FIRETRACE®

AUTOMATIC FIRE SUPPRESSION SYSTEMS

DESIGN, INSTALLATION, OPERATION AND MAINTENANCE MANUAL

FOR

FM-200® CLEAN AGENT PRE-ENGINEERED AUTOMATIC DIRECT FIRE DETECTION AND SUPPRESSION SYSTEM

Direct Low Pressure (DLP) Models:

DLP-300, DLP-600, & DLP-1200

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FM-200 is a registered trademark of Great Lakes Chemical Corporation

This Manual describes some applications and protection scenarios outside the scope of the FM Approval.

These systems are not to be used at FM Global insured locations for applications where FM Global specifically recommends smoke detection for actuation of the extinguishing system.

1.0 FORWARD

1.1 General

This manual is written for the fire protection professional that designs, installs, and maintains Firetrace FM-200 pre-engineered automatic direct fire detection and suppression systems.

Firetrace FM-200 automatic direct fire suppression systems are to be designed, installed, inspected, tested, maintained, and recharged by qualified trained personnel in accordance with the following:

- All instructions, limitations, etc. contained in this manual P/N 800023. All information contained on the agent cylinder nameplate(s).
- NFPA-2001, *Standard on Clean Agent Fire Extinguishing Systems.*
- FMRC Approval.
- Local Authority having jurisdiction.

1.2 Safety Precautions

Safety precautions are essential when any electrical or mechanical equipment is involved. These precautions should be followed when handling, servicing, and recharging Firetrace FM-200 fire suppression system cylinders and equipment. If safety precautions are overlooked or ignored, personal injury or property damage may occur.

The following symbols are used throughout this manual. Always heed these precautions. They are essential to the safe use of the equipment described in this manual.

DANGER:

This danger symbol identifies immediate hazards and provides specific instructions or procedures, which if not correctly followed **WILL** result in severe personal injury or death.

WARNING:

This warning symbol identifies specific instructions or procedures, which, if not correctly followed, **COULD** result in severe personal injury or death.

CAUTION:

This caution symbol identifies specific instructions or procedures, which if not correctly followed, **COULD** result in minor personal injury or equipment or property damage.

1.2.1 The following safety precautions should always be followed:

WARNING:

Pressurized (charged) cylinders are extremely hazardous and if not handled properly are capable of causing bodily injury, death or property damage.

1. Read and understand this manual and the other documents referenced herein.
2. Wear safety glasses when working with pressurized cylinders and charging equipment. It is recommended to wear leather gloves to avoid any cryogenic burns if FM-200 is accidentally discharged on or near the skin.
3. Make sure that the ball valve (attached to the top of the cylinder valve) is closed (lever is in "OFF" position), the detection/discharge tubing has been removed from the cylinder valve, before removing the cylinder from the installation, and before performing any charging, leak tests or salvage operations.
4. Follow all of the safety procedures included on the cylinder nameplate and in this manual.
5. Never assume that a cylinder is empty. Treat all cylinders as if they are fully charged.

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

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www.firetrace.com

2.0 INTRODUCTION

The Firetrace FM-200 pre-engineered automatic direct fire suppression systems are approved with Factory Mutual Research Global (FM). These systems are designed for total flooding applications, using FM-200 Clean Agent, in accordance NFPA-2001, *Standard on Clean Agent Fire Extinguishing Systems.*

The Firetrace Pre-Engineered Automatic Systems have been tested to limits established by FM in compliance with the requirements specified in UL 2166, *Standard for Halocarbon Clean Agent Extinguishing System Units, Factory Mutual Test Protocol,* and as detailed in this Manual.

Each installed pre-engineered system is equipped with its own detection/discharge tubing. The pre-engineered concept minimizes the amount of engineering involved in system design. When the detection/discharge tubing is 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. Each extinguishing unit, when installed, is a self-contained system, meaning that it is equipped with its own automatic (non-electric) detection system, which when actuated, automatically releases the suppression agent into the hazard area.

Since the units are listed as automatic systems (e.g. no simultaneous manual or electric actuation means is provided), only one (1) extinguishing unit can be used to protect one hazard. These extinguishing units **cannot** be combined to protect a larger size hazard, since they are not designed to provide for simultaneous actuation of two (2) or more units.

Local authorities having jurisdiction should be consulted as to the acceptability for particular hazards and requirements covering installation.

2.1 FM-200 Extinguishing Agent

The extinguishing agent used in Firetrace pre-engineered automatic direct fire suppression systems is Heptafluoropropane, more commonly known as FM-200.
FM-200 (1,1,1,2,3,3,3-heptafluoropropane, CF_3CHFCF_3) is a colorless odorless gas, low in toxicity, electrically non-conductive, leaves no residue, and is an extremely effective fire suppression agent.

FM-200 is included in NFPA-2001, under the generic name HFC-227ea, and has been evaluated and approved for use in occupied areas as a Total Flooding agent; when used as specified under the U.S. Environmental Protection Agency (EPA) SNAP Program rules. Refer to the SNAP Program rules for more information.

FM-200 extinguishes a fire by a combination of chemical and physical mechanisms without affecting the available oxygen. This allows personnel to see and breath, permitting them to safely leave the fire area. It is an effective Total Flooding extinguishing agent that can be used on many types of fires. It is effective for use on Class A surface fires, Class B flammable liquid fires, and Class C electrical fires.

2.1.1. Cleanliness

FM-200 is clean and leaves no residue, thereby minimizing after fire clean up, along with keeping expensive downtime to a minimum. Most materials such as steel, aluminum, stainless steel, brass, as well as plastics, rubber and electronic components are not affected by exposure to FM-200. This agent is also environmentally friendly, having an ozone depletion potential (ODP) of 0.00.

2.1.2. Decomposition

When exposed to temperatures of 1300^{o}F (700^{o}C) FM-200 will form products of decomposition (halogen acids). Test results have shown that when the agent is rapidly discharged, causing rapid extinguishment of flames, the amount of decomposition products formed is minimal.

2.1.3. Physical Properties of FM-200 (HFC-227ea)

Chemical Name: Heptafluoropropane (CF_3CHFCF_3)

Molecular Weight	170.03
Boiling Pont (^{o}F) @ 19.7 psia	1.9
Freezing Point (^{o}F)	- 204
Critical Temperature (^{o}F)	214
Critical Pressure (psia)	422
Critical Volume (ft^3/Ibm)	0.0258
Critical Density (Ibm/ft^3)	38.76
Specific Heat, Liquid (BTU/Ib-^{o}F) @ 77^{o}F	0.0282
Specific Heat, Vapor (BTU/Lb-^{o}F) @ constant Pressure (1 ATM.) @ 77^{o}F	0.185
Heat of Vaporization (BTU/Ib) at Boiling Point	56.7
Thermal Conductivity (BTU/h ft ^{o}F) of Liquid @ 77^{o}F	0.040
Viscosity, Liquid (Ib/ft hr) @ 77^{o}F	0.433
Vapor Pressure (psia) @ 77^{o}F	66.4
Ozone Depletion Potential	0.00

Refer to NFPA-2001 for additional information.

2.1.4. Fill Density

Each Firetrace FM-200 fire suppression system cylinder has been designed for a maximum fill density as shown in Table 3.1, and super- pressurized with nitrogen to 150 psig +10, -0 psig at 70^{O}F (10.4 bars gage + 0.7, -0 bars gage at 21^{O}C). It is important that these values not be exceeded.

Fill density and temperature significantly affect the pressure in the system cylinder. At elevated temperatures the rate of increase in pressure is very sensitive to fill density (see Figure 2.1). If the maximum fill density is exceeded, the pressure will increase rapidly with temperature increase so as to present a hazard to personnel and property. Adherence to the limits on fill density and pressurization levels will prevent excessively high pressures from occurring if the system cylinder is exposed to elevated temperature. This will also minimize the possibility of an inadvertent discharge of agent through the cylinder pressure relief device, where provided. It is recommended to not mount the cylinder in direct sunlight if this would create elevated cylinder temperatures.

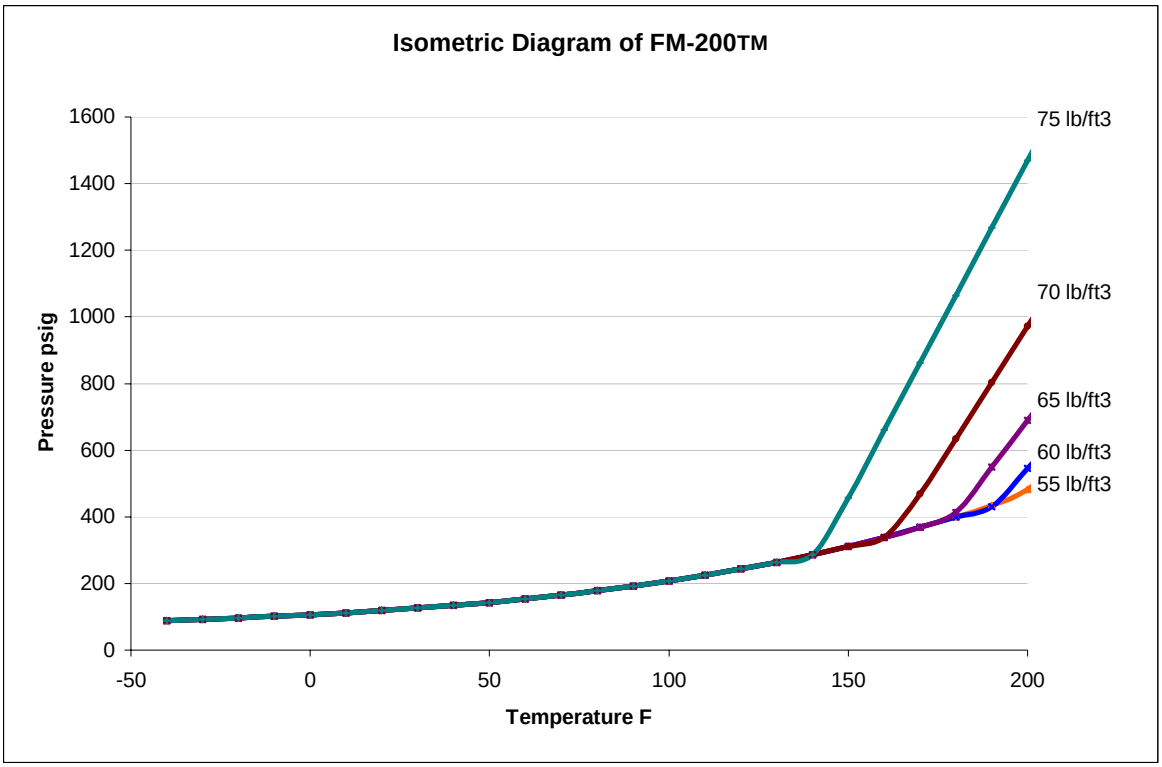


Figure 2.1: ISOMETRIC DIAGRAM
FM-200 PRESSURIZED WITH NITROGEN TO 150 psig AT 70°F

3.0 SYSTEM DESCRIPTION

3.1 GENERAL

The Firetrace FM-200 Automatic Direct systems are available in 3 sizes, namely:

Model DLP-300 : Charged with 3.0 Lbs. of FM-200
Model DLP-600 : Charged with 6.0 Lbs. of FM-200
Model DLP-1200 : Charged with 12.0 Lbs. of FM-200

These systems are designed for use in Total Flooding applications only, where the hazard is normally unoccupied, or in some applications where the hazard may be normally occupied. (See NFPA-2001, Section 1-6 for personnel safety exposure limits for FM-200 [HFC-227ea])

The Firetrace Direct Systems can be used, but are not limited, to protect the following:

- Electrical and electronic cabinets.
- Telecommunication areas.
- Data Processing areas and cabinets.
- Other high value assets.
- Laboratory fume /exhaust cabinets
- Pump enclosures
- UPS units
- Flammable Chemicals storage cabinets
- Generator Enclosures
- Transformer Cabinets
- Computer/Data Storage Cabinets
- CNC & VMC Machining centers
- Many other applications

FM-200 is a gaseous fire-extinguishing agent that is effective for use on:

- Class A – surface type fires
- Class B – flammable liquid fires
- Class C – electrical equipment fires

FM-200 should not be used where the following materials may be present.

- Pyrotechnic chemicals containing their own oxygen supply.
- Reactive metals such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium.
- Metal hydrides.
- Chemicals capable of undergoing autothermal decomposition, such as certain organic peroxides and hydrazine.

For hazards beyond the scope described above, it is recommended that the designer consult with Firetrace, NFPA-2001, and the local authority having jurisdiction, as to the suitability on the use of FM-200 for a particular hazard, for personnel exposure effects from the design concentration, and for installation requirements.

Firetrace FM-200 Automatic Direct Systems consists of the following major components:

- FM-200 Cylinder/Valve assembly.
- Cylinder Mounting Bracket.
- Firetrace detector, actuation and discharge tubing and fittings (no substitute).
- Pressure switch.

Once installed, the Firetrace Automatic System becomes a self-contained, self-actuating unit that does not require an external source of power or electricity.

