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LICHFIELD
FIRE & SAFETY
EQUIPMENT
CO. LTD.

LIFECO CO2
CARBON DIOXIDE
FIRE SUPPRESSION SYSTEMS

DESIGN, INSTALLATION, OPERATION AND MAINTENANCE MANUAL

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Revision History

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TABLE OF CONTENT

1.0 General Information

This document serves as a guide to designing a High Pressure CO_2 Fire Extinguishing System, using system hardware and components manufactured by LIFECO, according to UL.

1.1 Glossary

1.1.1 High Pressure Storage - Storage of CO_2, normally at 6.9 MPa at ambient temperature of 27°C

1.1.2 Total Flooding – Fixed supply of CO_2 permanently connected to fixed piping with nozzles arranged to discharge CO_2 into an enclosed space or enclosure about the hazard so that the design extinguishing concentration can be maintained

1.1.3 CO_2 Fire Extinguishing System - Fixed supply of CO_2 permanently connected to fixed piping and nozzles arranged to discharge CO_2 into the area being protected in such a manner that the design extinguishing concentration is achieved

1.1.4 Pilot Cylinder – CO_2 cylinder whose contents are only used for system actuation and whose contents do not form part of the quantity of extinguishant required

1.1.5 Local Application – Fixed supply of CO_2 permanently connected to fixed piping with nozzles arranged to discharge CO_2 directly on to the burning material or identified hazard

1.2 Warning Alarms

An audible (minimum sound level of 65 dB(A) or 5 dB (A) above the ambience sound level (whichever is greater) and visual alarm (minimum 50 rpm) shall be provided on all total flooding and local application systems. The alarm shall sound and flash during any delay period between fire direction and discharge and throughout the discharge. Alarm devices shall be supplied from an energy source sufficient to allow continuous operation of the audible alarm signal for a minimum of 30 min.

1.3 Shut Down of Plant Equipment

Before or simultaneously with, the release of a CO_2 system, all equipment capable of causing re-ignition of flammable material such as heating installation, gas burners, infrared lamps, etc. shall be switched off, except those required to provide life safety equipment.

1.4 Automatic Pressure Relief

CO_2 discharge may cause dangerous increase of pressure and may blow open doors or even weak walls or ceilings.

Venting shall be provided at the highest point of any room which is tightly closed, with:

$$X = 23.9 \frac{Q}{\sqrt{P}}$$

where,
X is the free venting area, in mm^2
Q is the calculated CO_2 flow rate, in kg/min, and
P is the permissible strength (internal gauge pressure) of enclosure (in bar).

In most cases, leakage around doors, windows, ducts and dampers, though not apparent or easily determined, may provide sufficient venting relief for normal CO_2 systems without special provisions being made.

1.5 Precautions during maintenance works

Provision shall be made to prevent automatic discharge during periods of entry by personnel where they may not be able to leave the room during any delay period.

This can be achieved by isolating the GAS DISCHARGE circuits on the Fire Alarm Control Panel.

1.6 Explosive Mixtures

In circumstances where explosive air/vapour mixtures may be present, the hazard area shall be carefully checked before any test discharge are made, due to the possibility of ignition by electrostatic discharge.

1.7 Compensation

Loses due to the following situations, shall be compensated, during the determination of CO_2 design quantity:

1.7.1 Unclosable openings and ventilation systems that **cannot** be shut down before or at least simultaneously with the initiation of discharge of the CO_2

1.7.2 Unclosable openings and where there is an absence of walls and/or ceilings

1.8 Discharge Test

Where Openings to the outside atmosphere, where wind conditions may greatly affect the CO_2 losses, discharge test to determine the design concentration shall be performed.

2.0 Agent

CO_2 is a colourless, odorless, electrically non-conductive, non-corrosive, and non-deteriorating inert Extinguishing agent.

At 0.03% in normal breathing air, CO_2, in gaseous state, at normal temperature (+15 °C) and atmospheric pressure, CO_2 has a density of 1.87kg/m^3, is 1.5 times heavier than air and spreads along the ground collecting in low-lying areas such as pits and cellars. It is a colourless and odourless gas (with a slightly pungent odour at high concentrations).

CO_2 can exist as a liquid below the critical temperature of 31°C and above the triple point with a temperature of -56.6 °C and 0.418 MPa gauge.

2.1 Storage And Pressure

This manual only limits to high pressure systems, where CO_2 are stored in seamless cylinders, at the filling ratio of 0.68 kg/Liter resulting in a pressure of 6.9 MPa at ambient temperature of 27°C.

2.2 Temperature

When discharged, liquid CO_2 is extremely cold (-78.5 °C) and may cause frostbite in contact with skin. If CO_2 snow comes into contact with the eyes, it may cause severe eye injury. Also rapid evaporation of the liquid can cause frostbite and cold burn.

2.3 Visibility

The discharge of CO_2 chills the moisture in the atmospheric causing the cloud effect, or sometimes called fogging. Fine white dry ice will be formed sometimes. Both this phenomenon reduces visibility in the area where CO_2 discharge takes place.

2.4 Noise

Loud noise may result from high pressure / velocity discharge from the nozzles.

2.5 Cleanup

CO_2 discharge needs minimum cleanup as the agent vaporizes almost completely immediately upon discharge leaving no residue or traces.

3.0 Use and Limitations

CO_2 is effective on:

a) Fires involving solid materials
b) Fires involving flammable liquids
c) Fire involving electrical installations

3.1 Areas of Use

Table 3.1 Examples of application hazard areas

Battery Rooms	Electric Generator	Paint Shops
Electrical Switch Rooms	EDM Machines	Paint Storage
Transformer Rooms	Switchgear Equipment	Printing Machines
UPS Rooms	Electric Motors	Dust Collector
Cable Trench	Raised Floor	Air Conveyors

3.2 Hazards where CO_2 NOT EFFECTIVE

CO_2 Extinguishing System is NOT EFFECTIVE on:

a) Materials having supply of oxygen, such as cellulose nitrate, gun powders, etc.

b) Reactive metals such as Kalium, Natrium (Sodium), Lithium, Magnesium, Titanium, Uranium or Plutonium

c) Metal Hydrides such as Sodium Hydride, Lithium Hydride, Calcium Hydride etc.

d) Areas where the construction of the enclosure to be protected **CANNOT** contain the CO_2

e) Areas where the walls and doors **NOT** capable of withstanding the effects of the fire for a sufficient time to allow CO_2 discharge to be maintained at the design concentration during the inhibition time

3.3 Areas where CO_2 System is PROHIBITED

In Malaysia, the authorities have issued notice of prohibition against the use of CO_2 Total Flooding Systems on **NORMALLY OCCUPIED AREAS**, therefore this system shall not be installed in such areas, unless approval from the authority are obtained.

3.4 Static Electricity

Discharge of liquid CO_2 into potentially explosive environment, may cause charging of Static Electricity on ungrounded components, which may result in an electric spark of sufficient energy to initiate an explosion.

4.0 Personnel Safety

Always wear **P**ersonal **P**rotection **E**quipment (PPE) as instructed when handling CO_2 System Equipment and components. Failure to do so is against the company's rules and regulations and is punishable under DOSH Regulations.

WARNING

4.1 CO_2 IS TOXIC, READ THIS AND TAKE PRECAUTIONS

IF INHALED, may cause suffocation, remove person to fresh air and keep comfortable for breathing. Get medical attention.

- ▶ Exposure to oxygen-deficient atmosphere (<19.5%) may cause dizziness, drowsiness, nausea, vomiting, excess salivation, diminished mental alertness, loss of consciousness and death.

- ▶ Exposure to atmospheres containing 8-10% or less oxygen will bring about unconsciousness without warning and so quickly that the individuals cannot help or protect themselves. Lack of sufficient oxygen may cause serious injury or death. Depending on concentration and duration of exposure to CO_2 may cause increased respirations, headache, mild narcotic effects, increased blood pressure and pulse, and asphyxiation.

- ▶ Symptoms of overexposure become more apparent when atmospheric oxygen is decreased to 15-17%. Contact with liquid may cause cold burns/frostbite.

4.2 First aid

The following Safety Requirements are to be taken into consideration by the System Installer.

Inhalation: remove victim to uncontaminated area and fresh air. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped

Skin/eyes contact: in case of frostbite spray with water for at least 15 minutes. Do not remove any clothing. Apply a sterile dressing. Obtain medical assistance. Immediately flush eyes thoroughly with water for at least 15 minutes, seek medical advice.

4.3 Agent Migration

Precautions for Low-Lying parts of protected areas

Where it is possible for CO_2 gas to collect in pits, wells, shaft bottoms or other low-lying areas, additional ventilation systems to remove the CO_2 after discharge shall be provided.

4.4 Safety Recommendations required by MS 1590, clause 5

In any proposed use of CO_2 Fire Extinguishing Systems where there is a possibility that people may be trapped in or enter into the protected area, suitable safeguards shall be provided to ensure prompt evacuation of the area, to restrict entry into the area after discharge, except where necessary to provide means for prompt rescue of any trapped personnel. Such safety aspects as personnel training, warning signs, discharge alarms, and breathing apparatus shall be considered. The following requirement shall be taken into account:

a) provision of exit routes which shall be kept clear at all times and the provision of adequate direction signs;

b) provision of alarms within such areas that are distinctive from all other alarm signals and that will operate immediately upon detection of the fire and release of the CO_2

c) provision of only outward swinging self-closing doors which shall be openable from the inside even when locked from the outside;

d) provision of continuous visual and audible alarms at entrances, until the atmosphere has been made safe;

e) provision for adding an odour to the CO_2 so that hazardous atmosphere may be recognized

f) provision of warning and instruction signs at entrances

g) provision of self-contained breathing equipment and personnel trained in its use;

h) provision of a means of ventilating the areas after extinguishing the fire; and

I) provision of any other safeguards that a careful study of each particular situation is necessary

4.5 Exposure

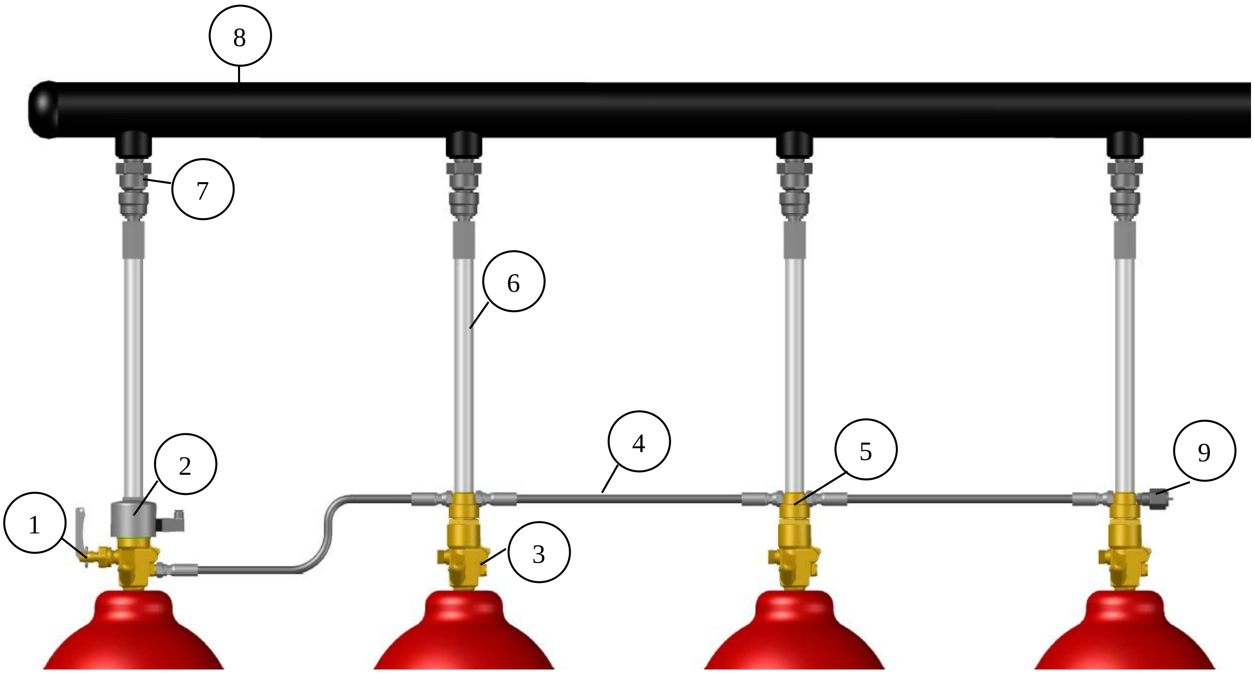
The following table gives the health effects of increasing exposure to CO_2 .

Table 4.5 Health Effects of high concentration of CO_2 (EPA430-R-00-002, Feb 2000)

Concentration (% CO_2 / Air)	**Time**	**Effects**
2%	Several Hours	Headache, dyspnea upon mild exertion
3%	1 Hour	Mild headache, sweating and dyspnea at rest.
4-5%	Within a few Minutes	Headache, dizziness, increased blood pressure, uncomfortable dyspnea
6%	1-2 minutes ≤ 16 minutes Several hours	Hearing and visual disturbances Headache and dyspnea Tremors
7-10%	Few minutes	Unconsciousness or near unconsciousness.
	1.5 minutes – 1 hour	Headache, increased heart rate, shortness of breath, dizziness, sweating, rapid breathing.
>10-15%	1 minutes to several minutes	Dizziness, drowsiness, severe muscle twitching and unconsciousness.
17-30%	within 1 minute	Loss of controlled and purposeful activity, unconsciousness, convulsions, coma and death.

5.0 System Components

The system consists of the following components:



1. Manual Actuator for solenoid valve	6. Discharge Hose W21.8-14TPI x 20mm BSP 500mm Straight
2. CO2 Solenoid valve DN12	7. Check valve
3. CO2 Discharge Valve DN12	8. Manifold
4. Pilot Hose M12-1.5 x 450mm DN6	9. Bleed valve
5. Pneumatic actuator 20bar	

Figure 5.0 A Typical CO_2 Total Flooding System

5.1 Cylinder Assembly

a) All CO_2 cylinders and valve assemblies and accessories are arranged to be accessible for inspection, testing and other maintenance when required.

b) All CO_2 cylinder are the same size, rechargeable and contain the same mass of CO_2.

c) Every cylinder comes with a protective cap for safe handling and transportation.

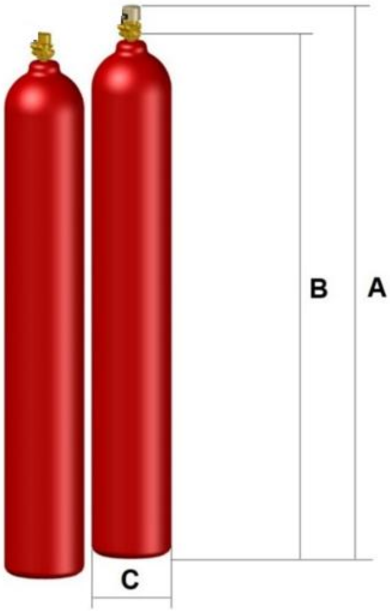


Figure 5.1 Cylinder Assembly

Table 5.1 Cylinders Specification

Description	Specification	
Part Number	LF-68CO-SV	LF-68CO-DV
Type	Solenoid valve	Discharge valve
Size	68L	
Cylinder Standard	ISO 9809-1	
Agent weight (CO_2)	45 kg	
Filled Pressure	58 bar at 21°C	
Cylinder Working Pressure	150 bar	
Cylinder Test Pressure	250 bar	
Total height, A	1597-1614mm	
Cylinder height, B	1532mm	
Cylinder Diameter, C	267mm	
Cylinder Tare Weight	70 kg	

5.2 Cylinder Handling and Support

All cylinder shall be firmly supported before put on service. The CO_2 cylinder bank are normally braced against a firm surface, such as the wall of the building, using full thread bolt and nuts, supported by an angle bar.

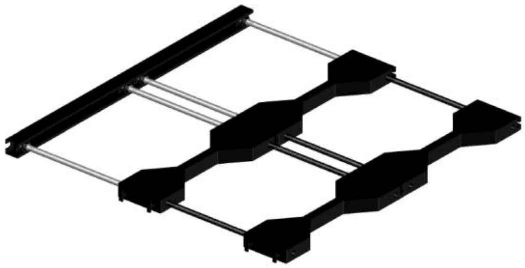


Figure 5.2.1 Cylinder Bracket

Table 5.2.1 Cylinder Bracket Technical Specification

Description	Specification
Material	Mild Steel
Paint	Epoxy Powder Coating (Black)
Mounting	Unistrut Channel

Part Number	Cylinder Size	Unistrut Channel Length	Row	Set comes with
LF- CB-80	68L	360 mm (14.2 inch)	1st Row	1x Strap, 2x M12 stud with c channel stopper, 2x washer, 2x Nut, 1x Unistrut channel
LF- CBX-80	68 L	N/A	2nd Row and above	1x Strap, 2x M12 stud

Pilot cylinder bracket designed to mount 4L and 10L Pilot cylinder to the wall. Pilot cylinder bracket features 2 strap design to give flexibility for adjustable height.

Figure 5.2.2 Pilot Cylinder Bracket

Table 5.2.2 Pilot Cylinder Bracket Technical Information

Description	Specification
Part Number	LF- CBP
Material	Mild Steel
Paint	Epoxy Powder Coating (Black)
Mounting	Wall

WARNING: Any cylinders, either filled or (deemed) empty, shall NOT be transported, without the **OUTLET SAFETY PLUG** and the **CYLINDER SAFETY CAP**. The outlet safety plug shall be removed only after the cylinders are firmly supported, and ready for connecting hoses.

The **OUTLET SAFETY PLUG** and the **CYLINDER SAFETY CAP** shall be retained and kept for future use. They shall NOT be disposed or lost.

5.3 Cylinder Valve Assembly

Valve operates by means of pressure differential piston. The valves incorporated with the features to enable it to be connected with manual and pneumatic actuator for actuation purpose. Each valve is provided with an anti-recoil cap. Only removed when connecting cylinder to pipework and refit when disconnecting the cylinder from pipework. There are 2 types of valves:

1) Discharge valve
2) Solenoid discharge valve

Figure 5.3.1 Discharge Valve

Table 5.3.1 Discharge Valve Technical Information

Description	Valve Size
Working Pressure	150 Bar
Part Number	LF-CODV
Outlet	W21.8 x 1/14”
Material	Brass
Test Pressure	360 Bar
Safety Disc Pressure	190 Bar
Equivalent Length	25.84m
Weight	1.16kg

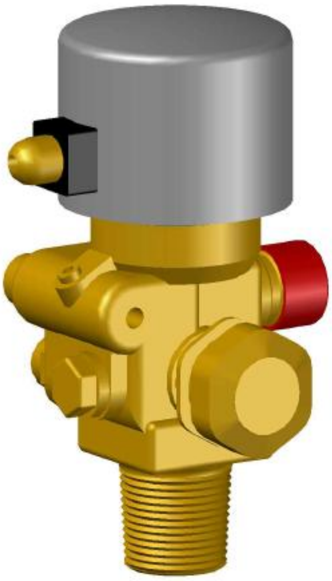


Figure 5.3.2 Solenoid Valve

Table 5.3.2 Solenoid Valve Technical Information

Description	Valve Size
Working Pressure	150 Bar
Part Number	LF-COSV
Outlet	W21.8 x 1/14"
Material	Brass
Test Pressure	360 Bar
Safety Disc Pressure	190 Bar
Equivalent Length	25.84m
Weight	1.55kg
Voltage	24 VDC
Max Current	0.4 A
Power consumption	9.3 W
Protection class	IP65

5.4 Pilot Cylinder

The cylinder assembly comprises of a cylinder factory fitted with a solenoid discharge valve (PN LF-IGEASV200) filled with nitrogen and pressurized to 200 Bar @ 15ºC (2900 psi @ 59ºF). Cylinders are available in 4L and 10L. Pilot assembly is to actuate cylinders pneumatically in a system and selector valve if system available. Pilot valve adaptor (PN: LF-PVA) is available to adapt the pilot cylinder to the pilot line.

