FM-200®

'TOTAL FLOODING'
FIRE SUPPRESSION SYSTEM

ENGINEERED SYSTEM INSTALLATION MANUAL (UL VERSION)

FM-200 is a registered trademark.

MANUAL NO. 570000-02
NOVEMBER 1, 2001

INSTALLATION GUIDE

(ENGINEERED SYSTEMS)

FM-200® 'TOTAL FLOODING'

FIRE SUPPRESSION SYSTEM

WARNING: THE DISCHARGE OF CLEAN AGENT SYSTEMS TO EXTINGUISH A FIRE CAN RESULT IN A POTENTIAL HAZARD TO PERSONNEL FROM THE NATURAL FORM OF THE CLEAN AGENT OR FROM THE PRODUCTS OF COMBUSTION THAT RESULT FROM EXPOSURE OF THE AGENT TO THE FIRE OR HOT SURFACES. UNNECESSARY EXPOSURE OF PERSONNEL EITHER TO THE NATURAL AGENT OR TO THE PRODUCTS OF DECOMPOSITION SHALL BE AVOIDED.

PYRO-CHEM

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About this Manual

This manual is a comprehensive guide that contains all the information necessary to design, install and maintain the FM-200® Engineered Suppression system supplied by Pyro-Chem. However the manual does not address information relating to fire detection. Refer to NFPA 2001, "Standard For Clean Agent Fire Extinguishing Systems," NFPA 72, "National Fire Code," NFPA 70, "National Electrical Code," and other applicable standards. Also, refer to the appropriate Pyro-Chem technical manual for detailed panel and design information.

Users of this manual are assumed to be competent fire engineers with a basic knowledge of such systems. The contents are arranged in a logical order describing the various procedures in turn, alternatively specific sections can be referred to as required. Users who are not familiar with the equipment should first read the complete manual.

Definitions

FM-200® FM-200® is a registered trade mark of the Great Lakes Chemical Corporation.

System In this manual 'system'refers to the suppression equipment and does not include any electrical system which may initiate an agent release.

Engineered Hydraulic flow program used to predict the two phase flow of FM-200® through a pipe network.

Contacts

Should any part of this manual not be understood, or there are any queries concerning a system, please contact:

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Introduction

FM-200® is a clean, safe fire fighting agent for use in total flooding automatic suppression systems. It is intended as a long term replacement for Halon 1301 and, while maintaining the excellent fire suppression properties of Halon, has none of the environmental problems. Storage and distribution requirements are similar to Halon and the majority of system components are identical. However, FM-200® is not a direct replacement for existing Halon 1301 installations due to the difference in agent quantity and discharge characteristics. The FM-200® design concentration for Class A hazards is 7.17% and for Class B hazards is at least 9.0%, therefore requiring approximately 45% additional storage capacity over that required for Halon in the same area.

The manufacturers claim that FM-200® is safer than Halon 1301 for use in total flooding applications and the U.S. Environmental Protection Agency (EPA) accepts extended use exposures of up to 9%. This has been further confirmed by a recently published HAG report. FM-200® is rated as Zero Ozone Depletion (ODP), is electrically non-conductive, clean, and leaves no residue. Refer to NFPA 2001, "Clean Agent Fire Extinguishing Systems," Section 1-6 "Safety," for additional exposure requirements.

The systems described in this manual are 'engineered.' Engineered systems for example can consist of several FM-200® tanks, manifolded together and connected via a pipe network to a number of discharge nozzles.

Systems may be activated mechanically or electrically. Mechanical manual actuation is via a strike knob attached to the tank valve. Electrical actuation is via a removable side mounted solenoid. The solenoid can be energized automatically by a signal from a detection and alarm control panel.

Users of this manual should find that sufficient information is provided to plan, design, purchase components, install, operate and maintain the system. However, in the event that part of the document is not understood, or if there is any concern as to the suitability of the protection, do not hesitate to contact one of our application engineers for the matter to be quickly resolved.

Approvals and Standards

Pyro-Chem's manufactured equipment and the FM-200® agent, manufactured by Great Lakes Chemical Corporation, have acquired comprehensive approvals and listings providing further support to the overall product.

FM-200® Agent

- Factory Mutual (Approved)
- Underwriters Laboratories Inc. (UL) Recognized Component
- NFPA 2001 Clean Agent Fire Extinguishing Systems (Listed Alternative)
- EPA SNAP Rpt. (Unrestricted Listed Alternative)
- Australian Industrial Chemicals Notification (Approved)
- German Institute for Environmental Hygiene and Medicine (Approved)

Pyro-Chem Manufactured Systems

- Underwriters Laboratories Inc. (UL) Listed

Pyro-Chem FM-200® Suppression System Units are to be designed, installed, inspected, maintained, tested and recharged by qualified, trained personnel in accordance with The Standard on Clean Agent Fire Extinguishing Systems, NFPA2001. To be used in accordance with Environmental Protection Agency (EPA) Significant New Alternatives Program (SNAP). Where determined to be appropriate by the authority having jurisdiction, applicable NFPA Standards may additionally be utilized to specific system requirements for these purposes.

Health and Safety

A properly designed and installed suppression system should not present any significant health or safety problems; however, there are basic precautions to be taken to avoid accidents, and aspects of the system operation that should be understood. End-users often require reassurance regarding the safety of personnel, and this can only be given if a thorough understanding of the properties of the agent and its effects in different situations are known.

Reference should be made to NFPA2001 for the toxic and asphyxiating hazards of clean agents replacements for Halon 1301.

FM-200®, like halon, extinguishes by causing a chemical reaction with the combustion products, and does not remove oxygen like CO_2 and other inert agents.

Therefore, exposure to FM-200® at the design concentration of 7.17%, and up to 9.0%, is not hazardous to health. Exposure to higher concentrations is permissible for limited periods. Refer to NFPA 2001, Section 1-6 "Safety," for exposure requirements. As with halons, the EPA and the National Fire Protection Association (NFPA) recommend that unnecessary exposure to any agent be avoided and that personnel evacuate protected areas as quickly as possible to avoid the decomposition products of the fire.

FM-200® can decompose at high temperatures to form halogen acids. If so, their presence is readily detected as a sharp, pungent odor long before hazardous maximum exposure levels are reached.

The noise created by the FM-200® agent discharging can be loud enough to startle people in the vicinity, but is unlikely to cause any permanent injury. Turbulence caused by the high velocity discharge can dislodge substantial objects directly in its path, and cause enough general turbulence within the protected area to move paper and light objects.

Direct contact with the vaporizing liquid discharged from an FM-200® nozzle has a chilling effect on objects and in extreme cases can cause frostbite to the skin. The liquid phase vaporizes rapidly when mixed with air and therefore limits the risk to the immediate vicinity of the nozzle. Reduction in visibility will occur due to the condensation of water vapor.

WARNING

The discharge of clean agent systems to extinguish a fire can result in a potential hazard to personnel from the natural form of the clean agent or from the products of combustion that result from exposure of the agent to the fire or hot surfaces. Unnecessary exposure of personnel either to the natural agent or to the products of decomposition shall be avoided.

HMIS: 2-0-0/heptafluoropropane/contents under pressure. 0-0-0/nitrogen expellant gas/very cold, contents under pressure. Consult Great Lakes Chemical Co., P.O. Box 2200, West LaFayette, IN 47996-2200. Emergency phone 800-949-5167.

First Aid

Skin Maintain at body temperature, thaw affected area with gentle heat. If frostbite occurs, seek medical attention. Do not rub affected area.

Eyes Apply gentle heat. Do not allow patient to touch affected area.

FM-200® Agent Characteristics

FM-200® (HFC-227ea) is a clean, gaseous agent containing no particles or oily residues. It is produced under ISO 9002 guidelines to strict manufacturing specifications ensuring product purity. FM-200® leaves no residue or oily deposits on delicate electronic equipment, and can be removed from the protected space by ventilation.

FM-200® is thermally and chemically stable, but without the extremely long atmospheric lifetimes associated with other proposed halon replacements. The atmospheric lifetime of FM-200® has been determined to be 36.5 years. The EPA does not consider FM-200® to be a long lived substance when discharged, and as such has placed no restrictions on its use.

Typical areas that can be protected by an FM-200® system are detailed below; the list is by no means complete:

Bank Vaults
Libraries
Rare Book Stores
Electronic Data Processing
Telephone Exchanges
Studios
Communication Centers
Transformer and Switchrooms
Control Rooms
Test Laboratories
Flammable Liquid Stores

The present understanding of the functioning of FM-200® is that 80% of its fire fighting effectiveness is achieved through heat absorption and 20% through direct chemical means (action of the fluorine radical on the chain reaction of a flame). Complete suppression using FM-200® has the following advantages:

- The low concentration of FM-200® required means less visual obscurity and minimal risk to personnel.
- The small quantity of agent discharged minimizes overpressurization of the protected area.
- Maximum safety for personnel due to low toxicity.
- Most effective when used with automatic detection to introduce FM-200® rapidly.
- The ability to prevent re-ignition as long as concentration levels are maintained.

FM-200® is stored as a liquified compressed gas and is discharged into the protected area as a vapor. It is stored in approved DOT4BW450 or DOT4BW500 tanks and is superpressurized with dry nitrogen to 360 psi (25 Bar) at 70 °F (21 °C).

WARNING

FM-200® shall not be used on fires involving the following materials unless they have been tested to the satisfaction of the authority having jurisdiction.

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

Agent Physical Properties

Chemical Structure	**CF_3CHFCF_3**
Chemical Name	**Heptafluoropropane**
Molecular Weight	**170.03**
Boiling Point	**1.9 °F (–16.36 °C)**
Freezing Point	**–204 °F (–131.1 °C)**
Critical Temperature	**214 °F (101.7 °C)**
Critical Pressure	**422 psi (29.1 Bar)**
Critical Volume	**.0258 cu. ft./lb. (274 cc/mole)**
Critical Density	**38.76 lb./ft³ (621 kg/m³)**
Saturated Vapor Density @ 68 °F (20 °C)	**1.95 lb./ft³ (31.18 kg/m³)**

Environmental	**FM-200®**
Ozone Depletion (ODP)	0
Atmospheric Lifetime (yrs)	36.5
(Reference: Great Lakes Chemical Corporation)	
Toxicology	
Acute Exposure LC50 (ppm)	>800,000
Cardiac Sensitization No Observed Adverse Effect Level (NOAEL)	9.0%
Lowest Observed Adverse Effect Level (LOAEL)	>10.5%
(Reference: NFPA 2001, 2000 Edition)	

Table 1: Toxicology/Environmental

System Components

This section describes the individual components that comprise a complete system. Some items are optional depending on the application, and are indicated as such.

Technical Information

Manufactured in accordance with DOT4BW450 or DOT4BW500 (343L tank manufactured in accordance with DOT4BW450 only).

ULC shipping assemblies are manufactured in accordance with TC4BWM31 (minimum).

Material	
Carbon %	0.220% max
Manganese %	1.250% max
Phosphorus %	0.045% max
Sulphur %	0.050% max

Tank marked service pressure:	DOT4BW450	DOT4BW500
Hydraulic test pressure:	900 (62.1 bar)	1000 (69.0 bar)
Working Pressure:	450 (31.0 bar)	500 (34.5 bar)

Paint Specification:	Red epoxy polyester or red polyester powder coated

FM-200® Tank

The agent storage tank consists of a tank fitted with a valve and internal syphon tube, factory filled with FM-200®, and superpressurized with dry nitrogen to 360 psi (25 bar) at 70 °F (21 °C). Tanks sharing the same manifold shall be equal in size and fill density. Tanks are available in various sizes (Figure 1). A nameplate is adhered to the tank displaying the agent weight, tare weight, gross weight, fill density and charge date.

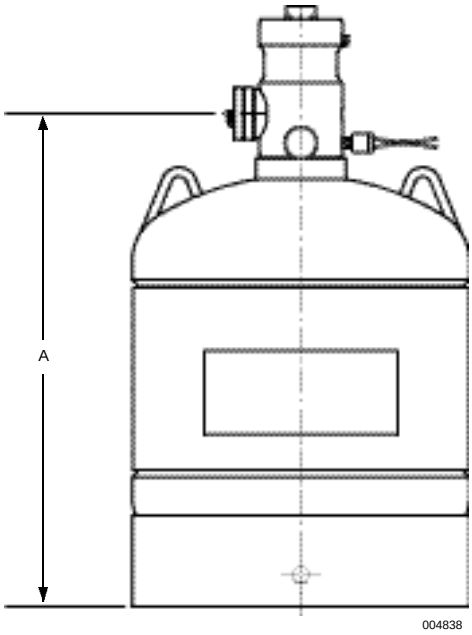

Figure 1 - FM-200® Tank

Part No. UL / ULC	Tank Capacity Lbs. (kg)	Outlet Size In.	Dim. A Nominal In. (mm)	Diameter In. (mm)	Empty Weight Lb. (kg)
570003/570320 (8 liter)	10 to 18 (4.5 to 8.0)	1 in. NPT	12 (304)	10 (254)	32.6 (14.8)
570004/570321 (16 liter)	20 to 39 (9.0 to 17.5)	1 in. NPT	19.8 (502)	10 (254)	40.6 (18.4)
570005/570322 (32 liter)	38 to 74 (17.0 to 33.5)	1 in. NPT	32.8 (833)	10 (254)	57.5 (26.1)
570006/570323 (52 liter)	59 to 117 (27.0 to 53.0)	2 in. NPT	23.5 (596)	16 (406)	108.3 (49.1)
570007/570324 (106 liter)	118 to 235 (53.5 to 106.5)	2 in. NPT	40.2 (1021)	16 (406)	158.3 (71.8)
570008/570325 (147 liter)	163 to 325 (74.0 to 147.5)	2 in. NPT	53.3 (1354)	16 (406)	198.2 (89.9)
570009/570326 (180 liter)	201 to 401 (91.5 to 182.0)	2 in. NPT	64.3 (1634)	16 (406)	233.2 (105.8)
570346/570370 (343 liter)	379 to 757 (172 to 343)	3.5 in. Flare	57.7 (1466)	24 (610)	456 (207)

Tank Label

The tank label details the weight of FM-200® contained, empty weight, fill density and charge date. Once the label is applied to the tank surface, and to avoid possible tampering, it can not be removed intact.

Technical Information

Material:	Aluminum
Dimensions:	6.5 in. (165 mm) x 9.5 in. (241 mm) (Part No. 570002) 22.0 in. (559 mm) x 2.0 in (51 mm) (Part No. 570001)

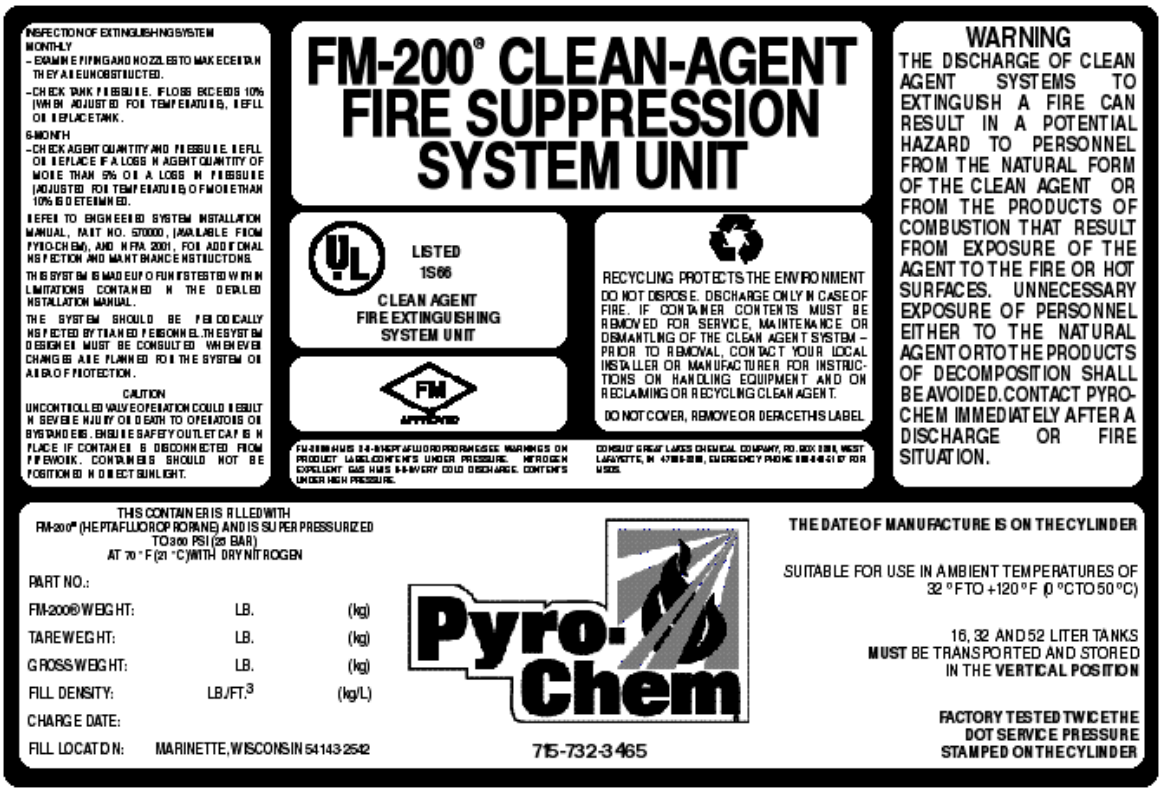

Figure 2 – Tank Label

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Mounting Brackets

The bracket assembly consists of a nut, bolt, and two bracket straps (back channel must be supplied by others. Approved type of Unistrut Channel is series P1000T, 41 mm x 41 mm or equal). To securely hold the tank in position during the system discharge, two bracket assemblies are required per tank. Exception: 8 liter size tank requires only one.

Each strap is notched for insertion into the back channel allowing the tank to be properly aligned. The bracket assembly is designed to be mounted to a rigid vertical surface with the tank assembly resting fully on the floor.

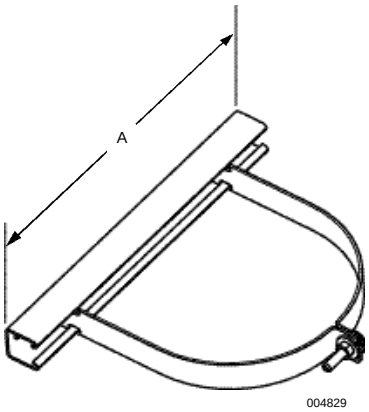


Figure 3 - Mounting Bracket

Part No.	Tank size	Dim. A
570085	10 in. dia. (254 mm) 8 to 32 Liter	15.7 in. (400 mm)
570092	16 in. dia. (406 mm) 52 to 180 Liter	23.6 in. (600 mm)
▸ 570336	24 in. dia. (610 mm) ▸ 343 Liter	27.3 in. (693 mm)

Valve Assembly

The Pyro-Chem designed and manufactured tank valve is the result of extensive research and development and incorporates many unique safety features. The valve assembly is factory-fitted to the tank and is supplied pre-assembled with a low pressure switch, pressure gauge and burst disc.

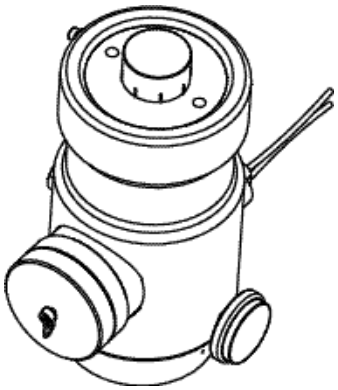


Figure 4 - Valve Assembly

1 in. valve assembly	Part No. 570040
2 in. valve assembly	Part No. 570066
▸ 3 in. valve assembly	Part No. 570302

Technical Information	1 in. and 2 in.	3 in.
Material:	Brass CZ 121	Brass UNS36000
Body Proof Pressure:	2175 psi (150 bar)	2000 psi (138 bar)
Outlet Adaptor:	1 in. NPT, 2 in. NPT	3.5 in. Flare*
Low Pressure Port:	1/8 in. NPT	1/8 NPT
Gauge Port:	1/8 in. NPT	1/8 NPT
Pilot Pressure Port:	1/4 in. BSPP	1/4 NPT
Solenoid Adaptor Port:	1/8 in. NPT	None

* Outlet adaptors are available for 3 in. NPT, 3 in. BSP, and ▸ 3 in. grooved.

Principle of Operation

The Pyro-Chem FM-200® valve is a high-flow-rate device specially designed for fire protection use. Operation is by means of a pressure-differential piston. Tank pressure is used within the valve to create a positive force on the piston, sealing the valve closed. Operation of the valve occurs when the upper chamber is vented faster than the 'make up device' in the shuttle can replace the pressure. Thereby allowing the shuttle to be forced up, and free flow of FM-200® from the valve. Upper chamber pressure is released by the electrical, mechanical or pneumatic actuator.

The valve incorporates the following features:

- A pressure operated safety release device (burst disc).
- Main outlet, fitted with safety shipping cap.
- A connection for a pneumatic or mechanical actuator, fitted with safety cap.
- A connection for an electrical solenoid.
- A connection for the pneumatic pilot signal output used for multiple tank operation.

Burst Disc

A burst disc is factory fitted to every valve assembly. It is designed to rupture when the tank becomes over pressurized when subjected to temperatures above the designed storage temperature of the tank.

004830

Figure 5 - Burst Disc

Technical Information

▸ Body:	Brass CZ 121 (1 in. and 2 in.) Brass UNS36000 (3 in.)
Rating:	725 psi (50 bar) (1 in. and 2 in.)
▸	760 psi (52 bar) (3 in.)
Thread (1 in. Valve):	M14 x 1.25 (Pt. No. 570053)
Thread (2 in. Valve):	M18 x 1.00 (Pt. No. 570039)
Hole Orientation:	90° to Body
▸ Torque: 1 in. Valve	13.3 ft. lb. (18 Nm) (M14 Thread)
Torque: 2 in. Valve	14.8 ft. lb. (20 Nm) (M18 Thread)
▸ Torque: 3 in. Valve	15.0 ft. lb. (20.3 Nm) (.9375 Thread)

Low Pressure Switch

A low pressure warning switch is fitted to every tank and must be utilized to safeguard the warranty requirements. The device continuously monitors the tank pressure and in the event of the pressure dropping below 290 psi (20 bar) the switch operates to enable the condition to be signalled to a control unit.

004836

Figure 6 - Low Pressure Switch (Part No. 570059)

Technical Information

Body:	Hermetically sealed Stainless Steel
Switch point:	Opens on fall at 290 psi ± 10 psi (20 bar ± .7 bar)
Switch Type:	Closes on rise at 350 psi ± 10 psi (24.1 bar ± .7 bar)
Proof pressure:	5003 psi (345 bar)
Connection:	Brass 1/8 in. NPT
Max. Current:	Max 2.9A
Voltage Range:	5-28 vdc
Wire Leads:	6 ft. (1.8 m)

Manual Actuator

The manual actuator is a simple 'strike knob' assembly which is fitted to the top of the valve assembly or solenoid actuator. Inadvertent operation is prevented by a pin which has to be removed before activation.

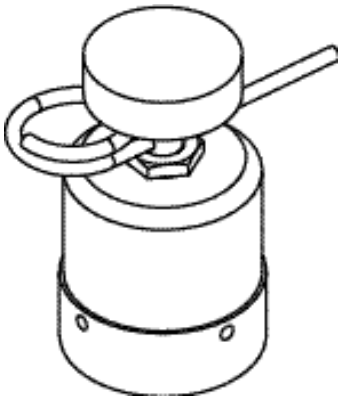


Figure 7 - Manual Actuator (Part No. 570095)

Technical Information

Body:	Brass CZ 121
Knob:	Nylon
Safety Pin:	Zinc Plated Mild Steel
Actuation Pin:	Stainless Steel
Min. Actuation Force:	5.73 lb. (25.5N)

Pneumatic Actuator

The pneumatic actuator is an assembly similar to the manual actuator but without the strike knob. Pressure from a 'master' tank or other sources is used to actuate the valve, via small bore piping or, preferably, a flexible hose.

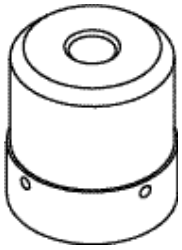


Figure 8 - Pneumatic Actuator (Part No. 570109)

Technical Information

Body:	Brass CZ121
Actuation Pin:	Stainless Steel
Pipe Connection:	1/4 in. BSPP Female
Min. Actuation Pressure:	29 psi (2 bar)

Removable Electrical Actuator

The removable electrical actuator is also similar to the manual actuator and mounts to the top of the tank valve. 24v dc is required for solenoid operation. Provision is made for the connection of a manual strike knob to the top of the actuator assembly.

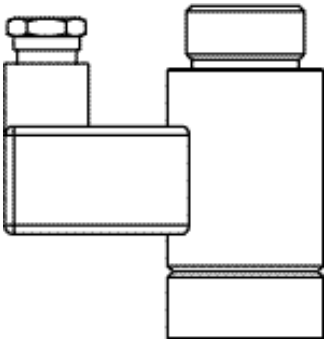


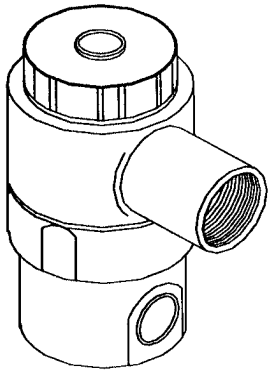
Figure 9 - Electrical Actuator (Part No. 570209)

Technical Information

Body:	Mild Steel & Dull Nickel
Swivel Nut:	Brass CZ121
Actuation Pin:	Stainless Steel
Actuation Type:	Latching
Rest Requirement:	Manual Force Required
Connection:	1 in. BSPP
Power Requirement:	24vdc
Current:	0.2A
Manual Actuation Force:	11 lb. (5 kgf)
Electrical Connection:	3-pin plug connector
Diode Type:	Suppression
Temperature Range:	–4 °F to +131 °F (–20 °C to +55 °C)
Life Span:	10 years from manufacture
Testing:	100% Check on Start / Finish position
Approval:	Underwriters Laboratories Recognized to UL508 Tested in accordance with UL864

Side Mounted Electrical Actuator

This solenoid actuator differs from other actuators in that it is side mounted. It can be located directly on the side of the valve or via a solenoid adaptor. The adaptor enables the actuator to be removed safely without actuation of the tank valve. It is designed to be used in explosive atmospheres (Class I, groups C and D, Class II, groups E, F & G). It is operated by a 24v dc input signal.



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▸ Figure 10 - Electrical Actuator (Part No 570147)*

Technical Information

Solenoid Enclosure:	Stainless Steel
Power Requirement:	24v dc
Power Consumption:	9.5 watts
Conduit Thread:	1/2 in. NPT
Pressure Connection:	1/8 in. NPT Female
Pressure Range:	0-1500 psi (0 - 103 bar)
Certification:	UL
Max. Ambient Temp:	221 °F (105 °C)
Solenoid Orientation Range:	0-30° Off Vertical

▸ * Not available on 3 in. Valve (343 Liter Tank)

▸ 1 in. and 2 in. Valve Flexible Discharge Hose

Multiple FM-200® tank installations are connected to the system by means of a flexible discharge hose. This enables tanks to be disconnected for maintenance or recharge without dismantling other tank mountings, manifold connections and pipework, etc.

The flexible discharge hose is connected to each manifold valve outlet. A swivel fitting at the inlet of the hose enables the tank to be readily coupled to the distribution system. Both size discharge hoses require the addition of a brass adaptor between the valve outlet and the swivel fitting at the inlet of the hose. Hose shipping assemblies include the required adaptor.

004831

Figure 11 - 1.25 in. (32mm) Discharge Hose (Part No. 570141)

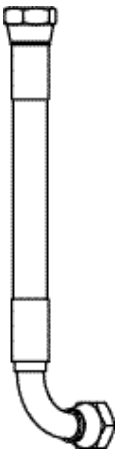

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Figure 11 - 2 in. (50mm) Discharge Hose (Part No. 570142)

▸ Technical Information	1 in. and 2in. Valve
Construction:	Twin steel wire braided Oil resistant Seamless synthetic rubber core to DIN 20022.
Connection:	Zinc Passivated Mild Steel
Max Bend Angle:	15° @ 32 °F (0 °C)

3 in. Discharge Hose/Check Valve Assembly

The discharge hose/check valve assembly (Part No. 69841) combines the elbow, hose, check valve, and swivel coupling for connection to the valve discharge outlet and the discharge manifold. The check valve provides a 1 1/2 in. height adjustment.

