tiles and/or create a spray of rust/dust, which, in the event of protecting an enclosure containing delicate equipment such as computers, would unnecessarily damage the equipment.

Consideration should be given to the fact that the pipe network is "open" under normal conditions and that humidity entering the pipe may result in corrosion. The rust flakes will loosen from the inside of the pipe during a release and may block orifices in the restrictor or in the nozzles, thus jeopardizing the agent release/distribution. It is recommended that "dirt" traps be used at the last nozzle in the line and at bends.

7-12.1 Selection of Piping Material

When selecting pipes fitted by the use of threaded fittings, compression fittings, or welded fittings, care must be taken to insure a smooth internal installation. In addition, the pipe selected must be of a noncombustible material with physical and chemical characteristics such that its integrity during discharge can be predicted with reliability.

It is important that the pipe selected have minimal internal corrosion, which can clog up discharge nozzles. Special corrosion-resistant materials or coatings shall be required in severely corrosive atmospheres. The selected piping schedule shall always be in accordance with the requirement of the authorities having jurisdiction.

Also important is that the interior of the pipe be free of burrs that may be present after cutting and threading.

A variety of pressure rated piping can be used: carbon steel, stainless steel 304 or stainless steel 316. Wall thickness of the selected pipe shall be calculated in accordance with ASME B31.1, Power Piping Code.

The internal pressure used for this calculation/selection shall be the system's maximum peak pressure calculated at the maximum operating temperature. In piping sections where a valve arrangement introduces a section of closed piping, such sections shall be equipped with a pressure relief device. Closed pipe sections are to be given attention equal to that given the discharge manifold.

7-12.2 Estimating Pipe Sizes

The following are approximate flow rates for estimating pipe sizes:

Table 7-10. Estimating Pipe Sizes

Pipe Size	Flow- Kgs/Minute							
	Schedule 40		Schedule 80		Schedule 160		Schedule XXS	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
1/2 in. (15 mm)	1.3	26.9	0.8	15.3	0.2	3.7	N/A	N/A
3/4 in. (20 mm)	3.0	60.1	2.3	46.1	1.3	25.6	N/A	N/A
1 in. (25mm)	5.1	101.6	4.2	84.0	2.9	58.5	1.2	23.3
1-1/4 in. (32mm)	8.6	172.3	7.5	149.3	6.2	124.0	3.6	72.8
1-1/2 in. (40mm)	11.4	228.8	10.1	201.0	8.1	162.7	5.6	111.7
2 in. (50mm)	18.0	360.9	16.1	321.1	12.5	249.7	10.1	201.8
2-1/2 in. (65mm)	25.1	501.1	22.4	447.4	19.0	379.7	13.6	272.2
3 in. (80mm)	37.9	757.3	34.0	679.4	28.1	561.8	22.0	439.3
4 in. (100mm)	65.1	1302.1	58.7	1173.4	47.3	946.7	39.9	798.1
5 in. (125mm)	104.9	2097.6	94.7	1893.7	75.1	1501.7	66.3	1326.9
6 in. (150mm)	157.5	3149.2	140.3	2805.8	111.4	2227.9	98.3	1965.4
8 in. (200mm)	298.2	5964.2	267.5	5349.9	205.4	4108.9	209.8	4196.1

Note: The Kidde Fire Systems' Nitrogen Flow Calculation Program must be used to verify exact pipe sizes, nozzle orifices and restrictor sizes for all system designs and installations. See Nitrogen Flow Calculation Manual, P/N 30000063.

7-13 PIPE HANGERS AND SUPPORTS

- All supports and parts thereof shall conform to the requirements for pressure piping ANSI B31.1, latest issue, and NFPA 2001.
- Conventional hanger design which is generally accepted as good practice, using standard stock or production units as manufactured by recognized reputable manufacturers, shall be utilized whenever possible but within the limits as set forth hereafter.
- All piping must be solidly anchored to walls, ceiling structure, or columns by angle iron brackets, support struts, or equivalent brackets where longitudinal or lateral sway may occur. Particular attention must be paid to the bracing of all piping changes in direction, nozzle piping, and storage unit header piping.
- All piping must be securely anchored to rigid support. Pipe supports and parts shall be steel and adequate to support the pipe in a sub-cold condition, and to allow for free and ample movement for contraction except where anchored, thereby preventing excessive stress. Pipe shall be supported and anchored as the piping system requires.
- Cast iron supports, half clamps, conduit clamps, malleable iron ring-type hangers, single beam clamps, or "C" clamps ***SHALL NOT BE USED*** to support piping. Beam clamps that grab both sides of the beam flange are acceptable, in addition to drilling of or welding to the beams (if authorized by owner).
- All parts of the supporting equipment must be fabricated and installed so that they will not be disengaged or distorted by movement of the supported pipe. **A pipe line is not to be supported from another pipe line**.
- All pipe supports shall be installed to avoid interference with other piping, hangers, electrical conduit, and supports or building structure and equipment.
- Supports shall be sufficiently close together to avoid excessive bending stresses from concentrated loads between supports. Spacing between supports is shown in Table 7-11.
- Where rod type hangers are permitted for intermediate support between rigid supports, they shall be a steel clevis hanger of the proper size for the supported pipe and with solid bar-type hanger rod. See Table 7-121 on the following page for rod sizes. Hanger rods shall not be subjected to stresses due to bending.

Note: "C" clamps are not acceptable to support rod hangers.

Generally it is acceptable to alternate hangers on rods. Where an intermediate hanger is used between two rigid supports, the distance between hangers shall be reduced to approximately 75 percent of the distances shown in Table 7-11.

Table 7-11. Maximum Spacing between Pipe Supports for Screwed, Welded, or Grooved Pipe

Nominal Pipe Size		**Maximum Span**	
inches	mm	feet	m
1/4	8	5	1.5
1/2	15	5	1.5
3/4	20	6	1.5
1	25	7	2.1
1-1/4	32	8	2.4
1-1/2	40	9	2.7
2	50	10	3.0
2-1/2	65	11	3.4
3	80	12	3.7
4	100	14	4.3
5	125	16	4.9
6	150	17	5.2
8	200	19	5.8

Table 7-12. Rod Size Determined by Pipe Size for Fire Protection

Pipe Size		**Rod Size**	
inches	**mm**	**inches**	**mm**
≤ 1	≤ 25	3/8	9.6
1-1/2 to 3	40 to 80	1/2	12.7
4 & 5	100 & 125	5/8	15.8
6	150	3/4	19.0
8	200	7/8	22.2

7-14 CLEANING OF PIPE NETWORK

Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, utilizing a suitable nonflammable cleaner. The pipe network shall be free of particulate matter and oil residue before installation of nozzles or discharge devices.

7-15 PRESSURE TESTING OF PIPE NETWORK

CAUTION

Never include actuation valves (cylinder or selector) as part of the piping network pressure test. As outlined in Section 6-5, always disconnect the cylinder outlet hose from the manifold check valve and cap all check valves (using cap P/N 70989017) prior to pressure testing of the piping network. For single cylinder systems, ensure the piping is plugged and the outlet hose detached before pressure testing.

Pneumatic pressure testing creates a potential risk of injury to personnel in the area as a result of airborne projectiles if rupture of the piping system occurs. Prior to the pneumatic pressure test being conducted, the protected area shall be evacuated and appropriate safeguards shall be provided for test personnel.