Table 2.3.1 Pilot Cylinder Technical Information

Description	Specification	
Working Pressure	200 Bar @ 15ºC	
Size	4L	10 L
Part Number (ISO 9809)	LF-04PC-200	LF-10PC-200
Outlet	W21.8 x 1/14”	
Test Pressure	300 Bar	
Safety Disc Pressure	270 Bar (3916psi)	
Gauge Port	M12 x 1.0	
Equivalent Length	25.84m	
Weight	10kg	19kg
Voltage	24 VDC	
Max Current	0.4 A	
Power consumption	9.3 W	
Protection class	IP65	
Overall height	500mm	950mm
Cylinder diameter	140mm	

Figure 2.3.1 Pilot Cylinder Assembly

5.4.1 Automatic Electric Actuation

Detection and control system (not included in this system) shall be designed and provided as per the authority requirement.

Upon detection and confirmation of a fire, the control panel shall send an Electrical Signal to the Electric Actuator on the Pilot Cylinder. An ALARM is normally confirmed by implementing a Double Knock regime, where the detection by a single device needs acknowledgement from another device to be confirmed as an ALARM.

5.4.2 Manual Actuator

The manual actuator is designed to be used and installed with Master cylinder (PN: LF-68CO-SV) and Pilot Cylinder for mechanically actuation. Safety pin is provided with every actuator to prevent accidental discharge. Actuation by removing safety pin and moving lever to 90˚. Manual actuator features retractable pin which reset when level back to original position.

Figure 5.4.2 Manual Actuator

Table 5.4.2 Manual Actuator Technical Information

Description	Specification
Part Number	LF-COMA
Body	Brass C3604BD
Level	Stainless Steel
Safety Pin	Stainless Steel
Piston Rod	Brass C3604BD
Connection	M20 x 1.5
Overall Size	48mm (H) x 28mm (W)
Mounting Torque	15 Nm ± 1

5.4.3 Pneumatic actuator

Pneumatic actuator is designed to be used and installed with slave (PN: LF-68CO-DV) for pneumatically actuation. The pneumatic actuator features a pneumatically driven piston that used to depress the valve core and opening the valve. The pressure from the master cylinder is used to actuate the cylinder discharge valve of slave cylinder via flexible hose.

Figure 5.4.3 Pneumatic Actuator

Table 5.4.3 Pneumatic Actuator Technical Information

Description	Specification
Part Number	LF-COPA
Body	Brass C3604BD
Actuation Pin	Brass C3604BD
Valve Connection	M36 x 1.5
Pneumatic Connection	2 x 1/8” BSP
Overall Size	56.5mm (L) x 40mm (Diameter)
Pilot Pressure	Min 20 Bar (290 psi), Max 360 Bar (5221 psi)
Mounting Torque	25 Nm ± 2

5.4.4 Pneumatic manual actuator

Pneumatic Manual actuator is designed to be used and installed on valve for mechanically or pneumatically actuation.

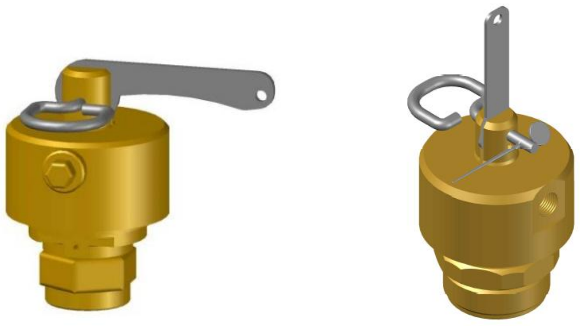


Figure 5.4.4 Pneumatic Manual Actuator

Table 5.4.4 Pneumatic Manual Actuator Technical Information

Description	Specification	
Part Number	LF-COMPA	LF-COMPA/1
Used with Valve	Discharge valve LF-CODV	Solenoid valve LF-COSV
Body	Brass C3604BD	
Actuation Pin	Brass C3604BD	
Valve Connection	M36 x 1.5	M20 x 1.5
Pneumatic Connection	2 x 1/8" BSP	
Overall Size	83mm (L) x 40mm (Diameter)	
Pilot Pressure	Min 8 Bar (116 psi), Max 300 Bar (4351 psi)	
Mounting Torque	15 Nm ± 1	

5.5 Discharge Hose

The discharge hose is equipped with a female swivel fitting at the inlet and enable to connect the cylinders to the manifold in multiple cylinder arrangements. This feature has enables cylinder to be disconnected during maintenance without any effort to remove other manifold connection and pipework.

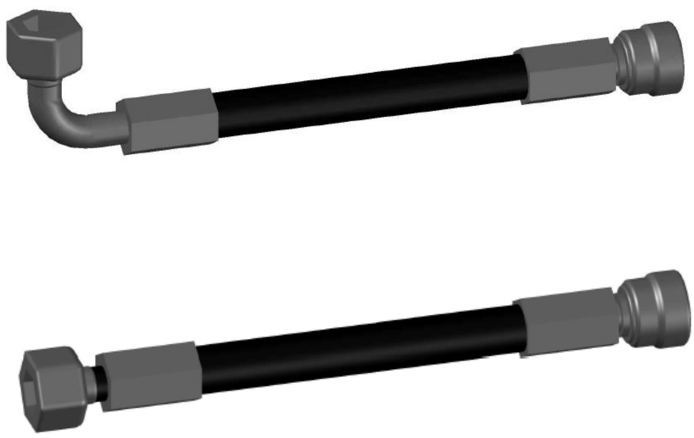


Figure 5.5 Discharge Hose

Table 5.5 Discharge Hose Technical Information

Description	**Specification**	
Part Number	LF-DH500E	LF-DH500S
Type	90˚ Elbow	Straight
Hose Material	Synthetic rubber	
Connection Material	Coated Steel	
Inlet Connection	W21.8 x 1/14”	
Outlet Connection	¾” BSP	
Min Bend Radius	250mm	
Max Working Pressure	360 Bar (5221 psi)	
Temperature Range	-20ºC to + 50ºC (-4 ºF to 122 ºF)	
Overall Length	500mm	
Size	DN12	

*Various length is available upon request.

5.6 Flexible Hose

The flexible hose is used to connect between the master cylinder valve port and slave cylinder pneumatic actuator and slave to slave cylinder pneumatic actuator. This flexible hose is act as a pressure connector.

Figure 2.12.1 Flexible Hose

Table 2.12.1 Flexible Hose Technical Information

Description	Specification	
Part Number	LF-PH350	LF-PH450
Hose Material	Synthetic rubber	
Connection Material	Coated Steel	
Connection	M12 x 1.5	
Min Bend Radius	30mm	
Max Working Pressure	360 Bar (5221 psi)	
Temperature Range	-20ºC to + 65ºC (-4 ºF to 149 ºF)	
Overall Length	350mm (L)	450mm(L)
Size	DN6	

*Various length is available upon request.

5.7 Bleed valve

Bleed valve is used and installed in pneumatic pilot lines to prevent and release unintended pressure developed in the pilot line.

Figure 5.7 Bleed Valve

Figure 5.7 Bleed Valve Technical Information

Description	Specification
Part Number	LF-BVPL
Material	Stainless Steel
Connection	1/8” BSP
Max Working Pressure	360 Bar (5221 psi)
Temperature Range	-20ºC to + 65ºC (-4 ºF to 149 ºF)
Overall Size	64mm (L) x 22mm (W)
Pressure	Closing : 0.4 Bar Increasing Pressure Opening: 0.5 Bar Falling Pressure

5.8 Manifold

Manifold is a steel pipework where contents of multiple cylinders discharged and direct connected to the appropriate pipe distribution system.

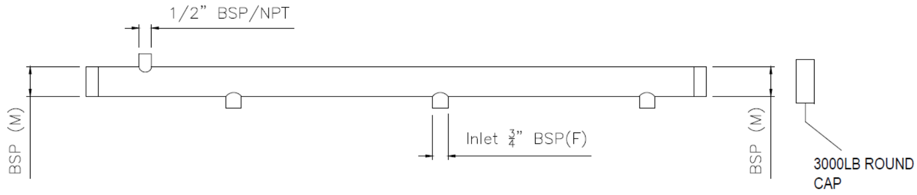


Figure 5.8.1 Manifold – Single Row

Table 5.8.1 Manifold Single Row Technical Information

Description	Specification
Cylinder size	80 L
Class	Schedule 80
Paint	Epoxy Powder Coating (Black / Red)
Working Pressure	90 bar
Test Pressure	180 bar
Port*	2-8
Size	3/4", 1", 1-1/4", 1-1/2", 2", 2-1/2", 3", 4"

Table 5.8.2 80L Manifold Single Row Part Number

MANIFOLD SIZE	20mm	25mm	32mm	40mm	50mm	65mm	80mm	100mm
No. of Port = 2	LF-2COM20-80	LF-2COM25-80	LF-2COM32-80	LF-2COM40-80	LF-2COM50-80			
No. of Port = 3	LF-3COM20-80	LF-3COM25-80	LF-3COM32-80	LF-3COM40-80	LF-3COM50-80	LF-3COM65-80	LF-3COM80-80	
No. of Port = 4		LF-4COM25-80	LF-4COM32-80	LF-4COM40-80	LF-4COM50-80	LF-4COM65-80	LF-4COM80-80	
No. of Port = 5		LF-5COM25-80	LF-5COM32-80	LF-5COM40-80	LF-5COM50-80	LF-5COM65-80	LF-5COM80-80	LF-5COM100-80
No. of Port = 6			LF-6COM32-80	LF-6COM40-80	LF-6COM50-80	LF-6COM65-80	LF-6COM80-80	LF-6COM100-80
No. of Port = 7			LF-7COM32-80	LF-7COM40-80	LF-7COM50-80	LF-7COM65-80	LF-7COM80-80	LF-7COM100-80
No. of Port = 8				LF-8COM40-80	LF-8COM50-80	LF-8COM65-80	LF-8COM80-80	LF-8COM100-80

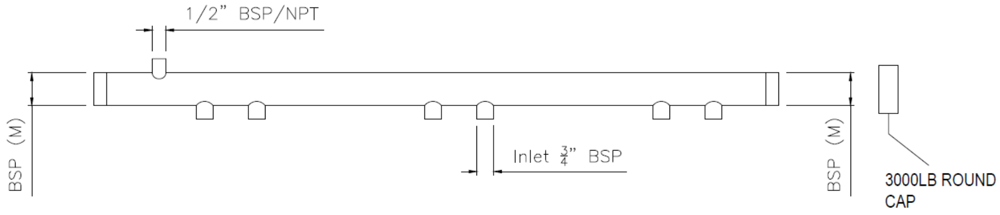


Figure 5.8.2 Manifold – Double Row

Table 5.8.3 Manifold Double Row Technical Information

Description	Specification
Cylinder size	80 L
Class	Schedule 80
Paint	Epoxy Powder Coating (Black / Red)
Working Pressure	90 bar
Test Pressure	180 bar
Port*	6
Size	Part Number
2"	LF-DR6COM50-80
2-1/2"	LF-DR6COM65-80
3"	LF-DR6COM80-80
4"	LF-DR6COM100-80

*Additional ports upon request.

5.9 Check Valve

Check valve is connected between discharge hose and constant pressure regulator before the manifold to prevent backflow of the agent during a discharge.

Figure 5.9.1 Check Valve

Table 5.9.1 Check Valve Technical Information

Description	Specification
Part Number	LF-CV
Nominal Size	12mm
Material	Stainless Steel
Connection	3/4" BSP Male
Working Pressure	360 Bar (5221 psi)
Overall Size	65mm (L) x 38mm (W)
Equivalent Length	0.48 m

The pilot line check valve is used to maintain pressure in a particular section of the pilot line or to ensure that nitrogen pressure from the pilot cylinder is operating the correct bank of cylinders.
A system using selector valve which consist of different numbers of cylinders for each hazard enclosure, can use the pilot line check valve to ensure the pilot pressure opens only the correct cylinder from the bank.

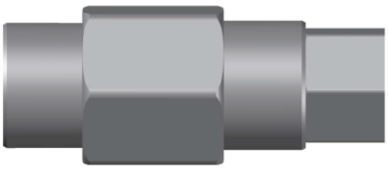


Figure 5.9.2 Pilot Line Check Valve

Table 5.9.2 Pilot Line Check Valve Technical Information

Description	Specification
Part Number	LF-CVPL
Material	Stainless steel
Connection	1/8” BSP Female
Working Pressure	360 Bar (5221 psi)

5.10 Fitting Adaptor

Connection adaptor and fitting for pilot line.

Figure 5.10.1 Connection adaptor and fitting

Table 5.10.1 Connection adaptor and fitting Technical Information

Description	**Specification**			
Part Number	LF-PHA	LF-SORS	LF-PVE	LF-SORT
Type	Straight	Tee (swivel on side)	Elbow	Tee (swivel on run)
Material	Steel (Zinc plated)			
Connection	1/8" BSP x M12 x 1.5	M12 x 1.5	M12 x 1.5	M12 x 1.5
Working Pressure	360 Bar (5221 psi)			

Table 5.10.2 Connection adaptor and fitting Technical Information

Description	**Specification**			
Part Number	LF-127N	LF-317N	LF-317A	LF-M12N
Type	Straight	Straight	Straight	Straight
Material	Steel (Zinc plated)			
Connection	1/2" BSP (Male)	1/8" BSP (Male)	M12 (F)x 1/8" BSP (M)	M12 (Male)
Working Pressure	360 Bar (5221 psi)			

Connection adaptor for pilot cylinder to pilot line.

Figure 5.10.2 Pilot Valve Adaptor

Table 5.10.3 Pilot Valve Adaptor Technical Information

Description	**Specification**
Part Number	LF-PVA
Material	Brass
Connection (Pilot Hose)	M12 x 1.5
Connection (Valve)	M21.8 x 1/14"
Working Pressure	360 Bar (5221 psi)

5.11 Discharge Nozzles

Nozzle sizes for ½” and ¾” pipes are available.
2 types of discharge pattern are available.
Type 360° discharges in all directions, while the Type 180° discharges in half circle, facing the direction of the discharge outlet holes. ½” Nozzles are equipped with filter at the inlet. Please see Table 5.16, for details on Discharge Rate of a particular orifice at a given pressure.

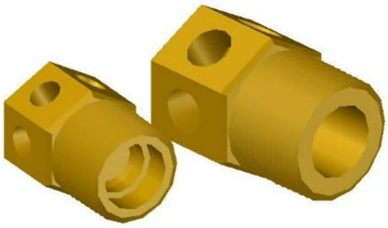


Figure 5.11a Discharge Nozzles

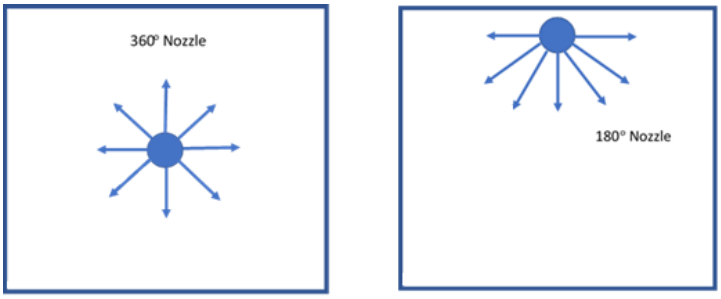


Figure 5.11b Discharge Nozzles Discharge Pattern

Table 5.11.1 Nozzle Specification

Part No	Description	Port	Port Size (mm)	Drill Size (mm)
LF-360CO2-15	CO2 Discharge Nozzle 1/2"NPT 360deg	6	7	1.2 - 9
LF-360CO2-20	CO2 Discharge Nozzle 3/4"NPT 360deg	6	10	10 - 16
LF-360CO2-25	CO2 Discharge Nozzle 1" NPT 3600deg	6	15	17 - 22
LF-180CO2-15	CO2 Discharge Nozzle 1/2"NPT 180deg	4	7	1.2 - 9
LF-180CO2-20	CO2 Discharge Nozzle 3/4"NPT 180deg	4	10	10 - 16
LF-180CO2-25	CO2 Discharge Nozzle 1" NPT 180deg	4	15	17 - 22

Table 5.11.2 Pilot Valve Adaptor Technical Information

Description	Specification
Material	Brass
Thread	NPT Male
Coverage	6m x 6m
Protection height	5.0m

Fog Nozzles are used for Local Application, where the protected equipment or enclosure does not meet the requirement for total flooding.

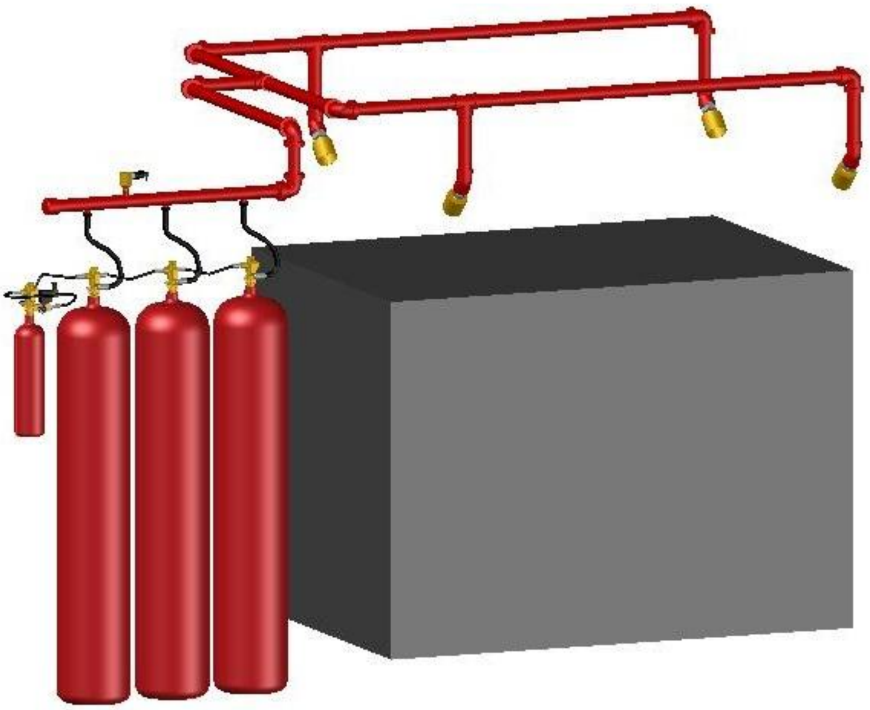


Figure 5.12 Example application of Fog Nozzle in a machining center.