The system utilizes unique Firetrace flexible tubing that is attached to the top of the cylinder valve. This tubing is pressurized with dry nitrogen, is temperature sensitive and acts as a continuous linear thermal detector that ruptures upon flame impingement. Once the detector tubing is ruptured forming a nozzle at the rupture point, allows the FM-200 agent to flow through, distributing the extinguishing agent through the nozzle into the protected area. Upon system actuation the pressure switch can be used to indicate system discharge, shutdown ventilation, shut-off electrical power, etc. as may be required.

⚠ CAUTION

This system is designed and Listed as an Automatic unit. No manual or electric means is provided for simultaneous actuation of multiple systems. Only one (1) unit can be used to protect one hazard. These extinguishing units cannot be combined to protect a larger size hazard, since they are not designed to provide for simultaneous actuation of two (2) or more units.

3.1.1 Operating Pressure:

The FM-200 cylinder is super-pressurized with dry nitrogen to 150 psig at 70^{o}F.

3.1.2 Operating Temperature Range Limitations:

The ambient operating temperature range for all system components is:
32^{o}F to +130^{o}F (0^{o}C to +54.4^{o}C).

3.2 COMPONENT DESCRIPTIONS

3.2.1 FM-200 Cylinder/Valve Assemblies (see dwgs. FDLP-001 and FDLP-002)

FM-200 is stored in DOT steel cylinders as a liquefied compressed gas, super-pressurized with nitrogen to 150 psig at 70^{o}F (1,034 KPa @ 21^{o}C). The cylinder/valve assemblies are available in 3 sizes, namely:

3 LB size; filled with 3.0 LBS (1.36 Kg) of FM-200
6 LB size; filled with 6.0 LBS (2.72 Kg) of FM-200
12 LB size filled with 12.0 LBS (5.45 Kg) of FM-200

Each cylinder is equipped with a nickel plated brass valve, a pressure gauge to monitor cylinder pressure, and a quarter turn ball valve that interfaces with the Firetrace detector tubing. The ball valve must be kept closed at all times when the cylinder is not in service.

In addition, all size cylinder valves are equipped with a pressure relief (rupture disc) device in compliance with DOT requirements.

Table 3.1 describes the 3, 6, and 12 LB cylinder assemblies. Each cylinder is equipped with a straight siphon tube and can only be mounted in a vertical (upright) position.

Nom Size	Assy Part No.	Outside Dia.		Overall Height		Internal Volume		FM-200™ Agent		Fill Density	
		In.	cm	In.	cm	In^3	cm^3	Lb.	Kg	Lb/ft^3	Kg/m3
3	900300	3.0	7.62	16.2	41.15	71	1,163	3.0	1.36	73	1,169
6	900301	4.25	10.8	17.7	44.96	149	2,441	6.0	2.72	70	1,121
12	900302	5.09	12.93	23.0	58.42	300	4,916	12.0	5.44	69	1,105

Table 3.1 : FM-200 Cylinder / Valve Assemblies

Table 3.2 describes the DOT Specifications used for the manufacture of the FM-200 cylinders.

Nominal Size	DOT Spec	Cylinder Service Pressure psig	DOT Cylinder Test Pressure	
			psig	kPa
3	4B240ET	240	480	3,310
6	4B-225	225	450	3,103
12	4B-225	225	450	3,103

Table 3.2 : DOT Cylinder Specifications

The Firetrace FM-200 Systems are designed for an operating temperature range of 32°F to +130°F (0°C to +54.4°C). Table 3.3 shows the cylinder gauge, pressure-temperature relationship based on a maximum fill density of 75 LB/Ft^3, and a charging pressure of 150 psig at 70°F

Cylinder Pressure			
Temperature		Pressure	
°F	°C	psig	kPa
0	-17.8	91	627
10	-12.2	97	689
20	-6.7	104	717
30	-1.1	111	765
40	4.4	119	820
50	10.0	128	883
60	15.5	139	958
70	21.1	150	1,034
80	26.7	163	1,124
90	32.2	177	1,220
100	37.8	192	1,324
110	43.3	209	1,441
120	48.9	228	1,572
130	54.4	249	1,717

Table 3.3 : Cylinder-Temperature Relationship

3.2.2 Cylinder Mounting Bracket (see dwg. FDLP-009)
A wall mounted painted steel bracket is used to mount the cylinder/valve assembly in a vertical (upright) position. Each bracket is equipped with two (2) integral quick-clamp straps.

3.2.3 Firetrace Flexible Detector, Actuation and Discharge Tubing (see dwg. FDLP-010)
For the direct FM-200 systems, the Firetrace tubing performs three functions; Heat detection, system activation, and FM-200 agent discharge. The tubing is installed throughout the hazard volume, with one end connected to the top of the FM-200 cylinder valve. The tubing is pressurized with nitrogen to 150 psig and maintains the system in the "OFF" position. An optional pressure gauge or pressure switch can be connected to the other end of the detector/discharge tube to monitor system pressure and/or signal system actuation etc. The detector/discharge tubing is heat sensitive and in a fire situation is designed to rupture at any point upon flame impingement. The rupture of the tube results in a formation of a discharge nozzle that will perform a complete discharge of the FM-200 agent.

3.2.4 Pressure Switch (see dwg. FDLP-011)
A pressure switch is provided as a standard part of the cylinder valve assembly and is connected directly into the pressurized portion of the cylinder valve. This pressure switch is used to monitor system pressure, system actuation and or to energize or de-energize electrically operated equipment.

An additional pressure switch is available as an optional item. This unit is connected at the end of the line of the Firetrace detector tubing to provide additional electrical functions as may be required. Firetrace recommends that all systems use a pressure switch coupled with some device to alert personnel in the event of a system discharge.

3.2.5 Recharge Adapter, FM-200 Cylinder (see dwg. FDLP-018)
The recharge adapter is installed in EOL (end of line) and it is used for refilling the cylinder with FM-200 agent.

3.2.6 Cylinder N_2 Recharge Adapter (see dwg. FDLP-013)
The N_2 recharge adapter is connected to Firetrace tubing, and the other end of the tubing is attached to the ball valve, located on top of the cylinder valve, during the charging procedure. The adapter is used to super pressurize the FM-200 cylinder with nitrogen.

3.2.7 Cylinder Hydrotest Adapters (see dwg. FDLP-014)
These adapters are available for use when a cylinder hydrostatic test is required in order to comply with DOT regulations.

3.2.8 FM-200 Warning Nameplate (see dwg. FDLP-015)
The Warning Plate is required to warn personnel not to enter the hazard area during or after discharge. Warning signs shall be provided in a conspicuous location, at the entrance to the protected areas, or in the case of cabinet protection on the front face of the cabinet.

4.0 SYSTEM DESIGN and LIMITATIONS

4.1 General

The Firetrace series of FM-200 Clean Agent Pre-Engineered Automatic Direct System units were tested and limits established by Factory Mutual Research Corp.

These systems were subjected to numerous performance and fire tests (as specified in NFPA-2001 and UL Standard 2166) in order to verify their suitability and to establish design limitations for:

- Hazard volume
- Discharge time and flow rates
- Design concentrations & design factors
- Detector/Discharge tubing placement

The pre-engineered automatic system concept minimizes the amount of engineering required when evaluating a design for a specific application. So long as the discharge/detection tubing is installed within the limits prescribed in this manual, no calculations are required for pressure drop, flow rates or discharge time. When the additional limitations of 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, NFPA-2001 and FMRC approval. Therefore, no discharge tests or concentration measurements should be required.

4.2 Design Procedure

The following procedures should be used to design a Firetrace Model DLP FM-200 pre-engineered automatic system. In addition, the applicable requirements specified in Chapter 3 of NFPA-2001 should be followed.

a. Conduct a survey and analysis of the hazard to be protected

b. Determine the height, length, and width of the enclosure. Calculate the volume. All of these parameters must be within the dimensional limits specified in this manual. (See Section 4.3, Table 4-1, and Figure 4-1).

c. Determine the anticipated minimum and maximum ambient temperatures expected within the enclosure to be protected.

d. Determine the minimum design concentration required for the hazard. (See Section 4.5 and Table 4-2).

e. Determine the integrity of the enclosure. Are there any openings that must be closed at the time of agent discharge?

f. Calculate the quantity of FM-200 agent required to provide the proper design concentration at the minimum anticipated ambient temperature in the hazard enclosure. (Refer to Section 4.7 and Table 4-3).

g. Determine the cylinder size required, based on the hazard volume limitations, enclosure size, and quantity of FM-200 agent required. **Remember, as cautioned in Table 4.1 of this manual, only one (1) extinguishing system unit can be used to protect one (1) hazard.**

h. Calculate the maximum concentration anticipated, based on the total quantity of FM-200 agent being used at the maximum ambient temperature expected within the enclosure (See Section 4.7). Using this data, evaluate personnel safety exposure limits as specified in NFPA-2001.

i. Determine the location of the FM-200 cylinder.

j. Determine the arrangement and placement of the Firetrace detector/discharge tubing (See Section 4.10).

k. Determine any auxiliary equipment requirements, such as pressure switch(es) to sound alarms, shut-down ventilation, shut-off electrical power, etc.

l. Prepare system drawings, bill of materials list, etc.; following the applicable sections of Chapter 3 of NFPA-2001.

4.3 Hazard Enclosure Size Limitations

The maximum dimensions and area coverage, for each size system unit, are shown in Table 4-1. The protected enclosure can be any size, shape, or volume, provided that the dimensions do not exceed the limitations shown in Table 4-1, except as noted. **(See Notes (a) and (b) below).**

TABLE 4-1
Enclosure Size Limitations

		Maximum Coverage				
Model	**FM-200™ (Lbs)**	**Length (Ft)**	**Width (Ft)**	**Height (Ft)**	**Area (Ft^2)**	**Volume (Ft^3)**
DLP-300	3.0	6 **(a)**	6 **(a)**	12	36	**(b)**
DLP-600	6.0	6 **(a)**	6 **(a)**	12	36	**(b)**
DLP-1200	12.0	6 **(a)**	6 **(a)**	12	36	**(b)**

Notes:

(a) The maximum length and width dimensions can vary from those shown in Table 4-1, provided that the maximum area coverage does not exceed 36 Ft^2. See Figure 4-1 for typical examples of configurations that meet the maximum area coverage limitations.

(b) The maximum volume varies as a function of the minimum design concentration and minimum anticipated design temperature requirement for the enclosure being protected.

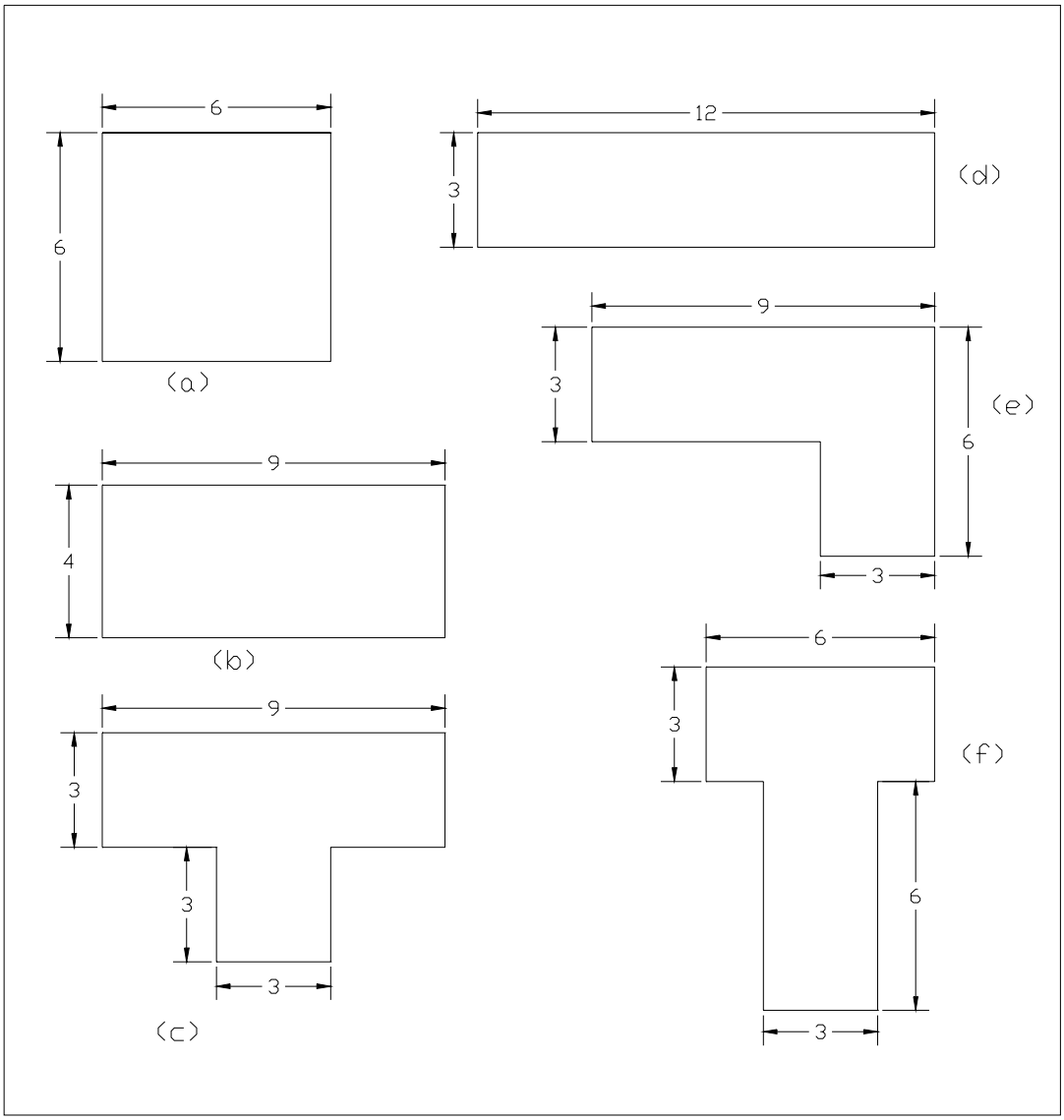


FIGURE 4-1
Typical Examples of Enclosure Configurations
That Meet The Area Coverage Limitations
(all dimensions in feet)

4.4 General Specifications

4.4.1 Discharge Time: Extended discharge criteria applies based on NFPA 2001, or as may be otherwise required by the authority having jurisdiction (AHJ).