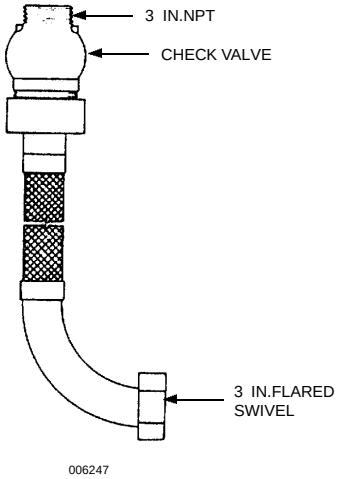


Figure 11 - 3 in. (75mm) Discharge Hose (Part No. 69841)

Technical Information	3 in. Valve
Construction:	
Hose:	Double braid stainless steel
Elbow:	Stainless steel UNS 30400
Valve Swivel Nut:	Stainless steel UNS 30400
Check Valve Swivel Nut:	Cadmium plated mild steel
Check Valve Body:	Cadmium plated mild steel
Check Valve Seal and Seat:	Brass UNS 36000
Spring:	Stainless steel
Test Pressure:	1000 psi (69 bar)
Minimum Burst Pressure:	2000 psi (138 bar)

3 in. Valve Single Tank Adaptors

When a single 343 liter tank module is being used without a manifold, three swivel adaptors are available for connection to the discharge outlet and either NPT, or BSPT, or grooved distribution pipe.

Part No.	Description
69470	3 in. Flared to 3 in. NPT
69471	3 in. Flared to 3 in. Grooved
570363	3 in. Flared to 3 in. BSPT

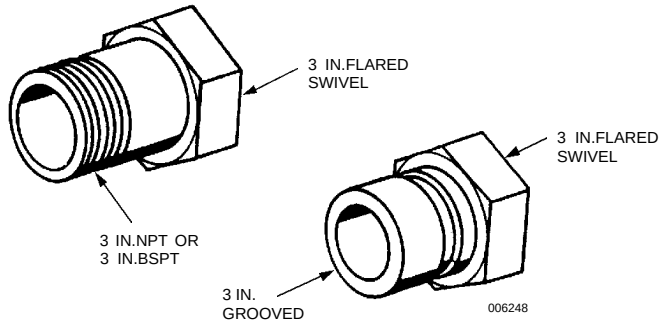


Figure 11a - 3 in. Valve Single Tank Adaptor

3 in. Valve Discharge Hose

The discharge hose (Part No. 69990) is used with the 3 in. NPT adaptor and 90° elbow to connect the tank valve outlet to the distribution piping in single tank systems. The hose is constructed of corrugated stainless steel tubing with stainless braid cover. The minimum bending radius for the 3 in. hose is 18 in. (46 cm).

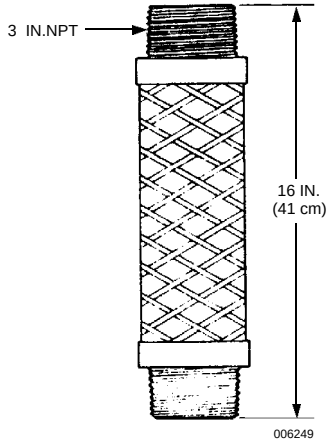


Figure 11b - 3 in. Valve Discharge Hose (Part No. 69990)

Solenoid Adaptor

The adaptor enables the actuator to be removed safely without actuation of the tank valve. To remove the solenoid, the adapter body should be unscrewed in the counterclockwise direction. This action will close the schrader valve and then allow the pressure between the schrader and solenoid actuator to be released safely through the threads of the adaptor body.

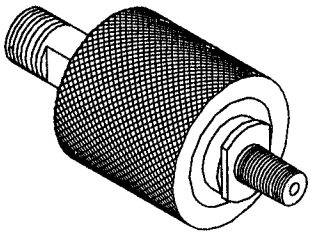


Figure 12 - Solenoid Adaptor (Part No. 570135)

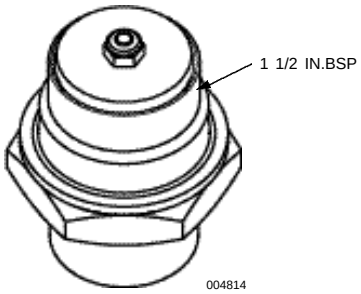
Technical Information

Body:	Brass CZ121
Circlip:	Stainless Steel
Max Working Pressure:	1088 psi (75 bar)
Proof Pressure:	2175 psi (150 bar)
Solenoid Connection:	1/8 in. NPT

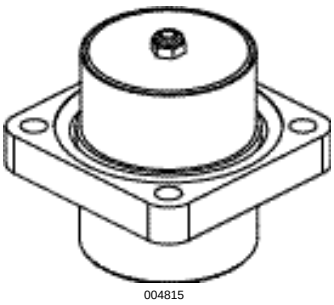
Manifold Check Valve

Manifold check valves are of mushroom pattern type and lift into the manifold as discharge occurs. The function of the check valve is to prevent loss of extinguishing agent during discharge from an outlet, should a tank have been removed. All check valves are supplied ready fitted to the manifold assembly.

1.25 in. (32mm) Check Valve Assy. Part No. 570111
2 in. (50mm) Check Valve Assy. Part No. 570121



1.25 in. Check Valve (Threaded)



2 in. Check Valve (Flanged)

Figure 13 - Manifold Check Valve

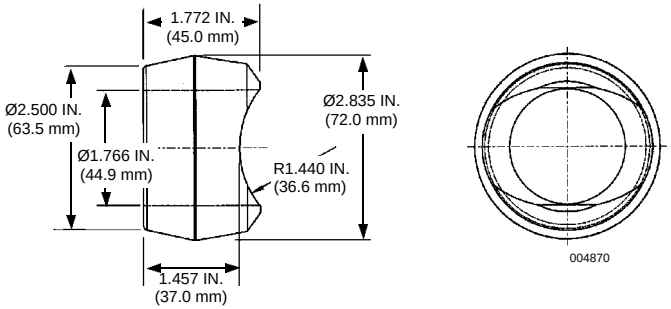
Technical Information

Body:	Brass CZ122
Stem:	Stainless Steel
Spring:	Stainless Steel

Manifold Inlets

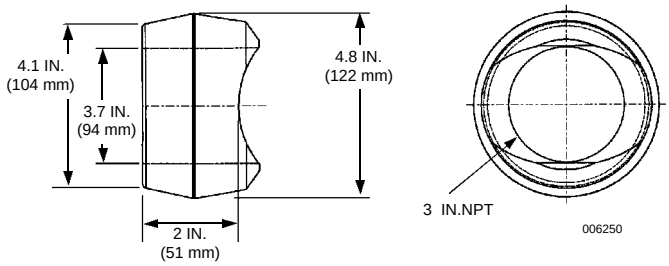
Manifold inlets are available for the construction of system manifolds. Two types of inlets are available: threaded and flanged.

THREADED INLET: The threaded inlet, Part No. 570222, is required when fabricating a manifold to be used with systems requiring the 1 1/4 in. (32 mm) check valve and the 1 1/4 in. (32 mm) flexible discharge hose. The threaded inlet (Part No. 570222) is used on 2 1/2 in. manifolds only.



Threaded Inlet Part No. 570222 for 2 1/2 in. Manifolds

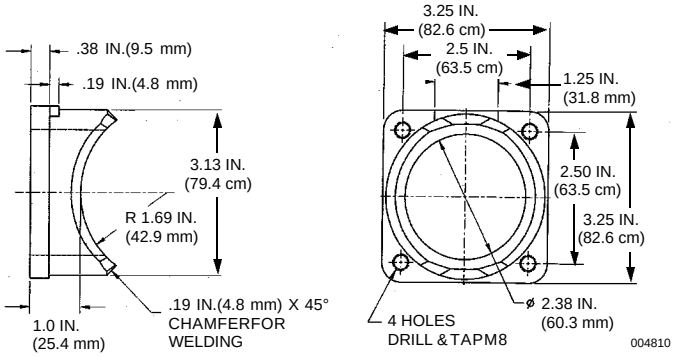
THREADED INLET: Threaded inlets, Part Nos. 53837 and 62516, are used when fabricating a manifold to be used with systems requiring the 3 in. (75 mm) discharge hose/check valve assembly. The threaded inlets are used on 4 in. (use Part No. 53837) and 6 in. (use Part No. 62516) manifolds. The threaded inlets are 3 in. NPT female.



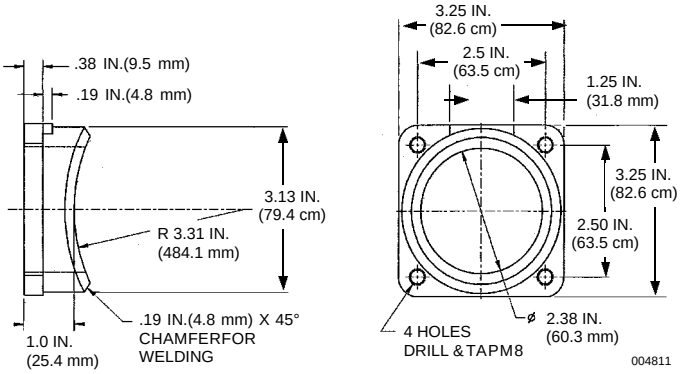
Threaded Inlet Part No. 53837 or 62516 for 4 in. or 6 in. Manifolds

Figure 14

FLANGED INLET: The flanged inlet is required when fabricating a manifold to be used with systems requiring the 2 in. (50 mm) check valve and the 2 in. (50 mm) flexible discharge hose. The flanged inlet is used on 3 in., 4 in., and 6 in. NPT manifolds. Two sizes of flanged inlets are available. On 3 and 4 in. NPT manifolds, use flanged inlet Part No. 570144. On 6 in. NPT manifolds, use Part No. 570145.



Flanged Inlet Part No. 570144 for 3 in. and 4 in. NPT Manifolds

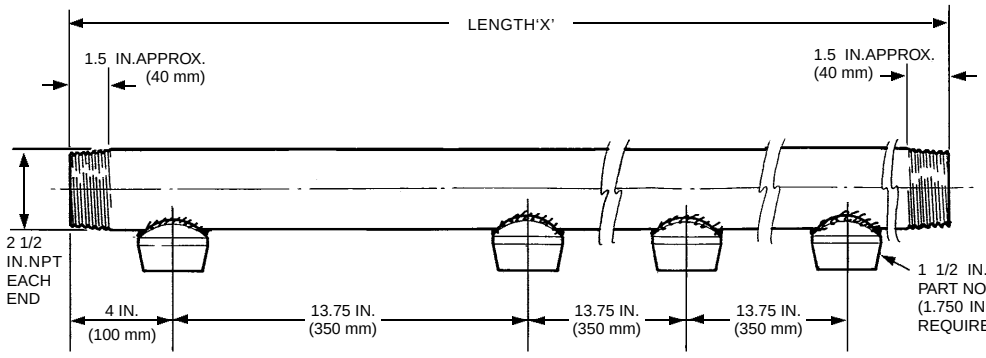


Flanged Inlet Part No. 570145 for 6 in. NPT Manifolds

Construction of Manifolds

Manifold are not supplied by Pyro-Chem. They must be constructed as needed using the manifold inlets specified on Page 14, Figure 14.

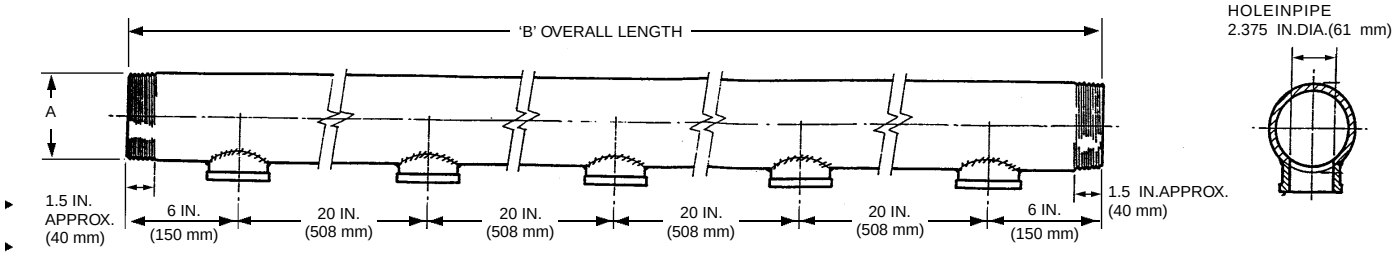
The following detailed information can be used for manifold construction. See Figure 14a.



Threaded

No. of Inlets	Length 'X'
2	21 21/32 IN. (550 mm)
3	35 7/16 IN. (900 mm)
4	49 7/32 IN. (1250 mm)

- PIPING MUSTBESCHEDULE80
- TESTPRESSURE– 1300 PSI(90 BAR)



Flanged

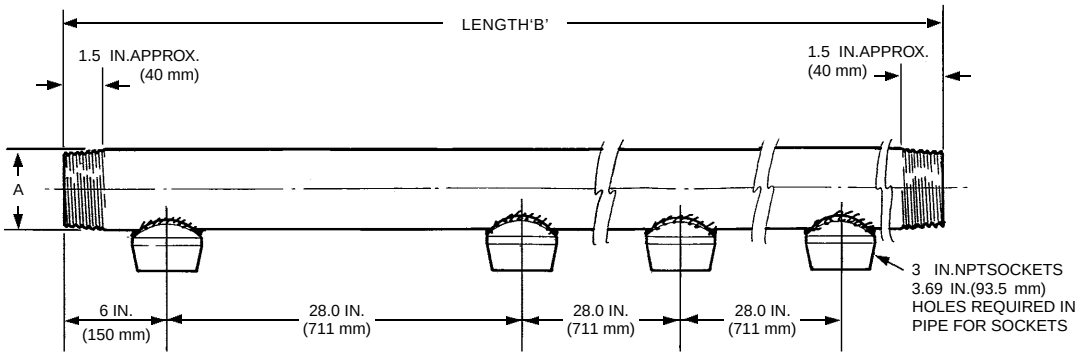
- PIPING MUSTBESCHEDULE80
- TESTPRESSURE– 1300 PSI(90 BAR)
- ALL DIMENSIONS MUST BE WITHIN ± 1/8 IN. (3.2 mm)
- AFTER WELDING, MAKE CERTAIN ALL INLET HOLES IN THE PIPE ARE CLEAN OF ANY WELD SPATTER AND OPEN COMPLETELY

Manifold information for 1 in. and 2 in. valves (1.25 in. and 2 in. Flexible Discharge Hoses)

Inlets	'A'	'B'	Flange Part No.
2	3 in. NPT	31 3/4 in. (808 mm)	570144
3	3 in. NPT	51 3/4 in. (1316 mm)	570144
4	3 in. NPT	71 3/4 in. (1824 mm)	570144
5	3 in. NPT	91 3/4 in. (2332 mm)	570144
2	4 in. NPT	31 3/4 in. (808 mm)	570144
3	4 in. NPT	51 3/4 in. (1316 mm)	570144
4	4 in. NPT	71 3/4 in. (1824 mm)	570144
5	4 in. NPT	91 3/4 in. (2332 mm)	570144
6	4 in. NPT	111 3/4 in. (2840 mm)	570144
3	6 in. NPT	51 3/4 in. (1316 mm)	570145
4	6 in. NPT	71 3/4 in. (1824 mm)	570145
5	6 in. NPT	91 3/4 in. (2332 mm)	570145
6	6 in. NPT	111 3/4 in. (2840 mm)	570145
7	6 in. NPT	131 3/4 in. (3348 mm)	570145
8	6 in. NPT	151 3/4 in. (3856 mm)	570145
9	6 in. NPT	171 3/4 in. (4364 mm)	570145
10	6 in. NPT	191 3/4 in. (4872 mm)	570145

Figure 14a

Construction of Manifolds (Continued)



Threaded

- PIPING MUSTBESCHEDULE80
- TESTPRESSURE– 1300 PSI(90 BAR)
- ALL DIMENSIONS MUST BE WITHIN ± 1/8 IN.(3.2 mm)
- AFTER WELDING, MAKE CERTAIN ALL INLET HOLES IN THE PIPE ARE CLEAN OF ANY WELD SPATTER AND OPEN COMPLETELY

Manifold information for 3 in. valve
(3 in. Discharge Hose/Check Valve Assembly)

Figure 14b

Inlets	'A'	'B'	Socket Part No.
2	4 in. NPT	40 in. (1016 mm)	53837
3	4 in. NPT	68 in. (1727 mm)	53837
4	4 in. NPT	96 in. (2438 mm)	53837
5	4 in. NPT	124 in. (3150 mm)	53837
6	4 in. NPT	152 in. (3861 mm)	53837
3	6 in. NPT	68 in. (1727 mm)	62516
4	6 in. NPT	96 in. (2438 mm)	62516
5	6 in. NPT	124 in. (3150 mm)	62516
6	6 in. NPT	152 in. (3861 mm)	62516
7	6 in. NPT	180 in. (4572 mm)	62516
8	6 in. NPT	208 in. (5283 mm)	62516
9	6 in. NPT	236 in. (5994 mm)	62516
10	6 in. NPT	264 in. (6706 mm)	62516

Flexible Pilot Hose

The flexible pilot hose is used to connect pressure activated devices to the system, e.g. tank, pressure switch, etc.

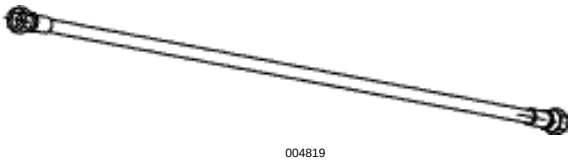


Figure 16 - Flexible Hose (Part No. 570143)

Technical Information

Outer sheath:	Stainless Steel Braided
Inner sheath:	PTFE to BS 4976
Max. Working Pressure:	2755 psi (190 bar)
Min. Burst Pressure:	11000 psi (759 bar)
MIn. Bend Radius:	2.4 in. (60mm) @ 32 °F ((0 °C)
Connections:	1/4 in. BSP swivel female
Length:	28 in. (710mm)

Male Pilot Hose Connector

The male pilot hose connector is used to connect two pilot hoses together for systems where a second tank of a different size is used to protect a different enclosure. For example: a large tank is protecting a room and a separate smaller tank protects the sub-floor, and both tanks are to actuate simultaneously, and a hose longer than Part No. 570143 is required.

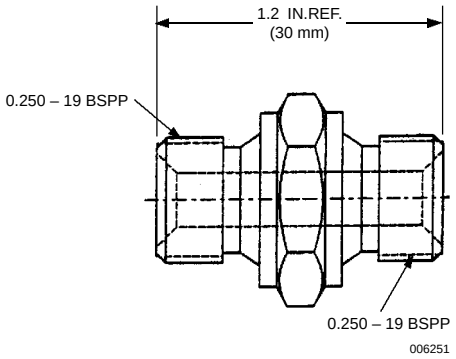


Figure 16a - Male Pilot Hose Connector (Part No. 570341)

Technical Information

Material:	Steel, zinc passivated
Connection:	1/4 in. BSPP x 1/4 in. BSPP

Male Adaptor

The male adaptor (Part No. 570148) connects the pilot hose to the 1 in. and 2 in. tank valve assembly. The male adaptor (Part No. 570342) connects the pilot hose to the 3 in. tank valve assembly and to the pressure switch.

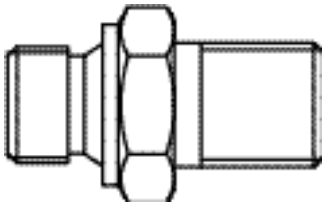


Figure 17 - Male Adaptor

Technical Information

Material:	Steel, zinc passivated
Connection:	1/4 in. BSPT x 1/4 in. BSPP (Part No. 570148) 1/4 in. NPT x 1/4 in. BSPP (Part No. 570342)

Male Tee

This is used primarily in manifold systems for connecting pilot lines from one tank to the next.

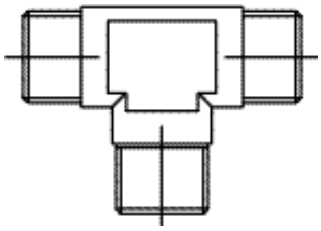


Figure 18 - Male Tee (Part No. 570150)

Technical Information

Material:	Brass
Connection:	1/4 in. BSPP x 1/4 in. BSPT

Male Elbow

This elbow can be used on the last tank when the pressure switch connection is taken from the manifold or piping networks.

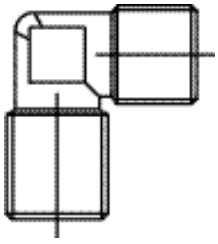


Figure 19 - Male Elbow (Part No. 570149)

Technical Information

Material:	Brass
Connection:	1/4 in. BSPT x 1/4 in. BSPP

Street Elbow

This elbow can be used to connect a pilot hose to a 3 in. valve. The street elbow's 1/4 in. NPT male thread screws into the valve body actuation port. The 1/4 in. NPT thread of the male adaptor (Part No. 570342) screws into the street elbow. The flexible pilot hose (Part no. 570143) would then screw onto the male adaptor.

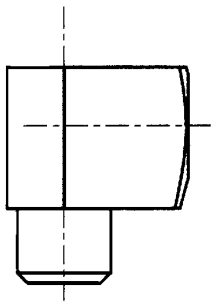


Figure 19a - Street Elbow (Part No. 417398)

Technical Information

Material:	Brass
Connection:	1/4 in. NPT x 1/4 in. NPT

Pressure Switch

The pressure switch is activated by pressure from the agent during discharge and can be used to signal to a control panel that the system has actually discharged. The pressure switch incorporates a reset button which has to be depressed following a discharge.

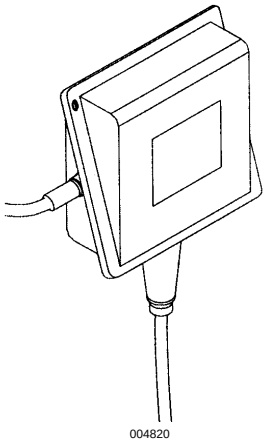


Figure 20 - Pressure Switch (Part No. 570151)

Technical Information

Housing:	Diecast Aluminum
Pressure Connection:	Nickel Plated Brass
Switch Point:	58 psi (4 bar) Rising
Tolerance:	+/– 5 psi (+/– 0.34 Bar)
Connection:	1/4 in. NPT Female
Proof Pressure:	2500 psi (172.4 bar)
DC Switch Rating:	1 A 24v DC
Temperature Range:	–40 °F to +160 °F (–40 °C to +71 °C)
Installation Environment:	non-corrosive / indoor

Discharge Nozzle

FM-200® is distributed within the protected area by the discharge nozzle which is sized to ensure the correct flow of agent for the risk. Nozzles are available with seven or eight ports to allow for 180° or 360° horizontal discharge patterns. Ports are drilled in .004 in. (0.1 mm) increments to the specified system design. Nozzles are supplied in Brass with NPT threads.

3/8 in. NPT Nozzle:	Part No. 570156
1/2 in. NPT Nozzle:	Part No. 570157
3/4 in. NPT Nozzle:	Part No. 570158
1 in. NPT Nozzle:	Part No. 570159
1 1/4 in. NPT Nozzle:	Part No. 570160
1 1/2 in. NPT Nozzle:	Part No. 570161
2 in. NPT Nozzle:	Part No. 570162

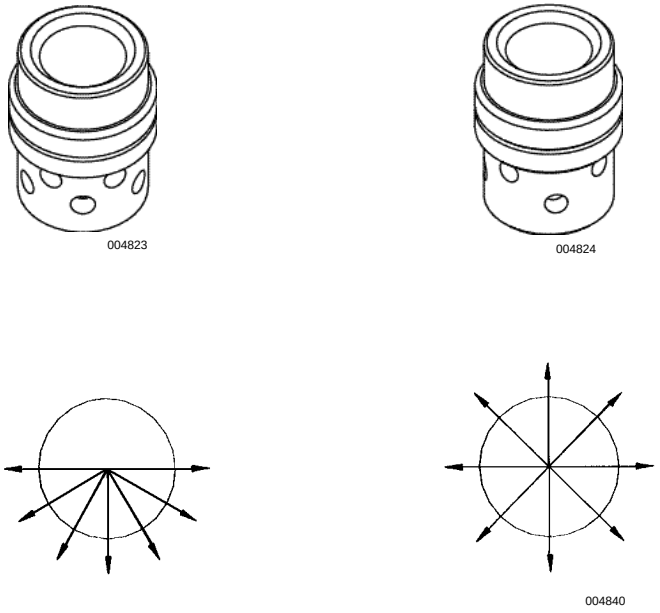


Figure 21 - 7 & 8 Port Nozzle Configuration

Technical Information

Material:	Brass

Door Sign

A door sign is required at each entrance to the risk to advise personnel that they are entering a protected area.

Door Sign (Part No. 570191)
for areas protected by concentrations greater than NOAEL (unoccupied spaces only).

for areas protected by concentrations less than NOAEL (Part No. 570192).

Technical Information

Material	0.08 in. (2mm) Craylon
Finish	Gloss, scratch resistant

Figure 22

Manual Release Sign

A sign should be located at each manual release position.

Figure 23 - Manual Release Sign (Part No. 570190)

Technical Information

Material	0.08 in. (2mm) Craylon
Finish	Gloss, scratch resistant

Liquid Level Measuring Device

The measuring device is used to measure the level of liquid FM-200 in 106, 147, 180, and 343L tanks. The weight of the FM-200 in the tank is determined by converting the level measurement into a weight measurement using the weight conversion tables in the maintenance section of this manual. The operating temperature range for the liquid level measuring device is 32 to 120 °F (0 to 50 °C).

The liquid level is found by lifting the measuring tape from inside the tube to the end (or approximately 3 in. above the anticipated liquid level) and slowly lowering the tape until a magnetic interlock with the float is felt. The tape will then remain in the up position, allowing a reading at the top of the housing. This measurement is accomplished without removing the tank from the fire suppression system.

The device can be installed in empty tank modules with the proper port or tanks can be ordered with the device already installed. When requesting factory installation, the liquid level measuring device must be ordered as a separate item with the tank module.

Tank Size	Liquid Level Measuring Device Part Number
106L	570277
147L	570278
180L	570278
343L	570278

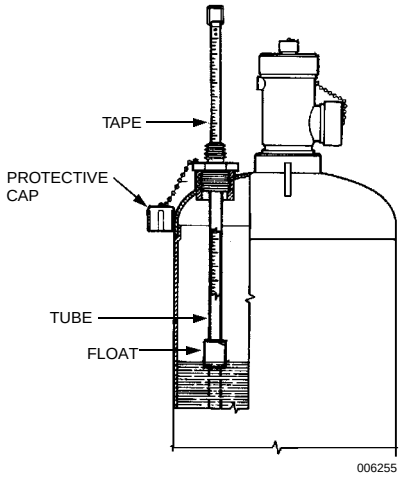


Figure 23a - Liquid Level Measuring Device

Technical Information

Mounting Thread:	1.3125-12UN-2A
Stem and Mounting Material:	Brass
Float Material:	ECCO

Typical Manifold System

Figure 24 indicates a typical two tank system complete with manual strike knob, pressure switch, 2 x low pressure switch, flexible connections, distribution pipework and nozzles.

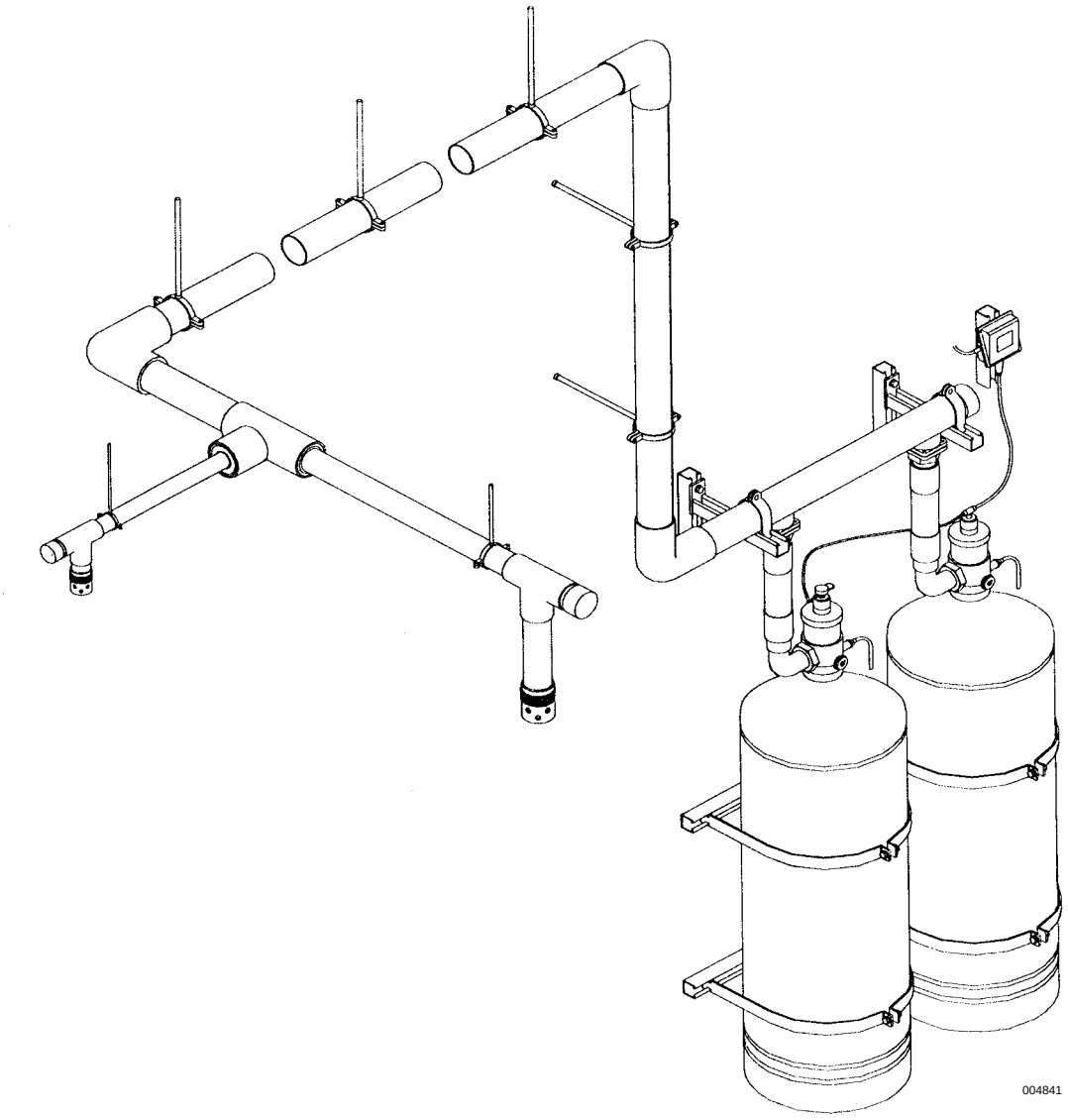


Figure 24 - Typical Manifold System

System Design

There are two main elements of system design. The first is the risk assessment; determining the type of protection required, considerations such as ventilation, openings and restrictions; equipment location. etc. The second is calculating the quantity of FM-200® required, including floor and/or ceiling voids, positioning of nozzles, electrical requirements, etc.