Note: The effectiveness of local application using fog nozzle has to be determined using local application method.

Table 5.11.3 Pilot Valve Adaptor Technical Information

Description	Specification
Part Number	LF-FGCO2-15
Material	Carbon Steel
Thread size	½" NPT Male
Coverage	1.2m x 1.2m
Protection height	Highest point of protection hazard to nozzle tip within 1.0m

5.12 Selector valve

Selector valves are flow control valves with open and closed condition. Selector valve used in application where multiple enclosure or areas require to be protected from a single bank cylinder system. All selector valves are equipped with pneumatic actuators and limit switches.

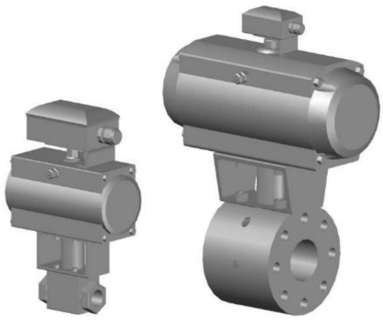


Figure 5.12 Selector Valve

Table 5.12.1 Selector Valve Technical Information

Description	Specification
Material	Stainless Steel
Connection	BSP
Working Pressure	140 Bar (2030 psi)
Nominal Control Pressure	6 Bar
Control Pressure zone	6 – 10 Bar
Complete Switching Time	≤ 3 s
Opening Angle	90˚C
Voltage	12 – 250 V AC/DC
Operating Current	0.1 – 10 A
Limit switch	2 change over contacts

Table 5.12.2 Selector Valve (threaded) Technical Information

Size	Part Number	Thread Connection	Weight
DN 20	LF-DIV20-BSP	¾" BSP	6.2 kg
	LF-DIV20-NPT	¾" NPT	
DN 25	LF-DIV25-BSP	1" BSP	7.0 kg
	LF-DIV25-NPT	1" NPT	
DN 32	LF-DIV32-BSP	1 ¼" BSP	11.0 kg
	LF-DIV32-NPT	1 ¼" NPT	
DN 40	LF-DIV40-BSP	1 ½" BSP	15.8 kg
	LF-DIV40-NPT	1 ½" NPT	
DN 50	LF-DIV50-BSP	2" BSP	18.5 kg
	LF-DIV50-NPT	2" NPT	

Table 5.12.3 Selector Valve (ISO Flange) Technical Information

Size	Part Number	Connection	Weight
DN 63	LF-DIV65-ISO	2-1/2"	48.4 kg
DN 80	LF-DIV80-ISO	3"	80.1 kg
DN 100	LF-DIV100-ISO	4"	113.4 kg

Table 5.12.4 Selector Valve (DIN Flange) Technical Information

Size	Part Number	Connection	Weight
DN 63	LF-DIV65-DIN	2-1/2"	59.5 kg
DN 80	LF-DIV80-DIN	3"	81.5 kg
DN 100	LF-DIV100-DIN	4"	105 kg

5.13 Pressure Switch

The discharge pressure switch function by sending signal to a control panel during a system discharged. It activates by the agent pressure during discharged and can be reset manually by pushing the top stem after activation.

Table 5.13 Discharge Pressure Switch Technical Information

Description	Specification
Part Number	LF-DPS
Body Material	Brass
Cover Plate	Mild Steel
Connection	1/2” NPT
Switch Configuration	3PDT, Three Pole Double Throw
Minimum Actuation Pressure	4 bar (58psi)
Maximum Operating Pressure	60 bar (870psi)
Electrical Rating	10A 250VAC 15A 125VAC 3/4HP, 250VAC 1,2, or 3 phase
Overall Size	100 mm (L) x 92mm (W) x 123mm(H) 3.94 inch(L) x 3.62 inch(W) x 4.84 inch(H)

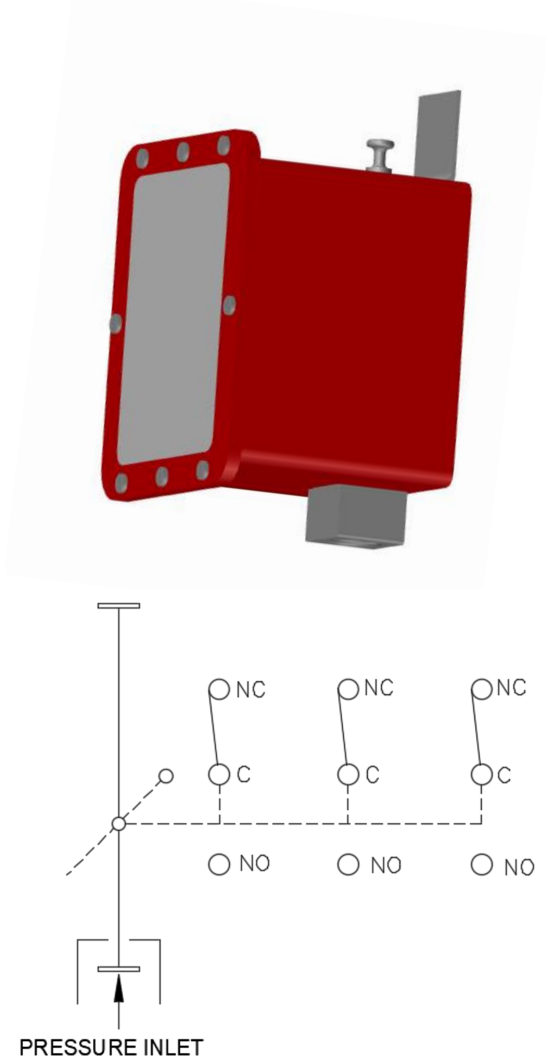


Figure 5.13 Discharge Pressure Switch & Wiring Diagram

5.14 Piping Distribution System

5.14.1 General

Pipework shall be non-combustible and able to withstand the expected pressure and temperature without damage.

NOTE: A120 pipes SHALL NOT BE USED

Table 5.14.1 CO_2 Pipe specification

Nominal Pipe Size (mm)	Pipework			
	Standard	Grade	Type	Sch
OPEN ENDED 15, 20, 25, 32, 40	API 5L	B	Seamless	40
OPEN ENDED 50, 65, 80	API 5L	B	Seamless	80
CLOSED SECTION All Sizes	API 5L	B	Seamless	80

Pipes and Fittings shall be ream, clean and blow out before installing.
After assembly, blow out entire pipe system before installing discharge nozzles.

5.14.2 Estimating Pipe Sizes

Pipe sizes may be estimated, prior to running a calculation, based on the following table.

Table 5.14.2 Pipe Sizes Selection based on CO_2 Flow Rate

Flow Rate kg/min	Pipe Size (mm)
6.8 – 45.4	15
45.8 – 90.7	20
91.2 – 158.8	25
159.2 – 317.5	32
318.0 – 453.6	40
454.0 – 725.8	50
726.2 – 1134.0	65
1134.5 – 1814.4	80

5.14.3 Fittings

Table 5.14.3 Pipe Fittings Specification

Nominal Pipe Size (mm)	**Fittings, Forged Threaded**	
	Standard	**Grade**
15, 20, 25, 32, 40, 50, 65, 80	ASME 16.11	ASTM A105N

5.14.4 Flanges

Where flanges are used, the following specification shall be followed.

Table 5.14.4 Flanges Specification

Piping	**Standards**	**Class**	**Material**	**Face**
Open Ended	ANSI B16.5	300	Forged Carbon Steel	Raised Faced with gaskets
Closed Section	ANSI B16.5	900	Forged Carbon Steel	

Bolts and nuts used shall conform to BS EN 1515: Part 1.
Pain washers, conforming to BS 4320, should be fitted under bolt head and nut.
A minimum of 2 threads should project above the nut when fully tightened.

5.14.5 Pipe Supports

Table 5.14.5 Pipework Supports and Hangers Spacing

Pipe Size (mm)	**Max Spacing Between Hangers (m)**
10	1.2
15	1.8
20	2.4
25	3.7
32	3.7
≥ 40	4.6

A hanger should be installed between fittings when the fittings are more than 2 ft (0.6 m) apart.
A hanger should be installed at a maximum of 1 ft (0.3 m) from the nozzle.

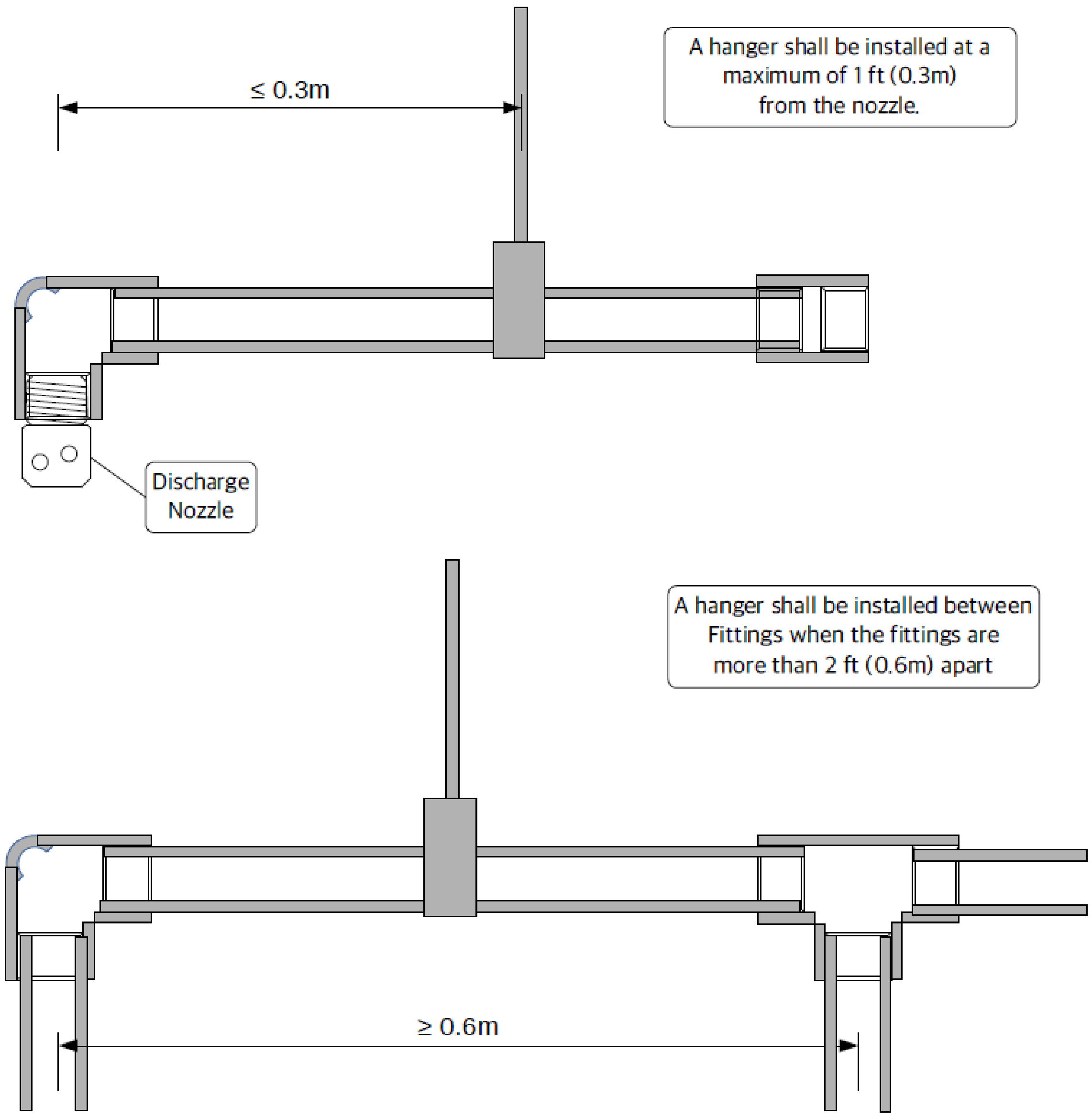


Figure 5.14.5 Pipework Supports and Hangers Spacing

5.15 Equivalent Lengths

5.15.1 Threaded Pipe Fittings

Table 5.15.1 Equivalent lengths of threaded pipe fittings

Nominal Dia. (mm)	Std Elbow 45° (m)	Std Elbow 90° (m)	Long Elbow 90° and Tee-Thru (m)	T-Side (m)	Union Coupling or Gate Valve (m)
10	0.18	0.40	0.24	0.82	0.09
15	0.24	0.52	0.30	1.00	0.12
20	0.30	0.67	0.43	1.40	0.15
25	0.40	0.85	0.55	1.70	0.18
32	0.52	1.10	0.70	2.30	0.24
40	0.61	1.30	0.82	2.70	0.27
50	0.79	1.70	1.10	3.41	0.37
65	0.94	2.00	1.20	4.08	0.43
80	1.20	2.50	1.60	5.06	0.55
100	1.50	3.26	2.00	6.64	0.73
125	1.90	4.08	2.60	8.35	0.91
150	2.30	4.94	3.08	10.00	1.10

5.15.2 Welded Pipe Fittings

Table 5.15.2 Equivalent length of welded pipe fittings

Nominal Dia. (mm)	Std Elbow 45° (m)	Std Elbow 90° (m)	Long Elbow 90° and Tee-Thru (m)	T-Side (m)	Union Coupling or Gate Valve (m)
10	0.06	0.21	0.15	0.49	0.09
15	0.09	0.24	0.21	0.64	0.12
20	0.12	0.33	0.27	0.85	0.15
25	0.15	0.43	0.33	1.10	0.18
32	0.21	0.55	0.46	1.40	0.24
40	0.24	0.64	0.52	1.60	0.27
50	0.30	0.85	0.67	2.10	0.37
65	0.37	1.00	0.82	2.50	0.43
80	0.46	1.20	1.00	3.11	0.55
100	0.61	1.60	1.30	4.08	0.73
150	0.91	2.50	2.00	6.16	1.10

5.16 Elevation Correction

Table 5.16 Elevation correction of CO_2 pressure in piping

Average Line Pressure (MPa)	**Elevation correction (MPa / m)**
5.17	0.0 080
4.83	0.0 068
4.48	0.0 058
4.14	0.0 049
3.79	0.0 040
3.45	0.0 034
3.10	0.0 028
2.76	0.0 024
2.41	0.0 019
2.07	0.0 016
1.72	0.0 012
1.38	0.0 009

Note: Elevation correction are NOT significant during pipe size and system flow rate estimation, however shall be factored in, while performing hydraulic calculation to determine the orifice sizes and predict of actual nozzle flow rate.

5.17 Nozzle Discharge Rate

Table 5.17 CO_2 Discharge Rate at Discharge Nozzles of various orifice

Orifice Pressure (MPa)	**Discharge Rate (kg/min/mm^2)**
5.17	3.255
5.00	2.703
4.83	2.401
4.65	2.172
4.48	1.993
4.31	1.839
4.14	1.705
3.96	1.589
3.79	1.487
3.62	1.396
3.45	1.308
3.28	1.223
3.10	1.139
2.93	1.062
2.76	0.9843
2.59	0.9070
2.41	0.8296
2.24	0.7593
2.07	0.6890
1.72	0.5484
1.38	0.4833

5.18 Instruction Signs

Warning Signs is available for mounting at the entrance and area of protected hazard. The warning sign is to warn personnel the space is protected by Carbon Dioxide System and should evacuate when the alarm sounds and do not enter after a discharged.

Figure 5.18a Warning Sign (Protected space Entrance)

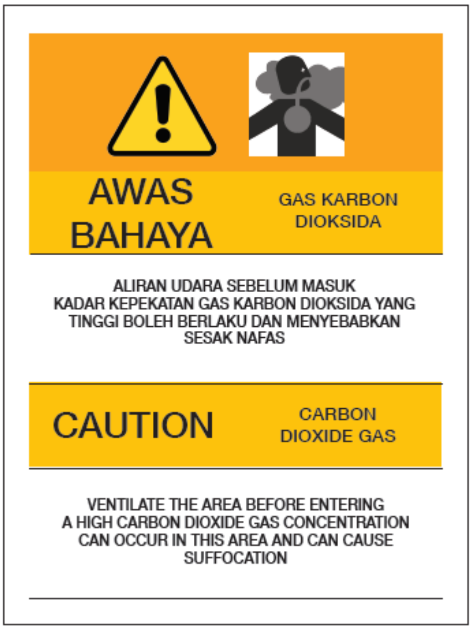


Figure 5.18b Warning Sign (CO2 Storage area Entrance)

6.0 System Design

This section provides guidelines to designing an engineered High pressure CO_2 system, for application on Surface fires, Deep Seated Fires and Electrical Installations. The designer is responsible to meet authority requirements.

The system specified in this manual is actuated automatically electrically and pneumatically, or manually pneumatically. Automatic system employs fire detectors and system control panels, along with electrically operated actuators for Pilot Cylinder and pneumatically operated actuators for CO_2 cylinders. The design and choice of detection and control system has to be properly carried out by the designer or installer responsible.

6.1 Total Flooding System Design

Only areas where the opening ratio, $R \leq 0.03$, is suitable to be protected by CO_2 Total Flooding System

where $R = \frac{TotalUnclosableOpenings(m^2)}{TotalSurfaceAreaofProtectedSpace(m^2)}$

Note: when $R > 0.03$, then Total Flooding is NOT Applicable, instead, Local Application shall be used.

After qualifying the area to be protected, as suitable for Total Flooding System, the system design can be proceeded as follow.