4.4.2 Storage and Operating Temperature Range: The Firetrace FM-200 system equipment is designed to be stored and operated at the ambient temperature range of 32°F to +130°F (0°C to +54.4°C).

4.4.3 System Operating Pressure: The normal system operating pressure is 150 psig at 70°F.

4.5 Minimum Design Concentrations

The minimum design concentrations to be used with Firetrace FM-200 systems includes a minimum safety factor (SF), as specified in NFPA-2001, Year 2000 edition; namely:

Hazard Type	Minimum Safety Factor
Class A (surface fires), including plastic materials typically found in electrical/electronic equipment	1.2
Class B Flammable Liquids	1.3

A 9.58% heptane design concentration was used for all of the Class B Automatic Extinguisher fire tests conducted per Section 36 of UL 2166. Since this value exceeded the limit specified in Section 61.2(c) of UL 2166, an additional multiplication factor (MF) of 1.117 must be added to establish the minimum design concentration for all other Class B fuels.

Table 4-2 lists FM-200 minimum design concentrations that must be used with Firetrace FM-200 systems for Class A hazards and the various Class B fuels shown.

Consult Firetrace Web site or contact Firetrace if the hazard you desire to protect is not listed.

TABLE 4-2
FM-200 extinguishing and design concentrations for Class A and class B fuels

Fuel	Extinguishing Concentration %	Minimum Design Concentration %
Class A (surface fires) [(a)] Including plastic materials typically found in electrical/electronic equip.	5.8	**7.0**
Class B fuels [(b)]		
Acetone	6.9	**10.0**
Ethanol	8.7	**12.6**
n-heptane	6.6	**9.58** [(c)]
Methanol	10.5	**15.2**
2-propanol	7.4	**10.7**
Toluene	5.2	**7.6**

Notes:

(a) The value for the Class A fuel extinguishing concentration was derived from fire tests conducted per section 34.2 of UL 2166.

(b) The Class B extinguishing concentration values were derived using the cup burner test method.

(c) The 9.58% heptane design concentration was used in the automatic extinguisher fire tests conducted per section 36 of UL 2166.

For all other Class B fuels not shown in Table 4-2, the minimum design concentrations shall be calculated as follows:

Min. Design Conc. = cup burner value x 1.3 (SF) x 1.117 (MF)
= 1.452 x cup burner value

4.6 Closeable Openings and Ventilation Shut-Down

Provisions must be made to provide means to close all openings in the hazard enclosure and shut-off ventilation at the time of system discharge.

4.7 FM-200 Design Concentration Flooding Factors

The total flooding quantity of FM-200 agent required, in order to achieve a specific concentration at a specific temperature, can be found in Table 4-3.

To find the total quantity of FM-200 required, multiply the hazard volume by the flooding factor (w/v) found in Table 4-3 that corresponds to the design concentration and temperature desired.

⚠ CAUTION

The quantity of agent required must be based on the lowest anticipated ambient temperature in the protected space.

TABLE 4-3
FM-200 Total Flooding Quantity

Temp. *t* °F	Specific Vapor Volume *S* (ft^3/lb)	FM-200 weight reqmt. per unit volume of protected space, w/v (lb/ft^3)									
		Design Concentration, *C* (% by volume)									
		7	8	9	10	11	12	13	14	15	16
0	1.8850	0.0399	0.0461	0.0525	0.0589	0.0656	0.0723	0.0793	0.0864	0.0936	0.1010
10	1.9264	0.0391	0.0451	0.0513	0.0570	0.0642	0.0708	0.0776	0.0845	0.0916	0.0989
20	1.9736	0.0381	0.0441	0.0501	0.0563	0.0626	0.0691	0.0757	0.0825	0.0894	0.0965
30	2.0210	0.0372	0.0430	0.0489	0.0550	0.0612	0.0675	0.0739	0.0805	0.0873	0.0942
40	2.0678	0.0364	0.0421	0.0478	0.0537	0.0598	0.0659	0.0723	0.0787	0.0853	0.0921
50	2.1146	0.0356	0.0411	0.0468	0.0525	0.0584	0.0645	0.0707	0.0770	0.0835	0.0901
60	2.1612	0.0348	0.0402	0.0458	0.0514	0.0572	0.0631	0.0691	0.0753	0.0817	0.0881
70	2.2075	0.0341	0.0394	0.0448	0.0503	0.0560	0.0618	0.0677	0.0737	0.0799	0.0863
80	2.2538	0.0334	0.0386	0.0439	0.0493	0.0548	0.0605	0.0663	0.0722	0.0783	0.0845
90	2.2994	0.0327	0.0378	0.0430	0.0483	0.0538	0.0593	0.0650	0.0708	0.0767	0.0828
100	2.3452	0.0321	0.0371	0.0422	0.0474	0.0527	0.0581	0.0637	0.0694	0.0752	0.0810
110	2.3912	0.0315	0.0364	0.0414	0.0465	0.0517	0.0570	0.0625	0.0681	0.0738	0.0797
120	2.4366	0.0309	0.0357	0.0406	0.0456	0.0507	0.0560	0.0613	0.0668	0.0724	0.0782
130	2.4820	0.0303	0.0350	0.0398	0.0448	0.0498	0.0549	0.0602	0.0656	0.0711	0.0767

To determine the weight of FM-200 agent required, at minimum design concentrations and minimum ambient temperatures **not** shown in Table 4-3, us the following equation:

W = (V/s) x [C/(100-C)] where: **W** = agent weight required (lbs)

V = volume of the protected space (ft^3)

C = volumetric concentration of FM-200 in air (%)

S = specific volume of superheated FM-200 vapor (ft^3/lb)

S can be calculated by use of the following formula: **S = 1.885 + 0.0046t**

Where: **t** = temperature of the enclosure (°F)

To check the actual concentration (C_{tmax}) of FM-200 achieved in the protected space, at the maximum anticipated ambient temperature, use the following equation:

$$C_{tmax} = 100/ [(V/W \times 1/S_{tmax}) + 1]$$

Where in this case: **W** = total weight of FM-200 actually being used (lbs)
S_{tmax}=specific volume of FM-200 vapor at max. temp. (ft^3/lb)
V = volume of the protected space (ft^3)

⚠ CAUTION

Care must be taken to see that the calculated concentration of FM-200, at the highest anticipated ambient temperature in the protected space, does not exceed the values specified in Section 1-6.1.2 and Table 1-6.1.2.1(c) of NFPA-2001, (yr. 2000 edition), when used in normally occupied spaces.

4.8 Maximum Volume Coverage

The maximum volume that can be protected by the Firetrace FM-200 system units is dependent on the design concentration and the minimum ambient design temperature specified for a given hazard.

Tables 4-4(a); 4-4(b); and 4-4(c), list the maximum volumes that can be protected by the 3, 6, and 12 lb. size system units.

TABLE 4-4(a)
Maximum Volume That Can Be Protected By The
3.0 Lb. FM-200 System Unit

Minimum Anticipated Design Temp. ^oF	Maximum Hazard Volume (ft^3)									
	Design Concentration, C (% by volume)									
	7	8	9	10	11	12	13	14	15	16
0	75	65	57	50	45	41	37	34	32	29
10	76	66	58	52	46	42	38	35	32	30
20	78	68	59	53	47	43	39	36	33	31
30	80	69	61	54	49	44	40	37	34	31
40	82	71	62	55	50	45	41	38	35	32
50	84	72	64	57	51	46	42	38	35	33
60	86	74	65	58	52	47	43	39	36	34
70	87	76	66	59	53	48	44	40	37	34

TABLE 4-4(b)
Maximum Volume That Can Be Protected By The 6.0 Lb. FM-200 System Unit

Minimum Anticipated Design Temp. ^{o}F	Maximum Hazard Volume (ft^3)									
	Design Concentration, C (% by volume)									
	7	8	9	10	11	12	13	14	15	16
0	150	130	114	101	91	82	75	69	64	59
10	153	133	116	105	93	84	77	71	65	60
20	157	136	119	106	95	86	79	72	67	62
30	161	139	122	109	98	88	81	74	68	63
40	164	142	125	111	100	91	82	76	70	65
50	168	145	128	114	102	93	84	77	71	66
60	172	149	131	116	104	95	86	79	73	68
70	175	152	133	119	107	97	88	81	75	69

TABLE 4-4(c)
Maximum Volume That Can Be Protected By The 12.0 Lb. FM-200 System Unit

Minimum Anticipated Design Temp. ^{o}F	Maximum Hazard Volume (ft^3)									
	Design Concentration, C (% by volume)									
	7	8	9	10	11	12	13	14	15	16
0	300	260	228	203	182	165	151	138	128	118
10	306	266	233	210	186	169	154	142	131	121
20	314	272	239	213	191	173	158	145	134	124
30	322	275	245	218	196	177	162	149	137	127
40	329	285	251	223	200	182	165	152	140	130
50	337	291	256	228	205	186	169	155	143	133
60	344	298	262	233	209	190	173	159	146	136
70	351	304	267	238	214	194	177	162	150	139

4.8.1 Example Calculations

The requirements given in Sections 4.1 through 4.8 describe the procedures to be used to design and size a Firetrace DLP FM-200 system.

The following example provides guidelines, following procedures 4.2.a, to 4.2.h., in order to determine the quantity of FM-200 agent required, cylinder size, and the maximum calculated FM-200 concentration anticipated in order to verify if the hazard space can be classified for normally occupied use.

Example:

Given:

- Hazard – Small electrical telecom room.
- Class A hazard
- Room size: 4' wd x 9' lg x 8' high. One (1) access door equipped with self closing apparatus. One (1) Ft^2 of louvered uncloseable opening located in the access door.
- Minimum anticipated ambient temperature: 50^oF
- Maximum anticipated ambient temperature: 90^oF

Procedure:

a. Determine min. design concentration regd (Refer to Table 4-2)

Use 7.0% min. design concentration for Class A surface fire hazard.

b. Calculate hazard volume (V) and area coverage (A).

$V = 4' \times 9' \times 8' = 288\ Ft^3$

$A = 4' \times 9' = 36\ Ft^2$

c. Calculate min. quantity (Q) of FM-200 required (Refer to Table 4-3)

Looking in the 7% design concentration column, and the 50^oF (min. design temp) row, shows that a flooding factor 0.0356 Lb/Ft^3 of FM-200 must be used.

$Q = 288\ Ft^3 \times 0.0356\ Lb/Ft^3 = 10.25$ Lbs. of FM-200 is required. (This then requires the use of 12.0 Lb size cylinder)

d. Refer to Table 4-4 (c).

A check of this Table verifies that one (1) 12.0 Lb size FM-200 system, at 50^oF and 7% concentration, can protect a hazard volume up to 337 Ft^3.

Then refer to Table 4-1. This Table shows that a 12 Lb system can protect a max. surface area of 36 Ft^2.

This check verifies that a 12 Lb size system is adequate and can be used to protect this hazard.

e. Now calculate the max. anticipated FM-200 concentration (C_{max}), based on use of a 12.0 Lb FM-200 system, and a max. anticipated temperature of 90°F (use the formula shown in section 4.7).

$C_{max} = 100/ [(V/W \times 1/S_{max}) + 1]$ where: V = 288 Ft3
W = 12.0 Lb
$S_{max} = 2.2994$

$C_{max} = 100/ [(288/12.0 \times 1/2.2994) + 1] = 8.74\%$

f. Review of NFPA-2001, 2000 edition [Section 1-6.1.2 and Table 1-6.1.2.1(c)], shows that a FM-200 max. concentration of 8.74% can be used in normally occupied spaces, provided that human exposure time is limited to 5.0 minutes.

4.9 Firetrace Detector/Discharge Tubing

For the direct FM-200 systems, the Firetrace tubing performs three functions; Heat detection, system activation, and FM-200 agent discharge.

The detector/discharge tubing is heat sensitive and in a fire situation is designed to rupture at any point along the tube upon flame impingement.

Location and spacing of the tubing is critical to the response time and discharge in the event of a fire. The tubing should be placed above the hazard areas being protected. Drawing FDLP-016 provides general guidelines for placement of the detector/discharge tubing along with the maximum spacing and height limitations. Depending on the configuration of specific hazards, the guidelines shown in Drawing FDLP-016 may, or may not, be applicable.

