PyroShield

environmental fire protection

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A GREEN SOLUTION

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Technical Manual – design, installation & maintenance

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SECTION 1. GENERAL INFORMATION

1.1 PYROSHIELD

PYROSHIELD has been introduced as an alternative to chemical agents, many of which have very long atmospheric lifetimes or damaging environmental properties.

PYROSHIELD is a clean agent gas mixture consisting of two naturally occurring gases that do not support combustion, nor have an impact on the ozone layer nor does it contribute to global warming.

The two gases, Nitrogen, and Argon are mixed in the following proportions:

Nitrogen	50%
Argon	50%

PYROSHIELD systems are designed to extinguish classes A, B, C & E fire (European Classification of Fires). PYROSHIELD extinguishes fires by lowering the oxygen content below the level that supports combustion. In simple terms if the oxygen content of the atmosphere is reduced to a level below 15% most ordinary combustibles will not maintain combustion. Typically a PYROSHIELD system will reduce the oxygen level to approximately 12.5%.

Since PYROSHIELD is stored as a gas, it discharges as an odourless, colourless medium, allowing people to safely exit a protected volume without obscured vision.

PYROSHIELD systems are particularly valuable in extinguishing fires in enclosures containing hazards or equipment where a clean, electrically non-conductive medium is essential or where other extinguishing mediums cannot be used e.g. foam.

CAUTION:
Handling and installation of PYROSHIELD should only be carried out by experienced personnel.

1.2 APPROVALS

The PYROSHIELD system has a full systems approval from Bureau Veritas. The components of the system have also been approved individually:

- PYOSHIELD cylinder: Lloyds Register
- PYROSHIELD valve: BAM (Bundesansalt Fur Materialprufung)
- Design Software: VDS

All approvals have been independently validated by the South African Bureau of Standards (SABS).

For a review of these approvals, please see Appendix 1.

1.3 PROPERTIES OF PYROSHIELD

Under normal conditions PYROSHIELD is an odourless, colourless gas with a density similar to that of air.

It must be recognised that in a fire condition, decomposition products from the fire itself, will create a hazard in the protected enclosure and the reduced oxygen level occurring in a fire situation may lower the resultant level below that calculated from the agent discharge alone. A key benefit of PYROSHIELD is that it does not decompose when subjected to heat from a fire so avoiding hazardous byproducts, unlike synthetic gases.

The following specification applies to PYROSHIELD.

Pressure	195 - 200 bar at 15°C
Argon	50%
Nitrogen	50%
Moisture	< 0.005%

1.4 SAFETY OF PYROSHIELD

1.4.1 GENERAL

Proper and safe PYROSHIELD design requires that the design concentration fall within a design window that places limitations on the upper and lower concentrations of oxygen. PYROSHIELD has been accepted for use in occupied spaces when the design concentration falls within this window. To see the material data sheet, please refer to Appendix 2.

1.4.2 PHYSIOLOGICAL EFFECTS

The following table details the physiological data on PYROSHIELD.

	PYROSHIELD CONC.	OXYGEN CONC.
No Observed Adverse Effect Level* (NOAEL)	43% (0.562**)	12%
Lowest Observed Adverse Effect Level* (LOAEL)	52% (0.733**)	10%

Table 1

* Based on physiological effects in humans in hypoxic atmospheres. These values are the functional equivalents of NOAEL and LOAEL values and correspond to 12 % oxygen for the No Effect Level and 10 percent oxygen for the Low Effect Level.

** Flooding Factor. (Approximate value based on 20°C)

1.4.3 NOISE

Discharge of a PYROSHIELD system can be loud enough to be startling but ordinarily insufficient to cause traumatic injury.

1.4.4 TURBULENCE

The discharge from nozzles may be enough to dislodge large objects in the path of the discharge. General turbulence in the enclosure may be enough to move light objects, unsecured paper etc. Ceiling tiles in the vicinity of the nozzles should be clipped in place.

1.4.5 VISIBILITY

Under normal conditions PYROSHIELD will not reduce visibility in the protected enclosure. However in a fire situation especially where large amounts of smoke are produced it is likely that the PYROSHIELD discharge will cause movement of smoke, which could reduce visibility in certain circumstances.

1.4.6 EXITS

Adequate means of escape from the protected area should be provided. Doors should open outwards and be self-closing. They should be arranged to open easily from inside and any doors that need to be secured must be fitted with an escape override.

1.4.7 PRE-DISCHARGE WARNING

Audible and visual pre-discharge alarms shall be provided within all protected areas to give positive warning of impending discharge.

1.4.8 POST-DISCHARGE VENTILATION

In order to allow for the ventilation of PYROSHIELD and fire byproducts, a normally closed means of ventilation with extract arrangements will be required as with any gaseous extinguishing system. The mechanical ventilation provided should not form part of the normal ventilation system. Controls for the ventilation system should be outside the protected volume and preferably be key operated. In certain circumstances the normally closed means of ventilation may be provided via doors and windows.

1.5 TYPES OF SYSTEMS

PYROSHIELD can only be used in a total flooding application. Therefore it should not be used for local applications and explosion suppression.

A total flooding system normally consists of fixed supply of PYROSHIELD connected to fixed piping with nozzles to direct the agent into an enclosed space about the hazard. In a total flooding system, the space around the hazard must be tight enough to hold the required percentage of PYROSHIELD concentration long enough to extinguish the fire and prevent re-ignition.

1.6 TYPES OF ACTUATION

A PYROSHIELD system is actuated pneumatically via a pilot cylinder. The pilot cylinder can either be actuated electrically or mechanically. Be aware that in accordance with NFPA 2001, in the case of automatic actuation, the system shall incorporate an audible and visual pre-discharge alarm with a time delay sufficient to allow personnel evacuation prior to discharge.

1.6.1 ELECTRICAL PILOT CYLINDER ACTUATION

Electrical automatic actuation of the pilot cylinder valve, via an accepted control panel (a control panel that complies with a standard), is accomplished by using a solenoid valve actuator. This is done by energising the solenoid with an electrical signal. This opens the pilot cylinder valve releasing nitrogen gas that pneumatically opens the PYROSHIELD cylinder valve/s.

1.6.2 MECHANICAL PILOT CYLINDER ACTUATION

Mechanical actuation is accomplished by using a manual lever actuator located on top of the pilot cylinder valve. If electrical actuation fails, by pulling the manual lever the pilot cylinder valve opens and so pneumatically actuates the PYROSHIELD cylinder/s.

1.7 TYPES OF DETECTION

Electrical automatic detection is used with the PYROSHIELD system.

Mechanical fixed temperature (fusible link) cannot be used in conjunction with the PYROSHIELD system. Aspirating detectors are not recommended for gas release (see BS 6266).

Electric operation of the PYROSHIELD system is obtained through the use of electronic control systems which monitor and control various system functions. Detection devices that can be used are: ionisation smoke detectors, photoelectric smoke detectors, fixed temperature detectors, rate of rise heat detectors and flame detectors.

When a detector senses a fire, a signal is sent to the control panel. The panel in turns sends a signal to a Gas Control Unit (GCU). The GCU operates the solenoid actuator that opens the pilot cylinder valve. This pneumatically opens the PYROSHIELD cylinder valves and releases PYROSHIELD down the piping network to be discharged out of the nozzles.

Also in accordance with NFPA 2001, adequate and reliable 24-hour minimum standby sources of energy shall be used to provide for operation of the detection, signalling, control, and actuation requirements of the system.

SECTION 2. PLANNING

One of the key elements for fire protection is to correctly define the hazard and select the best application method. A PYROSHIELD system is designed specifically for total flooding applications, and should not be used for local applications and explosion suppression. This section is subdivided into:

1. Total Flooding Application, and
2. Hazard Analysis

2.1 TOTAL FLOODING APPLICATION

A total flooding system is defined as a system consisting of a fixed supply of PYROSHIELD permanently connected to fixed piping, with fixed nozzles arranged to discharge PYROSHIELD into an enclosed space or enclosure about the hazard. The enclosure must be adequate to contain the discharge of agent to achieve the required PYROSHIELD concentration. Examples of this type of enclosure include rooms, vaults, and voids etc.

2.2 HAZARD ANALYSIS

A thorough hazard analysis is required to determine the quantity of protection required. It is important to cover each element and accurately record the information. This information will be used to determine the size of PYROSHIELD system required and also to determine at a later date if any changes were made to the hazard after the system was installed. Record size of hazard, any obstructions, enclosure openings/leakages, the altitude of the hazard and anything else that would concern system performance. Review each of the following criteria:

2.2.1 HAZARD TYPE

Describe in brief the types of hazards being protected. If protecting prefabricated booths or machines, record the manufacturer model number and anything unique about the hazard.

Also note whether the hazard is normally occupied or normally unoccupied or unoccupied. This serves to confirm the allowed design concentrations as stated by NFPA 2001.

NFPA 2001 states the following:

- Inert gas systems designed concentrations below 43% shall be permitted, given the following:
  - ⇒ the space is normally occupied
  - ⇒ means are provided to limit exposure to no longer than 5 minutes
- Inert gas systems designed to concentrations between 43% and 52% shall be permitted, given the following:
  - ⇒ the space is normally unoccupied
  - ⇒ means are provided to limit exposure to no longer than 3 minutes
- Inert gas systems designed to concentrations between 52% and 62% shall be permitted, given the following:
  - ⇒ the space is normally unoccupied
  - ⇒ where personnel could possibly be exposed, means are provided to limit exposure to less than 30 seconds
- Inert gas systems designed to concentrations above 62% shall only be used in unoccupied areas where personnel are not exposed to such oxygen depletion.

2.2.2 HAZARD DIMENSIONS

Sketch hazard and record all pertinent dimensions including all interior walls, location of doors and windows, and any permanent structures which may interfere with piping or discharge.

2.2.3 ENCLOSURE OPENINGS

Note all enclosure openings that should be sealed to maintain room integrity. Please note that a room integrity test should be performed to verify the hold time of the room and the required over pressurisation venting.

2.2.4 HAZARDOUS MATERIALS

PYROSHIELD has been certified to protect all classes of fire (whether surface or deep-seated), except class D type (Europe).

PYROSHIELD should not be used to fight fires involving:

- Chemicals containing their own supply of oxygen (i.e. cellulose nitrate).

- Mixtures containing oxidizing agents (i.e. sodium nitrate)
- Chemicals capable of undergoing autothermal decomposition (i.e. some organic peroxides).
- Reactive metals.
- Solid materials in which fires quickly become deep seated.

The following illustrates each class of fire:

CLASS A FIRES: This classifies fires that use ordinary combustible materials like cloth, papers, rubber and many plastics.

CLASS B FIRES: This classifies fires that use flammable liquids to combust, like oils, greases, oil based paints etc.

CLASS C FIRES: This classifies fires that use flammable gases to combust, like propane, methane, AV gas etc.

CLASS D FIRES: This classifies fires that use metals to combust, like magnesium, titanium, sodium, zirconium etc.

CLASS E FIRES: This classifies fires that use live electrical equipment to combust, like electrical cables, computer equipment etc.

2.2.5 VENTILATION CONSIDERATIONS

The hazard ventilation system is very important when considering total flooding applications. The ventilation system should be shut down and/or dampered before the start of the PYROSHIELD discharge.

Consider installing dampers wherever possible to restrict the fire to the protected enclosure and enhance the fire protection.

2.2.6 ELECTRICAL CONSIDERATIONS

It is recommended that all electrical power sources associated with the protected hazard be shut down before system discharge. This eliminates the potential of a fire being electrically reignited.

2.2.7 TEMPERATURE RANGE

The minimum and maximum temperatures of the protected volume should be anticipated. Varying temperature ranges affect the amount of PYROSHIELD that needs to be used.

Under increasing temperatures, the enclosure would need less PYROSHIELD to extinguish the fire as the air within the enclosure becomes less dense, thus having less oxygen. The reverse is true for decreasing temperatures.

The PYROSHIELD containers should be stored within the temperature range of -20^{o}C and +50^{o}C.

For detection and control systems the temperature range should not exceed -5^{o}C and +40^{o}C (at 93% humidity).

2.2.8 OTHER FACTORS THAT INFLUENCE SYSTEM DESIGN

The following should also be considered in order to perform a thorough hazard analysis:

PHYSICALLY IMPAIRED PERSONNEL:
Care should be taken that proper signs and prior warning is given so all personnel are aware that the system has been activated.

RESPONSE TIME OF FIREFIGHTING SERVICE:
Establish maximum time for a firefighting service to respond to a fire. This information can be used to determine whether a reserve system should be installed. The reserve system can provide a second discharge in the case of the fire reigniting.

RESERVE SYSTEM:
If a reserve system is required, determine whether it should be permanently connected or unconnected and located on the premises. This can affect your job cost estimate.

CYLINDER AND ACCESSORY LOCATION:
The storage of cylinders should meet the following:

- Temperature range is acceptable
- There is no risk from fire nor explosion
- Piping limitations are not exceeded
- Components are not subject to damage or vandalism.

DISCHARGE TEST/ROOM INTEGRITY TEST:
Determine if a discharge test is required. This will require prior preparation and will affect the total cost estimate. Please note: ISO 14520

states that a room integrity test is a mandatory requirement. This is also a cheaper and logistically more effective alternative to a discharge test.

AUTHORITY HAVING JURISDICTION

Contact the necessary authority to determine the requirements for:

- Minimum/maximum detector spacing
- Type of detection/control system that is acceptable
- What audible and/or visual alarms may be required

SECTION 3. SYSTEM COMPONENTS

3.1 CYLINDER ASSEMBLY

Each assembly is provided with a specific charge of PYROSHIELD to a maximum pressure of 200 bar (minimum 195 bar) at 15 degrees C.

Filling details for the container is shown in Table 2

CONTAINER SIZE (LITRES)	PYROSHIELD QUANTITY (CU.M)	PYROSHIELD QUANTITY (KG)
80	16.205	22.89

Table 2 Pyroshield Filling Details

Dimensions and weights for the assembly are shown in Table 3.

Containers are designed, manufactured and marked in accordance with EEC/84/525 and are pressure tested to 300 bar.

Labels providing handling, maintenance and recharge instructions are fitted to all containers.

CONTAINER SIZE (LITRES)	DIAMETER (MM)	OVERALL HEIGHT (MM)	TARE WT. (KG)	GROSS WT. (KG)
80	267	1885	99	123

Table 3 Cylinder Dimensions

The PYROSHIELD cylinders shall be black from base to shoulder. The shoulder shall consist of two yellow marked regions.