6.1.1 CO_2 Quantity Calculation

Step 1 : Determine the Volume of the enclosure to be protected, V_V
Step 2 : Determine the volume within the enclosure, that can be deducted, V_G
Step 3 : Determine the volume required to be compensated, V_Z
(Volume removed by ventilation that cannot be shut down during inhibiting period)
Step 4 : Determine the total surface area of the enclosure, A_V
Step 5 : Determine the unclosable surface area, A_{OV}
Step 6 : Determine the Material Factor, K_B of the fire hazards, see Table 6.1
Step 7 : Determine the design quantity of CO_2 , M

where, $M = K_B \times [0.2 \times (A_V + 30 \times A_{OV}) + 0.7 \times (V_V + V_Z + V_G)]$

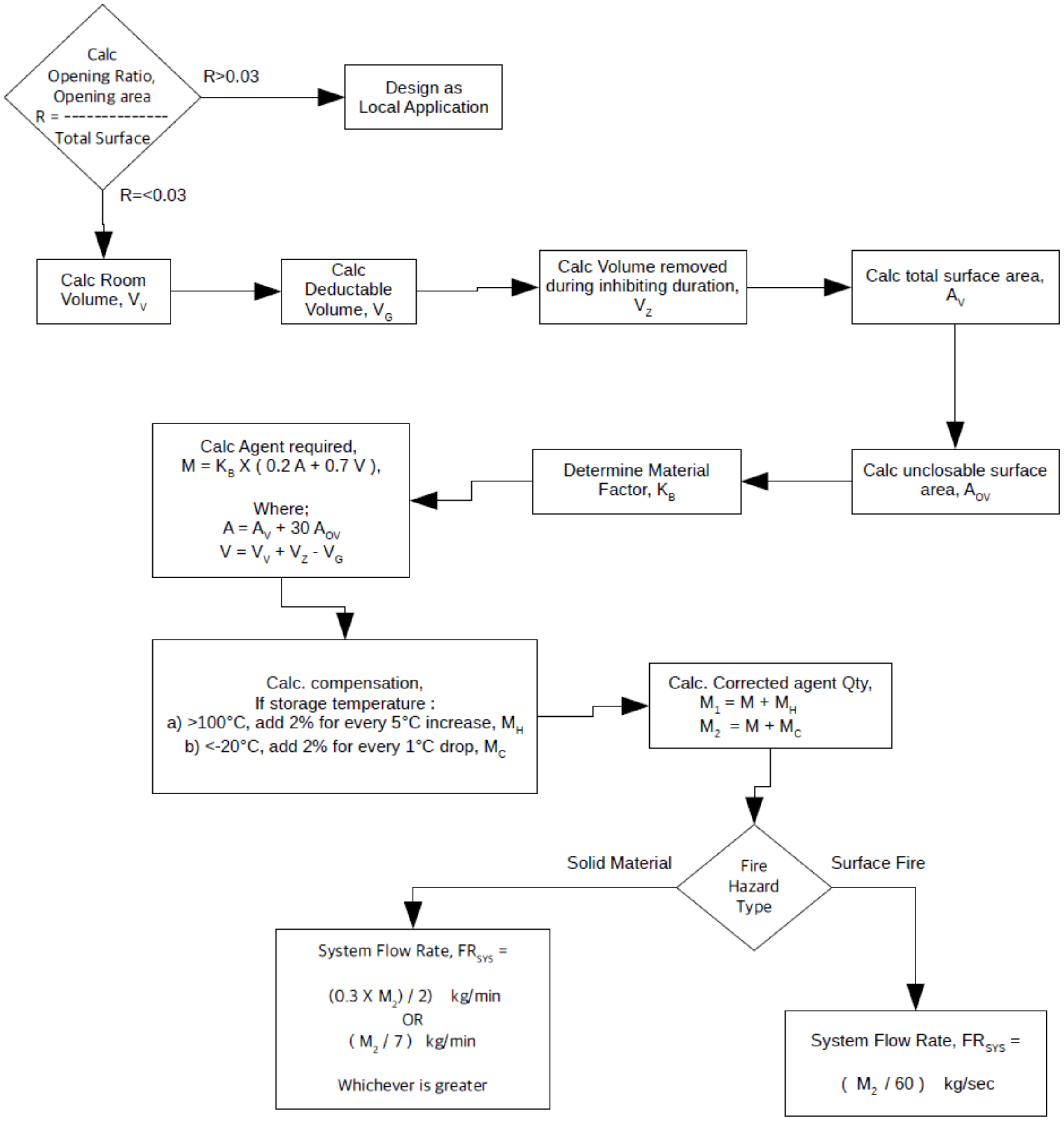


Figure 6.1.1 Total Flooding Calculation Flow Chart

6.1.2 Storage Temperatures Compensation for Abnormal Temperatures

Storage conditions shall be kept between -20 °C to +55 °C, otherwise compensation is required, as follow:

a) Add 2% for each additional 5 °C, if stored above 100 °C. The additional quantity shall not be discharged within the design discharge periods

b) Add 2% for each 1 °C drop, if stored below -20 °C. The additional quantity shall be discharged within the design discharge period.

6.1.3 Duration of Discharge

for surface fires, the calculated design quantity of CO_2, M_2, shall be discharged within 60 seconds. So, the system flow rate,

$FR_{SYS} = \frac{M_2}{60}$ kg/sec

for fires involving solid materials:
the design quantity shall be discharged within 7 minutes, where 30% concentration shall be achieved in the first two minutes. So, the system flow rate,

$FR_{SYS} = \frac{M_2}{7}$ kg/min ; OR ;

$FR_{SYS} = \frac{0.3xM_2}{2}$ kg/min ;

whichever is greater.

See 10.1 for EXAMPLE Calculation of a typical Total Flooding on Surface Fire.

See 10.2 for EXAMPLE Calculation of a typical Total Flooding on Deep Seated Fire.

6.1.4 Quantity of CO_2 to Be Stored

The calculated quantity of CO_2 shall be store so as to be available at all times and not usable for other purposes.

6.1.5 Quantity of CO_2 to Be Connected to System as Reserve

Where replenishment time after discharge, is longer than permitted, a permanently connected reserve supply of equal quantity to the main supply bank, shall be provided.

Table 6.1.5 Material Factors, (K_B), Design Concentrations and Inhibition Times

Combustion Material	Material Factor K_B	CO_2 Design Conc. (%)	Inhibition Time (min)
Fires Involving gases and			
acetone	1	34	-
acetylene	2.57	66	-
Aviation fuel grades 115/145	1.06	36	-
Benzol, benzene	1.1	37	-
butadiene	1.26	41	-
butane	1	34	-
butene-1	1.1	37	-
Carbone disulfide	3.03	72	-
Carbon monoxide	2.43	64	-
Coal / natural gas	1.1	37	-
cyclopropane	1.1	37	-
Diesel fuel	1	34	-
Dimethyl ether	1.22	40	-
dowtherm	1.47	46	-
ethane	1.22	40	-
Ethyl alcohol	1.34	43	-
Ethyl ether	1.47	46	-
ethylene	1.6	49	-
Ethylene dichloride	1	34	-
Ethylene oxide	1.8	53	-
gasoline	1	34	-
hexane	1.03	35	-
n-heptane	1.03	35	-
hydrogen	3.3	75	-
Hydrogen sulfide	1.06	36	-
isobutane	1.06	36	-
isobuthylene	1	34	-
Isobutyl formate	1	34	-
JP-4	1.06	36	-
kerosene	1	34	-
methane	1	34	-
Methyl acetate	1.03	35	-
Methyl alcohol	1.22	40	-
Methyl butane-1	1.06	36	-
Methyl ethyl ketone	1.22	40	-
Methyl formate	1.18	39	-
n-octane	1.03	35	-
pentane	1.03	35	-
propane	1.06	36	-
propylene	1.06	36	-
Quench, lube oils	1	34	-
Fires Involving Solid Materials			
Cellulosic materials	2.25	62	20
cotton	2	58	20
Paper, corrugated paper	2.25	62	20
Plastics material (granular)	2	58	20
polystyrene	1	34	-
Polyurethane, cured only	1	34	-
Special application cases			
Cable rooms and cable ducts	1.5	47	10
Data handling areas	2.25	62	20
Electrical computer installations	1.5	47	10
Electrical switch and distribution	1.2	40	10
Generators, including cooling	2	58	Until stopped
Oil filled transformers	2	58	-
Output printing areas	2.25	62	20
Paint spray and drying	1.2	40	-
Spinning machines	2	58	-
NOTE : Fire involving solid materials, usually of an organic nature in which combustion normally takes place with the formation of glowing embers.			

6.1.6 Simultaneous Flooding of Interconnected Volumes

In two or more interconnected volumes, where "free flow" of CO_2 can take place, or where the possibility of fire spread from one area to the other could occur, the CO_2 quantity shall be the sum of the quantities calculated for each volume. If one volume requires greater than normal concentration, the higher concentration shall be used in all interconnected volumes.

6.1.7 Determining Number and Location of Nozzles

a) 6 meter maximum spacing between nozzles (total flooding only).

b) Not more than 3 meters from a wall or major obstruction (total flooding only).

c) Try not to locate the nozzle near an unclosable opening unless using for screening

d) Make certain nothing interferes with the discharge pattern of the nozzle

e) Make certain the nozzle is not located so that it causes unduly splash of flammable liquids or creates dust clouds that might extend the fire, create an explosion, or otherwise adversely affect the contents of the enclosure.

f) When locating the nozzles, draw a sketch of the hazard and place the location of the nozzles on it. Dimension the location of the nozzles from the walls or major components in the hazard area. These locations and dimensions will be used later to determine piping lengths and number of fittings.

6.2 Local Application System Design

Local application are used when the extinguishment of surface fires in flammable liquids, gases and solids where the hazard is not enclosed or where the enclosure does not meet the requirement of total flooding (see 6.1).

There are two methods to calculate the system flow rate and quantity of CO_2 required.

6.2.1 METHOD 1 : Rate By Area Method

Rate by Area method is used when the fire hazard consists primarily of flat surfaces or low level objects associated with horizontal surfaces.

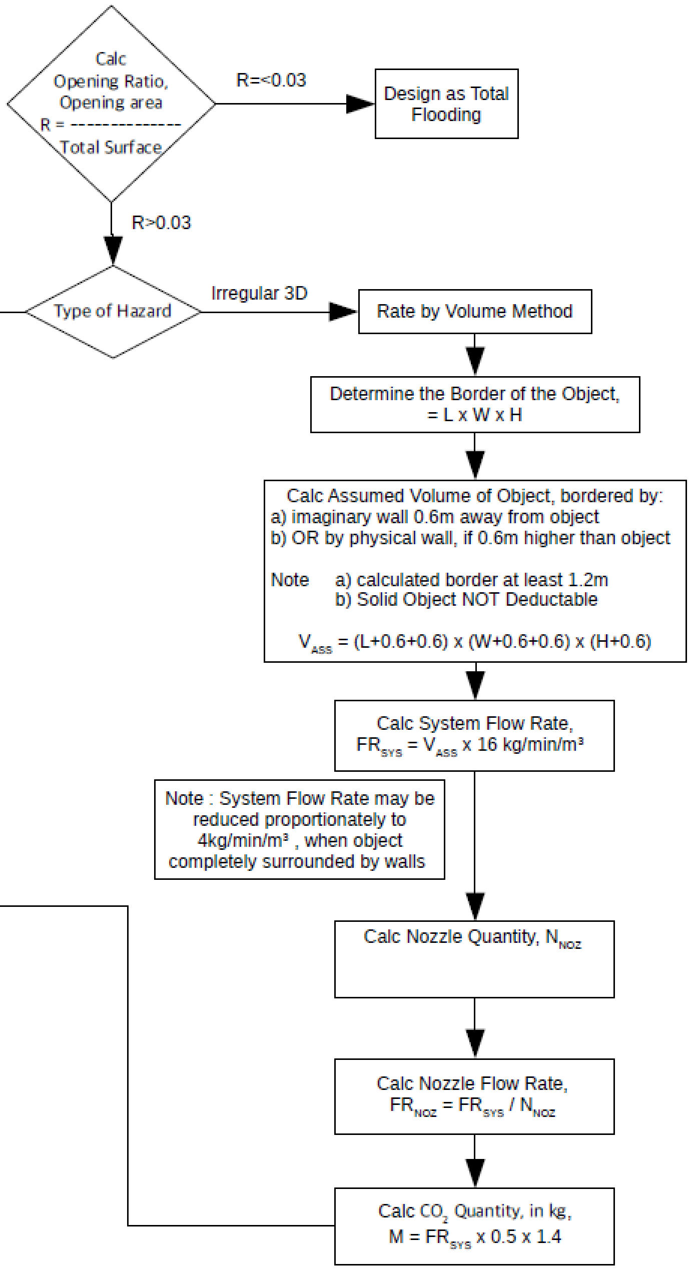


Figure 6.2.1 Local Application Calculation Flow Chart

6.2.1.1 Nozzle Coverage and Quantity Calculation

Space the nozzle to have the optimum coverage according to the coverage as per Figure 6.3.

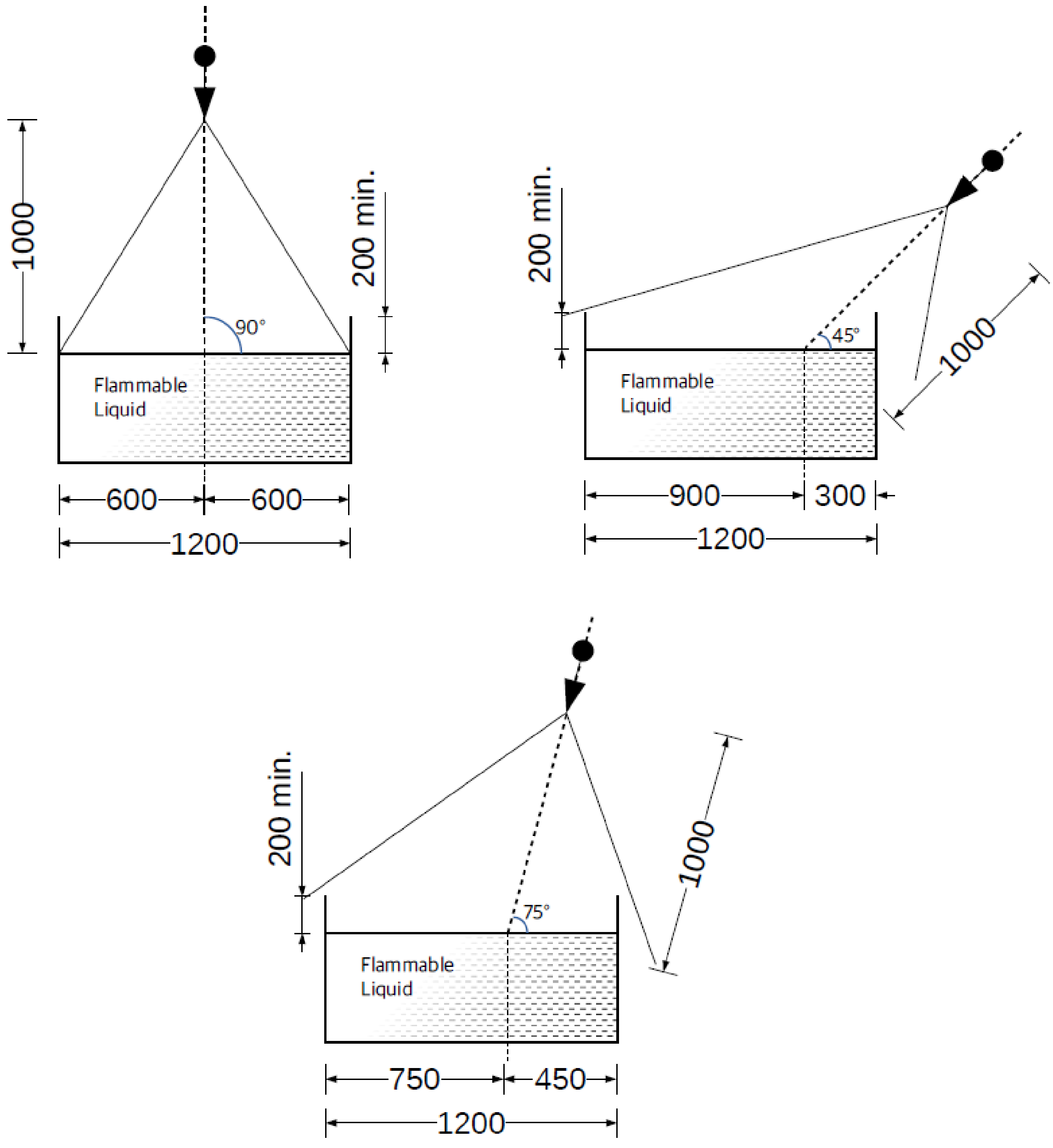


Figure 6.2.1.1 Fog Nozzle Coverage

6.2.1.2 System Flow Rate Calculation

The system flow rate is calculated from the total number of nozzles used multiply with the minimum effective nozzle flow rate FR_{NOZ} = 22kg / min per nozzle.

6.2.1.3 CO_2 Quantity Calculation

The design quantity of CO_2 required:

$M = FR_{NOZ} \times N_{NOZ} \times DT \times 1.4$

where :
a) FR_{NOZ} is the Flow Rate of each nozzle
b) N_{NOZ} is the Nozzle Quantity required, calculated as per coverage
c) DT is the minimum discharge time, 30 seconds
d) 1.4 is 40% extra, to compensate vapor phase which is ineffective on fire

Note: For fires involving Liquids of auto ignition temperature lower than its boiling point, the minimum discharge time shall be 3 min.

6.2.1.4 Nozzle Orifice Size Calculation

Nozzle orifice size is calculated when the piping layout is run through a hydraulic calculation.

See 10.3 for EXAMPLE Calculation of a typical Rate By Area Local Application

6.2.2 METHOD 2 : Rate By Volume Method

Rate by Volume method is used when the fire hazard consists of 3-D irregular objects that cannot be easily reduced to equivalent surface areas. Refer to Figure for calculation flow chart.

6.2.2.1 Object border determination

First, determine the border of the irregular shape object to be protected.

6.2.2.2 Assumed Volume Calculation

An assumed volume of protection is calculated from the determined object geometry, with an additional space of 0.6m from the edge of the object.

6.2.2.3 System Flow Rate Calculation

The system flow rate,

$FR_{SYS} = V_{ASS} \times AR$

where: a) V_{ASS} is the assumed volume of the protected object
b) AR is the application rate

Note: the basic application rate is 16 $kg/min/m^3$, which may be reduced proportionately, to a minimum of 4 $kg/min/m^3$ where all walls completely surrounding the enclosure.

6.2.2.4 Nozzle Quantity and Flow Rate Calculation

Determine the quantity of nozzle required, by applying the coverage per nozzle as in Figure, on the object to be protected, considering the delivery of the system flow rate at the same time.

After that calculate the flow rate on each nozzle.

6.2.2.5 CO_2 Quantity Calculation

The design quantity of CO_2 required:

$M = FR_{SYS} \times [DT] \times 1.4$

where: a) FR_{SYS} is the system Flow Rate
b) DT is the minimum discharge time, 30 seconds, as specified in MS1590:2003, Table 2.
c) 1.4 is 40% extra, to compensate vapor phase which is ineffective on fire

6.2.2.6 Nozzle Orifice Size Calculation

Nozzle orifice size is calculated when the piping layout is run through a hydraulic calculation.

See 10.4 for EXAMPLE Calculation of a typical Rate By Area Local Application.

7.0 Installation

The LIFECO CO2 High Pressure CO_2 System components are part of a CO_2 Fire Extinguishing System Package. The installer, or sub-contractor shall provide pipes, fittings, electrical wiring and conduits, pipe hangers, and all other necessary hardware and accessories to complete the installation to the satisfaction of the authority.

7.1 General Requirements

CO_2 Cylinders shall be located as near as practical to the enclosure they protect, preferably outside the enclosure. Storage inside the protected rooms, requires approval from the authority.

CO_2 Cylinders shall not be located so as to be subjected to severe weather conditions or to potential damage due to mechanical, chemical or other causes. Where potentially damaging exposure or unauthorized interference is likely, suitable enclosures or guards shall be provided.

Note: Direct sunlight has the potential to increase the CO_2 temperature above that of the surrounding atmospheric temperature.

7.2 Electrical Clearance

Safe Clearance between fire equipment and electrical hazard equipment in a room shall be observed.