NOTE: It is recommended that the tubing **not** be placed horizontally adjacent to potential fire sources as this may significantly increase response time.

5.0 INSTALLATION INSTRUCTIONS

This section provides installation instructions covering components and limitations described in sections 3 and 4 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 NFPA standard 2001.

⚠ WARNING

FM-200 cylinder/valve assemblies must be handled, installed and service in accordance with the instruction contained in this manual and on the cylinder nameplate. Failure to follow these instructions could result in severe injury , property damage or death.

5.1 FM-200 Cylinder/Valve and Bracket Assemblies

The FM-200 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 32^{o}F and + 130^{o}F (0^{o}C to +54.4^{o}C).

Cylinder and bracket must be mounted in the vertical plane with the cylinder valve 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 subject to accidental damage or movement. Suitable protection must be installed where necessary to prevent damage or movement.

⚠ CAUTION

Make sure that the ball valve, located on the top of the cylinder valve, is maintained in the "OFF" position. Failure to follow these instructions will result in actuation and discharge of the cylinder contents.

1. Securely mount the cylinder bracket to structural support using two (2) or more mounting holes shown in drawing FDLP-009.

2. Position cylinder in bracket with the pressure gauge facing out. Secure cylinder in place using the bracket straps.

5.2 Firetrace Detection/Discharge Tubing

⚠ CAUTION

1. **Do not kink, bend, or crush Firetrace tubing in order to prevent leakage, which could result in accidental system discharge.**
2. **Do not install tubing in a hazardous environment where the maximum ambient temperature exceeds 176°F (80°C)**
3. **Do not place the tubing on a surface where the temperature of the surface exceeds 140°F (60°C)**
4. **Maximum length of detector/discharge tubing shall not exceed 50 Feet.**

1. Follow guidelines as outlined in section 4.10 and drawing FDLP–016 for the tubing placement.

2. Secure detection/discharge tubing using P-clips at 1.5 Ft intervals.

3. Use appropriate rubber grommets when detection tubing is routed through sharp holes in order to prevent damaging to the tubing.

4. Connect end of line adapter and spring top unit to detection tubing as shown on drawing FDLP-010.

5. When installing tubing to the cylinder valve make sure that the detection/discharge tubing is pushed through the top of the ball valve inlet all the way through to the shoulder and then tighten the spring top unit to a torque of 4-6 Nm.

6. Ensure the detection/discharge tubing is pushed through the end of line adapter all the way through to the shoulder. Then tighten the spring top unit to the end of line adapter to a torque of 4-6 Nm.

7. The detector/discharge tubing is now ready to be pressurized with nitrogen. (see section 5.3 for pressurization procedure)

5.3 Pressurization of Detection/Discharge Tubing

1. Attach the filling adapter (P/N 600023) to the detector/discharge tubing end of line adapter.

2. Using a regulated dry nitrogen supply, pressurize the detection/discharge tubing with dry nitrogen through the filling adapter to 150 psig. It is recommended to have a portable dry nitrogen cylinder for on site use.

3. Remove the filling adapter and attach pressure gauge and 0-ring (Firetrace P/N 400011 and 400002, respectively) to verify that the tubing is pressurized to at least 150 psig at 70^{o}F (pressure may have to be adjusted for temperatures higher than 70^{o}F, see TABLE 3.3)

4. With gauge still attached to the filling adapter, test for leakage.
   - Apply soapy water solution to the cylinder valve connection, end of line adapter connection, and the pressure gauge connection. Observe for bubble leaks.
   - Wait 30 minutes, then observe pressure gauge. Any decrease in pressure is an indication of a leak.
   - In the event of a leak go back to section 5.2 and repeat steps 4 and 5.
   - If no leaks are observed proceed to step 5 of section 5.3.

5. If an optional pressure switch is to be installed in the EOL adapter, remove pressure gauge and install pressure switch and its other components as shown on drawing FDLP-010. Check pressure switch connection for bubble leaks using soapy water solution.

6. After confirming that there is no leakage within the detector tubing, rotate the ball valve lever counter clock wise to the “ON” position.

7. Attach tamper seal around the ball valve lever to secure it in the “ON” position.

8. Ensure appropriate electrical connections to the cylinder valve pressure switch, and to the optional EOL pressure switch to annunciate system discharge, shut down ventilation, etc., as may be required by the end user or the AHJ.

9. Attach the warning nameplate(s) (Firetrace P/N 600105) to the appropriate locations.

10. System is now fully armed and ready for use.

6.0 SERVICE, MAINTENANCE, & FILLING INSTRUCTIONS

⚠ WARNING

1. **FM-200 cylinder/valve assemblies must be handled, installed, inspected and serviced only by qualified and trained personnel in accordance with the instructions contained in this manual, the cylinder nameplate, NFPA-2001, and any other regulations and codes that may apply.**
2. **Before performing maintenance or refilling procedures refer to the material safety data sheets in the appendix at the back of this manual.**

6.1 General

A regular program of systematic maintenance must be established for continuous, proper operation of all FM-200 systems, and to avoid violating the warranty. A periodic maintenance schedule must be followed and an inspection log maintained for ready reference. As a minimum, the log must record: (1) inspection interval, (2) inspection procedure performed, (3) maintenance performed, if any, as a result of inspection, and (4) name of inspector performing task.

If inspection indicates areas of rust or corrosion is present, immediately clean and repaint the area. Perform cylinder hydrostatic pressure testing in accordance with Paragraph 6.5 of this manual.

6.2 Periodic Service and Maintenance

Perform service and maintenance of the FM-200 system in accordance with the schedule shown in TABLE 6.2

Schedule	Requirement	Reference Paragraph
Monthly	Visually inspect systems components. Check FM-200 cylinder pressure.	6.3.1
Semi-Annually	Check FM-200 cylinder weight and pressure.	6.3.2
Every 5 Years	Perform external visual inspection of FM-200 Cylinders.	6.3.3

TABLE 6.2
Periodic Service and Maintenance Schedule

6.3 Periodic Service and Maintenance Procedures.

6.3.1 Monthly: Performed by Owner or End User

1. Make a general visual inspection of the FM-200 cylinder and equipment for damaged or missing parts.
2. Ensure access to hazard areas and cylinders are unobstructed and that there are not obstructions to the operation of the equipment or distribution of FM-200 agent.
3. Inspect detection/discharge tubing in hazard area for abrasion, distortion, cuts, or dirt accumulation, and that there are no obstructions preventing tubing from sensing a fire should one occur.
4. Inspect FM-200 cylinder pressure gauge. If pressure gauge is not normal (150 psig at 70^{o}F) contact authorized Firetrace service company to inspect and recharge if necessary.
5. Verify that there have been no changes in the size of the enclosure and that no new ventilation has been added.

6.3.2 Semi-Annual Inspection

1. Check FM-200 cylinder for weight and pressure.
2. Remove cylinder from the installation as follows:
    - Close ball valve to the “OFF” position.
    - Disconnect detector/discharge tubing at the ball valve. Note: There will be a loss of nitrogen pressure out of the tubing.
    - Remove cylinder from bracket
3. Weigh cylinder. Compare measured weight with weight found on the cylinder nameplate. If the container shows a loss in agent quantity of more than 5 percent, or a loss in pressure (adjusted for temperature) of more than 10 percent, the cylinder shall be refilled or replaced.
4. Reinstall cylinder and re-pressurize detector/discharge tubing with nitrogen following the applicable procedures outlined in section 5.0.

6.3.3 Five Year Inspection

FM-200 cylinders continuously in service without discharging shall be given a complete external visual inspection in place, every five (5) years or more frequently if required.

Follow external visual inspection guidelines detailed in section 4-2.2 and 4-2.3 of NFPA-2001 (YR 2000 Edition)

6.4 Post Fire Maintenance

In the event of a system discharge the following procedures shall be performed.

6.4.1 FM-200 Cylinder Valve

Remove the cylinder assembly from the installation following procedures detailed in section 6.3.2, step 2. Inspect and service the FM-200 cylinder valve as follows:

Note: The FM-200 agent has a tendency to dissolve and wash away lubricants in the valve. Because of this, it is necessary to inspect and relubricate certain valve components prior to recharging the cylinder/valve assembly.

⚠ WARNING

Prior to removal of the valve from the cylinder, verify that all pressure has been released. To relieve any remaining pressure open the ball valve to the "ON" position and allow any residual pressure to leak out.

6.4.2 Valve Disassembly

1. Remove valve from cylinder
2. Unscrew siphon tube from the valve
3. Inspect valve "O-ring" on cylinder neck.
4. Replace if necessary and lubricate.
5. Attach siphon tube to valve
6. Screw valve on cylinder making sure there is lubricant on the cylinder neck.
7. Valve cylinder assembly is ready for filling.

(It is recommended that only Firetrace components be used should it be necessary to replace any worn parts)

6.5 FM-200 Cylinder Retest

Firetrace FM-200 cylinders are built to DOT-4B specifications and therefore fall under DOT regulations for retest prior to refill.

DOT-4B, 4BA and 4BW cylinders used exclusively in FM-200 service are required to be retested and restamped prior to recharge and shipment if the last retest date has expired.

Firetrace FM-200 (DOT-4B) containers requiring retest must be hydrostatically tested in accordance with DOT CFR Title 49, section 173.34(e). This periodic retest must be performed by an authorized retester having a current identification number issued by the Associated Administrator for Hazardous Material Safety of DOT, and must include an internal and external examination in accordance with CGA pamphlet C-6, C-6.1, C-6.2, or C-6.3, as applicable. The test procedures are described in CGA pamphlet C-1. Because volumetric expansion of the container must be measured, only the water jacket volumetric expansion method or the direct expansion method are acceptable.

As an alternate option, FM-200 agent containers may be given a complete external visual inspection, as detailed in section 173.34(e)(13), in lieu of hydrostatic test. The visual inspection shall be made only by competent persons. A person who performs the visual examination specified in 173.34(e)(13) is not required to have a retester's identification number.

Retest can be performed by either of the following methods:

Retest Method	First Retest Due (Yrs)	Subsequent Retest Due (Yrs)	Special Marking
Full hydrostatic test including determination of cylinder expansion.	5	5	Retest Date Month/Year
External visual inspection per paragraph 173.34(e)(13) and CGA pamphlet C-6, section 3.	5	5	Retest Date followed by "E"

6.6 Filling Procedures (see Drawing DLP-017)

1. Weigh and record cylinder empty weight and the valve.
2. Connect spring top unit with Firetrace tubing to the top of the cylinder valve as outlined in section 5.2 step 4.
3. Use the recharge/filling adapter shown in drawling FDLP-013 and quick connect Firetrace tubing to the adapter.
4. Connect FM-200 supply to the adapter. Record weight shown on the weighing scale.
5. Leave cylinder with line hooked up on scale and zero the scale.
6. Open the ball valve, and open the supply of FM-200 from bulk tank to fill the cylinder to the required weight.
7. Close supply of FM-200 while maintaining all connections.
8. Close the Ball valve.
9. Open the valve vent to bleed the excess FM-200 from the line, and then disconnect the FM-200 supply.
10. Connect dry nitrogen supply to the recharge/filling adapter, regulated to 150 psig.
11. Open ball valve and pressurize cylinder with dry nitrogen. Close ball valve and shake cylinder to allow for dry nitrogen to be absorbed by the FM-200. (Note: nitrogen absorption will result in some pressure loss).
12. Open the ball valve and pressurize back up to 150 psig at 70^{o}F, as will be indicated on calibrated master pressure gauge.
13. Repeat steps 11 and 12 until shaking of cylinder does not result in any pressure loss (i.e., no further nitrogen absorption) and a pressure of 150 psig is reached.
14. Close ball valve and the supply of dry nitrogen from the dry nitrogen source.
15. Open nitrogen vent valve in the nitrogen line. Vent all pressure.
16. Unscrew spring top from ball valve. Attach tamper seal to the ball valve lever to maintain in the “OFF” position.
17. Record weight and mark on label.
18. Cylinder is now ready to be transported to the installation site.

Note: All reasonable efforts must be made to prevent emitting any FM-200 to the environment during filling or servicing of Firetrace systems.

7.0 WARRANTY

FIRETRACE USA, LLC.
LIMITED WARRANTY & PURCHASER'S EXCLUSIVE REMEDY

****

Purchaser's Limited Warranty

Firetrace USA, LLC (hereafter referred to as Firetrace) provides the following **Limited Warranty** only to the original purchaser, who purchases the Firetrace system from an Authorized Firetrace Distributor. The **Limited Warranty** includes all Firetrace systems and its component parts supplied by Firetrace. Hereafter these products will be referred to as "Firetrace Products". When the Firetrace Products are properly installed by an authorized Firetrace distributor, ***in complete*** accordance with the written instructions contained in the instruction manuals, or other data supplied with Firetrace products, and when the Firetrace products have not subsequently been modified or altered, unless by express written instructions from Firetrace, then the Firetrace products are warranted to be free of defects in materials and workmanship for a period of three (3) years from the date of shipment from Firetrace, Scottsdale Arizona, as long as the following conditions are met:

(1) The ***original*** purchaser must maintain a semi-annual maintenance service agreement with an authorized Firetrace distributor, commencing with the date the Firetrace product was accepted by the purchaser and placed into service. The service agreement **shall** remain in effect for the duration of the warranty.
(2) The Firetrace Warranty Registration Card (P/N 800100) must be completed and returned to Firetrace within thirty (30) days of the installation of the Firetrace system.