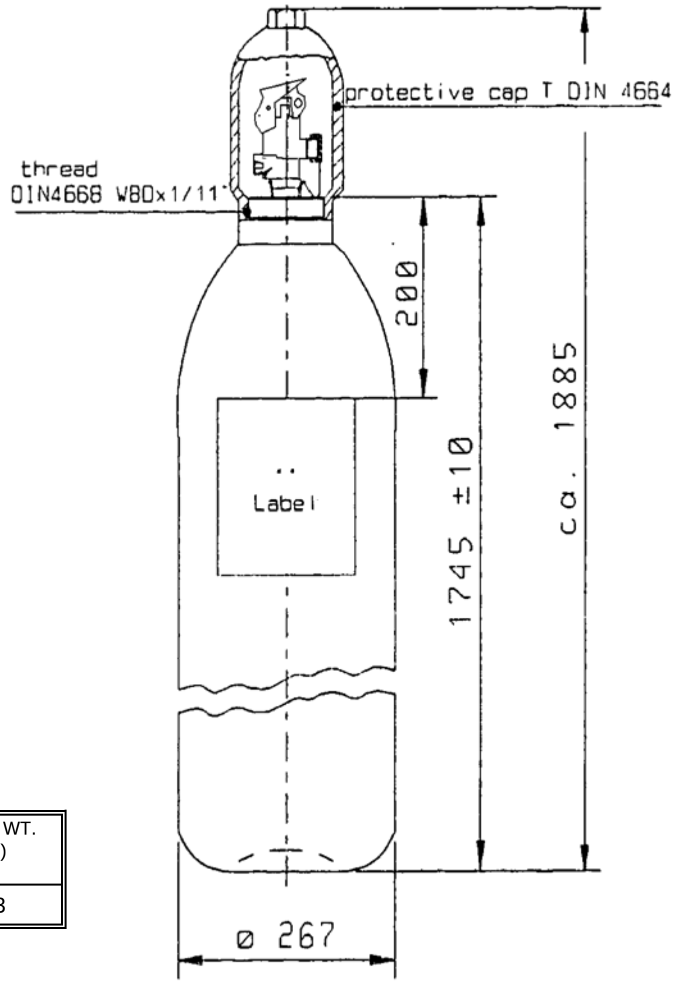

Figure 1 Cylinder Dimensions

3.2 CYLINDER LABELS

There are two labels which are fitted on each PYROSHIELD cylinder as identified below:

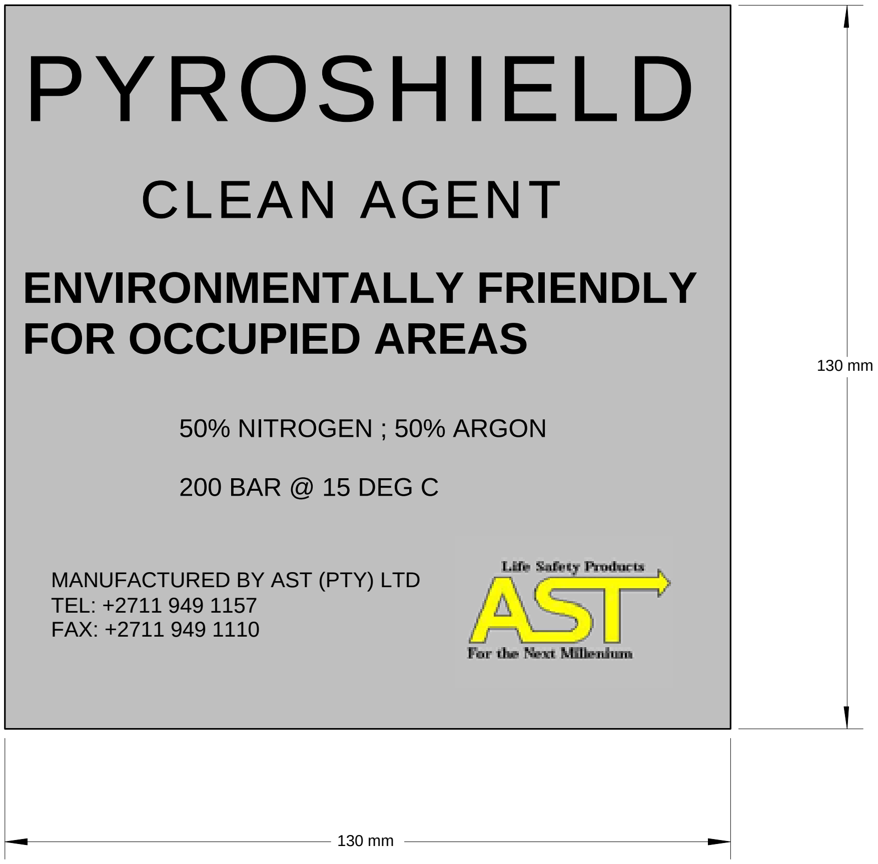

Figure 2 Pyroshield Cylinder Label

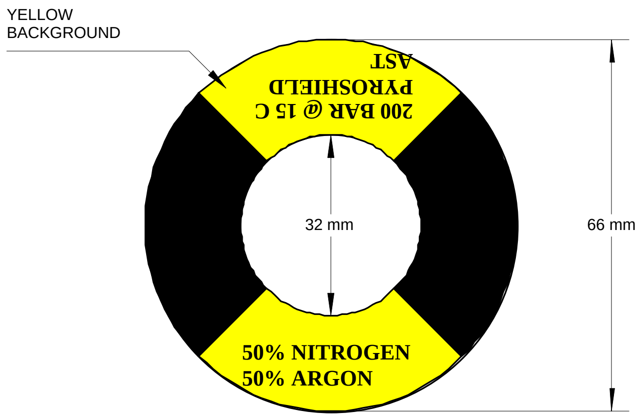

Figure 3 Pyroshield Cylinder Neck Label

3.3 CYLINDER VALVE

The PYROSHIELD 200 bar container valve is a quick action valve designed to be operated by means of a pneumatic actuator.

All valves are provided with a recoil plug, which is screwed into the PYROSHIELD discharge outlet. This is removed only when the container is to be connected into the pipework system and must be refitted immediately when the container is disconnected from the pipework (irrespective of whether the container is full or empty). Additionally the valve is fitted with a safety pin, which prevents accidental operation of the valve.

When installed in a system the valve is to be fitted with a pressure gauge to provide visual indication of container pressure. The valve will also provide visual indication as to whether the system has been operated.

A safety burst disc is incorporated in the valve and is designed to rupture at approximately 270 bar.

In the event that the safety burst disc ruptures PYROSHIELD will be discharged through the burst disc outlet. As a safety precaution a transport cap (supplied with all charged containers) is fitted.

When commissioning is complete the safety pin must be removed.

The valve requires a minimum control pressure to the actuation line inlet of 40 bar to cause operation.

The valve is factory tightened onto the cylinder to 160 (+10/-10) Nm with the applicable torque wrench.

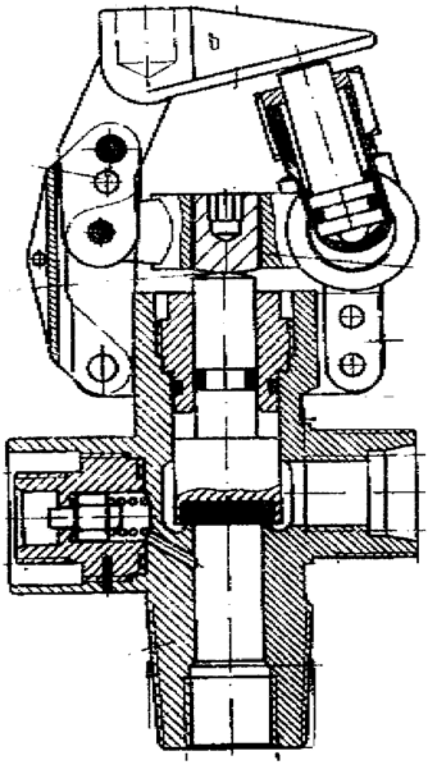

Figure 4 Pyroshield Container Valve

3.4 PRESSURE INDICATOR

The standard container pressure indicator indicates the PYROSHIELD pressure inside the container. It is fitted to the pressure gauge adapter of the container valve. The connection nut of the pressure indicator contains a pin, which opens a seal on the pressure gauge adapter when the pressure indicator is firmly attached to the valve. Fitting and removal of the pressure indicator can be carried out without loss of PYROSHIELD.

When fitting it is only necessary for the connection nut to be tightened with a torque wrench to within (20 – 25)Nm. It is recommended that it be tightened to 22.5Nm.

CAUTION:

Over-tightening may damage the 'O' ring seal, which may cause the assembly to leak.

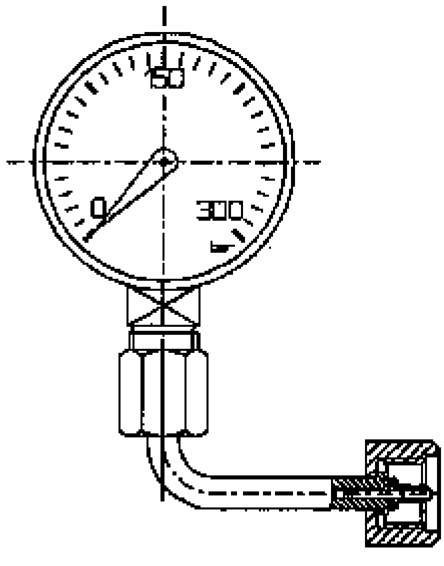

Figure 5 Container Pressure Indicator

3.5 MANIFOLDS

Manifolds are used on all multi-container arrangements and are designed to allow the installation of single and double rows of containers into a single manifold.

NB: When the manifolds are used on a single row of containers a ten-port manifold will be the maximum.

On double rows a maximum twenty-port manifold will be utilised.

The manifold is supported by a single or double row manifold clamp and bracket.

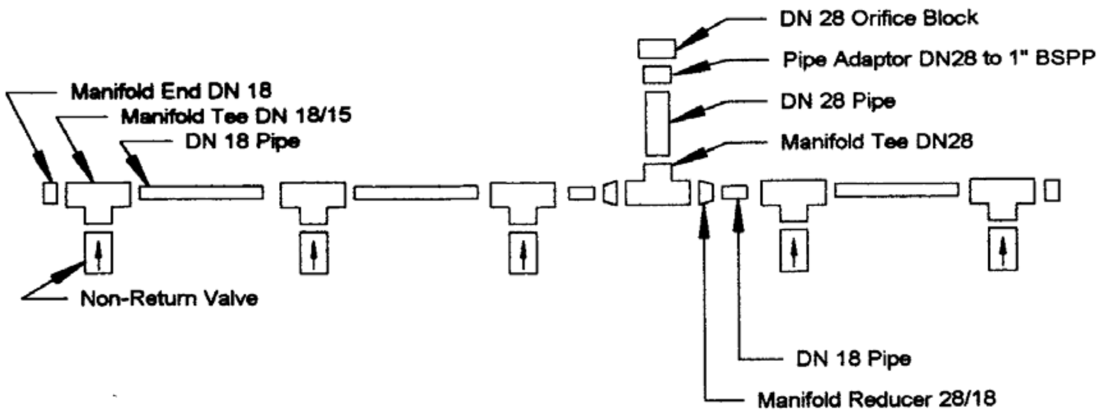

Figure 6 Typical Manifold Arrangement

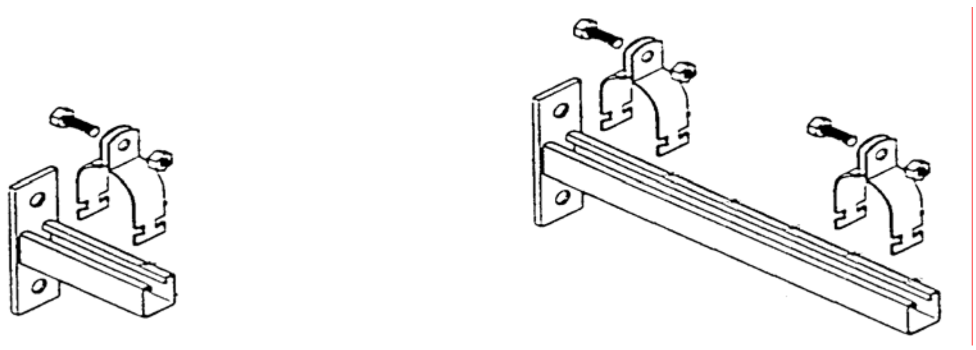

Figure 7 Single and Double Row Manifold and Clamps

3.6 HIGH PRESSURE FITTINGS

The high-pressure fittings used on the manifold and the pressure reducing orifice union are detailed in the table below.

PART NUMBER	DESCRIPTION	PIPE SIZE (mm)
PS/200/MANTEE1	Manifold tee DN18/15	20
PS/200/MANTEE2	Manifold tee DN28	30
PS/200/MANTEE3	Manifold tee DN42	45
PS/200/MANRED1	Manifold reducer 18/15	20
PS/200/MANRED2	Manifold reducer 28/18	30
PS/200/MANRED3	Manifold reducer 42/28	45
PS/200/MANELB	Manifold elbow DN28	30
PS/200/MANEND	Manifold end DN18	20
PS/200/PIPEDN18	DN18 Pipe (per mtr)	20
PS/200/PIPEDN28	DN 28 Pipe (per mtr)	30
PS/200/PIPEDN42	DN 42 Pipe (per mtr)	45

Table 4 Manifold Fitting Table

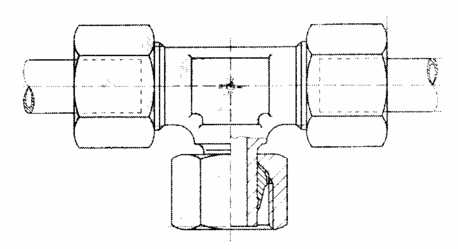

Figure 8 Manifold Tee

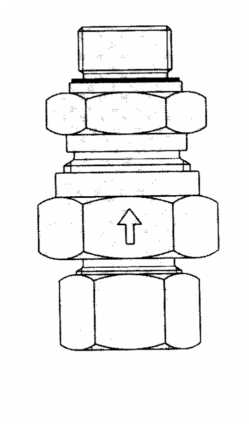

Figure 9 Non-Return Valve

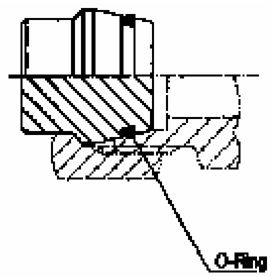

Figure 10 Manifold End Plug

3.7 DISCHARGE HOSE

The 13mm discharge hose connects the container valve outlet to the check valve on the manifold. Swivel female connections allow ease of installation in any orientation.

Since the hose ends incorporate 'O' ring seals the hose ends need only be hand tightened.

All discharge hose assemblies are pressure tested to 400 bars.

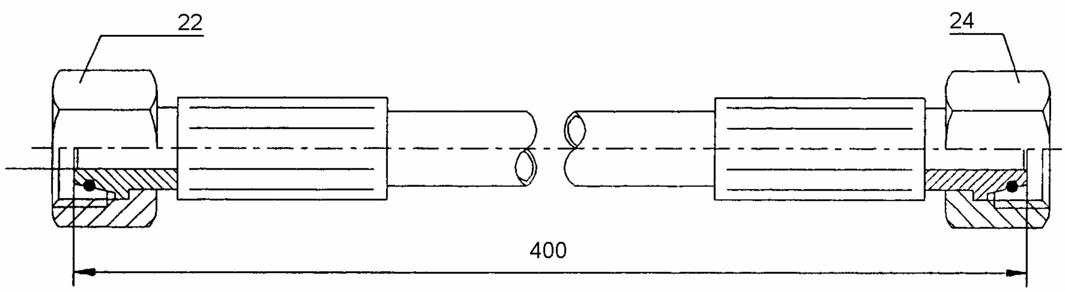

Figure 11 Typical Discharge Hose

Insert: MF 2000 Multifit Type
Tube: Oil resistant synthetic rubber
Reinforcement: Two high tensile steel braids
Cover: Environment resistant synthetic rubber
Type Approvals: Bureau Veritas (Type Approval Number: 21041/07214/A2/PRSO BV)
Temperature Range: -40^{0}C - +100^{0}C, Peaks 125^{0}C

Hose Size				Reinforcement Outer Diameter		Outer Diameter		Max. Working Pressure		Burst Pressure		Min. Bend Radius		Weight	
DN	dash	mm	inch	mm	inch	mm	inch	bar	psi	bar	psi	mm	inch	g/m	lb/ft
12	-8	12.7	½"	19.8	0.781	21.8	0.86	275	3980	1100	15950	178	7.01	620	0.42

Table 5 Technical Specifications for the discharge hose

3.8 ACTUATION LINE ACCESSORIES

All actuation fittings are pressure tested to 320 bar with the exception of hose assemblies which are pressure tested to 400 bar.

The accessories and fittings used in actuation lines are detailed below.

The check valve is used in the actuation lines on distribution valve. .

As a safety measure, it should be installed in pairs in critical locations. An arrow on the body of the unit indicates the direction of flow.

The actuation line vent end plug shall be fitted at the end of the actuation line, on the last PYROSHIELD cylinder valve. The end plug is used to prevent an unintentional build-up of pressure in the actuation line. The device will automatically relieve pressure up to approximately 3 bar, but will seal to completely prevent loss of actuation pressure above 3 bar.

This device should be gently tightened until the end plug and cylinder valve surfaces meet. No further tightening is required.

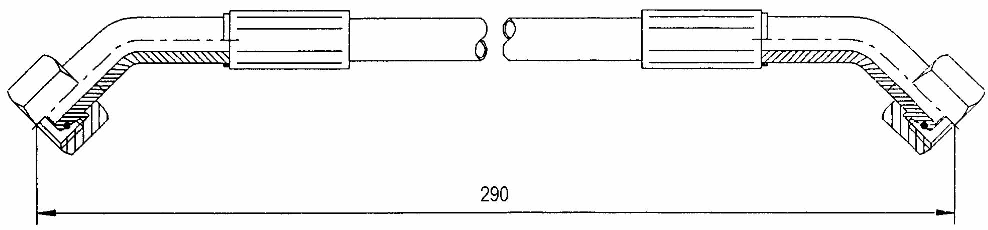

Figure 12 Actuation Hose

Insert: MF 2000 Multitype
Tube: Oil resistant synthetic rubber
Reinforcement: Two high tensile steel braids
Cover: Environment resistant synthetic rubber
Type Approvals: Bureau Veritas (Type Approval Number: 21041/07214/A2/PRSO BV)
Temperature Range: -40⁰C - +100⁰C, peaks 125⁰C

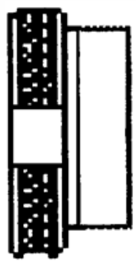

Figure 13 Actuation Line Vent End Plug

Hose Size				Reinforcement Outer Diameter		Outer Diameter		Max. Working Pressure		Burst Pressure		Min. Bend Radius		Weight	
DN	dash	mm	inch	mm	inch	mm	inch	bar	psi	bar	psi	mm	inch	g/m	lb/ft
6	-4	6.4	¼"	12.7	0.5	14.7	0.58	400	5800	1600	23200	100	3.94	360	0.24

Table 6 Technical Specifications for the Actuation hose

3.9 PYROSHIELD NOZZLES

All nozzles are specifically drilled to suit the individual design requirements.