Table 7.2 Safety clearance to enable operation, inspection, cleaning, repairs, painting and maintenance work to be carried out

Nominal System Voltage (kV)	**Basic Electrical clearance (phase to earth) (m)**	**Safety Working Clearance (vertical) (m)**	**Safety Working Clearance (horizontal) (m)**	**Insulation Height (Pedestrian Access) (m)**	**Phase to Phase Clearance (m)**
6.6 / 75	0.5	2.9	2.3	2.1	0.25
11 / 95	0.5	2.9	2.3	2.1	0.25
33 / 170	0.5	2.9	2.3	2.1	0.43
66 / 325	0.7	3.1	2.5	2.1	0.78
132 / 550 / 650	1.1	3.5	2.9	2.1	1.40
275 / 1 050 / 850	2.1	4.8	3.9	2.4	2.40
400 / 1 425 / 1 050	2.8	5.5	4.6	2.4	3.60

7.3 Cylinder Bank

The storage of CO_2 with valves, release mechanism, should be arranged in one room which is not exposed to fire danger, but which is situated near to the rooms or objects protected by the system and is easily accessible. The storage area shall be protected against the admittance of unauthorized persons. All CO_2 cylinders are filled with a filling ratio of 0.68 kg/Liter, and the storage temperature shall be between -20°C and 55°C. The Cylinder Bank shall be earthed electrically, to avoid accumulation of static electrical charges, as CO_2 Gas / Liquid flow will cause static electric charges.

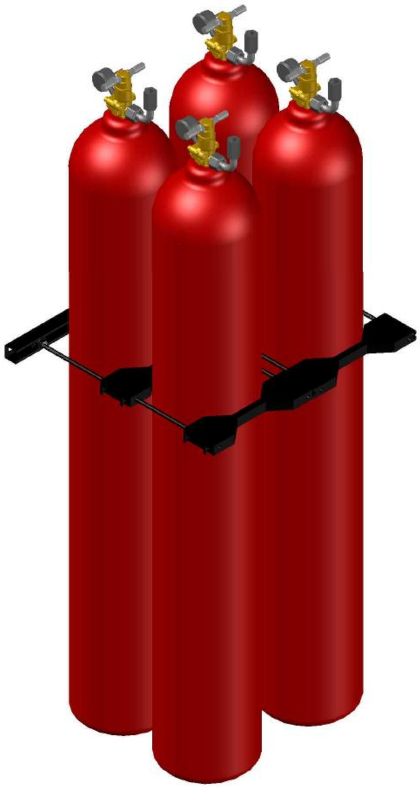


Figure 7.3.1 Bracket Fixing Heights

Cylinder Size	Height from Floor to Bracket	Label Location from Floor
68L	**1000 mm (39.4 inch)**	**13130000 mm (51.2 inch)**

Bracket Installation:

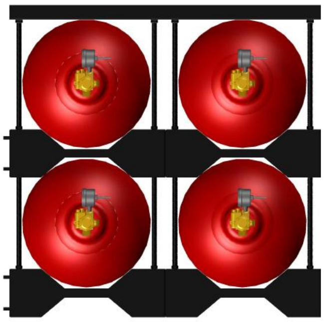
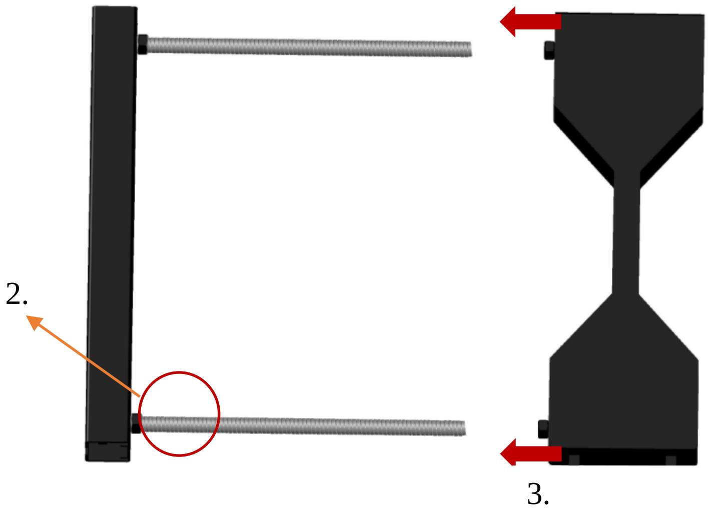
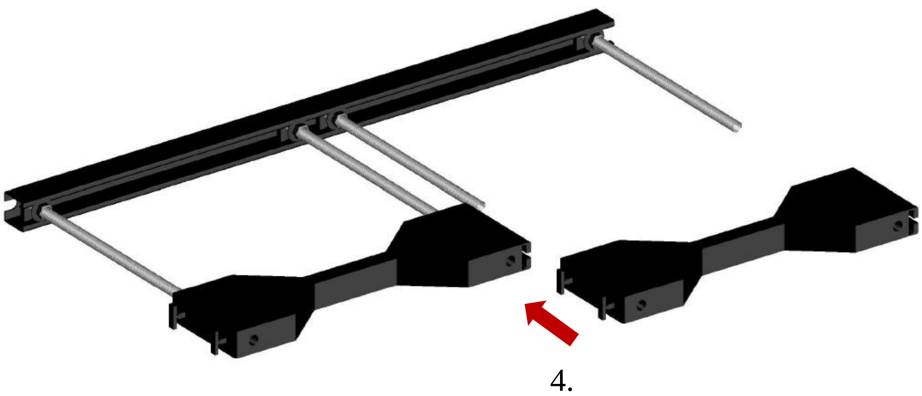


Figure 7.3.2 Bracket Top View

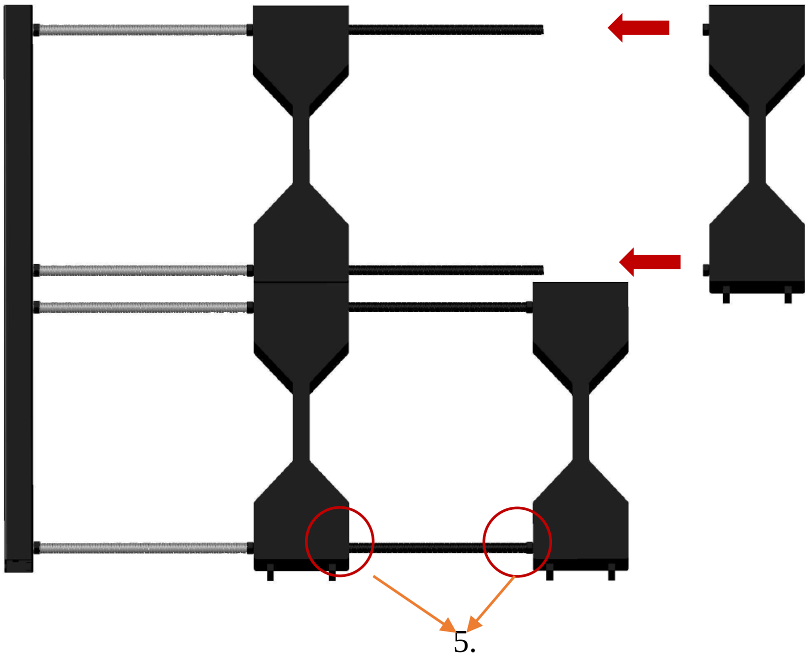
1. Install Unistrut channel to wall or supporting structure.
2. Install Stud with C channel stopper into Unistrut channel. Tighten stud with spanner.
3. Fit stud into bracket strap nut. Tighten nut with spanner.



4. Repeat step 2 and slot the second strap to the first strap channel. Then tighten nut with spanner.



5. Install additional stud provided to first row strap and connect to second row strap.



7.4 Manifold

The manifold shall be installed above the cylinders. The position of the corresponding inlet on the manifold, shall be aligned to the outlet on the corresponding cylinder valve, allowing the discharge hose to bend in a natural manner without causing any kinks, without exceeding the minimum bend radius.

7.5 Pilot Cylinder

The Pilot Cylinder shall be installed beside the cylinder bank. The pressure gauge shall face in a direction convenient for regular inspection. The height of the outlets shall be such that, it is aligned with the CO_2 cylinder pneumatic port.

Note: Avoid the pilot cylinder to sudden impact and vibration. NEVER expose the coil of the Electric Solenoid Actuator to any strong magnetic or electromagnetic pole or field.

7.6 Discharge Hoses

Connect the discharge hose to the check valves on the manifold inlets.
Then connect the other end (female swivel nut) to the CO_2 valve outlets.
DO NOT use PTFE Tape on the valve outlet.

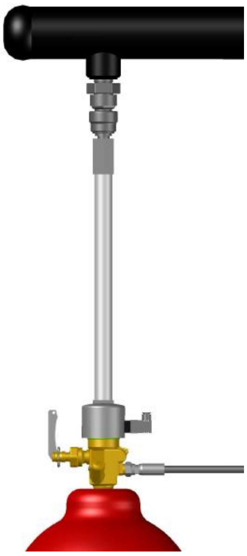


Figure 7.6a Discharge Hose connection to Cylinder Valve

7.7 Actuation Installation

7.7.1 Installation of Electrical actuator

Location of Installation

The electrical actuator is built in with Solenoid discharge valve DN12 (PN: LF-COSV).

CAUTION

The pilot wire must be free of any voltage when assembling the connector, otherwise accidental discharge of the extinguishing system may occurred.

- Interchanging polarity of the contacts Positive and Negative do not lead to malfunction of the valve. Ensure the ground connection is connected correctly.

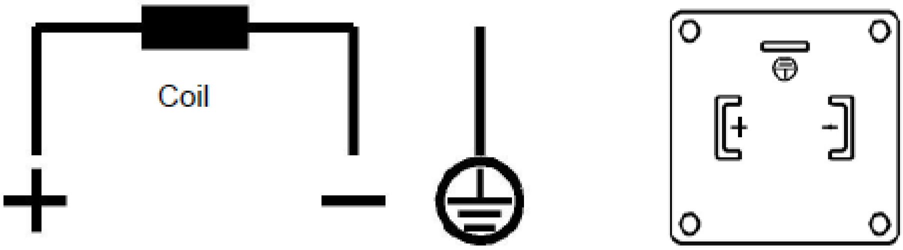


Figure 7.7.1 Electrical Actuator Wiring Diagram

7.7.2 Installation of Manual and Pneumatic actuator

- Release devices compatibility.

	Manual Actuator (PN: LF-COMA)	Pneumatic Manual Actuator (PN: LF-COMPA/1)	Pneumatic Manual Actuator (PN: LF-COMPA)	Pneumatic Actuator (PN: LF-COPA)
CO2 Solenoid Valve DN12 (PN: LF-COSV)	✓	✓		
CO2 Discharge Valve DN12 (PN: LF-CODV)			✓	✓

- Check the thread for impurities and damages.
- Mount and tighten the release devices with a requirement of 15Nm ± 1 (Solenoid valve), 25Nm ± 2 (Discharge valve).
- Do not transport cylinder with release devices mounted. Only installed when system is commissioned.
- Actuated release devices must be reset before mount.

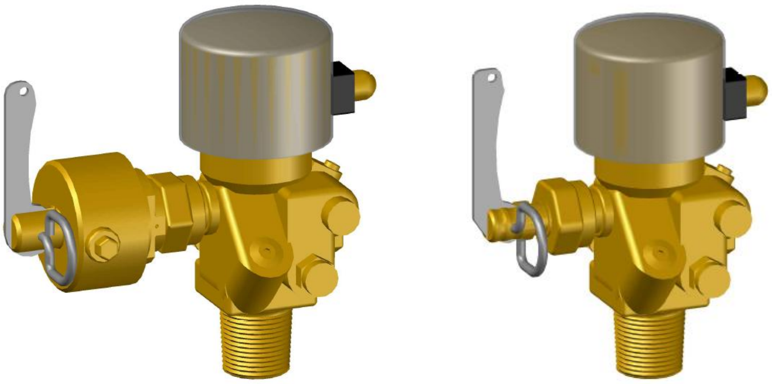


Figure 7.7.2 Solenoid valve with manual, pneumatic manual actuator

Manual actuator (PN: LF-COMA) and Pneumatic Manual actuator (PN: LF-COMPA/1) to be mount to the side of the discharge valve thread M20 x 1.5. Both actuators feature retractable pin which reset when level back to original position.

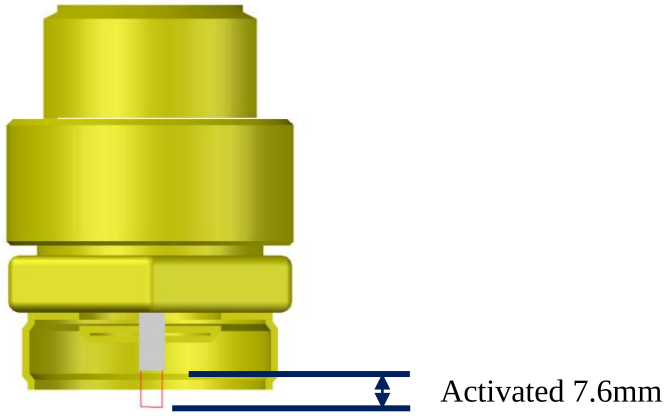


Figure 7.7.3 Pneumatic Actuator in Non-Fire/Fire Position

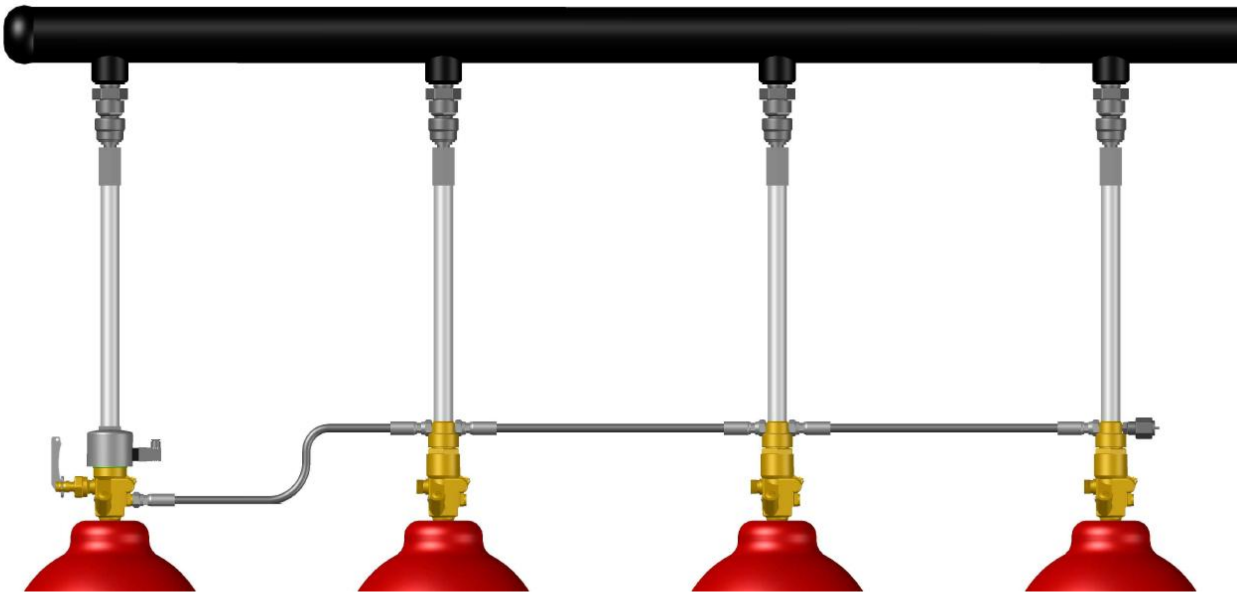


Figure 7.7.4 Pilot Hose installation

- Pneumatic actuator (PN: LF-COPA) must be installed on the slave cylinders only. Pin must be re-set before mount.
- The pneumatic actuators / pneumatic manual actuators are triggered thru the 1/8” connection thread.
- The pneumatic connection of slave cylinders is achieved by removing the 1/8” pressure plug of the master cylinder valve and fit the male adaptor. Install tee adaptor onto the pneumatic actua-tors.
- Connect one end of flexible hose to the male adaptor on the master cylinder and another end to the tee adaptor on the pneumatic actuator.
- One master cylinder and others slave cylinders are designated for multiple cylinders installed for intended to discharge simultaneously. In case there is a fire occurs, the master cylinder can be ac-tivated either electrically or manually. Whereas, the slave cylinders are activated pneumatically from the discharge action of master cylinder.
- Manual actuator (PN: LF-COMA) must be installed onto the master cylinder.
- For system with 2 or more master cylinder in between, pneumatic manual actuator (PN: LF-COMPA/1) must be installed on the second master cylinder and so on.

Table 4.2.1 Multiple Cylinders

Cylinder Size	Master Cylinder (Quantity)	Maximum Slave Cylinder (Quantity)	Maximum Cylinder in total (Quantity)
68L	1	43	44

Table 4.2.2 Multiple Cylinders (Pilot Actuation)

Pilot Cylinder Size	Pilot Cylinder (Quantity)	Maximum Cylinder (Quantity)
4L/10L	1	80

7.8 Distribution Piping

All piping shall be as specified in 5.14., using fittings as specified in 5.14.3.
Pressure tight connections threaded to ISO7-1 or equivalent shall be used.
Pipe works supports shall be as specified in Table 5.14.5

7.9 Nozzles

Discharge nozzles shall be calculated and positioned as per 6.1.7 and supported as per 5.14.5

Fixing of nozzle at the piping can only be done, after cleaning of piping as per 5.14.1
½" nozzles are fitted with filter, make sure the filter is properly positioned before tightening onto the piping.

Depending on the outcome of hydraulic calculation, each nozzle may have different size and orifice. Make sure the correct nozzle is installed at the correct location.

Where 180° type is used, the discharge hole shall be directed at the intended direction. All nozzles shall be installed vertically, unless otherwise specified.

Application and spacing of fog nozzle shall be as specified in Figure.

7.10 Pressure Switch

Discharge pressure switch can be install on the distribution pipe/ manifold.

- Discharge pressure switch can be installed on the distribution pipe or manifold after constant pressure regulator. It can be install with a ½" Pipe with Union or it can direct to the manifold with a ½" nipple.