Never include actuation valves (cylinder or selector) as part of the piping network pressure test, as outlined in Section 6.5, always disconnect the cylinder outlet hose from the manifold check valve and cap all check valves (using cap P/N 70989017), prior to pressure testing of the piping network. For single cylinder systems, ensure the piping is plugged and the outlet hose detached before pressure testing.

Pneumatic pressure testing creates a potential risk of injury to personnel, in the area as a result of airborne projectiles if rupture of the piping system occurs. Prior to the pneumatic pressure test being conducted, the protected area shall be evacuated and appropriate safeguards shall be provided for test personnel.

NFPA 2001: The piping shall be pneumatically tested in a closed circuit for a period of 10 minutes at 40 psig (276 kPa) per NFPA 2001. At 10 minutes after removal of the source of pressurizing gas, the pipe pressure shall not be less than 80 percent of the test pressure. **EXCEPTION**: *It shall be permissible to omit the pressure test if the total piping contains no more than one change in direction fitting between the storage container and the discharge nozzle, and if all piping is physically checked for tightness.*

Note: ISO 14520-1: Pneumatically tested at 45 psi (3 bar) for a period of 10 minutes using Air/Nitrogen or N2. Pressure drop not to exceed 20% of the test pressure at end of test.

Note: A test report/statement of completion must be issued.

7-15.1 Discharge Test

Per NFPA 2001, a discharge test is not generally recommended. Typically, a puff test or short duration flow test is used to confirm that all piping and nozzles in the system are clear of obstructions.

7-16 PRESSURE RELIEF VENTING

Fixed fire extinguishing systems, employing inert gases, extinguish fires by reducing the level of oxygen to below a level where combustion of the present flammables cannot be sustained. The required amount of gas discharged into a room or enclosure will result in a positive pressure that displaces the atmospheric air from the room. Suitable means of pressure relief venting must be provided in order to avoid structural damage.

The building element rating, the minimum rated construction element, shall govern as the basis for calculating the required opening.

It should be noted that over-pressure will affect the opening of doors into the room, i.e., if the door should open inwards, it will be almost impossible to open the door while the room is still pressurized. Doors that open outwards from the still pressurized room will create a potential risk for the person who tries to open the door, as the door plate may open with a tremendous force as soon as the door lock is freed.

No enclosure is 100% tight. A certain amount of leakage into adjacent areas is to be anticipated during and following a discharge of nitrogen agent. Consideration shall be given to concentration, products of combustion and the relative size of adjacent spaces. Additional consideration shall be given to exhaust/vent paths when opening or venting the enclosure after a discharge.

If defined, normal leakage can be taken into consideration when calculating/designing the relief vent opening.

Kidde does not take responsibility for verifying whether weak point(s) in an enclosure construction Windows, vent channels (Spiro Tubes sectioned by dampers, etc.), door frames, door plates at locks, ceilings, etc. are capable of withstanding the pressure buildup. In addition, Kidde does not have the expertise to supply or install enclosure/building relief vents.

7-17 PRESSURE RELIEF DEVICE VENTING

Closed piping sections shall be equipped with a pressure relief device to relieve the pressure in the event of heat exposure in excess of the system limitations, i.e., above 120°F (50°C).

Preferably, the relief should be vented to the atmosphere.

Note: For storage rooms having a relatively small volume compared with the volume of stored gas, consideration shall always be given to the risk of external heat exposure, ventilating conditions in the room, and so on.

7-18 SAFETY PRECAUTIONS - OCCUPIED SPACES

In areas that potentially could be occupied, the following shall be provided.

- Time-delay devices
  - For applications where a discharge delay does not significantly increase the threat from fire to life or property, extinguishing systems shall incorporate a pre-discharge alarm with a time delay sufficient to allow personnel evacuation prior to discharge.
  - Time-delay devices shall only be used for personnel evacuation or to prepare the hazard area for discharge.
- Automatic/Manual switch and lock-out devices where required.

Note: Although lock-out devices are not always required, they are essential in some situations, particularly for some specific maintenance functions.

- Exit routes that shall be kept clear at all times, emergency lighting and adequate directional signs to minimize travel distances. Outward-swinging, self-closing doors that can be opened from the inside, including when locked from the outside.
- Continuous visual and audible alarms at entrances and designated exits inside the protected area as well as continuous visual alarms outside the protected area that operate until the protected area has been made safe. Where required, pre-discharge alarms that are distinctive from other alarm signals and that will operate immediately upon initiation of the time delay cycle upon detection of a fire.
- Appropriate warning and instruction signs.
- Means for prompt natural or forced-draft ventilation of protected spaces after any discharge of extinguishant. Forced-draft ventilation will often be necessary. Care shall be taken to completely dissipate the hazardous atmosphere and not just move it to other locations, as Nitrogen and decomposition products are heavier than air.
- Provide instruction and conduct drills for all personnel within or near protected areas, including maintenance or construction personnel who may be brought into the area, to ensure their correct response upon system operation.
- In addition to the above, the following are recommended:
  - Self-contained breathing apparatus should be available and personnel trained in its use.
  - Personnel should not enter the enclosure until it has been verified as being safe.

7-19 SIGNS AND LABELING

7-19.1 Storage Room

All doors to the system storage room shall be marked with a sign with the following text in the local language:

"**Nitrogen Cylinder Storage Room:** ***Before entering, ensure Oxygen content is above 18%.***"

7-19.2 Nitrogen Cylinders

Each cylinder is labeled with a nitrogen agent label. The purpose of the label is to provide filling information, transport/safety information, inspection information and general precautions to be taken during re-installation of the cylinder.

7-19.3 Warning Alarms and Signs

Audible and visual alarm devices within, as well as outside the enclosure, shall be provided with warning signs.

Table 7-13. Warning Sign Part Numbers

Part Number	Description
38-509859-001	Exit Warning Sign
38-509860-001	Entrance Warning Sign

7-19.4 Pressure-Relief Vents (if used)

Relief vent openings shall be provided with a warning sign to caution personnel of possible pressure discharge.

7-19.5 Alarm and Detection

This manual does not cover detection and control systems. However, it shall be noted that in systems requiring more than 100 cylinders released simultaneously, additional solenoid valve(s) - one per every 100 cylinders - shall be energized simultaneously; and that in the case of selector valve systems, a solenoid valve for the selector valve shall also be energized.

When selecting a detection and control system, evaluate the ambient environmental conditions to determine the appropriate device and sensitivity in order to prevent false discharges while still providing the necessary earliest actuation. In high airflow environments, air-sampling detection devices should be considered.

Detectors installed at the maximum spacing as listed or approved for fire alarm use can result in excessive delay in agent release, especially where more than one detection device is required to be in alarm before automatic actuation results (cross zone system). Where there is a risk of a flammable atmosphere forming, the spacing and location of flammable vapor detectors requires careful consideration to avoid excessive delay in agent release.

Hazards associated with fast growing fires would include, but are not limited to, flammable liquid storage or transfer and aerosol filling areas.

CHAPTER 8
NITROGEN MSDS SHEET

PRODUCT NAME		TRADE NAME AND SYNONYMS
Nitrogen		Nitrogen; Nitrogen, Compressed
CHEMICAL NAME AND SYNONYMS		ISSUE/REVISION DATE
Nitrogen		June 1, 2003
CAS #	DOT ID NO.	DOT HAZARD CLASSIFICATION
7727-37-9	UN 1066	Division 2.2
FORMULA		CHEMICAL VAMILY
N_2		Inert gas

HEALTH HAZARD DATA

TIME WEIGHTED AVERAGE EXPOSURE LIMIT

Nitrogen is defined as a simple asphyxiant without other significant physiological effects. Oxygen levels should be maintained at greater than 18 molar percent at normal atmosphere that is equivalent to a partial pressure of 135 mm Hg (ACGIH 1990-1991). OSHA 1989 does not list a TWA for nitrogen.

