HFC-227ea FIRE SUPPRESSION SYSTEM

DESIGN, INSTALLATION AND ENGINEERING MANUAL FOR PYRO-200 SYSTEM

Rev 0	**First Listing Draft**	**02-20-2022**

FOREWORD

PHILOSOPHY STATEMENT

The philosophy at Adkinns Inc. (ADK) is to save our clients and customers valuable time and money by providing them with reliable and unparalleled “one-stop” fire protection solutions at reasonable prices. Our mission is to provide a fire safe environment for everyone, our vision is to become a leader in world-class fire-fighting products and our corporate culture of ”Nothing is constant ... the only constant is continuous improvement” attitude will ensure that ADK will continue to “Lead the fight against fire”.

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The components of the Halocarbon gas suppression system supplied by ADK are warranted to the original purchaser for 1 (one) year from the date of delivery against defects in workmanship and material. ADK will replace or repair any ADK supplied components which, in its opinion are defective and have not been tampered with or subjected to misuse, abuse or exposed to highly corrosive conditions provided that written notice of the alleged defect shall be given to ADK within 7 days after discovery thereof, and prior to the expiration of one year after order, and further provided that is ADK so instructs, such article or part thereof is promptly returned to ADK with shipping charges pre-paid.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

GENERAL INFORMATION

1.1 INTRODUCTION

The PYRO-200 Gas Fire Suppression system utilizes the halocarbon gas Heptafluoropropane (HFC-227ea), listed in ISO 14520-1, NFPA 2001 Standard on Clean Agent Fire Extinguishing System and U.S. Environmental Protection Agency. HFC-227ea is a colorless, odorless, liquefied compressed gas. It is stored as a liquid but discharge into the hazard as a colorless, electrically non-conductive gas vapor, which can be used to protect electronic equipment. Furthermore, PYRO-200 does not deplete the ozone layer therefore, makes it an environmentally adequate product.

The PYRO-200 Gas Suppression Systems are designed to suppress the following types of fires:

- **Class A - Surface Fires / Ordinary Combustible Fires**
- **Class B - Flammable Liquid Fires**
- **Class C – Energized Electrical Equipment Fires**

HFC-227ea fluid shall not be used on fires involving the following materials unless they have been tested to the satisfaction of the authority having jurisdiction:

- Reactive metals such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium & plutonium.
- Certain chemicals or mixture of chemicals such as cellulose nitrate and gunpowder, that is capable of rapid oxidation in the absence of air.
- Chemicals capable of undergoing auto thermal decomposition, such as certain organic peroxides and hydrazine.
- Metal hydrides.

1.2 APPROVALS AND STANDARDS

The manufactured equipment and HFC-227ea have comprehensive approvals to provide further support to the overall product.

HFC-227ea

- Underwriters Laboratories Inc. (UL)
- FM Approvals (FM)
- US EPA SNAP Rpt.
- NFPA 2001 Clean Agent Fire Extinguishing System

PYRO-200 System

- Underwriters Laboratories Inc. (UL)
- FM Approvals (FM)

1.3 HEALTH AND SAFETY

HFC-227ea extinguishes mainly through a combination of chemical and physical mechanisms through heat absorption with minimal effect on the depletion of oxygen. Coupled with the colorless and odorless properties of the gas, people will be able to see and breathe during a fire escape situation.

Generally, HFC-227ea is not hazardous to health if exposed at design concentration below 9%. However, unnecessary exposure of the gas should be avoided. Reason being, the discharge of HFC-227ea gas upon a fire might be hazardous from the undecomposed agent and the decomposition products of the fire. Therefore, upon operation of a system pre-discharge alarm, all personnel should evacuate protected areas as fast as possible.

Besides that, the high-pressure discharge of HFC-227ea fluid from a system nozzle can create a loud noise to startled people present in the area but any resulting injury is unlikely to occur. The high velocity discharge of HFC-227ea will cause a turbulence that can displace light objects. Direct contact with the vaporizing fluid from the system nozzle can cause a chilling effect on objects and cause frostbites on the skin in severe cases.

1.4 HFC-227ea PHYSICAL PROPERTIES

HFC-227ea mechanism of suppressing fire is through physically cooling the fire at the molecular level. HFC-227ea is an efficient heat transfer agent and suppresses fire by absorbing heat energy at its molecular level faster than the generated heat. The removal of thermal energy from the fire causes insufficient heat energy for combustion to occur. Additionally, free radicals are released into the fire to interfere with the chain reaction of the combustion process. This makes it a highly effective firefighting agent that is safe for people and causes no damage to equipment.

Table 1-1: HFC-227ea Physical Properties, Metric Units

Properties	Value	Units
Molecular Weight	170.03	-
Boiling Point @ 1.013 bar (absolute)	-16.4	℃
Freezing Point	-131	℃
Critical Temperature	101.7	℃
Critical Pressure	29.12	Bar
Critical Volume	274	cc/mole

Critical Density	621	kg/m^3
Specific heat, liquid @ 25 ºC	1.184	kJ/kg ºC
Specific heat, vapor @ constant pressure (1 atm) and 25ºC	0.808	kJ/kg ºC
Heat of Vaporization at boiling point	132.6	kJ/kg
Thermal conductivity of liquid @ 25 ºC	0.069	W/m ºC
Viscosity, liquid at 25ºC	0.184	centipoise
Relative dielectric strength at 1 atm at 734 mm Hg, 25ºC (N_2 = 1.0)	2	
Solubility of water in agent	0.06% by weight	ppm

(Reference: NFPA 2001)

CHAPTER 2

COMPONENT DESCRIPTION

The PYRO-200 gas system consists of field pipe work connected to a cylinder(s) through a manifold (if required), distribution pipe network and nozzles. At a reference temperature of 21°C, the PYRO-200 is stored at 25 bar, 42 bar and 50 bar within each cylinder. The proprietary system components, from cylinders to nozzles, are delivered in loose kit form and the items are bolted to a wall or solid framework. Each system is designed specifically for the area which it is protecting. Gas discharge times and gas distribution is achieved by the correct sizing of the orifice holes at the nozzle with the size engraved on the body.

The PYRO-200 system is operated by an electrical signal to a solenoid actuating device on the master or pilot cylinder. Operation of the said cylinder will pressurize the pneumatic actuating line which will operate the pneumatic release pistons on the slave cylinders causing these cylinders to discharge. The General Arrangement Drawings of piping runs can affect the final diameter of the orifices, therefore "as built" drawings must be done to enable all orifices to be calculated and drilled to suite.

2.1 PYRO-200 CYLINDER ASSEMBLY (WELDED)

HFC-227ea fluid is stored in the cylinder as a liquid, super pressurized with nitrogen. In addition, all cylinders and valves are provided with a safety cap and a protection cap. This is a safety feature to prevent uncontrolled, accidental discharge. The cylinder is designed to operate at a temperature range of -10 °C to 60 °C. Cylinders sharing the same manifold must be in equal size with the same fill density. A label is pasted onto the cylinder to display the filling pressure, agent weight, tare weight, gross weight and charge date.

WARNING:

THE VALVE OUTLET CAP MUST ALWAYS BE FITTED ONTO THE CYLINDER, IRRESPECTIVE OF WHETHER THE CYLINDER IS FULL OR EMPTY, WHEN IT IS NOT CONNECTED TO THE PIPE NETWORK OR MANIFOLD.

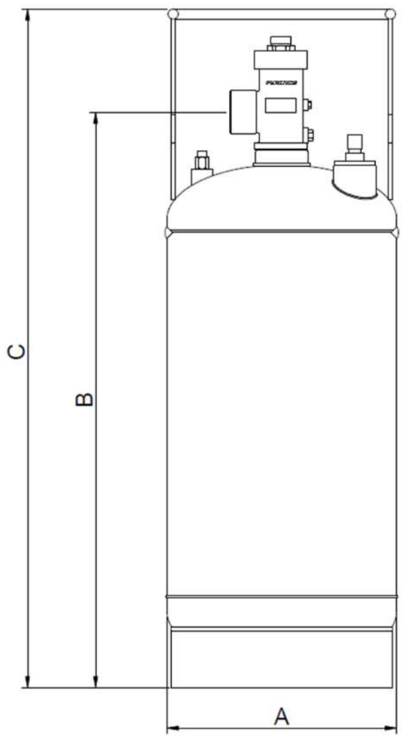


Figure 2-1: PYRO-200 Cylinders (Welded)

Specifications	
Materials	P355M, HP345
Filling – General Cylinder	0.5kg/L up to maximum of 1 kg/L
Filling – Cylinder with Liquid Level Indicator	0.5kg/L up to maximum of 0.8kg/L
Filling Pressure	25 bar or 42 bar @ 21°C
Test Pressure	63 bar or 101 bar
Standard of Compliance	TPED Directive 2010/35/EU DOT-4BW
Color	Red

2.1.1 TPED Cylinders

Table 2-1: Cylinder and Valve Assembly Dimensions for TPED Cylinders

Part Number	Capacity (L)	Valve Outlet Size (in.)	A (mm)	B (mm)	C (mm)	Burst Disc's Burst Pressure
PYR-INT-FS-WCYL-16L	16.6	1"	228.6	578	761	55Bar
PYR-INT-FS-WCYL-32L	32	1-1/2"	324	584	730	55Bar
PYR-INT-FS-WCYL-52L	52	1-1/2"	324	844	990	55Bar
PYR-INT-FS-WCYL-100L	100	1-1/2"	406	1019	1187	55Bar
PYR-INT-FS-WCYL-120L	120	2"	406	1192	1350	55Bar
PYR-INT-FS-WCYL-150L	150	2"	406	1437	1596	55Bar
PYR-INT-FS-WCYL-180L	180	2"	462	1317	1493	55Bar
PYR-INT-FS-WCYL-200L	200	2"	462	1447	1623	55Bar
PYR-INT-FS-WCYL-240L-2V	240	2"	508	1468	1656	55Bar
PYR-INT-FS-WCYL-240L-3V	240	3"	508	1523	1656	55Bar
PYR-INT-FS-WCYL-300L	300	3"	610	1363	1506	55Bar
PYR-INT-FS-WCYL-369L	369	3"	610	1608	1751	55Bar

Table 2-2: TPED Cylinders with Liquid Level Indicator

Part Number	Capacity (L)	Valve Outlet Size (in.)	A (mm)	B (mm)	C (mm)	Liquid Level Inlet Size
PYR-INT-FS-WCYL-240L-LLI	240	2"	508	1468	1656	2" -11.5 NPSC
PYR-INT-FS-WCYL-240L-3V-LLI	240	3"	508	1523	1656	2" -11.5 NPSC
PYR-INT-FS-WCYL-300L-LLI	300	3"	610	1363	1506	2" -11.5 NPSC
PYR-INT-FS-WCYL-369L-LLI	369	3"	610	1608	1751	2" -11.5 NPSC

**Cylinder dimensions shown on all tables above have a tolerance of ± 15mm.*

2.1.2 DOT Cylinders

Table 2-3: Cylinder and Valve Assembly Dimensions for DOT Cylinders

Part Number	Capacity (L)	Valve Outlet Size (in.)	A (mm)	B (mm)	C (mm)	Burst Disc's Burst Pressure
PYR-INT-FS-WCYL-D29L	29	1-1/2"	254	753	877	55Bar
PYR-INT-FS-WCYL-D52L	52	1-1/2"	406	600	-	55Bar
PYR-INT-FS-WCYL-D106L	106	1-1/2"	406	1035	-	55Bar
PYR-INT-FS-WCYL-D147L	147	2"	406	1377	-	55Bar
PYR-INT-FS-WCYL-D227L	227	2"	508	1408	-	55Bar
PYR-INT-FS-WCYL-D275L	275	3"	508	1666	-	55Bar
PYR-INT-FS-WCYL-D369L	369	3"	610	1572	-	55Bar

Table 2-4: DOT Cylinders with Liquid Level Indicator

Part Number	Capacity (L)	Valve Outlet Size (in.)	A (mm)	B (mm)	C (mm)	Liquid Level Inlet Size
PYR-INT-FS-WCYL-D227L-LLI	227	2"	508	1408	-	2" -11.5 NPSC
PYR-INT-FS-WCYL-D275L-LLI	275	3"	508	1666	-	2" -11.5 NPSC
PYR-INT-FS-WCYL-D369L-LLI	369	3"	610	1572	-	2" -11.5 NPSC

**Cylinder dimensions shown on all tables above have a tolerance of ± 15mm.*

2.2 PYRO-200 CYLINDER ASSEMBLY (SEAMLESS)

HFC-227ea fluid is stored in the cylinder as a liquid, super pressurized with nitrogen. In addition, all cylinder and valve are provided with a safety cap and a protection cap. This is a safety feature to prevent uncontrolled, accidental discharge. The cylinder is designed to operate at a temperature range of -10 ºC to 60 ºC. Cylinders sharing the same manifold must be in equal size with the same fill density. A label is pasted onto the cylinder to display the filling pressure, agent weight, tare weight, gross weight and charge date.

WARNING:

THE VALVE OUTLET CAP MUST ALWAYS BE FITTED ONTO THE CYLINDER, IRRESPECTIVE OF WHETHER THE CYLINDER IS FULL OR EMPTY, WHEN IT IS NOT CONNECTED TO THE PIPE NETWORK OR MANIFOLD.

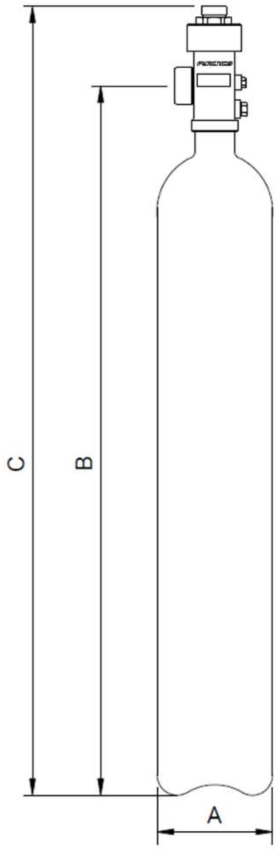


Figure 2-2: PYRO-200 Cylinder (Seamless)

Specifications	
Materials	Chromium Molybdenum Alloy Steel
Filling	0.5kg /L up to maximum of 1 kg/L
Filling Pressure	42bar and 50 bar @ 21ºC
Test Pressure	300 bar
Standard of Compliance	ISO 9809 – 1

Color	Red

2.2.1 TPED Seamless Cylinders

Table 2-5: TPED Seamless Cylinders and Valve Dimensions for Vertical Installation

Part Number	Capacity (L)	Valve Outlet Size	A (mm)	B (mm)	C (mm)	Burst Disc's Burst Pressure
PYR-INT-FS-SCYL-50L	50	1-1/2"	229	1496	1609	90Bar
PYR-INT-FS-SCYL-80L	80	1-1/2"	360	1081	1194	90Bar
PYR-INT-FS-SCYL-100L	100	1-1/2"	360	1296	1409	90Bar
PYR-INT-FS-SCYL-140L	140	2"	406	1385	1515	90Bar
PYR-INT-FS-SCYL-180L	180	2"	406	1715	1845	90Bar

**Cylinder dimensions shown on all tables above have a tolerance of ± 15mm.*

2.3 DISCHARGE VALVE ASSEMBLY SERIES 1”, 1-1/2” and 2” TYPE

The discharge valve assembly is of a pressure differential type and is used for fixed installations, gas suppression system up to 50 Bar. The discharge valve can be actuated electrically, pneumatically and / or manually with approved valve actuation components. A plastic protection cap is mounted onto the top of the valve to prevent dirt or particles from entering the control valve bore, which may cause a malfunction of the valve. It also prevents an accidental discharge of the cylinder.

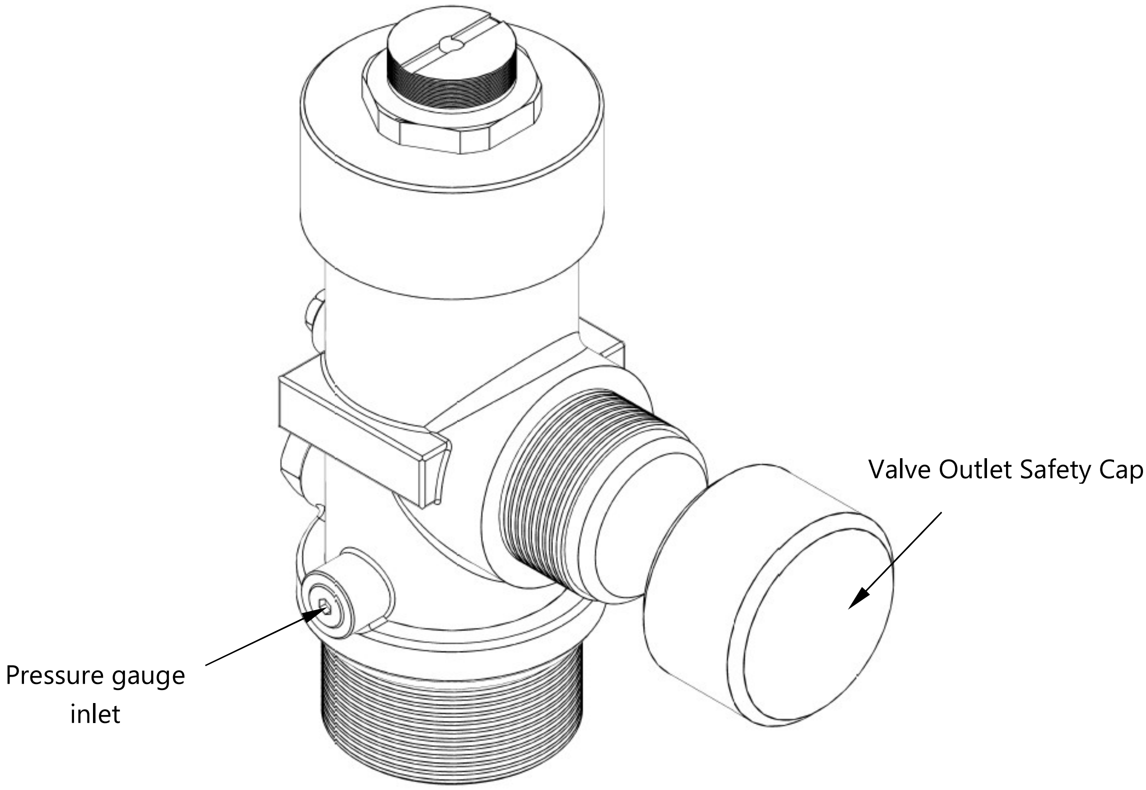


Figure 2-3: Discharge Valve

Specifications			
Part No.	PYR-INT-FS-DV-1	PYR-INT-FS-DV-1.5	PYR-INT-FS-DV-2
Valve Size	1”	1-1/2”	2”
Valve Body Material	Brass	Brass	Brass
Temperature Range	−10ºC to 60ºC	−10ºC to 60ºC	−10ºC to 60ºC
Actuator Connection	1-1/4” X 18UNEF	1-1/4” X 18UNEF	1-1/4” X 18UNEF
Pilot Hose Connection	1/8” NPT	1/8” NPT	1/8” NPT
Pressure Gauge Connection	1/8” NPT	1/8” NPT	1/8” NPT
Valve Outlet Connection	1-7/16” - 12 UN	1-7/8” - 12 UN	2-1/2” - 12 UN
Equivalent Length (m)	9	12.5	13

Note: All equivalent lengths given in Schedule 40, black pipe.

2.4 PYRO-200 VALVE ASSEMBLY SERIES 3" TYPE

The PYRO-200 3" valve assembly is of a pressure differential type and is used for fixed installations, gas suppression system up to 25 Bar only. There are two different types of 3" valve available; Screw Type Valve and Flange Type Valve. The PYRO-200 valve can be actuated electrically, pneumatically and / or manually with approved valve actuation components. A plastic protection cap is mounted onto the top of the valve to prevent dirt or particles from entering the control valve bore, which may cause a malfunction of the valve. It also prevents an accidental discharge of the cylinder.

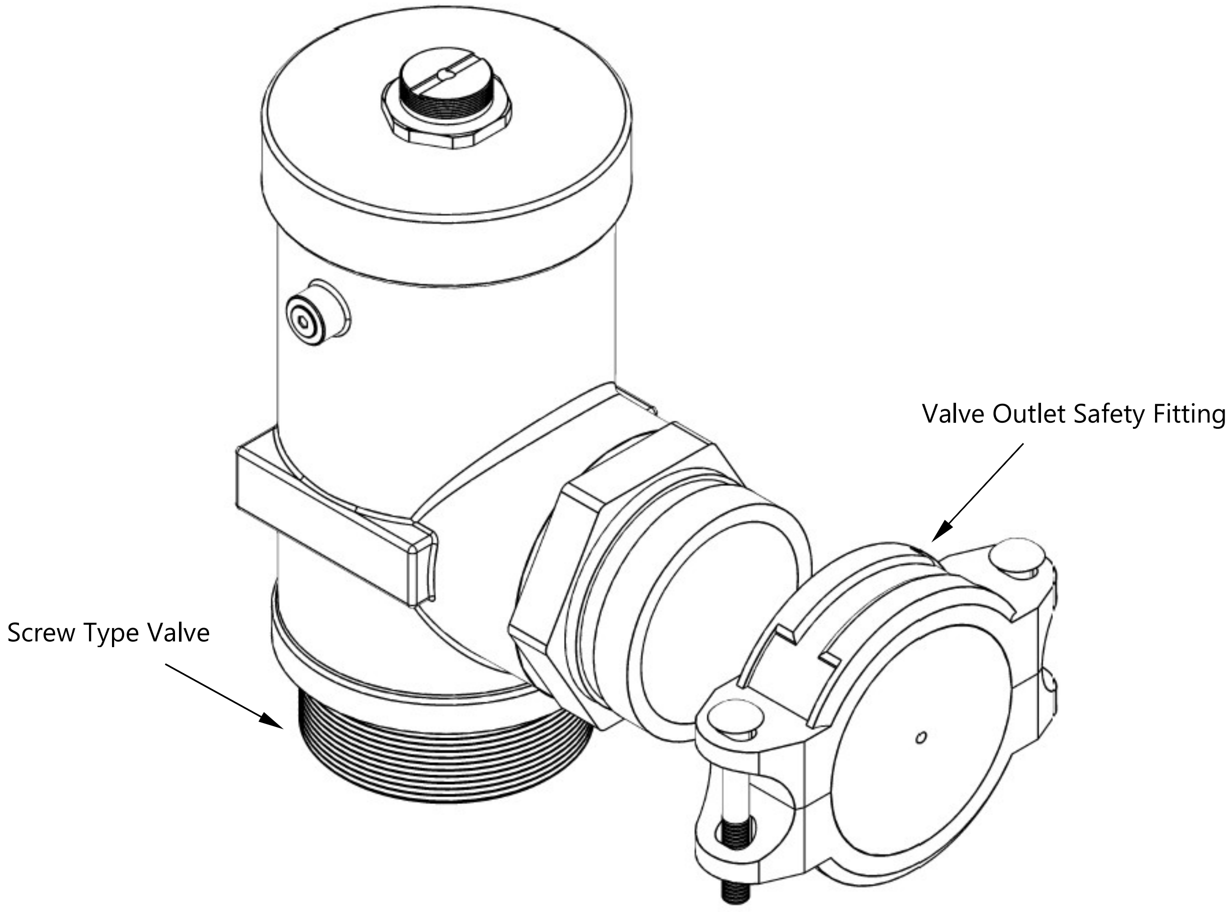


Figure 2-4: 3" Screw Type PYRO-200 Valve

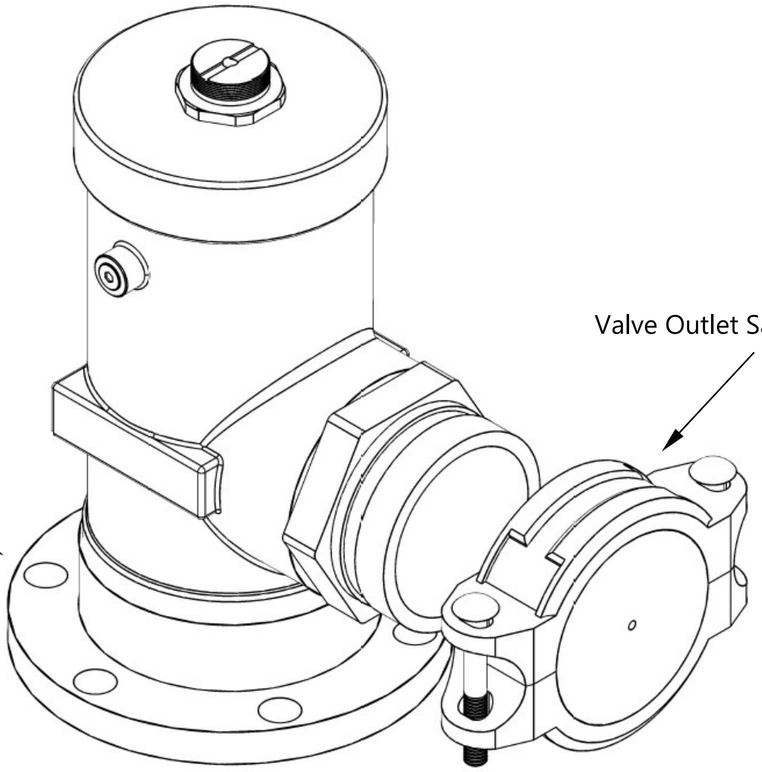


Figure 2-5: 3" Flange Type PYRO-200 Valve

PYRO-200 Valve Assembly	
Part No.	PYR-INT-FS-DV-3
Valve Size and Type	3″ Screw Type
Valve Body Material	Brass
Temperature Range	−10 ℃ to 60 ℃
Actuation Connection	1-1/4″ X 18UNEF
Pilot Hose Connection	1/8″ NPT
Pressure Gauge Connection	1/8″ NPT
Valve Outlet Connection	3″ Groove
Equivalent Length (m)	14

Note: All equivalent lengths given in Schedule 40, black pipe.

Flange	
Part No.	PYR-INT-FS-DVF-3
Flange Material	Brass
Temperature Range	−10 ℃ to 60 ℃
Connection to Valve	4″ x 12 UN
Connection to Cylinder	SS304 Cap Screw 5/8″ x 1-1/2″

2.5 VALVE OUTLET ADAPTOR

The valve outlet adaptor connects the cylinder valve outlet to the discharge piping when a flexible discharge hose is not used, for example, a single cylinder system.

