Foreword

This manual provides instructions and information on the Design, Installation and maintenance of the FSL CG^2 HFC-227ea Engineered System, referred to hereinafter as the CG^2 System.

Systems shall be designed, installed and maintained in accordance with this manual and the internationally recognised standards:

- NFPA 2001, Standard on clean agent fire extinguishing systems
- ISO 14520, Gaseous fire-extinguishing systems.
- EN 15004-1, Fixed fire fighting system – Gas extinguishing systems

Note: Any reference to ISO 14520 shall be read as ISO 14520 or EN 15004. (The part and clause references are correct for ISO 14520)

The manual must be read in conjunction with the International Standards because the requirements from the standards are excluded from the text.

CG^2 systems must be designed, installed, commissioned and maintained by qualified and competent personnel who have the relevant training and experience. Systems are Total Flooding and suitable for buildings, plant or other structures See ISO 14520-1 1.0

Any questions, queries and suggested improvements should be brought to the attention of FSL.

This design manual does NOT include the use of the CG^2 system for local application or explosion suppression systems and marine or aviation use. All are Engineered Total Flooding systems which must be designed using the FSL CG^2 Design calculation program. Pre-engineered systems are NOT covered.

FSL strives to continually improve its products and systems and this manual may not reflect the latest products.

The pressure vessel containing the fire extinguishing agent is generally referred to as a cylinder or container. This manual generally uses the word container.

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Introduction

The system provides a Total Flooding fire suppression system in accordance with NFPA 2001 or ISO 14520

HFC-227ea may be used in the protection of the following types of facilities:

- Data processing
- Process control rooms
- Telecommunications facilities
- High value assets

HFC-227ea is ***NOT*** suitable for:

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

Fire detection and Controls:
This manual covers the design and installation of the fire suppression/extinguishing system not the fire detection, actuation, or control requirements. These are important aspects to ensure the correct operation of the extinguishing system and must be completed by skilled and competent personnel to appropriate international standards e.g. ISO14520, NFPA2001, BS 5839, BS 7273.

These systems require fast detection and discharge to minimise the fire damage and the extinguishant decomposition. Do not delay the extinguishant discharge longer than is necessary to evacuate the protected space. Any delay will allow the fire to increase in size, producing more products of combustion and result in more decomposition products during the extinguishing process.

Approvals

This manual has been approved by the Loss Prevention Certification Board for the Design of FSL's CG^2 Clean Agent Engineered Systems using approved components and equipment. The Approval was obtained against LPS 1230.

Full details of the Scope, Qualifications/limitations can be found on the BRE Red Book live web site. www.redbooklive.com/

Approved System design concentrations.

Product Name	Risk	Design Concentration**
FSL CG^2	Class A (Standard)	7.9%
FSL CG^2	Class A (Cables)	8.5%
FSL CG^2	Class B	9.0%

** The design concentrations include a safety factor of 1.3 over the extinguishing concentration.
Note: Inerting is excluded from the scope of the LPCB approval

Equipment

HFC-227ea Physical Properties

HFC-227ea (CF_3CHFCF_3-heptaflouropropane) is colourless, odourless and electrically non-conductive. It leaves no residue and has acceptable toxicity for use in occupied spaces. HFC-227ea total flooding systems may be used for extinguishing fires of all classes within the limits specified in NFPA 2001 and ISO 14520-9

HFC-227ea suppresses a fire by a combination of Chemical (principally heat absorption) and physical mechanisms. The system should be designed to discharge within 10 seconds.

HFC-227ea is clean, efficient, environmentally acceptable, and leaves no residue, thus minimizing any downtime after a fire. Most materials contained in areas protected by HFC-227ea, such as aluminium, brass, rubber, plastics, steel, and electronic components, are unaffected when exposed to HFC-227ea.

HFC-227ea is stored as a liquid in steel containers and super pressurized with nitrogen to 25 bar to increase its discharge flow characteristics. When discharged, HFC-227ea will vaporize at the discharge nozzles and effectively mix with the air throughout the protected area.

HFC-227ea is suitable for extinguishing Class A, B and C type risks. Refer to the System Design section for specific guidance.

HFC-227ea Physical Properties	
Chemical Structure	CF_3CHFCF_3
Molecular Weight	170.0
Boiling Point 760 mm Hg	-16.4°C
Freezing Point	-131°C
Critical Temperature	101.7°C
Critical Pressure	2910 kPa
Critical Volume	274 cc/mole
Critical Density	621 kg/m
Heat of Vaporization @ Boiling Point	132.6 kJ/kg
Vapour Pressure	458kPa @ 25°C
Specific Heat, liquid at 25°C	1.184 kJ/kg-°C
Specific Heat, vapour at constant pressure (1 atm) and 25°C	0.808 kJ/kg-°C
Thermal conductivity of liquid at 25°C	0.069 W/m-°C
Viscosity, liquid at 25°C	0.184 centipoise
Ozone Depletion Potential	zero
Global Warming Potential	3500
Liquid density	1.41 kg/l

Safety Considerations

HFC-227ea has acceptable toxicity for use in occupied spaces as a total flooding agent. Refer to the NFPA 2001 and ISO 14520-9 or National guidelines for specific exposure limitations and discharge controls.

The Material Safety Data Sheet (MSDS) covering HFC-227ea should be read and understood prior to working with the agent. Safety items such as personnel training, evacuation plans and fire drills should be considered.

Refer to ISO 14520-9 5 for current Toxicity levels. The No observed adverse effect (NOAEL) level is 9% by volume and the Lowest observed adverse effect level (LOAEL) is 10.5%. For egress times from the protected space Annex G of ISO 14520-1 gives guidance.

We advise that all personnel are evacuated from the protected space prior to actuating the system to avoid them breathing the fires products of combustion. During the extinguishing process some decomposition products are produced, the amount of which is proportional to the fire size. Very low concentrations will be an irritant which will be a disincentive to enter the protected space and thus protect the health of personnel. The products of combustion and decomposition products can be acidic and corrosive to the contents of the protected space and should not be allowed to remain in the protected space. These products must be promptly and thoroughly ventilated from the protected space prior to allowing re-entry.

The gases may have migrated to neighbouring areas. Ensure that these areas are thoroughly ventilated.

Agent Decomposition Consideration

An unchecked fire will produce 'products of combustion' and at the seat of the fire only, HFC-227ea will decompose to extinguish the fire. These decomposition products are hazardous to health and should not be breathed.

On very hot surfaces (e.g., furnaces and ovens) HFC-227ea could decompose (typically above 600°C). The effects of HFC-227ea decomposition on equipment should be considered in hazards with high ambient temperatures.

Consideration should be given for providing adequate means of venting the protected area after a discharge.

Visibility

The discharge of HFC-227ea into a space may cause a reduction in visibility due to the moisture in the air condensing for a brief period. This will in disappear in seconds as the agent warms to the surroundings.

Chilling

The HFC-227ea is stored as a liquid and vaporises at the nozzle. Any direct contact with the issuing agent will cause rapid cooling and possibly frostbite. Do not mount any delicate equipment adjacent to the discharge nozzles.

Noise

The discharge may result in some noise from the nozzle.

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Consideration should be given for providing adequate means of venting the protected area after a discharge.

HFC-227ea agent storage containers

These are heavy and must be handled with care and the correct handling facilities. To prevent accidental discharge or damage to the equipment when not fully restrained (in the installed location) all actuators must be disconnected or removed where possible, all anti-recoil devices must be in place and transport caps fitted.

Equipment Description

HFC-227ea systems are intended to be used to suppress fires involving equipment or specific hazards. It is very effective where an inert, electrically non-conductive agent is required, or when clean-up of other agents presents a problem.

Each HFC-227ea system is specifically designed to accommodate the individual demands of the areas to be protected. The wide range of configurations of the components provides the flexibility necessary for this custom design.

An Engineered system requires that hydraulic flow calculations are undertaken to size the pipe work and discharge nozzles. Only the FSL program shall be used. Normal system design shall be at 21°C.

Cylinder/Container Assembly

HFC-227ea is stored in specially designed cylinder assemblies. Cylinders are available in various sizes. All cylinders are super pressurized with dry nitrogen to a pressure of 25 bar at 21°C. Each cylinder is equipped with an identification nameplate indicating the quantity of HFC-227ea, pressurisation level and filling station.

Containers/cylinders shall be constructed to National Standards and be independently certified for use in the region of use. Note that the 25 bar system will require different container working pressures. Acceptable standards for use in:

- Europe are EN 13322-1 Transportable cylinders – welded, EN 1964-2 transportable cylinders – seamless, Transportable Pressure equipment Directive (TPED 99/36 EC) and the carriage of dangerous goods by road regulations (ADR).
- USA is DOT 4BW500
- India IS7285-2