SYMPTOMS OF EXPOSURE

Effects of exposure to high concentrations so as to displace the oxygen in air necessary for life may include **any, all or none** of the following:

- Loss of balance or dizziness
- Loss of tactile sensations
- Heightened mental activity
- Weakened speech leading to the inability to utter sounds
- Rapid reduction in the ability to perform movements
- Tightness in the frontal area of the forehead
- Tingling of the tongue, fingertips or toes
- Reduced consciousness of surroundings

It should be recognized that it is possible that none of the above symptoms may occur in gas asphyxia so that there are no **definite** warning symptoms.

TOXICOLOGICAL PROPERTIES

Nitrogen is nontoxic but the liberation of a large amount in a confined area could displace the amount of oxygen in air necessary to support life.

Nitrogen is not listed in the IARC, NTP or by OSHA as a carcinogen or potential carcinogen.

Persons in ill health where such illness would be aggravated by exposure to nitrogen should not be allowed to work with or handle this product.

RECOMMENDED FIRST AID TREATMENT

PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO NITROGEN. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS.

INHALATION: Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. Unconscious persons should be moved to an uncontaminated area, given assisted respiration and supplemental oxygen. Further treatment should be symptomatic and supportive.

Figure 8-1. Nitrogen MSDS Sheet

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	
None	
PHYSICAL DATA	
BOILING POINT -320.5°F (-195.8°C)	LIQUID DENSITY AT BOILING POINT 50.46 lb/ft^3 (808.3 kg/m^3)
VAPOR PRESSURE @ 70°F (21.1°C)above the critical temperature of -232.6°F (-147°C)	GAS DENSITY AT 70°F, 1 ATM .0725 lb/ft^3 (1.161 kg/m^3)
SOLUBILITY IN WATER Very slightly	FREEZING POINT -345.9°F (-209.9°C)
EVAPORATION RATE N/A	SPECIFIC GRAVITY (AIR = 1) @70°F (21.1°C) = 0.97
APPEARANCE AND ODOR Colorless, odorless gas	

FIRE AND EXPLOSION HAZARD DATA			
FLASH POINT (METHOD USED) N/A	AUTO IGNITION TEMPERATURE N/A	FLAMMABLE LIMITS BY VOLUME LEL: N/A	UEL: N/A
EXTINGUISHING MEDIA Nonflammable, inert gas		ELECTRICAL CLASSIFICATION Nonhazardous	
SPECIAL FIRE FIGHTING PROCEDURES N/A			
UNUSUAL FIRE AND EXPLOSION HAZARDS N/A			

REACTIVITY DATA	
STABILITY STABLE [X] UNSTABLE [ ]	CONDITIONS TO AVOID N/A
INCOMPATIBILITY (MATERIALS TO AVOID) None	
HAZARDOUS DECOMPOSITION PRODUCTS None	
HAZARDOUS POLYMERIZATION MAY OCCUR [ ] WILL NOT OCCUR [X]	CONDITIONS TO AVOID N/A

Figure 8-2. Nitrogen MSDS Sheet, Continued

SPILL OR LEAK PROCEDURES
STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Uncontrolled releases should be responded to by trained personnel using preplanned procedures. In case of a release, evacuate all personnel from affected area. Use appropriate protective equipment - at a minimum, self-contained breathing apparatus and heavy gloves. The atmosphere must have at least 19.5% oxygen before personnel can be allowed in the area without self-contained breathing apparatus. Ventilate the affected area. Attempt to shut off the release by tightening the main valve. If this does not stop the release (or it is not possible to reach the valve), allow the gas to release in place.
WASTE DISPOSAL METHOD
Do not attempt to dispose of waste or unused quantities. Return in the shipping container, **properly labeled with any valve outlet plugs or caps secured and valve protection cap in place**, to your supplier. For emergency disposal assistance, contact your closest supplier location.

SPECIAL PROTECTION INFORMATION
RESPIRATORY PROTECTION
Positive pressure air line with mask or self-contained breathing apparatus should be available for emergency use.
VENTILATION AND ENGINEERING CONTROLS
Use with adequate ventilation - use a mechanical fan or vent area to outside to prevent accumulations of high concentrations which could reduce oxygen level to below 19.5%.
PROTECTIVE GLOVES
Mechanically resistant gloves should be worn when moving cylinders.
EYE PROTECTION
Safety goggles or glasses
OTHER PROTECTIVE EQUIPMENT
Safety shoes and other body protection appropriate for the task.

SPECIAL PRECAUTIONS			
SPECIAL LABELING INFORMATION			
DOT SHIPPING NAME	DOT SHIPPING LABEL	DOT HAZARD CLASS	DOT ID NO.
Nitrogen, compressed	Nonflammable gas	Division 2.2	UN 1066
SPECIAL HANDLING RECOMMENDATIONS			
Use only in well ventilated areas. Valve protection caps must remain in place unless cylinder is secured with valve outlet piped to use point. Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting cylinder to lower pressure (<3,000 psig) piping or systems. Do not heat cylinder by any means to increase the discharge rate of product from cylinder. Use a check valve or trap in the discharge line to prevent hazardous back flow into the cylinder. For additional handling recommendations, consult Compressed Gas Association's Pamphlets P-1, P-9, P-14, and Safety Bulletin SB-2.			

Figure 8-3. Nitrogen MSDS Sheet, Continued

SPECIAL PRECAUTIONS
SPECIAL PACKAGING RECOMMENDATIONS Nitrogen is noncorrosive and may be used with any common structural materials.
OTHER RECOMMENDATIONS OR PRECAUTIONS Compressed gas cylinders should not be refilled except by qualified producers of compressed gases. Shipment of a compressed gas cylinder that has not been filled by the owner or with his (written) consent is a violation of Federal law (49CFS). Always secure cylinders in an upright position before transporting them. Avoid transport on vehicles where the load space is not separated from the driver's compartment. Ensure the driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency. NEVER transport cylinders in trunks of vehicles, enclosed vans, truck cabs or in passenger compartments. Before transporting product containers, ensure that they are firmly secured and: ➤ cylinder valve is closed and not leaking. ➤ valve outlet cap nut or plug (where provided) is correctly fitted. ➤ valve protection device (where provided) is correctly fitted. ➤ there is adequate ventilation. ➤ compliance with applicable regulations is maintained.

Figure 8-4. Nitrogen MSDS Sheet, continued

CHAPTER 9
SERVICE AND MAINTENANCE

9-1 GENERAL

It is essential that the Nitrogen system be carefully maintained to ensure instant readiness when required. Routine maintenance is liable to be overlooked or given insufficient attention by the owner of the system. However, its neglect can imperil the lives of the occupants of the premises and result in a crippling financial loss.