Firetrace products that are not certified, as specified in the paragraphs 1 and 2 above, will carry a maximum limited warranty of one (1) year from the date of shipment from Firetrace.

Purchaser's Exclusive Remedy

The original purchaser's sole and exclusive remedy, unless varied by express written agreement with Firetrace, is as follows: Repair or replacement, at Firetrace's option, of any defective part which is returned to Firetrace within ninety (90) days of discovery of the defect.

Because of the deleterious effects of corrosion, heat, rust, dirt, debris and other factors of use and installation over which Firetrace has no control, **FIRETRACE MAKES NO OTHER WARRANTIES OF ANY KIND, WHETHER EXPRESSED OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITTNESS FOR A PARTICULAR PURPOSE, BEYOND THOSE EXPRESSLY PROVIDED FOR IN THIS *LIMITED* WARRANTY**. These warranties shall be void where defects occur due to improper maintenance, installation, service, alterations and/or modifications subsequent to installation, not expressly authorized in writing by Firetrace or due to intentional or negligent acts of the original purchaser or third parties.

Non-Assignability of Warranty

The limited warranty set forth herein may not be assigned, transferred or sold in any way and extends only to the *original* purchaser.

Disclaimer of Consequential Damages

In no event shall Firetrace be liable for any consequential or incidental damages arising from the purchase and/or use of Firetrace products, including but not limited to: damages resulting from loss of use of Firetrace products, the costs of replacing discharged suppression agent, damages for lost profits or income, or damages for resulting harm to property other than the Firetrace products.

Use of Non-Firetrace Components

All Firetrace systems must exclusively use Firetrace components, especially for connections made to the Firetrace tubing. Failure to exclusively use Firetrace components will void this limited warranty and release Firetrace of any and all liability on the performance of the Firetrace components and system.

SOME FACTORS INFLUENCING ENGINEERING DESIGN AND PRODUCT APPLICATION OF FIRETRACE SYSTEMS

The following are some of the factors that influence engineering design and application of Firetrace systems. In many cases, these factors are difficult to accurately estimate, and it is for these reasons that Firetrace makes ***no*** warranties other than those specifically stated in this **Limited Warranty**.

1. The Firetrace system has been designed to provide protection against fire, both existing and imminent, for a limited duration of time when: the system is fully operational; used in its normal, expected environment; the system and its component parts are properly installed, maintained, and operated in ***complete*** accordance with written instructions supplied with the system.

2. The duration of the protection against fires dependent upon a sufficient concentration of agent being maintained in the protected hazard area for a pre-determined period of time. This duration will be shortened by conditions or circumstances which may ventilate, cause the agent concentration dilution within the protected hazard area thereby causing an insufficient concentration of agent as is needed to extinguish or prevent the existence or re-ignition of combustion or fire. All hazard areas have different rate of ventilation, leakage, or agent dilution that, in many cases, may be impossible to predict or determine. Air vents, air conditioning systems, gaps and cracks in the enclosure, windows, cable and pipe penetrations, etc., all may effect the agent concentration and the duration of the protection against fire. Also, unforeseen changes in the configuration of a hazard area such as removal of a wall, an explosion or fire external to the protected space, changes in the enclosures configuration, etc. can influence the duration of the fire protection. It is because of these many, and varied, circumstances and conditions that Firetrace makes ***no*** warranty as to the duration of the protection against fire.

3. The effectiveness of an agent, such as FM-200 and/or CO_2, as a fire extinguishant is directly related to the concentration of the agent required to extinguish various substances. Not all substances require the same agent concentration to be extinguished. Therefore, Firetrace can only assume that the customer has properly defined the hazard area(s) being protected.

4. The effectiveness of the Firetrace system is dependent upon the timely discharge of the agent fire extinguishant in to the protected area. If unforeseen circumstances such as an explosion, failure of the detection system to activate the Firetrace system, failure to manually activate the system, etc. occur, they can prevent the system discharge from being accomplished in a timely manner, and the fire may become deep seated or out of control and completely destroy the hazard area. Since Firetrace has no control over these circumstances, there are ***no*** warranties as to the effectiveness of extinguishment of the fire other than those specifically stated in this **Limited Warranty**.

5. Even if the Firetrace system is completely effective in suppressing a fire, failure to remove the ignition source of the fire could result in a re-ignition of the fire. If possible, the source of the fire should immediately be eliminated to prevent re-ignition. Protection against re-ignition only exists when a sufficient concentration of agent remains in the hazard area, as stated above.

Since the effectiveness of the Firetrace system depends on when, under what circumstances, it is used, the judgment of operating personnel as to when to activate a Firetrace system, in an emergency, affects the protection provided by the system. Because of the widely carrying conditions and circumstances under which the Firetrace system can be used, some conditions can cause its effectiveness to be unpredictable. Therefore, evacuation of personnel from the protected areas ***must*** be accomplished without delay.

APPENDIX A

COMPONENT DESCRIPTION DRAWINGS

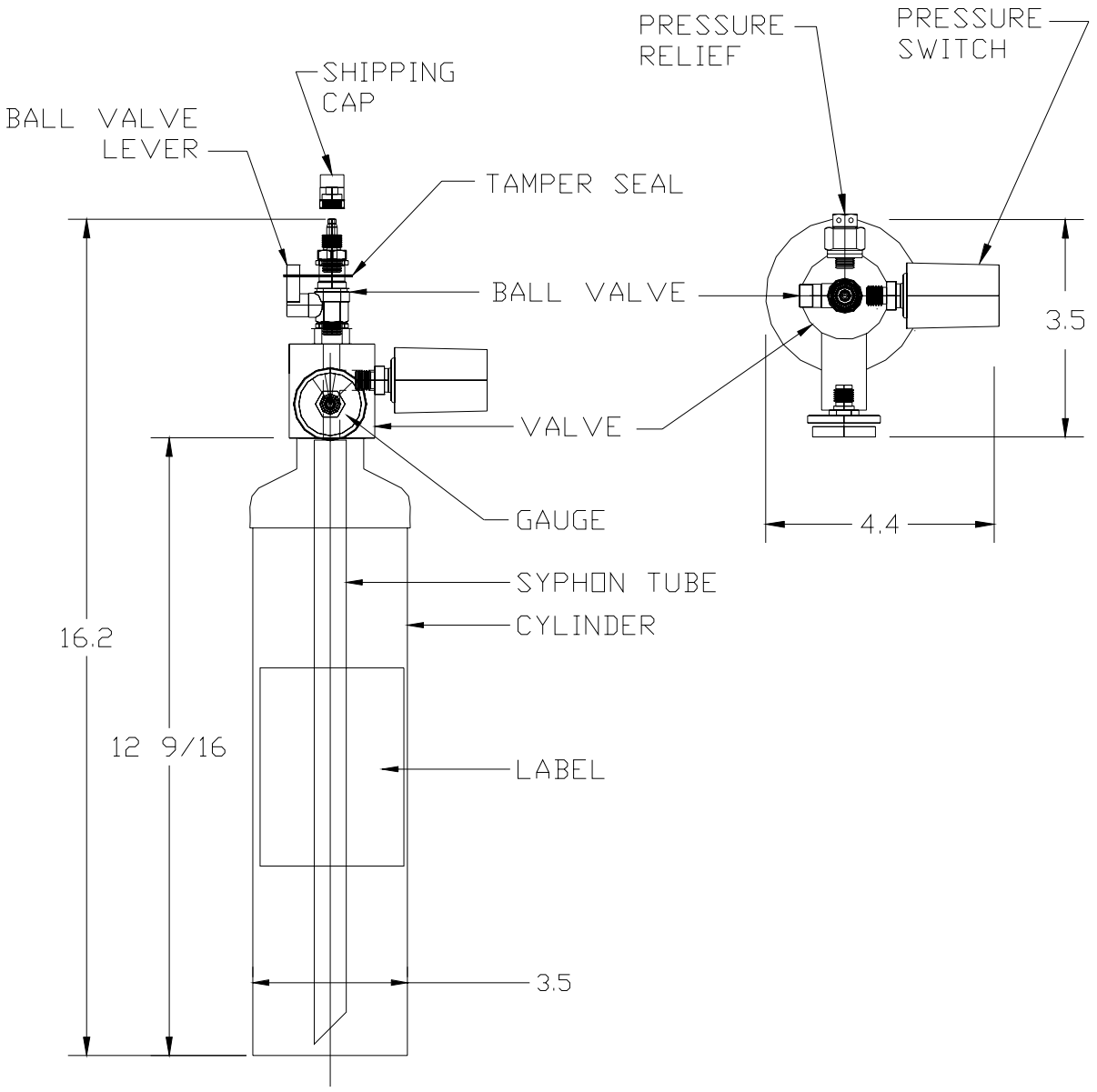
INSTALLATION DRAWINGS

FIRETRACE DLP SERIES
Component Description Drawings
Installation Drawings

Firetrace Drawing No.	Description	Part Number
FDLP-001	3 Lb. FM-200 Cyl./Valve Assy.	900400
FDLP-002	6 Lb. FM-200 Cyl./Valve Assy.	900401
	12 Lb. FM-200 Cyl./Valve Assy.	900402
FDLP-003	Washer, Pressure Switch	400003
FDLP-004	3 Lb. Cylinder 1-12 UNF/Collar	100301
FDLP-005	6 Lb. Cylinder 1-12 UNF/Collar	100601
FDLP-006	12 Lb. Cylinder 1-12 UNF/Collar	101201
FDLP-007	Cylinder Valve	300102
FDLP-009	3 Lb. Cylinder Bracket	100003
	6 Lb Cylinder Bracket	100006
	12 Lb Cylinder Bracket	100012
FDLP-010	Assembly Detection/Discharge Tubing	(See Drawing)
FDLP-011	Pressure Switch	400001
FDLP-012	Typical Installation – DLP System	---------
FDLP-013	Nitrogen Recharge Adapter	600027
FDLP-014	Cylinder Hydrotest Adapter, 3 Lb.	600028
FDLP-015	Warning Nameplate, FM-200	600105
FDLP-016	Typical Installation, Detector Tubing	--------
FDLP-017	FM-200 Filling Procedures	--------
FDLP-018	EOL Filling Adaptor	600023
FDLP-019	Cylinder Neck O-Ring Seat Seal	300220/300221 300205/300206