The drill size is hard stamped on each nozzle.

Each nozzle is permitted to cover an area up to 95 m^2.

Nozzles are provided in brass as standard.

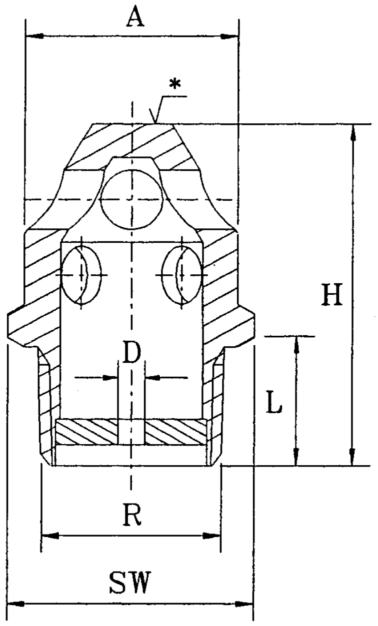

Figure 14 Pyroshield Nozzle
(*Orifice Diameter Stamped Here)

R	½" NPT	¾" NPT	1" NPT	1 ¼" NPT	1 ½" NPT
H	50	54	65	68	74
A	24	28	36	45	51
L	16	20	20	25	25
SW	24	28	36	45	51
D min.	3	10	15	20	26
D max.	10	15	20	26	36

Table 7 Pyroshield Nozzle Specifications

3.10 PRESSURE REDUCING UNIT

The pressure-reducing unit reduces the PYROSHIELD pressure from 200 bar in the manifold down to a minimum of 60 bar in the distribution piping.

Pressure reducing units are comprised of the following components:

a) Orifice block.
b) DN Pipe adapter.

N.B. Pressure reducing units are available in the following sizes: -

a) DN 18
b) DN 28
c) DN 42

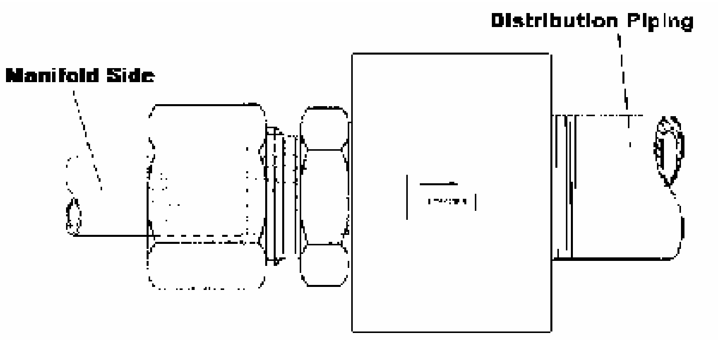

Figure 15 Pressure Reducing Unit

3.11 FIXING COMPONENTS

The fixing components for the PYROSHIELD racking system are detailed below. The system allows for single and double row racking arrangements.

SINGLE ROW MANIFOLD SUPPORT TABLE			
Part Number	Description	Cylinder Bank Size	
		1	2 - 10
PS/200/MBS	Short manifold bracket	0	2
PS/200/MBC	Manifold Clamp	0	2

Table 8 Single and Double Row Manifold Support

DOUBLE ROW MANIFOLD SUPPORT TABLE			
Part Number	Description	Cylinder Bank Size	
		4 - 16	17 - 20
PS/200/MBC	Manifold Clamp OL2028	4	8
PS/200/MBL	Long manifold bracket OL254/450	2	4

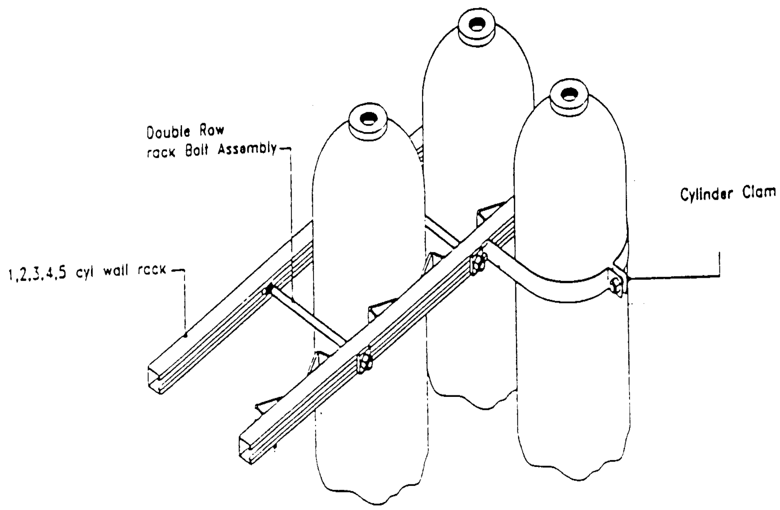

Figure 16 Typical Cylinder Racking Arrangement

3.12 DISTRIBUTION VALVE

Distribution valves are used in systems where several areas require to be protected from a single bank of containers.

The valves are operated electrically by a 24V dc signal or manually by use of the manual-operating lever

The distribution valve requires an instant current of 5A to satisfactorily operate with a running current of 1.9A. The precise configuration of the actuation system is requisite in order to ensure the system operates correctly.

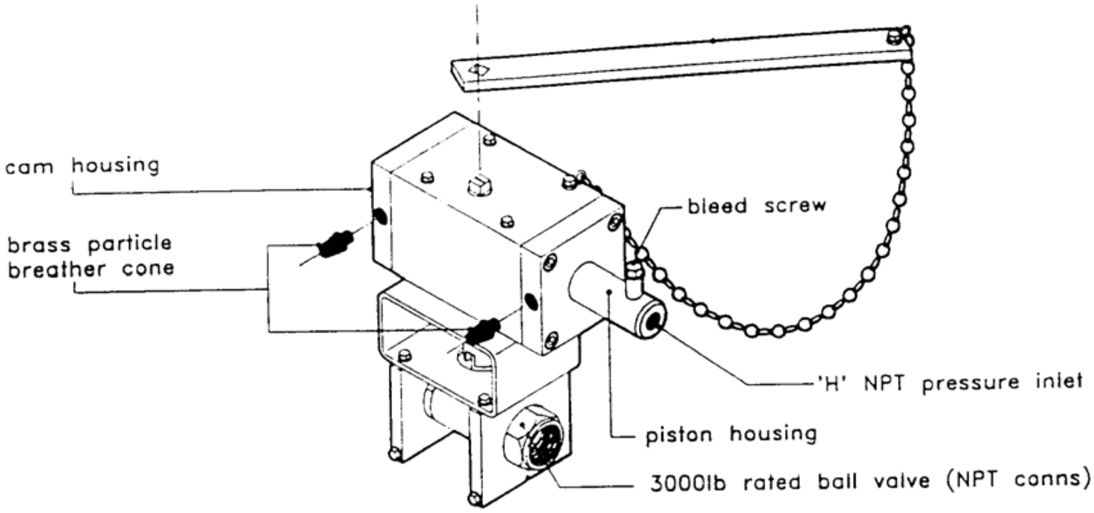

Figure 17 Distribution Valve

3.13 PILOT CYLINDER

A pilot cylinder shall be used to pneumatically operate the master container and /or distribution valves. It may be operated electrically using the release solenoid or manually by removing the safety pin and depressing the lever downwards.

The cylinder is manufactured in accordance with EEC/84/525 and is pressure tested to 280 bar. The maximum working pressure is set to 140 bar.

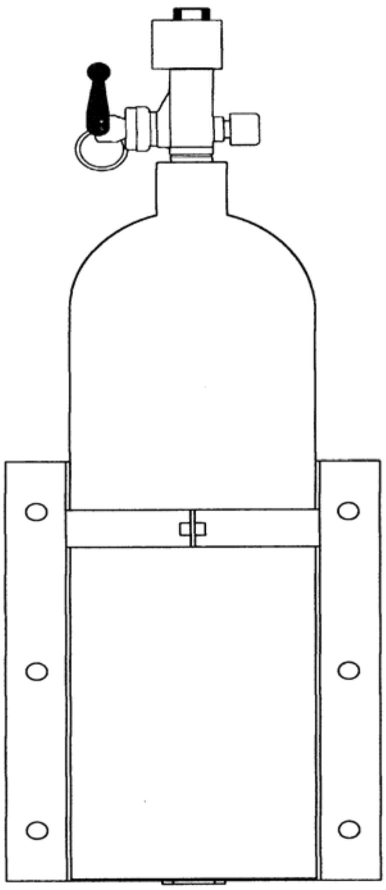

Figure 18 Pilot Cylinder

3.14 PILOT CYLINDER RELEASE SOLENOID

The pilot cylinder release solenoid is used to electrically operate the pilot cylinder. The solenoid is operated at 24V d.c. (Current consumption – 425 mA max.). Power consumption 10 watts max.

It is fitted directly onto the top of the pilot cylinder valve.

Note: The testing procedures are located under section 6.2 of this document.

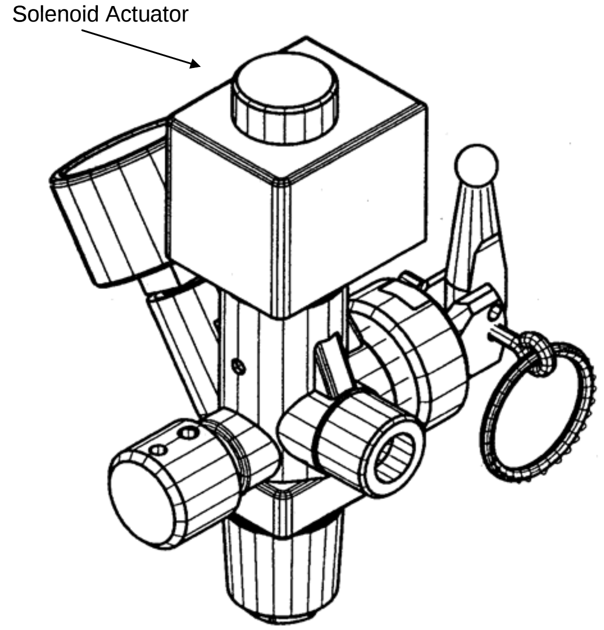

Figure 19 Pilot Cylinder Release Solenoid

CAUTION:

The central pin must be in the retracted position before the solenoid is fitted otherwise the pilot cylinder valve will be operated and will discharge immediately.

3.15 PILOT CYLINDER MANUAL ACTUATOR

The local manual actuator is used to mechanically operate the system at the container location.

Accidental operation is prevented by means of a steel safety pin. The steel safety pin must be removed to allow the use of the local manual actuator. After removing the steel safety pin, manual operation is effected by pushing the lever downwards.

The unit is designed so that it may be fitted directly onto the side of the pilot cylinder valve in conjunction with an electrical solenoid actuator. Pushing the operating lever downwards causes the central pin to move downwards onto the central operating pin of the solenoid actuator thus opening the valve.

Note: The testing procedures are located under section 6.2 of this document.

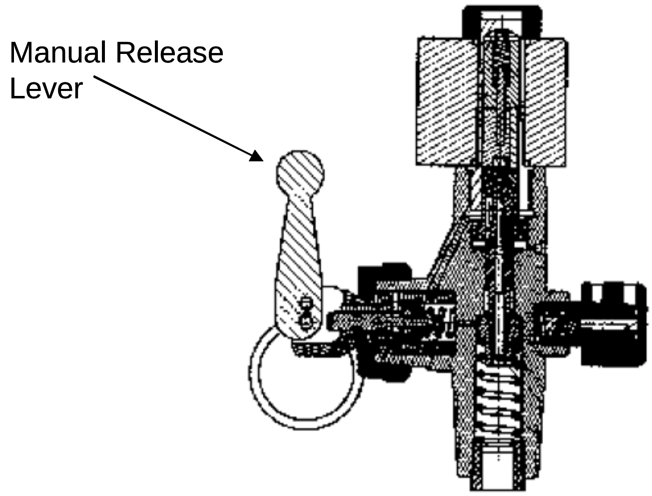

Figure 20 Pilot Cylinder Manual Actuator

3.16 MANUAL RELEASE CAUTION PLATE

The manual release caution plate provides instructions to personnel on the use of manual controls. One plate is to be fixed adjacent to all manual control positions.

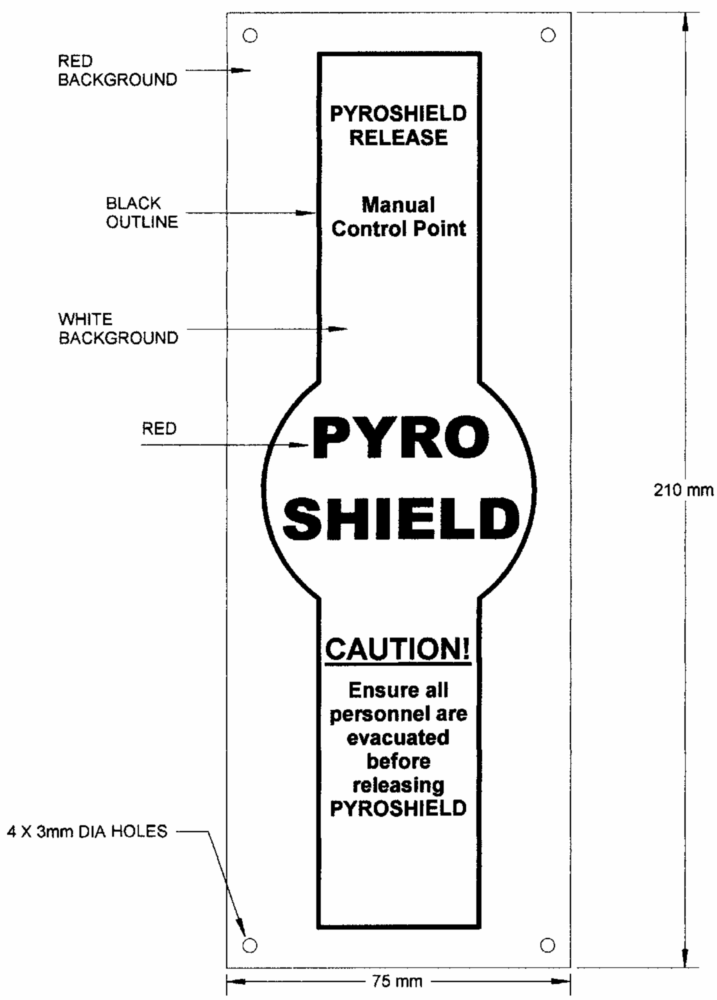

Figure 21 Manual Release Caution Plate

3.17 DOOR CAUTION PLATE

The door caution plate provides instructions to personnel who may enter an area protected with PYROSHIELD.

Door caution plates are to be fitted externally and internally to each entry and exit door.