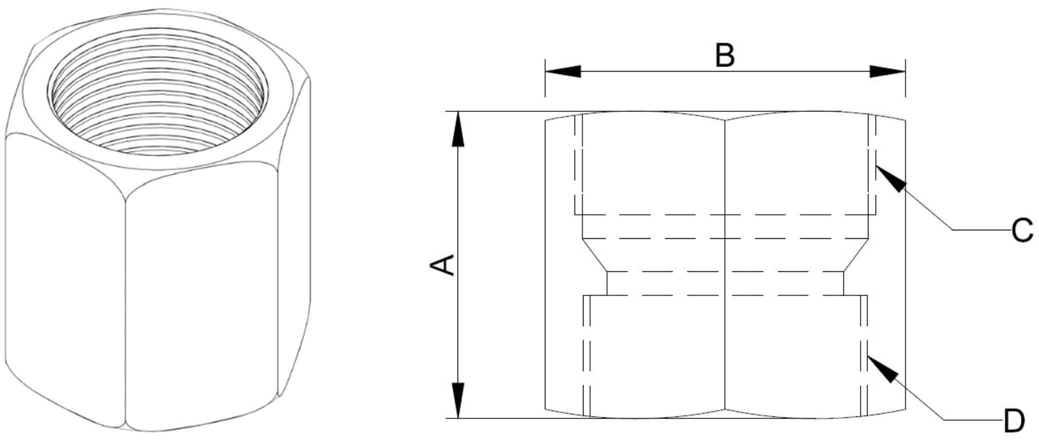


Figure 2-6: Valve Outlet Adaptor

Part No.	Valve Size	A (mm)	B (mm)	C	D
PYR-INT-FS-VOA-1V	1″	50	44.5	1-7/16″ – 12 UNJ	1″ BSP x 11 TPI
PYR-INT-FS-VOA-1.5V	1-1/2″	58	60.5	1-7/8″ – 12 UNJ	1-1/2″ BSP x 11 TPI
PYR-INT-FS-VOA-2V	2″	65	73.5	2-1/2″ – 12 UNJ	2″ BSP x 11 TPI

2.6 PYRO-200 CYLINDER LABEL

The cylinder label shows the details regarding the weight of HFC-227ea gas, tare weight, gross weight, filling pressure and charge date.

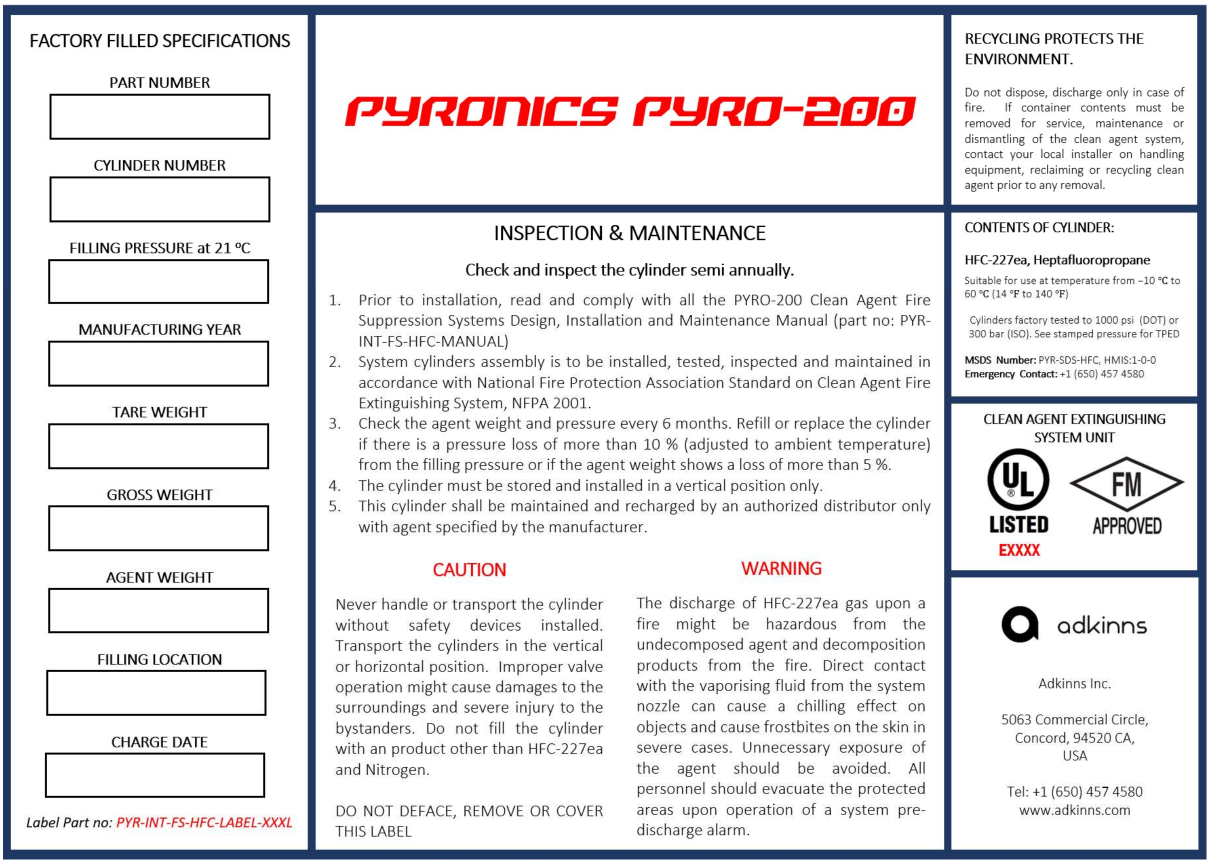


Figure 2-7: PYRO-200 Cylinder Label

Specifications	
Part Number	PYR-INT-FS-HFC-LABEL-100L
Material	Polyethylene Terephthalate (PET)
Size	297 mm x 210 mm

Specifications	
Part Number	PYR-INT-FS-HFC-LABEL-52L
Material	Polyethylene Terephthalate (PET)
Size	237 mm x 168 mm

2.7 ASSEMBLY PRESSURE GAUGE 25 BAR

The pressure gauge indicates the internal pressure of the PYRO-200 cylinders. It is installed onto the valve. 25 bar pressure gauge will be used in 25 bar PYRO-200 system cylinders.

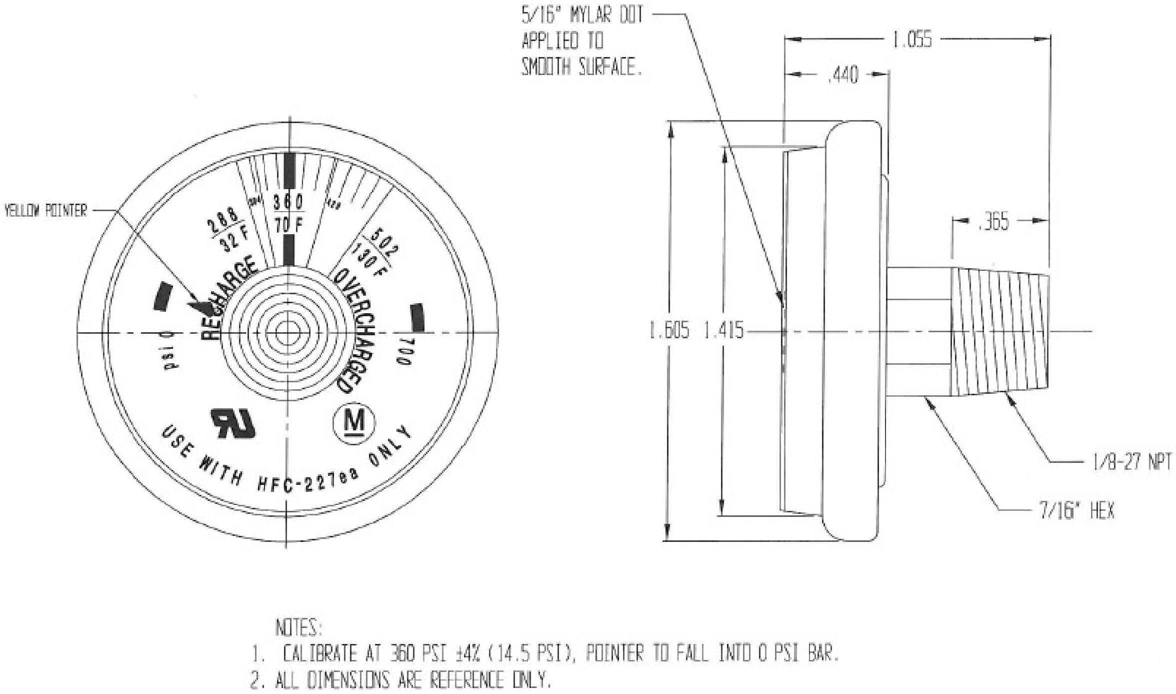


Figure 2-8: Pressure Gauge for 25 bar

Specifications	
Part Number	PYR-INT-FS-HFC-PG-25B
Type	Spring Tube Manometer
Temperature Range	−10 °C to 60 °C
Connection to Valve	1/8" NPT

2.8 ASSEMBLY PRESSURE GAUGE 42 BAR

The pressure gauge indicates the internal pressure of the PYRO-200 cylinders. It is installed onto the valve. 42 bar pressure gauge will be used in 42 bar PYRO-200 system cylinders.

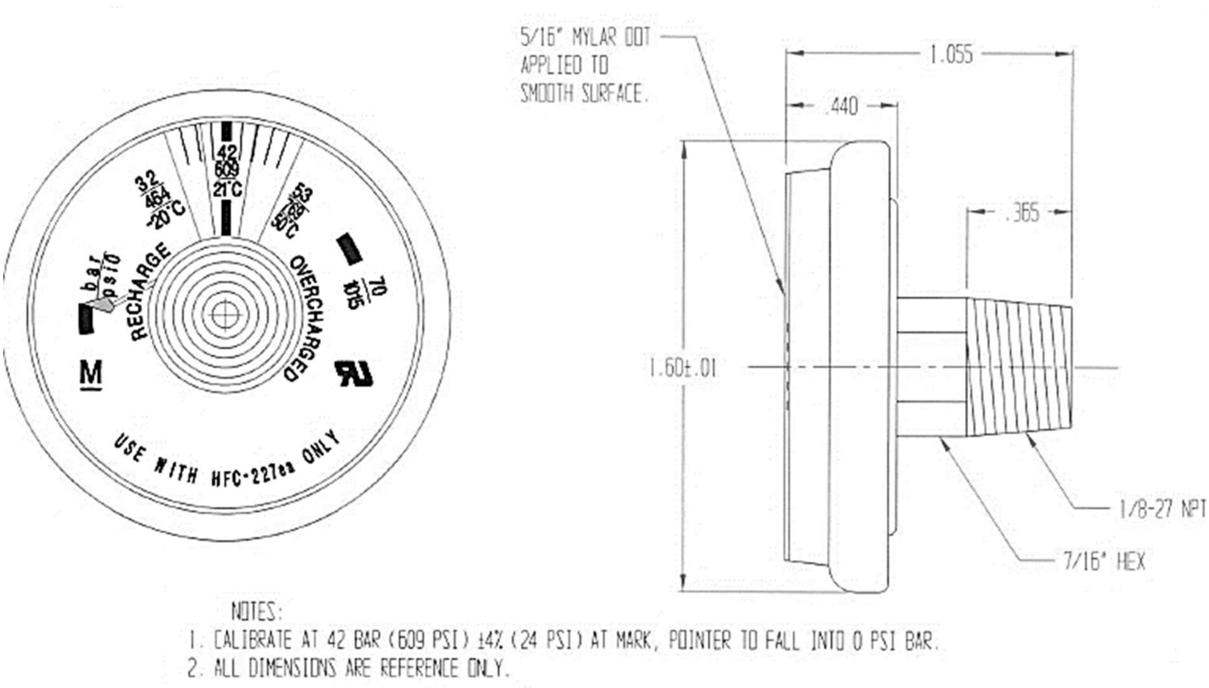


Figure 2-9: Pressure Gauge for 42 bar

Specifications	
Part Number	PYR-INT-FS-HFC-PG-42B
Type	Spring Tube Manometer
Temperature Range	−10 °C to 60 °C
Connection to Valve	1/8” NPT

2.9 ASSEMBLY PRESSURE GAUGE 50 BAR

The pressure gauge indicates the internal pressure of the PYRO-200 cylinders. It is installed onto the valve. 50 bar pressure gauge will be used in 50 bar PYRO-200 system cylinders.

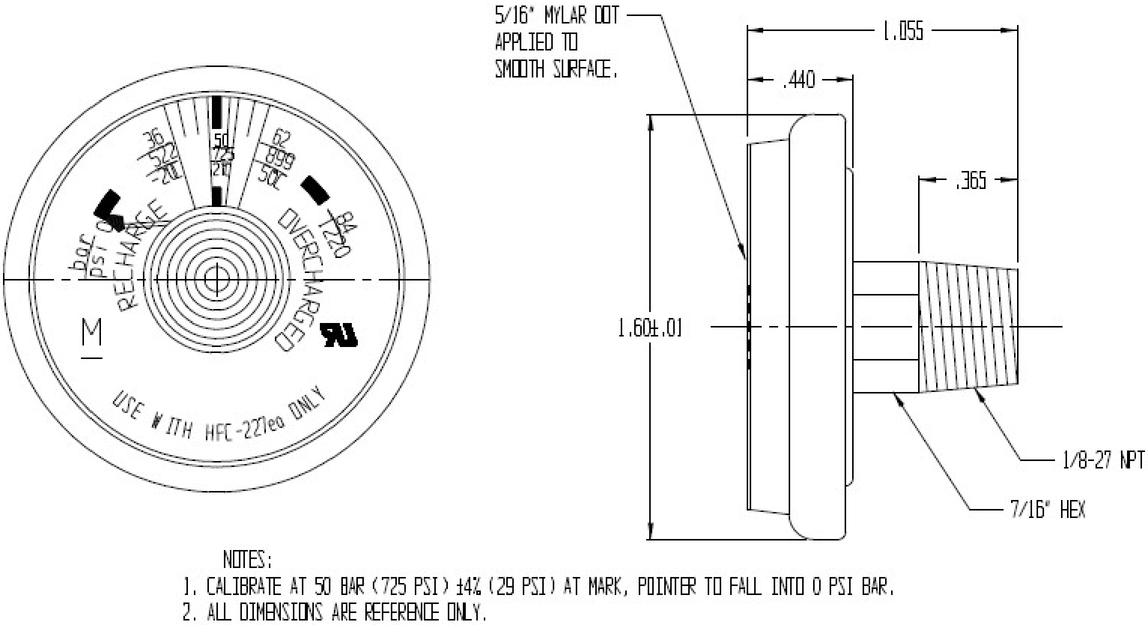


Figure 2-10: Pressure Gauge for 50 bar

Specifications	
Part Number	PYR-INT-FS-HFC-PG-50B
Type	Spring Tube Manometer
Temperature Range	−10 °C to 60 °C
Connection to Valve	1/8” NPT

2.10 ASSEMBLY PRESSURE GAUGE 25 BAR WITH LOW PRESSURE SWITCH

The pressure gauge with low pressure switch indicates and monitor the internal pressure of the PYRO-200 cylinders. It is installed onto the valve and connected electrically to the control panel. 25 bar pressure gauge with low pressure switch will be used in 25 bar PYRO-200 system cylinders.

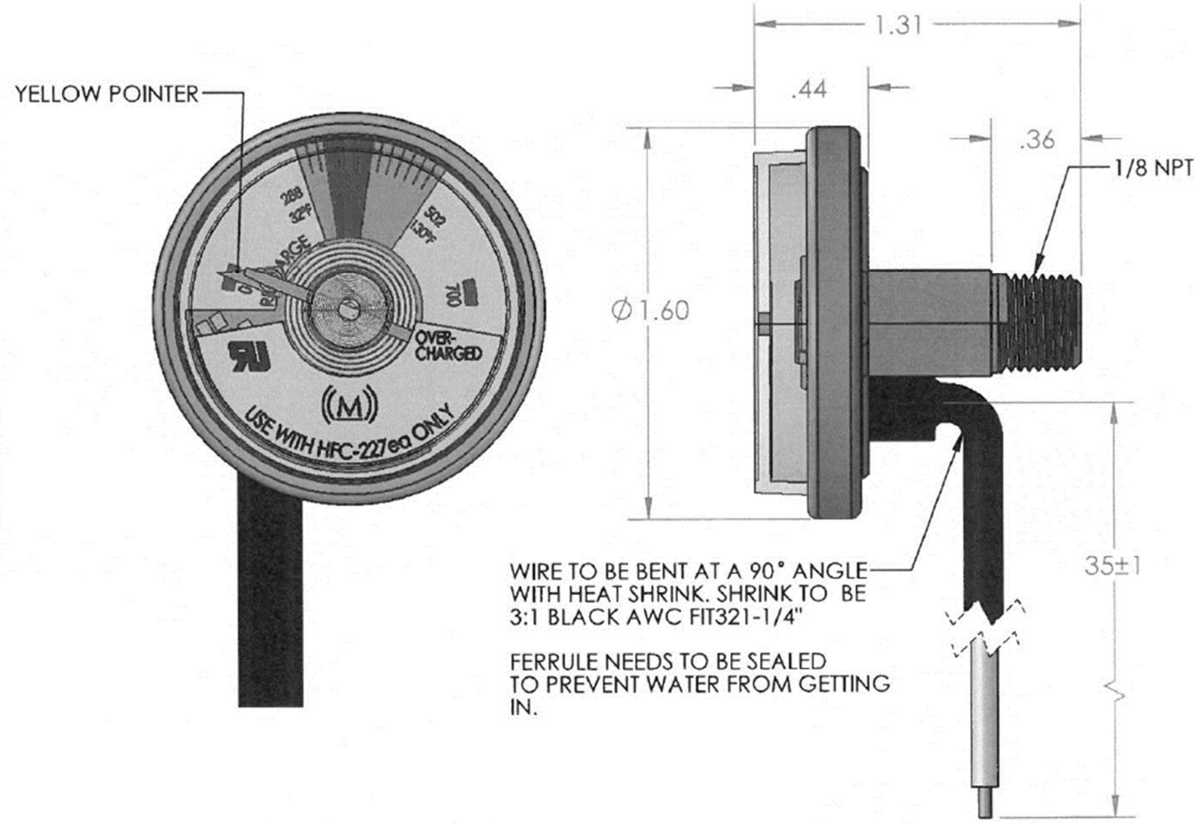


Figure 2-11: 25 bar Pressure Gauge with Low Pressure Switch

Specifications	
Part Number	PYR-INT-FS-HFC-PGS-25B
Wire	18 Gage SXL
Temperature Range	−10°C to 60°C
Connection to Valve	1/8" NPT

2.11 ASSEMBLY PRESSURE GAUGE 42 BAR WITH LOW PRESSURE SWITCH

The pressure gauge with low pressure switch indicates and monitor the internal pressure of the PYRO-200 cylinders. It is installed onto the valve and connected electrically to the control panel. 42 bar pressure gauge with low pressure switch will be used in 42 bar PYRO-200 system cylinders.

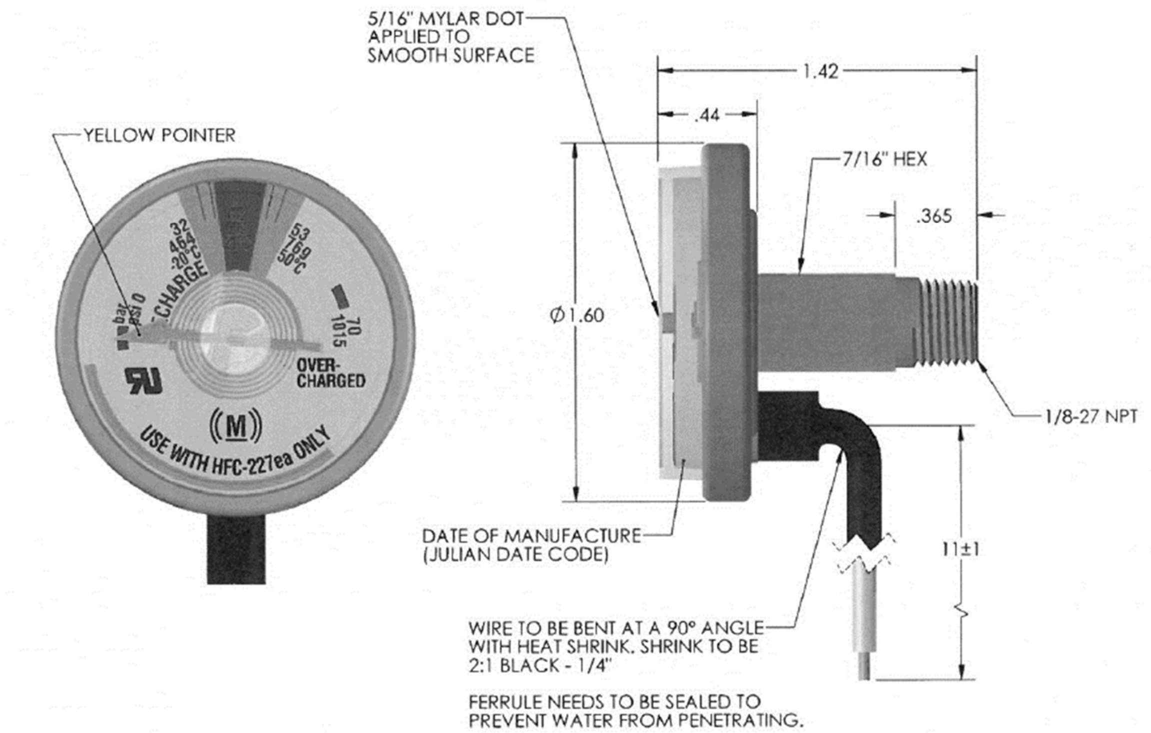


Figure 2-12: 42 bar Pressure Gauge with Low Pressure Switch

Specifications	
Part Number	PYR-INT-FS-HFC-PGS-42B
Wire	18 Gage SXL
Temperature Range	−10°C to 60°C
Connection to Valve	1/8” NPT

2.12 ASSEMBLY PRESSURE GAUGE 50 BAR WITH LOW PRESSURE SWITCH

The pressure gauge with low pressure switch indicates and monitor the internal pressure of the PYRO-200 cylinders. It is installed onto the valve and connected electrically to the control panel. 50 bar pressure gauge with low pressure switch will be used in 50 bar PYRO-200 system cylinders.

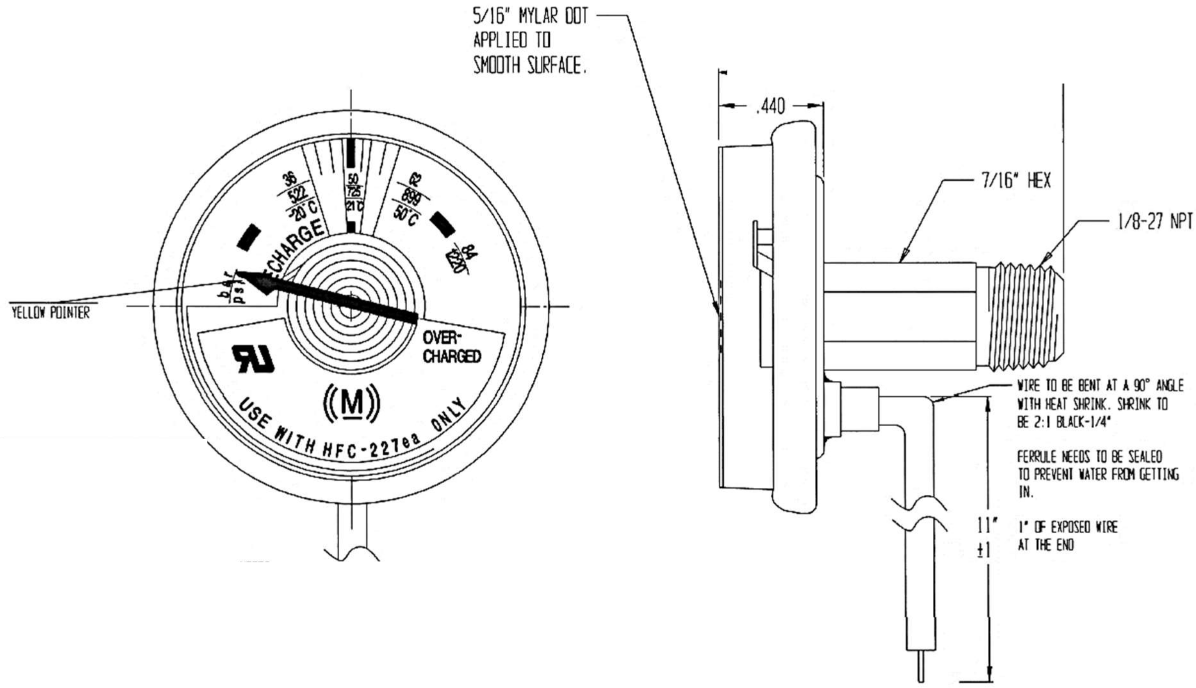


Figure 2-13: 50 bar Pressure Gauge with Low Pressure Switch

Specifications	
Part Number	PYR-INT-FS-HFC-PGS-50B
Wire	18 Gage SXL
Temperature Range	−10°C to 60°C
Connection to Valve	1/8” NPT

2.13 LIQUID LEVEL INDICATOR

The liquid level indicator is used to measure the liquid level of HFC-227ea for 100 L and 369L TPED cylinders. A measuring tape is place inside the tube. Pull the tape up to the maximum and then slowly lowering it until a magnetic interlock with the float is touched. The tape will remain above the neck ring to show the reading of the liquid level. The device is installed in an empty cylinder prior filling of HFC-227ea. It is suitable only for cylinder filling density of 0.8 kg/l and below.

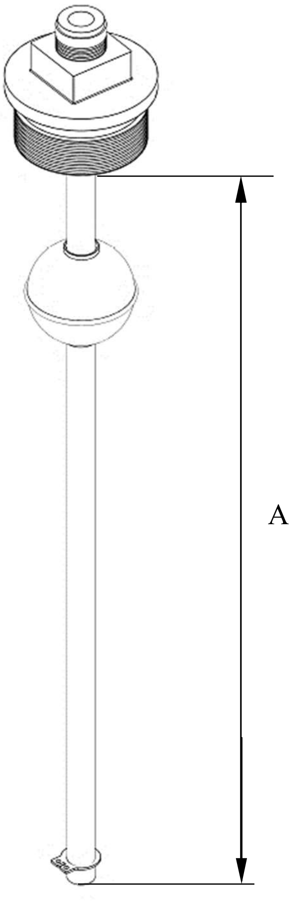


Figure 2-14: Liquid Level Indicator

Specifications	
Part Number	PYR-INT-FS-LLI
Cylinder Size	100L to 369L
Neck Ring Inlet Size	2”-11.5 NPSC
A (mm)	Varied according to cylinder

**Liquid level indicator subject to cylinder selection*

2.14 ELECTRICAL ACTUATOR WITH MANUAL CONTROL

The Electrical Actuator is used to actuate the system electrically. The actuator is installed on top of the master cylinder valve without any power supply until an event of emergency. A manual actuator can be installed as a backup or alternative solution on both the electrical actuator to discharge the HFC-227ea gas from the cylinder.