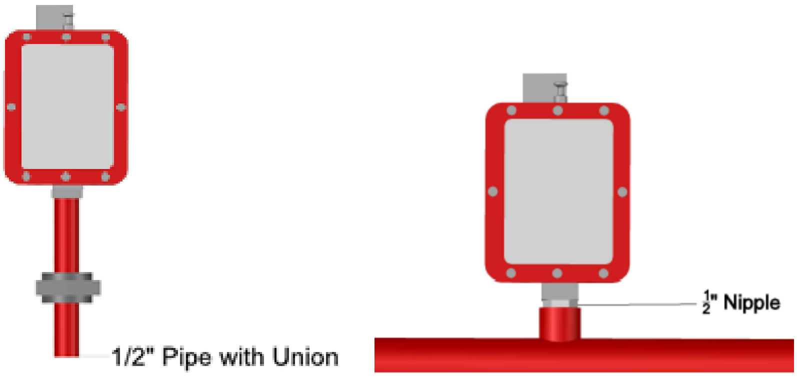


Figure 7.10.1: Distribution pipe / Manifold- Discharge Pressure Switch Installation

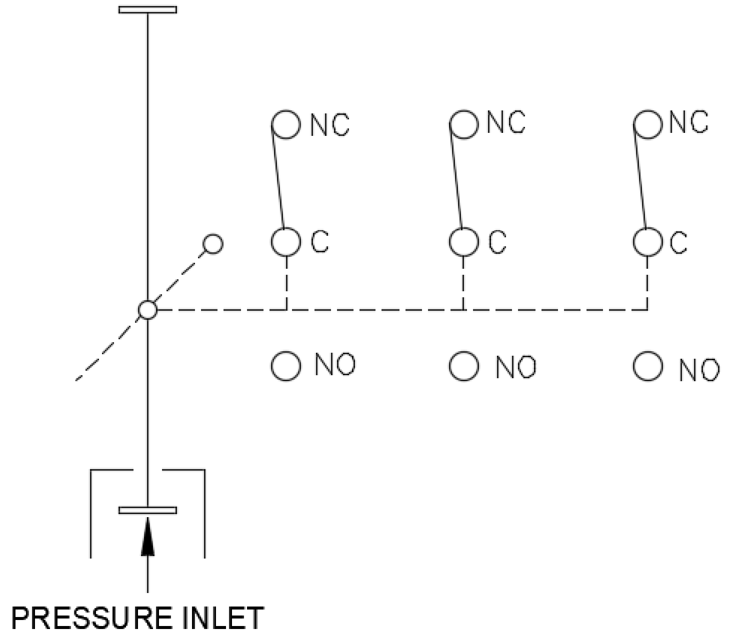


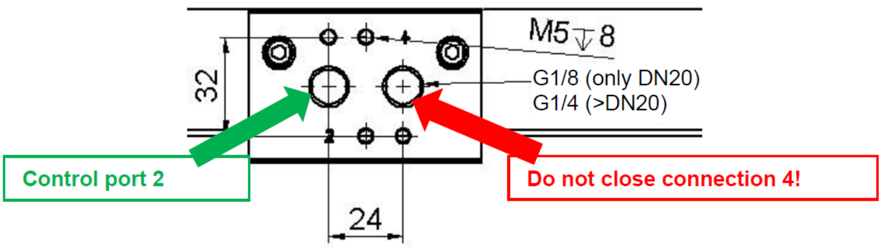
Figure 7.10.2: Discharge Pressure Switch Installation Wiring Diagram

7.11 Selector valve

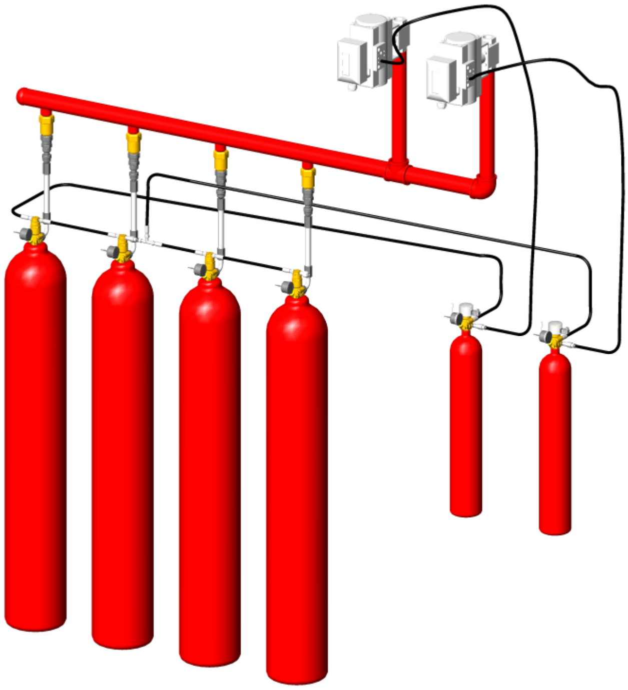
Location of Installation

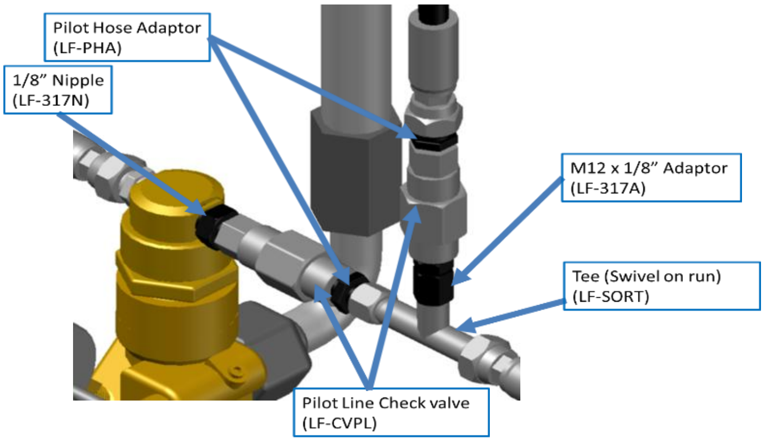
The selector valve installed between the end of the manifold and the discharge pipe system of the protected hazard.

Installation Instructions

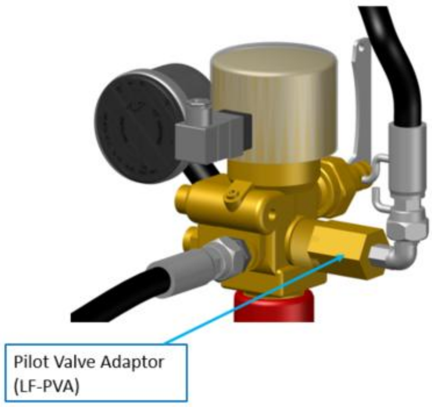


a. Fit the selector valve to the selector valve manifold.
b. Attach the pneumatic tubing from pilot cylinder to the selector valve pressure connection “2”.
c. Do not close connection “4”. Connection “4” is for venting purpose.
d. The control pressure must be maintained within 6 – 10 bar.
e. Connecting thread and flange connection must be free of impurities, grease and adhesive residue.
f. Fit the pilot line check valve to the pneumatic actuator. Using pilot line check valve to control the number of cylinders discharged into designated hazard.
g. Various fittings (adaptors, tee and elbow) are available to fit pilot line check valve and pilot hoses.





<u>Fitting Connection</u>



<u>Pilot Cylinder Fitting Connection</u>

8.0 Inspection and Commissioning

After installation each CO_2 fire extinguishing system shall be certified and checked by a professional engineer and endorsed by the authority to ensure that it will function correctly.

Please see **Appendix A - Carbon Dioxide System Acceptance Test Report** as a sample.

9.0 Maintenance Schedule

The system shall be checked and maintained regularly as required by the authority or at least yearly, whichever is sooner, by competent person recognized by the authority and having trained by the manufacturer.

Please see **Appendix B – Fixed CO_2 System Maintenance Schedule** as a sample

Note: Where CO_2 cylinders are disconnected from the system for servicing, they should be fully secured and restrained before any work on the valves or release mechanisms is started.

10.0 Example Calculation

10.1 EXAMPLE 1 : Total Flooding Application on Fires Involving Gases and Liquids

This sample calculation shows a Combustible Solvent, MEK, stored in a storage room, requires fire extinguishing protection.

10.1.1 EXAMPLE 1 : CO_2 Quantity Calculation

Hazard Protection Area	: Solvent Storage Room
Combustion Material	: Methyl Ethyl Ketone (MEK)
Occupied / Unoccupied	: Normally Unoccupied
Room Size	: 4.5m (L) x 3.5m (W) x 3.5m (H)
Unclosable Opening size	: 0.3m x 0.6m
Ventilation Not Able to Shut	: 15 m3
Deductable Volume	: NIL
K_B factor	: 1.22 (see table 6.1)

These data are fed into our CO_2 Quantity Calculation Spreadsheet, and the result shows 2 units of 45kg CO_2 Cylinder are required.

	COMBUSTIBLE MATERIAL		
kb	Material Conversion Factor	1.22	

Notes: R=<0.03, use Total Flooding

	ROOM SIZE		
L	Protected Room Length	4.5	m
W	Protected Room Width	3.5	m
H	Protected Room Height	3.5	m

	UNCLOSABLE OPENINGS		
Wo	Unclosable Opening Width	0.3	m
Lo	Unclosable Opening Length	0.6	m

	UNSTOPPABLE VENTILATION		
Vz	Extracted Volume	15	m3

	DEDUCTABLE OBJECT		
Ld	Deductable Length	0	m
Wd	Deductable Width	0	m
Hd	Deductable Height	0	m

	CO2 QUANTITY		
m	' = CO2 required		
	' = kb (0.2 x A + 0.7 x V)		kg
		82.55	kg
	@45kg Cyl	**2**	**nos**

	Calculation & Verification		
Av	Protected Room Surface Area	87.5	
Vv	Protected Room Volume	55.125	m3
Aov	Unclosable Opening Area	0.180	m2
Vg	Deductable Volume	0	m3
R	Opening Ratio	0.0033	
A	' = Av + 30 Aov		
		92.9	m2
V	' = Vv + Vz + Vg		
		70.125	m3

Figure 10.1.1 Sample Calculation of CO_2 Quantity Required

10.1.2 EXAMPLE 1 : CO_2 System Flow Rate Calculation

From the same Spreadsheet, the minimum System Flow Rate is calculated as 24.77 kg/min.

FLOW RATE to achieve 30% Concentration in 2 minutes	**24.77**	**kg/min**
OR		
FLOW RATE to achieve 100% Concentrationin 7 minutes	**11.79**	**kg/min**
Whichever is GREATER		
thus, MINIMUM SYSTEM FLOW RATE	**24.77**	**kg/min**

Figure 10.1.2 Sample Calculation of CO_2 System Flow Rate

10.1.3 EXAMPLE 1 : CO_2 Nozzle Quantity and Flow Rate Calculation

The Spreadsheet, shows One Unit of Discharge Nozzle is required with the Flow Rate of 24.77 kg/min.

Floor Area	15.75	m2
Coverage per Nozzle	25	m2
Minimum Nozzle Qty	**1**	**nos**
Nozzle Flow Rate	**24.77**	**kg/min**

Figure 10.1.3 Sample Calculation of CO_2 Nozzle Quantity and Flow Rate

10.1.4 EXAMPLE 1 : CO_2 Cylinder Location and Pipe Routing Diagram

The following step is to identify the storage cylinder location and the routing of the piping. Pay attention to the cylinder and pipe support requirements.

In this example, the cylinder will be sited at the entrance, as shown in the following diagram.

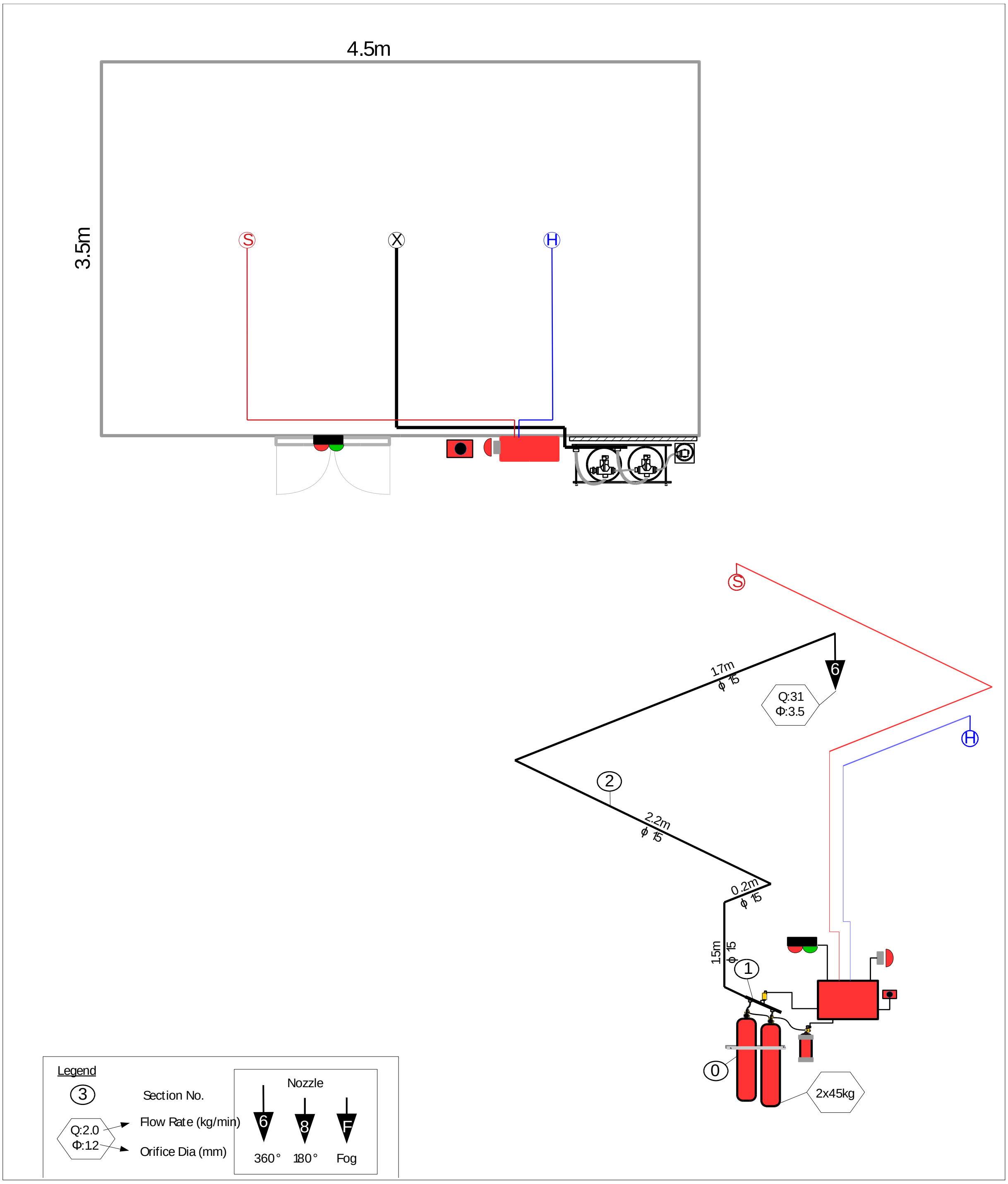


Figure 10.1.4 Sample Diagram of CO_2 Cylinder Location and Pipe Routing

10.1.5 EXAMPLE 1 : CO_2 Hydraulic Calculation

A hydraulic calculation is then run to determine the nozzle orifice sizes.

File Name: Sample CO2 Calculation.FC4

Consolidated Report

Customer Information

Company Name:
Address:

Phone:
Contact:
Title:

Project Data

Project Name:
Designer:
Number:
Account:
Location:
Description:

Hazard Report

System Type: Total Flooding
Design Total Discharge: 1.0 minutes
Design Liquid Discharge: 0.7 minutes

Hazard Number: 1
Name: Sample
Hazard Type: Total Flooding
Number of Nozzles: 1

Calculation Date/Time: Tuesday, 29 October, 2024, 11:10:54 AM

Key ID: 2131982646

Page: 1 of 8

LIFECO

Consolidated Report

Design Flow Rate: 45.00 kg/min
Agent Required: 45.00 kg

Agent Source Report

Agent:	CO2 High Pressure
Cylinder Name:	45 kg Cylinder
Cylinder Part Number:	LF-68CO-DV
Agent Per Cylinder:	45.00 kg
Number of Main Cylinders:	1
Number of Reserve Cylinders:	0
Cylinder Empty Weight:	74.00 kg
Weight, All Cylinders + Agent:	119.00 kg
Floor Area Per Cylinder:	0.07 m^2
Floor Loading Per Cylinder:	1669 kg /m^2

Calculation Date/Time: Tuesday, 29 October, 2024, 11:10:54 AM

Key ID: 2131982646

Page: 2 of 8

LIFECO

Consolidated Report

Parts Report

Cylinder Name: 45 kg Cylinder (Part: LF-68CO-DV)
Number of Cylinders: 1

Nozzle	Type	Nozzle Diameter	Nozzle Code	Nozzle Area	Part Number
H1-T01	360	15 mm	7.29	38.48 mm ²	15 mm-360-7 mm

Nozzle	Drill Diameter	Drill Size
H1-T01	7.0 mm	7 mm

Pipe & Fittings	Type	Diameter	Length	Elbows (90)	Elbows (45)	Tees	Unions
	40T	15 mm	6.30 m	3	0	0	0
	80T	25 mm	0.50 m	0	0	1	0

Other Objects	Name	Quantity	Part Number
	15 mm Flex Hose - 90 Bend	1	LF-DH500E
	21.8mm Check Valve	1	LF-CV
	End Cap	1	EndCap

System Acceptance Report

System Type:	Total Flooding
Cylinder Name:	45 kg Cylinder
Number of Main Cylinders:	1
Number of Reserve Cylinders:	0
Design Liquid Discharge Time:	42.0 sec
Design Total Discharge Time:	1 min, 0 sec

Calculation based on 20.0 degree C pre-discharge pipeline temperature.

