CONTENTS

1 – Introduction

This manual is written for the fire protection professional that designs, installs and maintains Forman Vehicle Services Ltd Indirect Low Pressure Integrated High-Throughput Integrated Bi-Directional System, this system must be designed, installed, inspected, tested, maintained and recharged by qualified trained personnel.

Safety Precautions

The following safety precautions must always be followed:

- Read and understand this Manual and the other documents referenced herein.

- The valve discharge ports must be sealed with the plugs provided at all times and only removed when the system is connected into the discharge pipeline.

- PPE suitable to the local environment should be worn when installing a Forman System. Wear safety glasses when working with pressurised cylinders and charging equipment.

- Make sure that Integrated Ball Valve (accessed by removing the top gauge of the cylinder valve) is in the closed (horizontal) position, the safety caps have been installed, and the detection tubing has been removed from the cylinder valve, before removing the cylinder from the installation and before performing any servicing, leak tests or system changing.

- Follow all the safety procedures included on the cylinder labels and within this manual.

- Never assume that a cylinder is empty. Treat all cylinders as if they are fully charged.

Any questions concerning the information contained within this manual should be addressed to:

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2 Ellerbeck Court
Stokesley Business Park
Stokesley
Middlesbrough
TS9 5PT
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Tel: 01642 713530
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2 – System Overview

The Forman Indirect Low Pressure Integrated High Throughput Bi-Directional (FILPINTHTBI) Fire Suppression System is fully compliant with the new UNECE regulation R107. It is designed for local applications within vehicle engine areas using ABC Dry Powder. In addition to the main engine compartment the system can also be extended to cover adjacent battery / heater compartments.
(Other Forman systems are available for the bespoke protection of remote electrical voids and lithium battery areas.)

The system uses linear heat detection tubing that can detect a fire, or a temperature above that of normal operation. The tubing offers detection along its entire length ensuring fast and accurate activation throughout the risk areas. In addition to the discharge nozzles the Forman system also uses patented “bi-directional” technology. This means that a percentage of the extinguishant is deployed directly from the activation burst hole ensuring that it immediately tackles the source of ignition. This unique function provides the ability to protect small or concealed areas without the need for additional diffusers. Using high quality ABC Dry Powder, the system is compatible with all potential fire classes including, diesel, electrical, Hybrid, Hydrogen and CNG.

The Forman system is designed to cover all principal risk areas within the engine compartment and the nozzle placement ensures that extinguishant is deployed over all identified hazards. The additional benefit of deployment from the tubing burst means that all areas are covered even if they were not initially identified as a primary risk.

The Forman system operates pneumatically and does not require energy from the vehicle to operate. The system is supplied with the VMMS (vehicle multi messaging system) that provides the driver with audible indications of the system status, as well as notifications of discharge or fault.

The VMMS also provides the facility to interface directly with the vehicle to achieve isolation of cooling fans and / or engine shutdown.

Each installed system is equipped with detection tubing, discharge piping and nozzles. The pre-designed concept minimizes the amount of engineering involved in the application design. When the discharge piping and nozzles are installed within the limitations stated in this Manual, no hydraulic calculations are required to determine pressure drop, agent flow, or discharge time.

The hazard being protected can be any size, shape, or volume provided that the hazard being protected is within the limitations described in this Manual. When installed, each extinguisher unit is a self-contained unit, meaning that it is equipped with its own automatic (non-electric) detection system. This system, when actuated, automatically releases the suppression agent into the hazard area.

These extinguisher units can be combined to protect a larger size hazard, and can be simultaneously actuated or a delayed discharge can be incorporated.

Upon actuation, an optional pressure switch can be used to indicate discharge, shutdown ventilation, close all openings, shut-off electrical power, etc. as may be required.

Dry Powder is stored in a steel cylinder pressurised with nitrogen to 12 bar at 21°C (174psig at 68°F). Each cylinder is equipped with a straight dip tube and can only be mounted in a vertical (upright) position.

Each cylinder is equipped with a plated brass valve, a pressure gauge to monitor cylinder pressure, an integrated quarter turn ball valve with pressure gauge to monitor Forman tubing pressure with an optional status indicator module (SIMI). The integrated ball valve must be kept in closed position at all times when the cylinder is not in service.

The system utilizes Forman flexible tubing that is attached to the top of the cylinder valve. This tubing is pressurised with nitrogen to maintain the cylinder valve is in the closed position. This tubing acts as a continuous linear thermal detector that ruptures to create a diffuser upon direct flame impingement or at high temperatures associated with fire conditions. Once the detection tubing is ruptured, the cylinder valve automatically opens, allowing the dry powder to flow through the discharge piping and through the Forman tubing, distributing the extinguishing agent through the nozzles into the protected area.