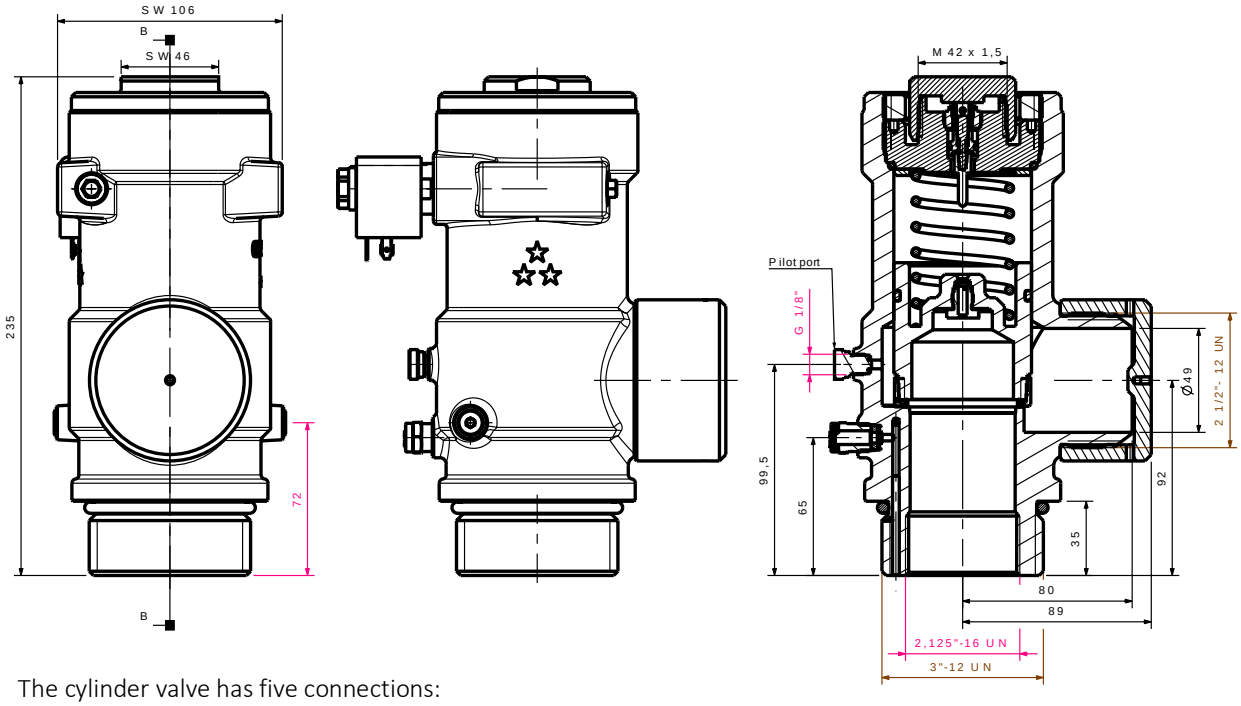
Each cylinder assembly has a rigid dip/siphon tube and is designed for mounting in a vertical position with the valve uppermost only.

Cylinder: The steel cylinders/containers are manufactured to the requirements various National Standards appropriate with their country of use. The fill range shall be 0.4 to 1.12 kg/litre. Note that the maximum fill range should only be used in conjunction with short pipe runs.
Do not leave the containers where they can be exposed to rapid changes of temperature from cold to hot because the internal pressure can rise significantly.

Dip Tube: The dip/siphon tube extends from the discharge valve to a closely controlled distance from the base of the container. (The minimum distance between the flat inlet to the dip tube and the base of the container, taking into account the worst case tolerance of the dip tube and container internal depth shall be 50% of the bore diameter of the dip tube). Maximum gap shall be the dip tube bore. This ensures a full liquid discharge of agent. Dip tubes are screwed into the valve and retained with a thread sealant.

Cylinder Valve: A pressure operated cylinder valve having a forged brass body and cap is attached to the cylinder neck and serves to control the flow of HFC-227ea from the cylinder.

NF2133** and NF2149** Series Valves.
The version shown here includes the Integrated Solenoid Release



The cylinder valve has five connections:

1. Top mounted Actuator connection.
2. Integrated electrical actuator. (dependent on valve version).
3. Pressure Gauge/Pressure switch Connection: This is a threaded connection housing a check valve and must be fitted with supplier approved devices to function correctly.
4. Outlet with JIC Male connection.
5. Discharge pressure connection to pressure actuate slave cylinders or operate a discharge pressure switch.
6. Rupture disc to discharge the top gas chamber of the container should the working pressure of the container be exceeded. Rupture discs are supplied rated for the charge pressure and the maximum working pressure of the container. Refer to the stamping on the disc holder. Do NOT attempt to dismantle the rupture disc assembly while pressurised.

Cylinders shall only be mounted with the valve uppermost and secured with the supplied straps to sound wall or secured racking.

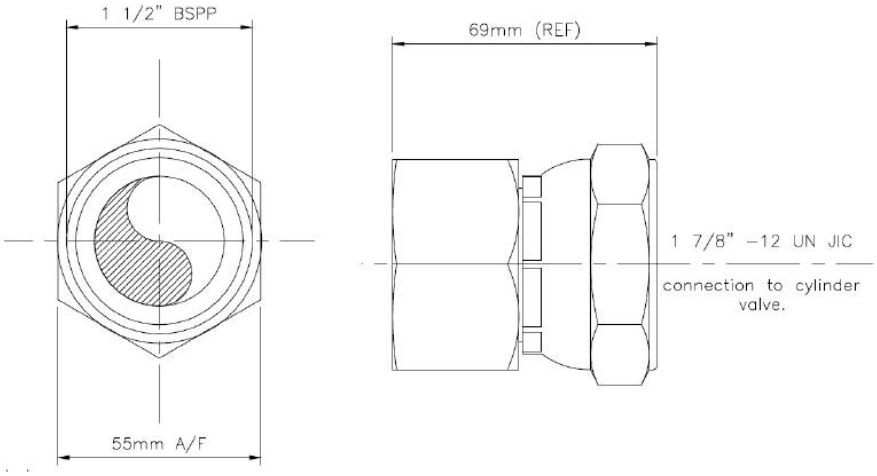
The minimum flow cross sectional area is compatible with the valve outlet sizes of 33 (855mm^2) and 49mm (1886mm^2). The actual flow characteristics are built into the FSL CG^2 flow calculation program which must be used for all system calculations.

Each valve is fitted with an over pressure relief disc which is set to protect the pressure vessel from excessive pressure.

Outlet Adaptors (Part no. NF2333050 NF2349050)

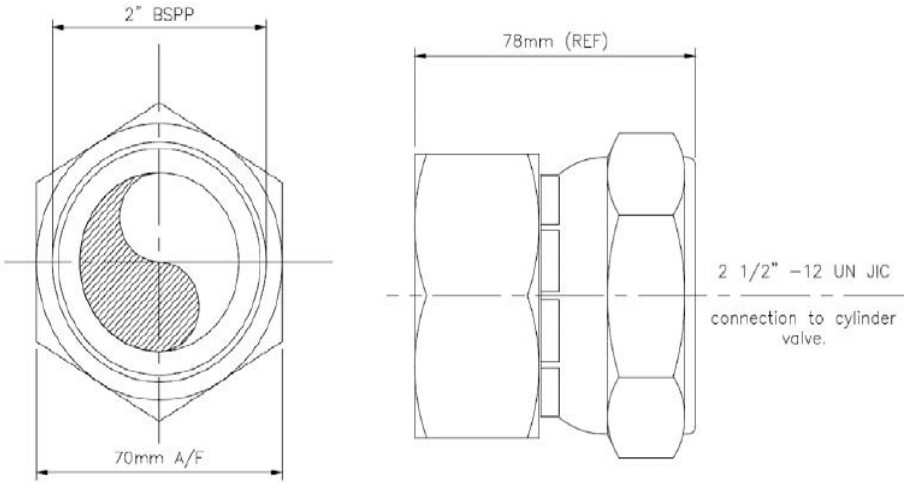
Provided with standard modular systems or single cylinder systems

33mm Outlet Adaptor – Compatible with 15ltr, 30ltr & 50ltr cylinders



Outlet Size = 1 ½" BSPP (Female)

49mm Outlet Adaptor – Compatible with 80ltr, 120ltr, 150ltr & 180ltr cylinders



Outlet Size = 2" BSPP (Female)

(Demonstration picture only)

Discharge flexible hoses (Part no. NF2333500 NF2349550)

Only the hoses supplied shall be used these have an appropriate pressure and flow rating.

If multiple cylinders are banked together for discharge into a common manifold then:

- All cylinders must be of the same size and fill and pressurisation
- All flexible hoses must be fitted with a Check/Non return valve.

Discharge Check Valves and Manifolds (Check Valves NF46000**)

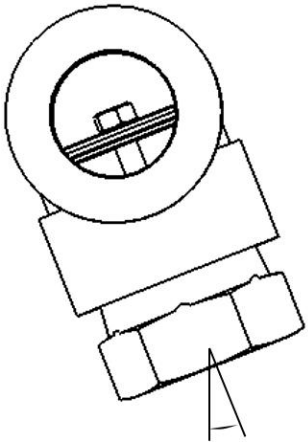
The Check valves are designed for fitment to welded socket* manifolds or screwed tee* fitting manifolds. Inlets must be at the bottom vertically downwards as the check is biased closed by gravity. (do NOT use horizontally or with the check valve at the top of the manifold.

Note*: the fitting screw thread must be concentric with the fitting body with a minimum throughway of 47mm (R1.5 inlet) and 62mm (R2 inlet) throughway through the fitting.

Part number	Inlet	Outlet	Minimum flow area	Use with Discharge Hose
NF24331	1 ½"	2"	804mm^2	NF2333500
NF24332	1 ½"	2"NPT	804mm^2	NF2333500
NF24491	2"	2 ½"	1590mm^2	NF2349550
NF24492	2"	2 ½"NPT	1590mm^2	NF2349550

Maximum service pressure 53 bar

Always fit check valve to manifold followed by the discharge hose to check valve.

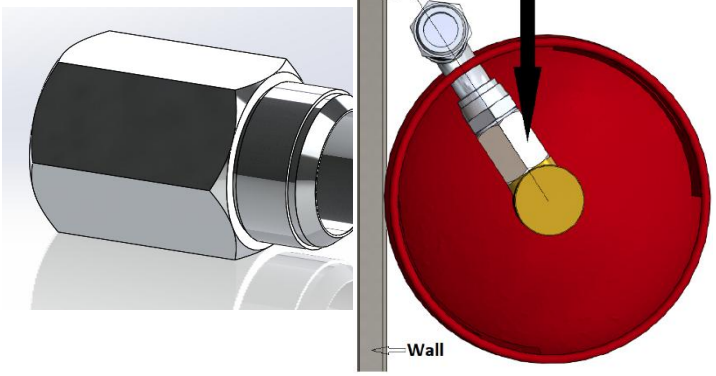


Side view of manifold showing the check valve in the open position.

Maximum 20 degrees from vertical

Outlet Spacer (Part No. NF234980)

(for manifold system, <u>only on 180l Cylinders</u>)



Discharge nozzles (Part no. NF2515** to NF2550**)

The discharge nozzle plays an important role in the system in that it controls the flow of extinguishant and distribution of extinguishant into the protected space.