Note: Safety should be a prime concern during installation, service, maintenance, testing, handling, and recharging of nitrogen systems and agent containers. All personnel who could be expected to inspect, test, maintain, or operate fire extinguishing systems shall be thoroughly trained and kept thoroughly trained in the functions they are expected to perform.Personnel working in an enclosure protected by a clean agent shall receive training regarding agent safety issues.The importance of maintenance cannot be too highly emphasized. As a minimum, the following should be required for maintaining the nitrogen system:

9-1.1 Cylinder Pressure

Although the pressure of all cylinders is checked at the commissioning stage, the pressures should be checked again approximately two (2) weeks after installation or after cylinder refilling following a system discharge.

9-1.2 Pressure Gauge

Visually check that all cylinder pressure gauges are reading the correct pressure as stated on the cylinder label (located on the cylinder body). If the cylinder gauge indicates a pressure less than 2750 psi (190 bar) at 70°F (21.1°C), the cylinder must be recharged.

Preventive Maintenance should be performed at least semi-annually.

9-1.3 Cylinder Valves

Check that the cylinder valve(s) are in the closed and sealed position.

9-2 PREVENTIVE MAINTENANCE - TEST AND SERVICE ANNUALLY

9-2.1 Hoses

Examine all hoses for signs of damage or wear. Replace if suspect. Additionally, all hoses must be hydrostatically tested every 5 years.

9-2.2 Selector Valve (if used)

If used, the selector valve should be manually activated and the operation of the optional selector valve limit switch observed (if used). Signal to be initiated on control panel. Replace the micro switch if found to be defective.

9-2.3 Distribution Pipe Network and Nozzles

All pipework and nozzles should be visually inspected for any signs of damage, deterioration or obstruction.

Nozzles should be checked for any signs of blockage and cleaned if appropriate. Any paint or lacquer shall be removed.

9-2.4 Protected Room

At least every twelve months, the protected room shall be thoroughly inspected to determine if changes to the volume, penetrations or leakages have occurred that could adversely affect the extinguishing performance of the system.

Where the integrity inspection indicates that changes in the conditions could result in an inability to maintain the extinguishing concentration, they shall be corrected or the system redesigned to provide the original degree of protection.

9-2.5 Pressure Testing of Nitrogen Cylinders

All cylinders must be removed, pressure tested and recertified as required by the authorities having jurisdiction.

9-3 NITROGEN CYLINDER ASSEMBLY

Visually check the following:

- The Nitrogen Cylinder is installed and secured in its mounting bracket.
- The discharge hose is connected to the check valve on the manifold and to the discharge port on the cylinder valve.
- The pneumatic actuator is fitted on the connection port on the Nitrogen cylinder valve.
- The pressure gauge or pressure gauge solenoid valve unit is fitted on the port of the Nitrogen cylinder valve.
- The actuator hose from the pressure gauge solenoid valve unit is fitted on the free port of the tee piece.

Refer to the following figures for system details.

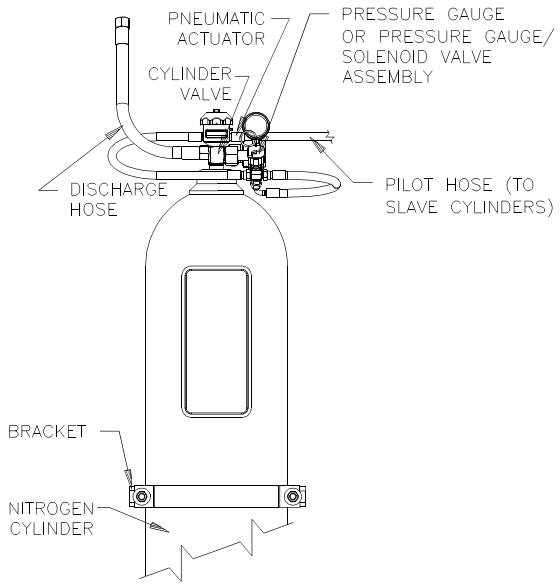


Figure 9-1. Nitrogen Cylinder Valve Assembly

9-4 PRESSURE GAUGE UNITS

9-4.1 Pressure Gauge with Supervisory Switch Assembly for Slave Cylinders

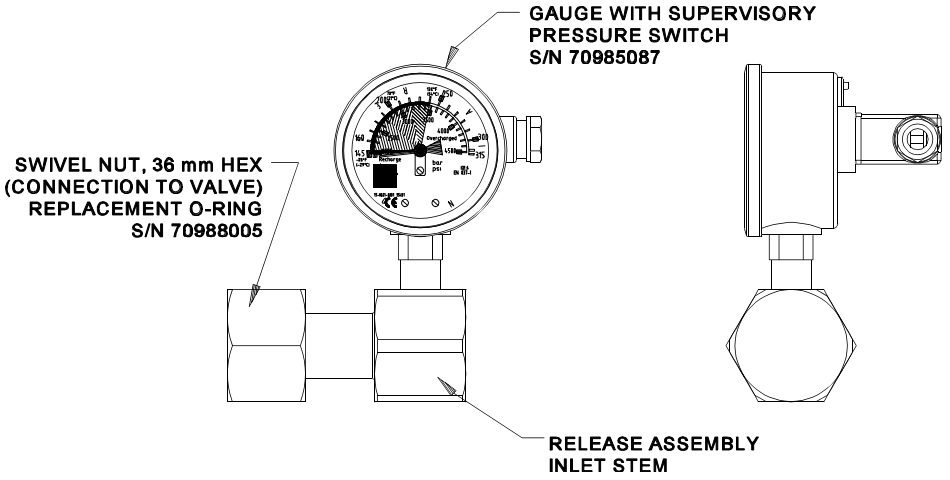


Figure 9-2. Pressure Switch with Supervisory Pressure Switch

9-4.2 Solenoid Valve, Gauge and Supervisory Pressure Switch Assembly for Pilot Cylinder(s)

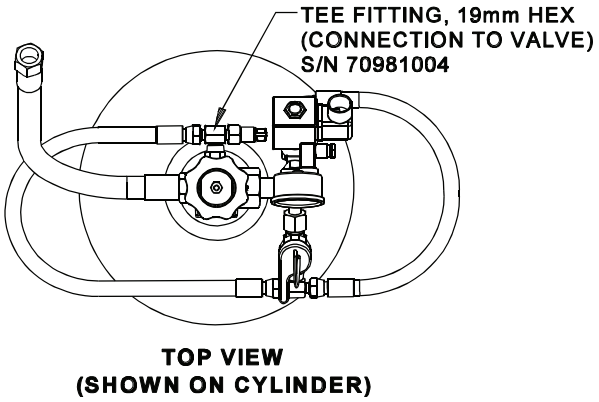


Figure 9-3. Top View (Shown on Cylinder)

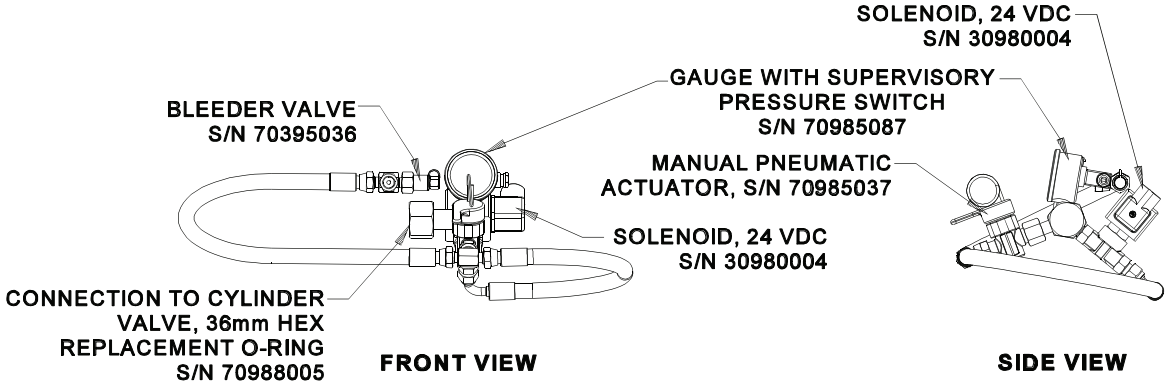


Figure 9-4. Front and Side Views of Solenoid Valve Assembly

9-4.3 Installation and Removal

The solenoid valve assemblies for 2900 psi (200 bar) systems are dismantled & installed on the cylinder in the following way