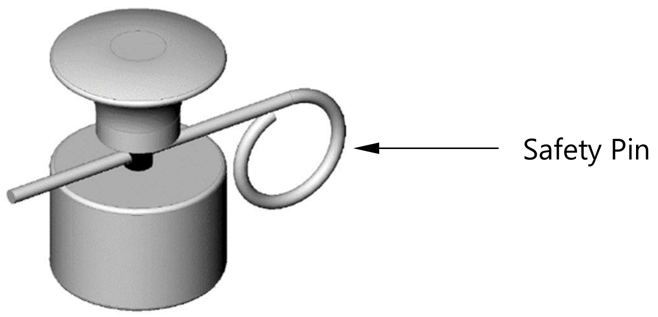


Figure 2-15: Manual Actuator

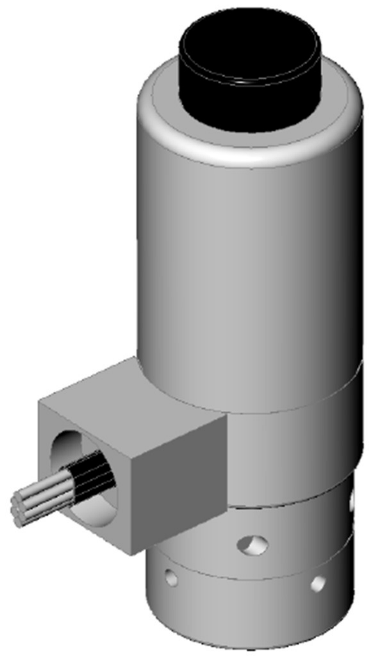


Figure 2-16: Electrical Actuators

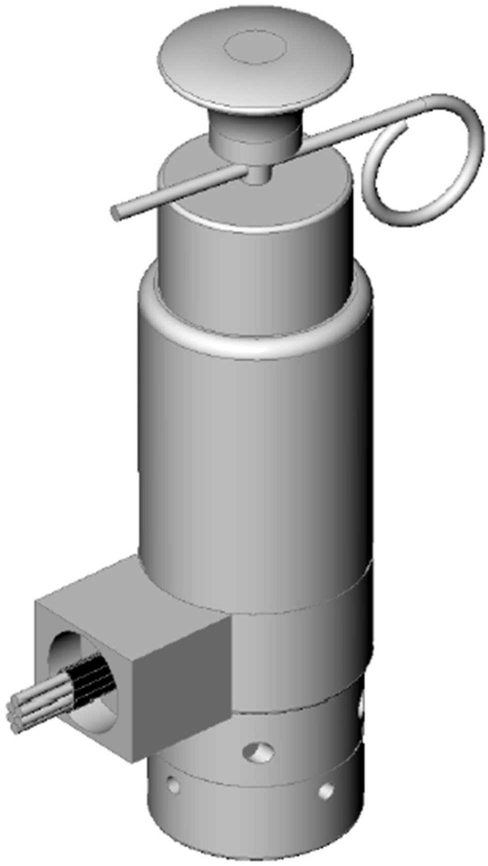


Figure 2-17: Electrical Actuator with Manual Actuator

Specifications (Manual Actuator)	
Part Number	PYR-INT-FS-MA
Material	Brass & Stainless Steel
Actuating Force	12 – 40 lbs
Connection	1-1/8″ x 18 UNEF

Specifications (Electrical Actuator)	
Part Number	PYR-INT-FS-EMA
Material	Brass & Stainless Steel
Actuating Force	12 – 40 lbs
Connection	1-1/4″ x 18 UNEF
Supply Voltage	24 VDC
Firing Current	0.5 Amp
Temperature Range	−10°C to 60°C

2.15 PNEUMATIC ACTUATOR

The pneumatic actuator(s) are installed in all the other slave cylinders. At first, the electical actuator will open the primary cylinder. After that, in rapid ocurring sequence, the pneumatic release device will open all the other cylinders.

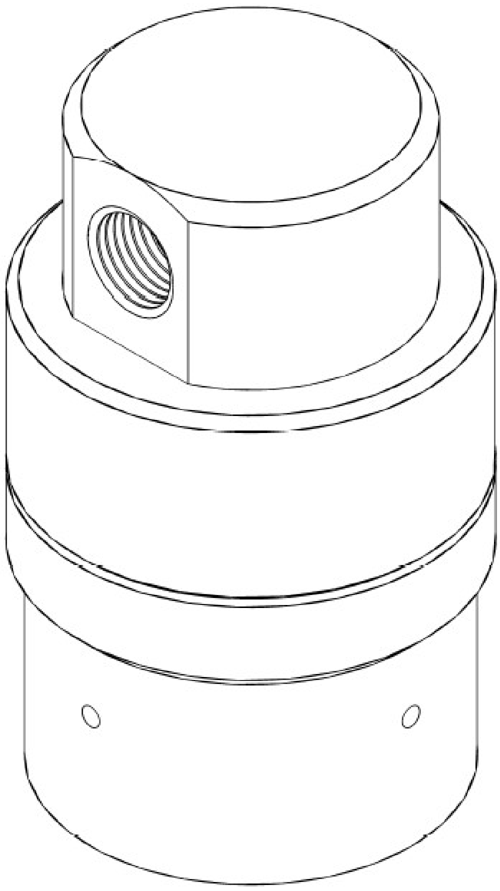


Figure 2-18: Pneumatic Actuator

Specifications	
Part Number	PYR-INT-FS-PA
Material	Brass
Connection	1-1/4” x 18 UNEF
Pilot Hose Connection	1/8” NPT

2.16 DISCHARGE HOSE

The discharge hose type DN38 is used for the valve assembly type DN38 for connection to the check valve DN50 where multiple cylinders are connected to a common manifold assembly. The discharge hose type DN50 is used for the valve assembly type DN50 for connection to the check valve DN65 where multiple cylinders are connected to a common manifold assembly.

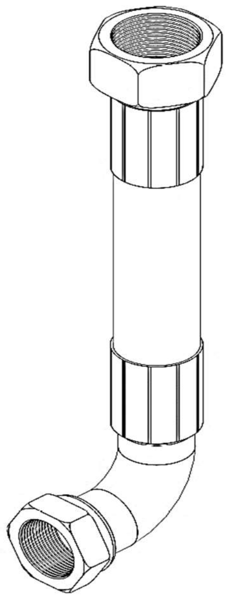


Figure 2-19: Discharge Hose

Specifications				
Part Number	PYR-INT-FS-DH-25B-1.5V	PYR-INT-FS-DH-45B-1.5V	PYR-INT-FS-DH-25B-2V	PYR-INT-FS-DH-45B-2V
Name	DN38		DN50	
Material	Synthetic Rubber Hose with high tensile steel wire single braid reinforcement	Synthetic Rubber Hose with high tensile steel wire double braids reinforcement	Synthetic Rubber Hose with high tensile steel wire single braids reinforcement	Synthetic Rubber Hose with high tensile steel wire double braids reinforcement
Max. Working Pressure	50 bar	90 bar	40 bar	80 bar
Temperature Range	−10 °C to 60 °C	−10 °C to 60 °C	−10 °C to 60 °C	−10 °C to 60 °C
Length from Elbow Inlet	465 mm	465 mm	520 mm	520 mm
Elbow Inlet	1-7/8” – 12 UNJ	1-7/8” – 12 UNJ	2-1/2” – 12 UNJ	2-1/2” – 12 UNJ
Outlet	2” BSP	2” BSP	2-1/2” BSP	2-1/2” BSP
Equivalent Length (m)	4.0	4.0	4.4	4.4

Note: All equivalent lengths given in Schedule 40, black pipe.

2.17 DISCHARGE HOSE WITH EXTENDED ELBOW

The extended elbow discharge hose is only available for DN50 valve with 25 bar system. This extended elbow enables the connection for a cylinder with a protective shroud to provide better flexibility during installation.

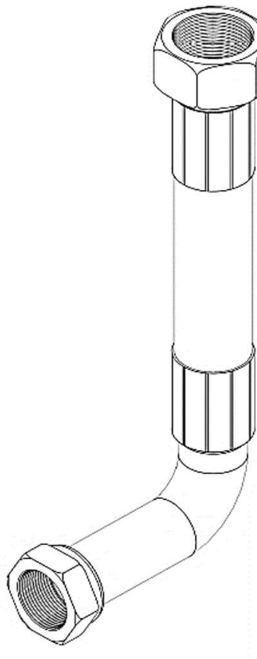


Figure 2-20: Extended Elbow Discharge Hose

Specifications	
Part Number	PYR-INT-FS-EEDH-25B-2V
Name	DN50
Material	Synthetic Rubber Hose with high tensile steel wire single braids reinforcement
Max. Working Pressure	40 bar
Temperature Range	−10 °C to 60 °C
Length from Elbow Inlet	520 mm
Elbow Inlet	2-1/2” – 12 UNJ
Outlet	2-1/2” BSP
Equivalent Length (m)	4.4

Note: All equivalent lengths given in Schedule 40, black pipe.

2.18 DISCHARGE HOSE FOR 3” VALVE

Discharge hose with configuration as figure below is only available for DN80 valve assembly. This discharge hose consists of 3” stainless steel hose, 90 degree grooved elbow and three 3” groove coupling. One side of the 90 degree grooved elbow is connected to the outlet of 3” valve by a 3” groove coupling. The other side will be connected to the stainless steel hose also by a 3” groove coupling. The other end of the stainless steel hose will then be connected to the check valve.

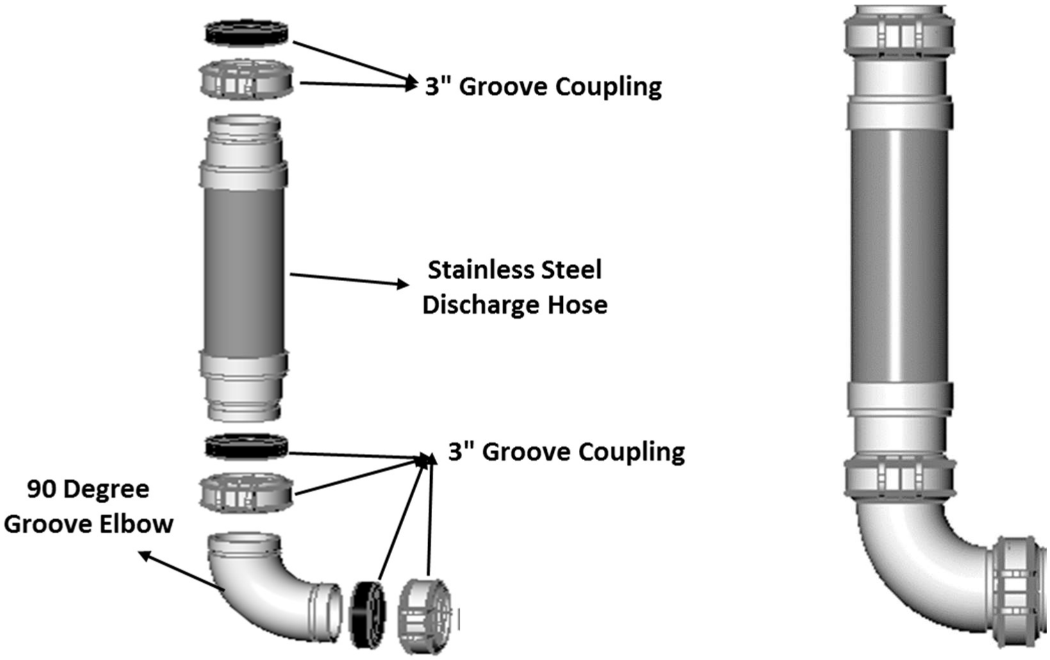


Figure 2-21: Arrangement for 3” Discharge Hose

2.18.1 3’’ STAINLESS STEEL HOSE

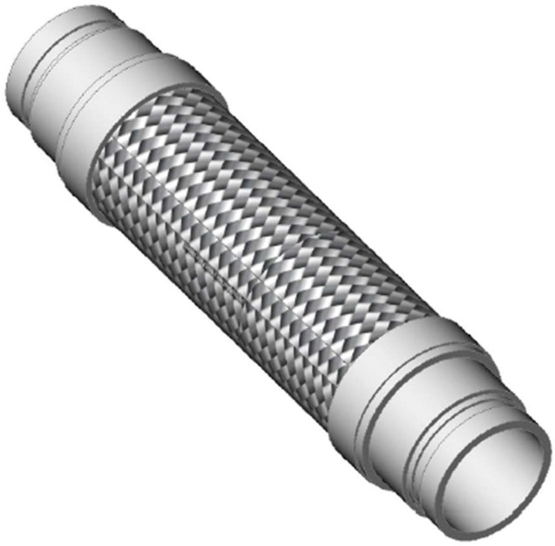


Figure 2-22: 3" Stainless Steel Hose

Specifications	
Part Number	PYR-INT-FS-DH-25B-3V
Material	Stainless Steel
Operating Pressure	28 bar
Temperature Range	−10 °C to 60 °C
Length	475 mm
Connection	3” Groove Connection
Equivalent Length (m)	4.7
Bend Limit	10°

Note: All equivalent lengths given in Schedule 40, black pipe.

2.18.2 3’’ GROOVE COUPLING

Figure 2-23: 3" 3” Groove Coupling

Specifications	
Part Number	PYR-INT-FS-GC-3
Material	Ductile Iron

2.18.3 3'' 90 DEGREE GROOVED ELBOW

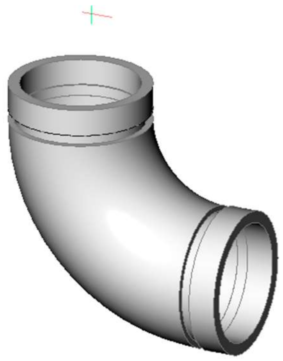


Figure 2-24: 3" 90 Degree Grooved Elbow

Specifications	
Part Number	PYR-INT-FS-90GE-3
Material	Ductile Iron
Connection	3" Groove Connection

2.19 PILOT LINE HOSE

The PYRO-200 pilot line hose is used to connect the pneumatic actuators from the master cylinder to slave cylinder(s). Each hose is fitted with a galvanized steel male connection fitting. A 1/8" nipple is used for connection to the master cylinder.

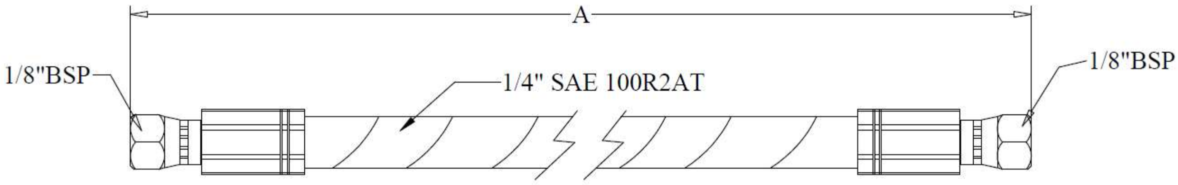


Figure 2-25: Pilot Line Hose

Specifications		
Part Number	PYR-INT-FS-PH-560	PYR-INT-FS-PH-760
Overall Length, A (mm)	560	760
Material	Synthetic Rubber Hose with 2 high tensile steel wire braids reinforcement	Synthetic Rubber Hose with 2 high tensile steel wire braids reinforcement
Max. Working Pressure	275 bar	275 bar
Temperature Range	−10 °C to 60 °C	−10 °C to 60 °C
Hose Connections	1/8" BSP	1/8" BSP
Fitting Connections	1/8" BSP	1/8" BSP

2.20 CHECK VALVE

The manifold check valve is fitted on the manifold and is used to prevent loss of agent should the system discharge while any cylinder is removed for maintenance.

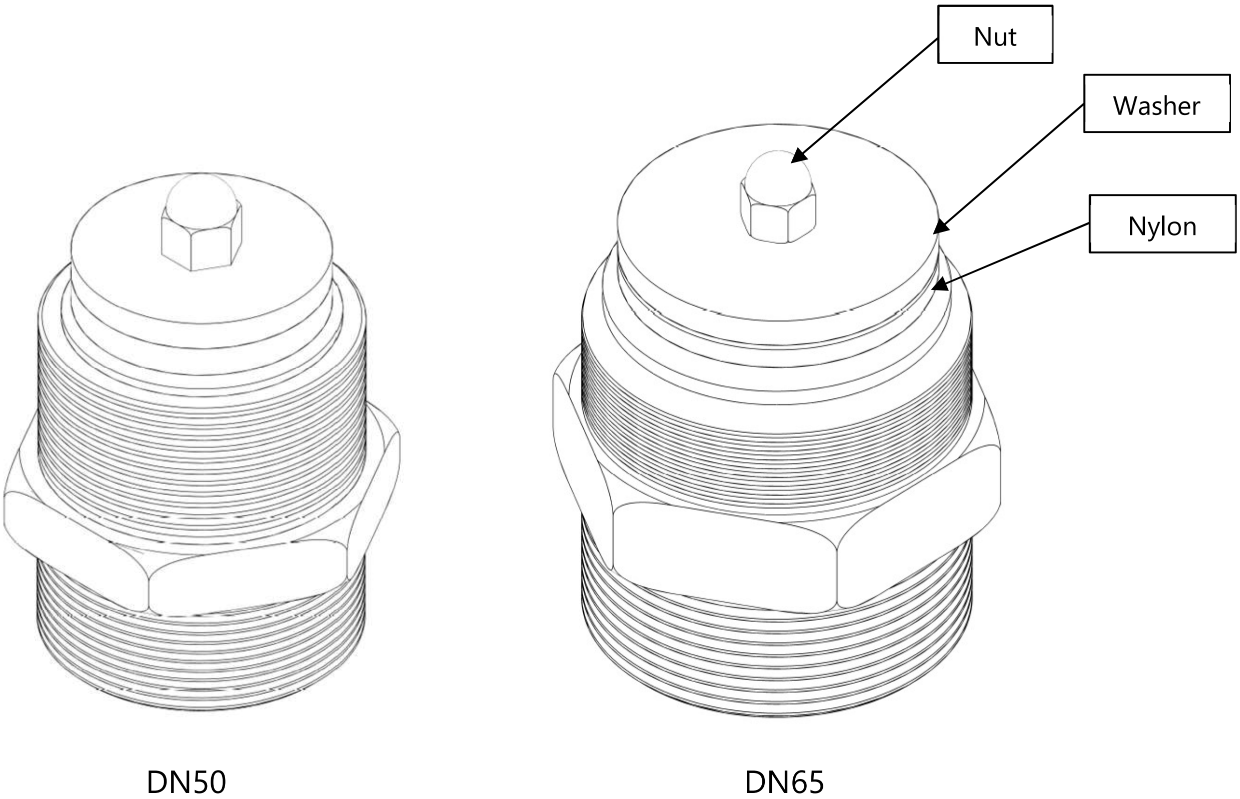


Figure 2-26: Check Valve

Specifications		
Part Number	PYR-INT-FS-CV-1.5	PYR-INT-FS-CV-2
Name	DN50	DN65
Overall Length (mm)	100	100
Material	Gun Metal	Gun Metal
Seat	Nylon	Nylon
Washer	Zinc Plated Mild Steel	Zinc Plated Mild Steel
Nut	Stainless Steel	Stainless Steel
Spline	Stainless Steel	Stainless Steel
Temperature Range	−10 °C to 60 °C	−10 °C to 60 °C
Inlet and Outlet Connections	2” BSP	2-1/2” BSP
Equivalent Length (m)	36.3	17.1

Note: All equivalent lengths given in Schedule 40, black pipe.

2.21 3" CHECK VALVE

The 3" check valve is only available for DN80 valve assembly. It is also used to prevent the loss of agent should the system discharge while any cylinder is removed for maintenance. The 3" check valve consists of a few components; check valve body, grooved reducer and two 6" groove coupling. The bottom part of the check valve body is connected to the grooved reducer by a 6" groove coupling and the top part of the check valve is connected to the manifold also by a 6" groove coupling. The arrangement can be seen in the figure below:

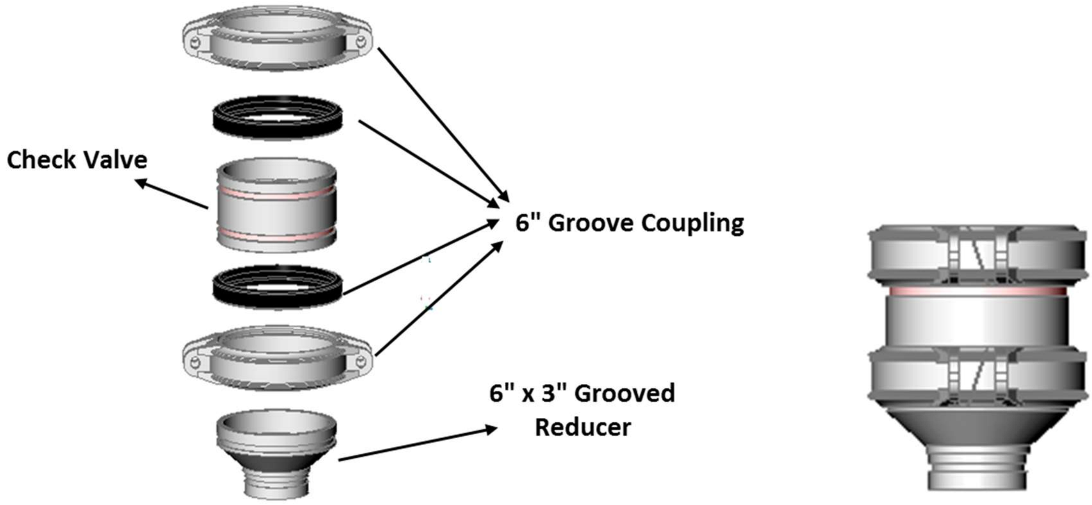


Figure 2-27: Arrangement of 3" Check Valve

2.21.1 3'' CHECK VALVE BODY

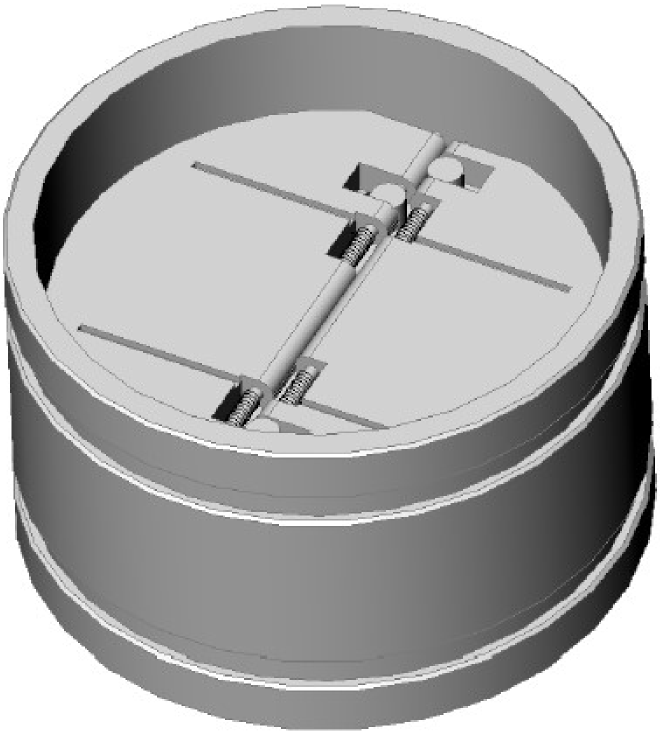


Figure 2-28: 3" Check Valve

Specifications	
Part Number	PYR-INT-FS-CV-3
Body Material	Steel, Zinc-Nickel Plated
Clapper Material	Brass
Temperature Range	−10 °C to 60 °C
Height	100 mm
Diameter	165mm
Connection	6" Groove Connection
Equivalent Length (m)	14

Note: All equivalent lengths given in Schedule 40, black pipe.

2.21.2 GROOVED REDUCER

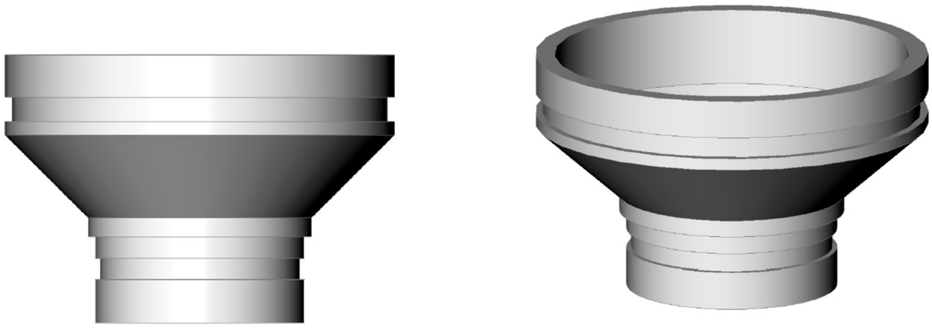


Figure 2-29: 6'' x 3'' Grooved Reducer

Specifications	
Part Number	PYR-INT-FS-GR-63
Material	Ductile Iron
Top Connection	6" Groove Connection
Bottom Connection	3" Groove Connection

2.21.3 6'' GROOVE COUPLING

Figure 2-30: 6'' Groove Coupling

Specifications	
Part Number	PYR-INT-FS-GC-6
Material	Ductile Iron

2.22 NOZZLE

There is one type of nozzle available in the PYRO-200 system, which is 360° discharge nozzle with 8 holes respectively. The orifice sizes of the nozzle are based on calculation done in the Jensen-Hughes software. The ports are drilled in 0.1 mm increments to the specified system design. The connection is BSP thread for all the nozzle.