Two types of nozzle are available namely 180 Degree for side wall mounting and 360 degree for centre space mounting. Both nozzles may be used for 25 bar systems. The minimum nozzle pressure shall be 5 bar unless the FSL CG^2 calculation software specifies a higher pressure.

The nozzle orifice is calculated by the FSL CG^2 Systems calculation program to discharge the agent within 10s. Where the nozzle orifice drilling is less than 2mm then an additional inline strainer must be fitted to the nozzle inlet.

Discharge Valve Actuation

In addition to the integral electrical actuator the cylinder valve can be fitted with a pneumatic actuator, pneumatic/manual actuator and an electrical solenoid actuator, providing the following methods of actuation.

- Pneumatic (Pneu) NF26020
- Manual (Man) NF26030
- Pneu/Man NF26030
- Electric (Elc) Integrated in Valves NF213312, NF213314, NF214912, NF214914 Operating Voltage 24Vdc ±10%, 0.25A ±10%
- Elc Detachable actuator NF26010 or 26011 'Electromagnetic Tripping Mechanism' Operating Voltage 24Vdc ±15%, 0.5A ±10% for 2 seconds
- Elc/Man Combination of above
- Elc/Man/Pneu Combination of above

All of the valve electrical release devices are energized (for 1s) by the control panel causing the valve to open fully. The integral release actuators in Valves NF213312, NF213314, NF214912, NF214914 must have the solenoid energised throughout the discharge (10s).

Pilot pressure actuation

The pneumatic actuation release pressure may be derived from a separate pilot gas cylinder. The minimum supplied pressure to guarantee actuation shall be 8 bar for 25 bar systems systems (note: actual actuation will be at a lower pressure). The designer shall ensure that this can be achieved by the choice of pilot cylinder and the maximum pilot line run from the pilot cylinder to the actuator. The pressure should be maintained for 10s (note: the discharge valve will latch in the open position during discharge). Any pilot pressure supply must be continuously monitored.

Slave actuation

One master valve may actuate up to 4 slave valves using the NF26020, NF26030 Release devices. Pressure to be taken from discharge valve 'Pilot Port' using Pilot Hoses NF271560 (note NF271xxx where xxx refers to the length in mm).
A pilot hose may also be used to connect to a Discharge pressure switch.
Maximum working pressure 210 bar, Minimum bend radius 100mm
Temperature range -20°C to +50°C

Pilot Hose

Pilot hoses are supplied with fittings and adaptor to suit connection onto the Pneumatic Actuators. Hose ends are G1/8".

Materials have been selected to give an extended life. Refer to the Maintenance section for details of life and inspection requirements.

Signs and Labels

All entrances to the protected space shall be identified as entering a space protected by HFC-227ea. The form of the label shall follow the guidance in NFPA 2001 and ISO 14520-1. This will contain a warning to evacuate the protected space upon the first fire alarm.

Within the protected space the following information shall be displayed:

- Identity of agent
- Design Volume
- Type of risk
- NOAEL/LOAEL levels
- Type of actuation (manual/automatic)

System design

The information contained in this section covers the design of engineered systems. The designer must be fully conversant with the relevant design codes i.e. NFPA 2001 or ISO 14520-1

The design of the system consists of the selection and proper placement of the following equipment:

- Container(s)
- Mounting bracket(s)
- Nozzle(s)
- Pipe and fittings
- Control panel(s)
- Detection
- Optional accessories

The selection and placement of the alarm and control devices shall conform to relevant International Standards.

System design procedure:

Agent Requirement

Complete a risk assessment and survey of the space to confirm:

- Sealing integrity (to prevent the loss of agent after discharge). The only way to ensure that the space is sufficiently sealed to retain the concentration for the minimum hold time is to undertake a room integrity test. In general the protected space must be completely sealed. This manual does NOT cover extended discharge and all spaces must be sealed sufficiently to hold the concentration from the initial discharge.
- Fire resistance of the enclosure
- Dimensions. Ensure that the difference between the Gross and the Net volume are taken into consideration. Follow ISO 14520-1 In general Ceiling and Floor voids should be treated as separate spaces.
- Use and occupancy
- Hazards to be protected. Hazards to be protected e.g. Class A, B and C. Refer to ISO 14520-1 7.1 and the LPCB listing for guidance on extinguishing concentrations.
  - Formula for calculating the quantity of agent is given in ISO 14520-9 Table 3 (Specific vapour volumes against temperature, formula and pre-calculation tables) and the FSL CG^2 Calculation program which should be run for every system automates this process and provides a record.
  - Always calculate the quantity of agent based on the minimum temperature of the protected space.
  - The Table, formula and calculation program takes into account temperature, specific volume of vapour and altitude (see ISO 14520-1 7.7 for the altitude correction factor).
  - The formula and tables take into account the loss of gas through openings during the discharge.
  - The maximum discharge time shall be 10s. No pre-calculation tables are given here (see ISO 14520-9 Table 3).
  - Should a single agent supply be available to protect more than one risk then the quantity should be sufficient for the largest risk. Take account of the achieved concentration in the smallest risk.
  - The calculation program takes into account the friction loss through the pipes, fittings and components and changes in elevation. Al the information is contained within the CG^2 Calculation program and this shall be the only method of designing and calculating a discharge pipe work system.
- As per ISO 14520-1 7.8 the minimum hold time for the concentration shall be 10 minutes. This should be longer for deep seated fires where more than 10 minutes is require for the ignition source to cool. Annex E of ISO 14520-1 gives formulae for calculating the minimum hold time and refer to the vapour density given in the specific agent data. If the pressure relief vents are not self-closing these free flow areas must be taken into consideration.
- Temperature. Temperature range of the hardware is -20°C to + 50°C and -10°C to +100°C for the protected space.
- Ventilation. All forced ventilation that is not 100% recycling the protected space air must be stopped prior to discharge.
- Altitude See ISO 14520-9 7.7 -1,000m to +4,500m
- Ensure that no other gaseous extinguishing system is installed.

- The agent will extinguish Class C Fires but consider the build-up of flammable gas which could produce an explosion hazard.
- Inerting should be considered with care because the discharging extinguishant could produce a static charge and ignite a flammable atmosphere. Refer to ISO 14520-9 7.5.2 for guidance on concentrations. Generally higher concentrations are required for inerting.
- Doors should open outwards and be fitted with self-closers to facilitate evacuation in the event of a fire.
- Consider the environmental impact of the system selected. Use the system which gives the lowest environmental impact against fire fighting effectiveness, speed of extinguishment, safety, weight and economics.
- Use the concentrations derived from the approval fire testing stated here in the manual to determine the quantity of agent. The concentration should be based on the highest concentration required for the fuel present in the risk area. Note the differences between NFPA 2001 or ISO 14520-9 standards on concentration requirements. For highly volatile fuel the inerting concentrations may be necessary. Where the design concentrations for extinguishing and inerting are not given follow the advice given on how to determine these.
- Ensure that the insurer, fire authority, building control authority and clients representative agrees to the design parameters.
- A full discharge test should not be carried out because of the environmental impact of the extinguishing agent. Should there be any doubt about the viability of the system then alternative arrangements should be made.

All of the above information and design parameters together with workings drawing must be submitted to the client's representation for acceptance and approval. See ISO 14520-9 7.2

Number of Containers

The number of containers used on a system is dependent on the system design configuration. A skilled system designer will consider all of the variables to determine the optimum solution.

Considerations may include:

Configuration	Consideration & benefits
Multiple modular containers spaced around the protected space.	Simple piping arrangements reducing pipe runs.
Central storage	May be remote from the protected space and may protect more than one space. All containers must be of the same size, fill and pressure.
Selector Valve	A central bank of containers may be used to protect more than one risk by using a selector valve to divert the agent to the appropriate risk. The logic of selecting the fill of each container and number to discharge for each risk needs to be done with care to ensure that the correct concentration is delivered to each risk. Any Selector valves used must be the "Full Bore" of the feed pipe and must be fully open as the agent discharges. The closed sections of pipe formed by the selector valves must protected by a pressure relief valve. Note: these have not been approved by the LPCB

One master cylinder can actuate up to four slave cylinders, therefore after a total of five cylinders, two master cylinders may be required

25 bar Container assemblies

Assy Part no.	Container Assembly	Valve	Empty wt. kg	Vol. l	Dia.	Cont. Spacing	Outlet height	Hose length	Manifold height	Bracket
NF2201502*	15 litre	33	19.5	15	254	314	453	500	NA	9254
NF2203020*B	30 litre	33	28.5	30	254	314	773	500	1325	9254
NF2205020*B	50 litre	33	42	50	324	384	809	500	1358	9324
NF2208020*B	80 litre	49	63	80	324	384	1215	550	1833	9324
NF2212020*B	120 litre	49	90.5	120	406	466	1192	550	1810	9406
NF2215020*B	150 litre	49	105	150	406	466	1432	550	2060	9406
NF2218020*	180 litre**	49	129	180	462	522	1322	550	1950	9462

Code *=0 No integrated solenoid (slave) *=1 Inc. integrated solenoid (master)

Tolerance +/- 10mm on cylinder heights Outlet spacer required on manifolded 180 litre.

Design systems up to 1.2kg/litre. For very short pipe runs fill ration may be increased up to 1.4 kg/Litre (undertake a system calculation to confirm).

"Maximum nominal fill" may be increased up to 1.1 x the volume in kg for short pipe runs but must be calculated before quotation.

Note: Container sizes and weights may vary dependent on the manufacturer and approval standard. Check for the latest data sheet.

** For the NF2218021*B 180 litre container the outlet spacer NF234980 must be used when using the NF2349550 Discharge Hose.

Container Location

Container mounting considerations include:

- Floor loading
- Access for installation, service and mechanical release of the system.
- Tampering, obstruction and damage.
- Environment (hot/cold, dirty, corrosive. Normally containers will be mounted with or adjacent to the protected space). Refer to the storage and use limitations.
- Distance from the protected space.
- Mount in a protected environment away from direct sunlight, corrosive atmospheres and away from wind and rain.
- Protect from exposure to mechanical damage and fire.
- Temperature to be within -20°C to 50°C
- The container storage should be ventilated.
- Always secure the containers to a wall or frame with the C shaped container straps provided.
- Only containers with the same fill and pressure may be connected to the same discharge manifold.