9-4.3.1 Disassembly

1. Dismantle all interconnecting pilot hoses.
2. Carefully loosen the 36 mm hex nut, used to attach the gauge assembly to the cylinder, to relieve pressure. (A loud, high-pitched sound will be heard during the venting. This is caused when the O-ring seal reaches the conical rim in the connection and releases the trapped pressure.)
3. When the pressure indicated on the pressure gauge has fallen to "0" unthread the gauge assembly from the cylinder valve.

9-4.3.2 Assembly

Note: Verify that all cylinders are properly restrained and that the discharge hose for each cylinder is
connected to both the cylinder valve and system piping prior to reassembly.

1. Ensure the O-ring in the swivel nut is in place and greased.
2. Fit the complete unit on the cylinder valve, adjust gauge so that it is positioned vertically and tighten the swivel nut by hand until pressure is indicated on the gauge.
3. Secure swivel nut by the use of a 36 mm wrench. Apply torque 34 - 37 lb-ft (46 - 50 Nm).
4. Check all connections for leaks using a spray leak detection liquid. There should be no visible leaks.
5. Do not connect the hose from the solenoid valve to the actuation port until after the unit has been pressurized and there is no leakage through the free hose end.
6. Attach the interconnecting pilot hoses between the cylinders. Use a fixed spanner wrench. Apply torque 1-18 lb-ft. (20-25 Nm).

Note: Do not turn unit after the swivel nut has been tightened.

9-5 AFTER SYSTEM RELEASE

After a discharge, return the system to operating mode as soon as possible. Ensure that the Nitrogen cylinder pressure gauge(s) on the refilled cylinder valve(s) reads 2900 psi (200 bar) at 70°F (21.1°C).

9-5.1 Cylinder Replacement

CAUTION

Safety is a prime concern. Never assume that a cylinder is empty. Treat all cylinders as if they are fully charged. The Kidde cylinder valve is capable of producing high discharge thrusts out of the valve outlet if not handled properly. Remember that pressurized cylinders are extremely hazardous. Always fit the cylinder valve with a protective cap before removing the cylinder(s) from the rack and/or moving the cylinder(s). Failure to do so can result in serious bodily injury and possibly death, as well as property damage.

When a Nitrogen cylinder has been operated or the remaining pressure is less than 2750 psi (190 bar), it should be refilled immediately to the normal operating pressure at 70°F (21.1°C).

1. Disable the solenoid release circuit on the control panel.
2. Remove the coil from the high pressure solenoid valve unit, remove nut/screw and pull out the coil.
3. Disconnect the pilot hose (19 mm hex) from the cylinder valve connection.
4. Carefully loosen the 36 mm swivel nut on the gauge unit to relieve pressure out the vent hole.
5. When the pressure indicated on the pressure gauge has fallen to zero (0), disconnect the gauge unit from the cylinder valve.
6. Disconnect the pilot hoses and discharge hoses from the cylinder valve outlets.
7. Fit the protective cap on the cylinder.
8. Remove the cylinder bracket.
9. Roll the cylinder out from the wall bracket, free of the manifold.
10. Place the cylinder on the cylinder carrier and tighten the holding strap
11. Move the cylinder to a truck and secure.
12. Repeat steps 1 - 11 until all cylinders have been placed on the truck.
13. When all cylinders are out of the room and secured on the truck, drive to nearest refilling station or contact Kidde.

Note: A nitrogen cylinder can weigh as much as 300 lbs. Always take precautions to prevent personnel injuries. All dismantled parts are to be treated with great care in order to avoid damage.

9-5.2 Re-installation

Follow steps 1-11 above in reverse order.

9-6 TESTING

9-6.1 Solenoid Valve - High Pressure

The operation of the solenoid valve unit on the Nitrogen cylinder shall be verified as follows:

1. Mechanically disconnect the pressure gauge solenoid valve unit from the Nitrogen cylinder valve.
2. Connect a pressure supply to the inlet of the unit.
3. Energize the solenoid valve (24 VDC 13 w).
4. Confirm operation.
5. Reinstall the pressure gauge solenoid valve unit. (Remember to install a new O-ring). Before connecting the hose to the pneumatic actuator, ensure that there is no leakage from the hose end.

9-6.2 Pneumatically-Operated Selector Valves

Check the operation of the pneumatically operated selector valves as follows:

1. Disconnect the instrument tubing from the pneumatic actuator on the selector valve.
2. Apply a pressure of 85-125 psi (6-8 bar) to the inlet port of the actuator.
3. Supply 24 VDC to the actuator solenoid; the valve should open.
4. Remove the 24 VDC power; the valve should close.
5. Remove the pressure from the actuator.
6. Close the valve using the handle on top of the valve (the valve will not close automatically).
7. The handle can also be used to open the valve during emergency conditions.

9-6.3 Pressure Regulator - Selector Valve Systems

Check the operation of the pressure regulator. If no full discharge test is performed, the operation/adjustment of the pressure regulator can be performed as follows:

1. Remove the regulator and install it in a test bench consisting of a pressure source of 2900 psi (200 bar), a calibrated pressure gauge 0-4,000 psi (0-300 bar) upstream, and a calibrated pressure gauge 0-300 psi (0-20 bar) downstream of the reducing valve.
2. Correct operation of the regulator will be indicated on the downstream pressure gauge, which should read approximately 85 - 125 psi (6 - 8 bar). The relief valve will open if the regulator outlet pressure exceeds 145 psi (10 bar).
3. If pressure is out of range, remove the cover and adjust by turning the internal screw until the required settings are achieved - clockwise to increase the pressure and counterclockwise to decrease the pressure.

No further dismantling of the regulator shall be done. Should the regulator be faulty, return to Kidde for factory repair or replacement.

9-7 TROUBLESHOOTING

9-7.1 Low Pressure in Cylinder

Should low pressure be indicated, the cause may be due to one of the following conditions:

- The cylinder valve handwheel is slightly open, partially releasing the contents.

  Action: Check that the valve is seating correctly (fully clockwise) and that the seal on handwheel is intact.
- The cylinder pressure is dependent on ambient temperature, thus a lower ambient temperature will cause a drop in pressure.

  Action: Check/confirm the ambient temperature of the cylinders.

9-7.2 Leaking Pressure Gauge Unit

- Check the swivel nut connection, the gauge connection, and the plug using leak detection liquid.

  Action: If leakage is detected at the swivel connection, dismantle and replace the O-ring (P/N 38-509870-001).
- If leakage is detected at gauge connection and plug, immediately contact Kidde's Field Service Department, or authorized distributor.

  Action: Contact Kidde's Field Service Department, or authorized distributor, immediately.