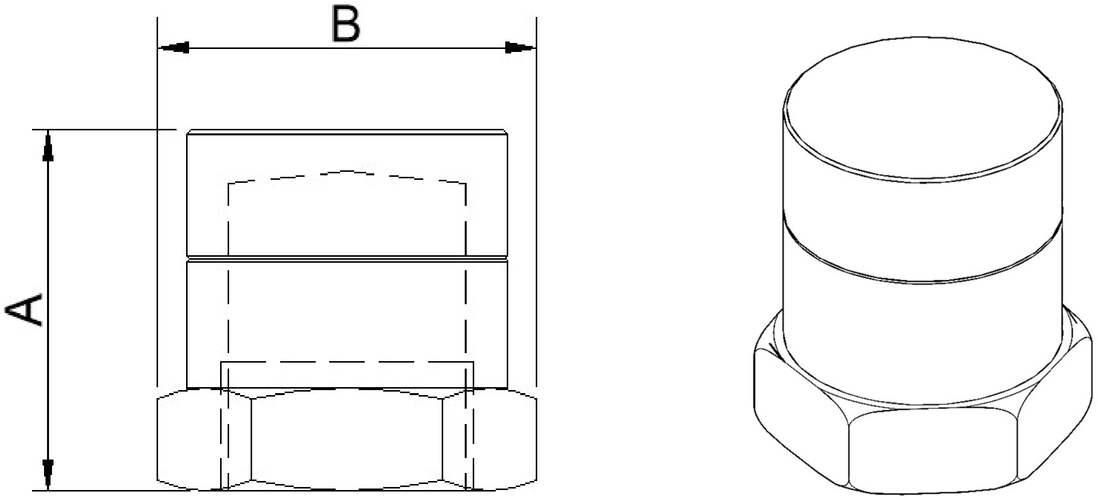


Figure 2-31: Nozzle

Table 2-6: Dimensions for 360° discharge nozzles

Part No.	Material	Sizes (inches)	A (mm)	B (mm)	Allowable Orifice Size, mm
PYR-INT-FS-HFC-DN-1.2	Brass	1/2"	45	31.75	2.2 – 4.9
PYR-INT-FS-HFC-DN-3.4		3/4"	45	38.10	3.4 – 6.6
PYR-INT-FS-HFC-DN-1		1"	56	44.45	4.3 – 8.4
PYR-INT-FS-HFC-DN-1-1.4		1-1/4"	65	50.80	5.6 – 11.0
PYR-INT-FS-HFC-DN-1-1.2		1-1/2"	70	63.50	6.5 – 12.9
PYR-INT-FS-HFC-DN-2		2"	88	76.20	8.4 – 16.6

**Allowable orifice size subject to design calculation*

2.23 CYLINDER MOUNTING EQUIPMENT

The steel bracket and strap are used to mount the cylinder in vertical position.

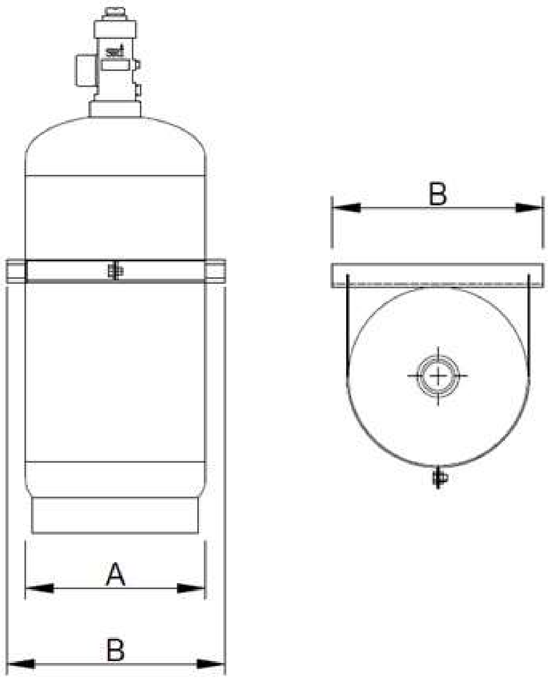


Figure 2-32: Cylinder mounting equipment

Table 2-7: Dimensions for cylinder mounting part

Part No.	Cylinder Outer Diameter, mm	A (mm)	B (mm)
PYR-INT-FS-SCMS-10L	140mm	140	300
PYR-INT-FS-SCMS-20.30L	204mm	204	300
PYR-INT-FS-SCMS-50L	228.6mm, 229mm, 232mm	229	300
PYR-INT-FS-WCMS-29L	254mm	254	300
PYR-INT-FS-WCMS-9.16L	267mm, 273mm	273	350
PYR-INT-FS-WCMS-32.52L	325mm	325	400
PYR-INT-FS-SCMS-80.140L	356mm, 350mm, 360mm	360	450
PYR-INT-FS-WCMS-52.150L	400mm, 406mm	406	500
PYR-INT-FS-WCMS-180.200L	462mm	462	550
PYR-INT-FS-WCMS-300L	508mm	508	600
PYR-INT-FS-WCMS-369L	610mm	610	700

**Dimension for bracket has a tolerance of ± 15mm*

2.24 SLAVE ARRANGEMENT COMPONENTS

For slave containers, the pneumatic connection is made using flexible pilot hose. To install the pilot hose, remove the pilot pressure port plug from the master container valve assembly and connect the male adaptor. After that, connect one end of the pilot hose to the pneumatic actuator. The maximum number of slave actuated cylinders is 5 containers (6 containers in total). After every 6 containers, another master container must be installed with an electrical actuator. All the electrical actuators must operate at the same time to ensure simultaneous discharge from all the cylinders used. Refer to Figure *2-35* and Figure *2-36* for more details regarding the arrangement for master-slave cylinders for welded cylinders and seamless cylinders respectively.

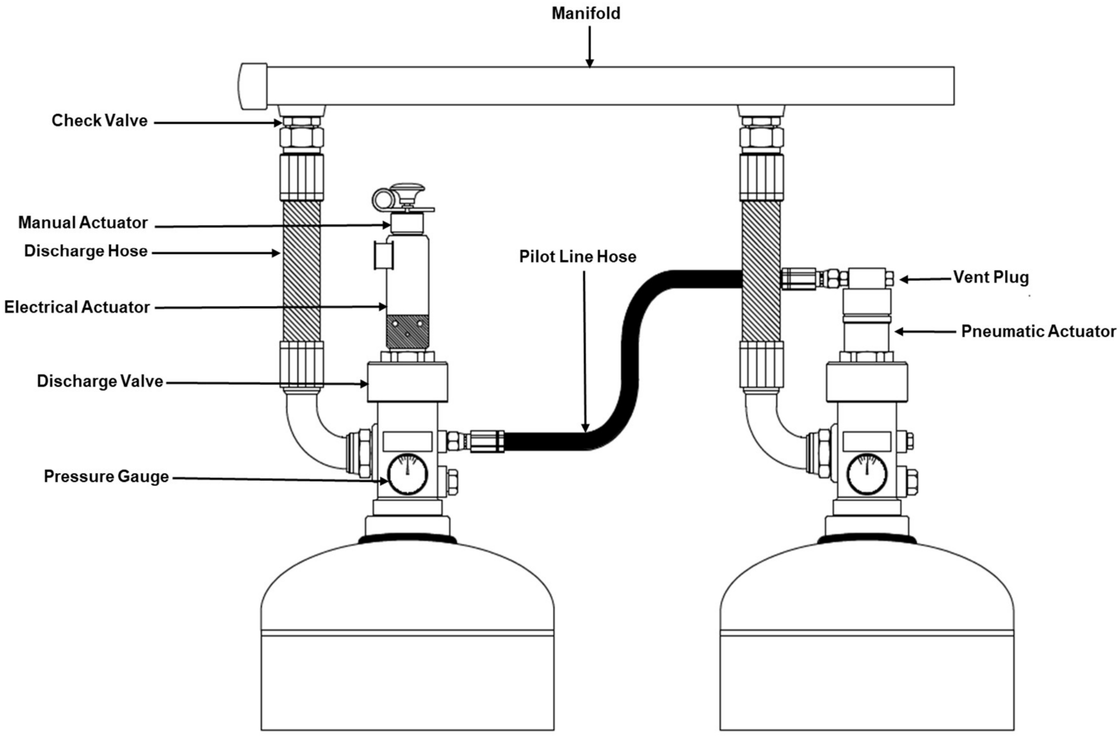


Figure 2-33: Master and Slave(s) Cylinder Arrangement

2.25 ARRANGEMENT FOR 3” VALVE SYSTEM

The master and slave arrangement for a 3” valve system is generally the same as the other system (Refer to Figure *2-33*). The only difference is the type of discharge hose and check valve used in the 3” valve system compares to the other system. The assembled discharge hose is connected to the check valve by a 3” groove coupling. The check valve will then be connected to the manifold by a 6” groove coupling.

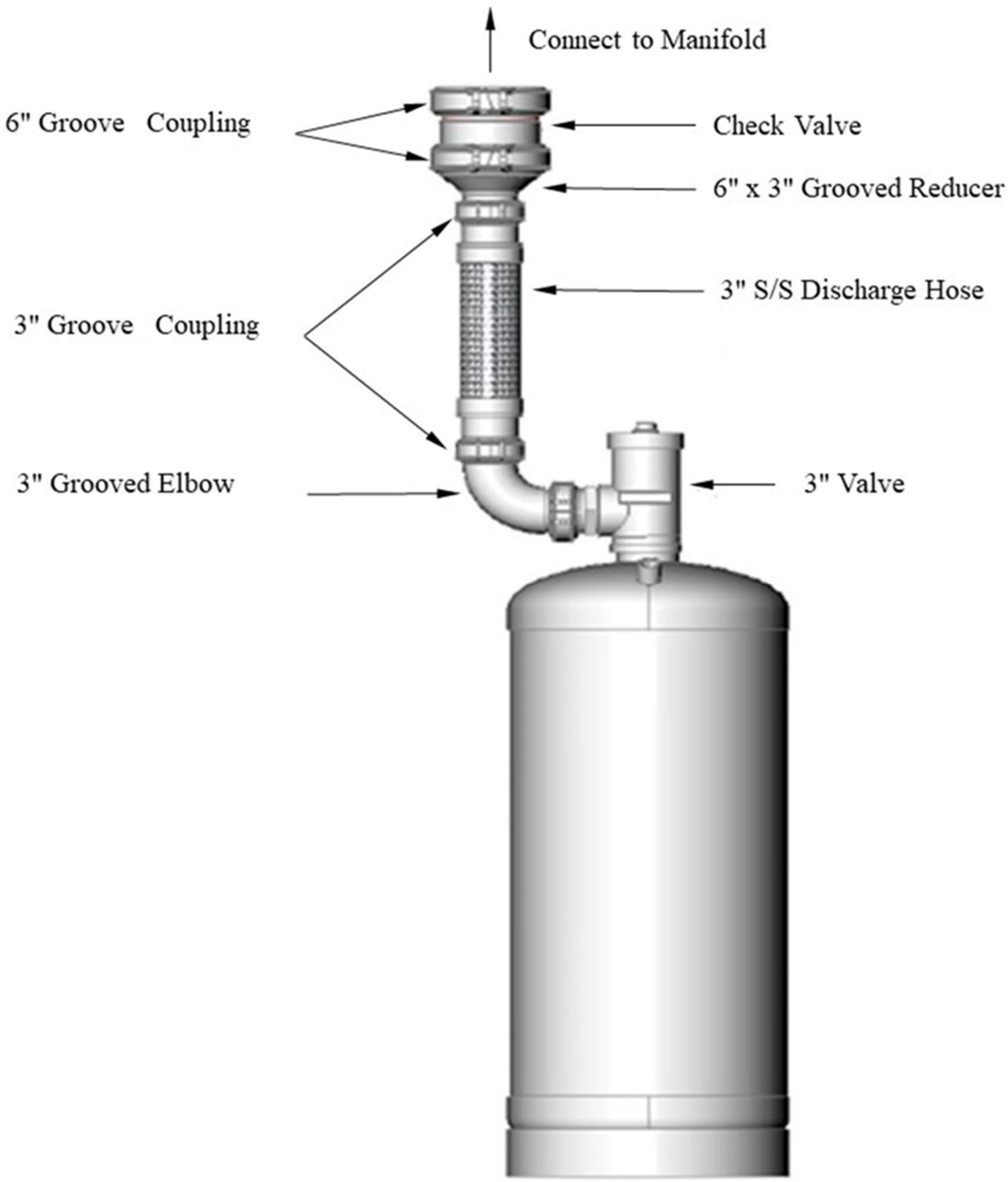
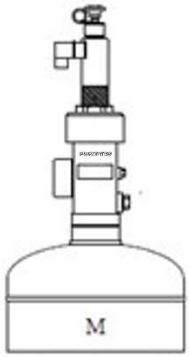
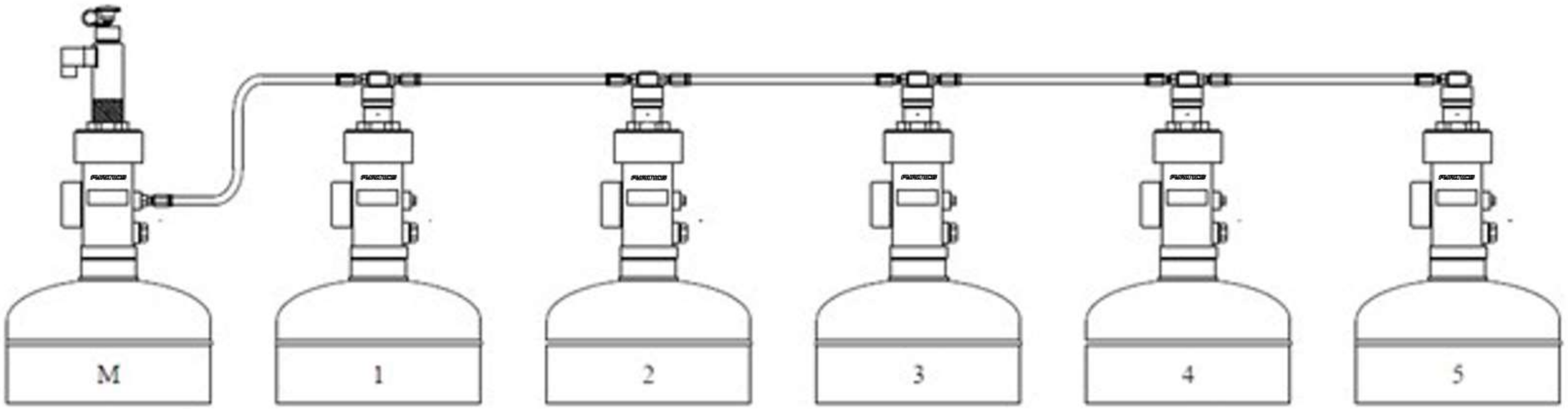


Figure 2-34: Arrangement for 3” Valve System

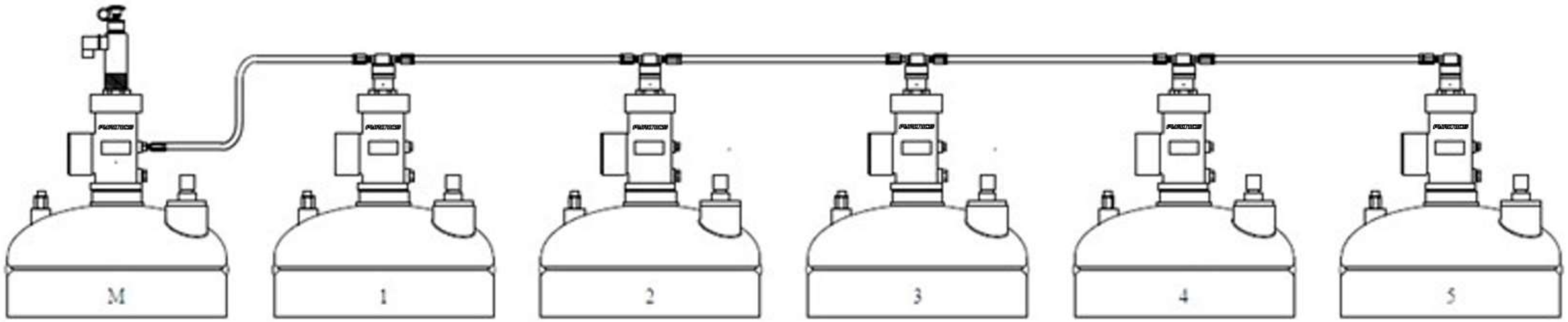
2.26 SLAVE ARRANGEMENT COMPONENTS (WELDED CYLINDERS)



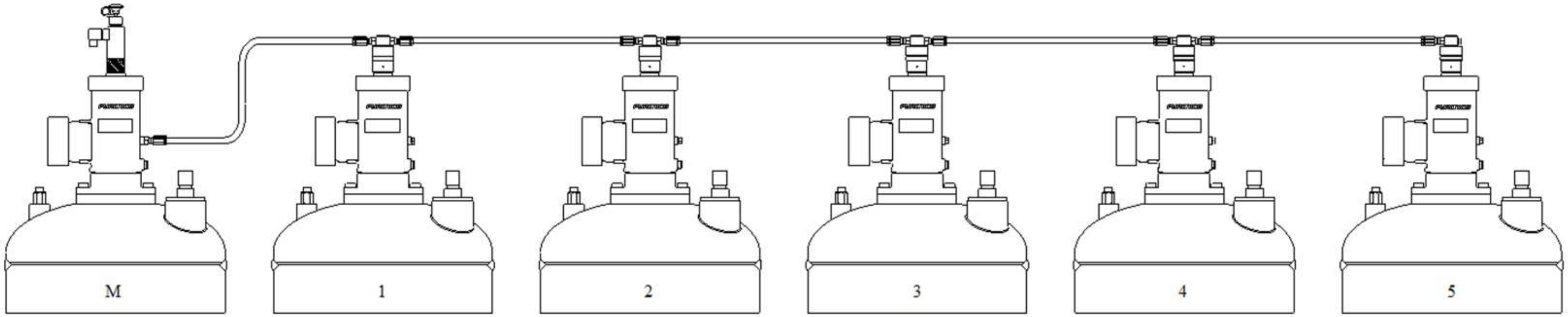
9 L to 32 L Master Cylinder – Maximum of one, 1" Valve cylinders can be used



52 L to 100 L Master Cylinder – Maximum of six, 1-1/2" Valve cylinders can be used



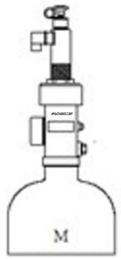
150 L to 200 L Master Cylinder – Maximum of six, 2" Valve cylinders can be used



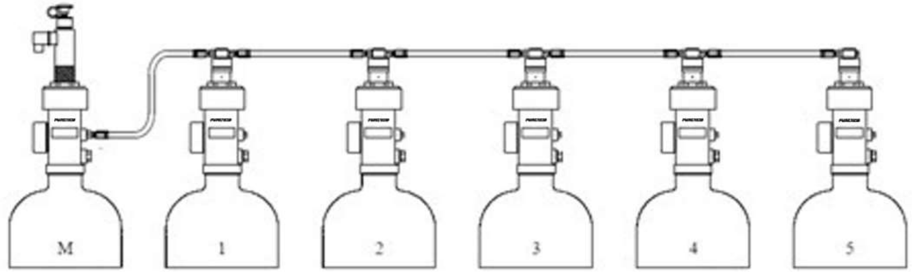
240 L to 369 L Master Cylinder – Maximum of six, 3" Valve cylinders can be used

Figure 2-35: Maximum Number of Pneumatic Actuator for Welded Cylinders

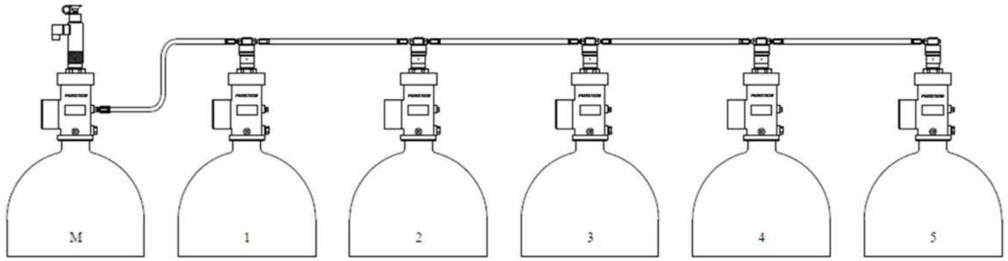
2.27 SLAVE ARRANGEMENT COMPONENTS (SEAMLESS CYLINDERS)



10 L to 30 L Master Cylinder – Maximum of one, 1" Valve cylinders can be used



50 L to 100 L Master Cylinder – Maximum of six, 1-1/2" Valve cylinders can be used



140 L Master Cylinder – Maximum of six, 2" Valve cylinders can be used

Figure 2-36: Maximum Number of Pneumatic Actuator for Seamless Cylinders

CHAPTER 3

SYSTEM DESIGN

In the design of a PYRO-200 Gas Fire Suppression system, there are two main elements of a system design. The first step in the design of PYRO-200 Fire Suppression System is risk assessment to be followed by calculating the volume of HFC-227ea required, including hazard volume, pipe sizing layout, positioning of cylinder and nozzles.

3.1 EVALUATION OF HAZARDS AND RISK

As a general rule, all fire protection systems begin with a risk assessment that should evaluate the following:

1. The consequences of material loss or interruption of services
2. Type of combustible materials are present
3. Possible sources of ignition either internally or externally
4. Evacuation of the area
5. Consequences of fire spread to adjoining areas
6. Whether the hazard area is or can be enclosed

Defining the hazard shall include the following steps:

1. Determine the fuel(s) within the risk which would propagate a fire once started. The fuel with the highest required agent concentration to govern.
2. Determine the closable and un-closable openings within the hazard enclosure which may affect the performance of the halocarbon gas system.
3. Determine whether the halocarbon gas system is to be used for extinguishing within the risk.
4. Determine the design temperature of the hazard enclosure.
5. Select the flooding factor / design concentration required for the risk. For the required agent flooding factor / design concentration requirement see Table 3-4 and
6. Table *3-5*.
7. All floor voids shall be included in the protection. All ceiling voids over 300 mm should be included in the protection. Ceiling voids less than 300 mm may require protection:

    a) If a hazard exists within them

    b) If there are un-closable openings into the main hazard

c) If the void forms part of the ventilation system.

This process will clarify whether an active fire protection system is required and whether the fire extinguishing gas is suitable and practical. In the design of a PYRO-200 Gas Fire Suppression system, it is important to correctly define the hazard and conduct a thorough survey to determine if the halocarbon gas system will properly protect the enclosure / hazards.

3.1.1 Types of Hazards

The PYRO-200 Gas Suppression are designed to extinguish fire in the classes of:

1. **Class A fire**: Fire in ordinary combustible materials. For example, fires involving solid material normally of organic nature such as wood, paper fabric, etc. These fires normally take place with the formation of glowing embers.
2. **Class A polymeric fire**: Fire in plastic materials such as polypropylene or PVC.
3. **Class B fire**: Fire in combustible liquids, mainly hydrocarbon, polar solvents, oils, tar, glycol and other additives. These fires mainly produce surface fires.
4. **Class C fire**: Fire that involves energized electrical equipment at 480 volts or less where the electrical resistivity of the extinguish media is of importance. These fires may include computer rooms, control rooms, transformers, oil switches, circuit breakers, rotating equipment, pumps and motors.

3.1.2 Hazard Volume

The hazard enclosure volume needs to be determined in order to calculate the amount of agent required and the number of cylinders used. Each enclosed space is considered as a risk area and requires at least one nozzle. In the calculation of the volume of the hazard, it is normally considered to be empty. However, if there are fixed, immoveable objects such as beams, columns and permanent dividers in the hazard area, their volumes shall be deducted from the total hazard volume. Calculate the volume using the internal dimensions of the enclosure in meters.

If the enclosure has solid immovable objects such as beams and columns, their volumes must be deducted to determine the net hazard volume. If the hazard / enclosure is designated as explosion-proof, the control system, releasing devices, electric valve actuators, pressure switches and pressure monitoring switches (if not approved for hazardous environments) must be located away from the hazard area and the system must be remotely piped to the area. Only the detectors, distribution piping, nozzles or other non-electrical parts may be located in the hazard, alternatively explosion-proof components must be used.

3.1.3 Ventilation

Discharge of HFC-227ea will induce a pressure change in the enclosure. The required amount of gas discharged into the enclosure will displace some of the atmospheric air from the room which results in a positive pressure within the room. Structural strength of the enclosure, eg: walls, ceilings, floors, window, etc. of the enclosure must be adequate enough to withstand any increase in pressure during discharge. Therefore, a ventilation system must be installed if the pressure change from discharge poses a threat to the structural strength of the enclosure. This is to prevent excessive pressure build up in the enclosure.

Normally, most small / medium sized enclosures have sufficient natural venting with the assumption that it has not been sealed too effectively. Larger enclosures requiring huge amounts of gas are more likely to require pressure relief dampers as the surface area to enclosure volume ratio falls. If the natural venting area is greater than the minimum required venting area, determine the agent holding time using the integrity test procedure.

A vacuum suction pump has to be installed along with the ventilation system to ventilate the enclosure thoroughly after discharge.

*Refer to FSSA Application Guide to Estimating Enclosure Pressure and Pressure Relief Vent Area for further info.

3.1.4 Agent Storage

The design temperature as well as the maximum ambient temperature for the hazard area must be identified. The agent required is based on the expected design ambient temperature in the hazard area. If the difference in the lowest and the highest expected ambient temperature is significant, it may be more appropriate to calculate the concentration level at a median expected ambient temperature to ensure that it does not exceed the NOAEL value for the agent as stated in NFPA2001 and ISO 14250 during the highest expected temperature whilst having a sufficient extinguishing concentration during the lowest expected temperature. The agent cylinder must be located indoors in an area with a temperature range from **-10ºC to 60ºC**. PYRO-200 system has 3 working pressures (25bar, 42bar, and 50bar). For system that requires distance of cylinder to be placed further away from the enclosure, a higher working pressure system shall be recommended in order to achieve the required discharge time.

In selecting a suitable location that is acceptable with the end-user, the following guidelines must apply:

1. The temperature range is within the limits
2. Piping limitation are not exceeded
3. Design working pressure
4. The components are not subjected to damage or vandalism
5. A manual release system is installed and accessible
6. Cylinders and actuation devices must be stored in a weatherproof area

7. If cylinders are stored in a dedicated area, ensure that the area is not used for storage of other equipment which may add a fire risk to the room.
8. The location should be a dry area and should not be subjected to a corrosive environment.

3.1.5 Reserve System

If a reserve system is required, determine if it should be permanently connected or stored on the premises. Generally, a reserve system is recommended if the hazard is located in a remote area where there are difficulties in recharging the cylinders within a reasonable time or the system is protecting a high risk/value hazard. The addition of a reserve system will invariably add to the job cost estimate.

3.1.6 Hazard/Enclosure Integrity Survey

An integrity test is recommended to determine the natural venting area and the agent retention prediction for the enclosure. This is to locate and effectively seal off any significant leaks that might result in the inability of the enclosure to hold the extinguishing agent concentration for the specified amount of hold time. A door fan test is recommended to establish the integrity of enclosures.

The door fan test uses a blower to blow air into or out the enclosure, creating a positive and/or negative pressure difference between in and outside of the enclosure. The pressure difference will force the air through all the air leaks present. If the enclosure has minimal air leaks, it will reduce the amount of air required to create a pressure change in the enclosure. Where the holding time is less than the specified time is indicated, additional sealing of the enclosure is required. Once the additional sealing has been completed the enclosure must be tested again to ensure the specified hold time will be achieved and sufficient venting area exists to prevent overpressure. This procedure must be repeated until these criteria are met.