A Site Survey/Request form is useful for addressing the relevant factors, and can be used subsequently to substantiate the design criteria. This can be found in Appendix A. All systems are designed in accordance with NFPA 2001.

Hazard Analysis

The first, and one of the most important, exercises in planning an FM-200® suppression system is the hazard survey. The information derived from the survey should include risk assessment, environmental conditions, personnel considerations, system operation both in normal conditions and after a discharge, access and construction limitations, dimensions, volumes, and any special requirements.

FM-200® systems are suitable for use in normal commercial and industrial environments. The design concentration for Class A& C fires is 7.17% but differs for Class B fires. For design concentrations for Class B flammable liquids, consult Pyro-Chem and NFPA 2001. However, the minimum design concentration for flammable liquids is 9.0% based on commercial grade heptane. All design concentration calculations are based on extinguishing concentrations plus an additional 20% safety factor for Class A& C and a 30% safety factor for Class B and all manually-actuated only systems. Rugged environments, and those requiring intrinsically safe or flameproof equipment, require special consideration and should be discussed fully with Pyro-Chem before finalizing a system design. FM-200® is suitable for use with the following materials:

Class A	Fires involving solid materials usually of an organic nature, in which combustion normally takes place with the formation of glowing embers.
Class B	Fires involving flammable liquids or liquefiable solids and flammable gases.
Class C	Fires involving energized electrical equipment where the electrical nonconductivity of the extinguishing media is of importance.

Note. Certain materials in this group may require increased concentrations to achieve satisfactory extinguishment. Consult Pyro-Chem fordetails of specific risks.

Design Concentrations are determined by NFPA 2001, 2000 edition, Paragraph 3-4.2 and UL-2166, first edition, Paragraph 61.2(b):

FM-200 cupburner valve is 6.7% for commercial grade Heptane. Nozzle distribution test concentration = 6.9%

Calculations:

Cupburner or fire test concentration x nozzle efficiency factor x safety factor

$$\text{Nozzle efficiency factor} = \frac{6.9}{6.7} = 1.03$$

Safety Factor: Class A = 1.2
Class B = 1.3
Class C = Class A

For Class A (Determined by fire test) – 5.8% x 1.03 x 1.2 = 7.17%
For Class B (Commercial grade heptane) – 6.7% x 1.03 x 1.3 = 9.0%
For Class B (Other Class B fuels) – cupburner x 1.03 x 1.3 = design concentration but not less than 9.0%
For Class C – Use at least design concentration for Class A surface fires (7.17%)

For systems with only manual actuation – cupburner x 1.03 x 1.3 = design concentration but not less than 9.0%

Caution. FM-200® is not effective on the following:

- Class A Deep seated fires.
- Class D Combustible metals.
- Chemicals capable of auto-thermal recomposition.
- Chemicals capable of rapid oxidation.
- Enclosures with hot surfaces >752 °F (>400 °C).

Hazard Structure

The protected enclosure shall be bounded by rigid elements of building construction. The ceiling should be not less than 1.0 ft. (0.3 m) above the hazard. The rigid elements should have a fire resistance of not less than 30 minutes.

During agent discharge, the hazard enclosure will experience a pressure change. The hazard structure must be capable of withstanding a pressure of 12.5#/ft^2 (600 pa) developed during discharge.

Hazard Volume

In total flooding applications, the hazard area must be an enclosed space with no significant openings so that the design concentration can be achieved and maintained. Generally, the calculation is based on an empty area; the subsequent furniture and fittings having little effect on the actual concentration. Similarly, large equipment cabinets and control panels should not be considered in the calculation as it is assumed that the internal area is required to be filled with agent.

Each enclosed space is considered as a hazard area and requires at least one nozzle. A floor void, ceiling void, cable duct, etc., is treated as a separate adjacent area and requires simultaneous discharge to occur.

Ceiling obstructions such as beams that are less than 12 in. (300mm) below the slab need not be considered. Obstructions greater than 12 in. (300mm) can affect the distribution of agent and may require additional nozzles. Consult Pyro-Chem if in doubt. Please note that floor voids cannot be protected separately from the associated room.

To determine the volume refer to the site drawings, ensuring that the scale is accurate and that heights are denoted, or make a sketch of the area adding dimensions and any relevant details. Calculate the volume of each area.

Ventilation

If the hazard enclosure has no means of adequate venting after discharge, consideration should be given to installing a normally closed means of ventilation with extraction arrangements which will discharge directly to open air.

Air conditioning and/or forced ventilation can affect the system performance and the quantity of agent required.

(i) Self-contained air conditioning unit

A self-contained unit conditions the air within the enclosure and does not rely on a fresh air supply, or draw air from other parts of the building.

If the hazard has a self-contained unit and it is located within the area without an outside air supply, no additional agent is required. It is not necessary to shut down the unit prior to a discharge as the mixing effect is beneficial.

(ii) Central air conditioning unit

A central air conditioning unit relies on air from outside and is often linked by ducts to other parts of the building, therefore, prior to a discharge, the unit should be shut down and/or dampers operated to close the ducts. Sufficient time must be allowed for the plant to stop, or dampers to close, before discharge occurs.

Dampers should be installed in both supply and return air ducts, as close as possible to the area. The duct volume between the unit and the damper must be added to the overall volume.

Hazard Temperature

Determine as accurately as possible the anticipated minimum and maximum temperatures likely to be experienced within the protected area. Minimum agent quantity requirements are based on minimum hazard temperature. At maximum temperature, hazard concentration must not exceed the NOAEL/LOAEL values for normally occupied spaces, reference NFPA 2001, Section 1-6 “Safety.”

Hazard Fuels

All fuels in the hazard must be identified and the corresponding agent concentration requirements for each must be determined. The design concentration (percent by volume) required for the hazard will be the highest concentration required by any one of the fuels present in the hazard.

Personnel Safety

Natural Agent: To avoid possible injury, avoid any exposure to FM-200® in volume concentrations greaterthan 9% unless using self contained breathing apparatus. Limit exposure times as stated in NFPA 2001, Section 1-6 “Safety.”

Symptoms of overexposure to concentrations greater than 10.5% may include dizziness, impaired coordination, reduced mental acuity, cardiac effects or unconsciousness. In the event of overexposure, remove to fresh air immediately and summon medical assistance.

Frostbite: Direct skin contact with FM-200® in the immediate area of discharge may cause frostbite.

Agent Quantities

Normally the agent quantity is the weight required to produce the desired concentration at the lowest temperature within the hazard enclosure.

Agent Storage

FM-200® is stored as a liquified compressed gas in appropriate tanks to meet DOT4BW450 or DOT4BW500 requirements. Nitrogen in the tank maintains a superpressurization of 360 psi (25 bar) at 70 °F (21 °C). The chosen location should provide protection from severe weather, mechanical, chemical, or other types of damage. The ambient temperature of the storage area must be between 32 °F to 120 °F (0 °C to 49 °C), the optimum temperature being 70 °F (21 °C).

Hydraulic calculations are made at 70 °F (21 °C). When the storage temperature varies by ± 10 °F (± 5.5 °C) from 70 °F (21 °C), there is a risk that the system will not supply the designed quantity of extinguishing agent.

Manifolds

It may be necessary to manifold agent tanks to provide the required amount of agent for a hazard, or to make available the proper increments of agent weight for the protection of multiple hazards.

Whenever tanks are manifolded, the following rules must be observed.

1. All tanks connected to the same manifold or pipe must be the same size and filled with the same agent weight and pressure.
2. Agent tanks must be located in a single row and spaced according to section.
3. A connected reserve may be employed in some circumstances providing a secondary supply of agent.
4. Flexible discharge hoses and check valves must be used at each inlet.

Agent Distribution

Distribution piping will be installed only with approved piping as indicated in Section 5.

Pipe size reductions may be made by using reducing tees or reducing bushings or reducing couplings.

Agent Flow Characteristics

Nitrogen Superpressurization

Nitrogen is added to the FM-200® tanks. This addition of nitrogen, known as superpressurization, will cause a portion of the nitrogen to mix with the FM-200®, the remaining portion of the nitrogen will remain in the vapor space above the liquid, providing the increased propulsion necessary to discharge the FM-200® from the tank.

Flow in Pipe

In a properly designed distribution piping network, the flow of FM-200® will consist of a two phase mixture of liquid and vapor. The properties of this mixture will vary with its composition; therefore, when the mixture contacts the pipeline walls, the friction decreases the density of the mixture resulting in a non-linear pressure drop and an increase in flow velocity.

Another consequence of two-phase flow is the potential for separation of liquid and vapor. In a properly designed pipe network, the velocity of the mixture will be high enough to maintain highly turbulent flow. However, if the pipeline diameter is too large for the design flow rate, the two phases may separate, leading to alternate discharges of liquid and vapor (slugging) or layering of the two phases. Therefore, the pipeline must be properly sized to keep the FM-200® flow turbulent enough to prevent phase separation.

Hydraulic calculations are made at 70 °F (21 °C). Temperatures other than 70 °F (21 °C) may result in variations in system discharge characteristics.

Initial Vapor Discharge

At the instant the discharge valve is opened, rapid expansion of the agent will cool the piping network.

Trailing Vapor Pressure

Discharge time is defined as the average liquid discharge time through all nozzles in the system. After the liquid portion of the discharge has been completed, there will be a short transition period followed by the delivery of the remaining FM-200® nitrogen mixture as a vapor. This is due to flashing of the trailing edge of the fluid as it moves from the tank to the nozzles. In some systems the transition period is relatively long; this can lead to confusion as to when the discharge is complete, possibly resulting in an inaccurate measurement of the discharge time.

Nozzle Selection and Location

The number of nozzles required is based on the hazard size and configuration and the coverage provided by the nozzle. Nozzles are available in 7-port or 8-port versions to provide 180 or 360 degree discharge patterns respectively. When considering the optimum nozzle location, the following factors should be taken into account.

- Nozzle location is affected by the shape of the hazard area.
- The maximum discharge radius is 28.6 ft. (8.7m) for a 360° nozzle and 33.0 ft. (10.05m) for a 180° nozzle.
- The maximum coverage area for either nozzle is 1026 ft.^{2} (95.3m^2).
- Nozzle orifices must not be placed where they may discharge into nearby objects.
- Nozzles must be installed within 12 in. (300mm) below the ceiling.
- 16 ft. (4.87 m) maximum protection height for 360° and 180° nozzles.
- 180 degree nozzles must be mounted adjacent to a wall and must be located to cover the entire area. The maximum distance from wall is 12 in. (300 mm) and the minimum distance is 2 in. (50 mm), measured from center of nozzle to the wall.
- 1 ft. (0.3 m) minimum void (sub-floors, false ceilings) height.

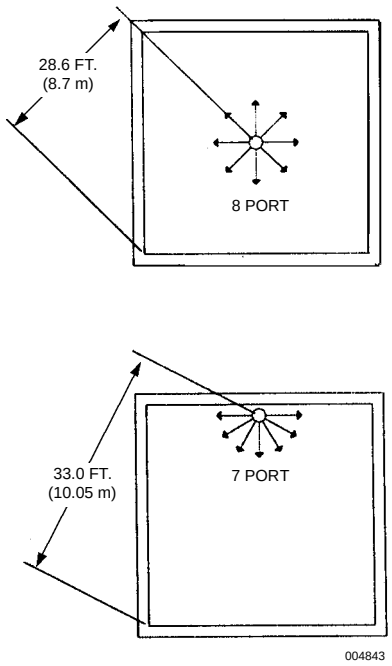


Figure 25 - Nozzle Discharge Radius

Example: Nozzle Selection

Switch Room:	4262.6 ft.^{3} (120.7 m^3)	1 x 7 port nozzle
Computer Room:	19237.1 ft.^{3} (543.3 m^3)	4 x 8 port nozzles
Floor Void:	2275.4 ft.^{3} (63.4 m^3)	2 x 8 port nozzles

Nozzle placement and piping arrangements for the example are shown in Figure 26.

System Design Procedure

The following procedure must be followed when designing FM-200® systems.

- Determine hazard material and required design concentration.
- Identify individual enclosure volumes and deduct any impermeable volumes where appropriate.
- Determine hazard altitude and correction factor.
- Calculate quantity of FM-200® per enclosure, at minimum design temperature.
- Determine tank size and fill density.
- Select nozzle type and location.
- Design pipe network.
- Calculate quantity of FM-200® per nozzle.
- Check percentage agent split at tee's.
- Identify all pipe lengths, rises, falls and nozzle reference numbers.

Note: The side tee splits shall be between 10-30%, bull tee splits will be between 30-70%. All tee outlets must be in the same horizontal plane. See Figure 25a.

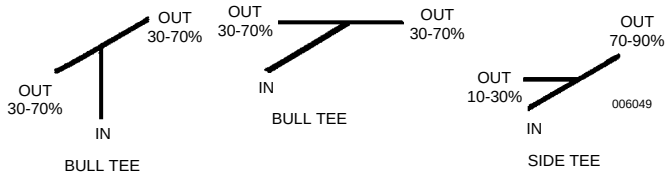


Figure 25a

The Hughes Hydraulic Flow Program contains the necessary on line screens to allow all the necessary inputs required for proper flow calculations.

Design Example – Calculations

Minimum Agent Quantity is based on the hazard volume at the minimum anticipated temperature and concentration required. To determine the minimum agent quantity the following equation is used:

$$W = \frac{V}{S} \left(\frac{C}{100-C} \right)$$

W = Weight of Agent required – lbs.

V = Hazard Volume – $ft.^3$

S = Specific Vapor Volume – $ft.^3/lb.$

S = 1.885 + 0.0046 t

t = Design Temperature in Hazard Area –°F

C = Required FM-200® Design Conc. (% by volume) at Design Temperature (t)

Example:

Calculation for two rooms and floor void with the following dimensions:

Switch Room: 22.9 x 22.7 x 8.2 ft. = 4262.6 cu. ft.
(7.0 x 6.92 x 2.5 m = 120.7 cu. m)

Computer Room: 52.5 x 39.4 x 9.3 ft. = 19237.1 cu. ft.
(16.0 x 12.0 x 2.83 m = 543.3 cu. m)

Floor Void: 52.5 x 39.4 x 1.1 ft. = 2275.4 cu. ft.
(16.0 x 12.0 x 0.33 m = 63.4 cu. m)

t = 70 °F (21 °C) for calculation example

Switch Room: (7.2% required design concentration) – example only

$$W = \frac{4262.6}{2.207} \text{ X } \frac{7.2}{(100-7.2)} = 149.9 \text{ lb.}$$

Computer Room: (7.2% required design concentration)

$$W = \frac{19237.1}{2.207} \text{ X } \frac{7.2}{(100-7.2)} = 676.3 \text{ lb.}$$

Floor Void: (7.2% required design concentration)

$$W = \frac{2275.4}{2.207} \text{ X } \frac{7.2}{(100-7.2)} = 80.0 \text{ lb.}$$

When the minimum quantity of FM-200® has been calculated the weight is compared to the available agent tank size. The tank size must be equal to or greater than the weight of agent (see Figure 1).

With the appropriate tank selected, the previous equation can be rearranged to determine the concentration based on the actual weight as tanks are filled to the nearest lb.

$$C = \frac{100\ WS}{WS + V}$$

To calculate the required agent for each hazard volume as a percentage of the total agent required;

$$\% \text{ Hazard Agent} = \frac{\text{Individual hazard Volume}}{\text{Sum of hazard volumes}}$$

Switch Room: 4262.6/25775.1 = 16.6% of Total Agent

Computer Room: 19237.1/25775.1 = 74.6% of Total Agent

Floor Void: 2275.4/25775.1 = 8.8% of Total Agent

It is determined from the above that both the Switch Room and the Computer Room can be fed by one manifolded system using 3 x 180 liter tanks, each filled with 276 lb. (125.2 kg) of Agent. The Floor Void would use 1 x 52 liter tank filled with 80 lb. (36.3 kg) as it requires less than 10% of the total Agent and therefore equates as follows. (Separate tank is required for floor void. If protected with nozzle from Computer Room system, the piping would be outside the tee split limits.)

Switch Room: 4262.6/23499.7 = 18.1% of Agent

Computer Room: 19237.1/23499.7 = 81.9% of Agent

Floor Void: 2275.4/2275.4 = 100% of Agent

The **minimum** enclosure concentrations can be calculated based on the actual tank fill 70 °F (21 °C) minimum design temperature).

Switch Room: $C = \frac{100\ (150.2 \text{ x } 2.207)}{(150 \text{ x } 2.207) + 4262.6} = 7.22\%$

Computer Room: $C = \frac{100\ (677.8 \text{ x } 2.207)}{(677.8 \text{ x } 2.207) + 19237.1} = 7.22\%$

Floor Void: $C = \frac{100\ (80 \text{ x } 2.207)}{(80 \text{ x } 2.207) + 2275.4} = 7.22\%$

After determining the minimum weight and concentration, the maximum concentration can be determined by recalculating the equation based on the maximum temperature anticipated in each enclosure 80 °F (27 °C) maximum design temperature. This calculation is required to determine if the maximum concentration is below the NOAEL limit for normally occupied areas.

Switch Room: $C = \frac{100\ (150.2 \times 2.2538)}{(150.2 \times 2.253) + 4262.6} = 7.36\%$

Computer Room: $C = \frac{100\ (677.8 \times 2.2538)}{(677.8 \times 2.253) + 19237.1} = 7.36\%$

Floor Void: $C = \frac{100\ (80 \times 2.2538)}{(80 \times 2.253) + 2275.4} = 7.34\%$

Piping Practices

Due to the two phase flow of FM-200®, certain piping practices must be adhered to. Mainly that the flow split must be on the horizontal plane. There are two types of tees used in FM-200® systems, a through/side tee and a bull tee. Both have limitations on the minimum and maximum allowable flow splits which are detailed on Page 24.

It should also be noted that system designers shall allow a minimum of 10 times the nominal pipe diameter around tee splits before any change of direction.

System designers should aim to design as far as possible balanced pipe networks, use minimum lengths of pipe, use minimum numbers of elbows, maximize pipe volume before the first tee and incorporate similar pipe run lengths to nozzles.

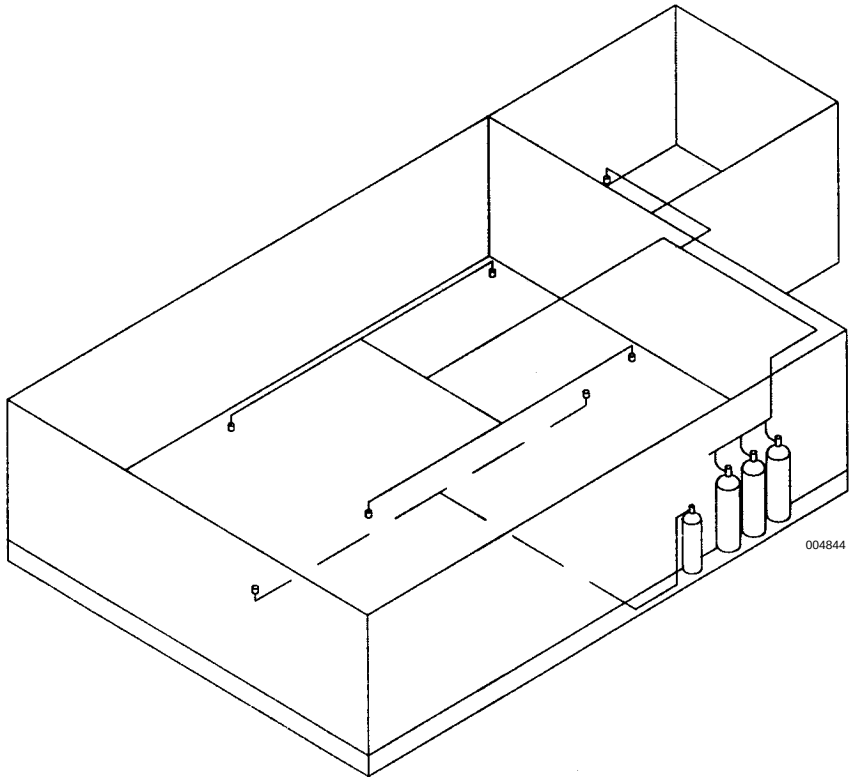


Figure 26 - Example Nozzle Location

Introduction

In determining the quantity of FM-200® required for a particular application, it is important to assess the hazard area correctly. The following information will need to be determined as discussed in Section 3.

1. Hazard Volume.
2. Minimum Room Temperature.
3. Hazard Type.
4. Height above sea-level.

The Hazard volume can be determined by calculating the room volume and deducting any impermeable volumes that may be contained within the area. The anticipated temperature of the Hazard area will normally be advised by the client. The agent concentration is dependent upon the type of hazard being protected, the type of nozzle used and hazard altitude. The quantity of FM-200® can be calculated by using the flooding factors (Table 2) or by using the formula (FM-200® Equation Calculations) and then multiplying by the altitude correction factor (table 3).

Example:

Hazard Volume: 9182 ft.^{3} (260 m^3)

Room Temperature: 70 °F (21 °C)

- Agent Concentration: 7.2%
- Flooding Factor: 0.0351

- **Quantity of FM-200® required: 0.0351 x 9182 = 322.3 lb.**

Note: Specific Vapor Volume data shown in Table 2 are experimentally derived values and the specific vapor volume equation (S) has a correlation coefficient of 0.99. However the equation can be used to give a close approximation of required agent quantities.

Temp. *t*	Specific Vapor Volume *s*	Weight Requirements of Hazard Volume, W/V (lb/ft^3) Design Concentration (% by Volume)						
(°F)	c(ft^3/lb)	6	7	7.17	8	9	10	11
10	1.9264	0.0331	0.0391	0.0401	0.0451	0.0513	0.057	0.0642
20	1.9736	0.0323	0.0381	0.0391	0.0441	0.0501	0.0563	0.0626
30	2.0210	0.0316	0.0372	0.0382	0.0430	0.0489	0.0550	0.0612
40	2.0678	0.0309	0.0364	0.0373	0.0421	0.0478	0.0537	0.0598
50	2.1146	0.0302	0.0356	0.0365	0.0411	0.0468	0.0525	0.0584
60	2.1612	0.0295	0.0348	0.0357	0.0402	0.0458	0.0514	0.0572
70	2.2075	0.0289	0.0341	0.0349	0.0394	0.0448	0.0503	0.0560
80	2.2538	0.0283	0.0334	0.0342	0.0386	0.0439	0.0493	0.0548
90	2.2994	0.0278	0.0327	0.0335	0.0378	0.0430	0.0483	0.0538
100	2.3452	0.0272	0.0321	0.0329	0.0371	0.0422	0.0474	0.0527
110	2.3912	0.0267	0.0315	0.0323	0.0364	0.0414	0.0465	0.0517
120	2.4366	0.0262	0.0309	0.0316	0.0357	0.0406	0.0456	0.0507
130	2.4820	0.0257	0.0303	0.0311	0.0350	0.0398	0.0448	0.0498
140	2.5272	0.0253	0.0298	0.0306	0.0344	0.0391	0.0440	0.0489

Table 2: FM-200® Weight Calculations

Table 3: Altitude Correction Factor

Altitude above sea Level	Correction Factor
-3000 ft. (-0.92 km)	1.11
-2000 ft. (-0.61 km)	1.07
-1000 ft. (-0.30 km)	1.04
0 ft. (0.00 km)	1.00
1000 ft. (0.30 km)	0.96
2000 ft. (0.61 km)	0.93
3000 ft. (0.91 km)	0.89
4000 ft. (1.22 km)	0.86
5000 ft. (1.52 km)	0.82
6000 ft. (1.83 km)	0.78
7000 ft. (2.13 km)	0.75
8000 ft. (2.45 km)	0.72
9000 ft. (2.74 km)	0.69
10000 ft. (3.05 km)	0.66

At elevations above sea-level, FM-200® has a greater specific volume because of the reduced atmospheric pressure. A system designed for sea-level conditions will therefore develop an actual higher concentration at levels above sea-level and an actual lower concentration at levels below sea-level. The adjusted agent quantity is calculated by multiplying W (from the equation below) by the altitude correction factor.

The design quantity of the FM-200 system shall be adjusted to compensate for ambient pressures that vary more than 11% (equivalent to approximately 3000 ft. (915 m) of elevation change) from standard sea level pressures (29.92 in. Hg at 70 °F (760 mm Hg at 0 °C)).

FM-200® Equation Calculations

The weight of agent required for a hazard area can also be calculated from the formula shown below;

$$W = \frac{V}{S}\left(\frac{C}{100-C}\right)$$

W = Weight of Agent required –lbs.

V = Hazard Volume –ft^3

S = Specific Vapor Volume –ft^3/lb.
where S = 1.885 + 0.0046 t

t = Design Temperature in Hazard Area –F°

C = Required FM-200® Design Conc. (% by volume) at Design Temperature (t)

Engineered Systems

Pyro-Chem's Engineered systems are based on a Hydraulic Flow Program developed by Hughes Associates Inc. The program predicts the two phase flow of FM-200® and nitrogen through a pipe network. Information detailing the enclosure is entered and the program calculates the required pipe sizes, nozzle drill sizes, average nozzle pressures and discharge time.

As system design calculations are critical to the success of the extinguishing system, only Pyro-Chem or Pyro-Chem trained personnel are permitted to perform system calculations. If in the future, companies other than Pyro-Chem wish to use the program, representatives will be required to attend a formal training session. All system calculations are conducted either by Pyro-Chem or authorized distributors.

Note. The calculation method has been designed for specific types of fittings, pipe, and pipe inside diameter. When these limitations are not maintained, there is a risk that the system will not supply the required quantity of extinguishing agent.

Program Parameters

When designing pipe network systems, the following design parameters should be considered to avoid system reject when running the calculation.

- 70.6 psi (4.87 bar) minimum nozzle pressure.
- 80% maximum agent in pipe.
- Between 6 - 10 seconds discharge time.
- 10 - 30% side tee split.
- 30 - 70% bull tee split.
- 31.2 to 62.4 lb./cu. ft. (0.5 to 1.0 kg/L)
- Maximum liquid arrival time imbalance of 1.0 seconds.
- Maximum liquid run out time of 2.0 seconds.
- Maximum nozzle height is 16.0 ft. (4.87 m).
- Minimum of 10% agent in pipe before first tee.
- Maximum of 20 nozzles per system.
- Maximum of 10 enclosures per system.

Program Parameters (Continued)

- The ratio between the nozzle area and the pipe cross sectional area immediately proceeding the nozzle is limited to a minimum of 0.20 (20%) and a maximum of 0.80 (80%).
- Maximum elevation difference in pipe runs:
  - Statement No. 1. If nozzles are only located **above** the tank outlet, then the maximum elevation difference between the tank outlet and the furthest horizontal pipe run or discharge nozzle (whichever is furthest) shall not exceed 30 ft. See Figure 26a.
  - Statement No. 2. If nozzles are only located **below** the container outlet, then the maximum elevation difference between the tank outlet and the furthest horizontal pipe run or discharge nozzle (whichever is furthest) shall not exceed 30 ft. See Figure 26a.
  - Statement No. 3. If nozzles are located both **above and below** the tank outlet, then the maximum elevation difference between the furthest horizontal pipe runs or discharge nozzles (whichever is furthest) shall not exceed 30 ft. See Figure 26a.

Note: If a system design violates these limits, contact Pyro-Chem to determine what action has to be taken.