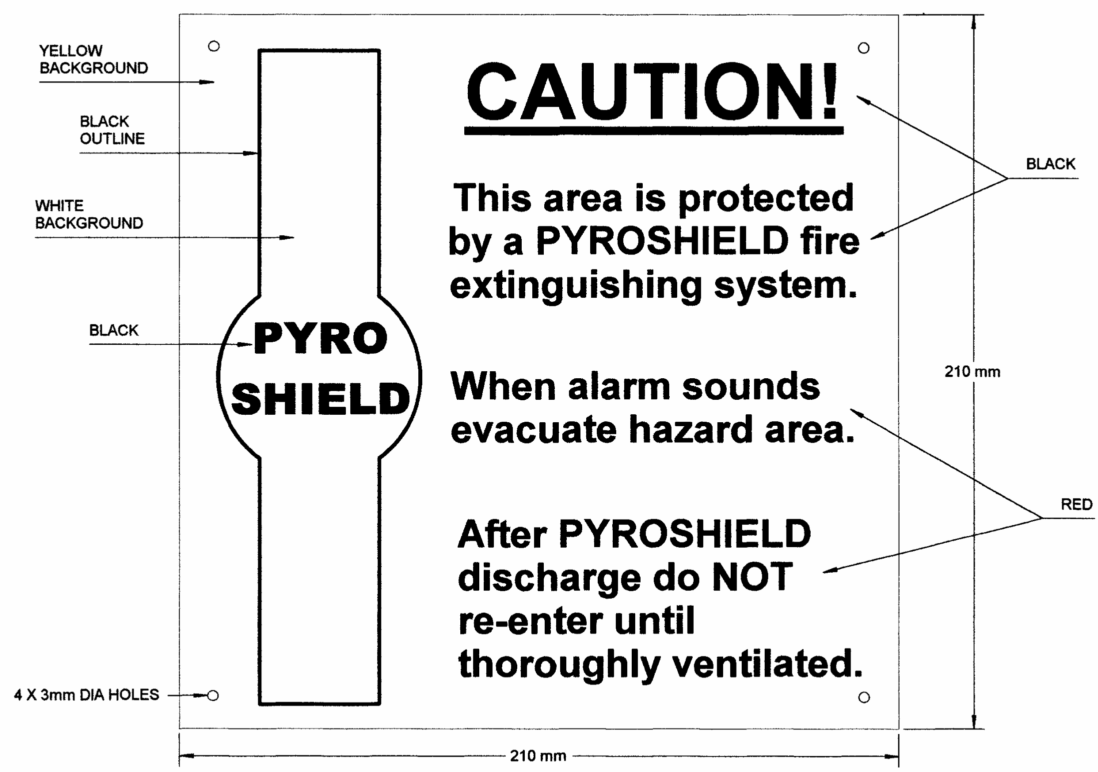

Figure 22 Door Caution Plate

3.18 PILOT ACTUATION HOSE

The pilot actuation hose connects the pilot cylinder valve and the nearest cylinder valve. When connecting, attach the male threaded connection to the nearest PYROSHIELD cylinder valve. This should be hand tightened. This facilitates an easy connection to the pilot cylinder valve with the swivel female side.

As the pilot actuation hose uses a fibre washer in conjunction with the swivel female, spanner tightening is required.

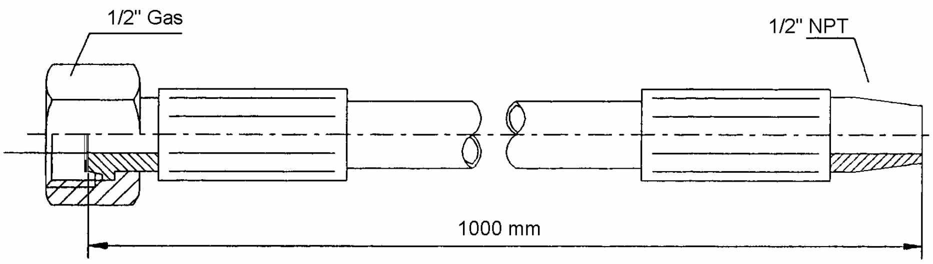

Figure 23 Pilot Actuation Hose

Insert: MF 2000 Multitype
Tube: Oil resistant synthetic rubber
Reinforcement: Two high tensile steel braids
Cover: Environment resistant synthetic rubber
Type Approvals: Bureau Veritas (Type Approval Number: 21041/07214/A2/PRSO BV)
Temperature Range: -40^0C - $+100^0$C, peaks 125^0C

Hose Size				Reinforcement Outer Diameter		Outer Diameter		Max. Working Pressure		Burst Pressure		Min. Bend Radius		Weight	
DN	dash	mm	inch	mm	inch	mm	inch	bar	psi	bar	psi	mm	inch	g/m	lb/ft
10	-6	9.5	3/8"	16.7	0.66	18.7	0.74	330	4780	1320	19140	127	5.00	510	0.34

Table 9 Technical Specifications for the Pilot Actuation Hose

SECTION 4. SYSTEM DESIGN

Information contained in this section has been based on the NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems and the Draft International Standard ISO 14520 Parts 1 and 14.

This section has been written to give an understanding in the application of PYROSHIELD systems. This system should only be applied for the total flooding of hazard enclosures.

4.1 CALCULATION METHOD

Prior to commencing with the design of any PYROSHIELD system, the designer should have, as a minimum the following details:

- Enclosure dimensions including fixed volumes.
- Specific details of the hazard
- The minimum and maximum temperatures of the hazard enclosure
- Height of the enclosure above (or below) sea level
- Confirmation that the containment is adequate
- Details of the ventilation system
- Intended occupancy of the enclosure

Also the storage container location should be noted – this should preferably be outside the protected enclosure, but must not be exposed to weather or other potential hazards. Floor loading should also be taken into consideration.

The following provides the correct manner in which to properly design a PYROSHIELD total flooding system. This is done using an example showing a step-by-step approach. Please also note that in the following calculations there are no rounding errors, and it has been calculated precisely.

STEP 1: Determine Protected Volume

As highlighted in Figure 24, there are two hazards; the computer room and the floor void.

Both of these volumes are determined separately.

Where Volume = Length x Breadth x Height

Then Computer Room Volume, V_1 = $(10 \times 5.8 \times 2.5)m^3$ = $145m^3$

And

Floor Void Volume, V_2 = $(10 \times 5.8 \times 0.5)m^3$ = $29m^3$

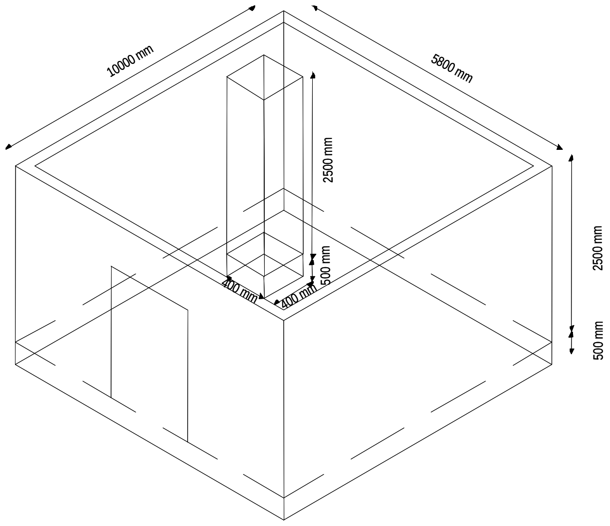

Figure 24 Computer Room with floor void

STEP 2: Determine Volume of Solid, Permanent Building Structures

Permanent impermeable building structures within the enclosure may be deducted from the gross volume, like that of the column highlighted in Figure 24.

Hence in this example, the permanent column volume is calculated for the room and floor void as follows:

C_1 = volume of column in room

Thus C_1 = $(0.4 \times 0.4 \times 2.5)m^3$
= $0.4\ m^3$

C_2 = volume of column in f/void

Thus C_2 = $(0.4 \times 0.4 \times 0.5)m^3$
= $0.08\ m^3$

STEP 3: Calculate Reduced Volume

Deduct the volume of the permanent column from the hazard volumes.

$R_1 = (145 – 0.4)m^3$
$= 144.6\ m^3$

$R_2 = (29 – 0.08)m^3$
$= 28.92\ m^3$

STEP 4: Determine total reduced volume

This step will be used to calculate the specific gas quantity of the PYROSHIELD system (see Step 21).

The total reduced volume, R_T is $(144.6 + 28.92)m^3 = 173.52\ m^3$

STEP 5: Determine Minimum Design Concentration

> *"The proportion of air that has been replaced by PYROSHIELD when the discharge is complete is called the <u>design concentration.</u>"*

PYROSHIELD systems are designed to extinguish classes A, B, C & E fires (Europe).

For class A and class E fires, a minimum of 38.5% design concentration shall be used.
For Classes B and C, refer to the list of substances and the minimum design concentration that is applicable in **Table 13**. These values are taken from the draft ISO 14520 standards.

They are based on the 'extinguishing value' plus 30% and then rounded up to the next nearest full number. The design concentration for fuels, which require lower than 40%, shall be raised to 40%.

For substances not on this list please consult Alien Systems & Technologies.

As the example is a computer room and floor void, then the hazard shall be classified as a class E fire (Europe). Hence an electrical fire risk. Therefore the design concentration shall be 38.5%.

STEP 6: Determine Minimum Pyroshield Agent Quantity

Once the design concentration has been established, the minimum Pyroshield quantity can be determined.

This is done by either of the following:

1. Multiply the net volume by a predetermined specific gas quantity **(see step 21)**.

2. Determine the agent quantity required by using the following formula cited from ISO 14520:

Agent Quantity, $Q = (V_H S_R \div S) \times [\ln(100 \div (100 – dc)]$

- S_R = specific vapour volume at filling temperature = $0.6960\ m^3\ kg^{-1}$
- S = specific vapour volume = $k_1 + k_2(T)$
- Where $k_1 = 0.6598$
- $K_2 = 0.002416$
- T = temperature (°C), the minimum ambient temperature of the protected area.
- dc = design concentration.
- V_H = reduced hazard volume

In this example the computer room and floor void are classed as class E fire and therefore a design concentration of 38.5% shall be used. The minimum ambient temperature was determined at 20°C.

Thus the initial agent of PYROSHIELD can be calculated for the computer room.

<u>Computer Room:</u>
$Q_1 = 144.6 \times [0.6960 \div (0.6598 + 0.002416(20))] \times [\ln(100 \div (100 – 38.5)] = 69.10\ m^3$.

<u>Floor Void:</u>
$Q_2 = 28.92 \times [0.6960 \div (0.6598 + 0.002416(20))] \times [\ln(100 \div (100 – 38.5)] = 13.82\ m^3$.

STEP 7: Altitude Correction Factors

Once the initial agent quantity is found, this must be adjusted in accordance with **Table 15** if the system is to be installed at altitudes that vary from sea level by more than 11%.

For example assuming that the computer room is at an altitude of 1000m above sea level, then the agent quantities is adjusted by the following:

<u>Computer Room:</u>

$A_1 = Q_1 \times 0.885$
$= 69.10 \times 0.885$
$= 61.15\ m^3$

<u>Floor Void:</u>

$A_2 = Q_2 \times 0.885$
$= 13.82 \times 0.885$
$= 12.23\ m^3$

STEP 8: Determine Total Pyroshield Quantity Required

Add the quantities for all the hazard areas to determine the total PYROSHIELD quantity.

Hence for the example, the PYROSHIELD quantities for both the computer room and the floor void must be added together.

Total Quantity, $A_T = A_1 + A_2$
$= (61.15 + 12.23) m^3$
$= 73.38\ m^3$

STEP 9: Determine the number of PYROSHIELD cylinders

Finally, the number of PYROSHIELD containers required can be calculated by dividing the final PYROSHIELD quantity by the capacity of each PYROSHIELD container according to **Table 10**.

Thus No. of cylinders, $C = A_T \div 16.21$
Hence $C = 73.38 \div 16.21 = 4.53$ cylinders
Therefore 5 cylinders of PYROSHIELD are needed.

STANDARD CONTAINER SIZES	**CAPACITY (VOLUME)**	**CAPACITY (MASS)**
80 litre	16.21 cu.m	22.89 kg

Table 10 Capacities of Standard PYROSHIELD Containers

STEP 10: Calculate the actual quantity of PYROSHIELD being supplied

To calculate the actual quantity of PYROSHIELD being supplied, the number of cylinders should be multiplied by the quantity of PYROSHIELD being supplied per cylinder.

In the case of the computer room, five cylinders are being supplied with each containing 16.21 m^3 of PYROSHIELD each.

Therefore the actual quantity is as follows

Actual Quantity, $P_T = (5 \times 16.21) m^3 = 81.05\ m^3$

STEP 11: Calculate the actual PYROSHIELD supplied per hazard area

The formula to determine the actual gas supplied per hazard area is as follows:

(minimum quantity of PYROSHIELD supplied for each area (from step 7) ÷ the **total** minimum quantity required (from step 8) x the actual quantity of PYROSHIELD supplied (from step 10). See examples.

<u>Computer Room:</u>

In this example the computer room required a minimum quantity of 61.15 m^3 of PYROSHIELD. The total minimum quantity required for the complete system is 73.38 m^3. The actual total quantity being supplied is 81.05 m^3.

<u>Computer Room:</u>

$P_1 = (61.15 \div 73.38) \times 81.05 = 67.54\ m^3$ is supplied to the computer room.

Floor Void:

In this example the computer room required a minimum quantity of 12.23 m^3 of PYROSHIELD. The total minimum quantity required for the complete system is 73.38 m^3. The actual total quantity being supplied is 81.05 m^3.

Floor Void:

P_2 = (12.23 ÷ 73.38) x 81.05 = 13.51 m^3 is supplied to the floor void.

STEP 12: Calculate the Actual PYROSHIELD flooding factor

> *"The ratio of the volume of an enclosure to the volume of PYROSHIELD injected into it is called the flooding factor."*

In order to verify that the actual PYROSHIELD flooding factor is within range (step 13), this needs to be calculated.

This is done by the following formula:

(actual PYROSHIELD agent supplied to area (step 11) ÷ altitude correction factor (step 7) ÷ total reduced volume of the hazard (step 4)

Computer Room:
F_1 = (67.54 ÷ 0.885) ÷ 144.6 = 0.528

Floor Void:
F_2 = (13.51 ÷ 0.885) ÷ 28.92 = 0.528

STEP 13: Verify actual flooding factor

Verify the actual flooding factor against **Table 20** to check the minimum safety precautions as stated in ISO 14520.

Please also note that the 'Halon Alternatives Group' report – "A review of the toxic and asphyxiating hazards of clean agent replacements for Halon 1301", advises that PYROSHIELD systems may be used in the fully automatic mode in occupied areas where the oxygen level does not reduce below 12%, i.e. below the NOAEL level (flooding factor 0.562).

In the event that the oxygen level is between 10% and 12% i.e. between the NOAEL and LOAEL levels (flooding factor 0.56 – 0.73), the system may be on automatic providing the enclosure can be evacuated in less than 30 seconds. Although ISO 14520 does advise that the system should be in manual when the hazard is occupied.

If the oxygen level falls below 10% (flooding factor greater than 0.73), the system must not be used in the automatic mode whilst the enclosure is occupied.

In the case of the example, the PYROSHIELD system's actual flooding factor is below 0.56 (see Step 12) and therefore can be used in the automatic mode.

Complete the same procedure as done in Step 12 at the normal and maximum ambient temperatures (by repeating steps 6 to 13). In this example through calculation, the actual flooding factor at 21^0 is 0.528 for both the computer room and floor void. At the maximum ambient temperature of 22°C, flooding factor is 0.528. Therefore this is within the NOAEL level of 0.56 for minimum, normal and maximum ambient temperatures.

If the actual flooding factor does not fall within either the NOAEL or LOAEL limits, it is strongly advised that NFPA 2001 and ISO 14520 be consulted. In the case that the actual flooding factor exceeds the LOAEL limit in a normally occupied area the following have to be installed:

1. Time delay device
2. Automatic/manual switch
3. Lock-off device

STEP 14: Determine the total discharge time

For all PYROSHIELD systems 95% of the design concentration will be achieved in 60 seconds as stated in ISO 14520.

STEP 15: Determine estimated flow rates

This step is needed to estimate the main feed pipe sizes (step 16) and for later calculations to determine drill sizes and pressure venting requirements.

According to ISO 14520, 95% of the design concentration should be discharged in 60 seconds.

Therefore to determine the flow rate for the main feeder pipe (nodes 7-8: Figure 25), first take 95% of the total required PYROSHIELD quantity supplied (step 8) and divide by the total discharge time (in minutes). This is summarised as follows:

(Total design quantity of PYROSHIELD x 0.95) ÷ discharge time (in minutes)

In the case of the example, the flow rate is calculated as follows:

The total agent supplied is 73.38 m^3,
thus (73.38 m^3 x 0.95) ÷ 1 = 69.71 m^3\min

Also calculate the flow rates for the room (nodes 8-10) and floor void (nodes 8-14) pipes. This is done by using the same formula but utilising the agent supplied to each volume as calculated in Step 7.

Room: (61.15 m^3 x 0.95) ÷ 1 = 58.09 m^3\min

Floor Void: (12.23 m^3 x 0.95) ÷ 1 = 11.62 m^3\min

STEP 16: Estimate the main pipe sizes required

Refer to Table 16 – Estimating Pipe Sizing Table on page 4-16.

In this example, the total system flow rate is 69.71 m^3\min, the room flow rate is 58.09m^3\min and the floor void flow rate is 11.62 m^3\min.