For more information refer to NFPA2001 -Standard for Clean Agent Fire Extinguishing Systems Annex C.

3.1.7 AUTHORITY HAVING JURISDICTION

Contact the end-user or the local authority having jurisdiction to establish the requirements for the following:

1. Detector spacing requirements
2. Type of detection and control system that is acceptable
3. Audio and visual alarms requirements
4. Inspection of equipment
5. If reserve system is required
6. Disposal of chemicals

3.2 DESIGN FLOW CHART

Determine the hazard altitude and correction factor

↓

Calculate agent quantity required pre enclosure at minium design temperature expected at enclosure

↓

Determine the size of cylinder needed and if necessary the no. of cylinders required

↓

Select the nozzle type and determine the location(s)

↓

Determine the location of the cylinder(s) to define the manifold layout (if multiple cylindersare used) and the distribution piping. Estimate the required pipe size

↓

Calculate quantity of agent per nozzle and check percentage agent split at Tees

↓

Identify all pipe lengths, rises, falls and nozzle reference numbers. Draw the isometric layout of pipe and node system

↓

Run the computer calculation for pipe sizing, nozzle sizes and orifice sizes, the predicted agent concentration and the predicted discharge times.

↓

Prepare contract drawings

3.3 AGENT QUANTITY

Calculation of the extinguishing agent quantity required is based on the lowest expected ambient temperature and the design concentration required to protect the hazard area. The following design concentrations at temperature of 21 °C or 70 °F (as specified in NFPA 2001: current edition) are used to determine the required amount of agent:

Table 3-1: UL Listed HFC-227ea Minimum Design Concentration Tested to UL 2166

Agent	Class A Design Concentration	Class B Design	Class C
HFC-227ea	6.7 – 7%	8.7%	7%

Table 3-2: FM Approved HFC-227ea Minimum Design Concentration Tested to FM 5600

Agent	Class A Design Concentration	Class B Design	Class C
HFC-227ea	6.96%	8.71%	7.83%

Table 3-3: NOAEL and LOAEL values for HFC-227ea

Agent	No Observable Adverse Effects Level (NOAEL) concentration	Lowest Observable Adverse Effects Level (LOAEL)
HFC-227ea	9%	10.5 %

NOTE: System designers must be aware of the NOAEL and LOAEL values for HFC-227ea when designing the system for normally occupied areas.

* NFPA 2001: current edition – Table A.5.4.2.2 (b)
* Higher design concentrations are required for protection of class B fuels. The minimum design concentration for protection of all class B hazards shall not be less than 8.71%. For design concentrations of other than class B (flammable liquids), contact Adkinns Inc.

3.3.1 CALCULATION OF AGENT REQUIRED

The quantity of agent required can be calculated with the following formula*:

$$Q = \frac{V}{S}\left(\frac{C}{100 - C}\right)$$

Where,
Q = Agent design quantity, kg

V = Hazard Volume, m^3

C = Design Concentration, volume percent %

S = K_1 + K_2 (T)

The relevant values for K_1 and K_2 are:

K_1 = 0.1269 and K_2 = 0.0005 for temperature in degree Celsius, °C

K_1 = 1.885 and K_2 = 0.0046 for temperature in Fahrenheit, °F

*Source - NFPA2001:2008 - Annex A, Table A.5.51(j)

Design Example:

Data Centre	- Room dimensions		= 8 m (L) X 6 m (W) X 2.65 m (H)
	- Floor void		= 8 m (L) X 6 m (W) X 0.35m (H)
Data Centre	- Room Volume		= 127.2 m^3
	- Floor Void Volume		= 16.8 m^3
Data Centre	- Net Hazard Vol.		= 144 m^3
Design Temperature			= 21 °C
Specific Vapor Volume, S			= 0.1374 m^3/kg
Design Concentration, C			= 7 % (Example Only)

Agent required:

$$Q = \frac{V}{S}\left(\frac{C}{100 - C}\right)$$

Data Centre	- Room	= 69.68 kg
	- Floor Void	= 9.2 kg
Total Agent Required		**= 78.88 kg**

3.3.2 Alternative Quick Calculation

Alternatively, the amount of agent required can be calculated using the flooding factors as shown in Table 3-4 and Table *3-5*.

Select the row corresponding to the lowest ambient temperature in the enclosure and identify the flooding factor based required design concentration at the column. Extrapolation will provide an acceptable flooding factor if the design concentration required is between those given in the Table 3-4 and Table *3-5*.

Table 3-4: HFC-227ea total flooding quantity (Metric Units)

Temp. °C	Specific Vapor Volume m^3/kg	Weight Requirements of Hazard volume, W/V (`kg/m^3) Design concentration (% per volume)							
T	S	6%	7%	8%	9%	10%	11%	12%	13%
-10	0.1215	0.5254	0.6196	0.7158	0.8142	0.9147	1.0174	1.1225	1.2301
-5	0.1241	0.5142	0.6064	0.7005	0.7987	0.8951	0.9957	1.0985	1.2038
0	0.1268	0.5034	0.5936	0.6858	0.7800	0.8763	0.9748	1.0755	1.1785
5	0.1294	0.4932	0.5816	0.6719	0.7642	0.8586	0.9550	1.0537	1.1546
10	0.1320	0.4834	0.5700	0.6585	0.7490	0.8414	0.9360	1.0327	1.1316
15	0.1347	0.4740	0.5589	0.6457	0.7344	0.8251	0.9178	1.0126	1.1096
20	0.1373	0.4650	0.5483	0.6335	0.7205	0.8094	0.9004	0.9934	1.1089
25	0.1399	0.4564	0.5382	0.6217	0.7071	0.7944	0.8837	0.9750	1.0684
30	0.1425	0.4481	0.5284	0.6104	0.6943	0.7800	0.8676	0.9573	1.049
35	0.1450	0.4401	0.519	0.5996	0.6819	0.7661	0.8522	0.9402	1.0303
40	0.1476	0.4324	0.5099	0.5891	0.6701	0.7528	0.8374	0.9230	1.0124
45	0.1502	0.4250	0.5012	0.579	0.6586	0.7399	0.8230	0.9080	0.9950
50	0.1527	0.418	0.4929	0.5694	0.6476	0.7276	0.8093	0.8929	0.9784
55	0.1553	0.4111	0.4847	0.5600	0.6369	0.7156	0.7960	0.8782	0.9623

Table 3-5: HFC-227ea total flooding quantity (Imperial units)

Temp. °F	Specific Vapor Volume ft^3/lb	Weight Requirements of Hazard volume, W/V (lb/ft^3) Design concentration (% per volume)							
T	S	6%	7%	8%	9%	10%	11%	12%	13%
10	1.9264	0.0331	0.0391	0.0451	0.0513	0.0570	0.0642	0.0708	0.0776
20	1.9736	0.0323	0.0381	0.0441	0.0501	0.0563	0.0626	0.0691	0.0757
30	2.021	0.0316	0.0372	0.0430	0.0489	0.0550	0.0612	0.0675	0.0739
40	2.0678	0.0309	0.0364	0.0421	0.0478	0.0537	0.0598	0.0659	0.0723
50	2.1146	0.0302	0.0356	0.0411	0.0468	0.0525	0.0584	0.0645	0.0707
60	2.1612	0.0295	0.0348	0.0402	0.0458	0.0514	0.0572	0.0631	0.0691
70	2.2075	0.0289	0.0341	0.0394	0.0448	0.0503	0.0560	0.0618	0.0677
80	2.2538	0.0283	0.0334	0.0386	0.0439	0.0493	0.0548	0.0605	0.0663
90	2.2994	0.0278	0.0327	0.0378	0.043	0.0483	0.0538	0.0593	0.065
100	2.3452	0.0272	0.0321	0.0371	0.0422	0.0474	0.0527	0.0581	0.0637
110	2.3912	0.0267	0.0315	0.0364	0.0414	0.0465	0.0517	0.057	0.0625
120	2.4366	0.0262	0.0309	0.0357	0.0406	0.0456	0.0507	0.056	0.0613
130	2.482	0.0257	0.0303	0.035	0.0398	0.0448	0.0498	0.0549	0.0602
140	2.5272	0.0253	0.0298	0.0344	0.0391	0.044	0.0489	0.054	0.0591

3.3.3 Atmospheric Correction Factor

Once the amount of agent required is calculated, it is necessary to adjust the quantity to compensate for ambient pressures that vary more than 11% [equivalent to approx. 3000ft (915m) of elevation change] from standard sea level pressures. [760mm Hg at 0°C (29.92 in. Hg at 70 °F)]. Refer to Table *3-6* for the appropriate factors.

Example Calculation:

Data Centre - Height from Sea Level = 1,500 ft

From amount of agent calculated =78.88 kg

Atmospheric Correction Factor, = 0.96

Amount of agent required with corrected factor = 78.88 kg x 0.96

= 75.73 kg

Table 3-6: Atmospheric Correction factors

Equivalent Altitude		Enclosure Pressure		Atmospheric Correction Factor
Ft	km	psia	mm Hg	
-3,000	-0.92	16.25	840	1.11
-2,000	-0.61	15.71	812	1.07
-1,000	-0.3	15.23	787	1.04
0	0	14.71	760	1.00
1,000	0.3	14.18	733	0.96
2,000	0.61	13.64	705	0.93
3,000	0.91	13.12	678	0.89
4,000	1.22	12.58	650	0.86
5,000	1.52	12.04	622	0.82
6,000	1.83	11.53	596	0.78
7,000	2.13	11.03	570	0.75
8,000	2.45	10.64	550	0.72
9,000	2.74	10.22	528	0.69
10,000	3.05	9.77	505	0.66

3.4 DETERMINE THE CYLINDER SIZE

The PYRO-200 system has the following cylinder sizes available. The filling ranges of the respective cylinders are indicated. Refer to Table *3-7* for the cylinder sizes and capacity.

Table 3-7: Cylinder Size

Standard of Compliance	Cylinder Type	Cylinder Capacity (L)	Minimum filling (kg)	Maximum Filling (kg)
TPED	Welded	9	4.5	9
		16	8	16
		16.6	8.3	16.6
		32	16	32
		52	26	52
		100	50	100
		120	60	120
		150	75	150
		180	90	180
		200	100	200
		240	120	240
		300	150	300
		369	184.5	369
	Seamless	10	5	10
		20	10	20
		30	15	30
		50	25	50
		80	40	80
		100	50	100
		140	70	140
		180	90	180
DOT	Welded	29	14.5	29
		52	26	52
		106	53	106
		147	73.5	147
		227	113.5	227
		275	137.5	275
		369	184.5	369
GB	Welded	70	35	70
		100	50	100
		120	60	120
		150	75	150
		180	90	180
		200	100	200
PESO	Seamless	34	17	34
		50	25	50

		80	40	80
		100	50	100
		120	60	120
		140	70	140

Welded cylinders are used for system operating pressure of 25bar at 21°C.
Seamless cylinders are used for system operating pressure of 42bar & 50bar at 21°C.

Example:
Amount of agent required, HFC-227ea = 78.88 kg
Actual supplied (roundup to 0.5kg) = 79.0 kg
Cylinder size required = 100 L

3.5 DETERMINE THE NOZZLE QUANTITY AND LOCATIONS

The number of nozzles required is based on the hazard site, its layout, the flow and the coverage provided by the nozzle. The nozzles are available in 360° discharge pattern only. The nominal sizes of the nozzle are: $^1/_2$", ¾", 1", 1 ¼", 1$^1/_2$" and 2". When considering the optimum nozzle location, the following criteria should be considered:

- Nozzle location is affected by the shape / layout of the hazard.
- The maximum area coverage for the nozzle is 98.7 m^2 (1062 ft^2).
- Maximum nozzle height coverage is 4.87 m (16 ft) (**NOTE:** use additional rows of nozzles for greater heights)
- Maximum distance between nozzles should not exceed 10.22 m (33.5 ft).
- 300 mm (1 ft) minimum void (sub-floors, false / suspended ceilings) height. Consider additional nozzles coverage in the void due to congestion of wirings, cables and equipment within the void(s)
- Nozzle orifices must not be aimed where they may discharge into nearby objects.

Additional nozzles may be required where obstructions such as beams or cable trays which could prevent or delay the creation of a uniform agent / air mixture.

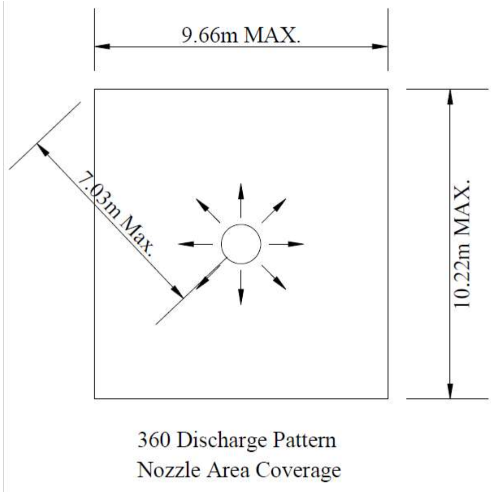


Figure 3-1: Nozzle Discharge Radius

IMPORTANT: Though a single nozzle can cover an area of 98.7 m^2, consideration must be given to the required quantity of gas which may be too much for a single nozzle to discharge. Therefore, it will be necessary to add additional nozzles in the enclosure.

3.5.1 Calculating the Quantity of Agent Through Each Nozzle

Based on the example mentioned, 2 nozzles are required for the respective area coverage. Since 2 voids are being protected with a single cylinder, the percentage of agent split at tees must be calculated to meet the minimum requirements.

Data Centre	- Room	= 69.68 kg
	- Floor Void	= 9.2 kg
Total agent required, Room + Floor Void		= 78.88 kg
Percentage of Agent required at Room		= 69.68/78.88 x 100
		= **88.33%**
Percentage of Agent required at Floor Void		= 9.2 /78.88 x 100
		= **11.66%**

NOTE: If the system is designed to protect 2 areas simultaneously in which the percentage of agent split is less than 10%, consider adding additional agent to the void to meet the requirement. However, if the protected area is a normally occupied area and the additional gas required exceeds the NOAEL value, a separate cylinder and distribution piping is recommended.

3.6 PIPE DISTRIBUTION REQUIREMENTS

For estimation of pipe sizes refer to

Table 3-8. Generally, one size larger pipe bore should be selected when estimating for large systems, and/or long pipe runs. The Jensen-Hughes computer calculations will be able to verify the piping distribution network. Since HFC-227ea is a liquefied gas, systems are stored and discharged as a dual-phase gas; the calculations are far more complex and have more limitations when compared to inert gas systems. There are several limits which need to be included in the design of the pipe work. They are:

- Flow split on a split tee is between 10:30
- Flow split on a bull tee is between 30:70
- All tee outlets must be in the same horizontal plane
- A minimum length of 10 times the nominal pipe diameter is needed around tee splits before any change of direction.

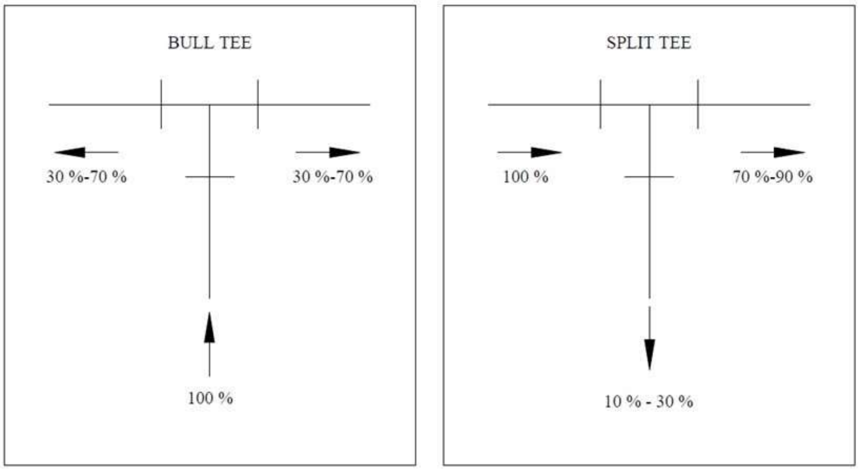


Figure 3-2: Tee Flow Splits

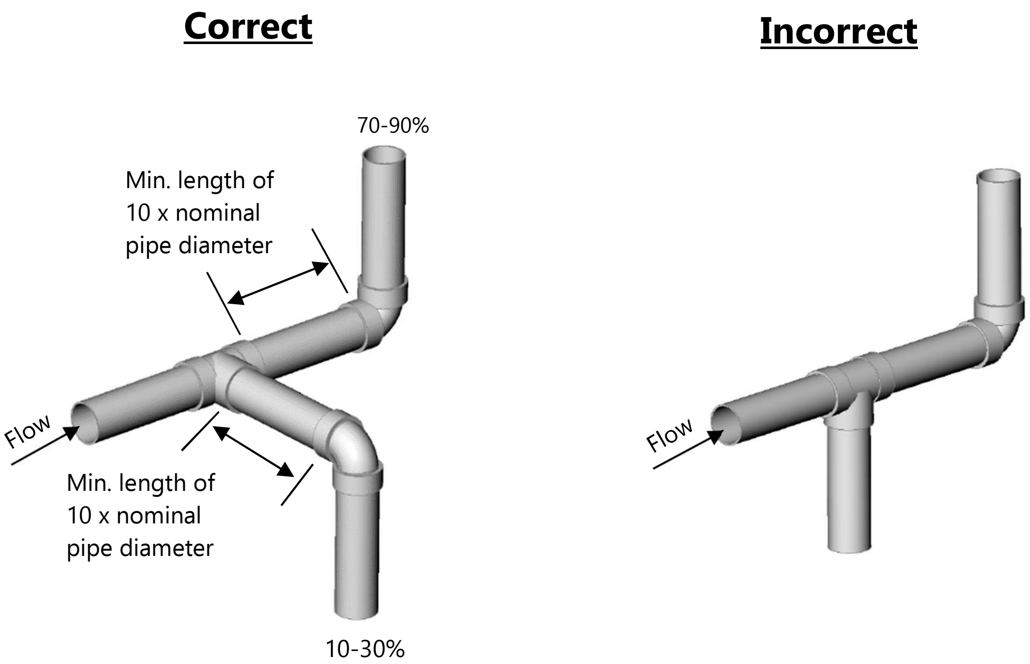


Figure 3-3: Side Tee Correct and Incorrect Orientation

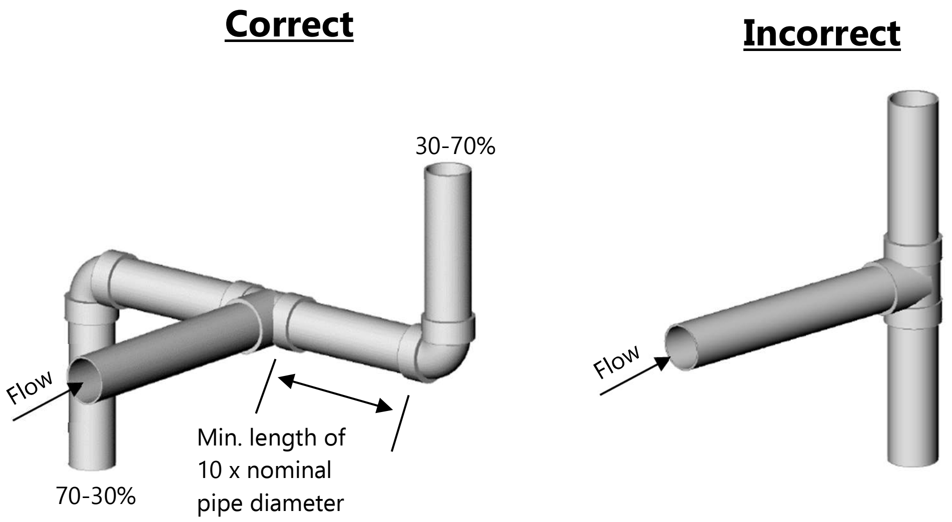


Figure 3-4: Bull Tee Correct and Incorrect Orientation

The maximum elevation difference in pipe runs of nozzles should be as follows:

1. If nozzles are only located above the tank outlet, then the maximum elevation difference between the tank outlet and the furthest horizontal pipe run or discharge nozzle shall not exceed 9.1 m (30 ft).
2. If nozzles are only located below the container outlet, then the maximum elevation difference between the tank outlet and the furthest horizontal pipe run or discharge nozzle (whichever is furthest) shall not exceed 9.1m (30 ft).
3. If nozzles are located both above and below the tank outlet, then the maximum elevation difference between the furthest horizontal pipe run or discharge nozzles (whichever is furthest) shall not exceed 9.1 m (30 ft).

NOTE 1: System designers should aim to design as far as possible balanced pipe networks, use minimum length of pipes and elbows, maximize pipe volume before the first tee and incorporate similar pipe run lengths to the nozzles.

NOTE 2: These rules only serve as a guide for initial design and estimation only. The final design needs to be verified by computer calculations.

Table 3-8: Pipe Size Estimation

Nominal Gas Flow Rate		Nominal Pipe Size (mm)	Nominal Pipe Size (mm)
Minimum (kg/s)	Maximum (kg.s)		
0.454	1.361	15	½
0.907	2.495	20	¾
1.588	3.855	25	1

2.722	5.67	32	1 ¼
4.082	9.072	40	1 ½
6.35	13.61	50	2
9.072	24.95	65	2 ½
13.61	40.82	80	3
24.95	56.7	100	4
40.82	90.72	125	5
54.43	136.1	150	6

NOTE: The above table is only a guide to estimate the pipe work and is for schedule 40 pipe.

Once the flow rate has been established, a suitable location for the cylinder storage has to be determined to begin design of the pipe distribution network. The cylinders and manifold layout can be configured depending on the space available. An example is shown in the drawing and component data section.

NOTE: Where multiple cylinders are connected to a manifold, all cylinders **MUST** be of equal size and filling capacity.

3.7 COMPUTER CALCULATIONS – JENSEN HUGHES PROGRAM

The basis for an optimal application of HFC-227ea fire extinguishing systems are the hydraulic equations coupled with the technical data of the installation components such as pipe diameters, nozzle placements, resistance coefficient. These data will determine the physical properties during discharge (pressure in the pipes, nozzle pressure, etc.). The Jensen-Hughes calculation software can calculate the HFC-227ea extinguishing installations of various construction. The computer program will calculate and verify/determine the following:

1) Piping dimensions
2) Maximum pressure in distribution pipe work
3) Orifice hole(s) diameter for each individual discharge nozzle
4) Agent gas concentration after 10 seconds for each protected void.
5) Final Agent concentration for each protected void after total discharge.
6) Discharge time at nozzle(s)

The parameters can be modified anytime to make a recalculation of the system to examine the effects on discharge time or distribution of the extinguishing agent at the various nozzles. It is necessary that the user of Jensen-Hughes software has adequate knowledge of HFC-227ea extinguishing system. All system calculation is conducted “in-house” or by authorized suppliers. Refer to Appendix G for the Jensen-Hughes Calculation sample report.

NOTE: Calculation software evaluated at 21 ºC. If ambient temperature exceeds 21 ºC±5.5 ºC, there is a risk that the system may not provide the designated quantity of agent.

NOTE: The calculation method has been designed for specific types of fittings, pipes, and pipe inside diameter. When these limitations are not maintained, there is a risk that the system will not supply the designated quantity of extinguishing agent.

3.7.1 Flow Limitations

When designing the pipe network systems, the following design parameters should be considered to avoid system reject when running the calculations.

Table 3-9: Flow Limitations Parameters

Design Parameters	Values
Duration of Discharge	6.1 – 10.0 seconds
Maximum percent in pipe	104 %
Minimum orifice area to pipe area ratio	21 %
Maximum orifice area to pipe area ratio	79%
Minimum nozzle pressure	6.1 bar
Maximum Liquid Arrival time	1.15 seconds
Maximum liquid run out time	1.8 seconds

3.8 PREPARATION OF CONTRACT DRAWINGS

3.8.1 Isometric Drawings

The isometric drawing shall be included as part of the calculation package and should show the following:

a) Pipe diameters and length
b) Nozzle flow rates (kg/sec)
c) Contract reference number
d) System title / name
e) Node numbers
f) Number of revision(s) if any
g) Name of Design Engineer

3.8.2 General Arrangement Drawings

General arrangement drawings to be drawn according to scale, dimensional plans and evaluations of the hazard showing:

1. Main structural features

2. Pipe routing
3. Bracket positions and details
4. Pipe specifications
5. Cylinder(s) location
6. Manifold position(s)
7. Nozzle(s) location
8. Detector(s) location
9. Audio & Visual Alarm equipment location
10. Bill of material(s)

3.8.3 Extended Discharge

Extended discharge is required where the hazard enclosure have un-closable openings or where the ventilation systems cannot be shut down. The rate of the agent discharge must be equal to that which escapes through the openings or loss through the ventilation system. To enable the calculation for extended discharge to be assessed accurately, an integrity test / door fan test **MUST** be carried out. The results of this test can be analyzed to quantify the hold time of the gas, and subsequent leak make-up to maintain the required gas concentration within the protected enclosure. Since the rate of discharge will normally be different from that required for the initial discharge, a secondary set of cylinders, nozzles and distribution piping network shall be installed. The required quantity of cylinders for extended discharge will normally be less than that of the initial discharge.

For guidelines on calculating the required amount of agent and discharge rate, please contact Adkinns Inc. Product Department for further information.

CHAPTER 4

INSTALLATION

Prior to installing the PYRO-200 gas fire suppression system, the installer must be familiar with the system and have experience in installation of high-pressure gas suppression systems. The installer must refer to the piping and instrumentation diagram and system arrangement drawings and check that all components are in order. If the installation is carried out by untrained or inexperience personnel, they may jeopardize the integrity of the system, their own safety and of others as well as the warranty of the system.

The instructions in this section and information contained in the component data sheets should be read by the installer. The location of the cylinder(s) shall have sufficient floor loading capability, a flat dry floor and walls or solid structures for securing the system. The owner / client should satisfy themselves in this regard.

All necessary work permits & procedures shall be obtained / established first to the satisfaction of the client, owner or the local authorities having jurisdiction.

4.1 SAFETY

Each PYRO-200 cylinder is filled with the required weight of gas (indicated on the cylinder label) and pressurized with nitrogen to desired pressure (25, 42, 50 bar) at a reference temperature of 21 °C. Safety precautions must be adhered to in the handling of the PYRO-200 cylinder(s) due to the inherent risks of pressurized tanks as well as the weight of the cylinder(s) itself.