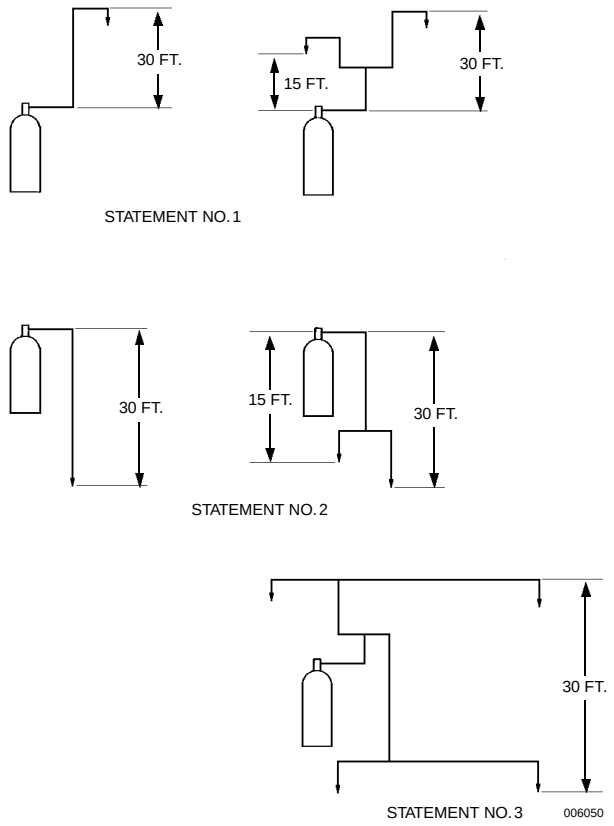


Figure 26a

Pipe Size In.	Minimum Flow Rate Lbs/sec	(kg/sec)	Maximum Flow Rate Lbs/sec	(kg/sec)
3/8	0.60	(0.27)	2.00	(0.91)
1/2	1.00	(0.45)	3.00	(1.36)
3/4	2.00	(0.91)	5.50	(2.50)
1	3.50	(1.59)	8.50	(3.86)
1 1/4	6.00	(2.72)	12.50	(5.67)
1 1/2	9.00	(4.08)	20.00	(9.07)
2	14.00	(6.35)	30.00	(13.61)
2 1/2	20.00	(9.07)	55.00	(24.95)
3	30.00	(13.61)	99.00	(40.82)
4	55.00	(24.95)	125.00	(56.70)
5	90.00	(40.82)	200.00	(90.72)
6	120.00	(54.43)	300.00	(136.10)

Table 4: Maximum and Minimum Flow Rates

NOTE: This information is for Schedule 40 pipe, and is for estimating only. Pipe and nozzle sizes need to be confirmed by the computer program.

Diameter In.	90° Elbow ft.	(m)	45° Elbow ft.	(m)	Thru Tee Ft.	(m)	Side Tee Ft.	(m)	Union Ft.	(m)
3/8	1.2	(0.40)	0.5	(0.18)	0.7	(0.24)	2.5	(0.82)	0.3	(0.09)
1/2	1.6	(0.52)	0.7	(0.24)	0.9	(0.30)	3.2	(1.04)	0.4	(0.12)
3/4	2.0	(0.67)	0.9	(0.30)	1.3	(0.42)	4.2	(1.37)	0.5	(0.15)
1	2.6	(0.85)	1.2	(0.40)	1.7	(0.55)	5.3	(1.74)	0.6	(0.18)
1 1/4	3.4	(1.13)	1.6	(0.52)	2.1	(0.70)	7.0	(2.29)	0.7	(0.24)
1 1/2	4.0	(1.31)	1.7	(0.61)	2.5	(0.82)	8.0	(2.65)	0.8	(0.27)
2	5.1	(1.68)	2.4	(0.79)	3.2	(1.06)	3.4	(1.40)	1.1	(0.37)
2 1/2	6.1	(2.01)	1.5	(0.94)	3.8	(1.25)	12.4	(4.08)	1.3	(0.43)
3	7.6	(2.50)	3.5	(1.16)	4.7	(1.55)	15.4	(5.06)	1.7	(0.55)
4	10.0	(3.26)	4.	(1.52)	6.1	(2.01)	20.2	(6.64)	2.2	(0.73)
5	12.4	(4.08)	5.9	(1.92)	7.8	(2.56)	25.5	(8.35)	2.8	(0.91)
6	15.0	(4.94)	7.1	(2.32)	9.4	(3.08)	30.5	(10.0)	3.3	(1.07)

Table 5: Equivalent Length for Pipe Fittings

NOTE: Figures are based on Schedule 40 ASTM A 106-77 pipe (nominal pipe size listed in table.)

Component	Nominal Pipe Size	Equivalent Length Ft.	(m)
1 in. Valve	1 in.	20	(6.1)
2 in. Valve	2 in.	35	(10.7)
1 1/4 in. Flex Hose	See Note 1	See Note 1	
2 in. Flex Hose	2 in.	17.6	(5.37)
1 in. Check and Flex	1 in.	24.9	(7.59)
1 1/4 in. Check and Flex	1 1/4 in.	50.2	(15.29)
2 in. Check and Flex	2 in.	39.4	(12.02)
3 in. Valve/Siphon Tube Assembly	3 in.	53.5	(16.3)
3 in. Check and Flex	3 in.	52.0	(15.8)

Table 6: Equivalent Length for Other System Components

Figures are based on Schedule 40 ASTM A 106-77 pipe (nominal pipe size listed in table.)

NOTE 1: Flex hose consists of two segments. The first segment has a diameter of 1 in. with a total equivalent length of 0.5 ft. (0.14 m). The second segment has a diameter of 1 1/4 in. with a total equivalent length of 35.2 ft. (10.74 m).

General Information

All installation shall be performed by an approved Pyro-Chem distributor with the correct equipment and previous experience of gaseous extinguishing systems. Installation instructions are described under the following main headings, and in the order of installation.

- Tank Installation
- Piping and Nozzles
- Actuation Controls
- Ancillary Equipment
- Completion Procedures

Specific installation drawings must be prepared for the hazard area in accordance with system design as calculated by the FM-200® Hydraulic Flow Program. These drawings should be followed closely in order to ensure the system meets its design criteria. The pipe network is sized in order to obtain correct discharge time, nozzle pressures, agent quantity and various other design considerations. If for any reason the pipe network requires modifications, the system must be recalculated before proceeding with installation. Installation drawings contain the following information;

- Enclosure Volumes
- Agent Quantities
- Scaled Pipe Network Plan
- Pipe Network Isometric
- Pipe Diameters, Pipe Length Drops & Rises
- Nozzle Data
- Tank Data
- Solenoid Actuator Technical Data
- Low Pressure Switch Wiring Chart
- Fittings Data

Installation drawings shall be submitted for approval to the appropriate authority having jurisdiction (AHJ) prior to system installation.

On receipt, unpack the Pyro-Chem supplied items and ensure that the components comply with the packing list and installation drawings.

The tank weight is checked at the factory prior to shipment and recorded on the label attached to the tank. If there is any doubt regarding the weight, or leakage is suspected, the tank should be weighed to confirm there is no weight loss. To check agent weight in 106, 147, 180, and 343L tanks with an installed liquid level measuring device, see Maintenance Section of this manual. Determine the tank storage temperature and refer to the Temperature Correction Chart to check the pressure within the tank (see Appendix B)

Tank Installation

The tank location is identified on the system drawings and should be protected from extremes of temperature, and be accessible for service and maintenance. The tanks must be firmly secured to a wall or bulkhead. **No Safety Outlet and Actuation Caps should be removed at this stage.**

3 in. (75mm) Safety Outlet Cap	Part No. 53489
2 in. (50mm) Safety Outlet Cap	Part No. 570073
1 in. (25mm) Safety Outlet Cap	Part No. 570047
1 in. (25mm) Actuation Cap	Part No. 570056

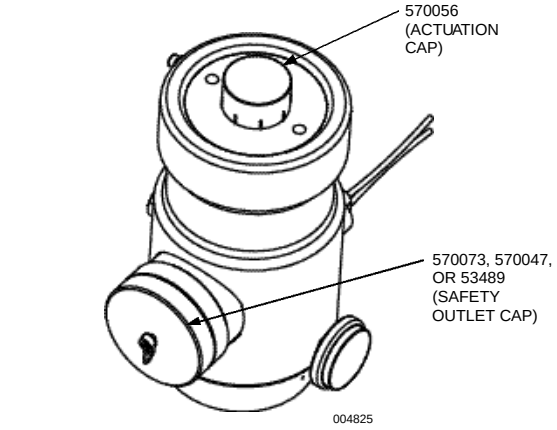


Figure 27 - Safety Outlet and Actuation Caps

Single Tank Installation

1. Mount the back channels of the mounting brackets to the wall at the appropriate heights (see table 7), using suitable anchor type bolts (not supplied).
2. Position the tank against the back channel with the valve outlet pointing left.
3. Insert the tank straps at top and bottom and secure with the bolts provided (see Figure 28).

> **Caution.** Do not remove **actuation** safety shipping cap until tank is connected to discharge piping. Failure to comply could result in personal injury or death from violent tank movement or overexposure to high concentrations of FM-200 if tank is actuated.

4. With tank properly secured in bracket, remove the discharge safety outlet cap from the discharge outlet.
5. **For 8 through 180 liter tanks (1 in. and 2 in. valves):** Connect the union/union elbow to discharge outlet (see Figure 28a).

   For 343 liter tanks (3 in. valve): Install single tank adaptor onto the discharge outlet. Either a grooved pipe, NPT, or BSPT thread adaptor may be used (see Figure 28a).
6. **For 8 through 180 liter tanks (1 and 2 in. valves):** Connect discharge hose or pipe directly to union/union elbow. Then pipe from discharge hose for remainder of system. See Pipe Installation in this section.

   For 343 liter tanks (3 in. valve): Connect elbow and discharge hose or pipe directly to the adaptor. A union is not required as the adaptors have swivel couplings to allow for pipe removal during recharge or maintenance. See Pipe Installation in this section.

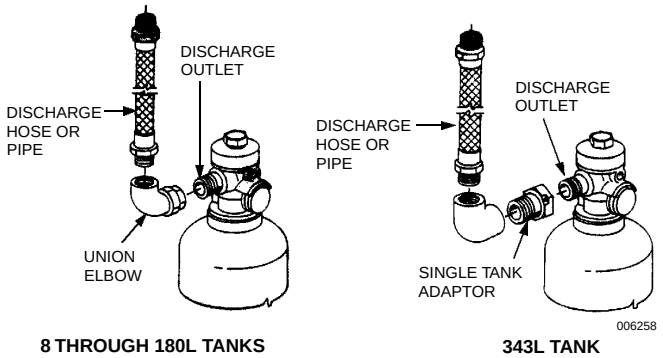


Figure 28a - Discharge Outlet Connections

Tank Size	No. of Unistrut Channels	Height From Floor to Bracket in.	(mm)
10 to 18 lbs. (4.5 to 8.0 kg) (8 liter)	1	5.0	(130)
20 to 39 lbs. (9.0 to 17.5 kg) (16 liter)	2	2.5, 13.0	(60, 330)
38 to 74 lbs. (17.0 to 33.5 kg) (32 liter)	2	6.25, 23.5	(160, 595)
59 to 117 lbs. (27.0 to 53.0 kg) (52 liter)	2	4.25, 13.5	(110, 343)
118 to 235 lbs. (53.5 to 106.5 kg) (106 liter)	2	11.75, 29.5	(300, 750)
163 to 325 lbs. (74.0 to 147.5 kg) (147 liter)	2	11.75, 39.25	(300, 1000)
201 to 401 lbs. (91.5 to 182.0 kg) (180 liter)	2	11.75, 47.25	(300, 1200)
379 to 757 lbs. (172 to 343 kg) (343 liter)	2	11.75, 43.25	(300, 1100)

Table 7: Bracket Mounting Heights

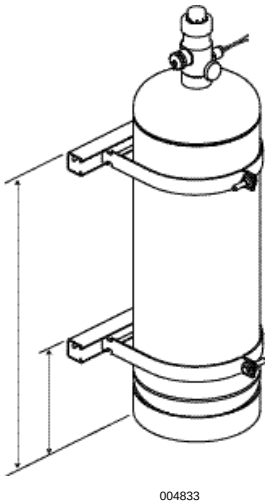


Figure 28 - Tank Strap Location

Multiple Tank Installation

Tanks are manifolded together for three main reasons;

- To reduce the amount of piping required by connection to one feeder pipe.
- For systems that require main and reserve.
- Combining the correct tanks to obtain the required quantity of agent within a specific hazard area.

A typical 3 in., three port manifold assembly consists of the manifold, three check valves and an end cap. Each check valve is bolted to a flanged inlet on the manifold (2 in. (50 mm) only) using four M8 x 20mm socket head screws.

1. Mount the mounting brackets to the wall at the appropriate heights (see table 8), using suitable anchor type bolts (not supplied).
2. Position the tanks against the back channels with the valve outlets pointing left at the required spacing for the manifold ports (see Figure 14, dimension B).
3. Insert the tank straps at top and bottom and secure with the bolts provided (see Figure 28).

Manifold Installation

1. Securely mount the manifold at the appropriate height as shown in Table 8.
2. **For 1 in. and 2 in. valves:** Remove outlet safety cap from tank valve and attach discharge hose between valve and manifold.

   NOTE: Before installing hose, remove adaptor from inlet end of each discharge hose and install onto valve outlet thread. Tighten securely. Then attach discharge hose to adaptor. Tighten securely.
3. **For 3 in. valve:** To install hose/check valve assembly between the valve discharge outlet and the pipe manifold, complete the following steps (see Figure 29).

> **Caution.** Make certain the swivel nut covers the paint on the check valve threads or malfunction of the hose/check valve combination may result. Do not overtighten, as the nut will bend the hose, resulting in flow restriction.

   a. Install the check valve into the manifold inlet.
   b. Align the valve outlet with the inlet of the discharge hose. Install the swivel nut on the discharge valve. Wrench tighten.
   c. Thread the hose swivel nut onto the check valve until the swivel nut covers the paint on the check valve threads. Secure the nut with the locking set screw (provided) to prevent the nut from loosening with vibration.

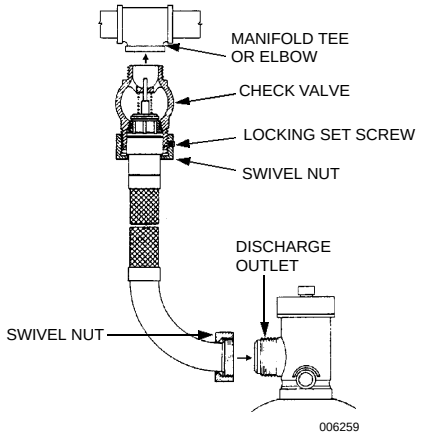


Figure 29 - Hose/Check Valve Installation

Tank Size	Valve Size	Manifold Size	Nominal Height From Floor to Bottom of Manifold Pipe
10 to 18 lb. (4.5 to 8.0 kg) (8 liter)	1 in. Outlet	2.5 in. NPT	29 1/2 in. (750 mm)
20 to 39 lb. (9.0 to 17.5 kg) (16 liter)	1 in. Outlet	2.5 in. NPT	37 3/8 in. (949 mm)
38 to 74 lb. (17.0 to 33.5 kg) (32 liter)	1 in. Outlet	2.5 in. NPT	50 3/4 in. (1289 mm)
59 to 117 lb. (27.0 to 53.0 kg) (52 liter)	2 in. Outlet	3 in. NPT	44 5/8 in. (1133 mm)
118 to 235 lb. (53.5 to 106.5 kg) (106 liter)	2 in. Outlet	3 in. and 4 in. NPT	63 in. (1601 mm)
163 to 325 lb. (74.0 to 147.5 kg) (147 liter)	2 in. Outlet	3, 4, and 6 in. NPT	76 in. (1931 mm)
201 to 401 lb. (91.5 to 182.0 kg) (180 liter)	2 in. Outlet	4 in. and 6 in. NPT	87 in. (2210 mm)
379 to 757 lbs. (172 to 343 kg) (343 liter)	3 in. Outlet	4 in. and 6 in. NPT	89.5 in. (2274 mm)

Table 8: Manifold Bracket Mounting Heights

Pipe Installation

In general, the installation should start at the union elbow/manifold assembly and progress along to the discharge nozzles. Install the pipework to the installation drawings provided, ensuring that the following is adhered to:

- The piping material must conform to the requirements of ASTM/ NFPA 2001 2-2.
- The pipe must be reamed, blown clear and swabbed with an appropriate solvent to remove mill varnish and cutting oil before assembly as required by NFPA 2001 2-2.
- PTFE (Teflon) tape is the only acceptable pipe sealant and must be applied to the male threads.

Pipe Hangers

Pipe hangers must be spaced according to the size of pipe (see table 11).

- Hangers must be placed within 12 in. (300 mm) of the discharge nozzle (see Figure 30).
- Hangers must be placed between elbows that are more than 12 in. (300 mm) apart (see Figure 31).
- Hangers must be fixed to a structure capable of supporting the pipework.

Pipe Reference	Connection	Pipe Type	Nominal Pipe Size
ASTM A-106 Seamless Grade C	Threaded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-106/A-53 Seamless Grade B	Threaded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-106/A-53 Seamless Grade A	Threaded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-53 ERW Grade B	Threaded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-53 ERW Grade A	Threaded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-53 Furnace Weld Class F	Threaded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-106 Seamless Grade C	Welded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-106/A-53 Seamless Grade B	Welded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-106/A-53 Seamless Grade A	Welded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-53 ERW Grade B	Welded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-53 ERW Grade A	Welded	Schedule 40	3/8 in. - 6 in. NPS
ASTM A-53 Furnace Weld Class F	Welded	Schedule 40	3/8 in. - 6 in. NPS

Table 9: US Steel Pipe Requirements

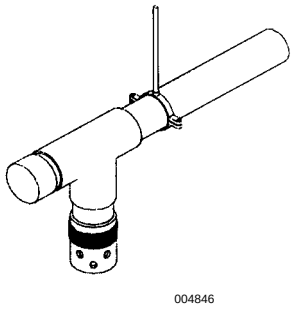
Fitting Description	Pipe Size
Class 300 Malleable or Ductile Iron	Up to or ≤ 3 in. NPS
1000-lb. Rated Ductile Iron or Forged Steel Class 300 Flanged Joints	> 3 in. NPS All

Table 10: US Fittings

Note: The Flow Program contains pipe and fittings options together with Equivalent Length information for pipe and fittings.

Pipe Size in.	Maximum Spacing ft.	(m)
3/8	5.0	(1.5)
1/2	5.0	(1.5)
3/4	6.0	(1.8)
1	7.0	(2.1)
1 1/4	8.0	(2.4)
1 1/2	9.0	(2.7)
2	11.0	(3.4)
2 1/2	11.0	(3.4)
3	12.0	(3.7)
4	14.0	(4.3)
6	17.0	(5.2)

Table 11: Hanger Spacing



▸ Figure 30 - Nozzle Support

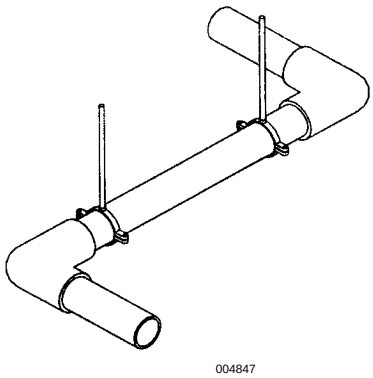


Figure 31 - Elbow Support

Grounding & Electrical Clearance

Systems within electrical substations or switchrooms shall be efficiently grounded to prevent the metalwork becoming electrically charged. Adequate grounding of systems will minimize the risk of electrostatic discharge. Where exposed electrical conductors are present and, where practicable, clearances no ▸ smaller than those given in table 12 shall be provided, between the electrical conductors and all parts of the system that may be approached during maintenance.

Max. Rated Voltage (kV)	Min. Section Clearance ft. (m)	Min. Ground Clearance ft. (m)
15	8.5 (2.59)	—
33	9.0 (2.74)	—
44	9.5 (2.89)	—
66	10.0 (3.05)	—
88	10.5 (3.20)	8.0 (2.44)
110	11.0 (3.35)	8.0 (2.44)
132	11.5 (3.50)	8.0 (2.44)
165	12.5 (3.81)	8.0 (2.44)
220	14.0 (4.27)	8.0 (2.44)
275	15.0 (4.57)	8.0 (2.44)

▸ Table 12: Safety Clearances.

Minimum clearance from any point on or about the permanent equipment where a person may be required to stand (measure from position of the feet). Section clearance - to the nearest unscreened live conductor in air. Ground clearance - to the nearest part not at earth potential of an insulator supporting a live conductor. Reference NFPA 2001, section 1-5.2

Nozzles

All nozzles require the installation of a dirt trap comprising 1 side tee, 2 nipples, and 1 pipe cap. Install the nozzle to the nipple on the dirt trap and check the nozzle orifice to ensure proper orientation. Dirt trap lengths should be no more than 10 times nominal pipe diameter.

A false ceiling comprising loose tiles must have the tiles retained within a 6.5 ft. (2m) radius of the nozzle, to prevent movement during system discharge. Nozzles should be a max- ▸ imum of 12 in. (300mm) below the ceiling.

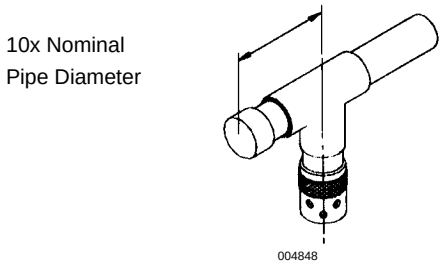


Figure 32 - Dirt Trap

Actuation Installation

The method of actuation depends on the system configuration and any specific contract requirements and can be broken down as follows:

- Single Tank Actuation
- Multiple Tank Actuation

Single Tank Actuation

Side Mounted Electrical Actuator (For Hazardous Atmospheres)

If electrical actuator is required, the addition of a solenoid adaptor, Part No. 570135, must be specified with the tank assembly order. This will allow removal in the field if necessary. The actuator cannot be removed or tested on site unless fitted with solenoid adaptor part no. 570135 as this will cause the upper valve chamber to be vented, discharging the tank (see figure 33 for location of side mounted actuator fitted with adaptor). Ensure that solenoid is installed between 0-30° off vertical. If no other actuators are to be installed, ensure that the actuation cap on the valve is left on.

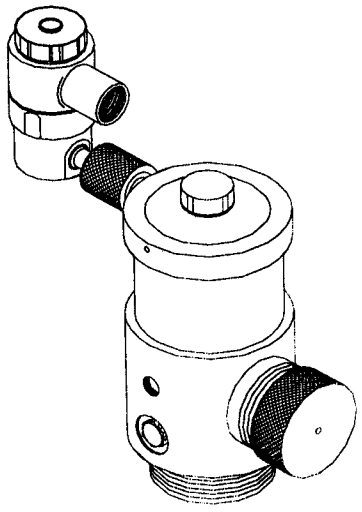


Figure 33 - Side Mounted Electrical Actuator & Solenoid Adaptor Location (Note: Cannot be used with 3 in. valve)

Figure 34 - Intentionally Left Blank

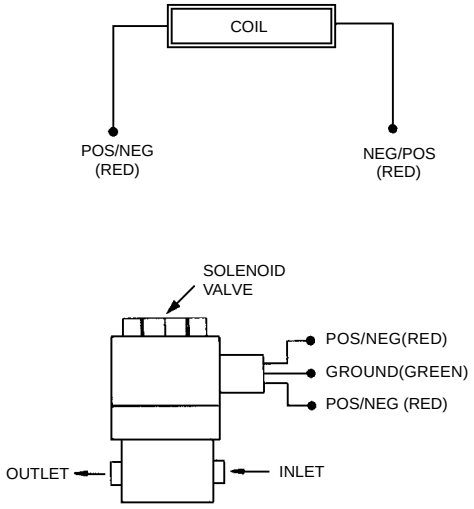


Figure 35 - Side Mounted Electrical Actuator Wiring Diagram

Removable Solenoid Actuator

The removable electrical actuator is fitted to the top of the valve assembly as follows:

- Check the actuator mechanism to ensure that it is in the non-fired position, i.e. pin retracted (see Figure 36).
- Remove the actuator cap from the top of the valve assembly (see Figure 27).
- Carefully screw the actuator to the valve assembly (see Figure 37).

Note: The actuator must be hand tight only.

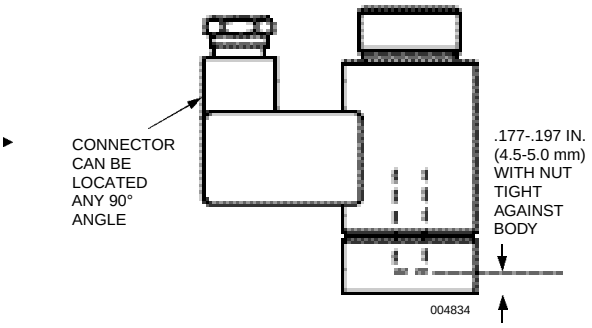


Figure 36 - Actuator Non-Fire Position

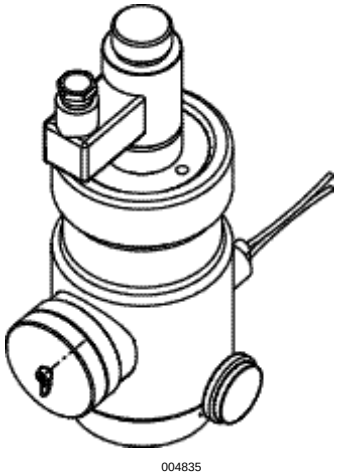


Figure 37 - Electrical Actuator Location

Caution. Before making electrical connection to the actuator, remove from the valve to prevent accidental discharge.

If no other actuators are to be installed ensure that the protective cap on the actuator is retained in position.

The electrical signal from the detection and/or control equipment is connected in accordance with the wiring diagram detailed in Figure 38 when all other installations have been completed.

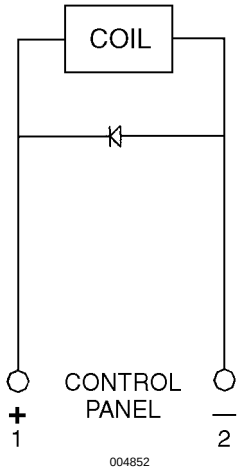


Figure 38 - Electrical Actuator Wiring Diagram

The Solenoid Actuator is installed with a suppression diode in parallel to the coil as indicated. Connect + from control panel to terminal 1 and – from control panel to terminal 2, on plug connector. End of line monitoring device (if required) to be installed on site.

Before this system is put into operation, the removable solenoid can be checked by firing the system. To do this, REMOVE THE SOLENOID ACTUATOR from the valve. With power to the actuator, the pin should be firmly in the down position.

Manual Actuator

The manual strike knob actuator can be fitted to the top of the electrical actuator or directly onto the valve, after first removing the protective cap.

> **Caution.** Before attaching the strike knob to the electrical actuator or valve, ensure that the firing pin is retracted and the safety pin is in place (see Figure 39). Raising strike knob manually DOES NOT reset pin. Pin must be pushed up manually. The strike knob must be hand-tight only.

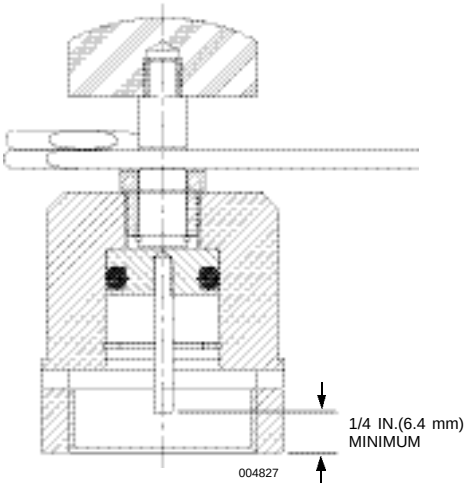


Figure 39 - Manual Actuator Non-Fire Position

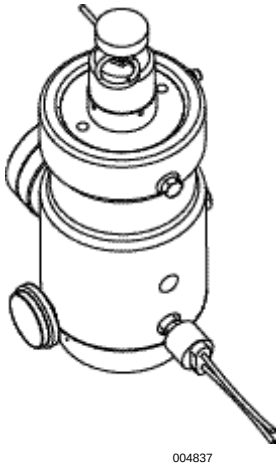


Figure 40 - Manual Actuator Location

Multiple Tank Actuation

Where several tanks comprise one system and are discharged simultaneously, one tank is designated as the 'master' tank, and the others are 'slave' tanks. The master tank can be actuated electrically or manually. The slave tanks are actuated pneumatically by the action of the master tank discharging.

Pneumatic Actuator

Check that the actuating plungers are in the raised position (see Figure 41). Remove the actuation cap from the top of the valve assembly (see Figure 27) and carefully screw the pneumatic actuator to the valve on each slave tank.

Note. The actuator must be hand-tight only.

> **Caution.** Pin must be pushed up manually.