Forman FILPINTHTBI consists of the following major components:

1. Cylinder / Valve Assembly
2. Cylinder Mounting Bracket
3. Forman detection / actuating / discharge tubing and fittings
4. Discharge Nozzles
5. Pressure Switch (Optional)
6. Discharge piping and Fittings

For a more comprehensive list of technical illustrations and part numbers, please see section 6.

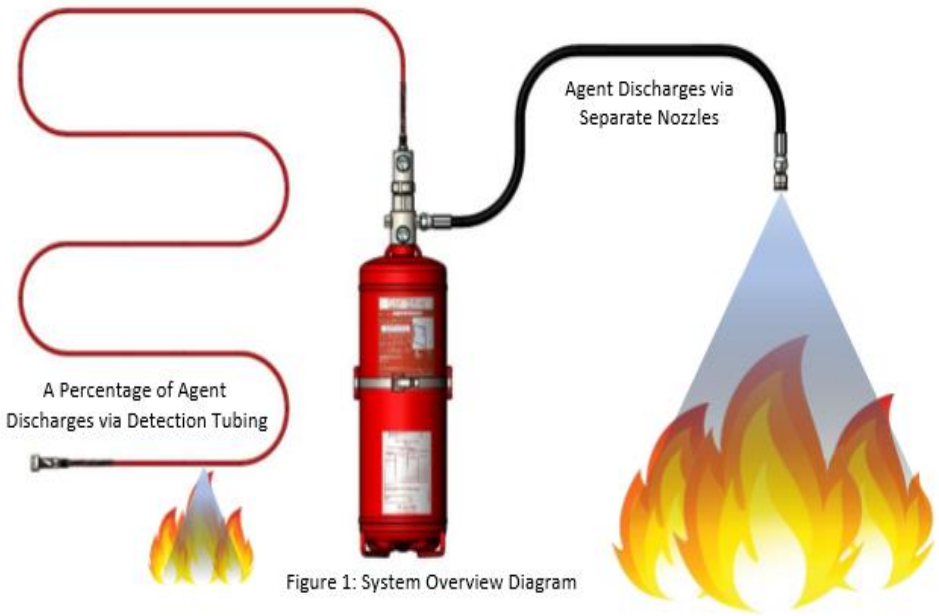


Figure 1: System Overview Diagram

ABC Dry Powder Extinguishing Agent

ABC dry powder has been treated to be water repellent and capable of being fluidized and free flowing so that it can be discharged through hoses and piping under the influence of an expellant gas. When discharged, dry powder will drift through the air and settle on surrounding surfaces.

Following a discharge, the exposed areas should be cleaned off within 24 hours. Dry powder can be cleaned up by one of the following methods: wiping, vacuuming, blowing off with an airline or pressure washing the exposed areas. In some cases, the powder should be scraped off a surface if that surface was hot at the time of discharge.

For hazard information, decomposition information, and physical properties of ABC Powder please refer to the Material Safety Data Sheet included with this manual.

3 – System Design and Limitations

The FILPINTHTBI Fire Suppression System design limitations were established and tested by Firetrace Ltd. The units are certified by SP Technical Institute of Sweden.

These units were subjected to numerous performance tests (as specified in (SPCR 183) to verify their suitability and to establish design limitations for :

1. Hazard Volume
2. Operating Temperature Range
3. Nozzle Placement
4. Nozzle Quantity
5. Maximum Length / Size of Piping and Number of Fittings

Forman systems are pre-designed to minimise the amount of engineering required when evaluating a design for specific application. As long as the discharge piping, nozzles and Forman tubing is installed within the limits prescribed in this manual then no further calculations are required for pressure drop, flow rates or, discharge time. When any additional limitations to hazard volume, area coverage, maximum height, design concentration, agent quantity, detector arrangement, etc, are also met, the system installation can be understood to comply with the design requirements, and UNECE R107. Therefore, no discharge tests or concentration measurements should be required.

Storage and Operating Temperatures

Forman cylinders are designed to be stored and operated at the ambient temperature range of
-20°C and +60°C (-4°F and -140°F)

System Operating Pressure

The normal operating pressure for Forman systems is 12 bar at 20°C (174psig at 68°F)

All Forman systems are designed for an operating temperature range of -20°C to +60°C. Table 1 shows the cylinder gauge pressure-temperature relationship based on a charging pressure of 12bar at 20°C.

Cylinder Pressure			
°C	**°F**	**bar**	**psig**
-20	-4	10.2	148.2
-10	14	10.6	154.7
0	32	11.1	161.1
10	50	11.5	167.5
20	68	12	174
30	86	12.4	180.4
40	104	12.9	186.9
50	122	13.3	193.3
60	140	13.8	199.8

Table 1: Cylinder Pressure-Temperature Relationship

Nozzle and Discharge Pipe Requirements

Specially designed High Throughput Powder Diffusers are used with the FILPINTHTBI System, this type of nozzle decreases discharge time and increases the spread of dry powder. The baseline engine compartment must be designed using at least 3 nozzles to suit hazard configuration of a 4m³ engine compartment.