Some safety precautions to follow are:

1. The valve outlet cap shall always be screwed onto the cylinder whenever the cylinder is moved, being loaded or unloaded.
2. Always use suitable lifting gear, (forklift, truck or hoist) when loading or unloading cylinder. Do not offload the cylinder by dropping them to the ground.
3. Use a suitable cylinder trolley to move the cylinders. Do not roll them on the ground.
4. At site, if the cylinder(s) are not to be installed immediately, secure them using ropes or belts in an upright position. The storage area must be dry and, in a place where they will not be damaged.
5. Do not remove the valve outlet cap from the cylinder unless the cylinders are securely held in position by its clamps or brackets.
6. Never attempt to remove an PYRO-200 valve from a pressurized cylinder.
7. Do not use extreme force (hammers, long levers, pipe wrench, etc.) on any part of the valve or actuating components.

8. Cylinders, valves, and actuating components SHALL NOT BE drilled, brazed, welded, machined or stamped. Only cleaning and painting of the cylinders is permitted.
9. In the event of any abnormalities such as jammed or deformed valves, cracks or other apparent weaknesses, keep away and inform the appropriate engineer.
10. Heavy protective gloves (preferably textile or leather) should be worn at all times for the manual handling of cylinders to minimize the risk of hand injury. During discharge, all connected parts of the cylinder and valve are likely to become very cold and there is a risk of "frostbite" if any of the parts are handled at that time with unprotected hands, particularly if hands are wet.
11. Safety footwear shall always be worn at all times.

4.2 INSTALLATION PROCEDURES

The following drawings and instructions should be as a minimum be in the possession of the installer:

1. P and I Diagram
2. Piping Plan
3. Cylinder Assembly
4. Electrical Wiring Diagram
5. Installation Procedures (This section)
6. Material List

4.2.1 Material Preparation

1. Prior to carrying out the assembly and installation of the system, ensure that all required materials have arrived at site and in good condition.
2. Ensure the protected areas and cylinder storage areas matches the drawings in layout and size. Inform the project manager of any discrepancies.

4.2.2 Transport and Storage of Materials

The PYRO-200 cylinder(s) must be fitted with valve outlet caps whenever they are moved or when they are not connected to the manifold. When the cylinders and associated equipment arrive on site, they shall be stored in a dry room within a temperature range of -10°C and 60°C until they are needed for installation. Secure the cylinders to prevent any falling or rolling of cylinders. Avoid exposing the cylinders to direct sunlight and heat.

For a 25 bar working pressure system, The PYRO-200 cylinder valve is fitted with a safety burst disc that vents the gas when the pressure within the cylinder reaches 55 bar. For 42 bar and 50 bar working pressure system, safety burst disc will vent when cylinder pressure reaches 90 bar.

The cylinders must not be dropped or rolled when transporting or moving them. A suitable trolley should be used to move the cylinders. For safety precautions, always wear thick gloves and safety shoes when handling the cylinders.

4.3 INSTALLATION OF CYLINDER(S)

Depending on the space available, the cylinder can be installed directly connected to the pipe network or to a manifold from 2 cylinders upwards.

1. Move the first cylinder into place. The valve outlet can be oriented to the left or right depending on the location of the pressure gauge.

   NOTE: When connecting the discharge hose to the manifold, ensure that the discharge hoses can be connected to the manifold with a smooth bend.

2. Move the remaining cylinders into place.

3. Continue to install the cylinders and the cylinder brackets until all cylinders are in place.

4. Unscrew the valve outlet protection cap from the cylinder valve. Store then in a secure place as they must be used whenever the cylinders are moved.

5. Use the valve outlet adaptor to connect a single cylinder to the pipe network. Where multiple cylinders are used fit one end of the discharge hose to the valve outlet and the other to the check valve at the manifold.

6. If the pressure gauge with integrated limit switch, connect the pressure gauge with integrated limit switch in a single wire loop (in series).

7. The following instruction is for installation of multiple cylinders with a master and slave cylinders configuration. Remove the plastic protection caps from the slave cylinders valve head. Make sure that no contamination or foreign objects have entered the bore hole of the valve. Screw the pneumatic actuator onto the valve by hand. DO NOT TIGHTEN THE ACTUATOR YET. Proceed to install the pneumatic actuating hoses next. This is to ensure that the pneumatic hoses can be installed easily.

8. On the master cylinder, the pilot connection plug must be removed and a nipple shall be installed in its place. To connect the pneumatic actuating hoses, the nipples must be screwed onto the pneumatic actuators first. Use 4-6 rounds of teflon tape on the thread connection to the pneumatic actuator. Tighten the connection using a spanner until it stops. Connect the pneumatic hose onto the actuator. At the last cylinder, a vent plug must be installed in pneumatic actuator to complete the pneumatic line. Make sure pneumatic actuator pin is in latched position before install it at discharge valve.

NOTE: The safety relief valve is located directly below the pilot connection plug. NEVER remove this safety relief valve otherwise gas will escape from this outlet.

9. When all the actuating hoses have been installed, tighten the pneumatic actuators to the valve by hand until it stops.

   NOTE: To ensure that the valve is functioning properly, all actuating components must be tightened by hand until it stops. (use a torque of 50 +/-15 Nm.)

4.3.1 Single Cylinder Installation

Wall Mounted Installation

1. Make sure there is at least 1 meter / 3 ft of free space is available in front of the cylinder for installation purposes.
2. Check that the wall and floor surfaces are flat. If it is uneven, repair them so that the cylinder can be safely and accurately installed.
3. If the floor is damp or is likely to be wet, the cylinder must be placed on top of metal grates or panels to keep it off the floor. This is to avoid corrosion on the bottom of the cylinders. The mounting height for the cylinder brackets shall be adjusted accordingly with due allowance for the thickness of the grates or panels.
4. If the flexible discharge hose is used to connect the cylinder to the distribution piping, ensure that a smooth bend is achieved. Make the necessary adjustments on the cylinder placement.
5. Place the bracket against the wall and mark out the 10mm diameter holes for the wall plugs / anchor bolts. Drill the holes for the M10 or $^3/_8$" wall plugs and insert the plugs in. Fix the bracket onto the wall. Tighten the nut for the wall plug according to the manufacturer's recommendation.

4.3.2 Multiple Cylinders Installation to a Common Manifold

1. Repeat procedures 1 to 5 but with allowances for installing additional cylinders.
2. The manifolds are **not supplied** by ADK and must be constructed as required. Piping material shall be ASTM A106 Sch.40 steel pipe or equivalent.
3. To avoid the hoses from rubbing on the cylinder valve, the manifold should be installed approximately 385mm from the back wall to the manifold center.

NOTE: A union is required to connect the manifold to the distribution piping.

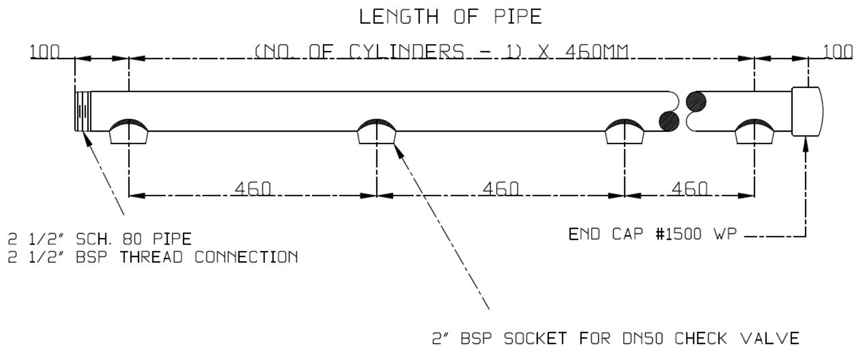


Figure 4-1: Manifold Information for 1-1/2" Valve and DN50 Check Valve

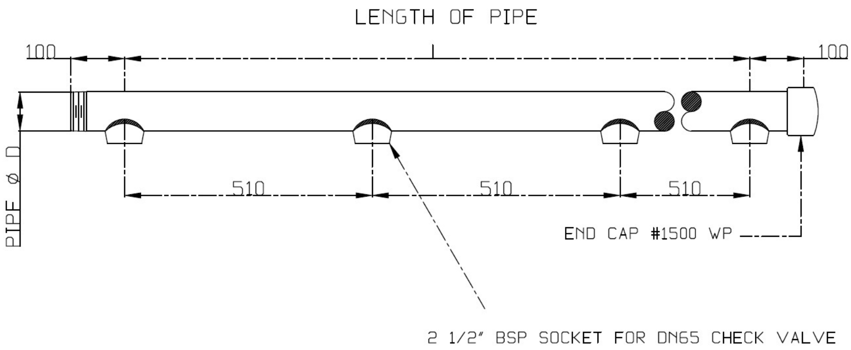


Figure 4-2: Manifold Information for 2" Valve and DN65 Check Valve

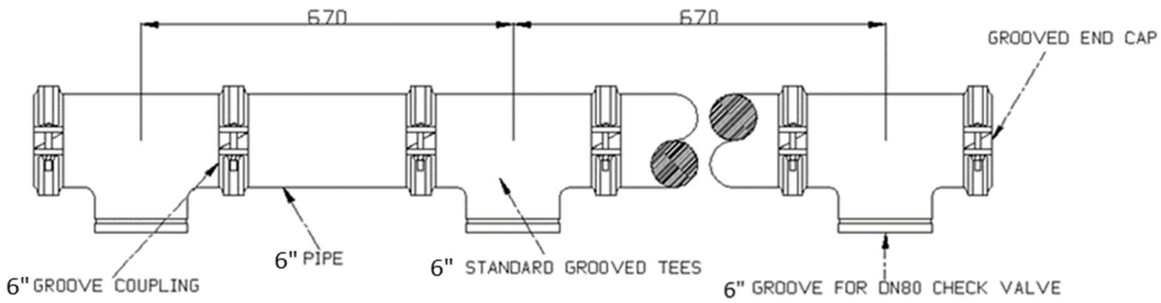


Figure 4-3: Manifold Information for 3" Valve and DN80 Check Valve

4.3.3 Actuator Installation

The type of actuator depends on the system configuration and any specific contract requirements. Actuator can be break down as follows:

- Electrical Solenoid Actuator
- Manual Actuator

Electrical Solenoid Actuator

1. The electric solenoid actuator is installed on the master cylinder valve. For single cylinder system, the electric solenoid actuator is fitted directly on the cylinder valve.
2. Check that the electric solenoid actuator is in the latched / retracted position. If the actuator is in the de-latched / released position, the actuator pin is 11mm – 12mm in length as shown in Figure *4-4*. Reset the actuator using the supplied reset tool.
3. To reset the actuator, screw in the reset tool onto the actuator until it stops and a small 'click' is heard. Remove the reset tool and check that the actuator is in the latched / retracted position (actuator pin length: 4.5mm – 5.5mm).

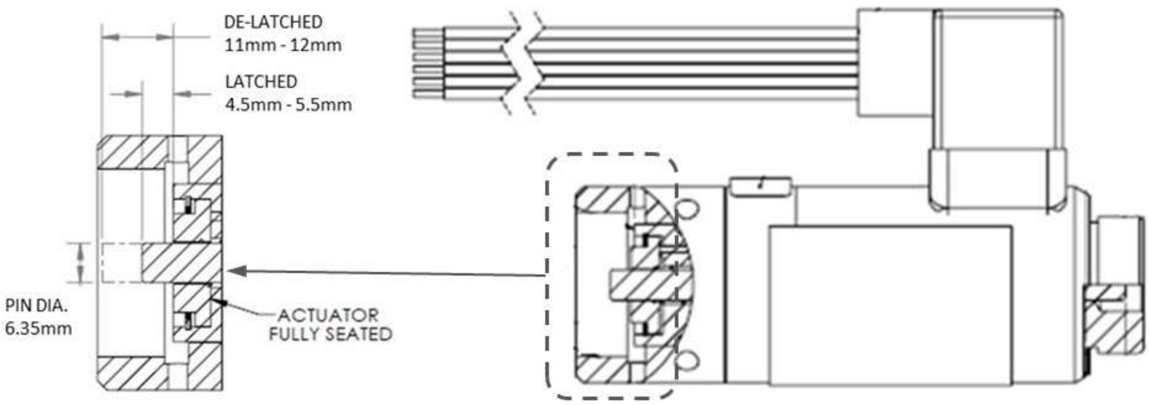


Figure 4-4: Latched and De-latched Pin Position for Electrical Solenoid Actuator

4. Terminate the electrical connection to the electric solenoid actuator.

   NOTE: Observe the polarity of the solenoid actuator. The actuator will not work if it is wrongly connected.

5. Test the operation of the solenoid actuator as follows:
   a) Energize the actuator and check that the pin fully extends without delay.
   b) Reset the electric actuator using the reset tool.
6. Fit the electric actuator onto the pilot or master cylinder valve by hand. Make it hand tight or use a torque of 50 +0/-15 Nm.
7. A plastic protective cap is fitted on the top of the electric solenoid actuator. Do not remove this cap unless a manual actuator is required.

Manual Actuator

1. The manual actuator is installed on the top of the electric solenoid actuator. Prior to installing the component, check that the pin is fully retracted and that the safety pin with safety seal is installed.
2. Remove the plastic protective cap from the top of the electric solenoid actuator. Screw in the manual actuator to the top of the electric solenoid actuator by hand until it stops.

4.4 INSTALLATION OF PIPE DISTRIBUTION NETWORK

The pipe network used shall be Sch. 40 ASTM A106B or A53B or other equivalent standards which can accommodate the maximum pressure calculated in the network. Refer to Table *4-1* to Table *4-3* for further details.

Piping should be installed in accordance with good commercial practice. Pipe threads should be cleaned of oil and swarf. Threaded joints should be sealed using PTFE on the male threads. Care should be taken to avoid possible restrictions due to foreign matter, faulty fabrication or improper installation. The piping system should be securely supported with due allowance 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 system should be attached to supports that are least likely to be displaced. Galvanized steel pipes are recommended as they are less likely to corrode within a short period of time. If rust flakes or particles are present within the pipe, they may come loose during a discharge and may be able to block off the orifices in the nozzles thus jeopardizing the release. Also, the rust cloud / spray may ruin the ceiling tiles or may damage sensitive equipment within the enclosure. Special coatings or corrosion resistant materials must be used in corrosive environments.

After installation of the pipe work it is recommended to flush the pipe work in order to remove dirt / particles, sealing material, cutting burrs, etc. as well as to verify that flow is continuous and that the piping is unobstructed. Flushing should be performed prior to the pressure testing of the pipe work and after any rectification work on the pipe network using dry air or other compressed gas. Make sure that no one is in any of the rooms in which the pipe work is to be flushed. Where necessary, filter bags should be used to collect any dirt or particles being blown out of the pipe work especially if there are equipment in the room.

The pipe work should be leak tested prior to installing the discharge nozzles. Leak testing of the distribution pipe work should be carried out as follows:

1. Verify that all manifold check valves are fitted onto the manifold (if used). Plug off the nozzle points using suitable plugs.
2. Connect the nitrogen test supply cylinder assembly to the manifold.

3. Make sure that no one is in any of the rooms in which the pipe work is to be tested.
4. Slowly pressurize the distribution pipe network to 3 bar.
5. Check the pipe network for leaks. If there are no leaks, proceed to pressure test the pipe work to 3 bar for about 10 minutes. Any pressure drop should not exceed 20% of the test pressure.
6. Release the pressure slowly after testing.
7. If rectification work was carried out, flush the pipe works first prior to pressure test the pipe work again.
8. The distribution pipe network materials and fittings used must be rated for a minimum working pressure of 416 psig for 25 bar system and 725 psig for 42 bar / 50 bar systems.

Table 4-1: Maximum Allowable Pressure (psig) for Steel Pipe with Threaded End Connections

Schedule	NPS Pipe Size	Wall Thickness	A-106C	A-53B A-106B	A-53B	A-53A A-106A
			Seamless	Seamless	ERW	Seamless
			21,000	18,000	15,360	14,400
40	1/2"	0.109	2593	2222	1896	1778
	3/4"	0.113	2234	1915	1634	1532
	1"	0.133	2026	1736	1482	1390
	1 1/4"	0.140	1782	1528	1304	1222
	1 1/2"	0.145	1667	1429	1220	1144
	2"	0.154	1494	1280	1093	1025
	2 1/2"	0.203	1505	1193	1100	1032
	3"	0.216	1392	1096	1018	954
	4"	0.237	1278	1022	935	876

(Source: NFPA2001 - Current Edition)

NOTE: Other pipes manufactured to equivalent standards / codes can be used so long as they are equal to or exceed the minimum working pressure.

Table 4-2: Maximum Allowable Pressure (psig) for Steel Pipe with Rolled Groove or Welded End Connections

Schedule	NPS Pipe Size	Wall Thickness	A-106C Seamless 21,000	A-53B A-106B Seamless 18,000	A-53B ERW 15,360	A-53A A-106A Seamless 14,400
40	½"	0.109	5450	4672	3986	3737
	¾"	0.113	4520	3875	3306	3100
	1"	0.133	4248	3641	3107	2912
	1 1/4"	0.140	3542	3036	2591	2429
	1 1/2"	0.145	3205	2747	2344	2197
	2"	0.154	2723	2334	1992	1867
	2 1/2"	0.203	2965	2542	2168	2033
	3"	0.216	2592	2221	1896	1777
	4"	0.237	2212	1896	1618	1516

(Source: NFPA2001 - Current Edition)

Table 4-3: Acceptable Fittings for PYRO-200 Gas System

Where Used Initial Charged Pressure (psig)	Acceptable Fittings	Maximum Pipe Size
416	Class 300 threaded malleable/ductile iron	up to 6" NPS
	Groove type fittings	up to 6" NPS
	Class 300 flanged joints	All

(Source: NFPA2001 - Current Edition)

NOTE: Other fittings manufactured to equivalent standard/codes can be used so long as they can withstand the working pressure.

4.5 INSTALLATION OF DISCHARGE NOZZLE

1. Install the appropriate nozzles with the correct orifice sizes in their designated locations as per the piping isometric drawing & plan.
2. Screw the discharge nozzles into their fittings, using teflon tape to make a tight seal. Use a spanner to tighten nozzles.

4.6 DETECTION AND CONTROLS

The PYRO-200 gas fire suppression system must be used in conjunction with a detection and control system in order for the extinguishing system to operate automatically. Some issues must be addressed before deciding on the best detection system. They are:

a) the speed of detection required

b) what phenomenon to detect, e.g. Smoke, heat, flame, gas, fuel mist, etc.

c) Relative acceptability of unwanted alarms

d) Cost effectiveness

Generally, all gaseous extinguishing system requires a detection and control system to operate automatically. Detectors are needed to sense the fire, while the control system would give the signal to all visual & audio alarms, shutdown auxiliary equipment, and activate the suppression system.

NOTE: UL Listed/FM Approved extinguishing system units with electrical activation require the use of UL Listed/FM Approved detection devices and UL Listed/FM Approved Fire Alarm Control Panel that is compatible with the electrical actuators and the detection devices. Please refer to the control panel manual for compatibility information.

4.6.1 Detection Speed

A gas extinguishing system's speed of extinguishment is usually more dependent on the response time of the detection system, rather than the discharge time of the gas. There is a wide variety of detection and control technologies available in order to cover the different types of fire risks. However, the technologies differ greatly in cost, and as such it is important to select a system that offers the client the optimum and cost-effective fire protection system.

4.6.2 Type of Detectors

The types of detectors commonly used in gaseous fire extinguishing systems are smoke detectors and heat detectors. For certain special hazards, flame detectors and gas detectors are used.

Smoke detectors are available in several types: optical, aspirated and air aspiration system. The first two types are widely available at reasonable prices and are commonly used. Aspirated type is slightly more expensive but their response time is faster. For an even faster response time an air aspiration system can be used. However, they are much more expensive and are more suited for clean room environments. Generally, the more sensitive the detectors, the more prone they are to false alarms.

Heat detectors are normally available in 3 types, rate of rise (ROR), fixed temperature or a combination of both ROR and fixed temperature. Heat detectors are less prone to false alarms and are cheaper compared to smoke detectors. However, in most cases, a fire may be underway before the heat detector operates. In high risks or sensitive areas using a gaseous extinguishing system, the delay of a heat detector would cause fire damages which might be unacceptable to the client.

Flame detectors are employed where flammable liquids or powders are present since fires spread very rapidly. Flame detectors are available in 2 types, ultra-violet (UV) and infrared (IR) flame detector. UV flame detector respond faster compared to the IR flame detector. UV detectors can be blinded by dirt or grease while IR detectors can be blinded by water. Consideration must be given to incorporate a monitoring system on these detectors to give a fault alarm if they are blinded.

4.6.3 Detector Spacing

Currently, there is no internationally recognized standard for detector spacing therefore the detector requirements shall be based on the respective countries' standard or as required by the local authority having jurisdiction.

There is a general consensus that while the detectors used for fire alarms can be installed at its maximum area coverage. Those used to trigger gas suppression systems should be reduced or halved. This is because detectors installed at the maximum approved spacing for fire alarm use could result in excessive delay in extinguishant release, especially when more than one detection device is required to be in alarm before automatic actuation.

Please refer to NFPA 72 for more information.

4.6.4 Detector Location

Detectors should be placed in a protected enclosure with the following aims:

1. To give the detectors the best chance to detect a fire quickly, and
2. To reduce the risk that the detectors give a false alarm.

To make sure that the detectors can sense a fire, do:

1. locate them at least 1 m from all obstructions.
2. assure a free passage of smoke to the detectors. Install detectors in a cable floor as well as the main room if the cable floor should also be protected.
3. evaluate the impact of the ventilation systems on detectors; they sometimes either prevent the smoke reaching the detection chamber or else contaminate detectors in air currents with dust.

Conventional detectors should be installed in crossed zones, where each zone is made up of detectors installed diagonally to each other. In any case a minimum of two detectors must operate before the gas is released automatically.

4.6.5 Typical Sequence

The following is a typical sequence of events (details may vary according to local practice or regulations):

1. A detector goes into alarm

2. Visual and audible pre-alarm is given
3. The ventilation system is automatically switched off
4. A second detector goes into alarm, confirming the fire condition.
5. Visual and audible fire alarm is given and the time delay is started.
6. Any automatic closing of doors or openings is initiated.
7. After the pre-set delay, a signal is sent to the electric actuator to release the gas.
8. A visual alarm is given, indicating the release of the gas.

Other possible events which could alter this sequence are:

1. The release signal may be manual; it will have the same effect as the second (confirmation) detection signal.
2. There might be an Abort or Hold switch to prevent a discharge, for example when people are present in the enclosure.

All control panels normally would have a facility for adjusting the time delay but the range may vary from 0 - 60s to 120s depending on the local requirements. It is not the intention of this section to recommend any particular makes of detectors and control systems since each country have their own standards and regulations. As such, the proposed detection and control system shall have the approval of the Local Authority having Jurisdiction.

4.7 MISCELLANEOUS

1) Install the PYRO-200 entrance warning signs on all entry doors into the protected area.

2) Check the integrity of the protected area for excessive openings which could result in unacceptable leakage of the clean agent but with sufficient venting to prevent overpressure following the PYRO-200 agent discharge.

   NOTE: A fan integrity test may be used to ascertain the integrity of the enclosure.

3) Check the interconnections between the electric solenoid actuator and the control panel, as well as the pressure switches and the audio & visual alarms plus equipment and ventilation systems shutdown.

CHAPTER 5

TESTING AND COMMISSIONING

5.1 PRE-COMMISSIONING CHECK LIST

1. Check that all pipes and fittings are in accordance with the correct specifications as shown on the General Arrangement Drawings. Check that the systems are installed in accordance to the drawings. Any deviations from the original design should be incorporated into "As Built". Check that all remedial works (if any) have been completed.
2. Check that all discharge nozzles with the appropriate orifice size are fitted in their designated locations.
3. Check all pipe supports and brackets to ensure that the system pipe work is firmly secured in position.
4. Check all cylinder supports and brackets to ensure that the cylinders are firmly secured in place.
5. Check all fittings and hoses are tightened and secured.
6. Check the cylinder pressure. The pressure may vary depending on the ambient temperature.

5.2 COMMISSIONING PROCEDURES

Testing the actuation of the system can be broken down into 2 separate functional tests; electrical and mechanical.

WARNING:

Before carrying out any functional tests, make sure that the electric solenoid actuator is removed from the master cylinder as well as disconnecting the pilot line hose connection from the master cylinder to the slave cylinder.

5.2.1 Electrical Actuation

1. Make sure that the electric solenoid actuator is in the "latched" position.
2. From the control panel, initiate a fire condition. This will start a time delay prior to actuation of the electric solenoid actuator. Depending on the local authority requirements the delay can be adjusted at the control panel from 0 to 60 seconds. Normally the delay is set at 30 seconds.

3. Note the delay period and verify the operation of the electric solenoid actuator at the end of the time delay by observing that the actuating pin has extended.
4. Use the supplied reset tool to rearm the electric solenoid actuator. Make sure to reset the control panel first prior to resetting the actuating device.

5.2.2 Mechanical Actuation

1. The manual actuator is fitted to the top of the electric solenoid actuator. Make sure that the electric solenoid actuator is in "latched" position.
2. Pull the safety pin out and operate the manual release lever.
3. Verify the operation of the electric solenoid actuator by observing that the actuating pin has extended.
4. Use the supplied reset tool to rearm the electric solenoid actuator. Make sure to reinstall back the safety pin on the manual actuator and seal it with a plastic tie / seal.

NOTE: Once the testing and commissioning has been completed, reinstall the electric actuator back onto the master cylinder valve by hand until it stops. Connect back the pilot line hose connection onto the slave cylinder.

5.3 COMMISSIONING FORMS

The Testing and Commissioning forms / checklist and Acceptance report shall be duly completed, and all necessary signatories obtained. Copies to be given to the relevant parties. Refer to Appendix A for the check list sample.

CHAPTER 6

SYSTEM OPERATION

The firefighting system shall be maintained in full operation condition at all times. The system shall be thoroughly inspected and tested for proper operation by competent personnel at regular intervals according to local regulations. A good maintenance program is intended to give maximum assurance that a system will operate effectively and safely. The procedures listed in this section are the minimum that is necessary to maintain a system. Prior to carrying out any maintenance or repair works, the people affected by the work must be informed for them to take the necessary precautions.

6.1 SAFETY NOTICES

1. All maintenance works shall be carried out by trained personnel who are familiar with the system and know the safety procedures. Untrained personnel could jeopardize the system and risk damaging property and injury.
2. Prior to carrying out any testing or maintenance works, the system must be inhibited appropriately to avoid accidental discharge of the system.
3. Before carrying out any testing or maintenance works on the system, permission or work permits shall be obtained first and the appropriate personnel warned where necessary.
4. Adequate precautions shall be taken to avoid any unwanted process or equipment shutdowns as a result of the testing or maintenance work carried out on the system.
5. Personnel working inside the protected area must be familiar with the operation of the system, and the action to be taken in the event of a fire.
6. In the event of a fire, all personnel must evacuate the protected area prior to the release of the gas system. A pre-discharge alarm must be given to allow personnel adequate time to evacuate the area.
7. The local Fire Department should be informed of the fire. No one should enter the protected area after a discharge other than the Fire Department personnel with breathing apparatus to confirm that the fire is out. The protected area can then be completely ventilated to extract the by-products of the fire.
8. In the event of an accidental discharge, all personnel should evacuate from the protected area. Ventilate the area first before entering the protected area. Send the empty cylinders for refilling soon as possible, if reserve bank of cylinders is available immediately connect the charged cylinders and send the empty cylinders for refilling.