By referring to the chart, the main downstream pipe is estimated to be 32 mm pipe (1¼" pipe), the room pipe is estimated to be 32 mm (1¼" pipe) and the floor void pipe is estimated to be 15 mm (½" pipe).

STEP 17: Determine the nozzle quantity

NOZZLE REQUIREMENTS:

- A single PYROSHIELD nozzle will cover a maximum of 95m^2. It is common practice to assign a PYROSHIELD nozzle for every 50 - 60m^2.
- Maximum nozzle height is 3.7m.
- In hazards with false ceiling tiles, nozzles should be located in the centre of the room. In hazards with false ceilings, the nozzle should be fitted with a rosette and all ceiling tiles within a 600mm radius of the nozzle should be clipped.
- For small rooms (no bigger than 25m^2) a PYROSHIELD nozzle can be wall-mounted.

To determine the nozzle quantity required, the total area of the room should be divided by 50m^2 and rounded up to the next whole number. The dividend will indicate the quantity of nozzles to be used. Be aware of the shape of the hazard, such as L-shaped rooms etc. This may require extra nozzle/s.

In the example, the area is (10 x 5.8) m^2 = 58m^2 for both the computer room and floor void. Therefore the nozzle quantity is:

<u>Computer Room:</u>
N_1 = (58 ÷ 50) = 2 nozzles

<u>Floor Void:</u>
N_2 = (58 ÷ 50) = 2 nozzles

STEP 18: Determine nozzle flow rate per hazard area

To calculate the nozzle flow rate you should:

1. Divide the flow rate for each hazard (step 15) by the number of nozzles.

In the case of the computer room and floor void, the nozzle flow rates are as follows:

<u>Computer Room:</u>
58.09 ÷ 2 nozzles = 29.05m^3\min per nozzle

<u>Floor Void:</u>
11.62 ÷ 2 nozzle = 5.81m^3\min per nozzle

STEP 19: Determine nozzle locations and piping layout

At this point, it is now necessary to develop an accurate piping layout or isometric drawing.

Locate the nozzles and the cylinders on an accurate sketch. Layout the manifold and sketch in the discharge pipe between the manifold and the nozzle(s). All pipe lengths must be included.

The pipe sketch must be very accurate. This information will be used to determine pipe diameters, nozzle and orifice drill sizes using a computer calculation program that simulates single phase hydraulic calculations.

If choosing a selector valve system design, refer to the selector valve section for information.

Before entering information into the computer calculation program, the piping should be noded, the correct cylinder arrangement selected and the nozzles should be coded.

- Piping node points – Piping sections are coded numerically starting from the inlet valve on the cylinder furthest from the manifold outlet. Each point where flow increases, direction changes or flow splits marks the end of a pipe section and the start of a new pipe section.
- Cylinder Arrangement – Cylinders can be arranged in a single or double row. 1 to 10 cylinders can be arranged in a single row. 4 to 20 cylinders can be arranged in a double row. For systems that require more than 20 cylinders, this would require extra banks of cylinders to be manifolded separately. These extra banks can be actuated simultaneously from the Gas Control Unit. The cylinder arrangement is important when selecting the correct manifold template on the computer program.
- Nozzles – Nozzles are indicated with a number 11001, 11002, 11003...etc (as shown on the example schematic drawing – Figure 25).

See example isometric drawing.

STEP 20: Determine open area required for venting during discharge

It is necessary to calculate the opening area needed for pressure venting to determine if the hazard area(s) include sufficient openings or if more openings are required.

To determine this, there is only one true way. A room integrity test should be completed which analyses the room's leakage and hold times that accurately determines the over-pressurisation venting requirements.

Alternatively there are approximations to venting such as the computer simulation program and the CEA formula. Of these two guides, the computer program is more accurate and a reference to this is advised.

The use of the following formula (cited from CEA) can be applied to determine an approximate calculation of the open area required for pressure venting:

$$A = \frac{F}{\sqrt{P}} \times 0.7742$$

A = free venting area (m^2)
F = maximum flow rate (kg/s)
P = maximum over pressure (Pa)
To determine P use the following:

Light construction = 250 Pa
Normal construction = 500 Pa
Vault construction = 1000 Pa
Voids = 100 Pa

In the case for the example, the computer room and floor void is constructed using partitioned walls.

<u>Computer Room:</u>

For the computer room the flow rate is $58.09m^3$\min. Therefore this needs to be converted into kilograms per second.

This is done by the following:
F = (58.09 x 22.89 ÷ 16.21) ÷ 60 = 1.367 kg\s
As the walls are partitioned, then P = 250 Pa

Thus A = 1.367 ÷ 15.81 x 0.7742 = 0.067 m^2

Floor Void:
For the floor void the flow rate is 11.62 m^3\min. Therefore this needs to be converted into kilograms per second.

F = (11.62 x 22.89 ÷ 16.21) ÷ 60 = 0.27 kg\s
As this is a floor void, then P = 100 Pa

Thus A = 0.27 ÷ 10 x 0.7742 = 0.021 m^2

STEP 21: Calculate the specific gas quantity

"the <u>specific gas quantity</u> is the ratio between the required amount (kg) of PYROSHIELD that is discharged into the hazard and the total reduced volume(m^3) of the hazard.

The specific gas quantity is a number to describe how much PYROSHIELD occupies 1m^3 of the total reduced hazard volume.

The formula for this is as follows:

Specific gas quantity = mass of required PYROSHIELD ÷ total reduced volume

Hence using the example:

The required amount of PYROSHIELD (Step 8) needs to be converted into kilograms. Thus is done by dividing the required gas quantity by 16.21 and multiplying it by 22.89.

Hence 73.38 ÷ 16.21 x 22.89 = 103.61 kg

This will need to be divided by the total reduced volume of the hazard (Step 5) which is 149.52 m^3.

Hence the Specific Gas Quantity, L = 103.61 ÷ 173.52 = 0.597 kg\m^3.

This number is important as it can be used in future to simplify the procedure in determining the required amount of PYROSHIELD for any further hazards (only Class A and E fires) on this site. For class B and C fires a higher design concentration will have to be used.

To determine the required amount of PYROSHIELD using the specific gas volume, simply multiply the hazard volume (m^3) by the specific gas quantity and this will give the required amount of PYROSHIELD (in kilograms) for the volume.

Once this is known, convert the required PYROSHIELD quantity in cubic metres and repeat from steps 9.

The specific gas quantity is also inputted into the computer program.

STEP 22: Perform flow calculations

With the information developed in Steps No. 18 and 19, run the computer program to determine the final pipe sizes, nozzle sizes and orifice size.

STEP 23: Revise worksheet

Rework the design worksheet for each area starting with the entry "Actual PYROSHIELD Supplied Per Area, Step 11" and ending in "System Discharge Time, Step 14". Replace the "actual PYROSHIELD agent supplied per area" with the agent quantities determined in the flow calculation program.

STEP 24: Verify actual system performance

Review the revised worksheet to verify that:

1. The agent concentration at maximum temperature is within the acceptable NOAEL and LOAEL limits for occupied or unoccupied spaces.
2. The agent quantity is above the amount required in the initial PYROSHIELD quantity box (see Step 7).
3. The discharge time from the flow calculation is equal to or less than that listed for all areas on the design worksheet.

STEP 25: Input data into the computer program to determine drilling sizes etc.

The pipe layout should be entered into the computer calculation program. Then the Hazard details should be entered (the reduced volume, structural strength, and the specific gas quantity).

4.2 SELECTOR VALVES

The following must be considered when designing and implementing a selector valve system:

1. Each hazard area must be treated as a separate system design.
2. Start with the largest system (system with the highest estimated flow rate). This is necessary so that the manifold size will handle the maximum quantity of PYROSHIELD.
3. After calculating the largest system first, complete additional system calculations on the remaining systems. Use the manifold pipe size calculated from the first system design (system with the highest flow rate).
4. Selector valve systems can be used for multi-hazards when all areas are considered separate fire hazards.
5. Selector valve locations should be installed in the piping network after the orifice union, assuming equal volumes, with a minimum amount of piping in between.
6. The piping and fittings located between the orifice assembly and the selector valve must be rated for a pressure of 85 bar or greater.
7. Downstream of the selector valve, use standard system piping based on the piping charts.

4.3 DETECTION SYSTEM REQUIREMENTS

Using the information recorded from the hazard analysis sub-section, now determine the detection system requirements.

The type of detection system used with the PYROSHIELD system should offer supervised input and output circuits and battery back-up. The type of hazard or the authority having jurisdiction will determine the detection system requirements.
In the case of South Africa the appropriate standards should be consulted:

- SANS 100 – 1
- BS 6266
- BS 7273 Part 1 – Detector Spacing

In all cases the detection, actuation, alarm and control systems shall be installed, tested and maintained in accordance with appropriate protective alarm and signalling system standards.
It is recommended that automatic detection and automatic actuation be used. ISO 14520 also states that where there is automatic detection & actuation, "provision shall also be made for manual operation."

ISO 14520 goes on to state that "Unless otherwise specified in a national standard, 24-hour minimum standby sources of energy shall be used to provide for operation of the detection, signalling, control and actuation requirements of the system."

It is recommended that the PYROSHIELD system be used with one of the four electric detectors: rate of rise/fixed temperature (thermal), ionisation smoke, photoelectric smoke, or flame.

4.3.1 HEAT DETECTOR

The electric heat detector is used on most detection and control systems. Electric heat detectors are designed to respond between the flame and heat stages and are recommended for most industrial hazards.

They are simple, stable and one of the most reliable devices in dirty environments. However, their sensitivity decreases, as they become dirty. They are selected by temperature range relative to the hazard temperature and other detection devices in the area. They are designed to compensate for thermal lag. The detector responds at an operating temperature approximately equal to the detectors rated operating temperature.

Please refer to BS 7273 Part 1 and BS 6266 for detector spacing.

4.3.2 SMOKE DETECTORS (IONISATION & OPTICAL)

Spacing on all smoke detectors should be 20 – 25m^2 at a height of 3m.. When designing detection systems, refer to the relevant international codes and standards for detailed information concerning detector locations and spacing. Please refer to BS 7273 and BS 6266 for detector spacing.

4.3.3 FLAME DETECTORS

Flame detector spacing depends on line of sight and detector sensitivity. Refer to the relevant international codes and standards for detailed information concerning detector locations and spacing. See also manufacturers recommendations.

4.3.4 BEAMS AND CEILING OBSTRUCTIONS

Beams and ceiling obstructions may be present which could obstruct detector placement over the hazard. Additional detectors may be required to provide adequate protection and to avoid obstructions. Refer to the relevant international codes and standards for detailed information concerning detector locations and spacing (i.e. SANS 100 – 1).

4.3.5 LAY OUT THE DETECTION AND CONTROL COMPONENTS ON THE HAZARD SKETCH

Now that the hazard has been analysed and the detection and control hardware has been selected, the sketch can be completed. The sketch should show the placement of the accessories as well as the detection, control and electrical components.

4.4 ACTUATION REQUIREMENTS

Combined methods of actuation are used in the PYROSHIELD system. The types of actuation are: electrical – pneumatic and manual – pneumatic.

4.4.1 PNEUMATIC ACTUATION

Pneumatic actuation is used with the valve actuators incorporated in the PYROSHIELD cylinder valve. The pressure is supplied from a remote pilot cylinder containing nitrogen. The pilot cylinder pressure pneumatically opens the cylinder valve.

4.4.2 MANUAL ACTUATION

Manual actuation can be used either with or without automatic detection based on the acceptance of the end user/consultant. A manual release lever is situated on the PYROSHIELD pilot cylinder valve that releases nitrogen at 140 bar that pneumatically operates the slave cylinder valve/s. One pilot cylinder is required on single or multiple cylinder systems. The pilot valve is the only cylinder that requires a manual actuator.

4.4.3 ELECTRIC ACTUATION

Electric actuation is used with the electric solenoid actuator mounted on the PYROSHIELD pilot cylinder valve and an acceptable detection and control system. When utilising electric actuation, a status/lock-off unit with the required electrical capacity must be used. Normal system design requires a gas control unit at the entrance with repeater units at the other entrances. The pilot valve is the only one that requires a solenoid actuator. On a two or more cylinder system, the remaining cylinders are actuated by the pressure generated within the actuation piping. The control system also provides a supervised method of cylinder actuation.

4.4.4 MULTIPLE CYLINDER ACTUATION

A maximum of 20 slave cylinders can be operated from a single active pilot cylinder. When more than 20 cylinders are required, additional pilot cylinders may be configured.

4.5 ACCESSORIES

Specific selection and placement of accessories that may be used with the PYROSHIELD system are:

PRESSURE SWITCH:

The pressure switch is operated by the agent pressure when the system is discharged. The piping to the pressure switch is normally run from the distribution piping, but can also be run from the manifold, providing that high pressure fittings and pipe are used. The pressure switch can be used to open or close electrical circuits to either shut down equipment or turn on lights or alarms or to signal the control panel.

ALARMS:

Several types of electric alarms are available. Each of these operate on 24VDC and must be used on the alarm circuit of an acceptable detection and control system. Refer to the appropriate detection and control system installation and maintenance manual for detailed design information.

CONTROL PANELS:

Several types of control panels are available. Refer to the appropriate detection and control system installation and maintenance manual for detailed design information.

GAS CONTROL UNITS:

Refer to the appropriate control system installation and maintenance manual for detailed design information.

GAS REMOTE UNITS:

Refer to the appropriate control system installation and maintenance manual for detailed design information.

GAS STATUS UNTIS:

Refer to the appropriate control system installation and maintenance manual for detailed design information.

4.6 RESERVE SYSTEM

Normally the end user or consultant will determine whether a hazard requires a reserve set of cylinders, either connected or spares.

The NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems, states "Where required, the reserve quantity shall be as many multiples of the primary supply as the jurisdiction considers necessary".

"Where uninterrupted protection is required, both primary and reserve supply shall be permanently connected to the distribution piping and arranged for easy changeover".

Certain insurers require that an extra full complement of charged cylinders (connected reserve) manifolded and piped to feed into the automatic system should be provided on all installations. The reserve supply is actuated by manual operation of the main/reserve switch on either electrically operated or pneumatically operated systems.

A connected reserve system is desirable for four reasons:

1. Protection should re-ignition occur.
2. Reliability should the main bank malfunction.
3. Protection during impairment when main tanks are being replaced.
4. Protection of other hazards if selector valves are involved and multiple hazards are protected by the same set of cylinders. See selector valve information.

If a full complement of charged cylinders cannot be obtained, or the empty cylinders recharged, delivered and reinstalled within 24 hours, a third complement of fully charged spare cylinders should be maintained on premises for emergency use. The need for spare cylinders may depend upon whether or not the hazard is under protection of automatic sprinklers.
When designing a system, always determine if, and what kind of, reserve system is required.

4.7 OTHER DESIGN CONSIDERATIONS

The following considerations must also be noted when completing the PYROSHIELD system design:

4.7.1 ROOM INTEGRITY AND PRESSURISATION

It is recommended that room integrity testing be performed on any protected volume to establish the total equivalent leakage area and enable a prediction to be made of the enclosure's ability to retain PYROSHIELD. The required retention time will vary depending on the particulars of the hazard but will not normally be less than 10 minutes. Longer retention times may sometimes be necessary if enclosures contain hazards that may become a deep-seated fire risk.

In considering room integrity the designer should be aware that the discharge of any gaseous extinguishing agent into an enclosure will give rise to a change in the pressure within that enclosure, which under some conditions could affect the structural integrity of the enclosure.

In some cases the protected enclosure will require a pressure relief vent and in all cases the client must be made aware of the pressurisation level expected within the enclosure.

The basis for these calculations will be the natural leakiness of the enclosure, which can only be assessed with any degree of accuracy by means of a room integrity test.

4.7.2 ELECTRICAL EARTHING AND SAFETY CLEARANCES

For guidance on the requirements for earthing and safety clearances refer to the appropriate section of ISO 14520 or NFPA 2001.

4.7.3 DRILLING DETAILS

For all drilling details, refer to the tables in the design tables section.

4.7.4 PIPEWORK AND FITTINGS

It is requisite that the correct grade of pipework and fittings are used in the system. It is therefore recommended that NFPA 2001 or the draft ISO standard ISO 14520 are consulted.