Container can only be mounted vertically with the valve uppermost.

Personnel safety check

Whilst it is highly unlikely that the achieved HFC-227ea concentration could be greater than the design concentration. Calculate the achieved concentration using the formula:

$$C\max = \frac{100 \times Wf \times S2}{(Wf \times S2) + V\min}$$

Where:
Cmax = Maximum Concentration % by volume
Wf = Stored weight of agent kg
S2 = Specific vapour volume at the highest protected space temperature. See ISO14520-9 for values.
Vmin = Minimum net volume of the protected space m^3

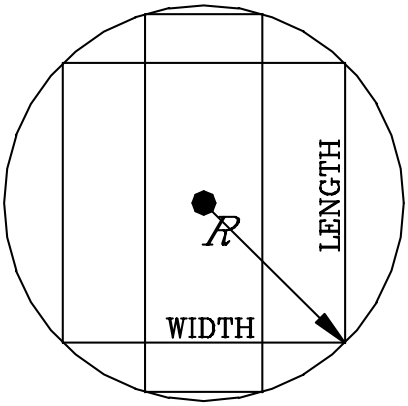
When the system is being used to protect manned areas this concentration must be determined and compared to the safe limits indicated in the relevant design standards (NFPA 2001 or ISO 14520-9 5 ISO 14520-1 5.2.2). If it is higher than the safe limits indicated then the Minimum safety precautions recommended in the relevant design standards must be included in the system design.

Nozzle Determination

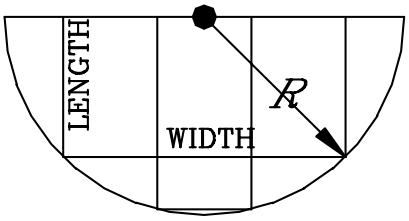
Decide on the most appropriate nozzle locations. 180° nozzles may be wall mounted and 360° nozzles ceiling mounted centrally in the space. Nozzles should be spaced to give an even coverage and best results can be expected by discharging similar quantities from each nozzle. Refer to the diagram below for maximum coverage details.

The larger nozzles can have very high discharge rates. The flow rate should be less than 8 kg/s for all spaces with false ceilings and moveable objects or where a high flow rate may have an impact. For shallow voids a flow rate of more than 4 kg/s should be avoided.

High cabinets can restrict the head space between the ceiling and the obstruction. Generally aim for a gap of 1m between ceiling and obstruction. For smaller gaps consider the obstruction as forming a compartment and add nozzles accordingly.



360° Nozzle



180° Nozzle

Any box inside the radius.	360°	180°
R Max	8m	11m
Maximum distance between nozzles	10m	11m
Maximum distance from wall		0.15m
Room height. Use multiple rows over max. height	0.3m to 4.9m	0.3m to 4.9m
Maximum distance from ceiling (single row)	0.25m	0.25m

There will be some turbulence around the discharge nozzle and ceiling tiles etc. should be fixed for a radius of 1m around the nozzle.

Ensure that the discharge will not directly impinge on nearby objects such as light fittings or disturb any flammable liquids.

For floor and ceiling voids consider the degree of clutter and obstructions that will impede the discharge flow. Place extra nozzles to compensate.

Position nozzles within 0.25m of the ceiling.

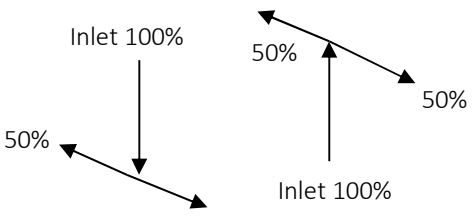
Nozzles may be mounted with their axis vertically down or up

In dirty environments the nozzles should be protected by blow off caps (not LPCB approved) which must be light to prevent becoming a damaging projectile and must be replaced after a discharge.

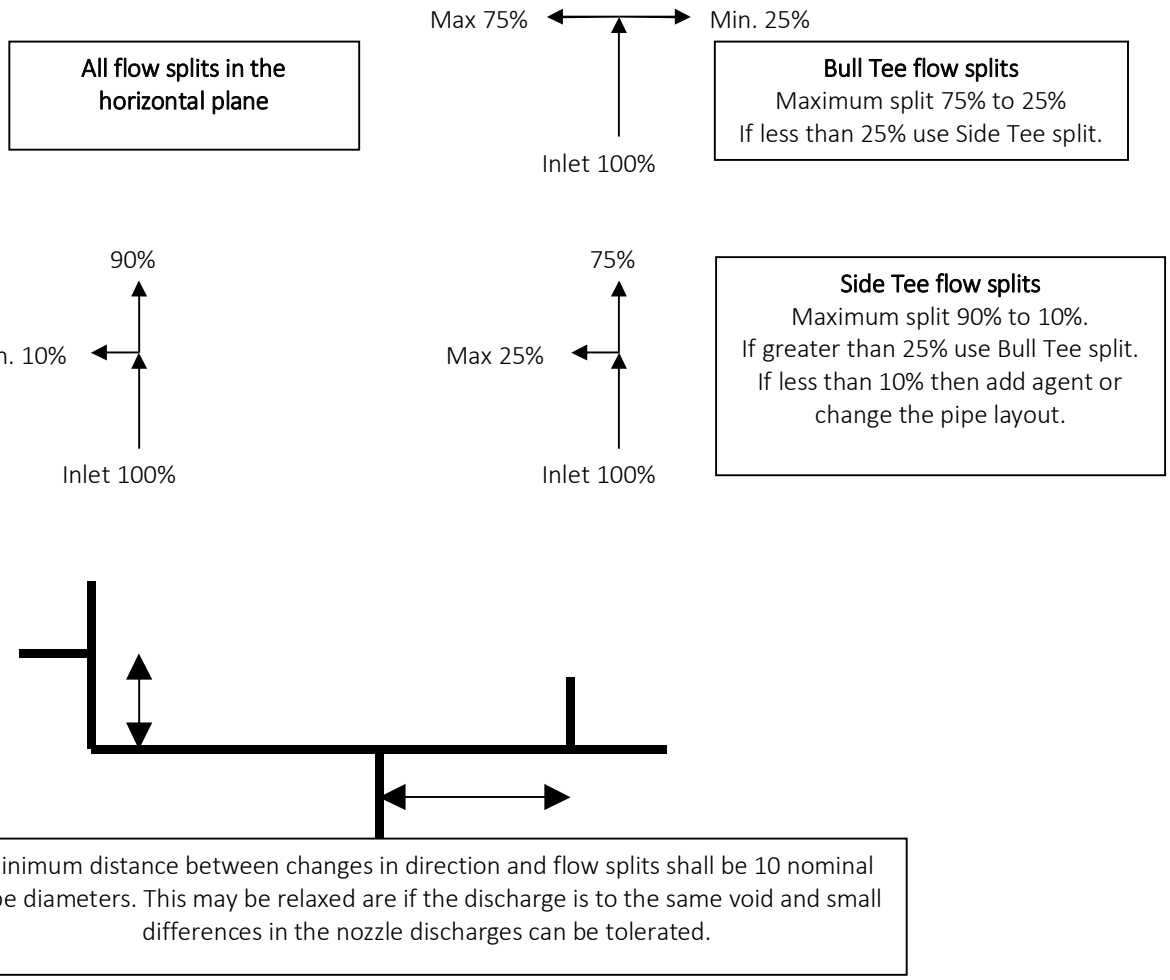
Piping configuration

Pipe-work must be installed in accordance with the International Standards.

The piping configuration should be kept as simple as possible with even flow splits which will aid the accurate distribution of agent. The flow splitting rules, as detailed below must be observed to ensure an accurate distribution. All flow splits MUST be in the horizontal plane except the 50% Bull head split shown below.



The only flow split permissible in the vertical plane



System hydraulic calculations

Only use the FSL CG^2 calculation program. This program will:

- Calculate the quantity of extinguishant based on the space volumes and temperature.
- Calculate the optimum pipe sizes based on the input schematic.
- Calculate the nozzle orifice size.

Containers, fills, valves, pipes and nozzles must be installed exactly as input to and specified by the program or the flow distribution and discharge time will not be accurate.

Should the 'as built' be expected to be different from the original design then calculate the system with a slightly shorter discharge time and only drill and fit the nozzles after recalculation using the 'as built' information.

The minimum nozzle pressure shall be 3 bar. Orifice plates should not be used to reduce the terminal pressure. The nozzle orifice area shall be a maximum of 90% of the feed pipe cross sectional area to ensure that the nozzle controls the flow not the feed pipe.

Nozzle orifice drilling

	DN15	DN20	DN25	DN32	DN40	DN50
Min. drill size (mm)	2.0	3.0	4.0	5.0	6.0	8.0
Max. drill size (mm)	5.1	6.9	8.8	11.5	13.5	14.5

Orifice size steps 0.1 mm < 10mm 0.5 mm >10mm

Venting Considerations

Venting of an enclosure may be necessary to relieve the under pressure due to the chilling of the air within the space and the following over pressure due to the extra volume being added to the space. The FSL CG[2] calculation program will calculate the minimum free vent area based on the maximum pressure that the protected space can withstand. Refer to the buildings structural engineer.

The protected space structure including the windows needs to be of adequate strength to withstand these under and over pressures.

The rule of thumb from the BSRIA document is $0.04m^2$ per $100m^3$. The actual value necessary can be calculated from the results of a Room integrity test where the actual room leakage and the strength of the protected space can be taken into account.

*BSRIA, "Fire Extinguishing Systems, A guide to their integration with other building services". www.bsria.co.uk

Leakage from the protected space

After discharge the HFC-227ea must be retained for a sufficient period of time to allow the cooling of the ignition source to prevent re-ignition. Refer to NFPA 2001 & ISO 14520-1 for guidance on the period.