6.2 OPERATION OF THE SYSTEM

The PYRO-200 clean agent fire extinguishing system utilizes the gas, Heptafluoropropane to extinguish a fire. A detection, visual/audio alarm and control system must be incorporated into the system for automatic operation. In the event of a fire, the detectors will sense the fire. The control panel initiates the pre-discharge audible and visual alarms for a pre-set time (depending on local regulations).

Thereafter, the alarms will change to discharge alarm; equipment and ventilation systems where applicable are shut down and the solenoid actuator on the master cylinder is energized. This releases the gas from the master cylinder, which in turn pneumatically actuates the other cylinders connected (if any) discharging the gas into the distribution pipe work throughout the protected area. Approximately 10 seconds after initial discharge, the gas concentration within the hazard is built up to the design concentration, suppressing and inhibiting the fire from propagating.

Most gaseous fire suppression systems do not cool the fuel(s) source. Therefore, the concentration must be maintained for a sufficient period of time for the fuel / ignition sources to cool down.

The PYRO-200 system can be manually activated by:

1. Operation of a break glass or key switch unit linked to the control panel.
2. Operation of the manual release lever on the master cylinder (when fitted).

Operation of the manual release devices shall trigger discharge alarms, shutdowns and agent release follow immediately.

6.3 POST FIRE

After extinguishment, a minimum agent hold time of 10 minutes must be maintained in accordance with NFPA 2001. Nobody shall be allowed into the area until it is cool down. A competent person must establish that the danger of fire no longer exists. If the local Fire Department was notified of the event, they shall be able to establish this. Thereafter, completely ventilate the protected area to remove the by-products of combustion and refresh the air within the area. The control panel must be reset to cancel the alarms.

CHAPTER 7

MAINTENANCE AND INSPECTION

This section provides user inspection and maintenance guidance for PYRO-200 Fire Prevention Systems. Regular inspection and maintenance must be performed to ensure that the system will function properly. Prior to carrying any maintenance on the system, the system should be inhibited electrically by the control panel (if available). Frequency and type of inspection and maintenance depend on the nature of installation, legal and official regulations, environmental conditions, etc. Inspection must be conducted by qualified personnel with a wide-ranging understanding of the installation.

7.1 MAINTENANCE

The system shall be maintained on a regular basis, at least on an semi-annual basis or as otherwise specified by the local authority having jurisdiction. Maintenance of the system shall include the following:

7.1.1 Protected Area/Enclosure

Survey the protected area to verify that it has not changed from what the system was designed to protect. While surveying, look for different fuels, new equipment, blocked open doors or dampers, new penetrations or gaps which may lead to loss of the hazard integrity, etc.

7.1.2 Discharge Nozzles

Check all nozzles to make certain they are in place and have not been tampered with. Check the nozzles for corrosion or damage, and that they are not obstructed internally or externally.

7.1.3 Distribution of Pipe Network

Check the condition of the piping to make certain that it is properly secured in the hangers, the brackets are not loose and all fittings are connected tightly.

7.1.4 Signage

Check all warning nameplates throughout the area. Ensure that they are in place, mounted securely, readable and are not damaged.

7.1.5 PYRO-200 Cylinders

For multiple cylinders system with a master cylinder, the pilot line hose must be disconnected from the slave cylinder. Thereafter, remove the electric solenoid actuator from the master cylinder. For single cylinder systems, proceed to remove the electric solenoid actuator once the system has been inhibited electrically if so equipped.

1. Check the cylinder bracketing. Ensure that the cylinders are secured in the brackets. Check for corrosion, damage or missing components. Check the frame and plates for damage or corrosion as well as loose or missing components.
2. Check the condition of all cylinders. Check for signs of damage or corrosion and check the cylinders' last hydro test date. (NFPA 2001 states "Cylinders continuously in service without discharging shall be given a complete external visual inspection every five year or more frequently if required. The visual inspection shall be in accordance with Compressed Gas Association Pamphlet C-6, Section 3; except that the cylinders need not be emptied or stamped while under pressure").
3. Cylinder(s) need to be removed and weight for any loss of agent. If a cylinder shows a loss of agent quantity of more than 5%, it shall be sent for recharging.

7.1.6 Pressure Gauge

1. Do not remove the pressure gauge after filling completion.

7.1.7 Liquid Level Indicator

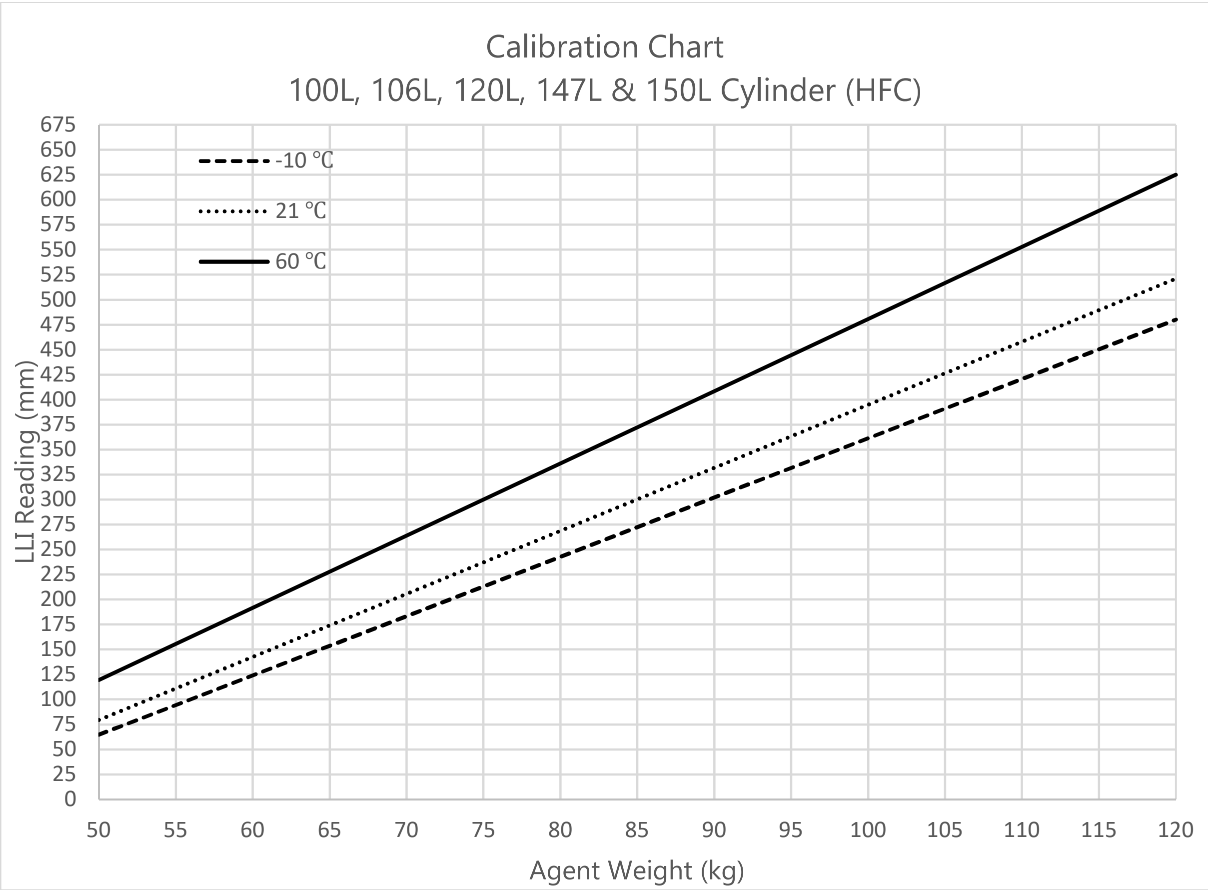


Figure 7-1: LLI Calibration Chart for 100L, 106L, 120L, 147L & 150L Cylinder

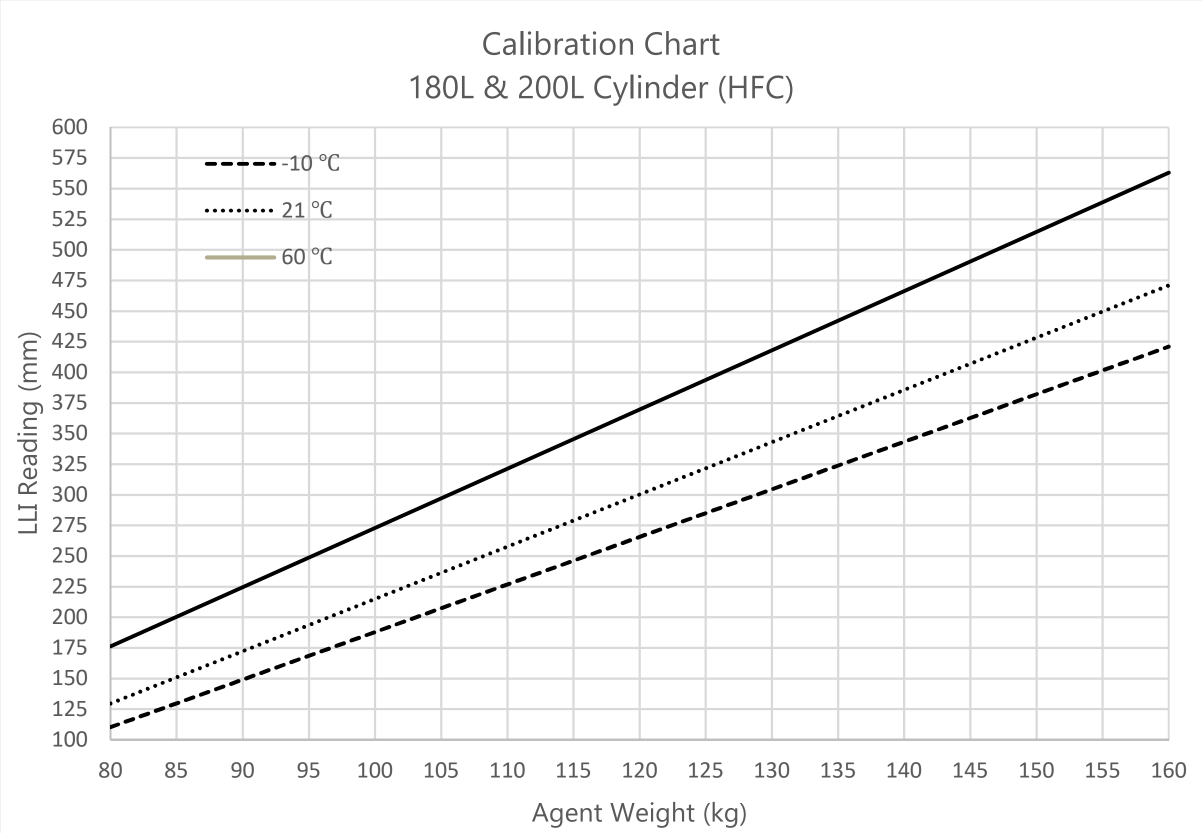


Figure 7-2: LLI Calibration Chart for 180L & 200L Cylinder

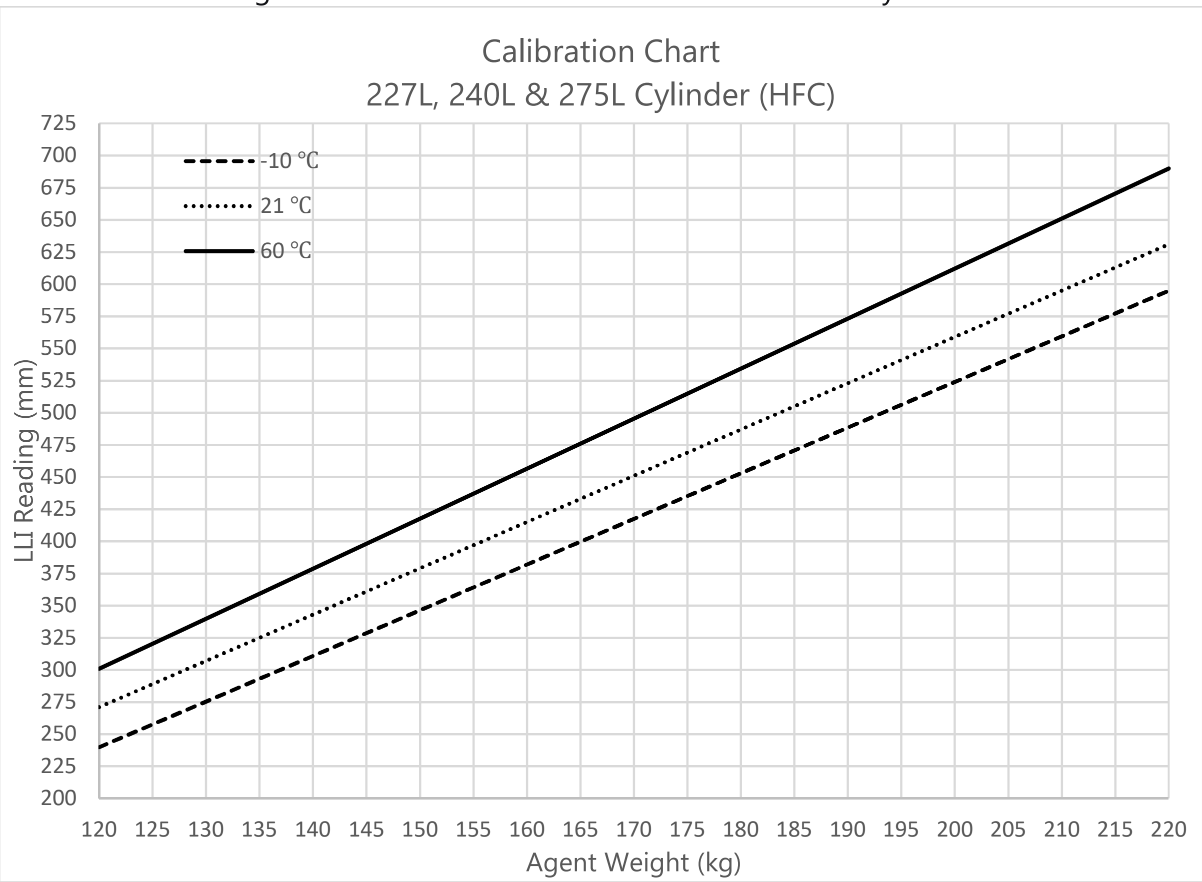


Figure 7-3: LLI Calibration Chart for 227L, 240L & 275L Cylinder

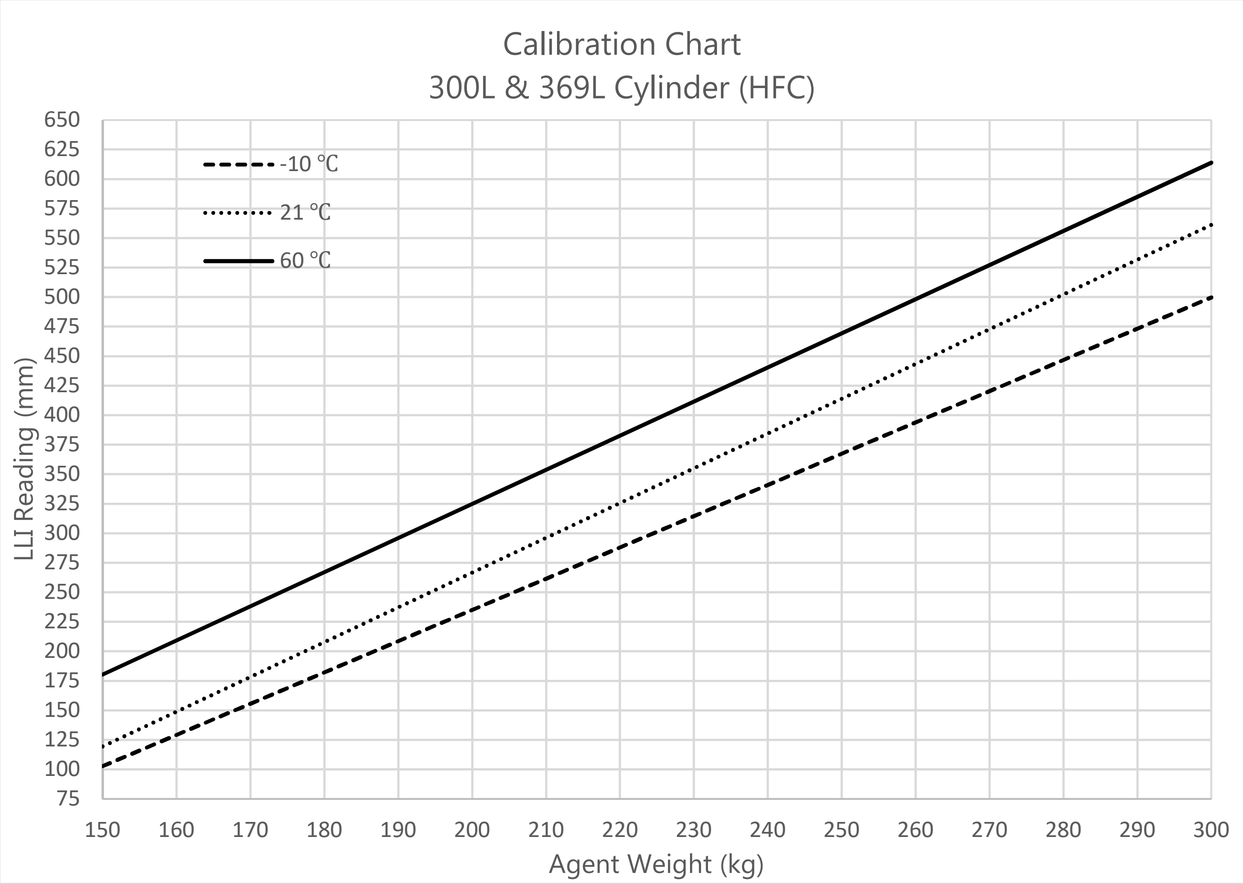


Figure 7-4: LLI Calibration Chart for 300L & 369L Cylinder

7.1.8 Hoses

Check the condition of all discharge hoses and pneumatic actuating hoses at least once a year. Ensure that all hoses are connected properly. Look for signs of structural problems like abrasions, cracks or weather checking. Replace any suspect hose. All hoses shall be tested every 5 years. Refer to NFPA 2001:Current edition clause 8.7.1 for detailed testing requirements.

7.1.9 Manifold

1. Check the condition of the manifold for signs of corrosion, damage or loose parts.
2. Check the bracketing for the manifold. Ensure that the manifold is secured on the brackets. Check for corrosion, damaged or missing parts.

7.1.10 Actuating Components

7.1.10.1 Electric Solenoid Actuator

The electric solenoid can be tested by electrical means. The solenoid should be tested in conjunction with the testing of the detection and control system. Reset the solenoid actuator using the clamping device.

7.1.10.2 Manual Actuator

For testing by mechanical means, the solenoid should be tested in conjunction with the manual actuator if so equipped. To operate the component, test it by pulling the safety pin out and push down on the lever until the activating pin on the electric solenoid actuator is released. Reinstall the safety pin and seal it back. Reset the electric solenoid actuator.

7.1.11 Electrical - Detection and Control

1. Check all switches on the system to assure that they will operate properly. These may include maintenance switches, abort switches, main/reserve switches, etc. Once completed, ensure that they are all set in the correct position.
2. Check condition of the control panel for tampering, corrosion or damage. Test the panel at this point by referring to the panel manufacturer's operation manual.
3. Check all detectors. Make certain they are in place, clean and not damaged. If required, check the sensitivity of each detector as per the instructions of the detector manufacturer.
4. Check all electrical manual release stations. Make certain they are in place, that they are not blocked or damaged. Operate each manual release system to make certain they operate the control panel. Reset each manual release station and seal with visual inspection seal.
5. While checking the detectors and electric manual release stations, inspect each audio/visual alarm device. Check the alarms condition and verify that they operate properly when energized. Reset the alarm circuit after each test.
6. Reset the entire system. This includes the control panel, all actuators, detectors, alarms, and switches. After all components have been reset, install actuators back onto the cylinder valves as well as the pilot actuating hose.

7.2 INSPECTION OF THE SYSTEM

An inspection is a "quick check" that a system is operable. It is intended to give reasonable assurance that the system is fully charged and will operate. This is done by seeing that the system has not been tampered with and that there is no obvious physical damage or any abnormal condition which can prevent operation of the system. The value of an inspection lies in the frequency and thoroughness with which it is conducted. Systems should be inspected at least once a month, or at intervals as required by the local Authority Having Jurisdiction.

The following should be performed during a PYRO-200 system inspection:

1. Visually inspect the hazard area to verify that it has not changed. Check for different fuels, new equipment, blocked open doors or damper, more movable solid objects added, etc.
2. Check detectors to make certain they are in place, not damaged or coated with dirt, grease, paint or any other contaminating substance which could affect its operation.

3. Check all audio and visual alarms for damage, dirt, corrosion, etc.
4. Check all manual release stations to assure that they have not been tampered with and are not blocked from use.
5. Check that the piping is secured and nozzles are in place. Make certain that the nozzles are not covered with dirt, grease or paint and that there is nothing structural blocking the discharge.
6. Visually inspect all components for signs of damage, such as disconnected or loose parts, corrosion, twisted or dented components, missing parts, etc.
7. Check each PYRO-200 cylinder pressure gauge to determine that the pressure within the cylinders is in the operational range.
8. Visually verify that the control panel is functioning properly.
9. Visually check the wiring of the electric solenoid actuator from the control panel to the pilot or master cylinder to make certain it has not been disconnected.
10. Perform any other checks that may be required by the local Authority Having Jurisdiction.
11. Record that the system has been inspected and inform the relevant personnel.

NOTE: All cylinders shall be returned to the manufacturer or authorized distributor for refilling or recharging. Filling by unauthorized sources or third parties could jeopardize the integrity of the system; safety of the personnel involved as well as voiding the warranty of the system if it is still within the covered period.

7.3 INSPECTION AND MAINTENANCE CHECKLIST

The inspection and maintenance forms/checklist and Acceptance report shall be duly completed, and all necessary signatories obtained. Copies to be given to the relevant parties. Refer to Appendix B for the check list sample. Record that the maintenance has been performed as required by the Authority Having Jurisdiction. Inform all personnel that the maintenance has been completed and the system is back to normal.

CHAPTER 8

POST DISCHARGE MAINTENANCE

The purpose of this section is to provide a general guideline on the filling of HFC-227ea for the PYRO-200 Gas Fire Suppression system cylinders. The intent is to have the highest guarantee for correct filling wherever in the world a PYRO-200 cylinder is filled. The filling procedures may be adjusted accordingly for the chosen filling station, provided the stipulated requirements for pressures and contents are complied with

The local distributor or agent is responsible to issue these procedures to the relevant filling station. It is the responsibility of the filling station to fill the PYRO-200 cylinders according to these procedures; attach filling tags, prepare filling lists, issue of letter of conformity, etc.

Before entering the enclosure after the discharge of HFC-227ea, ventilate the enclosure thoroughly by switching on the vacuum suction pump.

8.1 SPECIFICATIONS FOR HFC-227ea

*Refer to Table *1-1* in Section 1.4 for physical properties of HFC-227ea.

Table 8-1: Physical Properties of Nitrogen Gas (N_2) in NFPA 2001

Properties	Value	Units
Molecular Mass	28.02	-
Boiling Point @ 1.013 bar (absolute)	-195.8	°C
Freezing Point	-210.0	°C
Critical Temperature	-	°C
Critical Pressure	-	Bar
Critical Volume	-	cm^3/mol
Critical Density	-	kg/m^3
Vapor Pressure 20°C	-	Bar
Liquid Density @ 20°C	-	kg/m^3
Saturated Vapor Density @ 20°C	-	kg/m^3
Specific Volume of Superheated Vapor at 1.013 bar and 20°C	0.858	m^3/kg
Chemical name	N_2 (Nitrogen)	

Table 8-2: Specification for Nitrogen Gas (N_2)

Property	Requirement
Purity	99.9% by volume, min.
Moisture	50×10^{-6} by mass, max.
Oxygen	0.1% by volume, max.

NOTE: Only principal contaminants are shown. Other measurements may include hydrocarbons, CO, NO, NO_2, CO_2, etc. Most are < 20 $x10^{-6}$.

8.2 INSTALLATION OF PYRO-200 VALVE

The PYRO-200 valve is a pressure differential valve used for fixed fire extinguishing systems utilizing liquefied halocarbon gases supercharged with nitrogen to a storage pressure of 25 bar/42 bar/50 bar at 21 ºC depends on system design. The valve is kept shut by the pressure within the cylinder. The valve can be open by pneumatic or mechanical means by the use of specially designed actuating components.

Valve Assembly

Refer to Figure *8-1* for component illustration. Ensure the valve components are cleaned before assembly.

1. Open the top cover and take out the piston. Install an O-ring at the top and bottom of the piston.
   - 1" O-ring (Part no: PYR-INT-FS-OR-216 and PYR-INT-FS-OR-315)
   - 1-1/2" O-ring (Part no: PYR-INT-FS-OR-131 and PYR-INT-FS-OR-323)
   - 2" O-ring (Part no: PYR-INT-FS-OR-330 and PYR-INT-FS-OR-328)
2. Apply seal (Teflon tape) to the thread of piston base plug, then screw it to the piston and tighten it. Subsequently, apply grease on the O-rings at the piston and internal part of body valve.
3. Place the piston back into the valve body and press it in until it reaches the bottom.
4. Install the spring and put two different O-ring onto the cap of the valve. Press down the spring and screw in the cap.
   - 1" O-ring (Part no: PYR-INT-FS-OR-029 and PYR-INT-FS-OR-225)
   - 1-1/2" O-ring (Part no: PYR-INT-FS-OR-229 and PYR-INT-FS-OR-034)
   - 2" O-ring (Part no: PYR-INT-FS-OR-234 and PYR-INT-FS-OR-038)
5. Place a burst disc on to the burst disc port and screw the nut in with a tensile force of 45 Nm until a click sound is heard.
6. Seal the pilot hole with an end cap. The nut must be tape with PTFE sealing tape.
7. Place an O-ring at the valve neck thread, screw the valve and the dip tube into the cylinder.
   - 1" O-ring (Part no: PYR-INT-FS-OR-224)
   - 1-1/2" O-ring (Part no: PYR-INT-FS-OR-229)
   - 2" O-ring (Part no: PYR-INT-FS-OR-335)

NOTE: Care must be taken to use only clean cylinders without any remnants of Teflon tape, paint particles or other contaminants. After the valves are opened and then closed, such particles can cause leaks in the seat area and malfunction of the valve.