FIRETRACE
AUTOMATIC FIRE SUPPRESSION SYSTEM

COMPONENT DESCRIPTION
CYLINDER AND VALVE ASSEMBLIES
3 LBS

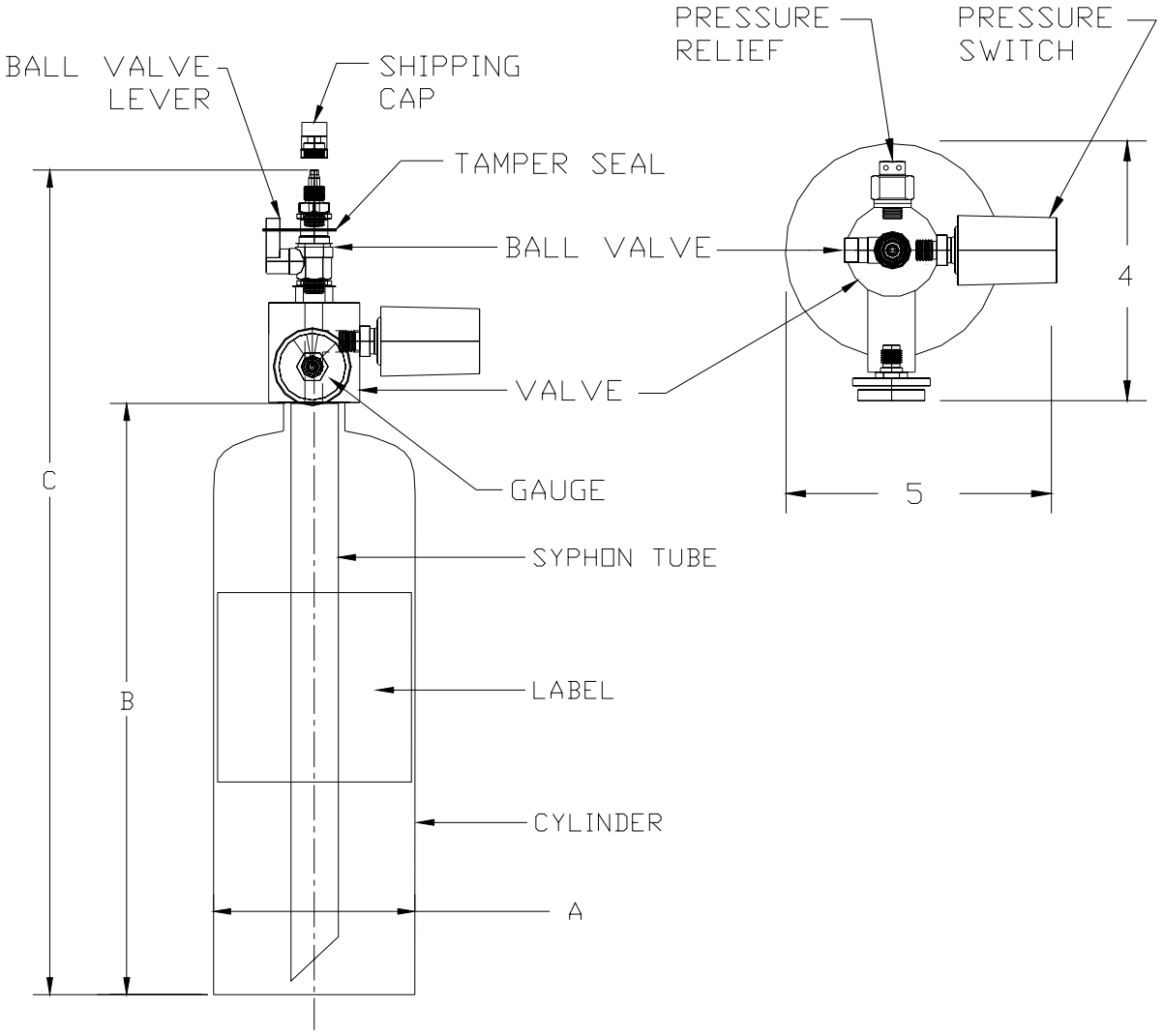


P/N: 900300
FDLP-001

12/27/01

FIRETRACE
AUTOMATIC FIRE SUPPRESSION SYSTEM

COMPONENT DESCRIPTION
CYLINDER AND VALVE ASSEMBLIES
6 AND 12 LBS



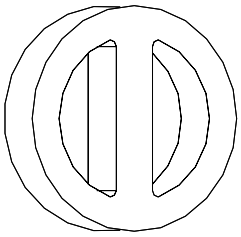
CYLINDER SIZE	DIMENSIONS (inches)			P/N
	A	B	C	
6 LBS	4.25	12.5	16.125	900301
12 LBS	5.15	17.75	21.125	900302

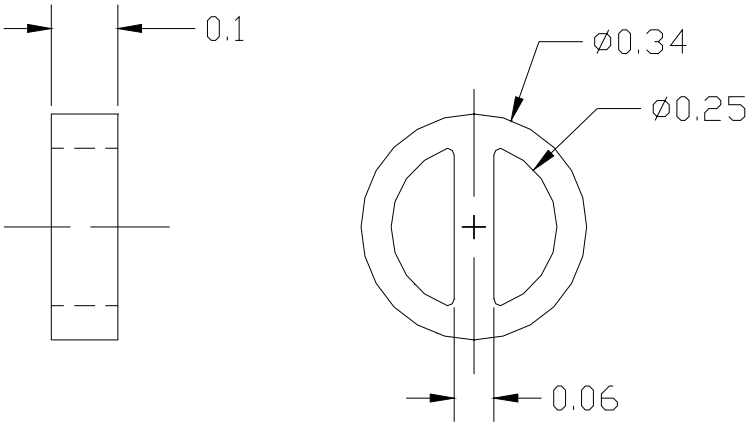
12/27/01

FDLP-002

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
PRESSURE SWITCH
WASHER





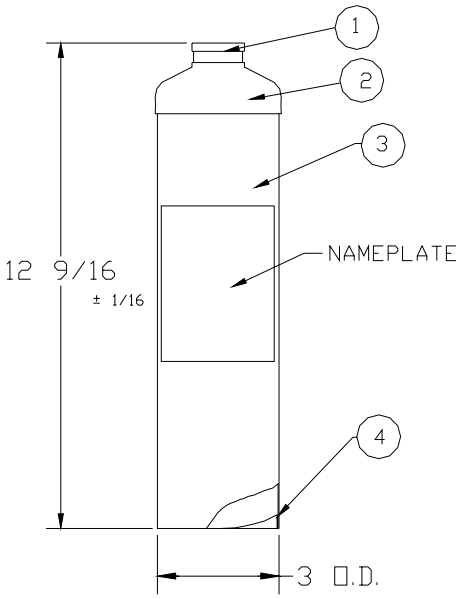
P/N: 400003
FDLP-003

12/27/01

FIRETRACE
AUTOMATIC FIRE SUPPRESSION SYSTEM

BILL OF CONTENTS		
ITEM	DESCRIPTION	QTY
1	CYLINDER COLLAR 1-12 UNF	1
2	CYLINDER TOP SHELL	1
3	CYLINDER SHELL	1
4	CYLINDER BOTTOM SHELL	1

COMPONENT DESCRIPTION
3 LB CYLINDER



NOTES:

1. SHELL DESIGN COMPLIES WITH REQUIREMENTS OF ANSI/UL 299 AND DOT 4B240ET.
2. SHELL ASSEMBLY IS COPPER BRAZED.
3. SERVICE PRESSURE: 240 PSIG.
4. VOLUME: 71 CU. IN.
5. TEST PRESSURE: 480 PSI FOR 30 SECONDS.
6. BURST PRESSURE: 1200 PSI MINIMUM.
7. SHELL TO BE RUST FREE, INSIDE AND OUTSIDE. COAT OUTSIDE SURFACE OF SHELL WITH OAKITE FORMULA C RUST INHIBITOR (5% OF HYDROTEST WATER VOLUME).
8. SHIP IN CARTONS TO PROTECT SHELL FROM DENTS AND SCRATCHES.
9. DOT TEST REPORTS REQUIRED WITH EACH SHIPMENT.
10. DOT MARKING TO BE ON BOTTOM EDGE OF SHELL IN 3/16" LETTERS 0.005 DEEP. MARKING TO COMPLY WITH 49 CFR 178 AND BE AS FOLLOWS: DOT 4B240ET AX MO YR () 123456 WHERE "MO" AND "YR" REPRESENT MONTH AND YEAR OF MANUFACTURE AND "123456" REPRESENTS THE SERIAL NUMBER.
11. MANUFACTURE DATE OF CYLINDERS TO BE SHOWN ON CARTON LABELS.

12/27/01

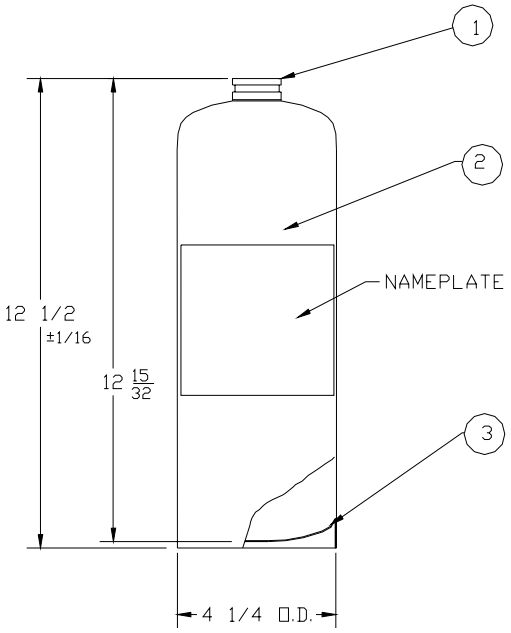
P/N: 100301
FDLP-004

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

BILL OF CONTENTS

ITEM	DESCRIPTION	QTY
1	CYLINDER COLLAR 1-12 UNF	1
2	CYLINDER SHELL	1
3	CYLINDER BOTTOM SHELL	1

COMPONENT DESCRIPTION
6 LB CYLINDER



NOTES:

1. SHELL DESIGN COMPLIES WITH REQUIREMENTS OF ANSI/UL 299 AND DOT 4B225.
2. SHELL ASSEMBLY IS COPPER BRAZED.
3. SERVICE PRESSURE: 225 PSIG.
4. VOLUME: 149 CU. IN.
5. TEST PRESSURE: 450 PSI FOR 30 SECONDS.
6. BURST PRESSURE: 900 PSI MINIMUM.
7. SHELL TO BE RUST FREE, INSIDE AND OUTSIDE. COAT OUTSIDE SURFACE OF SHELL WITH OAKITE FORMULA C RUST INHIBITOR (5% OF HYDROTEST WATER VOLUME).
8. SHIP IN "EGG CRATED" CARTONS TO PROTECT SHELL FROM DENTS AND SCRATCHES.
9. DOT TEST REPORTS REQUIRED WITH EACH SHIPMENT.
10. DOT MARKING TO BE ON BOTTOM EDGE OF SHELL IN 3/16" LETTERS 0.005 DEEP. MARKING TO COMPLY WITH 49 CFR 178 AND BE AS FOLLOWS:
    DOT 4B225 AX MO YR () 123456
    WHERE "MO" AND "YR" REPRESENT MONTH AND YEAR OF MANUFACTURE AND "123456" REPRESENTS THE SERIAL NUMBER.
11. MANUFACTURE DATE OF CYLINDERS TO BE SHOWN ON CARTON LABELS.

12/27/01

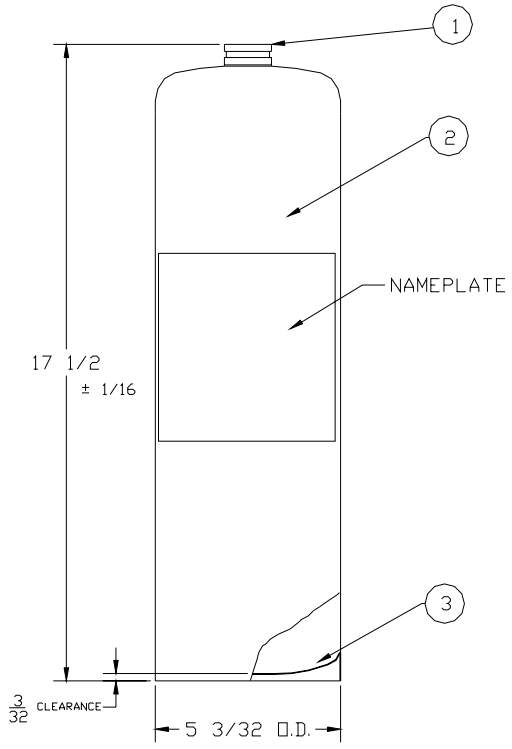
P/N: 100601
FDLP-005

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

BILL OF CONTENTS

ITEM	DESCRIPTION	QTY
1	CYLINDER COLLAR 1-12 UNF	1
2	CYLINDER SHELL	1
3	CYLINDER BOTTOM SHELL	1

COMPONENT DESCRIPTION
12 LB CYLINDER



NOTES:

1. SHELL DESIGN MEETS UL STANDARD 299 AND DOT 4B225 SPECIFICATIONS.
2. SHELL ASSEMBLY IS COPPER BRAZED.
3. TEST PRESSURE: 450 PSI FOR 30 SECONDS.
4. BURST PRESSURE: 900 PSI MINIMUM.
5. CLEAN AND DRY SHELL INSIDE AND OUTSIDE. SHELL TO BE RUST FREE.
6. PROTECT THREADS DURING SHIPPING AND HANDLING.
7. TEST REPORTS REQUIRED WITH EACH SHIPMENT.
8. DOT MARKING TO BE ON BOTTOM EDGE OF SHELL IN 3/16" LETTERS 0.005 DEEP. MARKING TO COMPLY WITH 49 CFR 178 AND BE AS FOLLOWS: DOT 4B225 AX MO YR () 123456 WHERE "MO" AND "YR" REPRESENT MONTH AND YEAR OF MANUFACTURE AND "123456" REPRESENTS THE SERIAL NUMBER.
9. SHIP IN "EGG-CRATED" TYPE CARTONS WITH FILLERS TO PROTECT FROM DENTS AND SCRATCHES.
10. COPPER BRAZING TO COMPLETELY SEAL CURCUMFRENTIAL JOINT.
11. WATER WEIGHT = 10.82 LBS. = 300 CU IN.
12. CYLINDER SURFACE TO BE FREE FROM EXCESSIVE BRAZING AND "RUNS".
13. MANUFACTURE DATE OF CYLINDERS TO BE SHOWN ON CARTON LABELS.