To ensure that the retention time is achieved a room integrity test must be carried out in accordance with the standards.

Control and release of the system

Refer to ISO 14520-1 6.4 for guidance. Where an automatic system is used then there must also be a manual release adjacent to the exit from the protected space.

National requirements must be followed for fire detection and controls. Suitable standards are BS 5839, BS 7273, BS 6266

The release and delays permitted are dependent on the type of occupancy see ISO 14520-1 5.2. For Occupied Spaces rules are given for concentration levels against the use of Time delays, Automatic/manual switch and Lock-off device. Separate requirements are given for 'normally unoccupied areas' and 'unoccupied areas'.

Reference to ISO 14520-1 and BS 5839, 7273, 6266 for:
Manual Control
Alarms
Hold switches
Time delays

Installation

Safety Procedure

To ensure the safety of personnel carrying out the installation and to prevent any accidental discharge of the container contents the steps below must be followed in order,

1. All containers must have;
   - Shipping Cap fitted to the Actuator port of the valve
   - Anti-Recoil cap fitted to valve outlet
   - Actuators NOT fitted
2. Fix containers to mounting bracket
3. Fix discharge pipe work complete with all nozzles and fit flexible hose to pipe work
4. When containers are connected to the pipework all open ends of the pipework must be capped. At least one cap in each network should have a small hole to indicate a discharge and vent the pipe work.
5. Fit discharge hose to container
6. Test actuators 'off' the container
7. Reset actuators and fit to valve once commissioning is complete

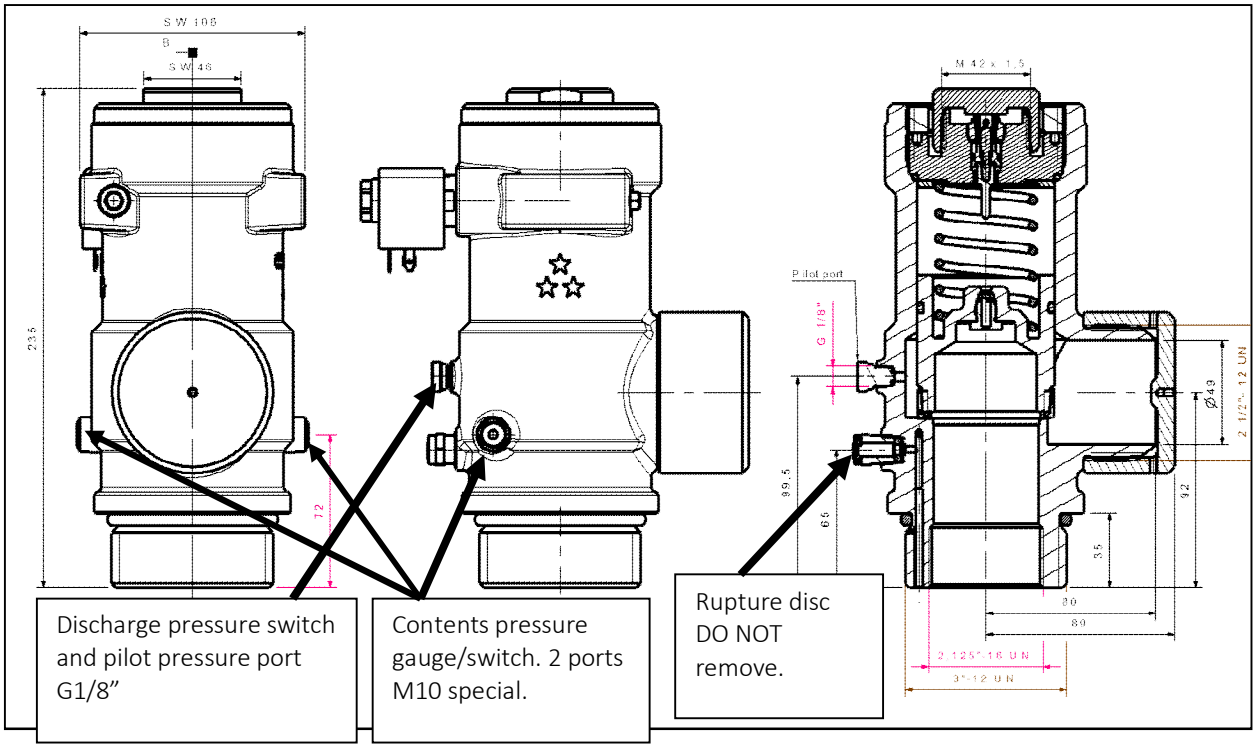
Containers/Cylinders and valve connections

The HFC-227ea cylinder is pressurized to 25 and must be handled carefully.

The discharge valve is constructed of heavy forged brass, it can be damaged if dropped or mishandled. Discharge of an unsecured and disconnected cylinder could be extremely dangerous and may result in injury or death, and/or damage to property.

Under normal conditions, the discharge valve cannot be discharged without having the various actuators attached. Never connect the actuators or have the solenoid pilot valve wired to the system's electrical controls until the cylinder has been properly secured in the cylinder rack and the discharge connection fittings connected to the system piping.

The anti-recoil cap should remain in place until removal is necessary to complete the connection of the valve to the system piping.

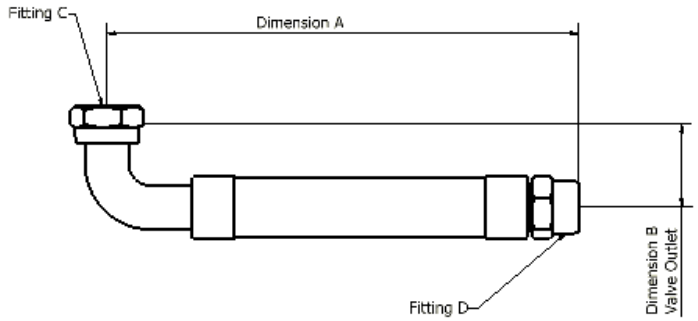


Discharge Hoses

Hose Assembly	Min. bend radius	Dimension A	Dimension B	Valve Fitting C JIC	Fitting D ISO 7-1*	Min. through bore
NF2333500	500	500	77	1-7/8 x 12	R 1-1/2	33.3
NF2349550	635	550	99	2-1/2 x12	R 2	44.5

***Connect to Check Valve or discharge pipe work before attaching to the discharge valve with the swivel connection.**

Note: Maximum bend between centre lines of fittings 20 degrees

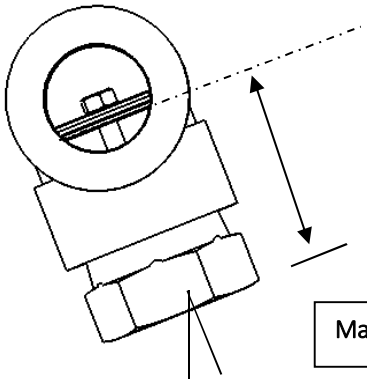


Discharge Check Valves and Manifolds

The Check valves are designed for fitment to welded socket* manifolds or screwed tee* fitting manifolds. Inlets must be at the bottom vertically downwards as the check is biased closed by gravity. (do NOT use horizontally or with the check valve at the top of the manifold.

Note*: the fitting screw thread must be concentric with the fitting body with a minimum throughway of 47mm (R1.5 inlet) and 62mm (R2 inlet) throughway through the fitting.

Always fit check valve to manifold followed by the discharge hose to check valve.
Fit using thread sealing tape.

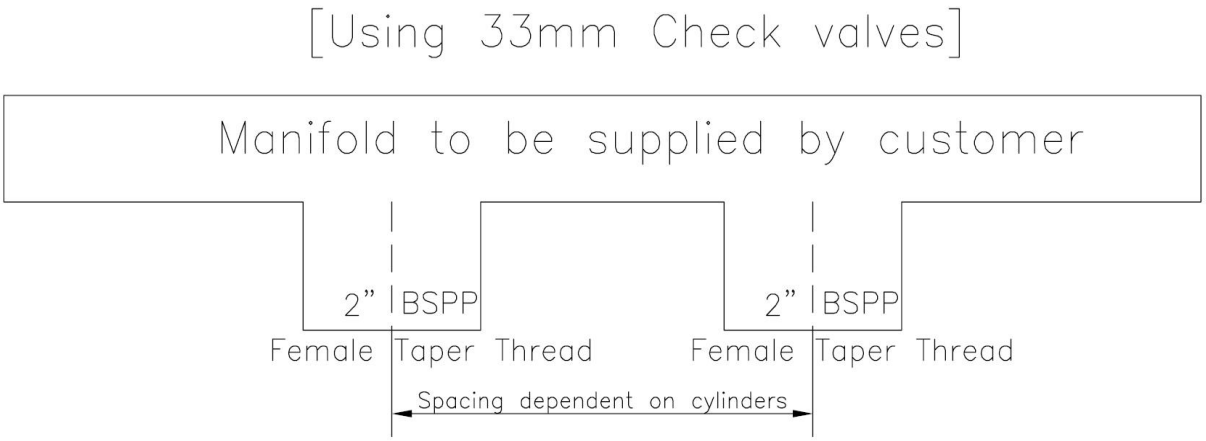


Inlet	Outlet	Minimum	Maximum
R 1.5 inlet	R 2 (2”)	100	110
R 2.0 inlet	R 2.5 (2 ½”)	120	130

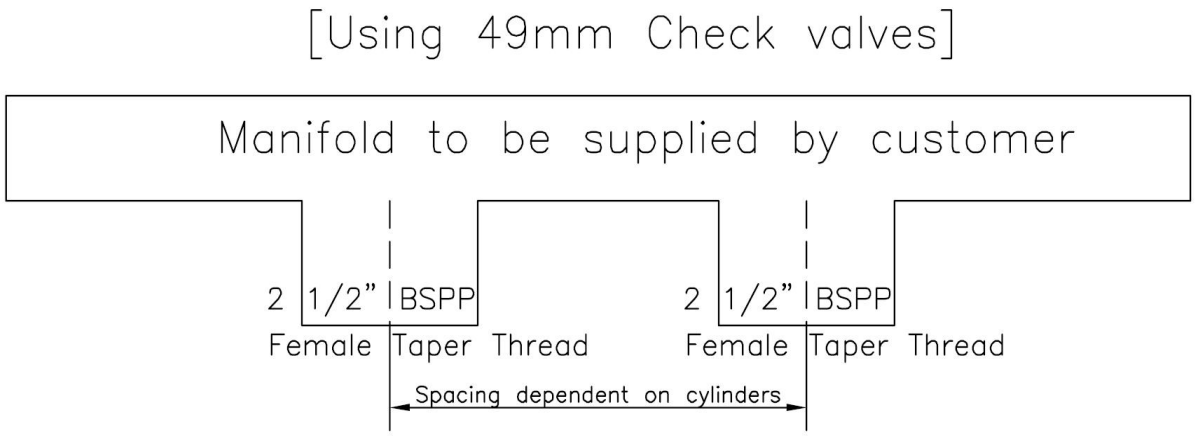
Ensure that the check valve fully opens and returns to the closed position after fitment. Pull the spindle until the check fully returns to its seat.