A standard nozzle layout would include nozzles being installed at the top of the engine compartment roof facing downwards in a pendant position. One nozzle shall be located above the exhaust manifold in the region where oil is most likely to spill. Another nozzle shall be in the region of prominent hazards.

Each cylinder valve is equipped with 3 discharge ports (DP). All three discharge ports are to be used on the engine compartment.

Discharge Piping Specifications

FILPINTHTBI Systems shall use flexible discharge hoses for the ABC Dry Chemical Distribution System. The following tubing shall be used:

Hose Fittings	Nominal Braid Dia(mm)	Nominal Hose O.D.(mm)	Max. Working Pressure		Min Burst Pressure		Min. Bend Radius		Weight Kg/m
			Bar	PSI	Bar	PSI	mm	IN"	
3/8"	15.3	17.4	180	2610	720	10440	130	5.118	0.337

Liner: Synthetic oil resistant rubber
Reinforcement: One high tensile steel wire braid
Cover: Anti-Abrasive synthetic rubber, resistant to oils, fuels and atmospheric conditions
Working Temp: -40°C to 135°C (-40°F to 275°F)
Intermittent Temp: 40°C to 140°C (-40°F to 284°F)

Forman Detection / Actuating / Discharge Tubing

For the FILPINTHTBI System, the Forman tubing is used as a combination for heat detection, system activation and system discharge.

The detection / actuation / discharge tubing is heat sensitive and in a fire situation is designed to rupture at any point along the tube upon direct flame impingement or at high temperatures associated with fire conditions. The Forman detection tubing will burst when subjected to temperatures above 120°c (248°F) and form a diffuser where a percentage of the Dry Powder will be deployed.

The maximum length of Forman detection tubing that can be used for FILPINTHTBI Systems is 20 metres.

4 – Forman Installation Instructions

This section provides installation instructions covering components and limitations described ins Section 2 and Section 3 of this manual.

All components should be installed to facilitate proper inspection, testing, recharging, and any other required service or maintenance as may be necessary. Equipment must not be subjected to severe weather conditions or mechanical, chemical, or other damage which could render the equipment inoperative. The equipment must be installed in accordance with instructions in this Manual and the UNECE R107.

Cylinder/Valve and Bracket Assemblies

Cylinders should be located as close as possible to the protected enclosure. In some cases, the cylinder can be mounted inside the protected enclosure. The assemblies shall be located in a readily accessible location to allow for ease of inspection, service, and maintenance. The cylinders shall be located in an environment protected from the weather and where the temperature range is between -20°C and +60°C (-4°F and +140°F).

The cylinder and bracket must be mounted in the vertical plane and in no circumstances, should the cylinder be positioned at an angle of more than 45° from vertical. The cylinder valve must be facing up and oriented so that the pressure gauge is facing out and away from the mounting wall to facilitate visual inspection.

Mount the cylinder where it will not be subjected to accidental damage or movement. Suitable protection must be installed where necessary to prevent damage or movement.

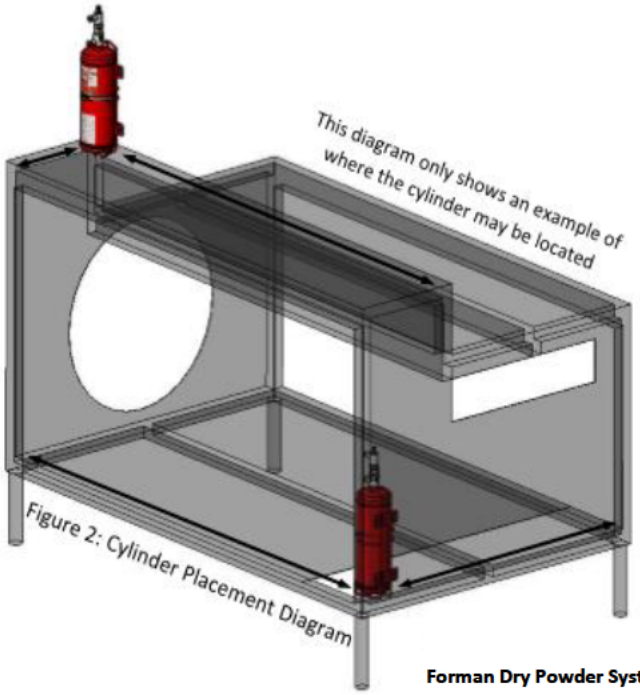
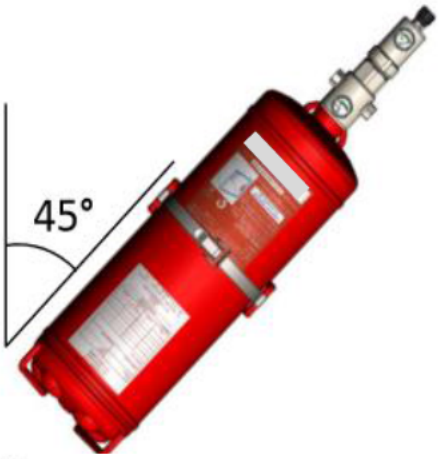


Figure 2: Cylinder Placement Diagram



It is recommended wherever possible that Forman cylinders can be mounted vertically. Where vertical positioning is not possible the system can be mounted within 45° of vertical.