	OPEN SECTION	CLOSED SECTION
Maximum Working Pressure	60 bar	240 bar
Test Pressure	80 bar	320 bar
Manufacture	Welded or Seamless	Seamless
Pipe Size From 15mm up to and including 40mm	ASTM A 106 B (Sch 40) BS 3601	ASTM 106 B (Sch 80) API 5L (Sch 80)
Pipe Size From 50mm up to and including 150mm	API 5L (Sch80 API) ASTM A 106 B (Sch 80) BS 3602	API 5L (Sch 160) ASTM A 106 B (Sch 160)

Table 11 Pipework

*** All closed section pipe work must be assembled using the special high-pressure fittings, unless the pipe work is manufactured off site and tested to 300 bars for a minimum of 2 minutes.**

**** The design of the piping and fittings should be in accordance with ASME B31.1 Power Piping Code. The installation of the pipe system shall be in accordance with BS 3351.**

Note: All pressure relief devices installed for protection of closed sections of piping, shall be designed and located so that the discharge from the device shall not injure personnel or pose a hazard.

	OPEN SECTION	CLOSED SECTION
Jointing method	Welded, Screwed or Flanged	Welded, Screwed or Flanged
Pipe /Fitting Size From 15mm up to and including 40mm	BS 3799 (screwed) BS 3799 (socket welded) BS1640 (butt welded)	BS 3799 (screwed) BS 3799 (socket welded) BS 1640 (butt welded)
Pipe/Fitting Size From 50mm up to and including 150mm	BS 3799 (screwed) BS 3799 (socket welded) BS 1640 (butt welded)	BS 3799 (socket welded) BS 1640 (butt welded)
Flanges-All sizes Raised Face	BS 1560 Pt2 Class 600 ANSI B 16.5 Class 600	BS 1560 Pt 2 Class 2500 ANSI B 16.5 Class 2500

Table 12 Fittings and Flanges

4.8 DEVELOP BILL OF MATERIALS

After completing the subsections of the design sections, finalise the system design by completing a bill of material for the system. The bill of material, hazard sketches, hydraulic calculations, and any notes should be kept on file for future reference.

4.9 PYROSHIELD CALCULATION SHEET

PYRO-SHIELD DESIGN CALCULATION WORKSHEET
200 BAR SYSTEMS ONLY ver 2.1

DATE: ______________________
QUOTE/JOB NUMBER: ______________________
CUSTOMER: ______________________

VOLUME CALCULATIONS:	AREA 1	AREA 2	AREA 3	AREA 4	AREA 5
Area Name:					
Length (m):					
Width (m):					
Height (m):					
Area (m2):					
Volume (m3):					
Volume Reductions:					
Structural Reductions (m3):					
Reduced Volume(m3):					
(Volume - Structural Reductions)					
Total Reduced Volume (m3):					
(Reduced Volume - Movable Object Reductions)					
ROOM MINIMUM AMBIENT TEMP.:					
DESIGN CONCENTRATION:					
FLOODING FACTOR:					
(From Formula or Table)					
INITIAL PYROSHIELD QUANTITY CALC.:					
PYROSHIELD Quantity (m3):					
ALTITUDE CORRECTION:					
Height Above or Below Sea Level (m):					
Factor:					
(From Design Manual Table)					
ACTUAL PYROSHIELD QTY (m3):					
TOTAL PYROSHIELD QTY (m3):					
(Sum of all Actual PYROSHIELD qty's)					

TOTAL PYROSHIELD QTY (m3): [ ]

CYLINDER REQUIREMENTS: **TOTAL CYLINDER CAPACITY (m3):**

80 ltr Cylinders:		
CYLINDER SIZE SELECTED:	80	
PYROSHIELD AGENT SUPPLIED (m3):		

	AREA 1	AREA 2	AREA 3	AREA 4	AREA 5
ACTUAL PYROSHIELD AGENT PER AREA (m3):					
ACTUAL PYROSHIELD FLOODING FACTOR:					
CONCENTRATION RANGE CHECK: *(Design Conc. Must be Below 52% For Occupied Spaces)*					
Room Max. Ambient Temp.:					
Design Concentration at Max. Temp:					
DISCHARGE TIME:					
Normal Ambient Temperature:					
Design Concentration at Ambient Temp.:					
(Locate Actual PYROSHIELD Conc. at Max. Temp. on Table, or Use Calc. in Standard)					
95% of Design Quantity Discharge Time (Sec.): *(60 Seconds)*					
95% of Design Quantity Discharge Time (Min): *(Discharge Time (Sec.) ÷ 60)*					
ESTIMATED FLOW RATES:					
Estimated System Flow Rate (m3/min):					
Estimated Main Feed Pipe Size: *(Refer to Pipe Sizing Chart)*					
Nozzle Quantity:					
Estimated Nozzle Flow Rate (m3/min):					
Estimated Nozzle Pipe Size:					
Pipe Size: *(Refer to Pipe Sizing Chart)*					
AMOUNT OF PYROSHIELD IN KG					
Amount (Kg):					
SPECIFIC GAS QUANTITY:					
Total PYROSHILD design Quantity (Kg):					
Specific gas quantity per area (Kg/m3):					

4.10 PYROSHIELD REFERENCE TABLES

MATERIAL	MINIMUM DESIGN CONCENTRATION
Acetone	39.7%
Acetonitrile	20.8%
AV Gas	34.3%
n-Butanol	42.3%
Cyclohexanone	41.2%
Diesel No. 2	33.9%
Carbon Disulphide	63.6%
N Buty Acetate	33.8%
Ethanol	39.0%
Ethyl Acetate	38.6%
Ethylene Glylol	38.7%
Gasoline (unleaded)	33.9%
Tetrahydrofuran	41.9%
Hexhane	38.0%
Isobutyl	38.0%
Methane	32.9%
Methanol	50.2%
Pyrolldine	40.3%
Isopro-ponal	36.0%
Nitro Methane	41.0%
Propane	44.6%
Morpholine	50.4%
Toluene	33.3%
Turbo Oil	20.7%
Nitro Methane	41.0%

Table 13 Minimum PYROSHIELD Design Concentration

Design temperature of hazard area (t)	Specific vapour volume of PYROSHIELD at design temp. (s)	Design Concentration (c)					
		34%	38%	42%	46%	50%	54%
		Agent Weight Requirements (cu.m PYROSHIELD/cu.m Enclosure Volume)					
-40	0.5631	0.524	0.603	0.688	0.778	0.875	0.980
-35	0.5632	0.513	0.591	0.673	0.761	0.856	0.959
-30	0.5873	0.503	0.579	0.659	0.746	0.839	0.940
-25	0.5994	0.493	0.567	0.646	0.731	0.822	0.921
-20	0.6114	0.483	0.556	0.633	0.716	0.806	0.903
-15	0.6235	0.474	0.545	0.621	0.702	0.790	0.885
-10	0.6356	0.465	0.535	0.609	0.689	0.775	0.868
-5	0.6477	0.456	0.525	0.598	0.676	0.761	0.852
0	0.6597	0.448	0.515	0.587	0.664	0.747	0.837
5	0.6718	0.440	0.506	0.576	0.652	0.733	0.822
10	0.6839	0.432	0.497	0.566	0.640	0.720	0.807
15	0.6960	0.424	0.488	0.556	0.629	0.708	0.793
20	0.7081	0.417	0.480	0.547	0.619	0.696	0.779
25	0.7201	0.410	0.472	0.538	0.608	0.684	0.766
30	0.7322	0.403	0.464	0.529	0.598	0.673	0.754
35	0.7443	0.397	0.456	0.520	0.588	0.662	0.742
40	0.7564	0.390	0.449	0.512	0.579	0.651	0.730
45	0.7684	0.384	0.442	0.504	0.570	0.641	0.718
50	0.7805	0.378	0.435	0.496	0.561	0.631	0.707
55	0.7926	0.373	0.429	0.488	0.553	0.622	0.696
60	0.8047	0.367	0.422	0.481	0.544	0.612	0.686
65	0.8167	0.362	0.416	0.474	0.536	0.603	0.676
70	0.8288	0.356	0.410	0.467	0.528	0.594	0.666
75	0.8409	0.351	0.404	0.460	0.521	0.586	0.656
80	0.8530	0.346	0.398	0.454	0.513	0.578	0.647
85	0.8651	0.341	0.393	0.448	0.506	0.569	0.638
90	0.8771	0.337	0.387	0.441	0.499	0.562	0.629

Table 14 Flooding Chart

EQUIVALENT ALTITUDE (METRES)	CORRECTION FACTOR
-1000	1.130
0	1.000
1000	0.885
1100	0.870
1200	0.858
1300	0.846
1400	0.834
1500	0.822
1600	0.810
1700	0.798

Table 15 Altitude Correction Factors

PIPE SIZE (NB)	FLOW RATE (CUM/MIN)
15mm(½")	15
20mm(¾")	25
25mm (1")	45
32mm (1¼")	85
40mm (1½")	120
50mm (2")	220
65mm (2½")	400
80mm (3")	750
100mm (4")	1100

Table 16 Pipe Size Estimation Chart

½" AND ¾" TYPES	¾" TYPES ONLY	1", 1¼" AND 1 ½" TYPES
Orifice Diameter	Orifice Diameter	Orifice Diameter
2.0mm	10.5mm	11.0mm
2.5mm	11.0mm	12.0mm
3.0mm	11.5mm	13.0mm
3.5mm	12.0mm	14.0mm
4.0mm	12.5mm	15.0mm
4.5mm	13.0mm	16.0mm
5.0mm	13.5mm	17.0mm
5.5mm	14.0mm	18.0mm
6.0mm	14.5mm	19.0mm
6.5mm	15.0mm	20.0mm
7.0mm	-	-
7.5mm	-	-
8.0mm	-	-
8.5mm	-	-
9.0mm	-	-
9.5mm	-	-
10.0mm	-	-

Table 17 Nozzle Drilling Details

PRU
Orifice Diameter
1.0mm
1.5mm
2.0mm
2.5mm
3.0mm
3.5mm
4.0mm
4.5mm
5.0mm
5.5mm
6.0mm

Table 18 Pressure Reducing Unit (Single Container Systems) Drilling Details

PRU Orifice Diameter
2.0mm
2.5mm
3.0mm
3.5mm
4.0mm
4.5mm
5.0mm
5.5mm
6.0mm
6.5mm
7.0mm
7.5mm
8.0mm
8.5mm
9.0mm
9.5mm
10.0mm
10.5mm
11.0mm
11.5mm
12.0mm
13.0mm
14.0mm
15.0mm
16.0mm
17.0mm
18.0mm
19.0mm
20.0mm
21.0mm
22.0mm
23.0mm
24.0mm
25.0mm
26.0mm
27.0mm
28.0mm
29.0mm
30.0mm
31.0mm
32.0mm
33.0mm
34.0mm
35.0mm

Table 19 Pressure Reducing Unit (Multiple Container Systems) Drilling Details

	PYROSHIELD CONC.	OXYGEN CONC.
No Observed Adverse Effect Level* (NOAEL)	43% (0.562**)	12%
Lowest Observed Adverse Effect Level* (LOAEL)	52% (0.733**)	10%

Table 20 The NOAEL & LOAEL levels as stated in ISO 14520

4.11 PYROSHIELD PIPE SCHEMATIC

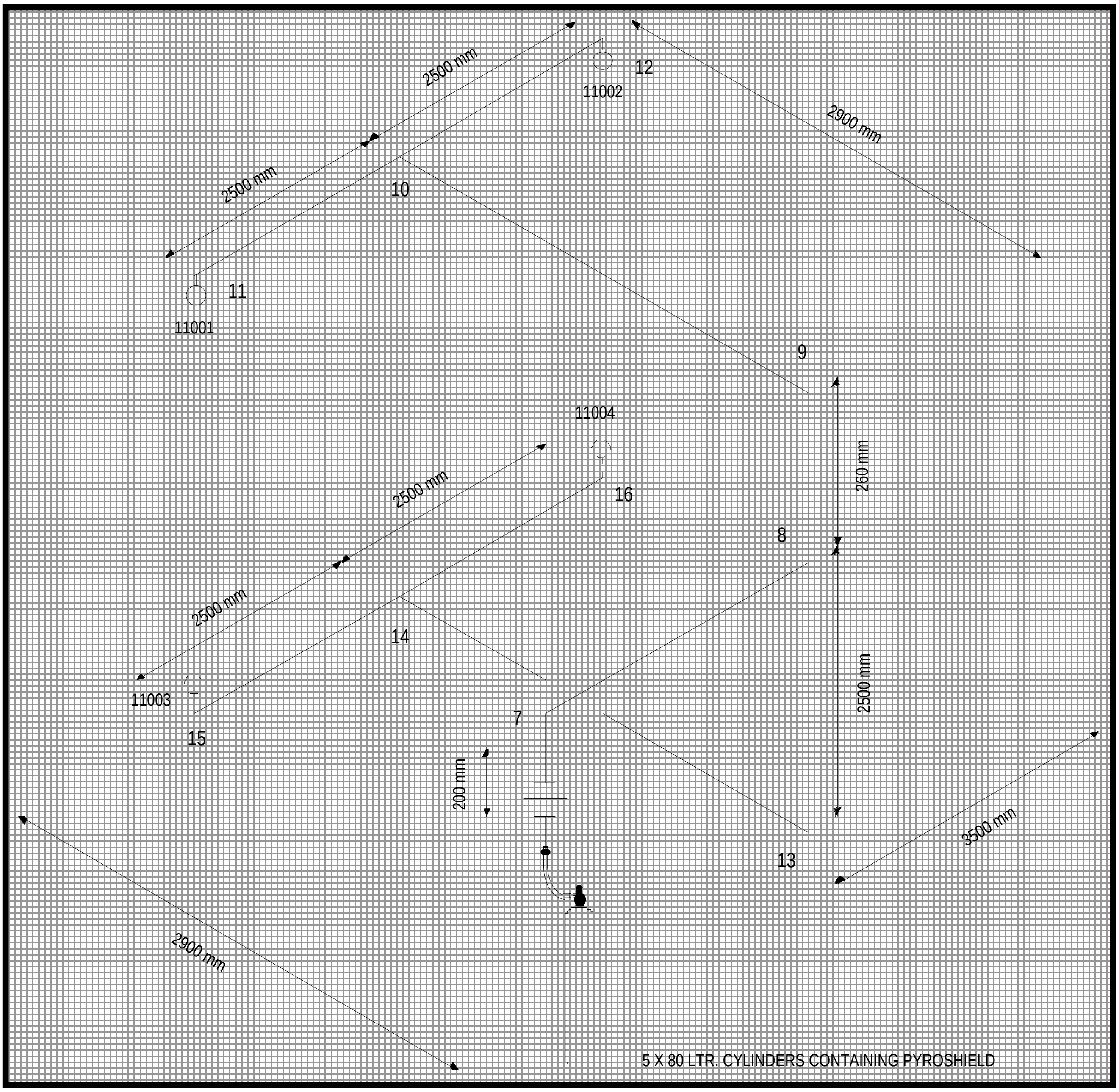

Figure 25 Example of isometric drawing

SECTION 5. INSTALLATION

This section provides guidance on the installation of PYROSHIELD Fire Fighting Systems. However, it is important that persons involved in the installation of this equipment have had previous experience in the installation of this or similar equipment.

Equipment is to be installed in accordance with the approved drawing. It is not permitted for changes to equipment, pipe work or nozzle positions to be made without the authority of the Design Engineer.

5.1 PRE-INSTALLATION STEPS:

Delivery and Handling of Equipment:

i) Check all equipment delivered against the delivery note.

ii) Notify A.S.T. should there be any discrepancy between the equipment received and that indicated on the Delivery Note.

iii) Store all equipment in a dry room at a temperature between 0°C and 50°C and protected from direct sunlight, until it is required for installation. Keep containers upright and secure them so that they cannot fall over.

Make no attempt to move PYROSHIELD containers unless they are fitted with transport caps and safety plugs.

To move PYROSHIELD containers use a trolley and if containers are to be raised over steps etc; ensure that appropriate lifting gear is employed. Under no circumstances must containers be rolled or dropped into position. Moving a container over a short distance is normally achieved by carefully rolling it on its edge.

Until containers are securely racked, the transport caps must not be removed.

5.2 INSTALLATION

The following steps should be followed when installing a PYROSHIELD system

5.2.1 CONTAINER FIXING

Cylinders may be located inside or outside the protected space, although it is preferable to locate them outside of the space. They must not be located where they will be exposed to a fire or explosion in the hazard. When they are installed within the space they protect they must be placed within a fire rated enclosure. Also a remote control must be installed to release the system safely outside the hazard area.

The container bank will be constructed to allow fitting to wall/supporting structure. Follow the instructions below depending on which fixing method is required.