Calculation Date/Time: Tuesday, 29 October, 2024, 11:10:54 AM

Key ID: 2131982646

Page: 3 of 8

LIFECO **Consolidated Report**

Total Flood Nozzle Summary

Haz.	Nozzle	Nozzle Code	Predicted Pressure bar	Agent Required kg	Predicted Agent Delivered kg	Predicted Agent Total Discharge Time
1	Sample					
	H1-T01	7.29	41.125	45.00	45.00	58.3 sec
			Excess Mass		-0.04	0.0 sec
			Hazard Totals	45.00	44.96	58.3 sec

Calculation Date/Time: Tuesday, 29 October, 2024, 11:10:54 AM

Key ID: 2131982646

LIFECO

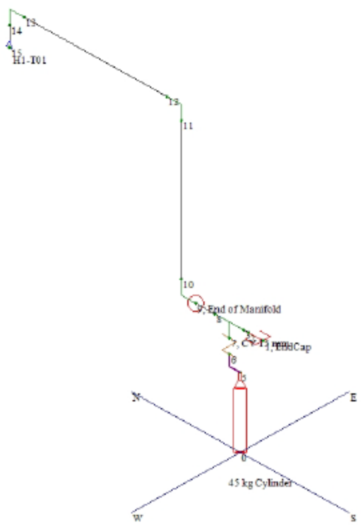
Consolidated Report

Pipe Network Report

Description	Pipe Section	Start Node	End Node	Pipe Type	Pipe Diameter	Pipe Length	Union	Total Elevation Change	Total Equivalent Length	Nozzle Name	Nozzle Size	Nozzle Type	Nozzle Code
Cylinder - On	Man.	0	5		25 mm	1.47 m	0	1.47 m	25.64 m				
Flex Hose	Man.	5	6		15 mm	0.46 m	0	0.23 m	8.38 m				
Check Valve ->	Man.	6	7		15 mm	0.04 m	0	0.04 m	1.80 m				
Tee	Man.	3	8	80T	25 mm	------	0	------	0.55 m				
Pipe	Man.	2	3	80T	25 mm	0.10 m	0	------	0.10 m				
End Cap	Man.	1	2		25 mm	0.10 m	0	------	999.00 m				
Tee	Man.	7	8	80T	25 mm	------	0	------	1.74 m				
Pipe	Man./End	8	9	80T	25 mm	0.40 m	0	------	0.40 m				
Elbow (90)	System	9	10	40T	15 mm	------	0	------	0.52 m				
Pipe	System	10	11	40T	15 mm	3.00 m	0	3.00 m	3.00 m				
Elbow (90)	System	11	12	40T	15 mm	------	0	------	0.52 m				
Pipe	System	12	13	40T	15 mm	3.00 m	0	------	3.00 m				
Elbow (90)	System	13	14	40T	15 mm	------	0	------	0.52 m				
Pipe&Nozzle	System	14	15	40T	15 mm	0.30 m	0	-0.30 m	0.30 m	H1-T01	15 mm	360	7.29

LIFECO
View #: 1 - Isometric View-Node

Consolidated Report

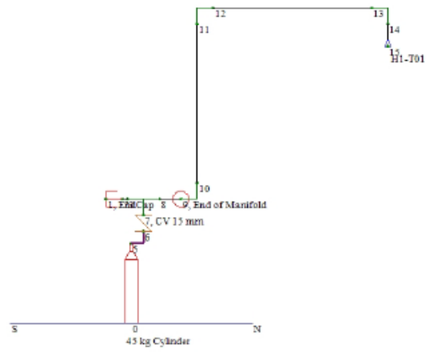


Key ID: 2131982646

Page: 6 of 8

LIFECO
View #: 5 - Standard Elevation View

Consolidated Report



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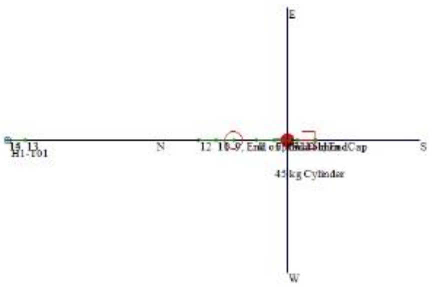
Page: 7 of 8

LIFECO
View #: 9 - Standard Plan View

Consolidated Report



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Page: 8 of 8

10.2 EXAMPLE 2 : Total Flooding Application on Deep Seated Fire

This sample calculation shows a Solid Combustible Material, Paper Rolls, stored in a storage room, requires fire extinguishing protection.

10.2.1 EXAMPLE 2 : CO_2 Quantity Calculation

Hazard Protection Area : Paper Rolls Storage Room
Combustion Material : Carbonous Fiber, Paper, Cardboards, Wooded Pallets, Plastic Wraps
Occupied / Unoccupied : Normally Unoccupied
Room Size : 25.5m (L) x 15.5m (W) x 3.5m (H)
Unclosable Opening size : 1.2m x 3.6m
Ventilation Not Able to Shut : 25 m3
Deductable Volume : NIL
K_B Factor : 2.25 (See Table 6.1)

These data are fed into our CO_2 Quantity Calculation Spreadsheet, and the result shows 62 units of 45kg CO_2 Cylinder are required.

	COMBUSTIBLE MATERIAL		
kb	Material Conversion Factor	2.25	
	ROOM SIZE		
L	Protected Room Length	25.5	m
W	Protected Room Width	15.5	m
H	Protected Room Height	3.5	m
	UNCLOSABLE OPENINGS		
Wo	Unclosable Opening Width	1.2	m
Lo	Unclosable Opening Length	3.6	m
	UNSTOPPABLE VENTILATION		
Vz	Extracted Volume	25	m3
	DEDUCTABLE OBJECT		
Ld	Deductable Length	0	m
Wd	Deductable Width	0	m
Hd	Deductable Height	0	m
	CO2 QUANTITY		
m	' = CO2 required		
	' = kb (0.2 x A + 0.7 x V)		kg
		2761.39	kg
	@45kg Cyl	**62**	**nos**

Notes: R=<0.03, use Total Flooding

	Calculation & Verification		
Av	Protected Room Surface Area	1077.5	
Vv	Protected Room Volume	1383.375	m3
Aov	Unclosable Opening Area	4.320	m2
Vg	Deductable Volume	0	m3
R	Opening Ratio	0.0031	
A	' = Av + 30 Aov		
		1207.1	m2
V	' = Vv + Vz + Vg		
		1408.375	m3

Figure 10.2.1 Sample Calculation of CO_2 Quantity Required

10.2.2 EXAMPLE 2 : CO_2 System Flow Rate Calculation

From the same Spreadsheet, the minimum System Flow Rate is calculated as 828.42 kg/min.

FLOW RATE to achieve 30% Concentration in 2 minutes	**828.42**	**kg/min**
OR		
FLOW RATE to achieve 100% Concentrationin 7 minutes	**394.48**	**kg/min**
Whichever is GREATER		
thus, MINIMUM SYSTEM FLOW RATE	**828.42**	**kg/min**

Figure 10.2.2 Sample Calculation of CO_2 System Flow Rate

10.2.3 EXAMPLE 2 : CO_2 Nozzle Quantity and Flow Rate Calculation

Using 22m^2 / nozzle coverage, results in 18 Unit of Discharge Nozzle is required with the Flow Rate of 46.02 kg/min.

Floor Area	395.25	m2
Coverage per Nozzle	22	m2
Minimum Nozzle Qty	**18**	**nos**
Nozzle Flow Rate	**46.02**	**kg/min**

Figure 10.2.3 Sample Calculation of CO_2 Nozzle Quantity and Flow Rate

10.2.4 EXAMPLE 2 : CO_2 Cylinder Location and Pipe Routing Diagram

The following step is to identify the storage cylinder location and the routing of the piping. Pay attention to the cylinder and pipe support requirements. In this example, the cylinder will be sited at the entrance, as shown in the following diagram.

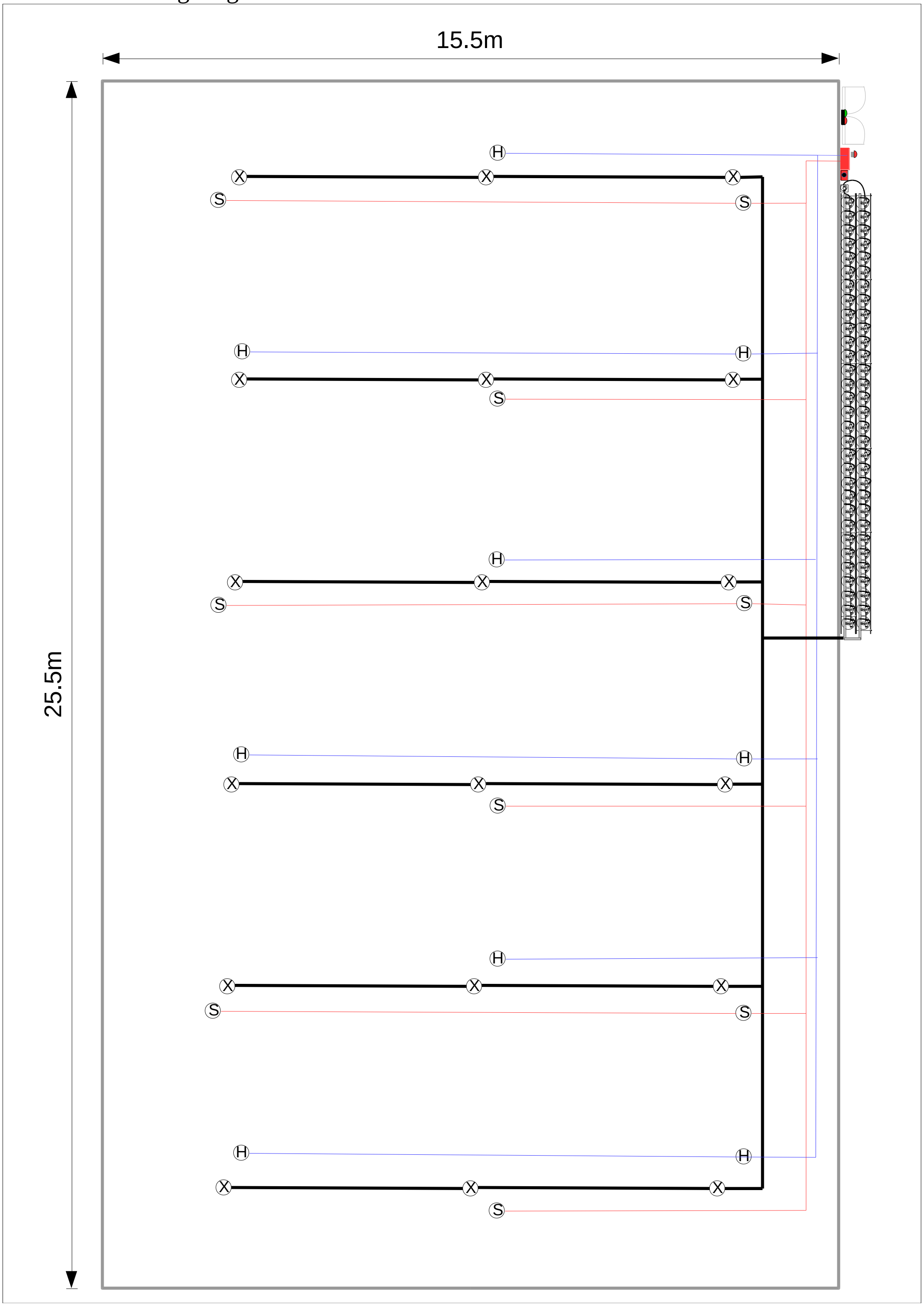

Figure 10.2.4a Sample Diagram of CO_2 Cylinder Location and Pipe Routing

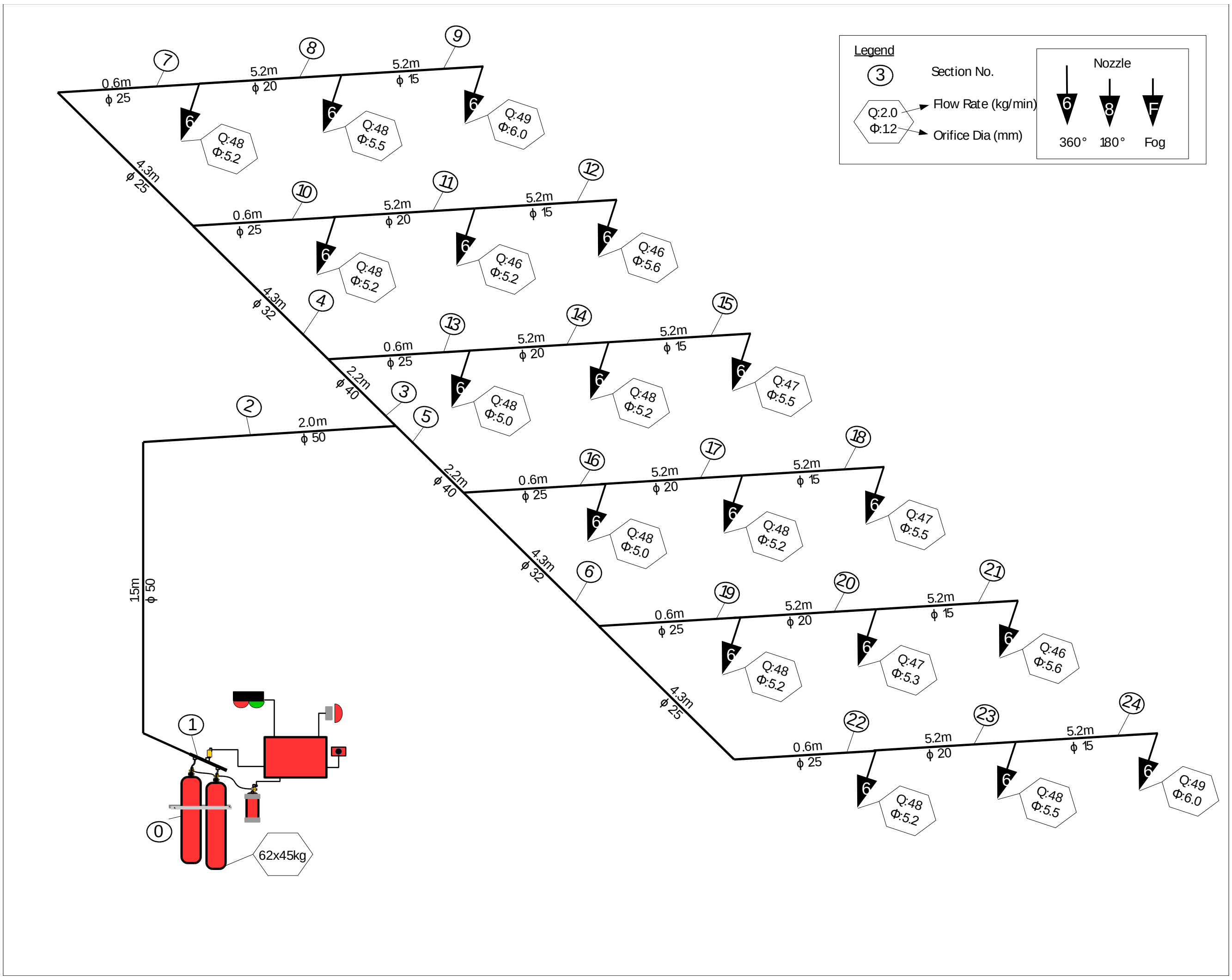

Figure 10.2.4b Sample Diagram of CO_2 Cylinder Schematic Pipin

10.3 EXAMPLE 3 : Local Application on Flammable Liquid Storage Tank

This sample calculation shows a Combustible Liquid, Ethyl Alcohol, stored in a storage tank, requires fire extinguishing protection. The tank is totally open without cover or enclosure, therefore rate by area method is applied.

10.3.1 EXAMPLE 3 : Nozzle Selection and Quantity Calculation

Hazard Protection Area	: Storage Tank
Combustion Material	: Ethyl Alcohol
Enclosure	: NIL
Tank Size	: 2.3m (L) x 1.0m (W) x 0.3m (D)
Surface Opening	: 2.3m x 1.0m
Freeboard	: 200mm
Temperature range	: 28° C - 35° C

Nozzle Selection is pick from SPEC/004d/19, where:

a) Flow Rate per Nozzle: 22.5 kg/min
b) Coverage per Nozzle : 1.2m x 1.2m, at perpendicular
c) Aiming Point : 600mm from edge

Nozzle Quantity required:

on the Length of tank	= 2.3m / 1.2m
	= 2 units
on the width of tank	= 1.0m / 1.2m
	= 1 unit
thus, Total Nozzle required	= 2x1
	= 2 units

10.3.2 EXAMPLE 3 : CO_2 Quantity Calculation

CO_2 Quantity Required	= [Nozzle Qty] x [Nozzle Flow Rate] x [Min. Discharge Time] x 1.4
	= 2 x 22.5 kg/min x 0.5 min. x 1.4
	= 31.5 kg
	= 1 unit of 45 kg CO_2 Cylinder

Note: Storage temperature not > 49° C, therefore, no compensation required.

10.3.3 EXAMPLE 3 : Nozzle Positioning Diagram

Next is to position the nozzles, resulting in the following.

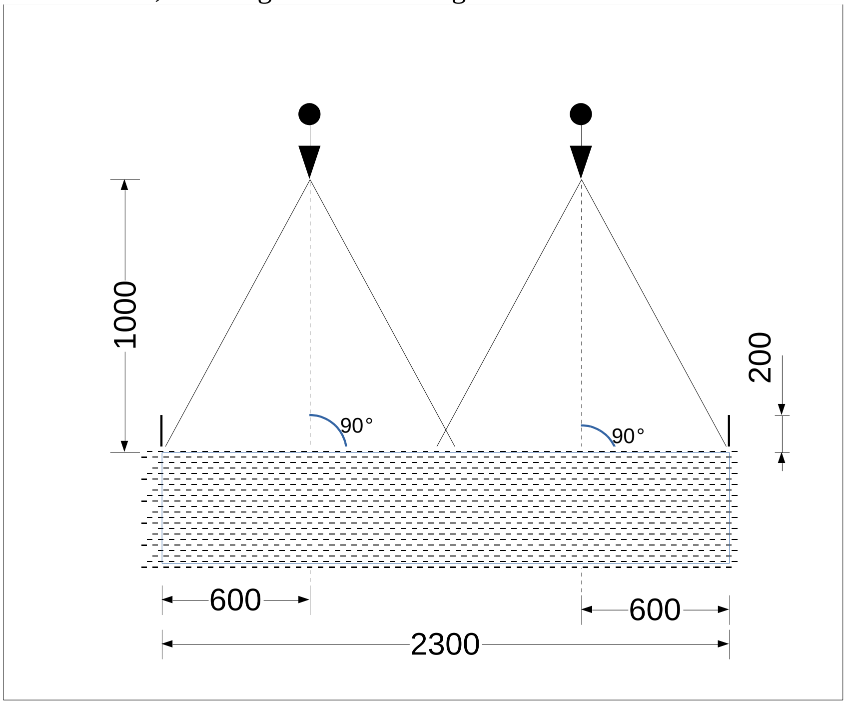

Figure 10.3.3 Sample of CO_2 Fog Nozzle Positioning for a Flammable Liquid Tank Local Application

10.4 EXAMPLE 4 : Local Application on Engine Bay

This sample calculation shows an engine bay in a ship engine room, requires fire extinguishing protection. The bay is situated on one corner of the room, and the engine is an irregular shape 3-D object, therefore rate by volume method is applied.

Hazard Protection Area	: Engine Bay
Combustion Material	: Diesel
Enclosure	:
Floor	: Yes
Ceiling	: 2.8m
Walls	: 2-sides – 2.2m height, 0.5m from Engine
	: 2 sides – without
Engine Size	: 2.6m (L) x 2.4m (W) x 1.2m (H)
Cylinder Storage Temp.	: 38° C

10.4.1 EXAMPLE 4 : Assumed Volume Size Calculation

The 2 partial walls are 2.2m, which is higher than 1.8m (Engine Height+0.6), therefore, the walls will be the edge for calculation.
The engine sits on a solid plinth. However, deduction is not allowed, therefore, the assumed height will have to include the plinth height.