Forman Dry Powder Systems are not suitable for horizontal mounting

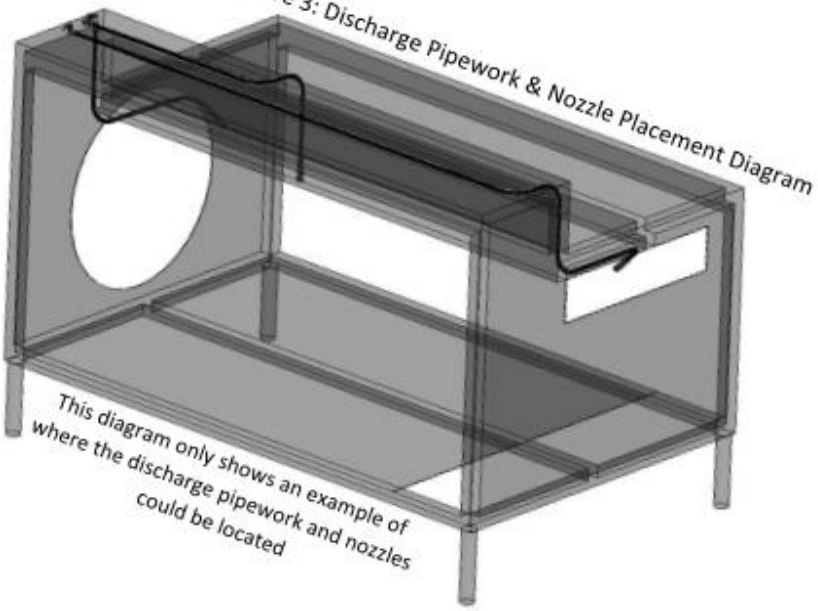
1. Securely mount the cylinder bracket to structural support using 4 or more mounting holes.
2. Position the cylinder in the bracket with the cylinder pressure gauge facing out. Secure the cylinder in place using the bracket latch.

Discharge Piping and Nozzles

1. It is advised that a risk assessment is carried out to determine appropriate discharge pipework and nozzle positioning.
2. Locate the nozzle(s) placement once the risk assessment has been carried out, ensuring design is within limitations and guidelines described in section 3.
3. Determine the routing of the discharge piping and verify that the pipe length from each discharge port does not exceed limitations and guidelines described in section 3.
4. Remove the safety fittings from the valve discharge ports as required. Secure the male 3/8 BSP fittings into each discharge port.
5. Install the discharge piping and fittings between the cylinder and nozzle(s). Secure pipework with the appropriate fittings as required.

For a more comprehensive list of Discharge Pipe Fittings, refer to section 6

Figure 3: Discharge Pipework & Nozzle Placement Diagram



Discharge Line Tees and Angles

Changes in direction of flow cause separation of expellant gas and dry chemical. To provide proper distribution of dry chemical when using a tee fitting special attention must be given to the method in which an approach is made after a change in direction. A single tee fitting shall be used per discharge piping.

Forman Detection / Actuation / Discharge Tubing

The Forman Automatic Detection tubing is the key part of the system and acts not only as the detector, actuator but also as the delivery method for a percentage of the ABC Powder.

The correct installation of the tubing is important to achieve optimum performance from the system. The tubing should be mechanically protected outside the identified risk area and should remain accessible to allow future servicing.

The tubing will activate at approximately 120°C and care should be taken to avoid attaching the tubing where temperatures above this are achieved during normal operation. It is recommended that the tube is a minimum of 150mm away from exceptionally hot surfaces or fitted with additional protection to avoid false activation.

For rear engine bus compartments, the Forman detection tubing is normally placed on the roof of the compartment. The tubing shall be placed as close as possible to high risk areas as long as they do not reach ambient temperature higher than 120°C (248°F). For example, a minimum distance from a turbo charger shall be 150mm (6 inches) to avoid premature tubing activation. See diagram below for a Forman detection tubing installation example.