- Check that there is at least 300mm free access at the ends of the container bank, and at least 1000mm free access at the front of the bank.
- Ensure that the floor and walls are flat. If it is suspected that the floor is likely to become wet, place the containers on metal grating to keep them off the floor.
- Protect the cylinders from direct sunlight and confirm that the temperature is within 0^{o}C and 50^{o}C.
- Mount the unistrut against the wall/support.
- Stand cylinders and fix the cylinder brackets, securing each cylinder

5.2.2 INSTALLATION OF MANIFOLDS

- Confirm that the correct size manifold has been delivered to site.
- Mount manifold on support brackets.
- Secure manifold brackets ensuring that the gas inlet tee pieces will align satisfactorily with gas cylinders.
- Fit non-return valves into tee pieces.

5.2.3 INSTALLING THE PRESSURE REDUCING UNITS

- Check against the drawing that the correct sized orifice has been supplied.
- Follow the procedure outlined below to ensure correct assembly of the pressure reducing unit:

Ensure the pressure-reducing unit is located in the pipe work as detailed on the installation drawing.

Screw in the downstream pipe work via a 'union' ensuring that the pipework fitted is a minimum length of 5 times the diameter of the pipe before any change in direction (i.e. the use of an elbow or 'T' piece).

5.2.4 PIPE WORK INSTALLATION

- Install all pipe work from the pressure-reducing unit to the nozzles in accordance with the approved installation drawing. **All nozzles are to be strictly positioned in accordance with these drawings and are to be adequately fixed to prevent movement resulting from the reaction to the discharg**e.
- If a requirement at the time of installation, carry out a purge of the pipework using, nitrogen or air. Ensure that all personnel are outside the protected area or any other area that could be affected by a discharge. If a purge of the pipework is not required or possible at this stage, ensure this is reported to the Project Manager so that arrangements can be made for this to be done at the commissioning stage.

5.2.5 INSTALLING THE CONTAINERS

- en the containers are in their general position in the "container" bank, align the discharge outlet with the manifold inlet via the painted silver dot, and screw the transport cap back on.
- Secure the first container to P1000 trunking using the securing loops provided. Bring the next container into position, and repeat operation. Continue with the installation of all containers as stated.

5.2.6 COMPLETING THE INSTALLATION

- When all containers are firmly secured remove the transport cap and remove discharge outlet safety plug. **Fit all manifold hoses hand tight only.**
- Install the actuation line using a combination of actuation hoses, adapters and washers. **Hand tighten actuation hoses only.**
- Fit the container pressure indicators to the valves. These are fitted hand tight and should give a pressure reading when correctly fitted. **Use a torque spanner set at 22.5 Nm to achieve this.**
- Use soap solution to check that the seal is tight. **Do not over-tighten as this could damage the O-ring**.
- Fit all door caution and manual control signs.
- Visually check installation for completion in accordance with the approved installation drawing.

SECTION 6. COMMISSIONING

This section provides guidance on the commissioning of PYROSHIELD Fire Fighting Systems and is in the form of a checklist to be completed by the commissioning engineer and must be completed for all installations. The commissioning schedule is detailed on pages 6-4 to 6-8.

It is requisite that persons carrying out commissioning of PYROSHIELD systems are experienced in the commissioning of this type of equipment.

Actuation lines are to be tested in accordance with the procedure detailed below, but only when remote actuation is used. A nitrogen container with a suitable regulator will be needed to test the actuation lines.

6.1 TEST PROCEDURE FOR PNEUMATIC ACTUATION LINES

- Check that actuation line plugs are fitted at the end of each line.
- Disconnect the actuation tubing at the master and pilot container.
- Connect the end of the hose from the test container to the open end of the actuation tubing. Ensure this joint is tight. For additional safety both the Engineer and test container should be outside the room housing the PYROSHIELD container bank.
- Set the outlet pressure on the Test Container regulator to 2 bar.
- Open the Test container valve to allow nitrogen into the actuation tubing, then close the valve.
- Leave the pressure in the actuation line for 3 minutes. If there is any loss of pressure check for leaks using soap solution. Repair any leaks before proceeding.
- Upon completion of the tests on the actuation lines safely disconnect the test container and remove all actuation line pressure via the actuation line end plug. Then re-seat end plug.

6.2 PILOT CYLINDER OPERATIONS TEST

- Remove the electrical plug from the solenoid.
- Remove the pilot actuation hose from the pilot cylinder valve outlet and retain the fibre washer.
- Fit the screw cap nut onto the outlet of the pilot cylinder – tighten with a spanner to ensure that it is gas tight.
- Ensure the manual lever is secured in the safe position.
- Activate the valve electrically for about 1 to 2 seconds and turn off the electrical supply. The valve will be heard to operate.
- Slacken the vent screw with hexagon socket by a half turn, thereby ventilating the upper valve area. You will hear the valve close.
- Carefully slacken the screw cap nut by half a turn. You will hear gas escaping for a short time: this demonstrates that the mechanical portion of the valve has operated correctly.

CAUTION:

The gas should stop escaping almost immediately. Otherwise, if the valve is not closed, the screw cap must not, under any circumstances, be detached.

- If the valve does not open or close this can indicate a malfunction of the valve, in which case the valve will need to be replaced. If the valve is open, discharge the cylinder through the valve outlet by gently slackening the screw cap nut. Take care to ensure that the cylinder is secured before attempting to discharge. Under no circumstances remove the outlet cap nut completely while it is under pressure.
- If the valve functions correctly, close the vent screw gas tight.
- Ensure that the electrical activation lines are free of voltage and re-fit the solenoid plug.
- Record data on "INSPECTION REPORT – PILOT CYLINDER ASSEMBLY" FORM ASTF 017A – PS/200/PCYLASS.
- Identify with GREEN sticker if assembly passes and RED sticker if assembly fails.

For further information please refer to Appendix 3.

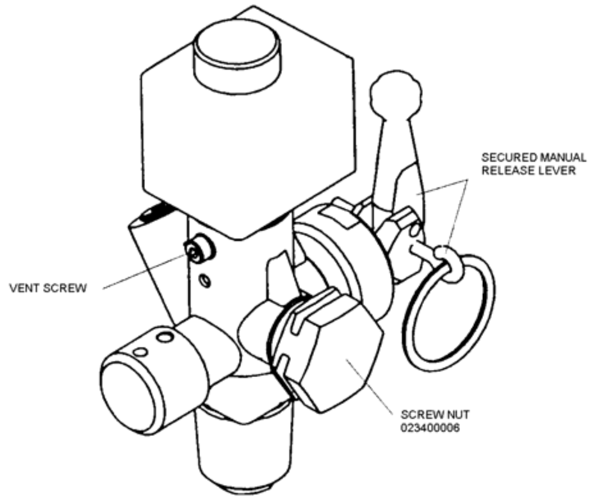

Figure 26 Pilot Cylinder Valve

TEMPERATURE (DEG. C)	MINIMUM PRESSURE AT INSPECTION (BAR)	NOMINAL PRESSURE (BAR)	MAXIMUM PRESSURE WHEN CHARGING (BAR)
-20	157	165	173
-15	161	170	178
-10	166	175	184
-5	171	18	189
0	176	185	194
5	181	190	199
10	185	195	205
15	**190**	**200**	**210**
20	195	205	215
25	200	210	220
30	204	215	226
35	209	220	231
40	214	225	236
45	219	230	241
50	223	235	247
55	228	240	252
60	233	245	256

Table 21 Pressure/Temperature Chart for Filling and Inspection

6.3 COMMISSIONING DOCUMENT (EXAMPLE)

COMMISSIONING DOCUMENT

CLIENT :--- ***COMMISSIONED BY:-----------------------------------***

ADDRESS:--- ***DATE:--***

--

PROTECTED AREA--

INITIAL INSTRUCTIONS	CHECK COMPLETED	REMARKS
a) Advise all personnel working in or near the protected area of possible audible/ visual alarms.		
b) Advise client of any equipment, which will be switched off during the tests.		
c) Re-measure the protected area and confirm that the quantity of agent supplied is sufficient for the measured volume.		
d) Check that the system has been installed in accordance with the drawings. Note any changes.		
e) Before carrying out any further checks ensure the Extinguishing system is isolated electrically and mechanically, remove any pneumatic actuators.		

ELECTRICAL CHECK LIST

Systems with automatic electrical detection (Coincidence operation)	CHECK COMPLETED	REMARKS
a) Place the system in automatic mode and check lamps are amber on control panel and all status units.		
b) Operate one detection zone.		
c) Check fire alarm sounds (First alarm only).		
d) Check extinguishant release solenoid does not operate.		
e) Switch system to manual mode and check lamps are green on control panel and all status/indicator units.		
f) Operate second detection zone.		
g) Check extinguishant release solenoid does not operate.		
h) Switch system to automatic mode with two detection zones still in alarm.		
i) Check evacuation alarm sounds.		
j) Check A/C shutdowns etc.		
k) Check extinguishant release solenoid operates after pre-determined time delay.		
l) Reset the pressure switch after manual test, and then reset the fire alarm system.		
m) Check operation of each electrical manual release unit in turn, and ensure operation of solenoid after pre-determined time delay.		
n) Check fire alarm and evacuation alarm sounds, and ensure operation.		
o) Reset system. Ensure frangible elements are refitted to manual release units.		

Systems with electrical manual release only.	CHECK COMPLETED	REMARKS
a) Operate each electrical manual release unit in turn.		
b) Check fire alarm and evacuation alarm sounds.		
c) Check all A/C shutdowns etc.		
d) Check extinguishant release solenoid operates after pre-determined time delay.		
f) Reset the fire alarm system. Ensure frangible elements are refitted to manual release units.		

Ancillary Tests	CHECK COMPLETED	REMARKS
a) Detach solenoid flexible lead and check system fault is generated.		
b) Check adequate and appropriate visual and audible warning devices are incorporated into the system.		
c) Record time delay. This should not normally exceed 30 seconds but must be sufficient for safe egress from protected area.		
d) Confirm all A/C systems are linked into the extinguishing system to shutdown prior to, or upon release of gas and these have been checked. Check any other systems that maybe required to operate or shutdown.		

MECHANICAL CHECK LIST

Pipework / Nozzles	CHECK COMPLETED	REMARKS
a) Check pipes and fittings are to the correct standard.		
b) Check pipe work supports have been fitted at the correct intervals and are suitable for the purpose.		
c) Check all nozzles are fitted in accordance with the design drawing. Check that nozzle orifice area corresponds to the approved installation drawing.		
d) Check all pipes and nozzles are sufficiently braced against the reaction to discharge.		
e) Check pipe work has been painted.		
f) Purge the pipe work to confirm it is continuous and free from debris, and oil.		
g) Remove nozzles to ensure they are free of debris following the purge.		
h) Steps (f) and (g) may be omitted from the commissioning procedure if written evidence is available that the pipe work was purged at an appropriate stage during installation.		

Containers	CHECK COMPLETED	REMARKS
a) Check containers are safe from mechanical damage, corrosion or unauthorised interference.		
b) Check container racking and brackets are correctly fitted.		
c) Check all containers are fitted with instruction plates properly completed.		

Record PYROSHIELD Container Details Below

Area Protected	Containers		Pressure (bar)	Temp. Deg.C	Corrections Required YES/NO
	Size (litres)	Serial no.			

Ancillary Checks	CHECK COMPLETED	REMARKS
a) Check pneumatic actuation tubing is firmly fixed.		
b) Check all pneumatic actuation-tubing connections are tight and tested in accordance with the instructions in Section 5 of the PYROSHIELD design manual.		
c) Check all pneumatic actuators are tested in accordance with the instructions in Section 5 of the PYROSHIELD design manual.		
D) Check any dampers close and/or fire curtains drop correctly to fully cover openings.		
e) Check that a container pressure indicator is fitted to each container, is indicating the container pressure and that it has been checked for leaks.		
f) Check pressure gauges are fitted to any pilot containers.		
g) Check solenoid flexible lead is correctly fitted and secured using fixing screw.		
h) Upon completion of all checks ensure solenoid is reset and fit solenoid to pilot cylinder and ensure it is fully tightened by hand.		
i) On systems utilising local manual actuator, check safety pin is fitted.		
j) Ensure local manual actuator is reset and fit to pilot cylinder and ensure it is fully tightened by hand.		
k) Check door caution plates are fitted at all doors into protected areas.		
l) Check manual release caution plates are fitted at all manual control points.		

Enclosure Integrity and Over Pressure venting	CHECK COMPLETED	REMARKS
a) Confirm that a Room Integrity check has been performed on the protected area.		
b) Record whether a satisfactory retention time was achieved.		
c) If not, visually inspect the protected area and record any leakage sites i.e. at cable entries.		
d) Confirm that calculations have been carried out to determine the over pressure venting requirements.		
e) Confirm that an over pressurisation vent has been installed if required.		

Completion	CHECK COMPLETED	REMARKS
a) On completion ensure client is informed of any outstanding actions on his part and confirm these in writing.		

SECTION 7. RESETTING AND RECHARGE

7.1 RESET DETECTION AND CONTROL SYSTEM

Refer to the appropriate manufacturers installation, operation and maintenance manuals for complete and detailed resetting instructions.

7.2 CHECK ELECTRICAL AND MECHANICAL EQUIPMENT

The following steps need to be followed when checking the electrical and mechanical equipment:

7.2.1 PIPING AND NOZZLES

A fire condition could cause damage to the piping and nozzles and possibly support members. Check all rigid pipe supports and all fitting connections. Take the nozzles off the piping, inspect for damage, corrosion, or obstructions, clean and re-install.

7.2.2 SELECTOR VALVE

Reset the selector valves by completing the following steps:

- Bleed all pressure by pushing and holding the bleed valve on the selector valve (if fitted).
- Reset manually with reset tool where required.
- If necessary, reset any selector logic control circuitry.

7.2.3 PRESSURE SWITCH

Reset the pressure switch by completing the following steps:

- Make certain all pressure in the line to the switch has been properly relieved.
- Push in red knob on end of pressure switch plunger.
- Make certain electrical function has been correctly reset.

Note: The self resetting type pressure switch will auto-reset and does not require manual intervention.

7.3 PLACE SYSTEM BACK IN SERVICE

7.3.1 RECHARGE CYLINDERS

CAUTION:

If maintenance is required to be performed on the valve before recharging, return to an authorised AST (pty) Ltd. recharging facility.

The following steps must be followed when removing discharged cylinders from the system:

1 Remove all electrical connections from the pilot cylinder valves. Next remove the pilot actuation hose. Note that the pilot cylinder will have to be returned for refill.
2 Remove all actuation hoses and hoses from valve outlet.
3 Disconnect flexible discharge hose from valve outlet. Refit safety plug into valve outlet.
4 Determine if discharged cylinder requires hydrostatic testing prior to being recharged. Note last hydrostatic date on cylinder collar.
5 Empty cylinder can now be sent to an authorised recharge facility for filling.
6 Recharging must be done by only AST (Pty) Ltd. authorised recharging facility.

7.3.2 ACTUATION HOSES AND FITTINGS

Re-install all actuation hoses and fittings previously removed. Pay particular attention to the fitting of o-rings in the actuation hose and fitting ends.

7.3.3 PILOT CYLINDER

1 Re-install the pilot cylinder and fit the pilot actuation hose ensuring that the fibre washer is correctly installed.
2 Ensure that there is no voltage on the pilot cylinder electrical connection and refit.
3 Follow the test procedure outline in section 6.2 to ensure that the pilot cylinder valve is functioning correctly.

7.3.4 NOTIFY OWNER

Notify the owner and consultant/responsible person that the system has been recharged and placed back in service.

Obtain written acceptance indicating that the system is handed over and back in service from the owner.

SECTION 8. INSPECTION & MAINTENANCE

This section provides guidance on the inspection and maintenance of PYROSHIELD Fire Fighting Systems. Inspection and maintenance as detailed should be carried out at regular intervals, although local conditions may indicate a need for more frequent visits. However, it is important that persons involved in the inspection and maintenance of this equipment have had previous experience with PYROSHIELD or similar equipment.

Before carrying out any checks, ensure the extinguishing system is isolated electrically and mechanically. Remove all actuators.

Upon completion of all checks ensure all electrical/mechanical actuators are reset and refitted.

8.1 INSPECTION

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 there is no obvious physical damage, or condition, to prevent operation. The value of an inspection lies in the frequency, and thoroughness with which it is conducted. Systems should be inspected at regular monthly intervals, or at more frequent intervals when circumstances require.