9-7.3 Leaking Pressure Gauge/Solenoid Valve Unit

- Check the connection swivel nut, the gauge connection and the solenoid valve connection using leak detection liquid.

  Action: If leakage is detected at the swivel connection, dismantle and replace the O-ring (P/N 38-509870-001).
- Leakage is detected at the gauge connection and/or solenoid valve.

  Action: Contact Kidde's Field Service Department, or authorized distributor, immediately.

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CHAPTER 10
FILLING INSTRUCTIONS

These procedures are included to allow the owner to inform the selected filling station about general guidelines for filling Nitrogen cylinders equipped with a Kidde high-pressure cylinder valve(s).

The intent is to have the highest guarantee of correct filling wherever in the world a Nitrogen cylinder is filled. The filling procedures may be adjusted according to the normal routines for the chosen filling station, provided the station complies with all stipulated requirements for pressures and contents

10-1 RESPONSIBILITIES

It is the responsibility of the owner or service contract holder to issue these procedures to the relevant filling stations. It is the responsibility of the filling station to fill cylinders according to these procedures (to attach filing labels, prepare filing list(s), issue letter of conformity, etc.).

10-2 GENERAL FILLING

The filling process may use pressure or weight as the means of controlling the quantity of the Nitrogen administered. The quantity and pressure must be in accordance with the specific requirements

10-2.1 Filling - Weight Controlled

The Kidde Nitrogen systems utilize cylinder storage pressures of 2900 psi (200 bar) at 70°F (21.1°C). Under these conditions, the Nitrogen cylinder fill density is .218 - .220 kg/l.

Table 10-1. Cylinder Volume and Mass

Cylinder Volume in Liters	Mass (kg)
80.0	17.5

10-2.2 Nitrogen Filling Table - Pressure/Temperature Relationship

Based on an ideal gas equation, corrected for Nitrogen compression factors at 70°F (21.1°C). The following graph is only valid after the temperature is equalized between the Nitrogen gas and the cylinder.

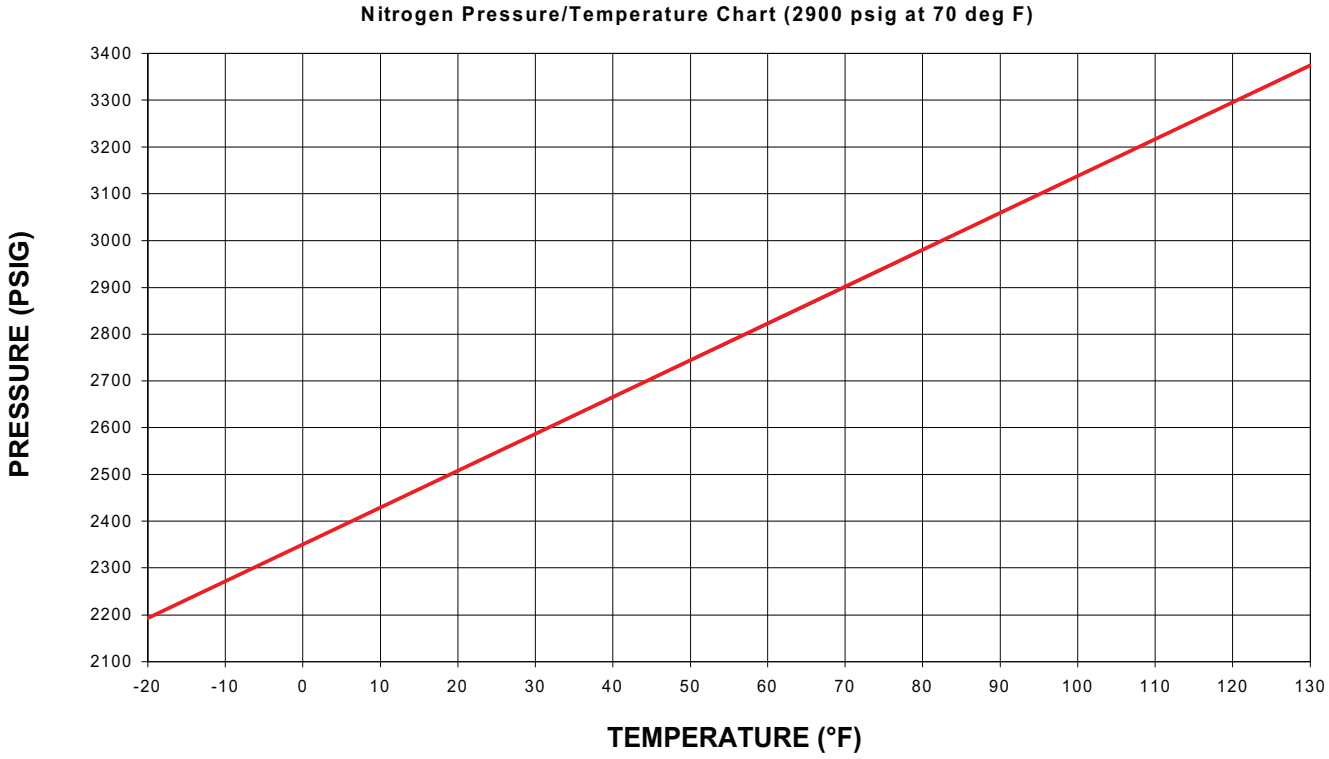

Figure 10-1. Nitrogen Pressure Temperature Chart

10-2.3 Refilling After Discharge

After discharge, the cylinders will remain pressurized to approximately 45 psi (3 bar) and thus contain dry Nitrogen from the previous filling.

The cylinder is to be repressurized according to local requirements. The surface treatment and coating shall be intact. If damaged, the topcoat shall be repaired according to the paint specification using compatible paint in the same color (RAL code).

Cylinders shall be restamped as required by local requirements and the service label on the cylinder shall be filled out.

10-3 NITROGEN VALVE

The Kidde Nitrogen cylinder valve is a pneumatically operated, quick opening valve. The valve is designed and suitable for use in fire extinguishing systems having a storage pressure up to 2900 psi (200 bar). The valve is held shut by the pressure within the cylinder.

The valve may be opened/closed manually by turning the handwheel clockwise/ counterclockwise. However, when valve is under pressure, the force required to turn the handwheel demands that a special tool be used. The opening/closing feature of the valve is only intended to allow a function check of the valve prior to filling. It is recommended that the valve be operated pneumatically when it is under pressure.

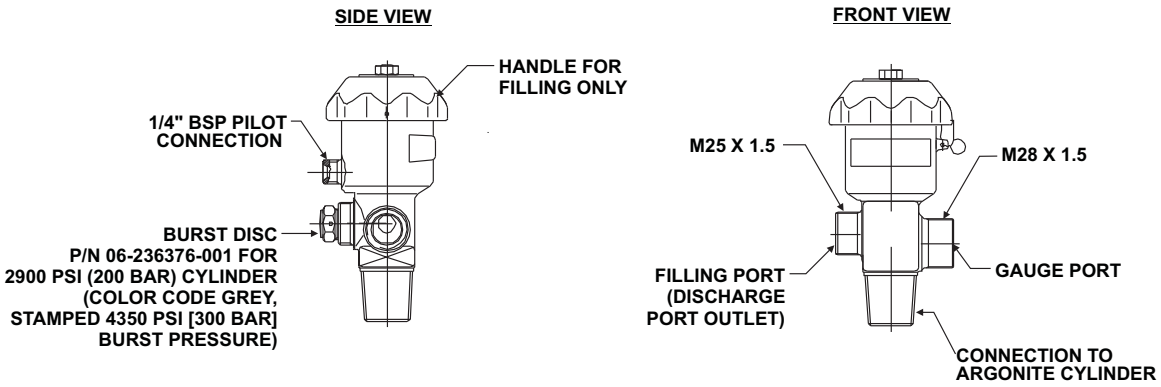

Figure 10-2. Nitrogen Cylinder Valve

10-4 FILLING

Filling is performed through the valve discharge port outlet .