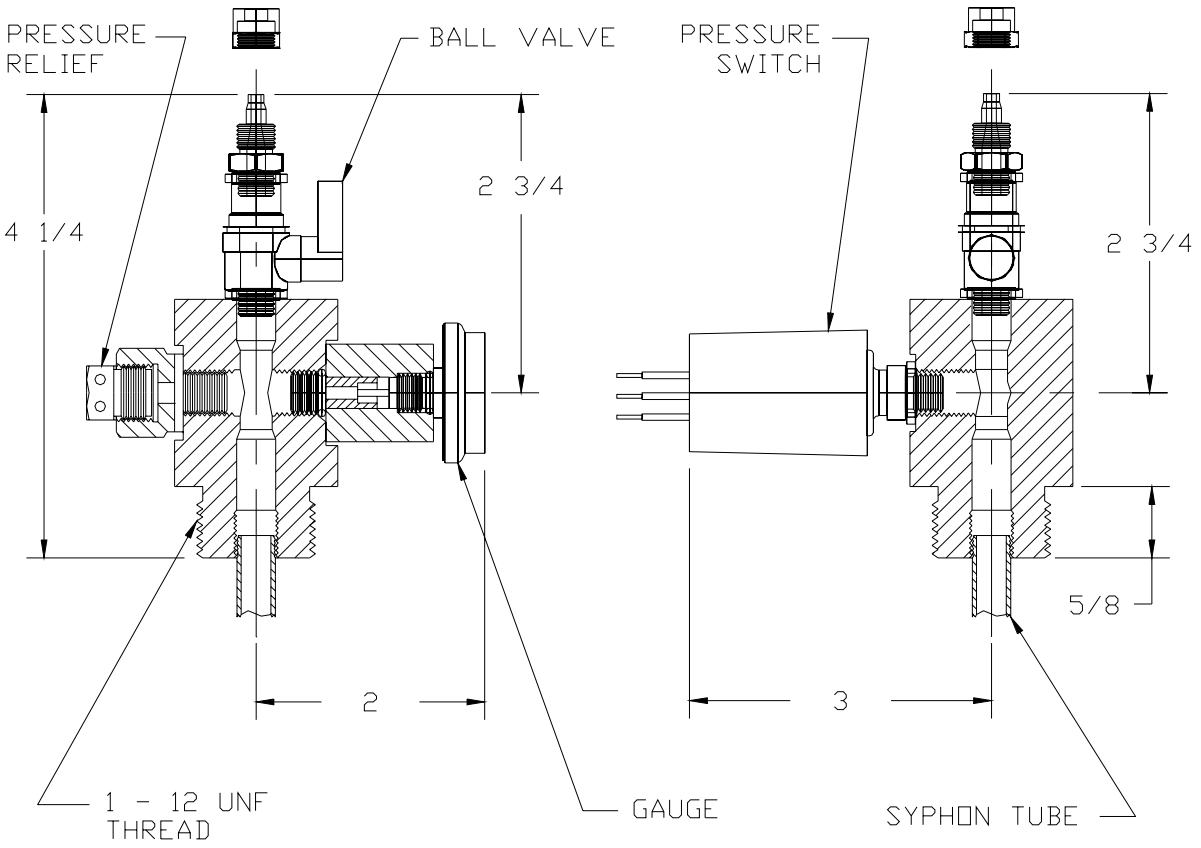
12/27/01

P/N: 101201
FDLP-006

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION

SMALL VALVE
(FOR 3, 6 & 12 LB CYLINDER)

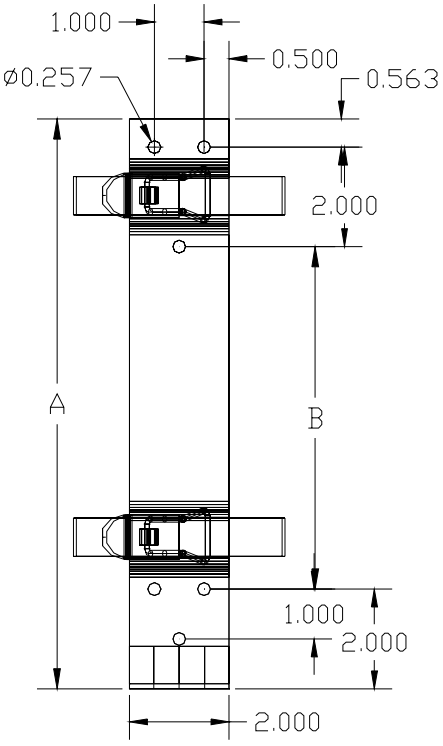


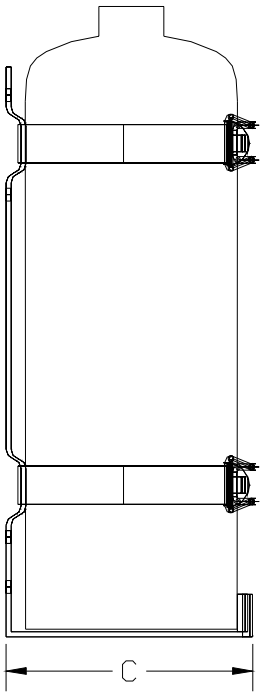
12/28/01

P/N: 300101
FDLP-007

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
CYLINDER BRACKETS





CYLINDER SIZE	DIMENSIONS (inches)			PART NUMBER
	A	B	C	
3 LBS	11.44	6.88	3.70	100003
6 LBS	11.44	6.88	4.95	100006
12 LBS	14.94	10.38	5.20	100012

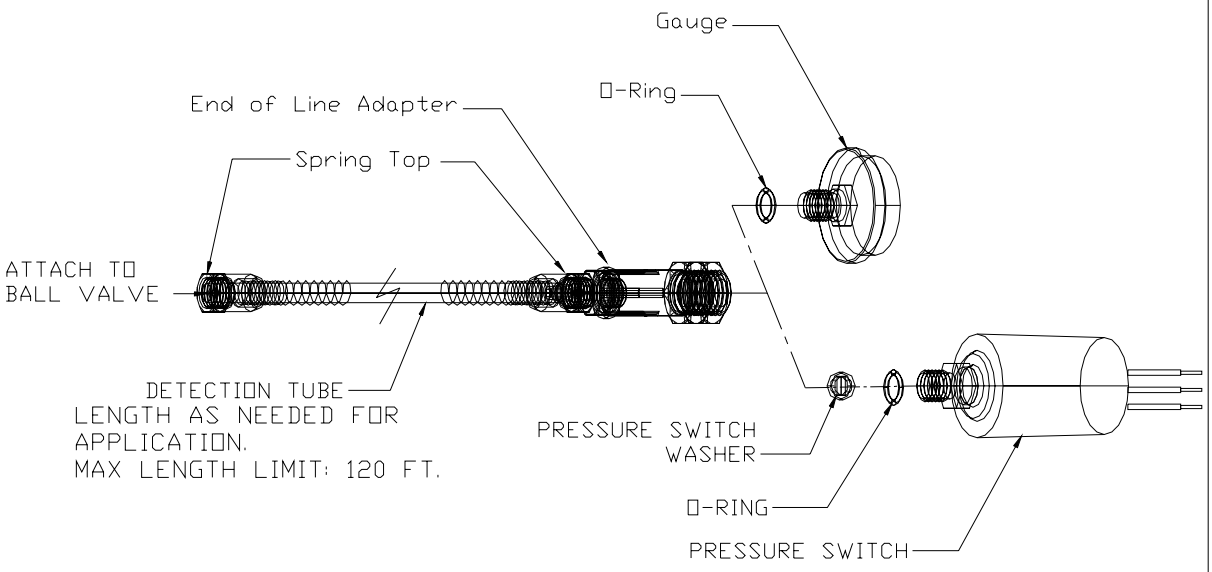
12/27/01 FDLP-009

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

DESCRIPTION	P/N
Spring Top	200160
End of Line Adapter	200161
"o" ring for Pressure Switch	400002
Pressure Gauge	400012
Pressure Switch Washer	400003
Pressure Switch	400001
"o" ring for Gauge	400002

COMPONENT DESCRIPTION

DETECTION TUBING

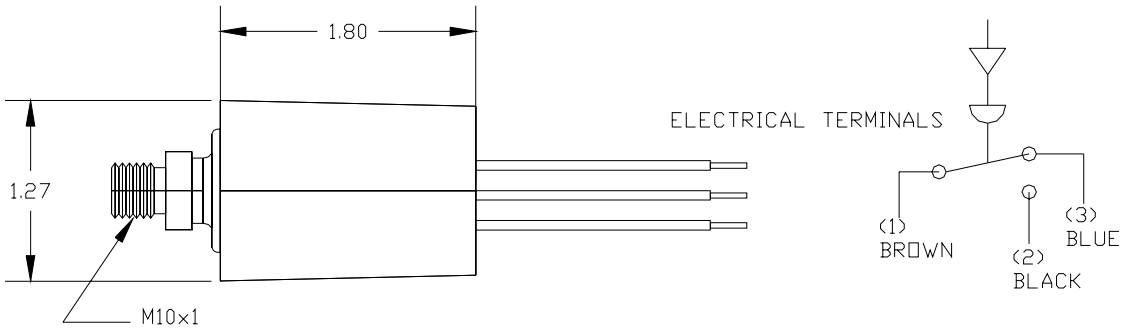


12/27/01 FDLP-010

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION

PRESSSURE SWITCH



ACTUATION PRESSURE: 135 +/- 10 PSIG
RELEASE PRESSURE: 70 +/- 10 PSIG
TEMPERATURE RANGE: -20F TO 150F
ELECTRICAL RATING:

TERMINAL 1 & 3:	120VAC - 25A, 13 FLA, 60 LRA, 125VA 240VAC - 25A, 10 FLA, 45 LRA, 125VA
TERMINAL 1 & 2:	120VAC - 10A, 5.8 FLA, 34.8 LRA, 125VA 240VAC - 5A, 2.9 FLA, 17.4 LRA, 125VA

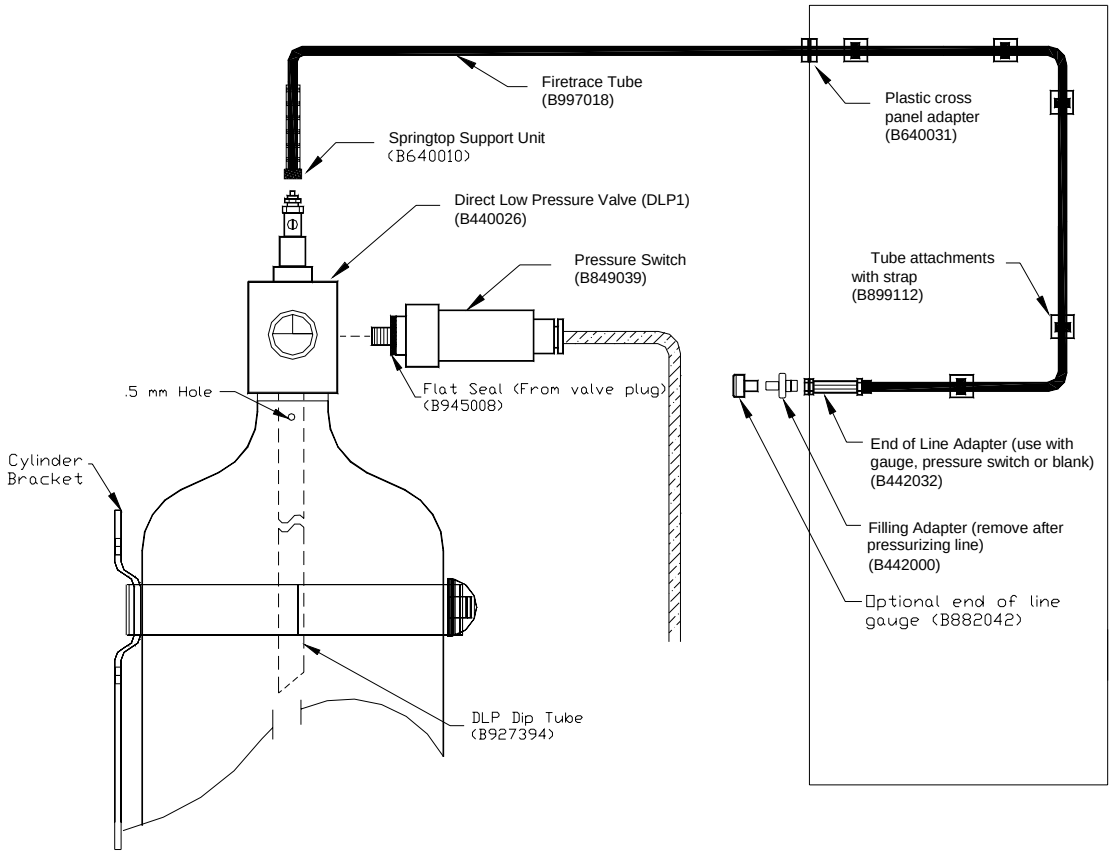
SWITCH CONFIGURATIONS: SPDT AT ATMOSPHERIC PRESSURE: CLOSED BETWEEN BROWN AND BLUE

P/N: 400001
11/20/01 FDLP-011

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
TYPICAL LOW PRESSURE
INSTALLATION