The following visual checks should be performed during a PYROSHIELD system inspection:

- Visually inspect the hazard area to verify that it has not changed. Look for different fuels, new equipment, blocked open doors or dampers, more movable solid object added etc.
- Check detectors to make certain they are in place, not damaged or coated with dirt, grease, paint, or any contaminating substance.
- Check all manual call points to assure they have not been tampered with and are not blocked from use.
- Check all alarm devices for damage, dirt, corrosion etc.
- Check that the piping is secure and nozzles are in place. Make certain the nozzles are not covered with dirt, grease, or paint and that there is nothing structural blocking the discharge.
- Visually inspect all components for signs of damage, such as disconnected or loose parts, corrosion, twisted or dented components etc.
- Check each cylinder to ensure that all hoses and actuators are securely fitted.
- Verify that all pressure switches are in place and are in the correct, non-operated position.
- Visually verify that control panel and/or releasing device is functioning properly.
- Perform any other checks that may be required by the consultant or end user.
- Record that the system has been inspected and inform the proper personnel.

8.2 MAINTENANCE

Systems shall be maintained at regular intervals, preferably at the very least every six months, or when specifically indicated by an inspection. Maintenance is a "thorough check" of the system. It is intended to give maximum assurance that a system will operate effectively and safely. It includes a thorough examination and any necessary repair, recharge or replacement. It will reveal if there is a need for hydrostatic testing of the cylinder. A maintenance schedule has been provided as part of this manual. Make certain that all people affected by the maintenance are informed before you start. This might include the owner, security personnel, the local Fire Department, and possibly local workers that may be affected by equipment shutdown or start up.

8.3 SERVICING AND MAINTENANCE SCHEDULE (EXAMPLE)

SERVICING AND MAINTENANCE SCHEDULE

CLIENT :--- ***SERVICED BY:***---

ADDRESS:-- **DATE:**--

PROTECTED AREA:--

INITIAL INSTRUCTIONS	CHECK COMPLETED	REMARKS
a) Advise all personnel working in or near to the protected area of possible audible/visual alarms.		
b) Advise client of any equipment which will shutdown during the tests.		
c) Check that the volume of the risk has not altered. If any doubt exists refer to the Design Engineer.		
d) Before carrying out any further checks ensure the Extinguishing system is isolated electrically and mechanically, remove all electrical and pneumatic actuators.		

ELECTRICAL CHECK LIST

Systems with automatic electrical detection (Coincidence operation)	CHECK COMPLETED	REMARKS
a) Place the system in automatic mode and check lamps are amber on control panel and all status units.		
b) Operate one detection zone.		
c) Check fire alarm sounds (first alarm only).		
d) Check extinguishant release solenoid does not operate.		
e) Switch system to manual mode and check lamps are green on control panel and all status units.		
f) Operate second detection zone.		
g) Check extinguishant release solenoid does not operate.		
h) Switch system to automatic mode with two detection zones still in alarm.		
i) Check evacuation alarm sounds.		
j) Check A/C shutdowns etc.		
k) Check extinguishant release solenoid operates after pre-determined time delay.		
n) Reset the fire alarm system.		
o) Check operation of each electrical manual release unit in turn, and ensure operation of solenoid after pre-determined time delay.		
p) Check fire alarm and evacuation alarm sounds.		
q) Reset system. Ensure frangible elements are refitted to manual release units.		

Systems with electrical manual release only.	CHECK COMPLETED	REMARKS
a) Operate each electrical manual release unit in turn.		
b) Check fire alarm and evacuation alarm sounds.		
c) Check all A/C shutdowns etc.		
d) Check extinguishant release solenoid operates after preset time delay.		
e) Upon operation check red lamps are lit on control panel (if applicable) and all status units.		
f) Reset the fire alarm system. Ensure frangible washers are refitted to manual release units.		

Ancillary Tests	CHECK COMPLETED	REMARKS
a) Detach solenoid flexible lead and check system fault is generated.		
b) Check adequate and appropriate visual and audible warning devices are incorporated into the system.		
c) Record time delay. This should not normally exceed 30 seconds but must be adequate for safe egress from protected area.		
d) Confirm all A/C systems are linked into the extinguishing system to shutdown prior to, or upon release of gas and these have been checked.		

MECHANICAL CHECK LIST

Pipework/Nozzles	CHECK COMPLETED	REMARKS
a) Check that the pipe work has not been altered or tampered with since the last visit.		
b) Check all nozzles are fitted in accordance with the design requirements and are aimed in the correct alignment away from obstructions or barriers that could prevent adequate distribution/mixing of the gas.		
c) Check all pipes and nozzles are adequately braced against the reaction to discharge.		
d) Check pipe work has been painted and/or properly identified.		
e) If any doubt exists concerning the integrity of the pipe work, arrange for it to be purged. Remove nozzles to check they are free of debris following the purge.		

Containers	CHECK COMPLETED	REMARKS
a) Check containers are safe from mechanical damage, corrosion or unauthorised interference.		
b) Check container racking and bracketry is complete and are correctly fitted.		
c) Check all containers are fitted with instruction plates properly completed.		
d) Note any containers requiring hydrostatic test.		

Record PYROSHIELD Container Details Below

Area Protected	Containers		Pressure (bar)	Temp. Deg.C	Corrections Required YES/NO
	Size (litres)	Serial no.			

Ancillary Checks	CHECK COMPLETED	REMARKS
a) Check pneumatic actuation tubing is firmly fixed and connections are tight.		
b) Check any dampers close and/or fire curtains drop correctly to fully cover openings.		
c) Check that a container pressure indicator is fitted to each container and is indicating the container pressure correctly and that it has been checked for leaks.		
d) Check pressure gauges are fitted to any pilot containers.		
e) Check solenoid flexible lead is correctly fitted and secured using fixing screw.		
f) Upon completion of all checks ensure solenoid is reset and fitted to the pilot cylinder.		
g) Ensure local manual actuator is reset and fitted to pilot cylinder.		
h) Check door caution plates are fitted at all doors into protected areas.		
i) Check manual release caution plates are fitted at all manual control points.		

Enclosure Integrity and Over Pressure venting	CHECK COMPLETED	REMARKS
a) Confirm that a Room Integrity check has been performed on the protected area.		
b) Record whether a satisfactory retention time was achieved.		
c) If not, visually inspect the protected area and record any leakage sites i.e. at cable entries.		
d) Confirm the free movement of any over pressure vent flaps.		
e) Confirm that an over pressurisation vent has been installed if required		

Completion	CHECK COMPLETED	REMARKS
a) On completion of the service ensure the client is informed of any outstanding items that require attention on his part and confirm these in writing.		
b) Obtain the signature of the client's representative on the handover certificate and leave a copy for the client.		

SECTION 9. APPENDIX 1

“Approval Documents For Pyroshield 200 Bar System”

SECTION 10. APPENDIX 2

“Material Data Sheet”

MATERIAL SAFETY DATA SHEET ACCORDING TO 91/155/EEC

I. IDENTIFICATION OF THE SUBSTANCE / PREPARATION
AND THE COMPANY

I.1 Trade name: PYROSHIELD

I.2 Manufacturer/Supplier: ALIEN SYSTEMS & TECHNOLOGIES (Pty) Ltd
P.O. Box 396
Walkerville
1876
South Africa
Tel: +2711 9491157
Fax: +2711 9491110
Data: +2711 9491110
e-mail: mike@astafrica.com

II. COMPOSITION / INFORMATION ON INGREDIENTS

II.1 Chemical formula: Gas mixture with:
50 Vol. % Nitrogen (N_2)
50 Vol. % Argon (Ar)

III. HAZARD IDENTIFICATION

III.1 For Human: see paragraph XI and XV.

III.2 For Environment: - none –

IV. FIRST AID MEASURES

IV.1 Inhalation: Take the injured person into the open air protecting yourself - if necessary consult a doctor.

IV.2 Eye contact: - none --

IV.3 Skin contact: -none –

IV.4 Ingestion: n.a.

V. FIRE-FIGHTING MEASURES n.a.

VI. ACCIDENTAL RELEASE MEASURES

VI.1 Personal precautions: Provide sufficient ventilation. Do not inhale gases/vapours/mist. If necessary, leave the room.

VI.2 Environmental precautions: n.a.

VI.3 Clean up methods: Ventilation of the rooms.

VII. STORAGE AND HANDLING

VII.1 Handling: Make sure container valve and connections are tight; Use in well ventilated areas. Only trained persons may handle compressed gas containers. Containers to be handled only with safety caps in place.

VII.2 Storage: To be stored only in original containers. Protect containers from heating over 50°C.

VIII. EXPOSURE CONTROLS / PERSONAL PROTECTION

VIII.1 Inhalation: Hand protection: If oxygen level is below 10 Vol. %, or in cases of long exposure, breathing apparatus (independent of circulating air) is necessary.

VIII.2 Hand protection: Protective gloves.

VIII.3 Eye protection: n.a.
VIII.4 Body protection: Protective shoes.

IX. PHYSICAL AND CHEMICAL PROPERTIES

IX.1 Chemical properties: Form: compressed gas
Colour: colourless
Odour: odourless
IX.2 Physical properties: Relative density: 1.41kg/cu.m@ 21degC
Vapour pressure: n.a.
Viscosity: n.a.
Solubility in water: 17,1 ml/l at 0°C
pH-value: n.a.
Flash point: n.a.
Ignition temperature: n.a.
Explosive properties: n.a.
Change of condition: n.a.

IX.3 Other data: Not flammable

X. STABILITY AND REACTIVITY

X.1 Conditions to avoid: Exposure of compressed gas containers to increased heat. Increased temperature will result in an increase in pressure which may cause the container burst disk to operate or in extreme cases the container to burst.
X.2 Materials to avoid: n.a.
X.3 Hazardous decomposition products: n.a.

XI. TOXICOLOGICAL INFORMATION

XI.1 Toxicological Information: Asphyxiant in high concentrations. In pure PYROSHIELD ® atmosphere there exists the danger of suffocation (through oxygen displacement).

XII. ECOLOGICAL INFORMATION

XII.1 Degradability: n.a.
Environmental impact rating: n.a
Acute aquatic toxicity: n.a.
Other indications: - none -

XIII. DISPOSAL CONSIDERATIONS

XIII.1 Product: - none

XIV. TRANSPORT INFORMATION

ALL FORMS OF TRANSPORT

Classification No. 2.2
Ing o. 2174
U.N. No. 1951

XV. OTHER INFORMATION

For application in fire extinguishing systems, the PYROSHIELD quantity is mainly designed to create oxygen concentrations between 10% and 15%, no hazards are known for the healthy human during short exposure in this atmosphere. However the combustion products from the fire itself could be highly toxic, therefore people shall always evacuate the protected volume when flooded with PYROSHIELD.

SECTION 11. APPENDIX 3

“Pilot Cylinder Valve Test”

SUBJECT : ASTWI 4.9 - 012 – PILOT CYLINDER VALVE TEST

REFERENCES

ALIEN SYSTEMS & TECHNOLOGIES (PTY) LTD QUALITY POLICY MANUAL

ISO 9001 – 1994 "INTERNATIONAL STANDARD FOR QUALITY SYSTEMS – MODEL FOR QUALITY ASSURANCE IN DESIGN, DEVELOPMENT, PRODUCTION, INSTALLATION AND SERVICING", ELEMENT 4.9

1.0 OBJECTIVE

To ensure that all Pilot Cylinder Valves are tested in accordance with specifications.

2.0 SCOPE

This procedure allows the simultaneous electrical & mechanical test of the pilot cylinder assembly as used by AST on their Pyroshield™ and CO_2 gas extinguishing systems.

The procedure shall only be performed by personnel who have undergone the necessary training at the premises of AST.

3.0 RESPONSIBLE PERSONS

Factory Manager
Assembler / Tester
Installation Contractors

4.0 PROCEDURE

EQUIPMENT

1. Screw cap nut for pilot cylinder.
2. Spanner & 3mm hexagon socket head wrench.

PERFORMANCE TEST - Refer to FIGURE 1.

1) Remove the electrical plug from the solenoid.

2) Remove the pilot actuation hose from the pilot cylinder valve outlet and retain the fibre washer.

3) Fit the screw cap nut onto the outlet of the pilot cylinder – hand tighten with a spanner to ensure that it is gas tight.

4) Ensure that the manual lever is secured in the safe position.

5) Activate the valve electrically for about 1 to 2 seconds and turn off the electrical supply. The valve will be heard to operate.

6) Slacken the vent screw with hexagon socket by a half turn, thereby ventilating the upper valve area. You will hear the valve close.

7) Carefully slacken the screw cap nut by half a turn. You will hear gas escaping for a short time: this demonstrates that the mechanical portion of the valve has operated correctly.

Note:
The gas should stop escaping almost immediately. Otherwise, if the valve is not closed, the screw cap nut must not, under any circumstances, be detached.

8) If the valve does not open or close this can indicate a malfunction of the valve, in which case the valve will need to be replaced. If the valve is open, discharge the cylinder

through the valve outlet by gently slackening the screw cap nut. Take care to ensure that the cylinder is secured before attempting to discharge. Under no circumstances remove the outlet cap nut completely while it is under pressure.

9) If the valve functions correctly, close the vent screw gas tight.

10) Ensure that the electrical activation lines are clear of voltage and re-fit solenoid plug.

11) Record data on “INSPECTION REPORT – PILOT CYLINDER ASSEMBLY”, FORM ASTF 017A – PS/200/PCYLASS

12) Identify with GREEN sticker if assembly pass and RED sticker if assembly fails.

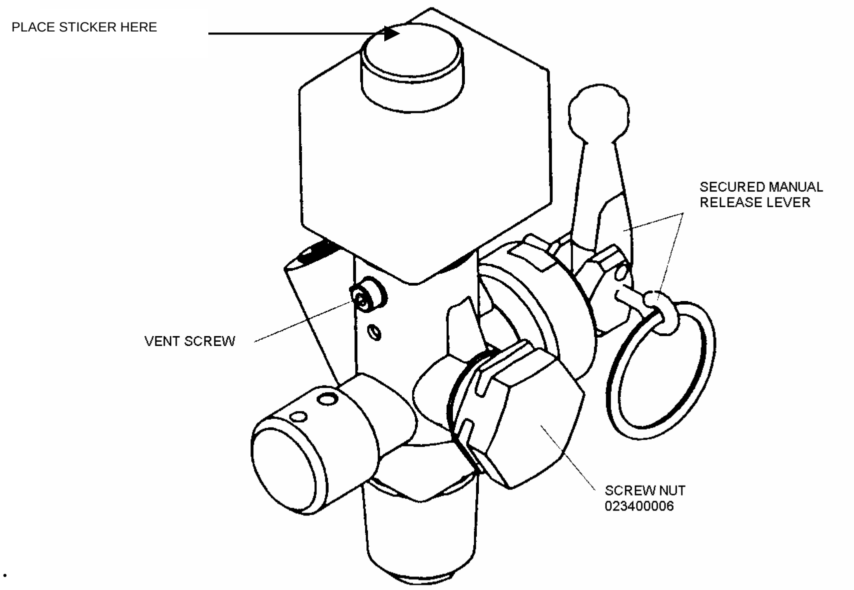

FIGURE 1.

5.0 APPLICABLE DOCUMENTS

5.1 RECORDS

“INSPECTION REPORT – PILOT CYLINDER ASSEMBLY”, FORM ASTF 017A – PS/200/PCYLASS

5.2 RECORD RETENTION

Refer to CONTROL OF QUALITY RECORDS – PROCEDURE 4.16.

SECTION 12. APPENDIX 4

"Inspection Report – Pilot Cylinder Assembly Form"

A.S.T. (PTY) LTD
CHECKLIST – FINAL INSPECTION
PILOT CYLINDER

CONTRACT NAME: ______________________ **JOB NO.:** __________

CUSTOMER: ______________________ **DATE:** ______________

INVOICE NO.: ____________________

INSPECTOR: ____

N/A = NOT ACCEPTABLE, ACC = ACCEPTABLE, REJ = REJECTED,
2ACC = ACCEPTABLE AFTER REWORK.

1.0 <u>VISUAL</u>

	N/A	ACC	REJ	2ACC
1.1 CHECK PART QUANTITIES.				
1.2 VISUAL CHECK PACKING.				

QUANTITY OF CYLINDERS INSPECTED: ______________________

QUANTITY OF CYLINDERS SUPPLIED: ______________________

<u>SPECIAL INSTRUCTIONS:</u>

RECORD CYLINDER SERIAL NUMBERS ON THE CYLINDER SERIAL NMBER RECORD AT THE BACK .

INSPECTORS SIGNATURE: ______________________ DATE: ______________

FACTORY MANAGER: ______________________ DATE: ______________