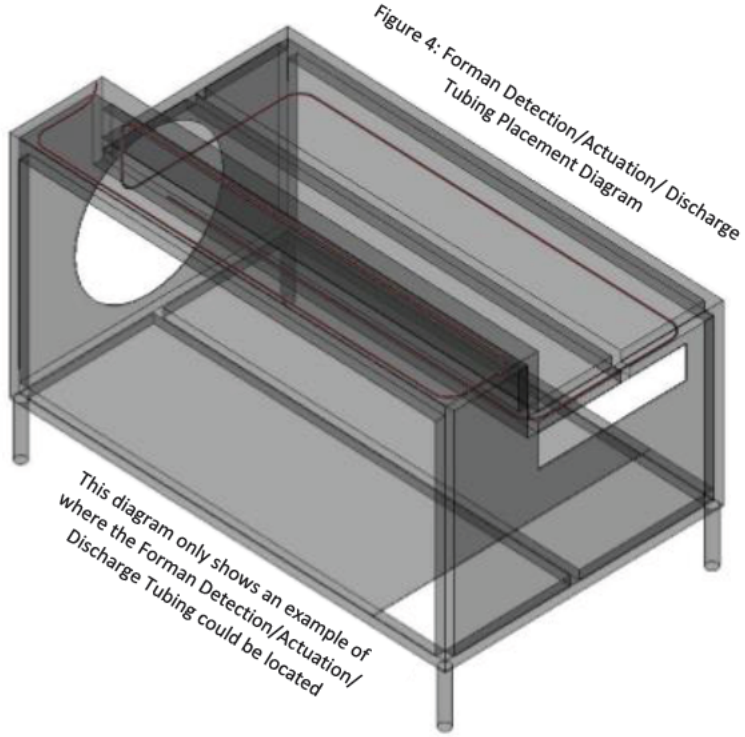


Figure 4: Forman Detection/Actuation/ Discharge Tubing Placement Diagram

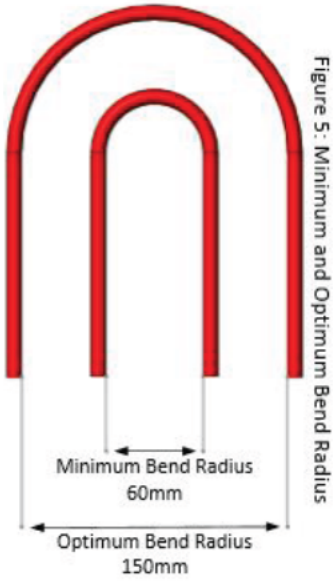


Figure 5: Minimum and Optimum Bend Radius

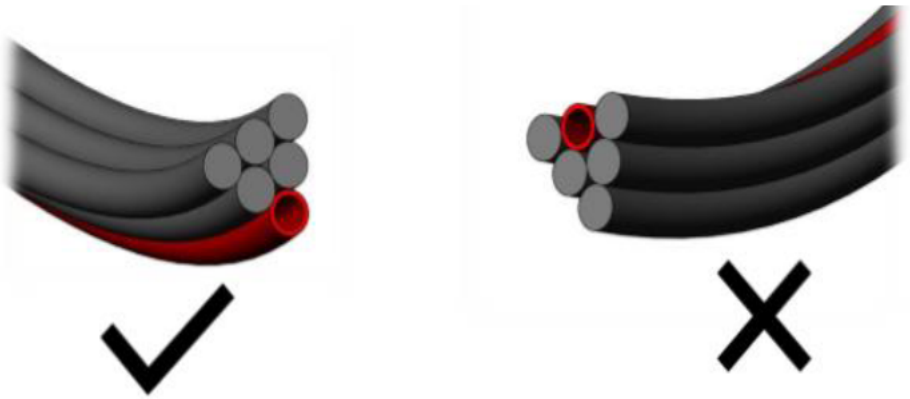
- The Forman detection tubing needs to be adequately fixed to retain its position.
- The tubing is a soft polymer and is susceptible to wear / chaffing when repeatedly rubbed against a hard or sharp surface.
- The tubing should be protected using nylon Kopex at all fixing points and where it passes through holes.
- The Forman tubing acts as the detector, actuator and provides delivery for a percentage of the extinguishant. It is imperative that the tubing is not kinked or crushed and the above minimum bending radius must be adhered to.
- Should the tubing be kinked or damaged in anyway then the Forman tubing in that section must be replaced.

- It is important that the detection tubing is exposed within the risk area. Kopex or other conduit sleeves should be kept to a minimum length (approx. 15mm (0.6”) either side of fixings) or where the tubing comes into contact with other surfaces.
- Always leave a small amount of slack tubing to the cylinder. Whilst this should also be secured it must be releasable to allow future servicing of the cylinder.
- It is important that fixings are not concealed as access is required during future servicing. When systems are installed during construction of the vehicle care should be taken not to fix the tubing anywhere that will not be accessible following installation of the engine and body parts.

The following models show both “Tyrap” and “P clip” methods of fixing, all of which are acceptable:

Both 8mm and 6mm Forman Tubing should be supported at maximum intervals of 200mm

When the tubing is installed with a group of other cables/pipes it must be positioned on the underside of the loom and must never be located within the centre of the loom



Connecting the Forman Tubing to fittings

All compression fittings must be secured in the following manner, alternatively push-in fitting can be used.

a) Cut the tube end ensuring the cut is clean and free from burrs. Check that no debris or swarf has been left in the tube.

b) Place the nut over the end of the tube with its threaded section towards the end you wish to create the flare on.

c) Push the tube firmly over the flaring tool ensuring the end of the tube bottoms out. Be careful not to kink the tube during this process.

d) The nut should be tightened finger tight and then using an appropriate spanner tightened firmly using only your hands, over tightening can crush the flare.

e) Slacken off the assembly and inspect the end to ensure flare has formed correctly, this flare can now be used to connect the tube to the system.