Do NOT fit the hose to discharge valve until all pipe work is complete and containers are secured in their racks.

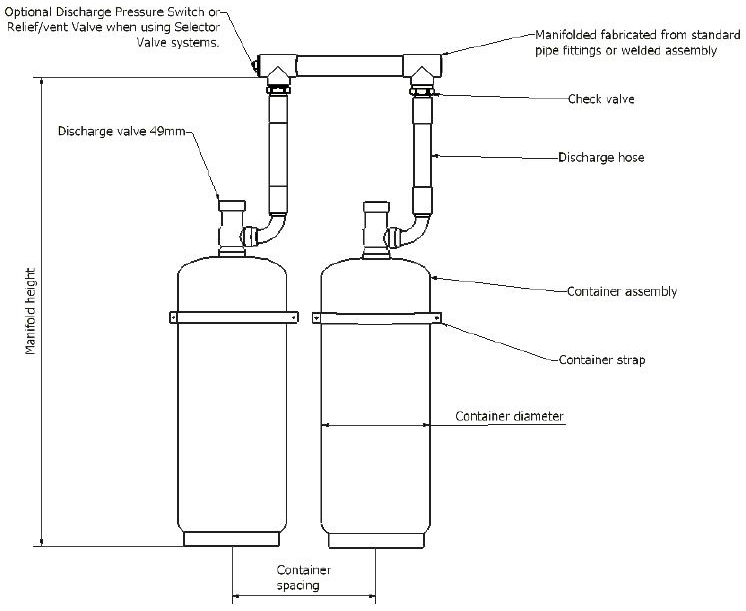
[Note: Manifold size to be determined by VdS flow calculation]



Arrangement for 15ltr, 30ltr & 50ltr cylinders



Arrangement for 80ltr, 120ltr 150 ltr & 180ltr cylinders



Please refer to FSL Container datasheet for spacing lengths

Discharge Piping

Only discharge piping as specified in NFPA 2001 or ISO14520-1 shall be used while taking into account the system pressure and any potentially closed sections (between selector valves if fitted) and national regulations. All closed sections of pipe work shall be protected by a relief valve (Relief valves are not LPCB approved).

Piping must be non-combustible and be able to withstand the protected pressures during discharge. The 25 bar systems will develop different pressures namely 34 and 53bar respectively at 50 degC. Suitable standards for use in Europe are EN 10241 2000 Pipe fittings and EN 10255 2004 Tubes.

In corrosive environments the pipe work shall be protected. In general all steel pipe work should be galvanised or zinc plated.

Follow the guidance in the international standards and local regulations on protecting the system and pipe work from mechanical damage, the effects of fire, earthing (see ISO 14520-1 5.5) and electrical clearance (see ISO 14520-1 5.4), marking of pipe work and the competency of the installer. Do not install pipe work where it could be subjected to mechanical damage or the effects of a fire.

All pipe size reductions must be made with reducing fittings, concentric reducers, and reducing couplings.

All pipes must be adequately fixed as dictated by the standards. Particular attention must be paid to the bracing of all piping changes in direction and nozzles.

Manifolds and cylinders shall be firmly fixed to take all of the thrusts during a system discharge.

Screwed pipe and fittings should be clean cut with full length threads. Joints should be made with pipe sealing tape or compound ensuring that the first 2 threads are not covered. This will ensure that no tape or compound enters the pipe work.

Welded joints must permit full flow. Mitre weld fittings are not acceptable.

All pipe work must be free from deformities and ridges that can impede the flow and all burrs and sharp edges must be removed.

Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, utilizing a suitable non-flammable cleaner. The pipe network shall be free of particulate matter and oil residue before installation.

Only install the pipe work as shown on the installation drawing and ensure that all flow splits are horizontal and the distance between changes in direction and flow splits are maintained. (See Design section).

No changes to the pipe work layout are permitted without the authority of the system designer. Any changes in lengths, pipe diameter and number of fittings will have a significant impact on the flow calculations.

All pipe sizes, flow rates and pressure drops shall be calculated using the FSL CG^2 calculation program. This takes into consideration pipe work and fitting friction pressure losses and changes in elevation as well as the minimum and maximum flow rate to ensure turbulent flow. Refer to the following table for an estimate of these.

Pipe work flow minimum and maximum flow rate

Estimated (mm)	Pipe Size Inches	Minimum flow rate kg/s	Maximum flow rate kg/s
10	3/8	0.3	0.9
15	1/2	0.5	1.5
20	3/4	1.0	2.6
25	1.0	1.5	3.8
32	1.1/4	2.6	5.9
40	1.1/2	3.8	8.8
50	2.0	5.9	15.0

65	2.1/2	8.8	26.3
80	3.0	15.0	43.1
100	4.0	26.3	57.6
150	6.0	57.5	143.8

Hangers and Bracing

All system piping, both vertical and horizontal must be suitably supported with hangers. Pipe hangers shall be capable of supporting the pipe under all conditions of operation and service. They shall allow the expansion and contraction of the piping, and prevent excessive stress resulting from transmitted weight being induced into the connected equipment. Pipes must be anchored to the building structure such as beams, columns, concrete walls etc., in order to prevent longitudinal or lateral movement or sway. Where practical, riser piping shall be supported independently of the connected horizontal piping. The piping must not be hung or supported from other piping systems (i.e. water, air pipes, etc.)
Generally no section of pipe should be without a hanger or brace. Maximum recommended spacing between hangers are given in NFPA 2001 and ISO14520-1

Discharge Nozzles

The discharge nozzles shall be installed as directed by the installation drawing in a manner so that they will not potentially cause injury to personnel. When discharged from the nozzle, the agent should not directly impinge on areas where personnel might be found in the normal work area. The agent shall not impinge on any loose objects on shelves, cabinet tops, or similar surfaces where loose objects could be present and become missiles.

Always check that the right nozzle, see stamping on the nozzle, is located in the correct position as directed by the installation drawing. Fitting the incorrect nozzle may impact the performance of the system.

Discharge Valve Pressure Gauge, Pressure Switch

NF284004 pressure gauge 0-60 bar

NF285022 pressure gauge including contact set at 22.5 bar falling.

The pressure gauge, pressure gauge with limit signal generator or pressure switch are connected to the valve via the M10x1 connection port. There are two ports on either side of the valve which can be used. Any unused port must have the plug fitted.

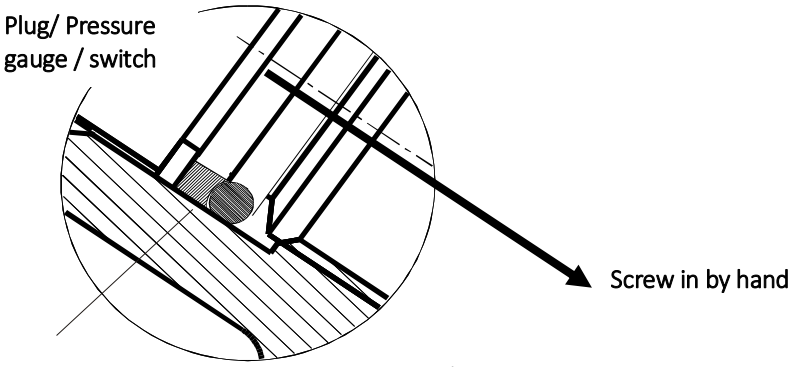
Only fit Firetrace products to ensure correct safe operation and to prevent leakage.

The gauges and switches can be mounted and removed with the valve pressurised.

Before screwing in the gauge, make sure that the O-ring seal and back-up ring are not damaged. If replacement is required, note the installation diagram below (O-ring towards the pressure).

Remove the pressure port plug (4mm hexagon key) and screw in by hand the pressure gauge or pressure gauge (do not tighten) and turn back a maximum of one revolution for correct orientation.

Use only original connecting parts designed for these valves.



Back-up ring
O-Ring

curvature of back-up ring
towards O-ring!

Assembly of the discharge valve actuators

All container valves are designed for automatic actuation by electric or pneumatic means and also manual actuation by using the range of actuators shown in the figures below.

DO NOT connect any actuators until the system is fully installed and tested. An inadvertent discharge can cause injury and damage.

Integrated Electrical Actuator

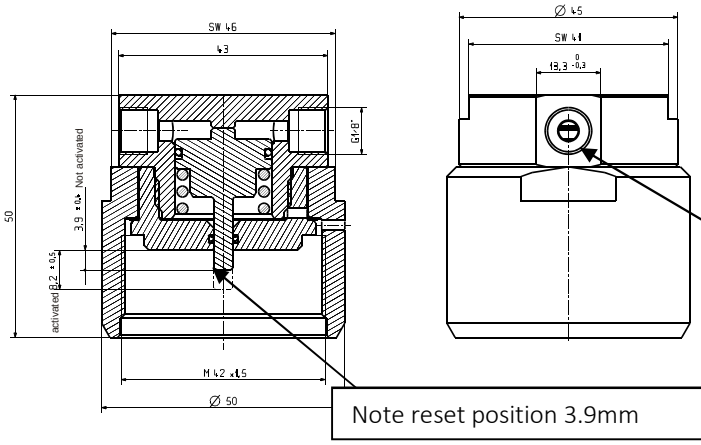
Do not connect the Actuator to the Discharge Control Panel until the Panel and wiring are fully checked and the system is to be brought into service.