TYPICAL DIRECT LOW PRESSURE (DLP) INSTALLATION

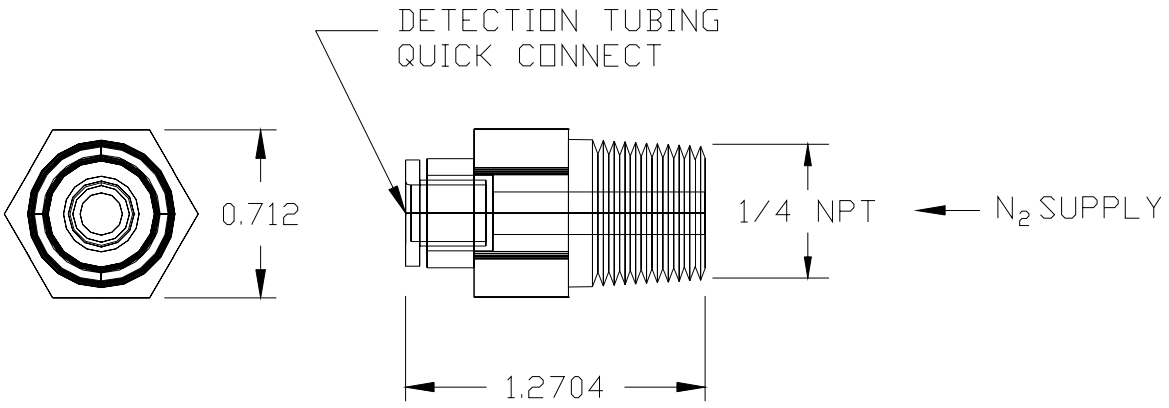


12/27/01

FILP-012

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
N_2 RECHARGE ADAPTER



MATERIAL: BRASS

P/N: 600027
FDLP-013

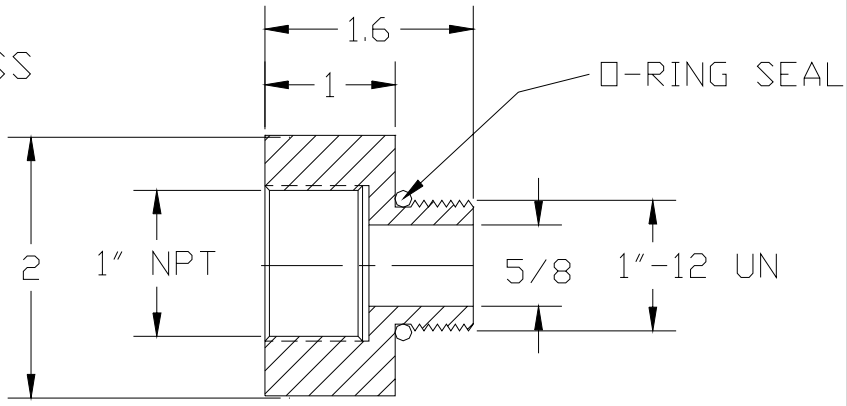
1/2/02

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
CYLINDER HYDROTEST ADAPTER

ADAPTER FOR CYLINDER

MATERIAL: BRASS
P/N: 600028

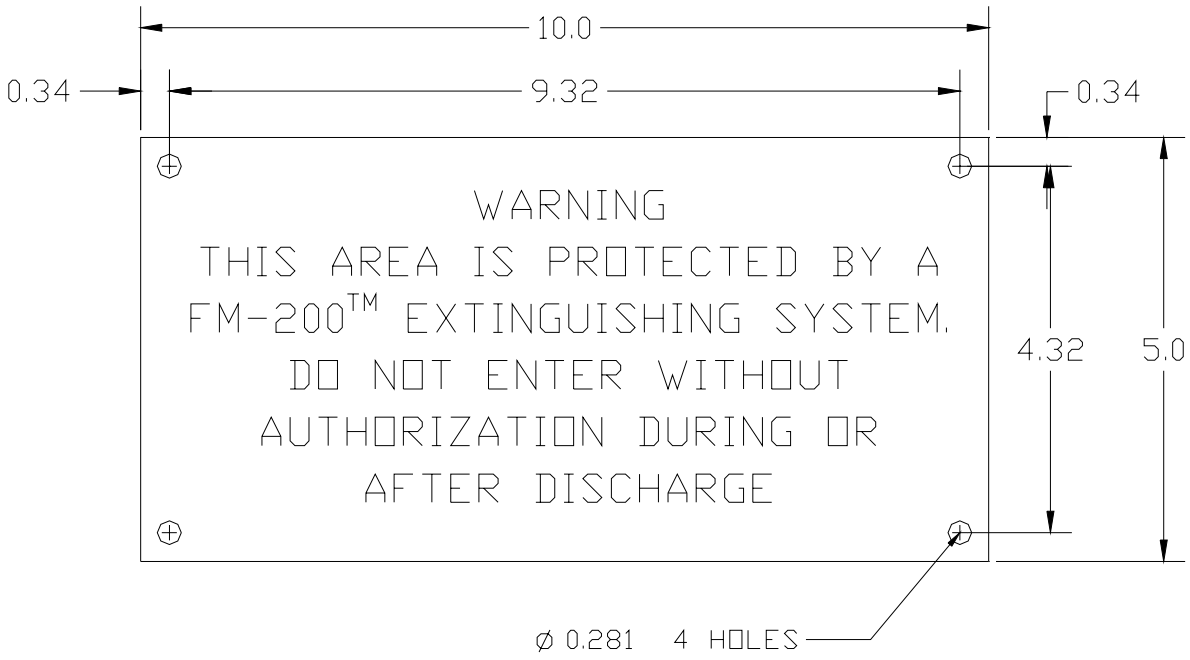


12/27/01

FDLP-014

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
WARNING NAMEPLATE (FM-200)



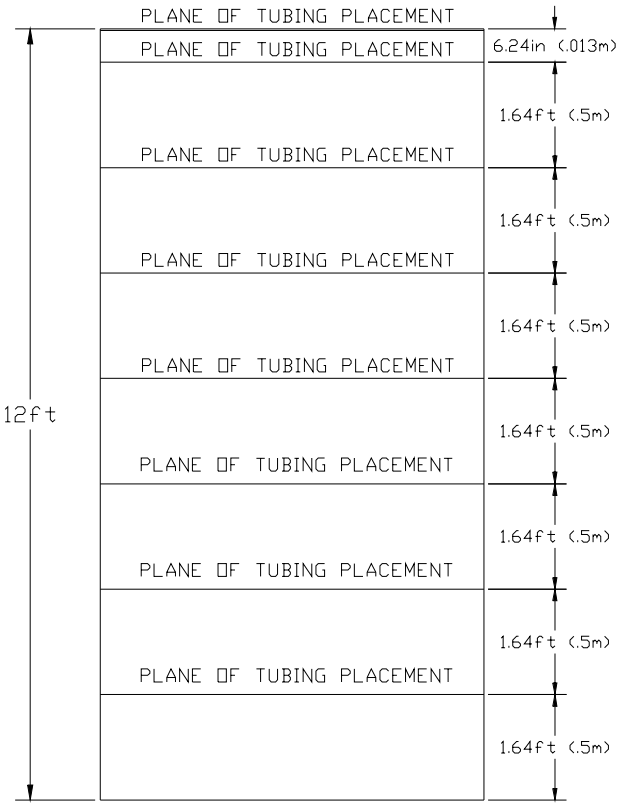
MATERIAL: ALUMINUM

P/N: 600105
FILP-015

12/27/01

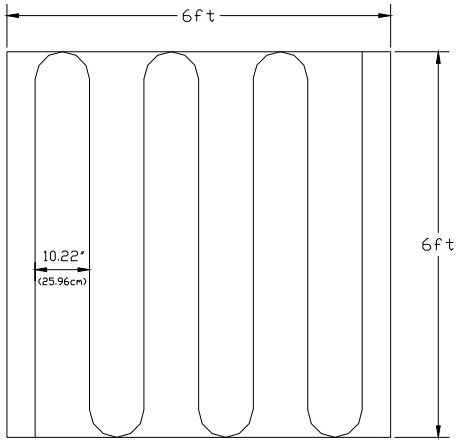
FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
TUBING PLACEMENT



MAXIMUM HEIGHT TUBING LAYOUT

TUBING PLACED AT
1.64ft (.5m) HIGH
INTERVALS



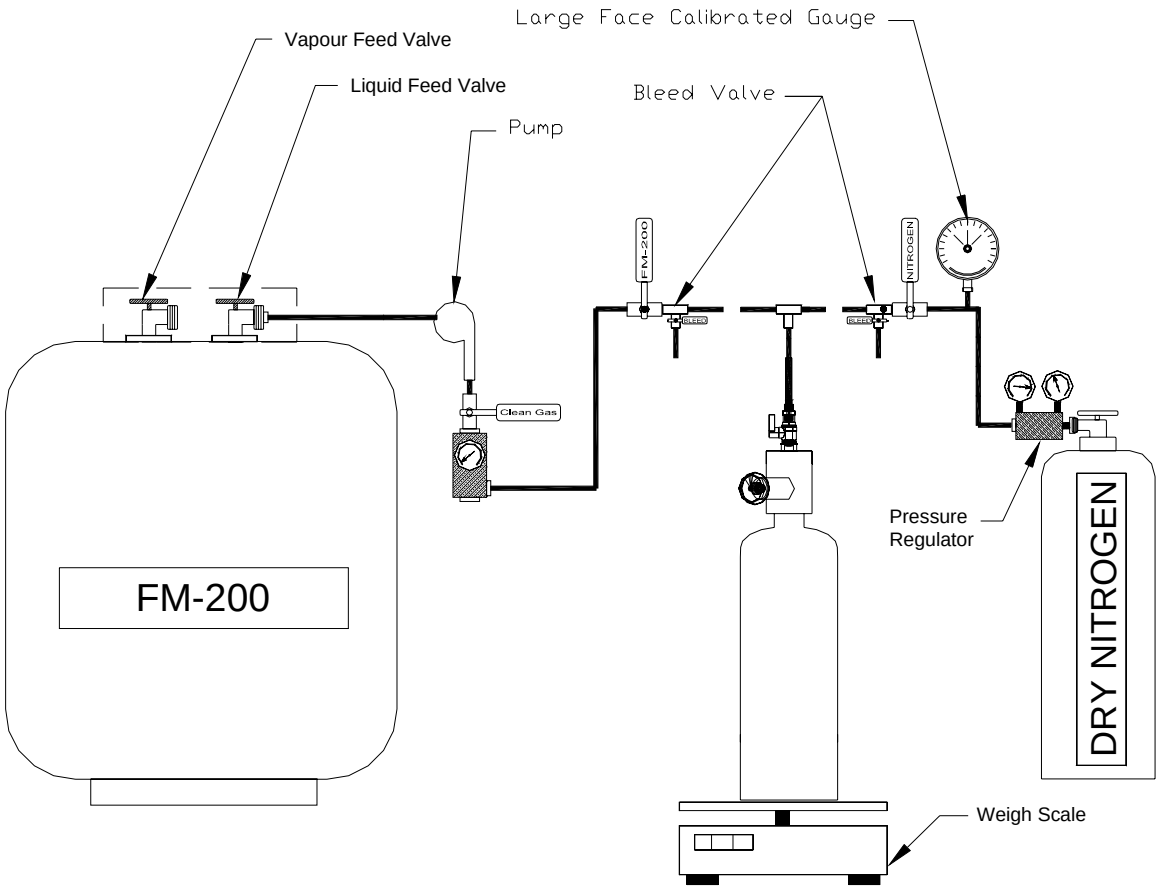
MAXIMUM AREA TUBING LAYOUT

04/24/02

FDLP-016

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

FM-200 EXTINGUISHING AGENT
FILL PRODEDURES

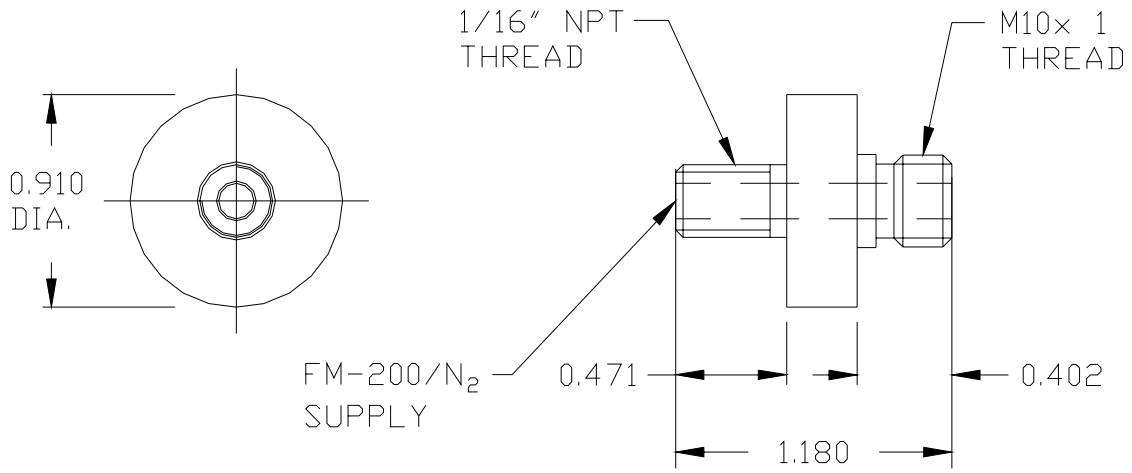


12/27/01

FDLP-017

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
EOL FILLING ADAPTER



MATERIAL: BRASS

P/N: 600023
FDLP-018

1/2/02

FIRETRACE
AUTOMATIC FIRE SUPRESSION SYSTEMS

COMPONENT DESCRIPTION
O-RINGS & SEALS

CYLINDER NECK O-RING

DLP-300 Systems	DLP-600/1200 Systems
P/N: 300220	P/N: 300221

SEAT SEAL

DLP-300 Systems	DLP-600/1200 Systems
P/N: 300205	P/N: 300206

12/27/01 FILP-019

APPENDIX B

Material Safety Data Sheets

Nitrogen

FM-200