Method used to create Flare

1. Tubing must be cut square.

The use of a Tube Cutter (Part Number: FT0127) is recommended to achieve an accurate cut

2. Insert tubing through the spring nut/nut.

3. Offer the tubing to the flaring tool, so that the end of the tube stops against the face of the flaring tool, tighten the nut hand tight.

4. Whilst holding the flaring tool handle, use an appropriate size spanner (12mm spanner from 6mm tube and 14mm spanner for 8mm tube) tighten the nut spanner tight, the recommended torque is 5.7nm.

5. Undo the nut and inspect the end to ensure the flare has formed correctly. The tubing is now ready to be connected to the system.

Visual representation of ideal flare.

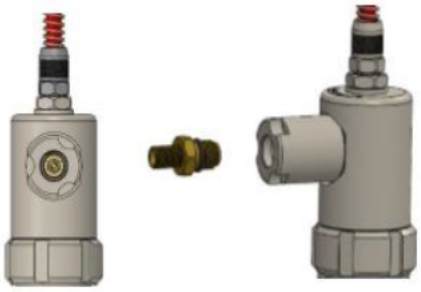
Commissioning Instructions

Locate cylinder and firmly secure with the bracket provided as specified in section 4.

Install detection tubing, discharge pipework and any accessories according to the procedure in section 4.

Remove black transportation cap from the top of the cylinder. Connect the Forman detection tubing to the top of the cylinder valve, tighten spring nut/nut using the appropriate sized spanner then secure the Forman detection tubing with appropriate methods of fastening.

Remove the gauge from the top section of the cylinder valve, this reveals the integrated ball valve which will be in the off position (horizontal) position).



A regulator and calibrated pressure gauge shall be used to pressurise the detection tubing with dry nitrogen through the filling adapter (FT0172), pressurise to 12bar (174psi).

It is recommended to have a portable dry nitrogen cylinder for on site use.

Remove the filling adaptor and thread the pressure gauge and 0-ring into its place to verify that the tubing is pressurised to at least 12 bar (174 psi). (pressure may have to be adjusted for temperature higher or lower than 20°C (68°F)).

Using tape, mark the location of the needle on the pressure gauge (*High Green*) and leave system for a minimum of ten minutes per metre of Trace Detection tube.

In the event of a leak go back to section 4 and check the installation of all fittings and accessories.

If the ball valve is opened abruptly, activation of the cylinder valve may occur, causing the system to discharge.

After confirming that there is no leakage within the detection tubing, remove the gauge from the top section of the cylinder valve and using the key provided SLOWLY rotate the ball valve counter clockwise to the "ON" position (vertical position)

The system is now live

An optional Pressure Switch Adapter can be fitted in either gauge adapters otherwise the gauges can be returned.

<u>Please note that the system will not operate with the isolator valve in the closed position, an optional status indicator module (FTSIMI) can be used to determine whether the valve is isolated or activated.</u>

Service and Maintenance for ABC Dry Chemical Systems

The Forman systems can operate in a harsh environment and are occasionally subjected to high temperatures and extreme vibration. It is essential that the systems are regularly serviced to ensure their correct operation

To comply with British Standard BS 5306 (section three) the following maintenance tasks should be carried out periodically.

The British Standard recommends that each system is visually inspected every 3 months and then fully serviced at a maximum interval as specified by the manufacturer.

All ABC Dry Powder systems require discharge testing at maximum 5 year intervals.

The following checks should be carried out on this inspection.

- Check the pressure gauge is reading high-green.
- Ensure physical changes of protected areas haven't affected cylinder suitability.
- Check external surface of the cylinder for evidence of rust or corrosion.
- Report any potential problems immediately.

In the event of activation of the system, a replacement should be obtained from Forman Vehicle Services Ltd.

Forman Vehicle Services Ltd recommends a visual inspection of a Forman system at least every three months.

Forman Vehicle Services Ltd recommend that all powder systems are fully serviced every 6 months by a competent engineer.