Thus, the Assumed Volume is determine as follow:

a) Assumed Space Length	= 2.6m + 0.5m + 0.6m	= 3.7m
b) Assumed Space Width	= 2.4m + 0.5m + 0.6m	= 3.5m
c) Assumed Space Height	= 1.2m + 0.2m + 0.6m	= 2.0m
d) Assumed Volume	= 3.7m X 3.5m X 2.0m	= 25.9 m3

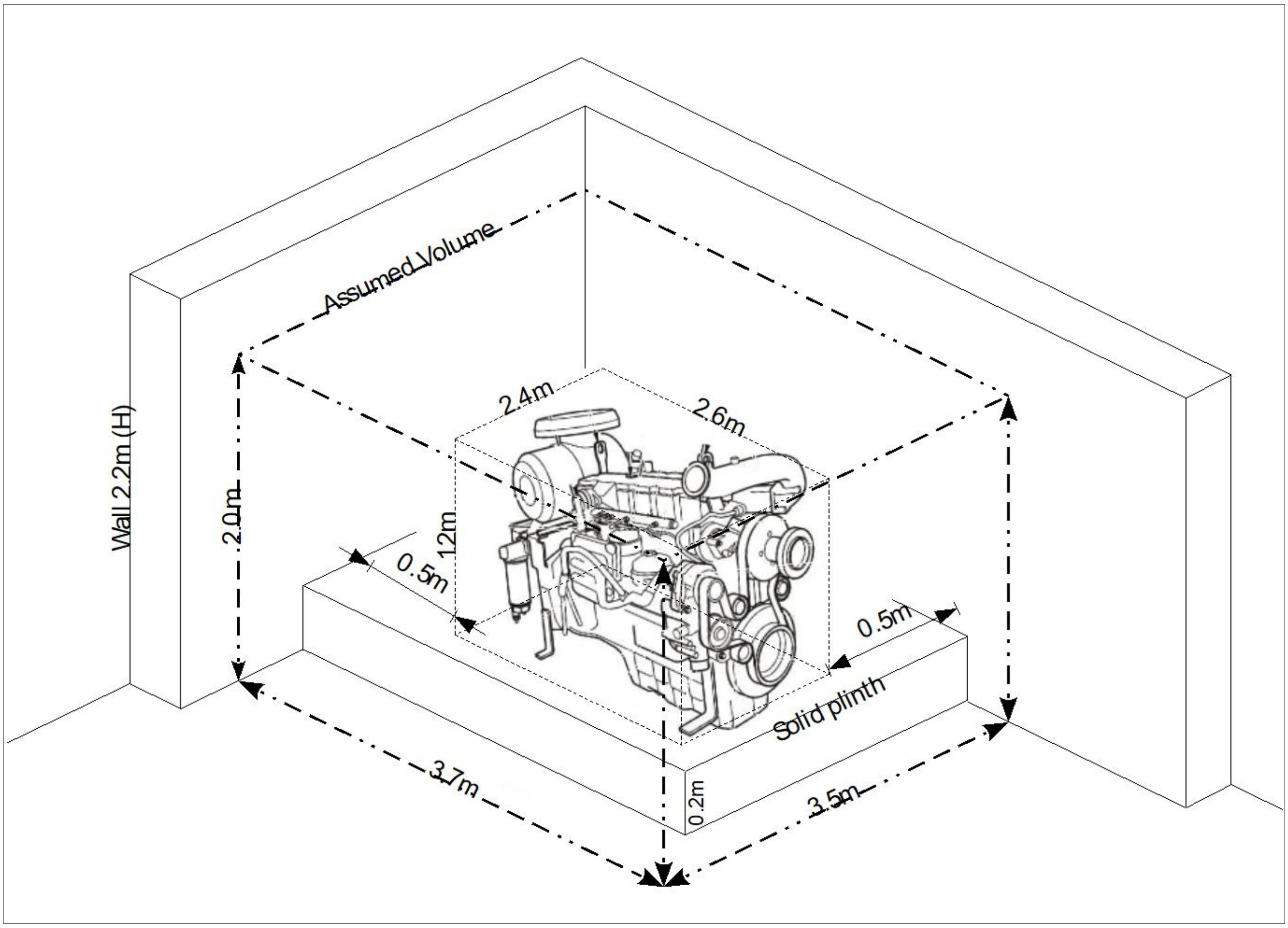

Figure 10.4.1 Sample Assumed Volume of a Local Application CO_2 System on Engine Bay

10.4.2 EXAMPLE 4 : System Flow Rate Calculation

Minimum System Flow Rate = [Assumed Volume] X [min. Basic System Flow Rate)
= 25.9 m^3 X 8kg/min/m^3
= 207.2 kg/min

Note: 8kg/min/m^3 is applied, considering that 2 sides of the engine bay is walled more than 0.6m than the engine.

10.4.3 EXAMPLE 4 : CO_2 Required Quantity Calculation

CO_2 Quantity Required = [Min. System Flow Rate] X [min. Discharge Time] x 1.4
= 207.2 kg/min X 0.5 min. x 1.4
= 145.04 kg CO_2
= 4 unit of 45 kg CO_2 Cylinder

Note: Storage temperature not > 49° C, therefore, no compensation required.

10.4.4 EXAMPLE 4 : Nozzle Selection and Quantity Calculation

a) Flow Rate per Nozzle: 22.5 kg/min
b) Coverage per Nozzle : 1.2m x 1.2m, at perpendicular
c) Aiming Point : 600mm from edge

Nozzle Quantity required = [System Flow Rate] / [Nozzle Flow Rate]
= 207.2 / 22.5
= 9.2 units

However, practically 6 units will be used, therefore, the required flow rate on each nozzle, is:

Corrected Nozzle Flow Rate = [System Flow Rate] / [Nozzle Quantity]
= 207.2 kg/min / 6
= 34.6 kg/min.

The hydraulic calculation will later calculate the required orifice size to support this flow.

10.4.5 EXAMPLE 4 : Nozzle Positioning And Piping Diagram

The nozzles are positioned such that 4 nozzles to aim on the 4 upper corners and 2 nozzles to aim at the top center of the engine, at the height of 2m, taken from the mid of the Engine.

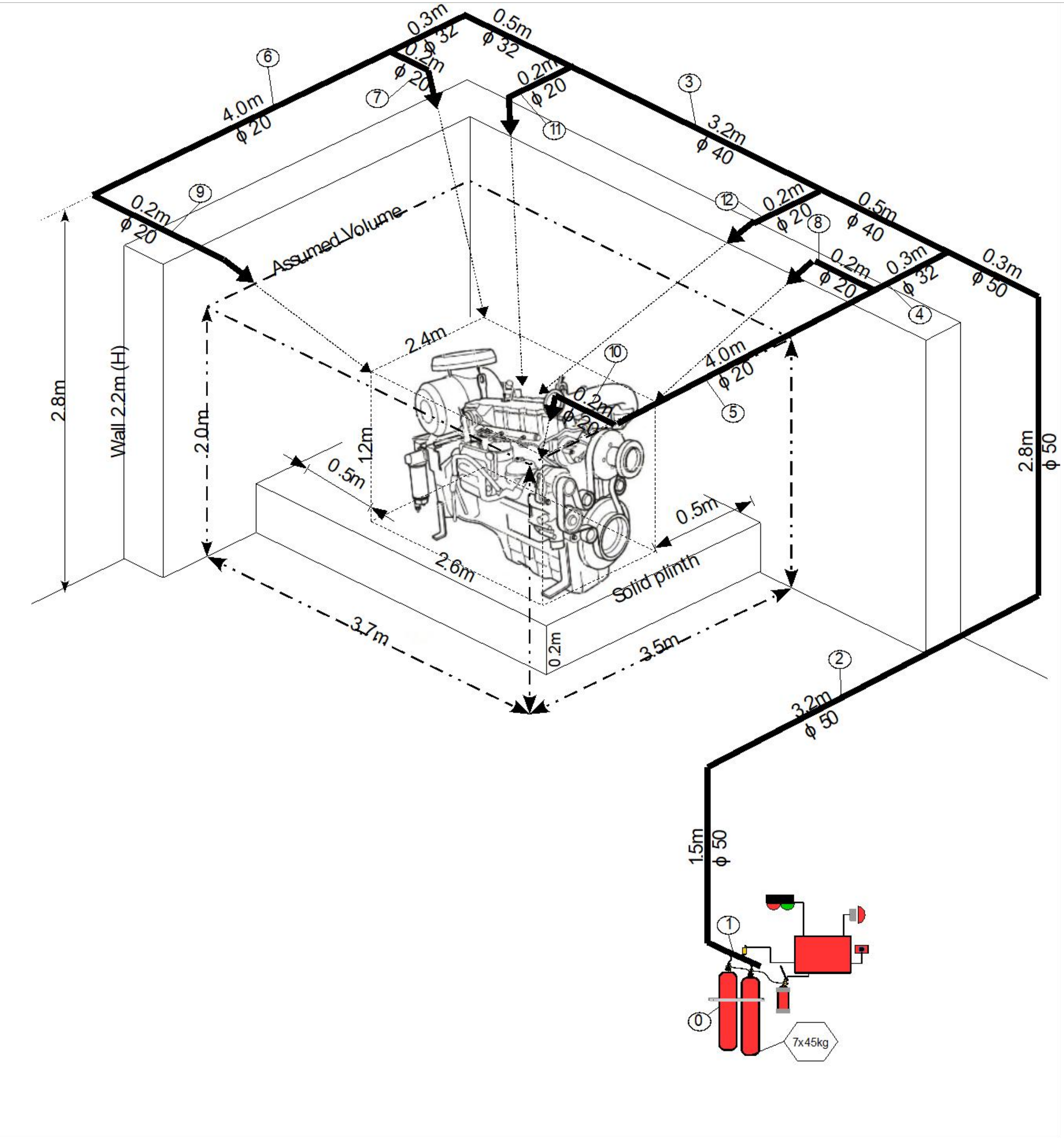

Figure 10.4.5 Sample of CO_2 Fog Nozzle Positioning and piping routing, for a Local Application, Rate by Volume Method on an Engine Bay

11.0 References

1. MS 1590 : 2003 Carbon Dioxide Extinguishing System – Design And Installation
2. NFPA 12 : 2018 – Standard On Carbon Dioxide Extinguishing System
3. EPA 430-R-00-002

12.0 About Us

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Appendix A – Carbon Dioxide System Acceptance Test Report

PROCEDURE

Upon completion of work, an inspection and test shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and the system left in service before contractor's personnel leave the job. A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor. It is understood the owner's representative's signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority's requirements or local ordinances.

Property Name :			Date :		
Property Address :					
Plans	Accepted by approving authorities (names):	Yes		No	
	Address:				
	Installation as per drawings?	Yes		No	
	All components used are approved?	Yes		No	
	If no, explain deviations:				
Instructions	Has person in charge of fire protection been briefed as to location of cylinders, and control valves and care and maintenance of the system? If no, explain:	Yes		No	
	Have copies of appropriate instructions and care and maintenance schedule given to the maintenance department? If no, explain:	Yes		No	
Location	Building or area protected: Explain:				
CO_2 Equipment	Carbon dioxide permitted as Fire Extinguishing Medium?	Yes		No	
	Normally Unoccupied Area?	Yes		No	
	Piping, equipment, and discharge nozzles proper size and location?	Yes		No	
	Location of Alarms and manual emergency releases acceptable?	Yes		No	
	Current hazard configuration comparable to original configuration?	Yes		No	
	Enclosure of hazard area sealed sufficiently?	Yes		No	
	All installed equipment approved for use?	Yes		No	
Pipe and fittings	Pipe types and class:				
	Pipe conforms to Standards& Grade?	Yes		No	
	Fittings conform to Standards & Grade?	Yes		No	
	If no, explain:				
Operational Test	Full operational test for single or multiple hazards:				
	Operational test of devices, including detection and actuation devices?	Yes		No	
	Design quantity CO2 through piping system effectively covers hazard for full time required and concentration level is achieved and maintained?	Yes		No	
Signatures	Name of installing contractor:				
	Tests witnessed by:				
	For property owner: Title: Date:				
	For contractor: Title: Date:				

Appendix B – Fixed CO2 System Maintenance Schedule

B.1 Monthly Inspection Schedule

Property Name :												Date :
Property Address :												
	1	2	3	4	5	6	7	8	9	10	11	12
VISUAL INSPECTION (Monthly)												
Nozzle and Pipe works for physical damage												
Control Panel for FAULT Indications												
Detector and Manual Override Switch for Physical damage												
Alarm Devices, Electric Actuators wiring still intact												
Cylinder conditions, rust, paintwork												
Cylinder Support – Loose, rust												
FUNCTIONAL TEST (Quarterly)												
Any Changes to Protected Area												
Detector Functionality												
Control Panel Functionality												
Activating Device Functionality												
REMARK												
Inspected by:												
Reviewed by:												
Acknowledged by:												

B.2 Yearly Inspection Schedule

Property Name :								Date :				
Property Address :												
	1	2	3	4	5	6	7	8	9	10	11	12
Functional Test (Yearly)												
Control Panel Functions												
Detector and Manual Override Switch												
Alarm Devices, Electric Actuators												
Stand-by Batteries												
Weight of CO_2 (kg). Loss of 10% requires refilling												
Cylinder #1												
Cylinder #2												
Cylinder #3												
Strength TEST (5 Yearly)												
Hose Pressure Test												
Manifold Pressure Test												
Cylinder Pressure Test												
Wiring Resistance Test												
Wiring Insulation Test												
Pressure Switch Functional Test												
REMARK												
Inspected by:												
Reviewed by:												
Acknowledged by:												

Appendix C – LIFECO CO2 System components and their part numbers

Components Description	Part Number
LIFECO CO2 68L 45KG Assembly c/w Solenoid valve	LF-68CO-SV
LIFECO CO2 68L 45KG Assembly c/w Discharge valve	LF-68CO-DV
4L Pilot cylinder 200bar Assembly	LF-04PC-200
10L Pilot Cylinder 200bar Assembly	LF-10PC-200
CO2 Solenoid valve DN12	LF-COSV
CO2 Discharge Valve DN12	LF-CODV
Manual actuator for Solenoid valve	LF-COMA
Pneumatic Manual actuator	LF-COMPA
Pneumatic Manual actuator for Solenoid valve	LF-COMPA/1
Pneumatic actuator 20bar	LF-COPA
Discharge Hose W21.8-14TPI x 20mm BSP 500mm Straight	LF-DH500S
Discharge Hose W21.8-14TPI x 20mm BSP 500mm 90˚Elbow	LF-DH500E
Pilot Hose M12-1.5 x 350mm DN6	LF-PH350
Pilot Hose M12-1.5 x 450mm DN6	LF-PH450
Pilot Hose adaptor	LF-PHA
Pilot Hose Tee connector (swivel on side)	LF-SORS
Pilot Hose Elbow	LF-PVE
Pilot Hose Tee connector (swivel on run)	LF-SORT
1/2" Nipple	LF-127N
1/8” Nipple	LF-317N
M12 x 1/8” adaptor	LF-317A
M12 Nipple	LF-M12N
IG Pilot Valve adaptor	LF-PVA
IG bleed valve	LF-BVPL
IG Check valve	LF-CV
IG Pilot Line Check Valve	LF-CVPL
CO2 Discharge Nozzle 1/2"NPT 360deg	LF-360CO2-15
CO2 Discharge Nozzle 3/4"NPT 360deg	LF-360CO2-20
CO2 Discharge Nozzle 1" NPT 3600deg	LF-360CO2-25
CO2 Discharge Nozzle 1/2"NPT 180deg	LF-180CO2-15
CO2 Discharge Nozzle 3/4"NPT 180deg	LF-180CO2-20
CO2 Discharge Nozzle 1" NPT 180deg	LF-180CO2-25
Fog Nozzle 1/2"	LF-FGCO2-15
267mm Diameter Bracket	LF- CB-80
267mm Bracket Extension	LF- CBX-80
IG 4L/10L Pilot Bracket	LF- CBP
Manifold 20mm 2 Port	LF-2COM20-80
Manifold 20mm 3 Port	LF-3COM20-80
Manifold 25mm 2 Port	LF-2COM25-80
Manifold 25mm 3 Port	LF-3COM25-80
Manifold 25mm 4 Port	LF-4COM25-80
Manifold 25mm 5 Port	LF-5COM25-80
Manifold 32mm 2 Port	LF-2COM32-80
Manifold 32mm 3 Port	LF-3COM32-80
Manifold 32mm 4 Port	LF-4COM32-80
Manifold 32mm 5 Port	LF-5COM32-80
Manifold 32mm 6 Port	LF-6COM32-80
Manifold 32mm 7 Port	LF-7COM32-80
Manifold 40mm 2 Port	LF-2COM40-80
Manifold 40mm 3 Port	LF-3COM40-80

Manifold 40mm 4 Port	LF-4COM40-80
Manifold 40mm 5 Port	LF-5COM40-80
Manifold 40mm 6 Port	LF-6COM40-80
Manifold 40mm 7 Port	LF-7COM40-80
Manifold 40mm 8 Port	LF-8COM40-80
Manifold 50mm 2 Port	LF-2COM50-80
Manifold 50mm 3 Port	LF-3COM50-80
Manifold 50mm 4 Port	LF-4COM50-80
Manifold 50mm 5 Port	LF-5COM50-80
Manifold 50mm 6 Port	LF-6COM50-80
Manifold 50mm 7 Port	LF-7COM50-80
Manifold 50mm 8 Port	LF-8COM50-80
Manifold 65mm 3 Port	LF-3COM65-80
Manifold 65mm 4 Port	LF-4COM65-80
Manifold 65mm 5 Port	LF-5COM65-80
Manifold 65mm 6 Port	LF-6COM65-80
Manifold 65mm 7 Port	LF-7COM65-80
Manifold 65mm 8 Port	LF-8COM65-80
Manifold 80mm 3 Port	LF-3COM80-80
Manifold 80mm 4 Port	LF-4COM80-80
Manifold 80mm 5 Port	LF-5COM80-80
Manifold 80mm 6 Port	LF-6COM80-80
Manifold 80mm 7 Port	LF-7COM80-80
Manifold 80mm 8 Port	LF-8COM80-80
Manifold 100mm 5 Port	LF-5COM100-80
Manifold 100mm 6 Port	LF-6COM100-80
Manifold 100mm 7 Port	LF-7COM100-80
Manifold 100mm 8 Port	LF-8COM100-80
Manifold 50mm 6 port - Double Row	LF-DR6COM50-80
Manifold 65mm 6 port - Double Row	LF-DR6COM65-80
Manifold 80mm 6 port - Double Row	LF-DR6COM80-80
Manifold 100mm 6 port - Double Row	LF-DR6COM100-80
Selector valve 20mm BSP	LF-DIV20-BSP
Selector valve 20mm NPT	LF-DIV20-NPT
Selector valve 25mm BSP	LF-DIV25-BSP
Selector valve 25mm NPT	LF-DIV25-NPT
Selector valve 32mm BSP	LF-DIV32-BSP
Selector valve 32mm NPT	LF-DIV32-NPT
Selector valve 40mm BSP	LF-DIV40-BSP
Selector valve 40mm NPT	LF-DIV40-NPT
Selector valve 50mm BSP	LF-DIV50-BSP
Selector valve 50mm NPT	LF-DIV50-NPT
Selector valve ISO Flange 65mm	LF-DIV65-ISO
Selector valve ISO Flange 80mm	LF-DIV80-ISO
Selector valve ISO Flange 100mm	LF-DIV100-ISO
Selector valve DIN Flange 65mm	LF-DIV65-DIN
Selector valve DIN Flange 80mm	LF-DIV80-DIN
Selector valve DIN Flange 100mm	LF-DIV100-DIN
Pilot Cylinder label	LF-CL3
LIFECO CO2 Cylinder label (252.8mm x 190mm)	LF-CL4
Discharge Pressure Switch	LF-DPS