A continuous 24Vdc 0.25A signal is required to be maintained throughout the discharge. Coil 6W, IP 54.

Add on Actuators

Discharge of the cylinder valve is initiated by the actuator depressing the control valve stem located at the top of the valve. During shipping and storage the control valve is protected by a shipping cap (028605042) to prevent accidental discharge and should only be removed in order to connect the cylinder valve actuator. Retain shipping cap for future use.

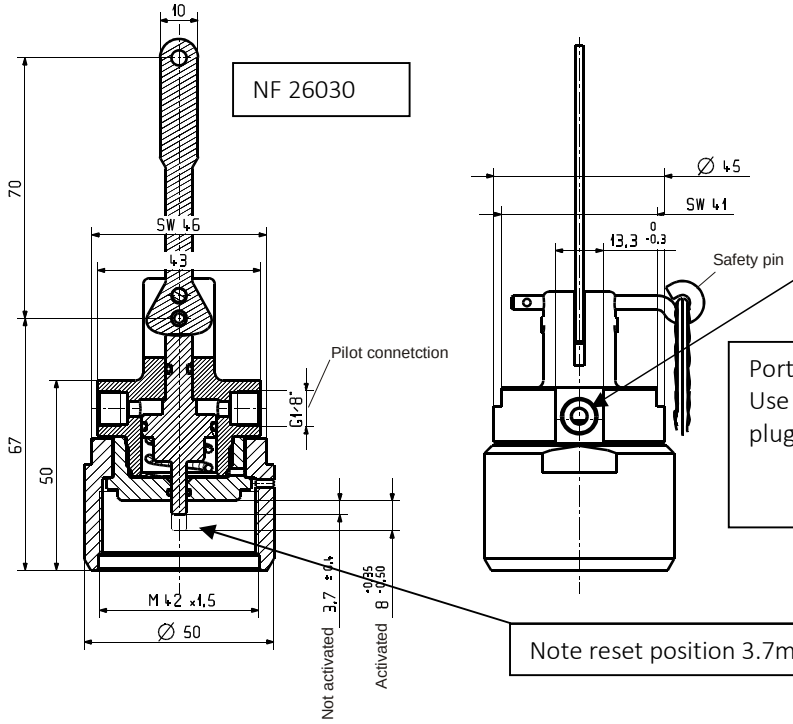
The actuator should only be installed after the connection of the cylinder valve to the completed piping.



NF 26020

Note reset position 3.9mm

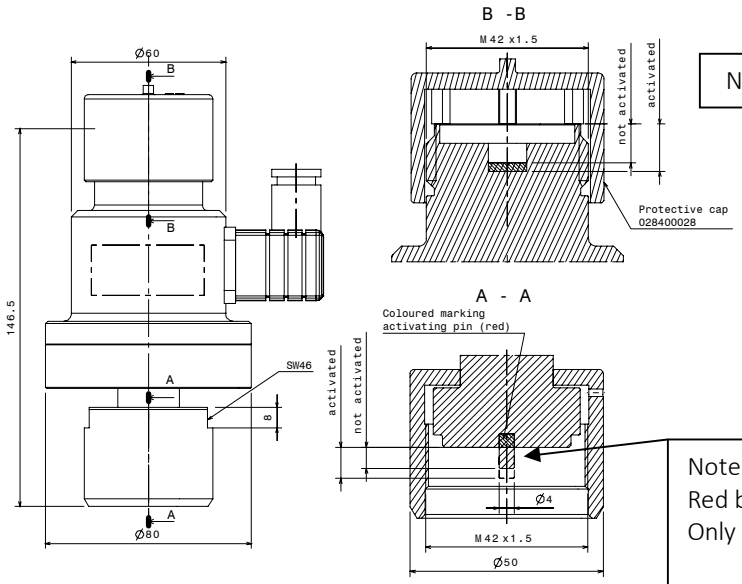
Seal the last open port with the G1/8 plug which was removed from the discharge valve Pilot port.



NF 26030

Ports unused on master discharge valve. Use ports to store any spare valve Pilot plugs.

Note reset position 3.7mm



NF26010 Without back EMF diode

Note: reset position 5.5mm
Red band shows when activated
Only use supplied reset tool NF26019

Important

Before fitting the Actuator to the valve check that.

- The cylinders are secured and the valves have been connected to the pipe work.
- The Shipping cap (028605042) is removed. Never leave the valve without the cap or actuator fitted.
- Ensure that the Actuator is not activated and is in the reset position see Figures above. An activated Actuator would cause an unintentional release while mounting the Actuator onto the valve.

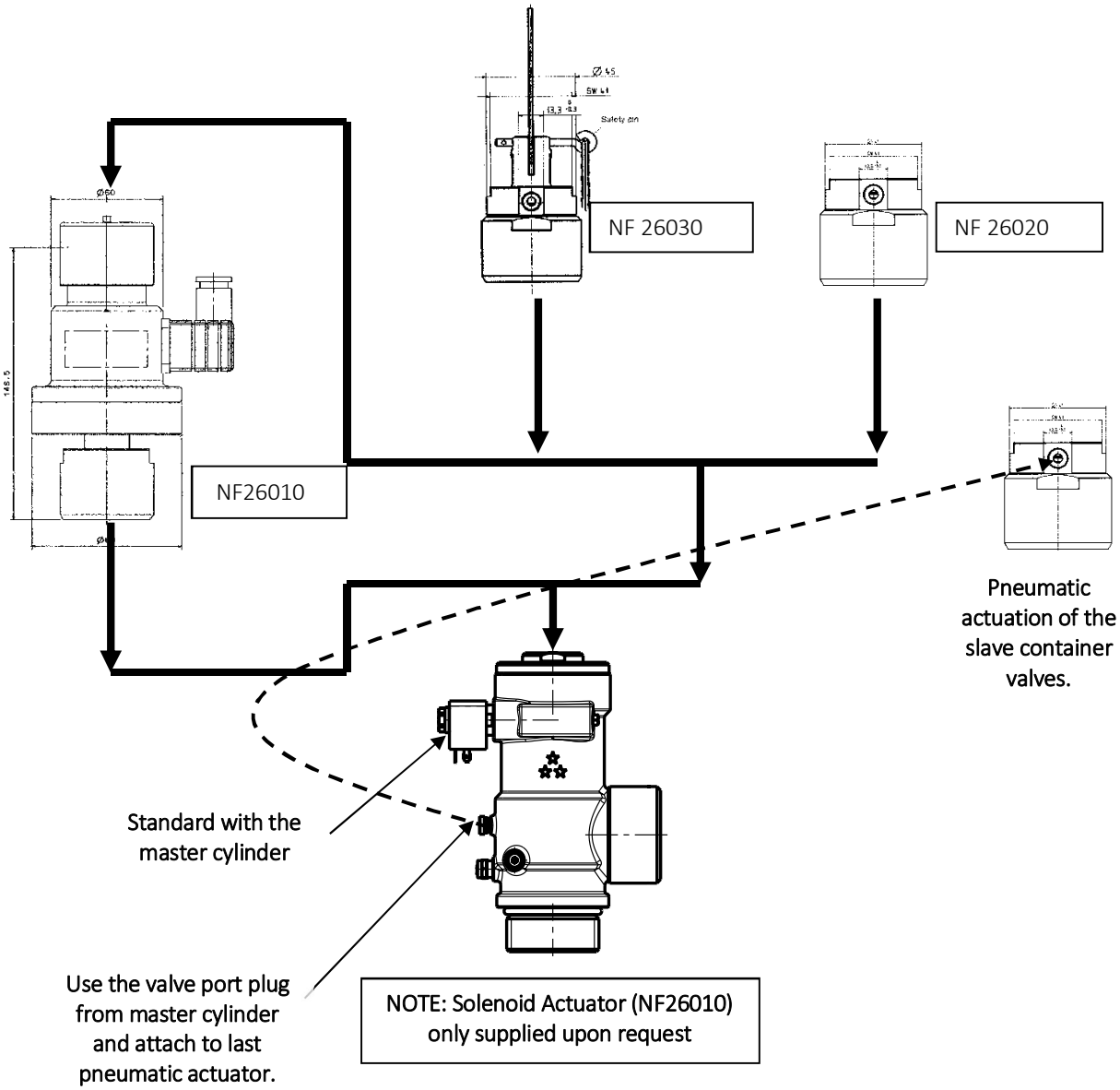
Connect the Actuators to the valves via the M42x1.5 connecting thread with a torque of 50Nm +0 -15Nm. Ensure that no contamination or foreign objects have entered the bore hole of the control valve.

If any hissing or discharge of gas is noticed during connection of the actuator - STOP AT ONCE and disconnect actuator from the valve.