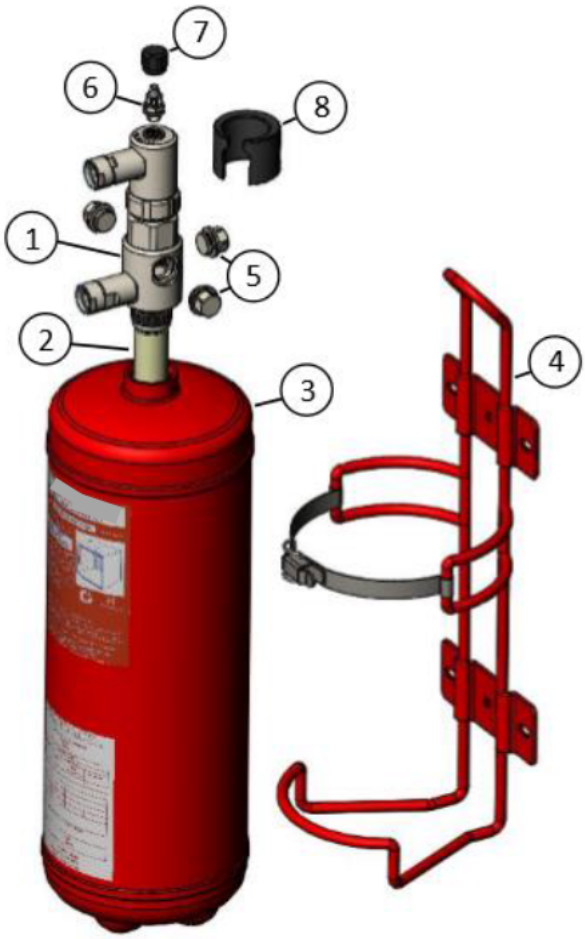
<u>If there's no visible sign of pressure drop then:</u>

- ✓ Check date of manufacture and record when discharge test is required (5 years from new date on cylinder).
- ✓ Check external condition of cylinder. Replace if there is any sign of damage or wear.
- ✓ Check gauge is facing upwards (if applicable) and that cylinder is installed as upright as possible. Where necessary reposition cylinder, or highlight any required modifications for return visit.
- ✓ Remove cylinder gauge and ensure correct operation. Clean and lubricate O ring and refit the gauge. (Due to possible pressure seepage, the gauge must be replaced as soon as possible.)
- ✓ Remove cylinder from bracket and agitate powder contents. (Cylinder should be inverted to achieve this. A noticeable movement of the contents should be apparent. A rubber mallet can be utilised to achieve this.)
- ✓ Inspect engine compartment and ensure Forman detection tubing is correctly installed and protecting entire risk area. Check for signs of wear/damage and tighten or replace fixings as necessary.
- ✓ Record details and date of service on cylinder label. Replace cylinder into bracket and ensure it is secured by clamp / Tyrap.

<u>If there is notable sign of pressure drop then the system must be replaced</u>

System Component List

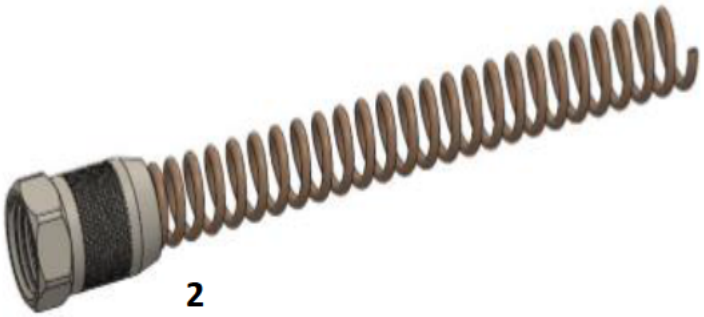
ITEM NUMBER	DESCRIPTION
1	Indirect Low Pressure High-Throughput Integrated Bi-Directional Valve
2	Diptube High-Throughput 426mm White
3	Steel Cylinder 6kg/Litre with ABC Powder
4	6kg Bracket with Stainless Steel Strap
5	ILP High-Throughput Bi-Directional M18x1 Plug
6	1/8" BSP Fitting for 8mm
7	Plastic Black Cap for 8mm
8	Optional Status Indicator Module



Detection Line Parts List

Part Number	Description
1	Male-Tube/Trace 8mm Trace 1/8” Male -8mm Special
2	Anti-Kink Spring Nut 8mm Stainless Steel
3	Banjo Tee Assembly for Valve Male
4	End of Line -12 bar c/w Integrated 8mm
5	8mm Blank/Stop End

1



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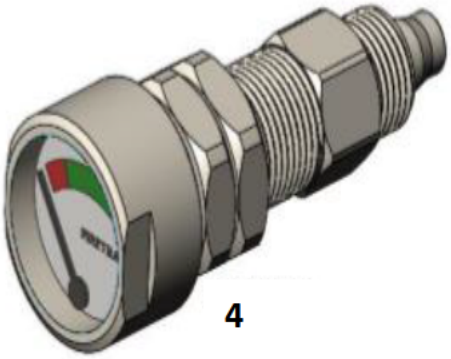

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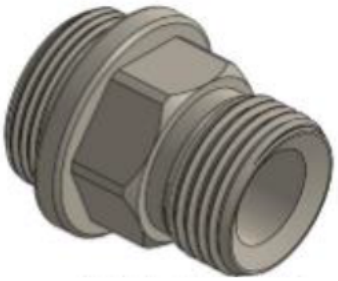
Discharge Line Parts List