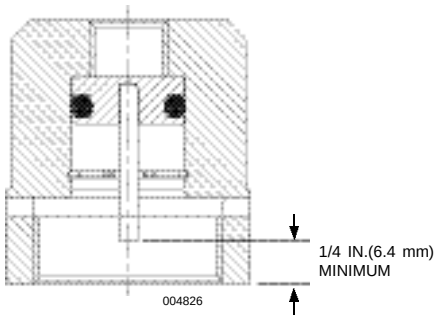


Figure 41 - Pneumatic Actuator Non-Fire Position

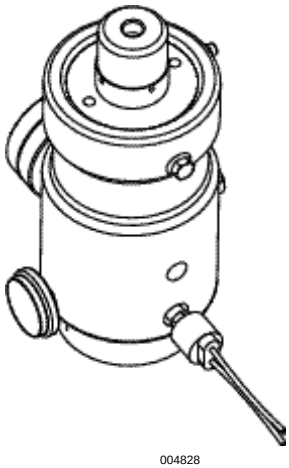


Figure 42 - Pneumatic Actuator Location

Slave Actuation Pilot Line

For slave tanks, the pneumatic connection is made using flexible pilot hoses. To fit the pilot hoses, remove the 1/4 in. pilot pressure port plug from the master tank valve assembly and install the 1/4 in. male adaptor (Part No. 570148) for the 1 in. and 2 in. valves, and a 1/4 in. NPT street elbow (Part No. 417398), and a male adaptor (Part No. 570342) for the 3 in. valve.

Install the pilot line tee (Part No. 570150) on to all pneumatic actuators (wrench tight). Connect one end of the pilot hose (Part No. 570143) to the adaptor on the master tank and one end to the pilot line tee on the pneumatic actuator. Connect pilot hoses between pilot line tees on all pneumatic actuators (see Figure 43). The maximum number of slave actuated tanks is 9 (10 tank system in total).

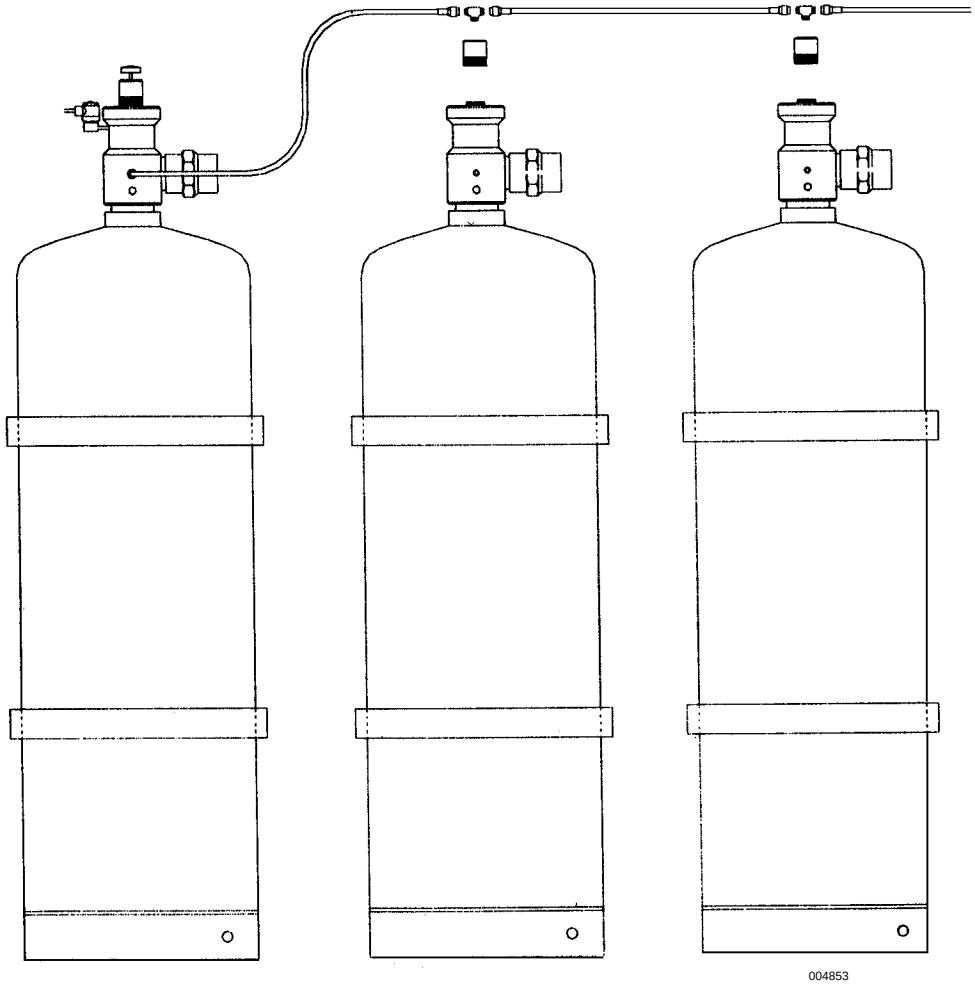


Figure 43 - Multiple Tank Actuation (viewed from back side)

Ancillary Equipment

Discharge Pressure Switch

- **Single Tank Systems**

- On single tank installations, the pressure switch should be located close to the valve assembly and connected with a pilot hose from the pressure port outlet on the valve to the connector on the pressure switch (see Figure 44).

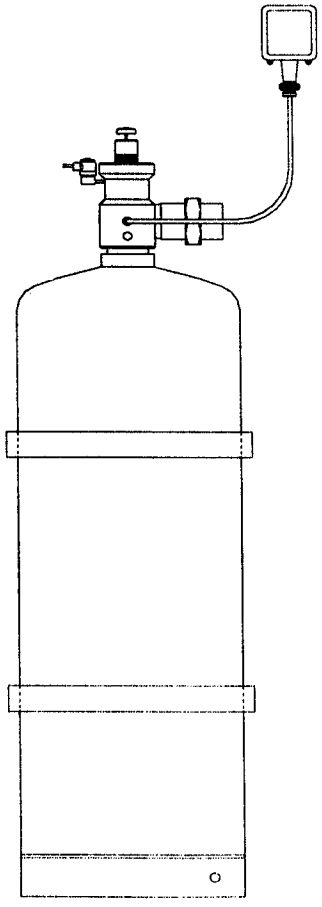


Figure 44 - Discharge Pressure Switch Installation

- **Multiple Tank Systems**

On multi-tank installations, the pressure switch should be located close to the last slave tank and connected by pilot hose to the tee connector on the pneumatic actuator (see Figure 45).

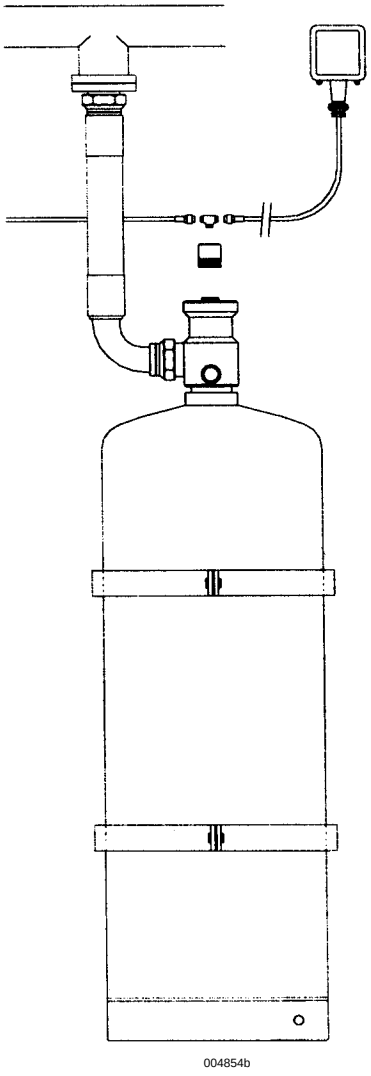


Figure 45 - Discharge Pressure Switch Installation

To wire the discharge pressure switch to the control panel, unscrew and remove the switch cover plate. Connect to the appropriate terminals on the microswitch or if supplied with wires, to the colored wires which are labeled as follows:

- Common (C) (violet)
- Normally Open (NO) (blue)
- Normally Closed (NC) (black)

Low Pressure Switch

All tank valves are 'Factory fitted' with low pressure warning switches. Voltage input can be applied to either terminal.

When the device is connected to a standard supervisory input circuit, there will be no distinction between a wiring fault and device actuation. This device is to only be utilized when accepted by the authority having jurisdiction.

Note: In the normal position, the switch contacts are closed. This will indicate a tank pressure above 300 psi (20.7 bar). If the switch contacts are open, the switch may have been subjected to low temperatures during shipping or storage. To close the switch contacts, the tank must be warmed to a temperature above 70 °F (21 °C). This will allow the tank pressure to close the switch contacts.

See Figure 46 for field wiring requirements.

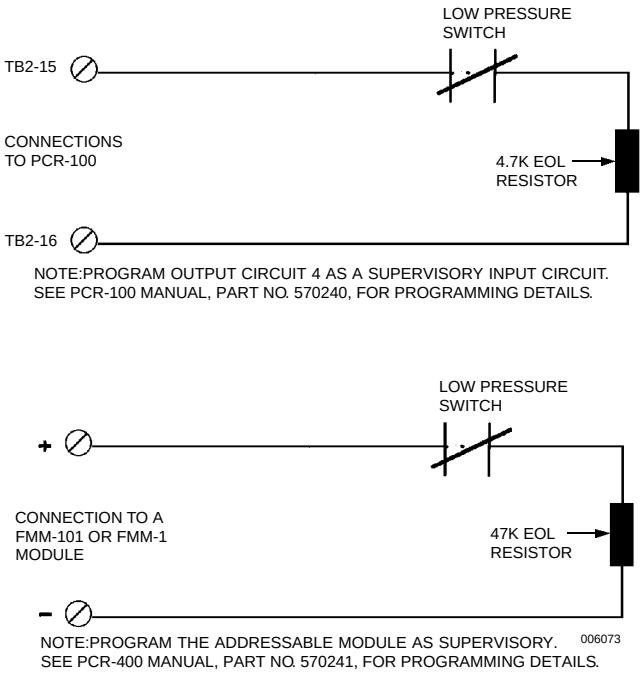


Figure 46

Accessories

Door Signs

Warning signs are required at all exits and entrances to protected area, ideally mounted on the door. Plates may be drilled and screw mounted or attached using suitable adhesive.

Manual Release Signs

Manual release signs are required at all manual actuators, remote manual actuators and call points. Plates may be drilled and screw mounted or attached using suitable adhesive.

Completion Procedures

For ease of reference, completion procedures may be subdivided into the following sections:

- Pre-Checks and Visual Inspections.
- Final Connections.
- Hand over Procedures.

CAUTION: The completion of the installation system, commissioning tests and handover may occur before the area is ready for use. In the event of delay between handover and the hazard area being available for protection, then the system must be left in a 'safe' condition to avoid accidental discharge. The system must only be made operative once the area for protection has been completed and is operational.

Pre-checks and Visual Inspections

General

When the installation is complete, and before making the final connections, the following checks should be made:

Mechanical Checks

Inspect protected area closely for conformance to original risk specifications and for enclosable openings or sources of agent loss which may have been overlooked in the original specification.

- Hazard areas should be thoroughly checked to ensure that enclosures have been properly constructed and that voids in floors and above suspended ceilings have been sealed.

Pre-checks and Visual Inspections continued…

Mechanical Checks continued

- All manifolds should be secured firmly to the wall or bulk head.
- Tanks should be securely held within brackets.
- Piping should be securely mounted within hangers.
- All pipe connections must be tight.
- Nozzles to be the proper type, correctly placed, and properly orientated.
- Check model and weight markings on tank nameplates to verify that correct tanks and charges have been installed as required.
- Verify that all warning and instruction signs are mounted where required.

Electrical Checks

The electrical systems may include interfaces with many other systems for alarm, indication, actuation, shutdown, etc. For complex electrical systems, the scope and operating requirements will be described in other documents. Electrical checks are given below for a basic system using electrical actuation of the tank valve;

- Remove top mounted or side mounted solenoid (if connected via solenoid adaptor) from valve. Check that solenoid is activated when system is triggered. If the solenoid adaptor is not present, remove electrical connections from side mounted solenoid and check wiring voltage is correct for actuation when system is operated.

During detection system actuation, verify the following functions operate;

- All apertures in hazard enclosure are closed by dampers or other suitable methods.
- Electrical equipment in the protected area is tripped and isolated.

Pneumatic Checks

The slave actuators on manifolded systems are fired by agent discharge. Pneumatic checks are detailed below;

- Remove pneumatic actuator(s) from tank valve.
- Disconnect pilot hose from the master tank valve adaptor (see Figure 43).
- Provide 58 psi (4 bar) pressure to the master tank valve pilot hose.
- Verify all pneumatic actuator pistons are in the fired position.

Before replacing the pneumatic actuators, ensure that all pistons are fully reset (see Figure 41). After reinstalling the pneumatic actuators, reconnect the pilot hose to the master tank valve adaptor (see Figure 43).

Final Connections

Discharge Piping

The final connection of the discharge piping occurs at the tank valve assembly. For single tank systems, the valve safety outlet cap can be removed and the discharge pipe connected to the tank outlet. For multi-tank systems, the valve safety caps can be removed and all discharge hoses fitted.

Handover Procedures

The entire system shall be thoroughly inspected to make sure that it is complete and that all tests required during installation have been properly carried out. In addition, the following items are particularly important.

1. A container should be refilled or replaced when it shows a loss in agent quantity of more than 5% or a loss in pressure (adjusted for temperature) of more than 10%. (Operating pressure of unit at 360 psi (25 bar) at 70 °F (21 °C)). Refer to Appendix B for pressures at other container temperatures.
2. Check tank weight information label against system requirement. If there is any doubt or if there has been a loss of pressure, the tank must be weighed.
3. Make sure the system is armed and the actuating systems are operational.

Ensure adequate escape routes with directional signs are provided. Issue of the appropriate documentation shall constitute completion of the handover procedure.

Appropriate records shall be issued by fire and/or insurance authorities as to the suitability, acceptability and availability of the system for the hazard area.

Introduction

The hazard integrity is the ability to retain the discharged FM-200®. For a total flooding suppression system to be effective, the design concentration must be achieved and then maintained for at least ten minutes. The only method of testing the agent retention within the protected area is to verify the integrity of the enclosure by applying proven test procedures.

The enclosure integrity test has been developed to locate the source of leaks and, from the data collected, predict the retention time, proving system performance and removing the need for actual FM-200® discharge. In order to determine with any degree of confidence that the hazard area will hold the gas for the required time period, where necessary an Enclosure Integrity Test in accordance with NFPA 2001 Appendix C must be conducted.

Principle

The test is conducted with a device known as a door fan, which has been used in the energy conservation field for over 25 years. It has three basic components as follows:

- An adjustable panel that fits in the doorway of the protected area
- A calibrated fixed speed fan
- A variable speed fan

The pressure created by the door fan causes the air to move through leaks in the enclosure at high speed making it easy to pinpoint where leaks exist. A cool chemical smoke or other air current indicator is used to detect the approximate size and location of leaks.

Equivalent Leakage Area (ELA)

The test to measure the ELA is conducted by blowing air into or out of the enclosure to develop the same pressure differential as would be created by the discharging FM-200®. By measuring the air flow required, it becomes possible to calculate the ELA, which is the total of all cracks, gaps and holes in the enclosure. The leakage measurement achieved by taking air out of the enclosure (depressurization), and then blowing air into the enclosure (pressurization), is then averaged.

Below Ceiling Leakage Area (BCLA)

Experience has shown that leakage above a suspended ceiling has a negligible effect on the FM-200® concentration. Like water leaking from the holes in the bottom of a swimming pool, FM-200® tends to escape from leaks in the lower part of the enclosure due to the weight of the mixture above it. The rate at which FM-200® is lost is therefore primarily governed by the leakage below the floor, and walls beneath the ceiling. This is called the Below Ceiling Leakage Area.

Predicting Retention Time

Once the ELA, BCLA and static pressures have been measured, the next step is to calculate the retention time of the enclosure. The formula is derived from a standard engineering/fluid dynamics principle. The result of the calculation is the number of minutes it takes for the FM-200®/air interface to reach the minimum protected height required, normally about 75% of the enclosure area.

Slab to Slab Walls

The only major limitation is that it cannot be used to accurately predict a retention time if the perimeter walls do not extend from slab to slab. The enclosure will almost invariably fail due to extensive leakage through the ceiling tiles.

Coordination and Planning

It should only be necessary to conduct one integrity test, therefore it is essential to ensure that the enclosure is ready, and that the relevant people have been informed. Having established that any outstanding works are completed prior to the test date, advise all interested parties in writing, if necessary, outlining the testing method and principles involved.

Integrity Test Procedure

Evaluation. The enclosure and immediate surrounding area is initially examined visually to assess the readiness for testing, the existence of any attached spaces that could affect the results, and that there is an adequate relief area and return air path. The volume of the enclosure is confirmed and the highest equipment measured to ascertain the required level for retention time.

Preparation. All doors outside the area that are required to be open for the test are wedged open with suitable signs posted to advise personnel. Where voids are protected by FM-200®, tiles are removed to ensure a uniform air flow.

The enclosure is put in the state it would be in prior to a discharge, e.g. ventilation system shut down, dampers closed, etc.

Note. Equipment within the enclosure that does not affect the integrity may be left running to prevent unnecessary disruption and inconvenience.

Ventilation. Air conditioning and/or forced ventilation can affect the system performance and the quantity of agent required.

A. Self-contained air conditioning unit

A self-contained unit conditions the air within the enclosure and does not rely on a fresh air supply, or draw air from other parts of the building. If the hazard has a self-contained unit and it is located within the area without an outside air supply, no additional agent is required. It is not necessary to shut down the unit prior to a discharge as the mixing effect is beneficial. However if the air-conditioning unit is left running, a depleting concentration rather than a descending FM-200®/air interface will be formed. The concentration will be depleted due to leakage. Therefore the enclosure should be over-gassed to obtain the required ten minute retention time at minimum concentration.

B. Central air conditioning unit

A central air conditioning unit relies on air from outside and is often linked by ducts to other parts of the building, therefore, prior to a discharge, the unit should be shut down and/or dampers operated to close the ducts. Sufficient time must be allowed for the plant to stop, or dampers to close, before discharge occurs.

Dampers should be installed in both supply and return air ducts, as close as possible to the area. The duct volume between the hazard and the damper must be added to the overall volume.

Door Fan Installation. A door fan unit is installed in the designated test door in accordance with the manufacturer's instructions.

The gauges are zeroed by taking them to full scale deflection and holding for approximately ten seconds, after which the gauges are gently tapped and zeroed.

Enclosure Evaluation

Static Pressure Measurements. With the door fan equipment fully installed and set up, but with all openings closed, a measurement of any pressure difference between the enclosure and the relief area is made. If the measurement is unduly high its causes are ascertained and if possible permanently reduced or eliminated.

Total Enclosure Leakage Method. Using an adequate range on one fan, or a number of fans, a pressure difference of between column pressure and column pressure plus 30% is created. The pressure difference, and the air flow required to generate this, is then recorded. This is carried out for both pressurization and depressurization modes. The total equivalent leakage area and the predicted retention time is calculated.

Suspended Ceiling Leakage Neutralization Method. This procedure is used to improve the accuracy of the predicted retention time where a reasonable air-tight ceiling exists, whether or not the ceiling is protected with FM-200®.

Note. Leak paths through the ceiling may be temporarily sealed.

The volumes above and below the false ceiling are depressurized to the same extent but using separate fans. This is confirmed by using cool chemical smoke to check that no air is flowing through the false ceiling.

Readings of the pressure difference between the enclosure, relief area, and the air flow through the fan(s) used to depressurize the room and false ceiling are made, and then the procedure is repeated in the pressurization mode. The below ceiling leakage area is then calculated and used in conjunction with the ELA to predict a revised retention time.

Calculation

A portable computer is used to collate the data and calculate the values. The associated printer provides a detailed hard copy of the data on site.

RETROTECDISCHARGESIMULATIONVER. HA5.1
RETENTIONTIMEPREDICTIONMODEL

Location:	Test Enclosure
Rom Name:	Test House
Testing Company:	Pyro-Chem
Technician:	C Uzzell
Date:	12/12/96
Whole Room Test.	
All Outputs are in METRICUnits.	
Gas Being Modeled:	FM200
Lbs/Kgs of Agent in Cylinder(s):	17.00
Net Room Volume (m3):	30.00
Room Height (m):	3.20
Minimum Protected Height (m):	2.90
Minimum Retention Time (min):	10.00
Initial Gas Concentration (%):	7.22
Static Pressure @Discharge:	0.00
Equivalent Leakage Area (ELAm2):	0.0050
Hole in Ceiling (m2):	0.0025
Hole in Floor (BCLAm2):	0.0025

This Room PASSES the Test as the Predicted Retention Time is 10.1 minutes for the agent/air interface to drop below the minimum protected height.

Witnessed by:

X_____

Software Conforms to 1992 NFPA 12A/2001 TCDRoom Integrity Procedure.

Maximum Allowable ELA(M2):	0.005
Interface Height @ 10 minutes:	2.903

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Leakage Location

If the enclosure fails the test, or if the client requests, an inspection of the enclosure with the door fan running can be made. This makes it possible to locate the source of any leakage by using cool chemical smoke. This procedure also tests the efficiency of any dampers, etc.

FANTESTING READINGS & DATA

Location:	Test Enclosure	
Rom Name:	Test House	
Operator and Gauges Location	DEPRESSURE OUT	PRESSURE OUT
Room Pressure Gauge Reading	14.0	14.0
Corrected Room Delta P(ps)	–14.0	14.0
Blower Range config Used	0.1	0.1
Flow Pressure Gauge Reading	45.0	45.0
Corrected Flow Pressure	31.0	45.0
Calculated Air Flow (ls)	13.4	16.2
Temp. Corrected Flow	13.4	16.2
Leakage Area (m2)	0.0046	0.0055
Average Leakage Area (m2)	0.0050	

RM=	1.639	PC=	13.7
AT=	0.003	AL=	0.002
C3=	3.019	C4=	0.000
GD=	7.260	K1=	1.8850
AR=	9.374	T=	605.679
PA=	13.7	FA=	0.500
CF=	1.000	K2=	0.0046
EL=	0.000	TD=	20.000

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▸ Figure 47 - Typical Print-out

General Comments

Personnel required to work in the protected area should be familiar with the detection and suppression equipment installed, and trained in fire procedures. All life-saving equipment must be properly maintained.

The method of system operation is chosen at the design stage to suit the protection required for the hazard area and the environmental factors appropriate to that area. This part of the document provides information relevant to ALLthe standard operational systems to cover the eventuality of changes to, or expansion of the original design.

System Detection and Actuation

General

Each system is designed to suit the hazard area, whether the area is normally manned or unmanned, and whether the detection/actuation devices are to be manual or automatic.

The arrangement of systems is large but from an operational point of view, the systems are best grouped as:

- Manual.
- Fully Automatic.
- Automatic with Manual Intervention.

Manual System

Manual systems depend on human detection of a fire in the hazard area and prompt action to actuate the local or remote strike knob for the FM-200® system to discharge and flood the protected area and suppress the fire.

All other instructions associated with manual operation form part of the user's procedures on safety precautions and fire drill. If required, Pyro-Chem can assist the user to prepare the procedures for safety and fire precautions.

Fully Automatic System

Where a sensitive fire detection system is included for the automatic release of extinguishing agent, the system shall only be capable of automatic release once two or more sensors detect the fire.

The number of detectors and their spacing is designed to ensure a satisfactory response time. To ensure personnel may safely evacuate the risk area, an adjustable time delay should be fitted such that sufficient time may elapse prior to system discharge. Ideally, the delay period shall not exceed 30 seconds.

Prior to system discharge (and at the commencement of any time delay period) a clearly audible alarm different from any other used shall sound and continue until the complete system is reset. In areas of high ambient noise level, a visual indication may also be required, in addition to the audible warning.

The design of a system for automatic detection, signal distribution, alarms, etc. is not always of Pyro-Chem supply. Therefore, details appertaining to fire detection and alarm operation and maintenance are not included in this document.

ULListed Detection & Control Equipment

Detectors shall be UL Listed for the intended application. Control Panels shall be UL Listed for releasing device service and compatible with detection and Pyro-Chem's FM-200® Engineered Total Flooding Fire Suppression System.

Fully Automatic System with Manual Intervention

Manual intervention of an automatic system may be included for the following condition:

- **Where personnel are required to work within the protected area.**

  In protected areas where personnel are present and the concentration is greater than NOAEL, it is recommended that the automatic feature of the system is isolated during occupation. This may be achieved either by an electrically contacted lock assembly or by a clearly marked key switch at a suitable location outside the risk area.

Conditions During a Fire

The user's fire and safety instructions to personnel should include advice on the conditions prevailing during the discharge of an FM-200® system. This advice is intended to prepare the personnel for the situations likely to arise and therefore minimize the risks of panic. Three major conditions prevail during FM-200® discharge of which personnel should be made aware:

FM-200® Concentration

FM-200® total flooding systems greater than 9% design concentration should only be used with manual actuation in normally occupied areas. A normally occupied area is designed as an area intended for occupancy.

Any area protected by FM-200® should be evacuated prior to start of system discharge. Refer to NFPA 2001, Paragraph 1-6.1.2.1 for additional information.

FM-200® Decomposition

FM-200® decomposes when exposed to temperatures exceeding 900 °F (482 °C), such as flames, hot metal surfaces, etc. The rate of this decomposition is dependent upon the size of the area where extreme temperatures are found, and also upon the length of FM-200® exposure time.

To avoid decomposition, Pyro-Chem systems are designed to discharge and suppress the fire quickly. The average duration of discharge for these systems (at 68 °F (20 °C)) is less than 10 seconds, so the minimum amount of decomposition occurs. Hydrogen Fluoride is the most toxic decomposition product. This material generates a sharp acrid odor, which is easily detected and acts as a warning and a good safeguard to personnel.

FM-200® Discharge Conditions

FM-200® has low boiling point, consequently the discharge is very cold at the point where it leaves the nozzle. Care should be taken to avoid working within 3 ft. (1 m) of FM-200® discharge nozzles.

The velocity of discharge of FM-200® from a discharge nozzle is very high. Care should be taken to insure that objects which may become dangerous projectiles are secured or removed from the hazard area.

Actions Following a Fire

General

These notes are only applicable to the hazard area(s) protected by a FM-200® fire suppression system. Where such a system may form part of, or combine with other forms of fire protection systems, then composite instructions for all systems are necessary to ensure the safety of personnel and property following a fire. Pyro-Chem is available to assist in preparing composite instructions.

Actions Immediately Following a Fire

These actions should, at a minimum, include the following:

- Advise the emergency services, Fire, Accident, Police, if appropriate.
- Organize a "roll-call" of employees and any visitors.
- Prevent unauthorized personnel from entering the hazard area.
- In the case of deep seated fires, the hazard space should be kept tightly closed for at least 60 minutes after discharge of the FM-200® extinguishing agent. It is essential that the fire be completely suppressed before ventilating the space. Before permitting anyone to enter the space, ventilate thoroughly or ensure self-contained breathing equipment is used.
- Do not enter the hazard area in which fire has been suppressed with an open flame or lighted cigarette as the possible presence of flammable vapors may cause re-ignition or explosion.

Should it be necessary to enter a space containing FM-200® or decomposition products, the following precautions should be taken:

- Use a fresh air mask or self-contained breathing equipment.
- Do Not use a filter mask or canister-type mask.
- **Do Not** enter space unless you are under observation from outside the space, or tethered by a lifeline.
- Ensure that all pressurized equipment is isolated or safe from release.

Introduction

This section provides user inspection and maintenance guidance for FM-200® Engineered Systems. A log book will be provided to record all inspections, maintenance, measurements and actions taken. The continued capability for effective performance of an FM-200® Total Flooding Fire Suppression System depends on fully adequate maintenance procedures, with periodic testing. Reference NFPA 2001 section 4-1 to 4-6.

User's Program of Inspection

The installer should provide the user with an inspection program for the system and components. The program shall include instructions on the action to be taken in respect of faults. The user's inspection program is intended to detect faults at an early stage to allow rectification before the system may have to operate.

A suitable program is as follows:

Weekly Check of Hazard Area

Inspect the hazard area against the original layout to ensure that there have been no changes that might affect the proper performance of the fire protection system. Changes might include:

- Contents of area.
- Use of area.
- Air Handling equipment in area.
- Openings in area.
- Floor/ceiling voids.
- Partitioning.

Weekly Check of Tanks

Check storage tank pressure gauges and ambient temperature, compare these pressures to the Temperature Correction Chart to determine temperature corrected pressure. If the tank corrected pressure shows a loss of more than 10%, the tanks should be removed for weighing. All measurements and actions shall be recorded in the log book.

Weekly Check of System Components

Make a visual inspection of the system components, distribution piping and nozzles. Check the immediate vicinity of all equipment to ensure that no accidental damage or tampering has occurred.

Weekly General Check

Inspect the hazard area, access routes, tank storage area, floor voids and areas above suspended ceilings to ensure housekeeping is good and that no refuse has accumulated. Ensure that access to the system tank assemblies and local remote controls is unobstructed.