Install the pressure gauge onto the valve by removing the plug at the pressure gauge port. Make sure that the port is free from debris or contaminants. Mount the pressure gauge onto the port by hand until it stops, then turn back a **MAXIMUM OF ONE REVOLUTION** for correct orientation of the gauge.

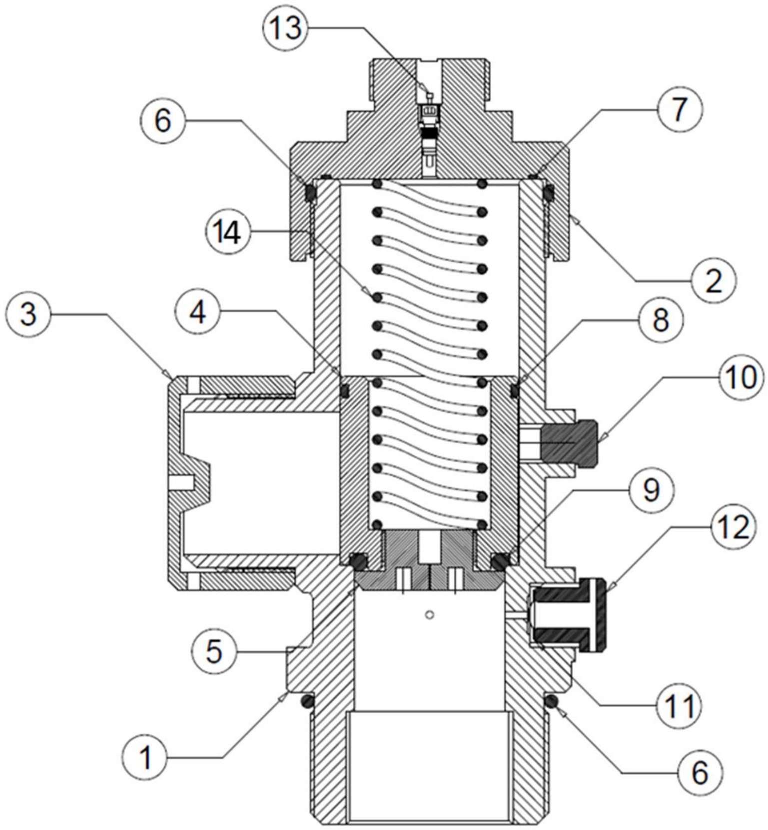


Figure 8-1: Valve components

Table 8-3: Valve Component Description

No	Description
1	Valve Body
2	Top Cover
3	Safety Recoil Cap
4	Clamp Plate
5	O-ring
6	O-ring
7	O-ring
8	O-ring
9	O-ring
10	Pilot Hose Vent Plug
11	Burst Disc
12	Vent Plug
13	Valve Core
14	Spring

8.3 FILLING METHOD

Filling of the cylinder is through the valve outlet. Make sure that all pressure has been relieved from cylinder before filling. Filling has to be done in a UL Listed/FM Approved filling station. Refer to Appendix C and D for filling check list sample.

1. With the tank ready for filling, a check is made to the filling instruction sheet and the tank fill weight, time, date and fills detail record. Make sure that there is no actuating component mounted on the valve.
2. The tank is placed on a scale, secured properly with chain or cable, and the appropriate filling adaptor attached to the valve discharge outlet.
3. Attach the fill hose line from the filling station to the filling adaptor.
4. Reset the scale to zero to compensate for the tank weight and the filling hose.
5. Switch on the pump and fill the tank to the required weight. When the correct fill is reached, switch off the pump.
6. Attach the nitrogen supply to the line. With a separate calibrated pressure gauge indicator adjust the nitrogen pressure to the required pressure with due allowance to the ambient temperature. Check that the pressure gauge attached to the tank is within ± 1 bar of the fill gauge. Replace the tank gauge if it is out of this tolerance.
7. Agitate the tank to accelerate nitrogen absorption and top off the pressure accordingly. Switch off the nitrogen supply once absorption has stopped.
8. Vent the fill hose to atmosphere. If the pressure drops to zero on the fill station gauge within 10 seconds, the valve has closed properly.
9. Make certain the vent valve is closed when not required, to prevent contamination to the fill line.
10. Check all ports for leak by submerging tank in water bath.
11. Remove the fill hose and the outlet fill adaptor. Leak test the valve outlet. If there are no leaks attach the valve outlet safety cap.
12. Reset scale and record gross weight.
13. Make certain all protective caps are in place and place tank in a holding area for leak monitoring for at least 24 hours prior to delivery.
14. After 24 hours, leak test the valve and tank assembly once more and check that the pressure is correct. Top up with nitrogen if necessary.

8.4 CYLINDER MAINTENANCE

Initial Filling

1. Cylinders shall be new or have been pressure tested according to local requirements. The date and marking of the pressure test shall be clearly stamped on the cylinders as required by local regulations.

2. The PYRO-200 cylinders are factory painted to Signal Red (RAL3000) color. For other color requirements according to local regulations, the cylinders shall be painted first prior to filling.
3. The cylinders must be cleaned and dried out internally prior to fitting of valve. This is to avoid any contaminants from lodging onto the valve seat after opening and closing of the valve which may cause the valve to leak or malfunction.
4. Filled cylinders to be provided with a label indicating the contents and the pressure.

Recharge / Refill after discharge

1. A residual pressure of ±3 bar will remain in the cylinder after discharge. For safety reasons, the valve outlet safety cap must be fitted to avoid an accidental escape of this residual gas prior to refilling of the cylinder.
2. Wherever required, the cylinders shall be pressure tested. NFPA 2001 states that cylinders that have discharged or leaked need to be pressure tested again if more than 5 years have passed since the last pressure test. Cylinders that are continuous in service need not be tested but must be inspected. They shall be required to discharge and pressure test again after 10 years have passed from the last test date.
3. Where necessary, the cylinders shall be refurbished and repainted again prior to refilling.
4. Recharged cylinders to be provided with a label indicating the contents and the pressure.

NOTE: A pressure regulator must be used if the pressure source is from a high-pressure gas tank

APPENDIX

A. TESTING AND COMMISSIONING CHECK LIST FOR PYRO-200 SYSTEM.

Item	Description	Yes	No	Remarks
	Piping			
1	Check that the correct pipe schedule and fittings were used. Refer to isometric drawings for specifications.			
2	Check that the pipe routing and size correlate with the pipe plan and piping isometric drawings. Any major modifications to be noted and handed over to the project engineer for verification calculation			
3	Check that the piping network are securely fastened to a solid and stable structure using appropriate supports. Check that all bolts are tighten properly.			
4	Check that the piping network has been flushed/dried out and pressure tested. Test report to be issued by the installer.			
5	Check that all discharge nozzles are installed securely and are not obstructed. Verify that each nozzle with the correct orifice size is installed at the correct location as per piping isometric drawing.			
	Cylinders			
6	Check that the number, their filling weight and pressure correspond with the project specification			
7	Check that they are not damage, paint has been touched up			
8	Check that the wall brackets are securely fastened to a solid and stable structure. Check that all bolts are tighten properly.			
9	Check that all cylinder clamps are mounted properly and all bolts are securely fastened.			

10	Check that each cylinder has been labelled and the label has been filled correctly.			
Manifold (if used)				
12	Check that the manifold arrangement is in accordance with the drawings.			
13	Check that the manifold brackets are securely fastened to a solid and stable structure. Check that all bolts are tightened properly.			
14	Check that the manifold is securely fastened to the brackets			
15	Check that the manifold assembly is securely fitted to the distribution pipe network.			
Accessories				
16	Check that the discharge hose(s) has a smooth bending, is not stretched, compressed or kinked			
17	Check that the discharge hose(s) has been securely fixed onto the discharge valve outlet and the manifold check valve.			
18	Check that pressure on each cylinder is within the acceptable range. Refer to Pressure-Temperature chart			
19	Check that the pressure gauge orientation is correct, i.e. The dial gauge face is legible.			

B. INSPECTION AND MAINTENANCE CHECK LIST FOR PYRO-200.

Item	Description	Yes	No	Remarks
	Piping			
1	Inspect /Check that the piping network is secured. No damaged, loose, missing or corroded components.			
2	Check that all discharge nozzles are installed securely and are not obstructed.			
	Cylinders			
3	Visually inspect the cylinders for signs of damage, corrosion or abnormalities			
4	Check the hydrostatic test date. Send for testing if more than 5 years have passed from the last test date prior to recharging or refilling of the cylinder.			
	WARNING: Prior to removing the cylinder(s) for weighing, ensure that the system is locked off and all actuating components are removed. Install the valve outlet cap immediately after removing the cylinder from the distribution piping / manifold.			
5	Check the pressure of the cylinder. (25 bar/42 bar/50 bar @ 21 °C depends on system design) If the pressure loss is more than 10 % (adjusted for ambient temperature) the cylinder must be sent for recharging.			
6	Check that each cylinder has a label stating the contents. Note the gross weight of the cylinder. Weight the cylinder. If the cylinder shows an agent loss of more than 5 % it shall be sent for recharging.			
7	Check that all cylinder clamps are mounted properly and all bolts are securely fastened.			

C. FILLING CHECK LIST

Item	Description	Checked	Comments
1	List the cylinder serial number on filling list		
2	Make sure that there are no actuating components attached to the valve and that there is no foreign matter / debris on the Valve outlet prior to connecting the filling hose.		
3	Fill the liquefied gas to the required weight.		
4	Super pressurize with dry nitrogen to the required pressure. (25 Bar/42 Bar/50 Bar @ 21°C)		
5	Agitate the cylinder. Top up with nitrogen if necessary.		
6	Check for leaks on the valve. No leaks are accepted.		
7	Screw on the valve outlet safety cap.		
8	Fit the plastic protective cap onto the valve.		
9	Attach the cylinder label with relevant details as required.		
10	Secure cylinder(s) on transport cage or pallets.		
11	Ship to receiver or site as per order.		
12	Issue the filling list.		
13	Issue the letter of conformity to the client or purchaser.		

D. FILLING LIST

The filling station is required to fill in the Filling List and a copy to be issued to the client or purchaser. A copy is to be included in the shipment. As well as the filling list, the filling station shall issue a letter of conformity for every batch of cylinders filled.

A sample of the list is as follows:

Filling List No.:		Purchase Order No.:		
Client:				
Cylinder S/N:	Cylinder Vol: L	Filled N_2 to: 25 Bar	Date of Filling	Filler's Signature

E. SAFETY DATA SHEET

MSDS Number: PYR-SDS-HFC
HMIS:1-0-0
Revision Date: February 20, 2022

Material safety data sheet for HFC-227ea

Section 1: Identification of the material and supplier	
Product name	HFC-227ea
Recommended use	Fire extinguishing agent
Supplier identification	Adkinns Inc. 5063 Commercial Circle, Concord, 94520 CA, USA Tel: +1 (650) 457 4580 www.adkinns.com

Section 2: Hazards identification		
Emergency overview	Misuses or intentional inhalation abuse can cause suffocation or death. Direct eye or skin contact with the liquid or cold gas can cause chilling or possibly frostbite on exposed tissues.	
Acute Health Effects	**Eyes**	Direct eye contact may cause severe burns or frostbite
	Skin	Direct skin contact may cause severe burns or frostbite
	Inhalation	Acts as an asphyxiant
	Ingestion	Not considered a route of exposure
Chronic Health Effects	Not known.	
Medical conditions aggravated by overexposure	Pre-existing disorders like cardiac, respiratory or central nervous system disorders may be susceptible to the effects of overexposure.	

Section 3: Composition/information on ingredients		
Chemical characterization	CAS-Number	EC-Number
1,1,1,2,3,3,3-Heptafluoropropane >99.9%	431-89-0	207-079-2

Section 4: First aid measures	
Inhalation	Move victim to fresh air; if necessary, provide artificial respiration or oxygen. Put victim at rest and keep warm. In the event of persistent symptoms, seek medical treatment.

	The use of epinephrine, symptomatic or other stimulates may increase susceptibility to cardiac sensitization
Skin contact	Thoroughly wash skin with soap and water. In case of skin irritation, consult a physician.
Eye contact	Immediately flush eyes with plenty of flowing water for 10 to 15 minutes holding eyelids apart. Check and remove any contact lenses. Immediately seek medical attention.
Ingestion	No information available

Section 5: Firefighting measures	
Extinguishing media	All conventional media are suitable
Advice for firefighters	Wear a self- contained breathing apparatus and chemical protective clothing.

Section 6: Accidental release measures	
Personal precautions	Ventilate affected area. Do not breathe vapor/aerosol. Wear appropriate protective equipment and keep unprotected people away

Section 7: Handling and storage	
Handling	High-pressure gas. Do not puncture or incinerate cylinder. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide or drop. Use a suitable hand truck for cylinder movement. Never allow any unprotected part of the body to touch uninsulated pipes or vessels that contain cryogenic liquids. Prevent entrapment of liquid in closed systems or piping without pressure relief devices. Some materials may become brittle at low temperatures and will easily fracture.
Storage	Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over.

Section 8: Exposure controls/personal protection		
Engineering controls	Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.	
Acute Health Effects	**Eyes**	Tightly sealed goggles according to EN 166
	Skin	Wear suitable protective clothing

	Inhalation	NIOSH/MSHA approved self-contained breathing apparatus for entry into areas where high concentrations may exist
	Hands	Wear protective gloves according to EN 374. Observe glove manufacturer's instructions concerning penetrability and breakthrough time.

Section 9: Physical and chemical properties	
Physical state	Gas
Molecular weight	170.03
Color	Colorless
Odor	Odorless
Flash point (PMCC) (ºC/ºF)	Not applicable
Special gravity	1.4
Boiling point	-16.36 ºC
Vapor density	6.04
Vapor pressure at 20 ºC	58.8 psia
Critical pressure	2912 kPa
Critical density	0.621 kg/dm^3
Critical temperature	101.7 ºC

Section 10: Stability and reactivity	
Reactivity	May cause strong exothermic reaction when exposed to freshly abraded aluminum surfaces at very high temperature or pressure. Chemically active metals: Potassium, calcium, powdered aluminum, magnesium and zinc.
Chemical stability	Stable under recommended storage conditions.
Conditions to avoid	Avoid contact with strong alkali or alkaline earth metals, finely powdered metals such as aluminum, magnesium and zinc.
Hazardous decomposition products	Hydrogen fluoride, hydrofluoric acid, carbonyl fluoride, carbon monoxide and carbon dioxide

Section 11: Toxicology	
Acute toxicity (oral)	Lack of data
Acute toxicity (dermal)	Lack of data
Acute toxicity (inhalative)	Lack of data
Skin corrosion/irritation	Lack of data
Eye damage/irritation	Lack of data
Sensitization to the respiratory tact	Lack of data

Skin sensitization	Lack of data
Genotoxicity	Lack of data
Carcinogenicity	Lack of data
Reproductive toxicity	Lack of data
Aspiration hazard	Lack of data

Section 12: Ecological information	
Ozone depletion potential	0
Global warming potential	3500

Section 13: Disposal consideration	
Waste disposal	Products removed from the cylinder must be disposed of in accordance with appropriate Federal, State, and local regulations. Do not dispose of locally. Do not dispose of the product in the domestic waste or at any waste collection places.

Section 14: Transport Information		
Emergency action code	**UN**	3296
	Class	2.2
	Hazard label	Compressed nonflammable gas
	Packing Group	Not applicable

Section 15: Regulatory information
Not classified as dangerous according to Directive 67/548/EEC & Directive 1999/45/EEC

Section 16: Other information		
NFPA	**Health**	1
	Flammability	0
	Reactivity	0
	Special Hazards	None
HMIS	**Health**	1
	Flammability	0
	Reactivity	0
	Protection	X
Disclaimer	The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and believe. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release. It is not to be	

	considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

F. PRESSURE – TEMPERATURE CURVE

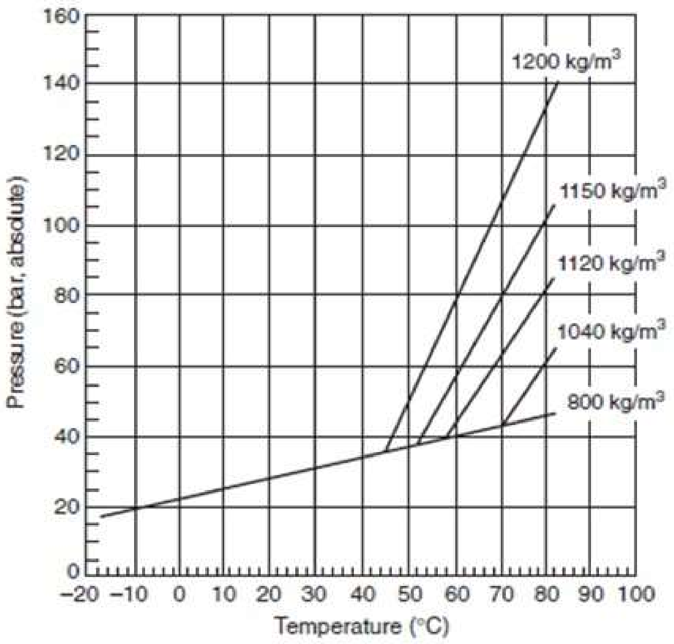


Figure 9-1: HFC-227ea Pressurized to 24.8 bar with Nitrogen at 21 °C Temperature Correction Chart

(Source: NFPA2001 - 2000 Edition)

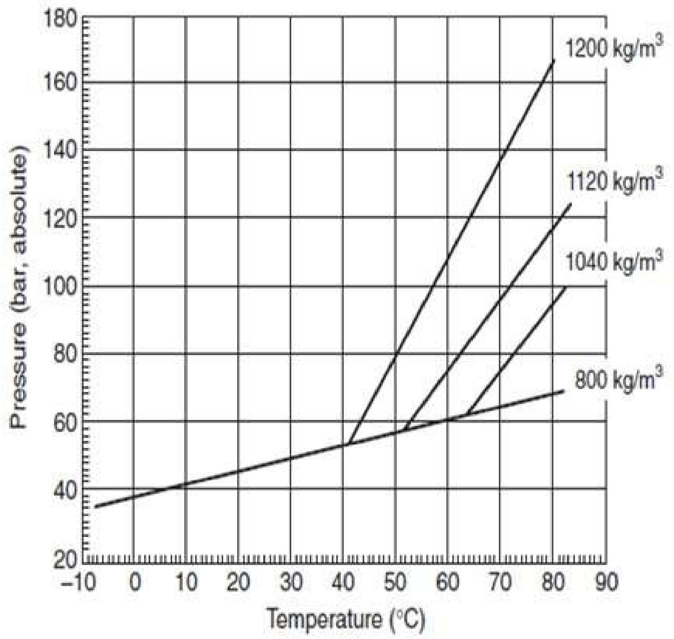


Figure 9-2: HFC-227ea Pressurized to 41 bar with Nitrogen at 21 °C Temperature Correction Chart

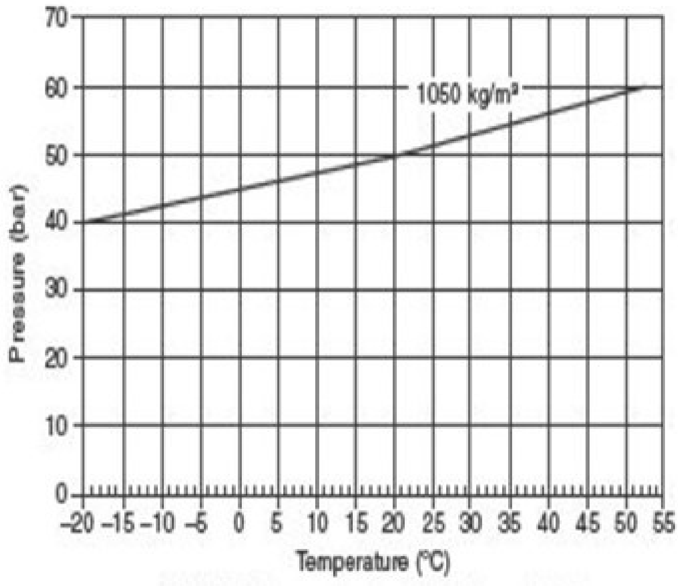


Figure 9-3: HFC-227ea Pressurized to 50 bar with Nitrogen at 20 ºC Temperature Correction Chart

G. JENSEN HUGUES SOFTWARE SAMPLE CALCULATION

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Adkinns Flow Calculation Software v4.00 (HFC-227ea)
Component of UL / FM Approved System

File Name: Hyd.FC4

Consolidated Report

Customer Information

Company Name:	ABC Company
Address:	123, Commercial Circle, Concord, CA USA
Phone:	+1 (650) 111 1111
Contact:	James
Title:	Mr.

Project Data

Project Name:	Calculation Test
Designer:	John Mayhem
Number:	A2977
Account:	123-123
Location:	Test Floor
Description:	HFC Test Calculation for Test Room

Enclosure Report

Elevation: 0 m (relative to sea level)
Atmospheric Correction Factor: 1 (NFPA 2001)

Enclosure 1 Server Room

Enclosure Temperature:		Number of Nozzles:	2
Minimum:	21.0 C	Width:	8.00 m
Maximum:	21.0 C	Length:	7.00 m
Max. Concentration:	0.00 %	Height:	3.00 m
Design Concentration:		Volume:	168.00 m^3

Calculation Date/Time: Tuesday, 26 October, 2021, 1:29:07 PM

Key ID: 1012229865

Page: 1 of 7

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Adjusted:	6.71 %	Non-permeable:	0.00 m³
Minimum:	6.70 %	Total Volume:	168.00 m³
Min. Agent Required:	87.81 kg		
Adjusted Agent Required:	88.00 kg		

Agent Source Report

Agent:	HFC-227ea / Propellant N2
Cylinder Name:	150 L Cylinder - 25 bar
Cylinder Part Number:	150 L Cyl - 25 bar
Agent Per Cylinder:	88.00 kg
Cylinder Pressure:	24.8 bar
Fill Density:	0.587 kg / l
Number of Main Cylinders:	1
Number of Reserve Cylinders:	0
Cylinder Empty Weight:	54.40 kg
Weight, All Cylinders + Agent:	142.40 kg
Floor Area Per Cylinder:	0.16 m²
Floor Loading Per Cylinder:	890 kg /m²

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Page: 2 of 7

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Parts Report

Total Agent Required: 88.00 kg

Cylinder Name: 150 L Cylinder - 25 bar (Part: 150 L Cyl - 25 bar)

Number of Cylinders: 1

Nozzle	Type	Nozzle Diameter	Nozzle Area	Part Number
E1-N1	360	32 mm	567.06 mm ^{2}	32 mm-360-9.5 mm
E1-N2	360	32 mm	567.06 mm ^{2}	32 mm-360-9.5 mm

Pipe & Fittings	Type	Diameter	Length	Elbows (90)	Elbows (45)	Tees	Unions
	40T	32 mm	6.26 m	2	0	0	0
	40T	40 mm	6.84 m	2	0	1	0
	40T	50 mm	2.30 m	0	0	0	0

Other Objects	Name	Quantity	Part Number
	50 mm Flex Hose - 90 Bend	1	50 mm Flx

System Acceptance Report

System Discharge Time: 6.1 seconds
Percent Agent In Pipe: 37.6%
Percent Agent Before First Tee: 27.9%
Dead Volume: 0.0% (0.00 kg)

Enclosure Number: 1
Enclosure Name: Server Room
Minimum Design Concentration: 6.70%
Adjusted Design Concentration: 6.71%
Predicted Concentration: 6.71%

Calculation Date/Time: Tuesday, 26 October, 2021, 1:29:07 PM

Key ID: 1012229865

Page: 3 of 7

Consolidated Report

Maximum Expected Agent Concentration: 6.71% (At 21.0 C)

Nozzle	Minimum Agent Required	Adjusted Agent Required	Predicted Agent Delivered	Average Nozzle Pressure
E1-N1	43.91 kg	44.01 kg	44.00 kg	8.013 bar
E1-N2	43.90 kg	43.99 kg	44.00 kg	8.013 bar

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Key ID: 1012229865

Page: 4 of 7

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Pipe Network Report

Description	Pipe Section	Start Node	End Node	Pipe Type	Pipe Diameter	Pipe Length	Union	Total Elevation Change	Total Equivalent Length	Nozzle Name	Nozzle Size	Nozzle Type	Nozzle Area
Cylinder - On	Man.	0	2		50 mm	0.94 m	0	0.94 m	13.00 m				
Flex Hose	Man./End	2	3		50 mm	0.70 m	0	0.33 m	4.40 m				
Pipe	System	3	4	40T	50 mm	2.30 m	0	2.30 m	2.30 m				
Elbow (90)	System	4	5	40T	40 mm	------	0	------	1.31 m				
Pipe	System	5	6	40T	40 mm	3.60 m	0	------	3.60 m				
Elbow (90)	System	6	7	40T	40 mm	------	0	------	1.31 m				
Pipe	System	7	8	40T	40 mm	3.24 m	0	------	3.24 m				
Tee	System	8	9	40T	32 mm	------	0	------	2.29 m				
Pipe	System	9	10	40T	32 mm	2.00 m	0	------	2.00 m				
Elbow (90)	System	10	11	40T	32 mm	------	0	------	1.13 m				
Pipe&Nozzle	System	11	12	40T	32 mm	1.13 m	0	-1.13 m	1.13 m	E1-N2	32 mm	360	567.06 mm^2
Tee	System	8	13	40T	32 mm	------	0	------	2.29 m				
Pipe	System	13	14	40T	32 mm	2.00 m	0	------	2.00 m				
Elbow (90)	System	14	15	40T	32 mm	------	0	------	1.13 m				
Pipe&Nozzle	System	15	16	40T	32 mm	1.13 m	0	-1.13 m	1.13 m	E1-N1	32 mm	360	567.06 mm^2

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Key ID: 1012229865

Page: 5 of 7

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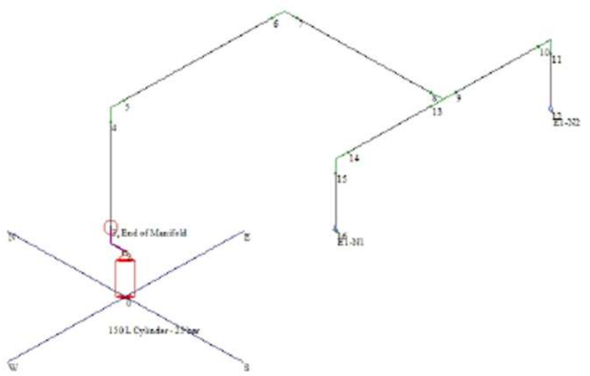

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Page: 6 of 7

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