Part Number	Description
1	ILP High-Throughput Bi-Directional M18x1 Plug
2	High-Throughput Diffuser 3/8” BSP
3	ILP High-Throughput Bi-Directional Valve M18x1 – 3/8” Adapter
4	1m 3/8” Flexi Hose 90° Female to Straight Female
5	3m 3/8” Flexi Hose 90° Female to Straight Female
6	4m 3/8” Flexi Hose 90° Female to Straight Female
7	3/8” Tee 10mm-10mm-10mm

1

2



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4 & 5 & 6

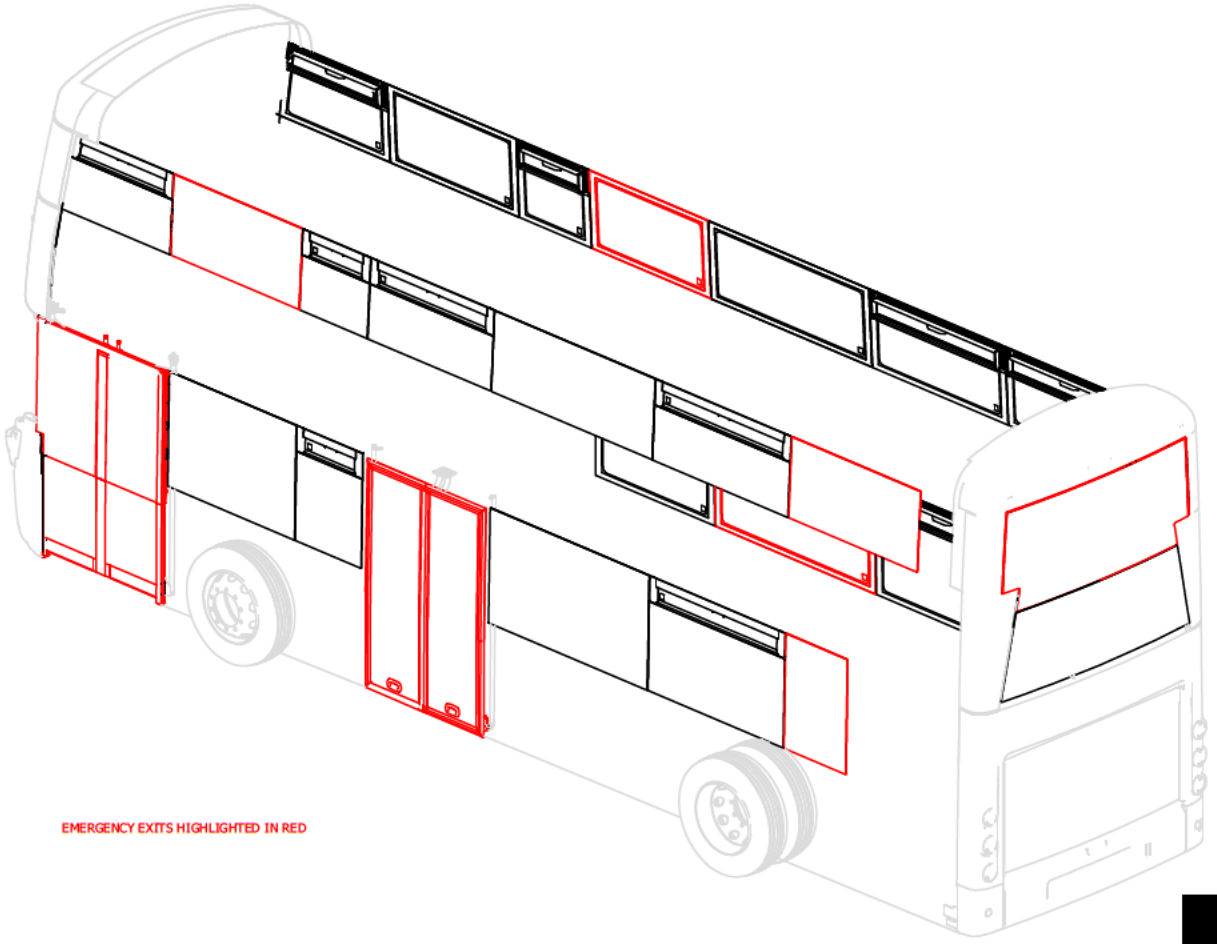
7

STREETDECK H2 10.9
Powerfloor FC

APPENDIX 5 ANNEX B

EMERGENCY EXIT LAYOUT

CUS-03565



EMERGENCY EXITS HIGHLIGHTED IN RED

Provisional drawing

[redacted]

** Maximum capacity to be confirmed with final body weight & options
- All above dimensions are for reference only and may vary. Seat pitches may vary depending on chosen seat type.
- Wright Bus reserve the right to alter specifications as deemed necessary due to continuous improvement initiatives.