Monthly Check of Signs

Inspect system and protected spaces to ensure that warning signs, safety precautions and operating instructions are posted and clearly visible.

Monthly Personnel Training Check

Check that all personnel who may have to operate the equipment or system are properly trained and are authorized to do so, and in particular that new employees have been instructed in its use.

Contract Service & Maintenance

Systems shall be thoroughly inspected and tested for proper operation by qualified contract personnel. Before any checks are carried out, ensure the extinguishing system is isolated electrically and mechanically and remove all solenoid and pneumatic actuators. No maintenance work should be carried out without obtaining approval from the Fire Safety Director and advising any personnel within the hazard area. The following Program should be carried out in addition to the User's Program of Inspection. The user shall be provided with a signed and dated report of the inspection advising any rectification carried out or needed.

3-Month Actuator Check.

Test and service all actuating mechanisms.

3-Month Electrical Systems Check

Test and service all electrical detection and alarm systems.

6-Month Tank Check

Externally inspect tanks for signs of damage or unauthorized modifications. Check tank labels are securely fixed and legible. Check tank brackets and fittings.

6-Month Contents Check

Examine the tank pressure gauge reading and refer to the temperature correction chart. If the tank pressure corrected to temperature is below 10% of the stated pressure, it must be replaced or recharged.

Verification of the content of FM-200® in the tanks may be achieved through either liquid level detection or tank weighing. If tanks show a extinguishant loss of more than 5% or a pressure loss for superpressurized liquefiable gases (adjusted for temperature) of more than 10%, the tank should be refilled or replaced.

Tank Weighing

Where a Client does not wish to use a Pyro-Chem maintenance contract or the specialized liquid level detection equipment, then tanks must be weighed to establish the FM-200® content. The weighing procedure is as follows:

- Remove all manual controls, pressure actuators and pressure actuation pipe or tubing and flexible electrical connectors.
- Disconnect and remove discharge piping/discharge hoses from tank valves.
- Install Safety Outlet Caps onto tank valves.
- Remove tanks from bracketing and weigh tanks. Any tank showing more than the maximum allowable weight loss must be recharged by a qualified recharge agent.
- Record weight of tank on record tag.
- Replace tanks in bracketing and remove Safety Outlet Caps.
- Reconnect discharge piping/discharge hoses and all control heads, pressure actuators, pressure actuation pipe or tubing and flexible electric connectors.

Using the Liquid Level Measuring Device

The Pyro-Chem liquid level measuring device is used to determine the liquid FM-200® level in 106, 147, 180 and 343 liter storage tank assemblies. During a maintenance examination, the measuring device will enable a service representative to convert a linear measurement to agent weight in order to determine if the tank has any weight loss. This measurement is accomplished without removing the FM-200® tank from the fire suppression system.

Operation

To measure the liquid FM-200® level:

1. Remove the protective cap from the measuring device housing.
2. Lift the measuring tape to the end (or approximately 3 in. above the expected level). Slowly lower the tape until a magnetic interlock is felt (see Figure 48).

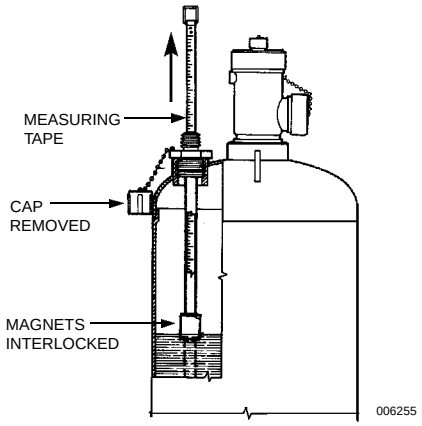


Figure 48 - Liquid Level Measuring Device

3. Read the measurement on the tape directly at the top of the plastic sleeve in the measuring device housing (see Figure 49). Record this measurement and note the temperature of the tank module.

> **Notice.** The tank module temperature can be determined by measuring the ambient temperature at the tank location. The tank must be stored at this temperature for at least 24 hours to obtain an accurate liquid level reading.

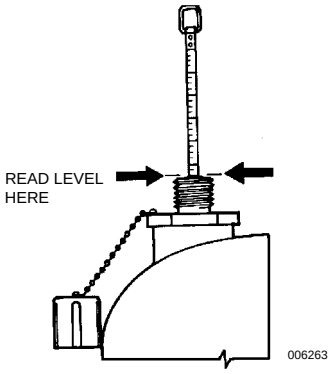


Figure 49 - Reading Liquid Level

4. To reinstall tape, quickly pull on the tape to disengage the magnetic interlock. Then slide the tape into the housing and replace the protective cap.

5. Using the Weight Conversion Table located in Appendix E, determine the FM-200® weight of charge as follows:
   a. Find the liquid level reading along the left hand vertical line of the table.
   b. From that point, follow the horizontal line to the point where it intersects with the temperature column (using the FM-200® tank temperature noted in Step 3).
   c. Read the weight of FM-200® at the level/temperature column intersection.

6. Compare the weight from the table to the weight of charge stamped on the tank nameplate. If the measurement shows a net weight loss of more than 5%, the tank must be weighted to verify the liquid level measurement. If the weight loss still exceeds 5% of the weight of charge, the tank requires recharging.

Example – Using the Tank Weight Conversion Table

A semi-annual weight check is being performed on a 180 Liter FM-200 tank filled with 301 lbs. (137 kg) of FM-200®. The temperature of the tank is 60 °F (16 °C). The liquid level measuring device reading is 14 1/4 in. (36.2 cm).

Find the 14 1/4 in. (36.2 cm) line on the left side of the 180 liter tank table and read horizontally across the table to the 60 °F (16 °C) column. Then, by reading the weight of FM-200® at the level/temperature column intersection, it is determined that the weight of FM-200 is 299.2 lbs. (136 kg).

To determine if this is within the 5% weight loss tolerance, multiply the weight of charge (taken from the tank nameplate) by 0.95 to determine the minimum weight of FM-200® required in this tank:

301 lb. x 0.95 = 286 lb. (137 kg x 0.95 = 130 kg)

Because the measured weight of FM-200®, 299.2 lb. (136 kg), is more than the minimum required FM-200® weight of 286 lb. (130 kg), the weight of FM-200 is within the 5% weight loss tolerance.

If the measured weight had been less than the 5% weight loss tolerance, the tank should be weighted to verify the liquid level measurement. If the weight loss still exceeds 5% of the weight of charge, the tank must be recharged.

6-Month Control Valve & Actuator Check

Check all manual and pneumatic actuators for free movement of the piston. Replace whole unit where appropriate. Check all control valves for correct manual function and automatic valves additionally, for correct automatic function.

6-Month Pipe Network Check

Externally check pipework to determine its condition. Replace or pressure test and repair as necessary pipework showing corrosion or mechanical damage.

6-Month Nozzle Check

Inspect nozzles for dust and debris, clean out where necessary.

6-Month Enclosure Check

Carry out a full visual check of the enclosure for integrity and confirm the dimensions and the configuration of the hazard are as the original drawings or previous visit. If drawings are not available and this is the first visit, then dimensions should be taken and passed to the engineering department together with the quantity of agent to enable a calculation to be carried out to ensure the correct quantity of gas has been used.

12-Month Hose Check

All system hoses should be examined for damage. If visual examination shows any deficiency, the hose shall be replaced.

12-Month Integrity Test

Integrity test the enclosure to determine if the leakage area has changed sufficiently from that measured during installation.

Personnel Training

All persons who may be expected to inspect, test, maintain or operate the fire suppression system shall be kept adequately trained in the functions they are expected to perform.

Personnel working in an enclosure protected by a gaseous extinguishant shall receive training in the operation, use of the system and safety issues.

Mechanical Servicing Procedure

a. Remove valve actuator(s) (where possible) from the tank valve(s) and replace actuation cap(s).

b. For master/slave system, complete the following steps to check the slave actuation system:

1. Disconnect pneumatic valve actuators from the slave tank valves and install actuation caps.

2. Disconnect the pilot loop from the master tank valve and install the appropriate plug.

3. Introduce 58 psi (4 bar) pressure into the pilot actuation line to the pneumatic actuators.

4. Check that the pistons in the pneumatic valve actuators have fully fired.

5. Before installing the pneumatic actuator onto the tank valve, ensure that the piston is reset.

c. This section only applies if:

(1) Pyro-Chem distributor is performing the maintenance on the detection system.

(2) If the servicing of the detection system is being performed at the same time as the mechanical service by another nominated body.

i) Remove solenoid actuators from valve assembles.

ii) Activate the detection system in accordance with procedures provided with the system. When this test is performed, the release circuit of the detection system must operate the electric actuators causing the plungers to be firmly extended.

iii) Examine the auxiliary electrical device, such as alarms, door closers, etc., to insure all have operated correctly.

iv) Ensure actuator is reset before reinstalling.

d. For master/slave system, remove the appropriate port plug and reconnect the pilot actuation line to the slave port on the back of the master valve.

e. If Pressure switch(es) have operated, check that connected devices have activated or shut down as required and reset.

Specialized Maintenance Duties

Tank Hydrostatic Pressure Testing

Refer to NFPA 2001, Paragraph 4-2, for testing and inspection information.

Finally

Perform a final visual inspection of the system and the protected area to ensure that all equipment has been reinstalled and reconnected properly. Ensure that any associated control/indication panel is displaying normal operation. Complete the site log book, recording work completed and parts used. Inform the responsible person that the work is complete and that the system is back on-line.

Recharging

This section describes the procedures required to enable the refilling of a tank that has been discharged and will require recharging. This covers 1 in. (25 mm), 2 in. (50 mm), and 3 in. (75 mm) valve/tank assemblies.

To correctly complete the following procedures, it is necessary to use the following tool kits, refurbishing kits, and testing/filling components:

- 1 in. Valve Tool Kit – Part No. 570154
- 1 in. Valve Refurbishing Kit – Part No. 570152
- 2 in. Valve Tool Kit – Part No. 570155
- 2 in. Valve Refurbishing Kit – Part No. 570153
- 3 in. Valve Refurbishing Kit – Part No. 570373
- 1 in. Bottom Cap (testing) – Part No. 570272
- 2 in. Bottom Cap (testing) – Part No. 570276
- 3 in. Bottom Cap (testing) – Part No. 570374
- 1 in. Filling Adapter Cap – Part No. 570180
- 2 in. Filling Adaptor Cap – Part No. 570184
- 3 in. filling Adaptor Cap – Part No. 69891
- Closing Down Adaptor – Part No. 570131

Valve Teardown

After a discharge, the valve assembly must be disassembled, cleaned, O-Rings replaced, burst disc replaced, if necessary, and tested. See Figure 1 or Figure 2 for component description.

1. Check to make certain the tank contains no pressure. Do this by weighing the tank and comparing the weight with the stamped weight; Visually determining the pressure gauge reads zero; and also carefully look into the valve outlet. If the shuttle is above the top of the outlet, the cylinder is empty and contains no pressure. If the shuttle is below the outlet, the tank still contains pressure and must be properly bled down before proceeding.

2. Remove valve from tank. Loosen set screw on valve and remove siphon tube. (Siphon tube for 343L tank stays in the tank collar.)

3. Unscrew top cap by removing set screw located behind safety chain mounting screw. Also, remove the schrader valve from the top cap (3 in. valve does not use a set screw, external type valve cap).

4. Remove the O-Ring below the top cap. Replace with new O-Ring in a later step.

5. Remove the shuttle from the valve body.

6. The shuttle contains two O-Rings. First, remove the upper O-Ring and replace with a new, lubricated O-Ring. Lubricate O-Rings with PTFE silicone grease or equal.

   1 in. valve shuttle – upper O-Ring No. 122 Part No. 570044

   2 in. valve shuttle – upper O-Ring No. 227 Part No. 570072

   3 in. valve shuttle – Replace shuttle (part of Refurbishing Kit, Part No. 570373)

7. Remove bottom cap from shuttle and replace O-Ring with lubricated O-Ring.

   1 in. valve shuttle – bottom O-Ring No. 212 Part No. 570048

   2 in. valve shuttle – bottom O-Ring No. 327 Part No. 570057

   3 in. valve shuttle – (part of Refurbishing Kit, Part No. 570373)

8. Clean inside surfaces of valve body. Be careful not to scratch surface. Spray a small quantity of PTFE silicone grease into the bore of the valve body.

9. Install bottom cap to shuttle, using Loctite #254, and return shuttle to inside of valve body (not required for 3 in valve).

10. Install new lubricated O-Ring into valve body groove for top cap seating surface or unto top cap for 1 in. valve.

    1 in. valve – O-Ring No. 122 Part No. 570044 (install in top cap groove)

    2 in. valve – O-Ring No. 231 Part No. 570069 (install in valve body groove)

    3 in. valve – O-Ring No. 345 Part No. 570295 (install in groove below valve body/cap threads)

11. Install new schrader valve, torque to 5.4 in. lb. (0.6 Nm), into top cap. Install top cap to valve and lock into place with set screw (3 in. valve does not use set screw).

12. Replace neck O-Ring with new, lubricated O-Ring.

    1 in. valve – O-Ring No. 327 Part No. 570057

    2 in. valve – O-Ring No. 337 Part No. 570076

    3 in. valve – O-Ring No. 343 Part No. 570294

13. If the outlet adapter is damaged, remove, clean internal threads, apply Loctite #648 to the threads of the new outlet adapter and tighten securely (3 in. valve has outlet adaptor integral with valve body).

14. If the pressure gauge or pressure switch needs to be replaced, remove the component. Check the setting of the internal set screw by tightening in fully and then loosen by 1/2 a turn. Apply Teflon tape to male thread and install new component (3 in. valve utilizes a schrader valve and a rivet between the gauge and the schrader valve to allow removal and replacement of the gauge).

15. Replace burst disc if ruptured or damaged. Remove old burst disc. Install new disc. **Do not apply Teflon Tape to threads.** Torque to 159 in. lb. (18 Nm) for 1 in. valve and 177 in. lb. (20 Nm) for 2 in. valve, and 180 in. lb. (20.3 nNm) for 3 in valve.

16. Valve assembly is now ready to be leak tested. See Testing Section.

17. If burst disc assembly has been replaced, complete "Burst Disc Pre-Dome Procedure" also.

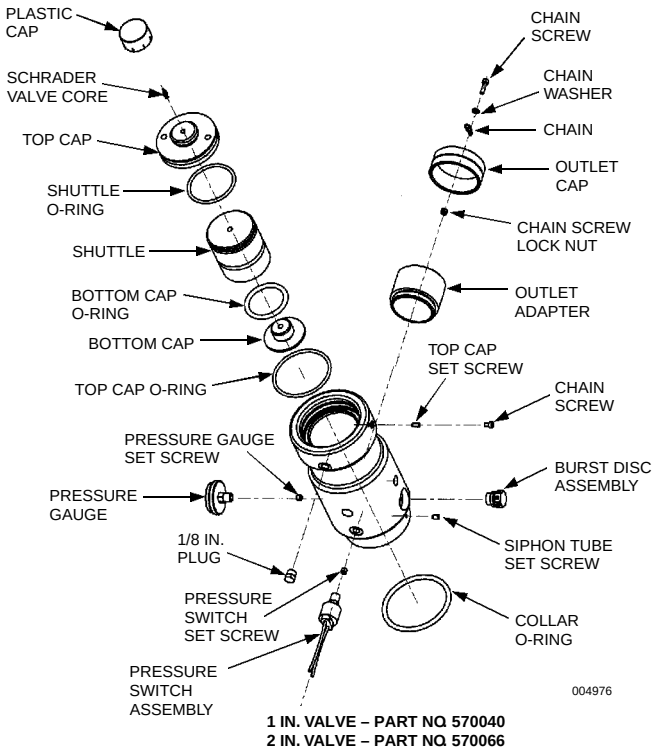


Figure 1

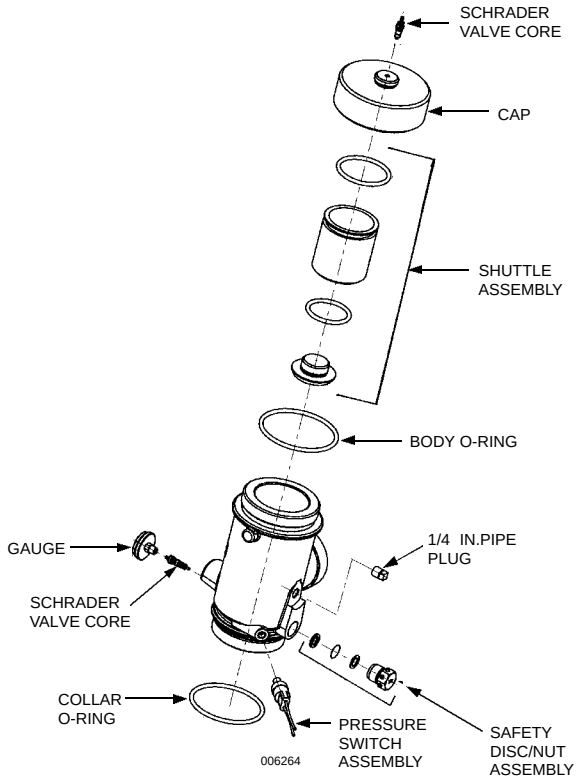


Figure 2 – 3 in. Valve (Part No. 570302)

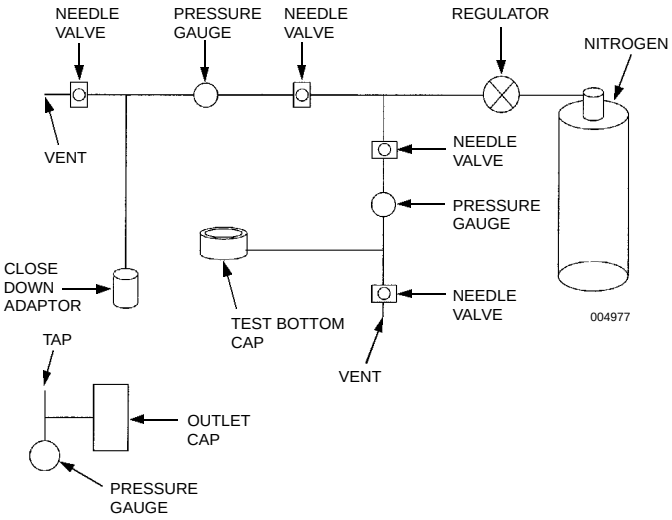
Testing

On completion of the valve tear down, the valve assembly requires two tests – Leak Test and Pre-Dome Test (Pre-Dome Test is required only if burst disc had been replaced).

The tests must be conducted using a nitrogen source, a test bottom cap and an outlet filling adapter cap. See Figure 3 for Test Station Component Layout.

1. The valve assembly is assembled to the test bottom cap. The outlet adaptor cap is assembled to the valve outlet. Attach the nitrogen line and make certain the vent tap on the filling adapter cap is closed.
2. Burst Disc Pre-Dome Procedure – The nitrogen regulator is opened to 580 psi (40 Bar) and the pressure to the valve, through the test bottom cap port, is slowly increased to this pressure. This is to pre-dome the burst disc. This pressure is held for 1 minute ensuring that there is no drop in pressure indicated by the testing gauge on the nitrogen test setup.
3. Pour water/soap solution into the top cap schrader valve and apply leak detection spray to all ports on the valve. If no leaks are present, the pressure to the valve must be reduced to 363 psi (25 bar) and the closing down adaptor must be attached. To close the shuttle down, 580 psi (40 bar), must be applied through the closing down adaptor.
4. Check for leaks.
5. Slowly release the gas from the test setup, vent the closing down adaptor, and make certain that the outlet cap adapter vent tap is opened before removing the adaptor.

6. If a leak had been discovered, it must be rectified and retested. If the leaks persists, the valve assembly must be rejected.



▸ Figure 3

▸ Replacing Valve Assembly to Tank

1. Clean threads on tank collar. Make certain not to damage O-Ring seal surface.
2. Remove any debris from inside the tank.
3. Apply a small amount of PTFE silicone grease to the clean tank neck threads.
4. Clean the siphon tube.
5. For 1 in. and 2 in. valve, use Loctite 572, apply it around the circumference of the siphon tube, above the set screw hole. Position the tube into the valve assembly, ensuring that the set screw holes line up (does not apply to 3 in. valve – tube remains in tank).
6. Remove any excess Loctite and lock in set screw.
7. Assemble valve/tube assembly (make certain O-Ring is on valve body) into tank and tighten securely, using the "C" spanner wrench.

Field Installing Liquid Level Measuring Device

Caution. Tank must be completely empty before removing the liquid level device or the port plug. Severe injury or damage could occur if tank contains pressure.

If desired, and the tank is equipped with a port for the liquid level measuring device, it can be installed before filling the tank.

To install the liquid level measuring device, remove the plug in the liquid level port on the tank.

Make certain the O-ring on the device, and the threads on the device and the tank port, are clean. Apply a small amount of PTFE silicone grease to the O-ring and the threads on the device.

Install the device into the port and tighten to a metal to metal contact.

Caution. When superpressurizing, a pressure regulator must be used when the pressure source is a tank of high pressure gas.

Filling

1. With the tank ready for filling, a check is made to the filling instruction sheet and the tank fill weight, time, date, and fill detail record.
2. The tank is placed on a scale, secured properly with chain or cable, and the appropriate filling adaptor attached the valve discharge outlet.
   1 in. Filling Adapter Cap – Part No. 570180
   2 in. Filling Adaptor Cap – Part No. 570184
   3 in. Filling Adaptor Cap – Part No. 69891
3. Attach the fill hose/vent line from the filling station to the filling adaptor.
4. Reset the scale to zero to compensate for the tank weight and the fill hose.
5. Switch on the pump marked "LIQUID" and fill the tank to the required weight. Refer to the Fill Tolerance Table. When the correct fill is reached, switch off the pump.
6. Remove the tank from the scale. Zero the scale and reweigh the tank to verify the fill is within the tolerance, adjust if required.
7. Attach the low pressure switch wires to the test box and regulate the nitrogen pressure to 200 psi (13.8 bar) on the fill station and turn on pressure.
8. Slowly increase the nitrogen pressure to the stated pressure on the filling instruction sheet, making the relevant allowances in pressure to compensate for the current room temperature (See Temperature Correction Chart). Note: The pressure gauge attached to the tank is not to be used to determine when the intended charging pressure has been reached. Check that the tank pressure gauge reads within +/– 14.5 psi (+/– 1 bar) of the fill gauge. Replace tank gauge if outside this tolerance. Ensure that the test box registers a change in switch contacts at approximately 350 psi (24.1 bar) rising pressure.
9. Agitate the tank to accelerate nitrogen absorption into the agent and top off the pressure accordingly. Switch off the nitrogen supply once absorption has stopped.
10. Attach the closing down adaptor to the tank valve top cap and connect the nitrogen closing down line. Regulate the nitrogen pressure to 580 psi (40 bar) from the fill station.
11. Open the closing down valve for 1 second only to force the valve shuttle down. The tank valve can be heard closing. Turn off the nitrogen supply and vent the closing down line.
12. Vent the fill hose to atmosphere. If the pressure drops to zero on the fill station gauge within 10 seconds, the valve has closed properly.
13. Remove the closing down line adaptor.
14. If the valve does not close after 5 applications, the tank must be de-pressurized. Refer to "Bleeding Down Tank through Fill Station" Section. Make certain vent valve is closed, when not required, to prevent contamination to the fill line.
15. Check all ports with leak detection spray and check schrader valve with water/soap solution. Minor leaks may be corrected by tightening the component.
16. Remove the fill hose and the outlet fill adapter. Leak test the outlet and attach the safety cap. Note: When leak testing the outlet with spray, do not look directly into port. Examine quickly from an angle.
17. Reset scale and record gross weight.
18. Make certain all protective caps are in place and place tank in holding area for leak monitoring for at least 24 hours prior to returning back into the system.
19. After 24 hours, leak test the valve and tank assembly. See detailed test information noted in the Tank/Valve Assembly Leakage Test Section.

Tank/Valve Assembly Leakage Test Section

This test is required to all filled FM-200 tank/valve assemblies after left to stand in a secured area for at least 24 hours. The test equipment used is a leak detector and calibration gas.

1. 24 hours after filling, the valve pressure gauge should be checked for pressure loss (refer to temperature correction chart to adjust for temperature change). The tank/valve assembly should then be checked for leakage, using a Halotek leak detector unit.
2. Switch on the fan to pressurize/purge the room for a minimum of 20 minutes before testing.
3. The Halotek unit and calibration gas should be taken to an FM-200 free environment and calibrated.
4. Adjust the Halotek leak detector, in clean air, to pulse 2 to 4 pulses per second.
5. Conduct a stability check by leaving the Halotek unit for approximately 3 minutes in a clean air environment. If the pulse rate stays within the range of 2 to 4 pulses per second, proceed to the Repeatability Check. If the stability check is inconclusive, repeat the stability check in an alternative clean environment. If stability problems persist, contact Pyro-Chem.
6. The leak standard of 0.21 oz./year should be conditioned to a temperature of 68 °F +/– 9 °F (20 °C +/– 5 °C) for at least 24 hours.

Calibration Repeatability Test

1. Remove the cap from the leak standard. Screw the calibration nozzle into the outlet of the bottle and open the hand valve fully.
2. Place the Halotek probe into the calibration nozzle. Within 5 seconds the pulse rate should start to increase and be a continuous tone within 15 seconds.
3. Remove the probe from the nozzle and position the Halotek unit away from the gas source. The pulse rate should revert back to the original rate of 2 to 4 pulses per second within 15 seconds.
4. Repeat the test two more times. If the repeatability test indicates that the unit is functioning within the set parameters, proceed to the Tank Leak Test. However, if the repeatability test is inconclusive, repeat it in an alternative clean environment. If repeatability problems persist, contact Pyro-Chem. Close the hand valve of the leak standard after use.

Tank Leak Test

Carefully probe the tank/valve assembly at all probes and openings. Ensure that the probe is not brought into direct contact with any objects. If it is, it could result in false readings. Make sure the dwell time is sufficiently long (more than 5 seconds) to ensure any leak is detected. Any significant and repeatable increase of the audible pulse rate should be taken as an indication of a leak and the tank and valve assembly should be rejected.

Once the leakage source has been corrected, the tank and valve assembly should be leak tested again.

Emptying a Charged Tank Through The Fill Station

Emptying a charged tank is required if the leak cannot be corrected. Attach the appropriate outlet adaptor to the valve and connect a line to a storage vessel. The line to the storage vessel should be equipped with a shut off valve.

> **Caution.** Make certain the tank is securely chained to a rigid surface. Failure to do so could cause severe tank movement upon actuation, resulting in personal injury or property damage.

Make certain the shut off valve on the storage vessel line is closed. Actuate the tank. Open the shut off valve and flush the FM-200 into the storage vessel. Shut off the line and vent the remaining pressure to atmosphere.