Prior to starting the filling process, check the valve operation by opening/closing the valve. Connect the valve-filling inlet to the Nitrogen filling systems.

Table 10-2. Part Numbers and Descriptions

Part Number	Description
38-509801-001	Filling Adapter, valve discharge port to 1/4" NPT
38-509802-001	Filling Adapter, valve discharge port to CGA-580
38-509871-001	Spare O-ring

10-4.1 Filling Through Discharge Port/Valve Outlet

The valve outlet thread is male, M25 x 1.5. The orifice area is: 0.0491 in2 (31.67 mm2)

10-4.1.1 Tools:

- Filling Adapter
- Filling valve with female adapter (1/4" NPT) with a venting valve to be used (pressure in supply line to be vented prior to disconnecting the filling adapter from the filling inlet).
- Handle for opening/closing the valve.

Note: Torque required to manually open/close the valve during the filling process:

Table 10-3. Torque Pressure - Opening and Closing

Pressure PSI/Bar	Torque To Open		Torque To Close	
	Nm.	in-lb	Nm.	in-lb
0	2.5	22.1	1.5	13.3
2900 psi/200 bar	6.0	53.1	5.0	44.3

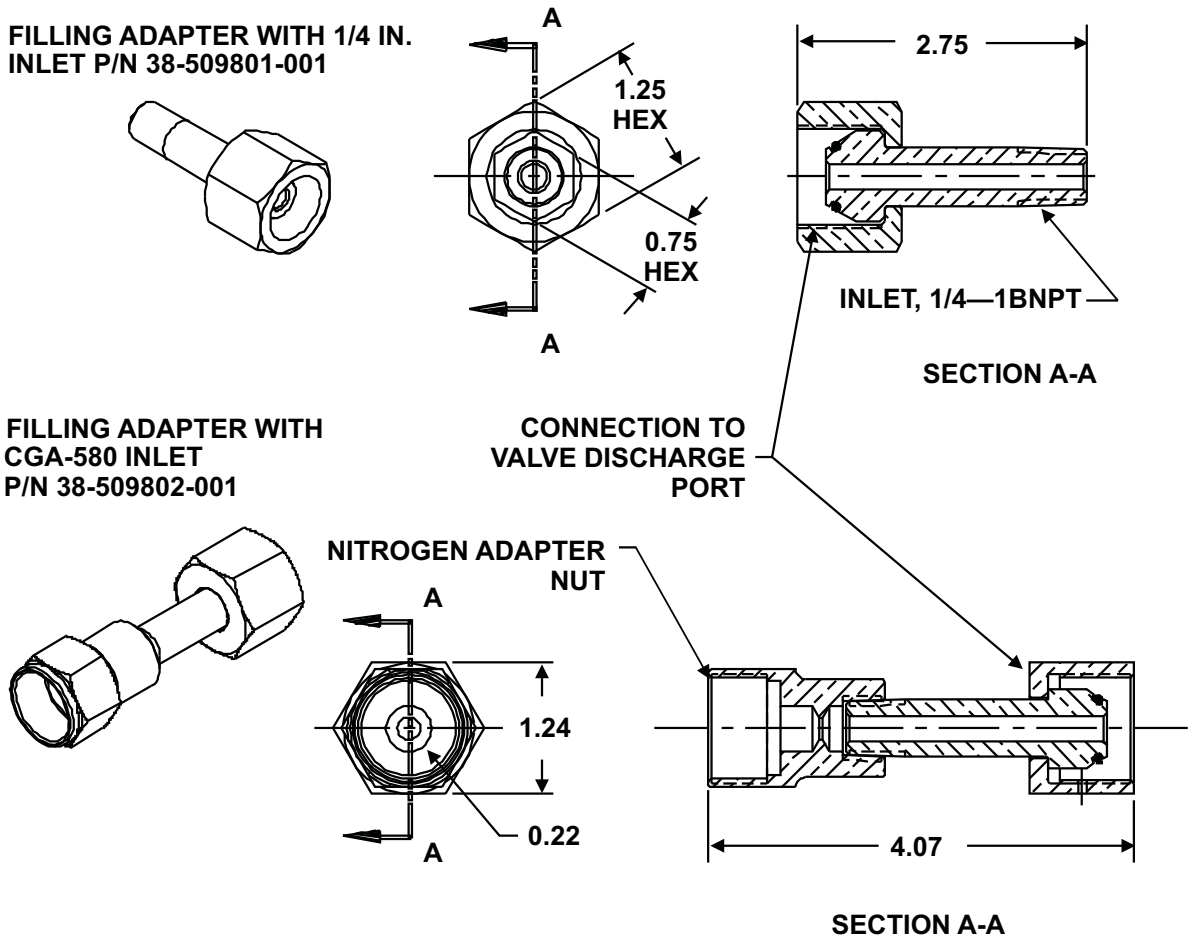

Figure 10-3. Filling Adapters

10-4.2 Filling Check List

Table 10-4. Filling Check List

Step	Description	Checke	Comments
1	List the cylinder number on filling list		
2	Check the valve function by using the handwheel to open and close the valve.		
3	For filling through the valve discharge outlet, the valve shall be fully open during filling. Open the valve by turning the handwheel counterclockwise until resistance		
4	Fill to the required pressure. If filling by weight, check weight against the table in paragraph 10.2.1.		
5	When filling is completed and both gases filled, check the Nitrogen pressure. Close the valve by turning the handle clockwise until firm resistance is met.		
6	Leak test all connection points, no leaks to be accepted.		
7	Seal off valve, use hole in handwheel and eye on valve body.		
8	Fit cylinder with protective transport cap.		
9	Attach the label, completed as required.		
10	Secure cylinder in transport cage or on pallets.		
11	Ship to Receiver/Site as agreed		

Note: A transport label must always be on the transported cylinder(s). See Paragraph 10.8 for a description of the labels and Part Numbers.

10-5 FILLING LIST

The Filling Station is responsible for completing the Filling List and issues a copy to the purchaser, as well as including a copy with the shipment.

10-6 LETTER OF CONFORMITY

If required, the filling station shall issue a letter of conformity covering the filled cylinders, as follows:

> This is to certify that to the best of our knowledge, the filling of the cylinders referenced in Filling List No. xxxxx, Order No.xxxxxx, Client xxxxxx, have been filled with 100% Nitrogen in accordance with the requirements provided in these filling instructions.