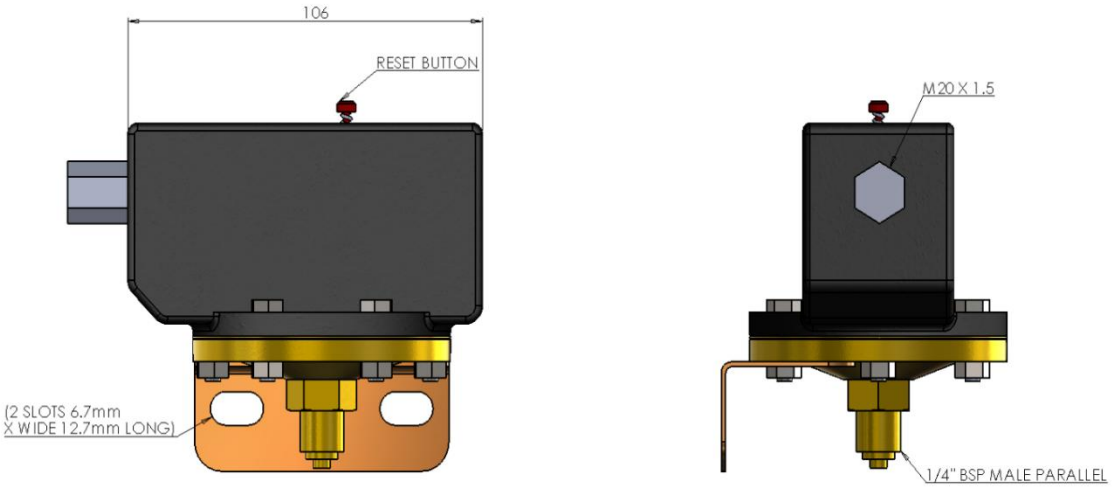
Pneumatic Actuator Connection Hoses (Part no. NF271560)

Only use the hoses supplied. Adaptors are supplier to connect onto the actuators.
Note: Minimum bend radius 110mm

Actuation Options



Assembly includes the discharge hose (NF280211)



Discharge pressure switch (NF280210)

Use to confirm the discharge of a system. The switch is wall mounted and connected to either the 'discharge pressure switch or pilot pressure port' on the discharge valve or the discharge manifold using the pilot hose NF280211.

Specification

Pressure connection	G1/4" (1/4" BSP male parallel)
Material wetted parts	Brass with beryllium copper diaphragm
Switch housing	Connection M20x1.5. Ingress protected to IP65
Electrical	SPDT Microswitch 10A 250V 50Hz, 1A 30V dc inductive load.
Set pressure	2 bar rising. Latching manual reset by top mounted button.
Mounting bracket	Included.
Note: Not LPCB Approved	

[DPS to be mounted on wall]

Glossary: 1. Pneumatic manual actuator 2. Integrated Solenoid 3. Actuation hose 4. Outlet adaptor 5. Cylinder Pressure gauge 6. Discharge pressure switch 7. Pneumatic actuator 8. Cylinder strap 9. Unistrut (supplied by customer)

Installation Check List

Prior to verification and test the installer should check the following:

Containers	
• Correct weight	
• Pressure	
• Fixed	
Piping	
• Continuous	
• Blow through	
• Correct size	
• Flow splits correct	
• Fixed	
Nozzle	
• Correct size and orifice	
• Correct type	
• Orientation	
Labels	
• Container	
• Manual release	
• Door warning	
• System installer/maintenance	

Verification and Test

General

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

- Conformance to system design.
- Suitability of piping, its correctness to project design, and its support and bracketing.
- Conformance to the system stated operating sequence.
- The suitability of the hazard environmental control, safety precautions, sealing etc.
- Compliance with the requirements of the relevant design code.

Piping

Field installed piping shall be tested as per EN15004, ISO 14520, NFPA 2001:
After the installation of the system piping is completed, and prior to the connection of the containers, nozzles, actuators, etc., the discharge piping shall be pneumatically tested for leakage.
Plug or cap all piping outlets and pneumatically test in a closed circuit for a period of 10 minutes at 2.5/3.0 bar. Hold the pressure for at least 10 minutes. At the end of 10 minutes, the pressure drop shall not exceed 20% of the test pressure.

The pressure test may be omitted if the total piping contains no more than one change in direction fitting between the storage container and the discharge nozzle, and if all piping is physically checked for tightness.

Pneumatic testing can be dangerous ensure that all personnel are away from the area and that appropriate safeguards have been taken.

Under no conditions should water be used in testing.

Closed sections of pipe shall be hydraulically tested prior to installation to 1.5 times the working pressure. The pipe must be fully dried before installation.

Nozzles

Each nozzle has orifices drilled to suit the specific location and discharge flow requirements. The part number stamped on the bottom of each nozzle identifies the number and size of the drill holes.

- Verify that pipe and nozzle orifice sizes are as indicated on the drawings and that the nozzles are orientated to discharge correctly i.e. orifices pointing towards the remote parts of the protected space.

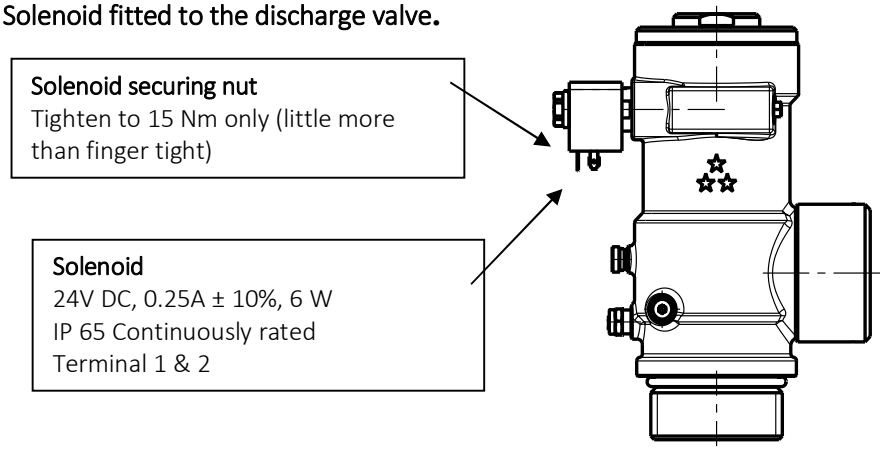
- Ensure that each nozzle pipe drop is bracketed or braced against the nozzle discharge thrust, and that the nozzle cannot swivel on its pipe fitting.

Electrical

All testing of the extinguishing system electrical circuits shall be carried out in accordance with the fire fighting system control panel manual.

All testing is to be performed with the actuator disconnected from the valve.

Integrated Solenoid fitted to the discharge valve.



Electrical Connection procedure

1. Wire release circuit to Solenoid plug before fitting plug to solenoid.
2. Check circuit
3. Unscrew 'solenoid securing nut' and slide 'solenoid' from spindle
4. Connect plug to solenoid
5. Insert steel rod/bolt through solenoid and note that it slides freely.
6. Activate the release circuit and note that the rod is magnetized to the solenoid.
7. Reset the control panel and note that the rod slides freely.
8. Slide the solenoid over the valve spindle and retain with the solenoid securing nut. DO NOT over tighten or bend the valve spindle.

Separate Solenoid Actuator NF2601*

Note: This procedure must <u>not</u> be carried out on the Integral Electric Actuator.

With all solenoids connected electrically operate the discharge circuit. All solenoids should operate. Verify that the pin moves to released position. Reset all solenoids and repeat for each initiating sequence.

- On completion of <u>all</u> the testing and when the system is being restored to or placed in service, reset all solenoid actuators to the position shown in Figure 4.3 Check that the solenoid has latched correctly by exerting light finger pressure on the top of the exposed pin, the actuator should <u>not</u> operate under this pressure. Reconnect the actuators to the container valves.

Containers

- Inspect container(s) and ensure bracketing and piping are secure.
- Check pressure gauge and ensure pressure is correct for temperature of the container. Pressure should be 25 barg ±10% at 20°C. Correct for the actual temperature back to 20°C. Refer to ISO14520-9 figure 1 for 25bar systems for the pressure temperature relationship. Note that the pressure is dependent on the fill ration of the container. .
- Verify that the weight of the container contents is clearly shown on the label and that the liquid level is marked.
- Ensure that appropriate identification, operating and warning signs are mounted or posted.
- Ensure that components are installed in accordance with the appropriate project drawings.

Maintenance

The system shall be regularly inspected to ensure that it is fully operational. The interval between inspections and the scope are covered in NFPA 2001 and ISO 14520-1.

Before attempting any maintenance inform the system owners that the maintenance is about to be carried out to ensure that they have made other arrangements for the protection of the protected space during the period that the system will NOT be available.

Isolate the discharge circuit electrically at the control panel and for added safety remove the electrical connection to all solenoid actuators. Remove all actuators from the discharge valves.

The inspection shall include:

- The protected space to ensure that there have NOT been any changes affecting the design or discharge retention.
- Damage to any equipment or pipe work
- The Alarm and Control system should also be inspected at the same time. Pay particular attention to the interface between the suppression system and the control system.
- Auxiliary equipment such as pressure switches, door closures, dampers, air handling shutdown must be checked for correct operation.
- Agent containers. These shall be check weighed or the contents checked with a liquid level device as well as the cylinder pressure. This needs to be compensated for temperature and the agent fill ratio. Guidance is given in NFPA 2001 and ISO 14520-1. Should the Contents or Pressure show a loss trend or more than 5% by weight or 10% by pressure then these must be withdrawn from service and recharged.
- Pilot and Discharge hoses are to be checked every 12 months for any signs of deterioration either in the metal fittings or hose. Hoses will deteriorate when subjected to continuous high temperatures, excessive bending or high Ultra Violate Light levels. The hoses should be replaced every 10 years or sooner if there any signs of deterioration.
- Check Valves are to be checked externally every 12 months for any signs of deterioration. The internal seals should be replaced every 10 years.

Recharge after discharge

- Disconnect and remove all of the actuators and cylinder pressure switches.
- Fit anti recoil caps to all valves prior to removing them from their racking.
- Only skilled and trained operatives shall recharge the cylinders while following the valve maintenance and recharge procedures.
- Before returning to service all cylinders should be conditioned for at least 24 hours for the Nitrogen to be absorbed and the temperature stabilised. Check for leaks at all joints, check weigh the cylinder (note the extra weight of the Nitrogen) and cylinder pressure.
- Enter the details on the fill label.
- Return to service.

Temperature/Pressure HFC 227ea

Recharge if below minimum pressure

Temp. DegC	25 Bar @20°C Container	Minimum pressure at temp.*
25 bar	bar	bar
10	22	**19**
11	22	**20**
12	22	**20**
13	23	**20**
14	23	**21**
15	23	**21**
16	23	**21**
17	24	**21**
18	24	**22**
19	24	**22**
20	25	**22**
21	25	**23**
22	25	**23**
23	26	**23**
24	26	**23**
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42	32	**28**
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47	33	**30**
48	33	**30**
49	34	**30**
50	34	**31**