Fill Tolerance Table

Tank Size	Fill Tolerance	Charging Pressure
8 Liter	+0.09, –0 lb. (+0.04, –0 kg)	+11, –0 psi (+0.75, –0 bar)
16 Liter	+0.18, –0 lb. (+0.08, –0 kg)	+11, –0 psi (+0.75, –0 bar)
32 Liter	+0.35, –0 lb. (+0.16, –0 kg)	+11, –0 psi (+0.75, –0 bar)
52 Liter	+0.57, –0 lb. (+0.26, –0 kg)	+11, –0 psi (+0.75, –0 bar)
106 Liter	+1.10, –0 lb. (+0.50, –0 kg)	+11, –0 psi (+0.75, –0 bar)
147 Liter	+1.65, –0 lb. (+.075, –0 kg)	+11, –0 psi (+0.75, –0 bar)
180 Liter	+2.21, –0 lb. (+1.00, –0 kg)	+11, –0 psi (+0.75, –0 bar)
343 Liter	+3.31, –0 lb. (+1.50, –0 kg)	+11, –0 psi (+0.75, –0 bar)

FM-200 Temperature Correction Chart (50 lb./cu. ft) Pressurized to 360 psi (gauge) at 70 °F (24.8 bar at 21 °C)

Temperature °F	(°C)	Developed Pressure Psi	(Bar)	Temperature °F	(°C)	Developed Pressure Psi	(Bar)	Temperature °F	(°C)	Developed Pressure Psi	(Bar)	Temperature °F	(°C)	Developed Pressure Psi	(Bar)
32	(0)	288	(19.9)	55	(12.8)	331	(22.8)	78	(25.6)	377	(26.0)	101	(38.3)	428	(29.5)
33	(0.5)	290	(20.0)	56	(13.3)	333	(22.9)	79	(26.1)	379	(26.1)	102	(38.9)	430	(29.6)
34	(1.0)	292	(20.1)	57	(13.9)	335	(23.1	80	(26.7)	381	(26.3)	103	(39.4)	432	(29.8)
35	(1.6)	294	(20.2)	58	(14.4)	337	(23.2)	81	(27.2)	383	(26.4)	104	(40.0)	435	(30.0)
36	(2.0)	295	(20.4)	59	(15.0)	339	(23.4)	82	(27.8)	385	(26.6)	105	(40.6)	437	(30.1)
37	(2.8)	297	(20.5)	60	(15.6)	341	(23.5)	83	(28.3)	387	(26.7)	106	(41.1)	440	(30.3)
38	(3.3)	299	(20.6)	61	(16.1)	343	(23.6)	84	(28.9)	389	(26.9)	107	(41.7)	442	(30.5)
39	(3.9)	301	(20.8)	62	(16.7)	344	(23.8)	85	(29.4)	392	(27.0)	108	(42.4)	444	(30.6)
40	(4.4)	303	(20.9)	63	(17.2)	346	(23.9)	86	(30.0)	394	(27.2)	109	(42.8)	447	(30.8)
41	(5.0)	305	(21.0)	64	(17.8)	348	(24.0)	87	(30.6)	396	(27.3)	110	(43.3)	449	(31.0)
42	(5.6)	306	(21.1)	65	(18.3)	350	(24.2)	88	(31.1)	398	(27.4)	111	(43.9)	452	(31.1)
43	(6.1)	308	(21.3)	66	(18.9)	352	(24.3)	89	(31.7)	400	(27.6)	112	(44.4)	454	(31.3)
44	(6.7)	310	(21.4)	67	(19.4)	354	(24.4)	90	(32.2)	402	(27.7)	113	(45.0)	457	(31.5)
45	(7.2)	312	(21.5)	68	(20.0)	356	(24.6)	91	(32.8)	405	(27.9)	114	(45.6)	459	(31.7)
46	(7.8)	314	(21.6)	69	(20.6)	358	(24.7)	92	(33.3)	407	(28.1)	115	(46.1)	462	(31.9)
47	(8.3)	316	(21.8)	70	(21.1)	360	(24.8)	93	(33.9)	409	(28.2)	116	(46.7)	465	(32.0)
48	(8.9)	318	(21.9)	71	(21.7)	362	(25.0)	94	(34.4)	411	(28.4)	117	(47.2)	467	(32.2)
49	(9.4)	320	(22.0)	72	(22.2)	364	(25.1)	95	(35.0)	414	(28.5)	118	(47.8)	470	(32.4)
50	(10.0)	321	(22.2)	73	(22.8)	366	(25.3)	96	(35.6)	416	(28.7)	119	(48.3)	472	(32.6)
51	(10.6)	323	(22.3)	74	(23.3)	368	(25.4)	97	(36.1)	418	(28.8)	120	(48.9)	475	(32.7)
52	(11.1)	325	(22.4)	75	(23.9)	371	(25.6)	98	(36.7)	421	(29.0)				
53	(11.7)	327	(22.6)	76	(24.4)	373	(25.7)	99	(37.2)	423	(29.2)				
54	(12.2)	329	(22.7)	77	(25.0)	375	(25.8)	100	(37.8)	425	(29.3)				

Warranty

Following the commissioning of the system, all equipment will be covered by the company's twelve month parts warranty (excluding parts accidentally or maliciously damaged by others). For further information, refer to Pyro-Chem's Terms and Conditions document.

Disclaimers & Limitations

While every care has been taken in the publication of this installation manual to describe our products accurately, it is not considered binding. Pyro-Chem reserves the right to make any alterations without notice.

APPENDIX A – SITE SURVEY / PROPOSAL REQUEST FORM

FROM: _____ DATE:_____

ADDRESS: _____ CONTACT: _____

_____ TEL NO._____

_____ FAX NO._____

_____ REF NO._____

One of the most important aspects in providing the most cost effective application of the FM-200® 'Total Flooding'fire suppression system is the site survey. This procedure and the information gathered provides the basis for the system design procedure. All the relevant information obtained concerning the hazard, the environment, personnel and required sequence of operation will be used to select, sell and install the FM-200® 'Total Flooding'system.

HAZARD ATMOSPHERE:

☐ NORMAL _____

☐ FLAMEPROOF (Specify Zone)_____

☐ EXPLOSION PROOF (Specify Zone) _____

HAZARDOUS MATERIAL:

☐ CLASS A (Surface fires, involving normal combustible material (eg paper, cloth plastics etc.))

☐ CLASS B (Flammable liquids and gas fires, materials such as oils, greases, tar and petrol.)

(specify Material)_____

_____

☐ CLASS C (Electrical equipment, (eg computers, data processing, transformers, switches and rotating equipment.))

> **CAUTION:** FM-200® is not effective on deep seated fires, combustible metals, chemicals capable of rapid oxidation, chemicals capable of auto thermal decomposition, inerting or explosion suppression, enclosures containing hot surfaces.

HAZARD VOLUME(S):

Correctly determining the hazard volume is one of the most important aspects when designing an FM-200® system, as the agent quantity is determined by the hazard volume. It is important that the hazard area be enclosed on all sides so that the required concentration level is achieved and maintained. All walls must have a minimum fire rating of 30 mins.

Hazard Area	Length (m)	Width Room (m)	Height Floor (m)	Void Depth (m)	Ceiling Void Depth (m)
Extra volume to be allowed for.					
Height above sea level.					

VENTILATION:

The hazard ventilation system can effect both the quantity of FM-200® and the number of detectors required, is the system:

☐ SELF CONTAINED_____

☐ CENTRAL _____

Central air conditioning systems draw air from an outside source and therefore at least one of the following must occur:

☐ ELECTRICALSHUT DOWN OF THE VENTILATION SYSTEM.

☐ INSTALLATION OF DAMPERS WITHIN THE AIR SUPPLY AND RETURN DUCT.

NOTE: If dampers are present, the volume of duct work from outside the hazard area to the location of the damper must be added to the total hazard volume.

CEILING CONSTRUCTION:

☐ ARE CEILING OBSTRUCTIONS PRESENT ? (Any obstructions over 12 in. (300mm), if so indicate on hazard drawing)

☐ ARE CEILINGS A MINIMUM OF 1.5 FT. (0.5m) ABOVE HAZARD?

TEMPERATURE RANGE:

MINIMUM ANTICIPATED TEMPERATURE: ^{o}F

MAXIMUM ANTICIPATED TEMPERATURE: ^{o}F

▸ TANK STORAGE TEMPERATURE: ^{o}F

▸ **TANK LOCATION:**

▸ Show preferred tank location on hazard drawing.

OTHER DETAILS:

☐ IS A ROOM INTEGRITYTEST REQUIRED?

☐ IS A RESERVE SUPPLY REQUIRED?

▸ ☐ IS A SPARE TANK REQUIRED?

☐ IS ELECTRONIC WEIGHT MONITORING REQUIRED?

☐ IS A MAINTENANCE PRICE REQUIRED?

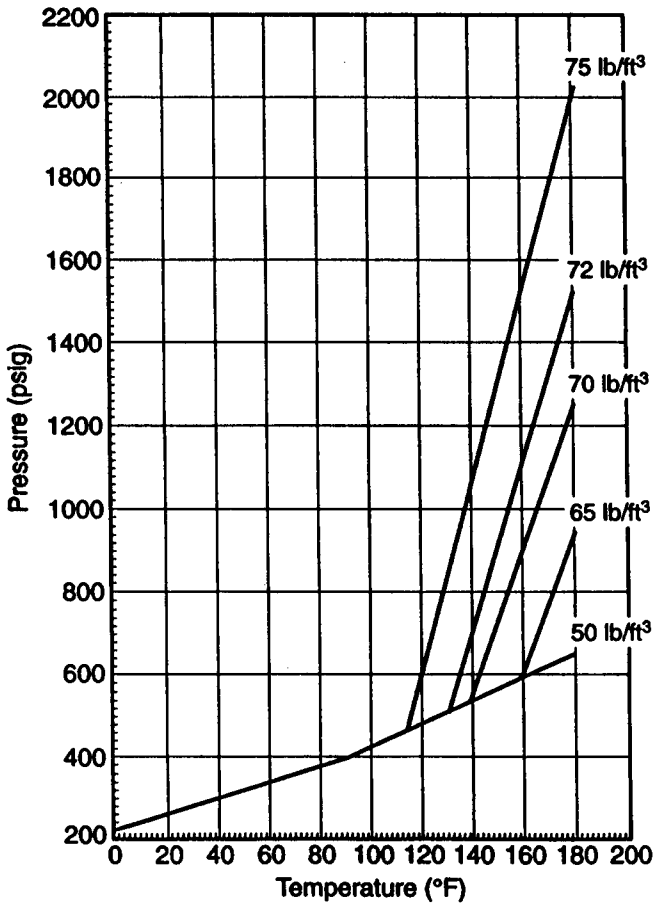
PLEASE RETURN THE COMPLETED FORM TO:

PYRO-CHEM
ONE STANTON STREET
MARINETTE, WISCONSIN 54143-2542
U.S.A.

TELEPHONE: 800 526-1079
FAX: 877 329-7976
www.pyrochem.com

ISOMETRIC DIAGRAM:

FM-200® PRESSURIZED to 360 PSIG (25 bar) WITH NITROGEN AT 70 °F (21 °C)



NOTES:

PyroChem

1 Stanton St.
Marinette, WI 54143
Pyro-Chem FM-200 Flow Calculation - PYCM3.00
UL: EX4986
Project: Example calculation
File Name: C:\Program Files\Pyro-Chem\FM-200 FlowCalc PYCM3.00\Projects\testmana.FLC
Calculation Date/Time: Tuesday, May 29, 2001, 2:05:43 PM

Consolidated Report

Customer Information

Company Name:	PyroChem
Address:	1 Stanton Street
	Marinette, WI 54143-2542
Phone:	800-526-1079
Contact:	John Kehoe
Title:	Technical Services Engineer

Project Data

Project Name:	Example calculation
Designer:	J. Kehoe
Number:	
Account:	
Location:	
Description:	

006059a

Consolidated Report
Enclosure Information

Elevation:	0 ft (relative to sea level)
Atmospheric Correction Factor:	1
Enclosure Number:	1
Name:	Switch Room
Enclosure Temperature...	
Minimum:	70 F
Maximum:	70 F
Maximum Concentration:	7.216 %
Design Concentration...	
Adjusted:	7.215 %
Minimum:	7.200 %
Minimum Agent Required:	149.9 lbs
Width:	22.9 ft
Length:	22.7 ft
Height:	8.2 ft
Volume:	4262.6 cubic ft
Non-permeable:	0.0 cubic ft
Total Volume:	4262.6 cubic ft
Adjusted Agent Required:	150.2 lbs
Number of Nozzles:	1

006059b

Consolidated Report
Enclosure Information

Elevation:	0 ft (relative to sea level)
Atmospheric Correction Factor:	1
Enclosure Number:	2
Name:	Computer Room
Enclosure Temperature...	
Minimum:	70 F
Maximum:	70 F
Maximum Concentration:	7.215 %
Design Concentration...	
Adjusted:	7.215 %
Minimum:	7.200 %
Minimum Agent Required:	676.3 lbs
Width:	39.4 ft
Length:	52.5 ft
Height:	9.3 ft
Volume:	19237.1 cubic ft
Non-permeable:	0.0 cubic ft
Total Volume:	19237.1 cubic ft
Adjusted Agent Required:	677.8 lbs
Number of Nozzles:	4

006059c

Consolidated Report
Agent Information

Agent: FM-200 / Propellant N2
(FM-200 is a Trademark of Great Lakes Chemical Corp.)

Adjusted Agent Required:	828.0 lbs
Cylinder Name:	180 Liter DOT Cylinder
Cylinder Part Number:	570009
Number of Main Cylinders:	3
Number of Reserve Cylinders:	0
Manifold:	End, 3 x 180 Liter Cylinders, 3 in., vert.
Pipe Take Off Direction:	Up
Agent Per Cylinder:	276.0 lbs
Fill Density:	42.9 lbs / cubic ft
Cylinder Empty Weight:	233.2 lbs
Weight, All Cylinders + Agent:	1527.6 lbs
Floor Area Per Cylinder:	1.40 square ft
Floor Loading Per Cylinder:	365 lbs / square ft

Pipe Network

Part 1 - Pipe

			Pipe			
Description	Start	End	Type	Diameter	Length	Elevation
Main Cyl. X 3	0	1		2 in	5.36 ft	5.36 ft
Manifold X 3	1	2	US40B TS	2 in	2.43 ft	2.02 ft
Manifold X 1	2	3	US80B TS	3 in	3.83 ft	0.00 ft
Pipe	3	4	US40B TS	4 in	1.50 ft	1.50 ft
Pipe	4	5	US40B TS	4 in	1.50 ft	0.00 ft
Pipe	5	6	US40B TS	4 in	7.40 ft	0.00 ft
Pipe	6	7	US40B TS	3 in	12.30 ft	0.00 ft

006059d

Consolidated Report

Part 1 - Pipe

Description	Start	End	Pipe Type	Pipe Diameter	Pipe Length	Pipe Elevation
Pipe	7	8	US40B TS	3 in	26.20 ft	0.00 ft
Pipe	8	9	US40B TS	2-1/2 in	9.80 ft	0.00 ft
Pipe	9	10	US40B TS	2 in	13.10 ft	0.00 ft
Pipe/E2-N1	10	11	US40B TS	2 in	0.30 ft	-0.30 ft
Pipe	9	12	US40B TS	2 in	13.10 ft	0.00 ft
Pipe/E2-N2	12	13	US40B TS	2 in	0.30 ft	-0.30 ft
Pipe	8	14	US40B TS	2-1/2 in	9.80 ft	0.00 ft
Pipe	14	15	US40B TS	2 in	13.10 ft	0.00 ft
Pipe/E2-N3	15	16	US40B TS	2 in	0.30 ft	-0.30 ft
Pipe	14	17	US40B TS	2 in	13.10 ft	0.00 ft
Pipe/E2-N4	17	18	US40B TS	2 in	0.30 ft	-0.30 ft
Pipe	6	19	US40B TS	2 in	1.00 ft	0.00 ft
Pipe	19	20	US40B TS	2 in	20.60 ft	0.00 ft
Pipe/E1-N1	20	21	US40B TS	2 in	0.30 ft	-0.30 ft

Part 2 - Equivalent Length

Start	End	90	45	Thru	Side	Union	Other	Added	Total
0	1	0	0	0	0	0		0.00 ft	35.0 ft
1	2	0	0	0	0	0	2inDH&CV	0.00 ft	41.8 ft
2	3	1	0	0	3	0		0.00 ft	61.8 ft
3	4	0	0	0	0	0		0.00 ft	1.5 ft
4	5	1	0	0	0	0		0.00 ft	12.2 ft
5	6	1	0	0	0	0		0.00 ft	18.1 ft
6	7	0	0	1	0	0		0.00 ft	17.4 ft

006059e

Consolidated Report

Part 2 - Equivalent Length

Start	End	90	45	Thru	Side	Union	Other	Added	Total
7	8	1	0	0	0	0		0.00 ft	34.4 ft
8	9	0	0	0	1	0		0.00 ft	23.2 ft
9	10	0	0	0	1	0		0.00 ft	24.3 ft
10	11	1	0	0	0	0		0.00 ft	5.8 ft
9	12	0	0	0	1	0		0.00 ft	24.3 ft
12	13	1	0	0	0	0		0.00 ft	5.8 ft
8	14	0	0	0	1	0		0.00 ft	23.2 ft
14	15	0	0	0	1	0		0.00 ft	24.3 ft
15	16	1	0	0	0	0		0.00 ft	5.8 ft
14	17	0	0	0	1	0		0.00 ft	24.3 ft
17	18	1	0	0	0	0		0.00 ft	5.8 ft
6	19	0	0	0	1	0		0.00 ft	12.2 ft
19	20	1	0	0	0	0		0.00 ft	26.1 ft
20	21	1	0	0	0	0		0.00 ft	5.8 ft

Part 3 - Nozzles

Start	End	Flow	Name	Size	Type	Nozzle Area
0	1	276.0 lbs				
1	2	276.0 lbs				
2	3	828.0 lbs				
3	4	828.0 lbs				
4	5	828.0 lbs				
5	6	828.0 lbs				
6	7	677.8 lbs				
7	8	677.8 lbs				
8	9	339.0 lbs				
9	10	169.5 lbs				
10	11	169.5 lbs	E2-N1	2 in	8 Port-BR	1.5462 square in
9	12	169.5 lbs				
12	13	169.5 lbs	E2-N2	2 in	8 Port-BR	1.5462 square in
8	14	338.8 lbs				
14	15	169.5 lbs				
15	16	169.5 lbs	E2-N3	2 in	8 Port-BR	1.5462 square in
14	17	169.3 lbs				

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Consolidated Report

Part 3 - Nozzles

Start	End	Flow	Name	Size	Type	Nozzle Area
17	18	169.3 lbs	E2-N4	2 in	8 Port-BR	1.5462 square in
6	19	150.2 lbs				
19	20	150.2 lbs				
20	21	150.2 lbs	E1-N1	2 in	7 Port-BR	1.2684 square in

Parts Information

Total Agent Required: 828.0 lbs
Cylinder Name: 180 Liter DOT Cylinder (Part: 570009)
Number Of Cylinders: 3

Nozzle	Type	Diameter	Nozzle Area	Part Number
E1-N1	7 Port-BR	2 in	1.2684 square in	570162
E2-N1	8 Port-BR	2 in	1.5462 square in	570162
E2-N2	8 Port-BR	2 in	1.5462 square in	570162
E2-N3	8 Port-BR	2 in	1.5462 square in	570162
E2-N4	8 Port-BR	2 in	1.5462 square in	570162

Nozzle	Drill Diameter	Drill Size
E1-N1	0.4803 inches	12.2 mm
E2-N1	0.4961 inches	12.6 mm
E2-N2	0.4961 inches	12.6 mm
E2-N3	0.4961 inches	12.6 mm
E2-N4	0.4961 inches	12.6 mm

Pipe:	Type	Diameter	Length
	US80BTS	3 in	3.83 ft
	US40BTS	2 in	75.50 ft
	US40BTS	2-1/2 in	19.60 ft
	US40BTS	3 in	38.50 ft
	US40BTS	4 in	10.40 ft

'Other' Items:

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Consolidated Report

3 - 2 in Check&Flex (Part: 570142 and 570121)

List of 90 degree elbows:
6 - 2 in
2 - 3 in
2 - 4 in

List of Tees:
2 - 2-1/2 in
1 - 3 in
1 - 4 in

System Acceptance

System Discharge Time: 9.9 seconds
Percent Agent In Pipe: 63.7%
Percent Agent Before First Tee: 17.4%

Enclosure Number: 1
Enclosure Name: Switch Room

Minimum Design Concentration: 7.200%
Adjusted Design Concentration: 7.215%
Predicted Concentration: 7.241%
Maximum Expected Agent Concentration: 7.241% (At 70 F)

Nozzle	Minimum Agent Required	Adjusted Agent Required	Predicted Agent Delivered	Nozzle Pressure (Average)
E1-N1	149.9 lbs	150.2 lbs	150.8 lbs	120 psig

Enclosure Number: 2
Enclosure Name: Computer Room

Minimum Design Concentration: 7.200%
Adjusted Design Concentration: 7.215%
Predicted Concentration: 7.210%
Maximum Expected Agent Concentration: 7.210% (At 70 F)

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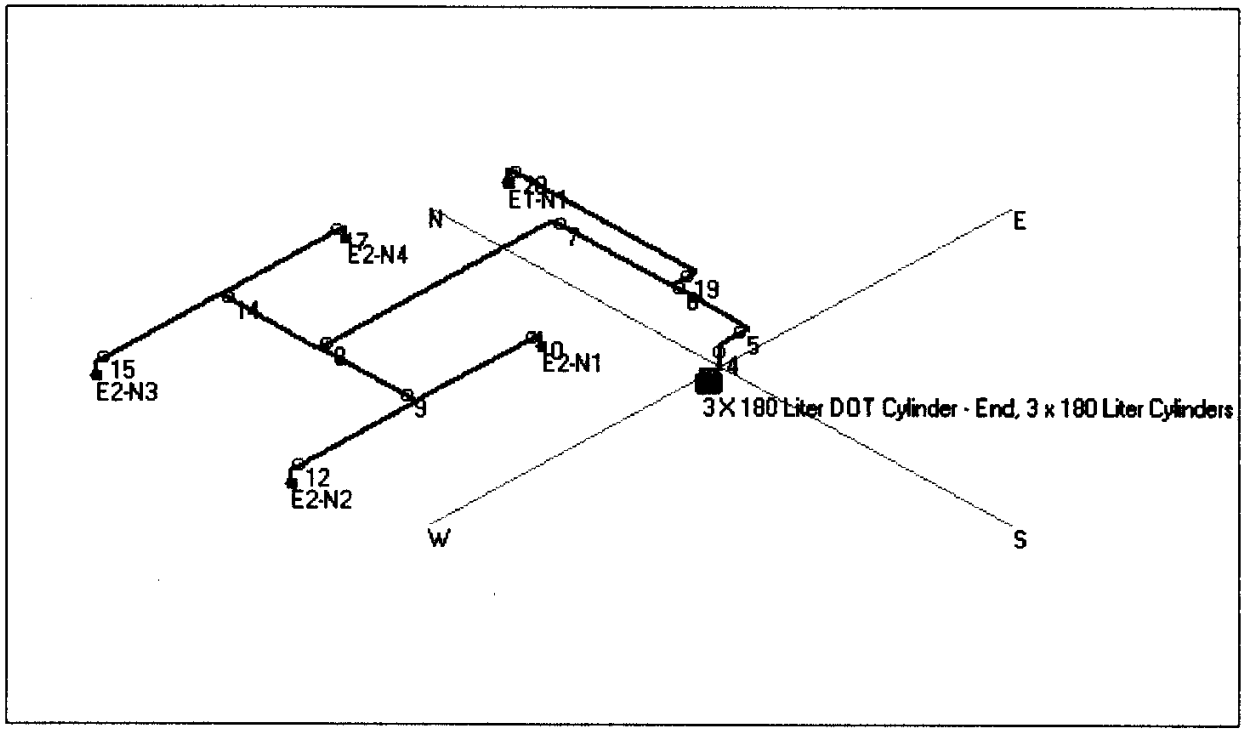
Nozzle	Minimum Agent Required	Adjusted Agent Required	Predicted Agent Delivered	Nozzle Pressure (Average)
E2-N1	169.1 lbs	169.5 lbs	169.3 lbs	90 psig
E2-N2	169.1 lbs	169.5 lbs	169.3 lbs	90 psig
E2-N3	169.1 lbs	169.5 lbs	169.3 lbs	90 psig
E2-N4	168.9 lbs	169.3 lbs	169.3 lbs	90 psig

Standard Isometric View



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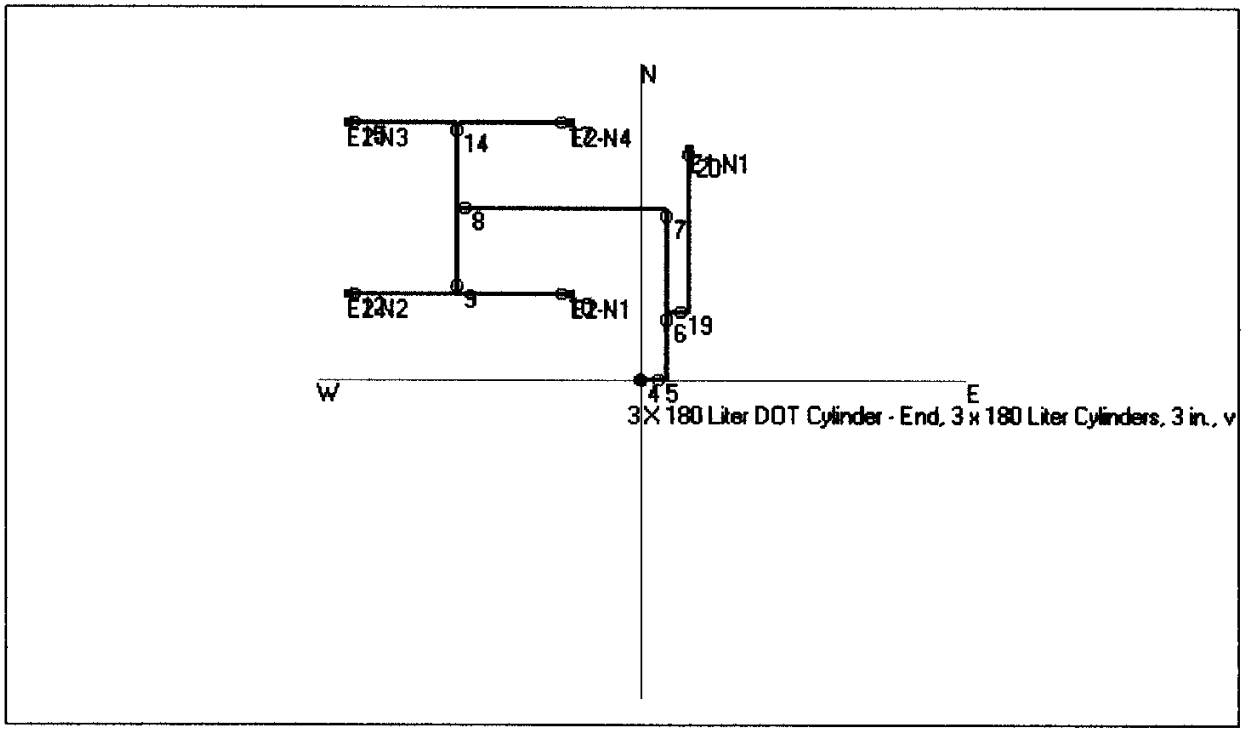
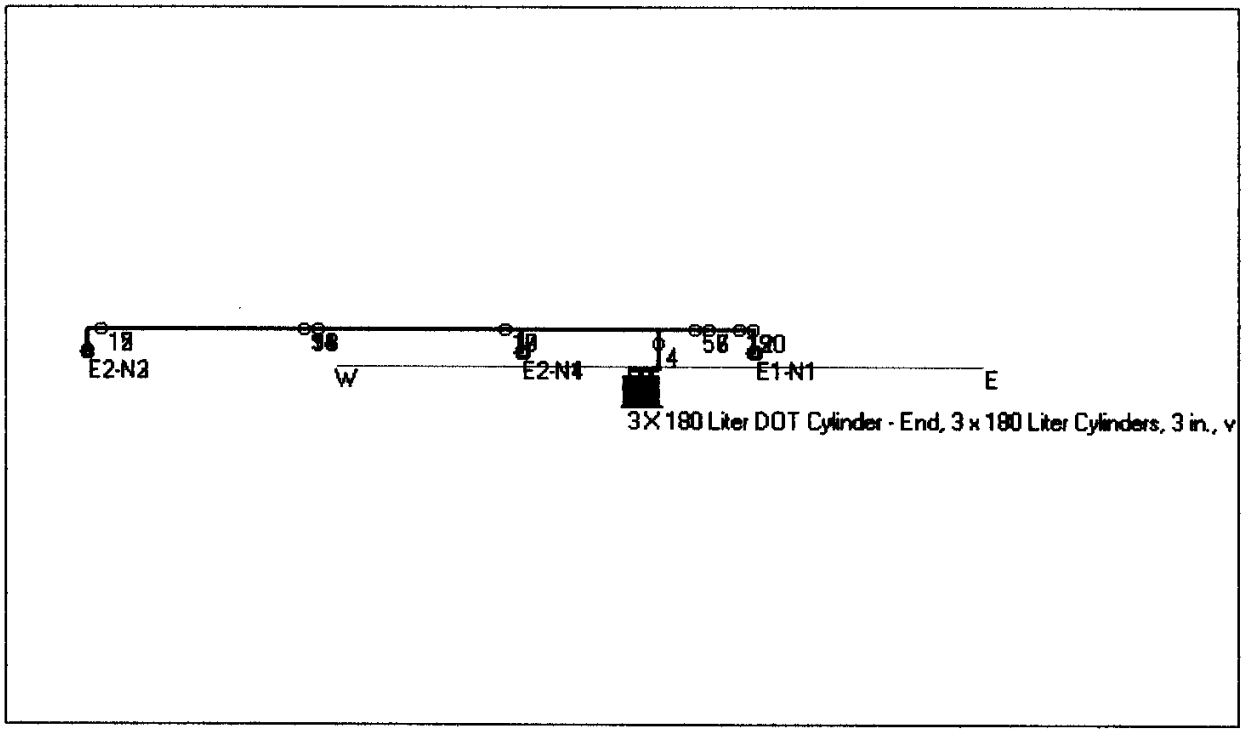
Consolidated Report

Standard Plan View



Standard Elevation View



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Great Lakes Chemical Corporation MATERIAL SAFETY DATA SHEET

MSDS Number: 00057 **Effective Date:** 4/7/98
Product Name: **FM-200** **Page:** 1 of 9

SECTION I - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name:	**FM-200**
Manufacturer:	Great Lakes Chemical Corporation
Address:	P.O. Box 2200
City:	West Lafayette
State:	Indiana
Zip:	47996-2200
Emergency Telephone Number:	**1-800-949-5167**
Information Telephone Number:	1-765-497-6100 **Fax:** 1-765-497-6123
Chemtrec Phone:	**1-800-424-9300**
Effective Date:	4/7/98
Supercede Date:	8/11/97
MSDS Prepared By:	Regulatory Affairs Department/Great Lakes Chemical Corporation
Synonyms:	1,1,1,2,3,3,3-Heptafluoropropane, 2H-Heptafluoropropane
Product Use:	Fire extinguishing, fire suppression, explosion suppression and inerting agent
Chemical Name:	1,1,1,2,3,3,3-Heptafluoropropane
Chemical Family:	Halogenated alkane

Additional Information

No information available

SECTION II - COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENT NAME	CAS No.	%	EXPOSURE LIMITS
1,1,1,2,3,3,3-Heptafluoropropane	431890	>99	Y (Hazardous) Not established (OSHA PEL TWA) Not established (OSHA PEL STEL) Not established (OSHA PEL CEIL) Not established (ACGIH TLV TWA) Not established (ACGIH TLV STEL) Not established (ACGIH TLV CEIL)

*Mixture. Indented chemicals components of mixture.