Filling List No.:		**Order No.:**		
Client:				
Cylinder Number	**Cylinder Size (15.9 L, 66.7 L, or 80 L)**	**Nitrogen Pressure**	**Fill Date**	**Filler's Signature**

Figure 10-4. Filling List

10-7 CYLINDER TRANSPORT LABELS

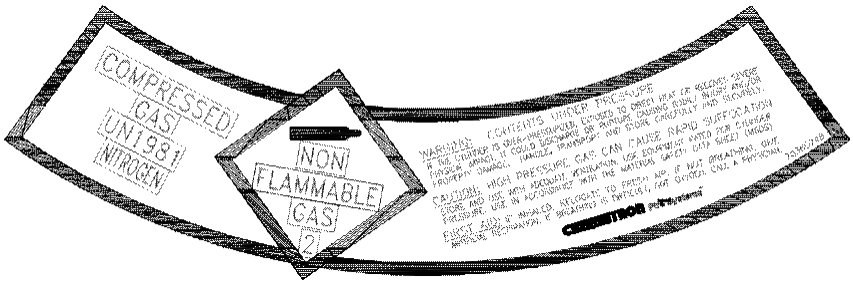

Figure 10-5. Nitrogen Compressed Gas Label - P/N 70960748

APPENDIX A
NITROGEN SURFACE FIRE REQUIREMENTS

A-1 SHEETS

Concentration Required: _____% | **Sheet 1**

Kidde Fire Systems

NITROGEN SURFACE FIRE REQUIREMENTS

Project: _____ **Date:** _____

Hazard: _____ **Engr:** _____

Type of Combustible: _____

■ **Volume**

_____ L x _____ W x _____ H = _____ Cu Ft/Meters

_____ L x _____ W x _____ H = _____ Cu Ft/Meters

_____ L x _____ W x _____ H = _____ Cu Ft/Meters

_____ L x _____ W x _____ H = _____ Cu Ft/Meters

Total = _____ Cu Ft/Meters

■ **Nitrogen Required** (Refer to Tables on Sheets 2 & 3)

_____ Volume x _____ (concentration factor) = _____ Kgs

_____ Kgs x _____ (atmospheric correction factor) = _____ Kgs

Total Kilograms Required = _____

■ **Storage Required**

_____ Kgs Req'd / _____ Kgs/Cyl = _____ Cylinders

_____ Cylinders Main & _____ Cylinders Reserve

Description		Stock #	Usable Capacity (Kgs)
■ **80 Liter Cylinder Assembly** (Filled cylinder & valve)			
200 bar	D.O.T. & TC Versions	10980090	17.3
■ **66.7 Liter Cylinder Assembly** (Filled cylinder & valve)			
200 bar	D.O.T. & TC Versions	10980091	14.4

Description		Stock #	Usable Capacity (Kgs)
■ **15.9 Liter Cylinder Assembly** (Filled cylinder & valve)			
200 bar	D.O.T. & TC Versions	10980093	3.4
D.O.T. = Department of Transportation (US) TC = Transportation Canada			

Figure A-1. Nitrogen Surface Fire Requirements

Concentration Required: _____ %							Sheet 2
Kidde Fire Systems			**NITROGEN SURFACE FIRE REQUIREMENTS**				
Total Flooding Quantities - Volume Requirements of Nitrogen - Metric - Kg/M^3							
Temp (°C)	**Design Concentration (% by Volume)**						
	36	**37**	**38**	**40**	**42**	**46**	**50**
-30	0.758	0.786	0.812	0.868	0.926	1.047	1.178
-25	0.728	0.754	0.780	0.834	0.889	1.005	1.131
-20	0.700	0.725	0.749	0.801	0.854	0.966	1.087
-15	0.673	0.697	0.721	0.770	0.821	0.929	1.045
-10	0.647	0.671	0.694	0.741	0.790	0.894	1.006
-5	0.624	0.646	0.668	0.714	0.761	0.861	0.968
0	0.601	0.622	0.644	0.688	0.733	0.830	0.933
5	0.579	0.600	0.621	0.663	0.707	0.800	0.900
10	0.559	0.579	0.599	0.640	0.683	0.727	0.869
15	0.540	0.559	0.578	0.618	0.659	0.745	0.839
20	0.522	0.540	0.559	0.597	0.637	0.720	0.810
25	0.504	0.522	0.540	0.577	0.616	0.696	0.783
30	0.488	0.505	0.522	0.558	0.595	0.673	0.758
35	0.472	0.489	0.506	0.540	0.576	0.652	0.733
40	0.457	0.473	0.490	0.523	0.558	0.631	0.710
45	0.443	0.459	0.474	0.507	0.541	0.611	0.688
50	0.429	0.445	0.460	0.491	0.524	0.593	0.667
55	0.416	0.431	0.446	0.476	0.508	0.575	0.646

Figure A-2. Nitrogen Surface Fire Requirements, continued

Concentration Required: _____ %	Sheet 3

Kidde Fire Systems

NITROGEN SURFACE FIRE REQUIREMENTS

Total Flooding Quantities - Volume Requirements of Nitrogen - US Standard - Kg/Ft^3							
Temp (°F)	Design Concentration (% by Volume)						
	36	37	38	40	42	46	50
-20	0.02129	0.02220	0.02280	0.02436	0.02598	0.02939	0.03306
-10	0.02035	0.02107	0.02180	0.02329	0.02484	0.02810	0.03160
0	0.01947	0.02017	0.02086	0.02229	0.02377	0.02689	0.03024
10	0.01865	0.01932	0.01998	0.02135	0.02277	0.02575	0.02897
20	0.01788	0.01852	0.01915	0.02047	0.02183	0.02469	0.02777
30	0.01716	0.01777	0.01838	0.01964	0.02094	0.02369	0.02665
40	0.01648	0.01706	0.01765	0.01886	0.02011	0.02275	0.02559
50	0.01584	0.01640	0.01696	0.01813	0.01933	0.02187	0.02460
60	0.01523	0.01578	0.01632	0.01744	0.01859	0.02103	0.02366
70	0.01466	0.01518	0.01571	0.01678	0.01790	0.02024	0.02277
80	0.01412	0.01463	0.01513	0.01617	0.01724	0.01950	0.02194
90	0.01361	0.01410	0.01458	0.01582	0.01662	0.01880	0.02114
100	0.01313	0.01360	0.01407	0.01503	0.01603	0.01830	0.02040
110	0.01267	0.01313	0.01358	0.01451	0.01547	0.01750	0.01969
120	0.01224	0.01268	0.01311	0.01401	0.01494	0.01690	0.01901
130	0.01183	0.01225	0.01267	0.01354	0.01444	0.01633	0.01837

Figure A-3. Nitrogen Surface Fire Requirements, continued

Concentration Required: _____ %			Sheet 4

Kidde Fire Systems

NITROGEN SURFACE FIRE REQUIREMENTS

Elevation Correction Factors

Altitude		Enclosure Pressure		Correction Factor
Feet	Kilometers	PSIA	cm Hg	
-3,000	-0.92	16.25	84.0	1.11
-2,000	-0.61	15.71	81.2	1.07
-1,000	-0.30	15.23	78.7	1.04
0	0	14.71	76.0	1.00
1,000	0.30	14.18	73.3	0.96
2,000	0.61	13.64	70.5	0.93
3,000	0.92	13.12	67.8	0.89
4,000	1.21	12.58	65.0	0.86
5,000	1.52	12.04	62.2	0.82
6,000	1.83	11.53	59.6	0.78
7,000	2.13	11.03	57.0	0.75
8,000	2.44	10.64	55.0	0.72
9,000	2.74	10.22	52.8	0.69
10,000	3.05	9.77	50.5	0.66

Note: Multiply the correction factor by the sea level design quantity of Nitrogen to obtain the correct quantity for a given altitude.

Figure A-4. Nitrogen Surface Fire Requirements, continued

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06-237459-001 Rev. AA