Additional Information

No information available

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SECTION III - HAZARDS IDENTIFICATION

Emergency Overview:	Colorless gas Odorless Direct eye or skin contact with the liquid or cold gas can cause chilling or possibly frostbite of exposed tissues. May cause central nervous system effects. Inhalation of high concentrations can be harmful or fatal due to oxygen deprivation and/or heart irregularities.
Relevant Routes of Exposure:	Inhalation
Signs and Symptoms of Overexposure:	Symptoms similar to oxygen deprivation (headache, nausea, dizziness or loss of consciousness) may result from overexposure by inhalation. Heart irregularities such as irregular pulse or heart palpitations may indicate cardiac sensitivity. Cold, white or discolored skin or in severe cases blistering, can be a sign of frostbite caused by cold liquids or gases.
Medical Conditions Generally Aggravated By Exposure:	Persons with preexisting cardiac, respiratory, or central nervous system disorders may be more susceptible to effects of an overexposure. The use of epinephrine or similar compounds can increase susceptibility to heart irregularities caused by excessive exposure to these types of compounds.
Potential Health Effects:	See Section XI for additional information.
Eyes:	Direct eye contact with the liquid or cold gas can cause chilling or possibly frostbite of exposed tissues.
Skin:	Direct skin contact with the liquid or cold gas can cause chilling or possibly frostbite of exposed tissues.
Ingestion:	Not expected to be a hazard in normal industrial use.
Inhalation:	Inhalation of high concentrations can be harmful or fatal due to oxygen deprivation and/or heart irregularities (arrhythmias). Misuse of the product by deliberately inhaling high concentrations of this gas could cause death without warning.
Carcinogenicity:	
NTP:	No
IARC:	No
OSHA:	No
ACGIH:	No
OTHER:	No

Additional Information

No information available

SECTION IV - FIRST AID MEASURES

Eyes:	Flush with water. Get medical attention.
Skin:	Flush with water; if frostbite occurs get medical attention.
Ingestion:	No information available
Inhalation:	Remove person to fresh air; if not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical

SECTION IV - FIRST AID MEASURES

	attention.
Antidotes:	No information available
Notes to Physicians and/or Protection for First-Aiders:	The use of epinephrine or similar compounds can increase susceptibility to heart irregularities caused by excessive exposure to these types of compounds.

Additional Information

No information available

SECTION V - FIRE FIGHTING MEASURES

Flammable Limits in Air (% by Volume):	Not applicable
Flash Point:	Nonflammable gas
Autoignition Temperature:	Not available
Extinguishing Media:	All conventional media are suitable.
Fire Fighting Instructions:	Keep cylinders cool with a water spray applied from a safe distance. Use a self-contained breathing apparatus if containers rupture or release under fire conditions. Do not allow reentry into areas where this material has been released without first ventilating to remove products of combustion/decomposition.
Unusual Fire and Explosion Hazards:	Although containers of our product are provided with pressure and temperature relief devices, containers can rupture if exposed to localized heat. Thermal decomposition will generate toxic and corrosive gases.
Flammability Classification:	Nonflammable gas
Known or Anticipated Hazardous Products of Combustion:	Decomposition by elevated temperatures (fire conditions, glowing metal surfaces) may generate hazardous decomposition products common to other CFCs, HCFCs or HBFCs. These can include hydrogen fluoride, carbon monoxide, carbon dioxide and others.

Additional Information

NNo information availabl

SECTION VI - ACCIDENTAL RELEASE MEASURES

Accidental Release Measures:	Evacuate the area and ventilate. Do not enter areas where high concentrations may exist (especially confined or poorly ventilated areas) without appropriate protective equipment including a self-contained breathing apparatus.
Personal Precautions:	See Section VIII.
Environmental Precautions:	No information available

Additional Information

No information available

SECTION VII - HANDLING AND STORAGE

Handling:	Use the same type of precautions as would be used in handling any cryogenic gas. Protect container from damage. Handle in well-ventilated areas. When this material is used as a firefighting agent in fixed or portable extinguishing systems, follow manufacturer's instructions for operation, inspection, maintenance and repair of the system.
Storage:	Store in a cool, dry, well-ventilated area away from incompatible materials. Keep container tightly closed.
Other Precautions:	No information available

Additional Information

No information available

SECTION VIII - EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls:	No information available
Ventilation Requirements:	Use local ventilation to minimize exposure to gas. Use mechanical ventilation for general area control.
Personal Protective Equipment:	
Eye/Face Protection:	Chemical splash goggles when handling liquid
Skin Protection:	Use lined neoprene gloves if handling liquid. Clothing designed to minimize skin contact
Respiratory Protection:	Wear a NIOSH/MSHA approved self-contained breathing apparatus in emergency situations. Consult the OSHA respiratory protection information located at 29CFR 1910.134 and the American National Standard Institute's Practices of Respiratory Protection Z88.2.
Other Protective Clothing or Equipment:	No information available
Exposure Guidelines:	See Section II.
Work Hygienic Practices:	Wash thoroughly after handling. Wash contaminated clothing before reuse. Make sure piping is empty before doing maintenance work.

Additional Information

No information available

SECTION IX - PHYSICAL & CHEMICAL PROPERTIES

Appearance:	Colorless gas
Boiling Point:	-16.4 degrees C (3 degrees F)
Bulk Density:	Not available
Color:	Colorless
Decomposition	

SECTION IX - PHYSICAL & CHEMICAL PROPERTIES

Temperature:	Not available
Evaporation Rate:	Not available
Freezing Point:	Not available
Heat Value:	Not available
Melting Point:	-131 degrees C (-204 degrees F)
Molecular/Chemical Formula:	C3HF7
Molecular Weight:	170
Octanol/Water Partition Coefficient:	Not available
Odor:	Odorless
Odor Threshold:	Not available
Particle Size:	Not available
Percent Volatile:	Not available
pH Value:	Not available
pH Concentration:	Not available
Physical State:	Gas
Reactivity in Water:	Not water reactive
Saturated Vapor Concentration:	Not available
Softening Point:	Not available
Solubility in Water:	260 mg/L
Specific Gravity or Density (Water=1):	1.46
Vapor Density:	6.04
Vapor Pressure:	58.8 psia at 70 degrees F (21 degreesC)
Viscosity:	Not available
Volatile Organic Compounds:	Not available
Water/Oil Distribution Coefficient:	Not available
Weight Per Gallon:	Not available

Additional Information

No information available

SECTION X - STABILITY AND REACTIVITY

Stability: Stable under normal conditions of handling and use.

Conditions to Avoid: None

Incompatibility With Other Materials: Powdered metals (ex. Al, Mg, or Zn) and strong alkalis, oxidizers or reducing agents are not compatible with this and most other halogenated organic compounds.

Hazardous Decomposition Products: Thermal decomposition may produce the following:

SECTION X - STABILITY AND REACTIVITY

Hydrogen fluoride
Carbon monoxide and carbon dioxide

Hazardous Polymerization: Will not occur

Conditions to Avoid: None

Additional Information

No information available

SECTION XI - TOXICOLOGICAL INFORMATION

VALUE (LD50 OR LC50)	ANIMAL	ROUTES	COMPONENTS
>788,696 ppm/4H	Rat	Acute Inhalation	1,1,1,2,3,3,3-Heptafluoropropane

Toxicological Information:

The human health hazards of this product are expected to be similar to other liquified gases including N2, CO2, CFCs, HCFCs, and HBFCs. Therefore, direct eye or skin contact with the liquid or cold gas can cause chilling or possibly frostbite of exposed tissues. Inhalation of high concentrations can be harmful or fatal due to oxygen deprivation and/or heart irregularities (arrhythmias). Misuse of the product by deliberately inhaling high concentrations of this gas could cause death without warning. Persons with preexisting cardiac or central nervous system disorders may be more susceptible to effects of an overexposure.

When tested with and without metabolic activation over a concentration range of 43.9-93.5%, heptafluoropropane was not mutagenic in S. typhimurium. Neither toxicity nor mutagenicity was observed in a mouse lymphoma assay when heptafluoropropane was tested to a concentration of 56.8%. Neither toxicity nor an increase in micronuclei was observed in mice exposed to 10.5% heptafluoropropane. Therefore, there is no evidence that heptafluoropropane is capable of inducing gene or chromosomal mutations in vitro or chromosomal effects in vivo. In other studies, heptafluoropropane did not show genotoxicity or cytotoxicity.

Animal studies have found the rat 4 hour LC50 to be >788,696 ppm (~80%), the highest level tested. A cardiac sensitization study in dogs found the No Observable Adverse Effect Level (NOAEL) to be 9.0%. The Lowest Observable Adverse Effect Level (LOAEL) for this study was reported to be 10.5%. A 90 day inhalation study did not find any exposure related effects at 105,000 ppm (10.5% vol./vol.), the highest level tested. Inhalation studies looking for developmental effects on pregnant rabbits and rats or their offspring did not show any exposure related effects at the highest concentrations tested (105,000 ppm).

Additional Information

No information available

SECTION XII - ECOLOGICAL INFORMATION

Ecological Information: No information available

Additional Information

No information available

SECTION XIII - DISPOSAL CONSIDERATIONS

Disposal Considerations: Non-contaminated product is reclaimable. Contact Great Lakes Chemical Corporation for information. Otherwise, dispose of waste in an approved chemical incinerator equipped with a scrubber as allowed by current Local, State/Province, Federal/Canadian laws and regulations.

Additional Information

No information available

SECTION XIV - TRANSPORT INFORMATION

U.S. DOT

Proper Shipping Name:	Heptafluoropropane
Hazard Class:	2.2
ID Number:	UN3296
Packing Group:	N/A
Labels:	Nonflammable gas
Special Provisions:	N/A
Packaging Exceptions:	306
Non-Bulk Packaging:	304
Bulk Packaging:	314, 315
Air/Rail Limit:	75 kg
Air Cargo Limit:	150 kg
Vessel Stowage:	A
Other Stowage:	N/A
Reportable Quantity:	N/A

AIR - ICAO OR IATA

Proper Shipping Name:	Heptafluoropropane
Hazard Class:	2.2
ID Number:	UN3296
Subsidiary Risk:	N/A
Packing Group:	N/A
Hazard Labels:	Nonflammable gas
Packing Instructions:	200
Air Passenger Limit Per Package:	75 kg
Packing Instruction - Cargo:	200
Air Cargo Limit Per Package:	150 kg
Special Provisions Code:	N/A

WATER - IMDG

SECTION XIV - TRANSPORT INFORMATION

Proper Shipping Name:	Heptafluoropropane
Hazard Class:	2.2
ID Number:	UN3296
Packing Group:	N/A
Subsidiary Risk:	N/A
Medical First Aid Guide Code:	350

Additional Information

EmS No. 2-09

SECTION XV - REGULATORY INFORMATION

U.S. Federal Regulations:	The components of this product are either on the TSCA Inventory or exempt (i.e. impurities, a polymer complying with the exemption rule at 40 CFR 723.250) from the Inventory.
State Regulations:	None known
International Regulations:	This material (or each component) is listed on the following inventories: EU - EINECS Canadian WHMIS Hazard Class and Division = A.
SARA Hazards:	
Acute:	Yes
Chronic:	No
Reactive:	No
Fire:	No
Pressure:	No

Additional Information

The above regulatory information represents only selected regulations and is not meant to be a complete list.

SECTION XVI - OTHER INFORMATION

NFPA Codes:	
Health:	1
Flammability:	0
Reactivity:	0
Other:	0
HMIS Codes:	
Health:	1
Flammability:	0
Reactivity:	0
Protection:	X
Label Statements:	Not available
Other Information:	Abbreviations: (L) = Loose bulk density in g/ml LOEC = Lowest observed effect concentration

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SECTION XVI - OTHER INFORMATION

MATC = Maximum acceptable toxicant concentration
NA = Not available
N/A = Not applicable
NL = Not limited
NOEC = No observed effect concentration
NOEL = No observable effect level
NR = Not rated
(P) = Packed bulk density in g/ml
PNOC = Particulates Not Otherwise Classified
PNOR = Particulates Not Otherwise Regulated
REL = Recommended exposure limit
TS = Trade secret

Additional Information

Information on this form is furnished solely for the purpose of compliance with OSHA's Hazard Communication Standard, 29CFR 1910.1200 and The Canadian Environmental Protection Act, Canada Gazette Part II, Vol. 122, No. 2 and shall not be used for any other purpose.

Revision Information:
Section XIV - IMDG Code Information
Section XV - Regulatory Information

006060i

106L Tank

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
7.5										
7.75	110.9	110.4	109.8							
8	113.2	112.8	112.2	110.9	109.7					
8.25	115.6	115.1	114.5	113.2	112.0	111.2	110.4			
8.5	118.0	117.5	116.8	115.5	114.2	113.4	112.5	111.7	110.8	
8.75	120.4	119.8	119.1	117.8	116.5	115.6	114.7	113.8	112.9	
9	122.8	122.2	121.4	120.1	118.7	117.8	116.9	115.9	114.9	112.0
9.25	125.1	124.5	123.7	122.4	121.0	120.0	119.0	118.0	116.9	114.0
9.5	127.5	126.9	126.1	124.6	123.2	122.2	121.2	120.1	119.0	116.0
9.75	129.9	129.2	128.4	126.9	125.5	124.4	123.4	122.2	121.0	118.0
10	132.3	131.6	130.7	129.2	127.7	126.6	125.5	124.3	123.0	120.0
10.25	134.7	133.9	133.0	131.5	130.0	128.9	127.7	126.4	125.1	122.0
10.5	137.1	136.3	135.3	133.8	132.3	131.1	129.9	128.5	127.1	124.0
10.75	139.4	138.6	137.6	136.1	134.5	133.3	132.0	130.6	129.1	126.0
11	141.8	141.0	140.0	138.4	136.8	135.5	134.2	132.7	131.2	128.0
11.25	144.2	143.3	142.3	140.6	139.0	137.7	136.4	134.8	133.2	130.0
11.5	146.6	145.7	144.6	142.9	141.3	139.9	138.5	136.9	135.3	132.0
11.75	149.0	148.1	146.9	145.2	143.5	142.1	140.7	139.0	137.3	134.1
12	151.4	150.4	149.2	147.5	145.8	144.3	142.9	141.1	139.3	136.1
12.25	153.7	152.8	151.5	149.8	148.0	146.5	145.0	143.2	141.4	138.1
12.5	156.1	155.1	153.8	152.1	150.3	148.7	147.2	145.3	143.4	140.1
12.75	158.5	157.5	156.2	154.4	152.6	151.0	149.4	147.4	145.4	142.1
13	160.9	159.8	158.5	156.6	154.8	153.2	151.5	149.5	147.5	144.1
13.25	163.3	162.2	160.8	158.9	157.1	155.4	153.7	151.6	149.5	146.1
13.5	165.7	164.5	163.1	161.2	159.3	157.6	155.9	153.7	151.5	148.1
13.75	168.0	166.9	165.4	163.5	161.6	159.8	158.0	155.8	153.6	150.1
14	170.4	169.2	167.7	165.8	163.8	162.0	160.2	157.9	155.6	152.1
14.25	172.8	171.6	170.1	168.1	166.1	164.2	162.4	160.0	157.6	154.1
14.5	175.2	173.9	172.4	170.4	168.3	166.4	164.5	162.1	159.7	156.1
14.75	177.6	176.3	174.7	172.6	170.6	168.6	166.7	164.2	161.7	158.1
15	179.9	178.6	177.0	174.9	172.9	170.9	168.9	166.3	163.7	160.1
15.25	182.2	180.9	179.2	177.2	175.1	173.1	171.0	168.4	165.8	162.1
15.5	184.6	183.2	181.5	179.4	177.4	175.3	173.2	170.5	167.8	164.2
15.75	186.9	185.5	183.7	181.6	179.6	177.5	175.4	172.6	169.8	166.2
16	189.3	187.8	185.9	183.8	181.8	179.6	177.5	174.7	171.9	168.2
16.25	191.6	190.1	188.2	186.1	184.0	181.8	179.7	176.8	173.9	170.2
16.5	194.0	192.4	190.4	188.3	186.2	184.0	181.8	178.9	175.9	172.2
16.75	196.3	194.7	192.6	190.5	188.4	186.2	184.0	181.0	178.0	174.2
17	198.6	197.0	194.8	192.7	190.6	188.3	186.1	183.0	180.0	176.2
17.25	201.0	199.2	197.1	194.9	192.8	190.5	188.3	185.1	182.0	178.2
17.5	203.3	201.5	199.3	197.1	195.0	192.7	190.4	187.2	184.0	180.2
17.75	205.7	203.8	201.5	199.3	197.2	194.9	192.6	189.3	186.0	182.3
18	208.0	206.1	203.8	201.6	199.4	197.0	194.7	191.4	188.1	184.3
18.25	210.4	208.4	206.0	203.8	201.6	199.2	196.8	193.5	190.1	186.3
18.5	212.7	210.7	208.2	206.0	203.8	201.4	199.0	195.5	192.1	188.4
18.75	215.0	213.0	210.5	208.2	206.0	203.6	201.1	197.6	194.1	190.4
19	217.4	215.3	212.7	210.4	208.2	205.7	203.3	199.7	196.1	192.4
19.25	219.7	217.6	214.9	212.6	210.4	207.9	205.4	201.8	198.1	194.4
19.5	222.1	219.9	217.2	214.9	212.6	210.1	207.6	203.9	200.2	196.5

APPENDIX E – WEIGHT CONVERSION TABLE
(English Version)

106L Tank (Continued)

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
19.75	224.4	222.2	219.4	217.1	214.8	212.2	209.7	206.0	202.2	198.5
20	226.8	224.5	221.6	219.3	217.0	214.4	211.9	208.0	204.2	200.5
20.25	229.1	226.8	223.8	221.5	219.2	216.6	214.0	210.1	206.2	202.6
20.5	231.4	229.1	226.1	223.7	221.4	218.8	216.2	212.2	208.2	204.6
20.75	233.8	231.3	228.3	225.9	223.6	220.9	218.3	214.3	210.2	206.6
21	236.1	233.6	230.5	228.1	225.8	223.1	220.5	216.4	212.3	208.6
21.25	238.5	235.9	232.8	230.4	228.0	225.3	222.6	218.4	214.3	210.7
21.5	240.8	238.2	235.0	232.6	230.2	227.5	224.8	220.5	216.3	212.7
21.75			237.2	234.8	232.4	229.6	226.9	222.6	218.3	214.7
22			239.5	237.0	234.6	231.8	229.1	224.7	220.3	216.7
22.25					236.8	234.0	231.2	226.8	222.3	218.8
22.5					239.0	236.2	233.4	228.9	224.4	220.8
22.75							235.5	230.9	226.4	222.8
23							237.7	233.0	228.4	224.9
23.25							239.8	235.1	230.4	226.9
23.5							242.0	237.2	232.4	228.9
23.75									234.4	230.9
24									236.5	233.0
24.25										235.0
24.5										237.0

147L Tank

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
10										
10.25	154.2	153.8	153.3							
10.5	156.7	156.3	155.8	154.4	153.0					
10.75	159.2	158.7	158.2	156.7	155.3	154.2	153.0			
11	161.7	161.2	160.6	159.1	157.6	156.4	155.2	153.2	151.2	
11.25	164.2	163.7	163.0	161.5	159.9	158.7	157.4	155.4	153.4	
11.5	166.7	166.1	165.4	163.8	162.3	161.0	159.7	157.6	155.5	
11.75	169.2	168.6	167.8	166.2	164.6	163.2	161.9	159.7	157.6	
12	171.7	171.1	170.2	168.6	166.9	165.5	164.1	161.9	159.8	153.3
12.25	174.2	173.5	172.7	170.9	169.2	167.7	166.3	164.1	161.9	155.4
12.5	176.7	176.0	175.1	173.3	171.6	170.0	168.5	166.2	164.0	157.6
12.75	179.2	178.5	177.5	175.7	173.9	172.3	170.7	168.4	166.2	159.7
13	181.7	180.9	179.9	178.1	176.2	174.5	172.9	170.6	168.3	161.9
13.25	184.2	183.4	182.3	180.4	178.5	176.8	175.1	172.7	170.4	164.0
13.5	186.7	185.8	184.7	182.8	180.9	179.1	177.3	174.9	172.5	166.2
13.75	189.2	188.3	187.2	185.2	183.2	181.3	179.5	177.1	174.7	168.3
14	191.7	190.8	189.6	187.5	185.5	183.6	181.7	179.2	176.8	170.5
14.25	194.2	193.2	192.0	189.9	187.8	185.9	183.9	181.4	178.9	172.6
14.5	196.7	195.7	194.4	192.3	190.2	188.1	186.1	183.6	181.1	174.8
14.75	199.2	198.2	196.8	194.7	192.5	190.4	188.3	185.8	183.2	176.9
15	201.7	200.6	199.2	197.0	194.8	192.7	190.5	187.9	185.3	179.0
15.25	204.3	203.1	201.7	199.4	197.1	194.9	192.7	190.1	187.5	181.2
15.5	206.8	205.6	204.1	201.8	199.5	197.2	194.9	192.3	189.6	183.3
15.75	209.3	208.0	206.5	204.1	201.8	199.4	197.1	194.4	191.7	185.5
16	211.8	210.5	208.9	206.5	204.1	201.7	199.3	196.6	193.9	187.6
16.25	214.3	213.0	211.3	208.9	206.4	204.0	201.5	198.8	196.0	189.8
16.5	216.8	215.4	213.7	211.3	208.8	206.2	203.7	200.9	198.1	191.9
16.75	219.3	217.9	216.2	213.6	211.1	208.5	205.9	203.1	200.3	194.1
17	221.8	220.4	218.6	216.0	213.4	210.8	208.1	205.3	202.4	196.2
17.25	224.3	222.8	221.0	218.4	215.7	213.0	210.3	207.4	204.5	198.4
17.5	226.8	225.3	223.4	220.7	218.1	215.3	212.5	209.6	206.7	200.5
17.75	229.3	227.7	225.8	223.1	220.4	217.6	214.7	211.8	208.8	202.6
18	231.8	230.2	228.2	225.5	222.7	219.8	216.9	213.9	210.9	204.8
18.25	234.3	232.7	230.7	227.8	225.0	222.1	219.1	216.1	213.0	206.9
18.5	236.8	235.1	233.1	230.2	227.4	224.4	221.3	218.3	215.2	209.1
18.75	239.3	237.6	235.5	232.6	229.7	226.6	223.6	220.4	217.3	211.2
19	241.8	240.1	237.9	235.0	232.0	228.9	225.8	222.6	219.4	213.4
19.25	244.3	242.5	240.3	237.3	234.3	231.1	228.0	224.8	221.6	215.5
19.5	246.6	244.9	242.7	239.7	236.7	233.4	230.2	226.9	223.7	217.7
19.75	249.0	247.3	245.1	242.0	239.0	235.7	232.4	229.1	225.8	219.8
20	251.4	249.6	247.3	244.3	241.3	237.9	234.6	231.3	228.0	221.9
20.25	253.7	251.9	249.6	246.6	243.6	240.2	236.8	233.4	230.1	224.1
20.5	256.1	254.2	251.8	248.8	245.8	242.4	239.0	235.6	232.2	226.2
20.75	258.5	256.5	254.1	251.1	248.0	244.6	241.2	237.8	234.4	228.4
21	260.8	258.8	256.3	253.3	250.2	246.8	243.4	239.9	236.5	230.5
21.25	263.2	261.2	258.6	255.5	252.4	249.0	245.5	242.1	238.6	232.7
21.5	265.6	263.5	260.8	257.7	254.6	251.1	247.6	244.2	240.8	234.8
21.75	267.9	265.8	263.1	260.0	256.8	253.3	249.8	246.3	242.9	237.0
22	270.3	268.1	265.3	262.2	259.0	255.5	251.9	248.4	245.0	239.1

APPENDIX E – WEIGHT CONVERSION TABLE
(English Version)

147L Tank (Continued)

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
22.25	272.7	270.4	267.6	264.4	261.2	257.6	254.0	250.5	247.0	241.3
22.5	275.0	272.7	269.8	266.6	263.4	259.8	256.1	252.6	249.1	243.4
22.75	277.4	275.0	272.1	268.9	265.6	261.9	258.2	254.7	251.1	245.5
23	279.8	277.4	274.3	271.1	267.8	264.1	260.4	256.7	253.1	247.6
23.25	282.1	279.7	276.6	273.3	270.0	266.3	262.5	258.8	255.2	249.6
23.5	284.5	282.0	278.8	275.5	272.2	268.4	264.6	260.9	257.2	251.7
23.75	286.9	284.3	281.1	277.8	274.4	270.6	266.7	263.0	259.2	253.7
24	289.2	286.6	283.3	280.0	276.6	272.7	268.8	265.1	261.3	255.8
24.25	291.6	288.9	285.6	282.2	278.8	274.9	270.9	267.1	263.3	257.9
24.5	294.0	291.2	287.8	284.4	281.0	277.0	273.1	269.2	265.4	259.9
24.75	296.3	293.6	290.1	286.7	283.2	279.2	275.2	271.3	267.4	262.0
25	298.7	295.9	292.3	288.9	285.4	281.4	277.3	273.4	269.4	264.1
25.25	301.1	298.2	294.6	291.1	287.6	283.5	279.4	275.4	271.5	266.1
25.5	303.4	300.5	296.8	293.3	289.8	285.7	281.5	277.5	273.5	268.2
25.75	305.8	302.8	299.1	295.5	292.0	287.8	283.7	279.6	275.5	270.3
26	308.2	305.1	301.3	297.8	294.2	290.0	285.8	281.7	277.6	272.3
26.25	310.5	307.4	303.6	300.0	296.4	292.2	287.9	283.7	279.6	274.4
26.5	312.9	309.8	305.8	302.2	298.6	294.3	290.0	285.8	281.6	276.4
26.75	315.3	312.1	308.1	304.4	300.8	296.5	292.1	287.9	283.7	278.5
27	317.6	314.4	310.3	306.7	303.0	298.6	294.2	290.0	285.7	280.6
27.25	320.0	316.7	312.6	308.9	305.2	300.8	296.4	292.1	287.8	282.6
27.5	322.4	319.0	314.8	311.1	307.4	302.9	298.5	294.1	289.8	284.7
27.75	324.7	321.3	317.1	313.3	309.6	305.1	300.6	296.2	291.8	286.8
28	327.1	323.6	319.3	315.6	311.8	307.3	302.7	298.3	293.9	288.8
28.25	329.4	326.0	321.6	317.8	314.0	309.4	304.8	300.4	295.9	290.9
28.5			323.8	320.0	316.2	311.6	307.0	302.4	297.9	293.0
28.75			326.1	322.2	318.4	313.7	309.1	304.5	300.0	295.0
29			328.3	324.5	320.6	315.9	311.2	306.6	302.0	297.1
29.25			330.6	326.7	322.8	318.1	313.3	308.7	304.1	299.2
29.5					325.0	320.2	315.4	310.8	306.1	301.2
29.75					327.2	322.4	317.5	312.8	308.1	303.3
30					329.4	324.5	319.7	314.9	310.2	305.3
30.25					331.6	326.7	321.8	317.0	312.2	307.4
30.5							323.9	319.1	314.2	309.5
30.75							326.0	321.1	316.3	311.5
31							328.1	323.2	318.3	313.6
31.25							330.3	325.3	320.4	315.7
31.5									322.4	317.7
31.75									324.4	319.8
32									326.5	321.9
32.25										323.9
32.5										326.0

180L Tank

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
2.5	189.9	188.9	187.5							
2.75	192.4	191.3	190.0	188.7	187.4					
3	195.0	193.8	192.4	191.1	189.7	189.2	188.7			
3.25	197.5	196.3	194.9	193.5	192.1	191.5	190.9			
3.5	200.0	198.8	197.3	195.9	194.5	193.8	193.1	189.5	185.9	
3.75	202.5	201.3	199.7	198.3	196.8	196.1	195.4	191.7	188.0	
4	205.0	203.8	202.2	200.7	199.2	198.4	197.6	193.9	190.2	
4.25	207.5	206.2	204.6	203.1	201.6	200.7	199.8	196.1	192.4	
4.5	210.1	208.7	207.0	205.5	203.9	203.0	202.1	198.3	194.5	
4.75	212.6	211.2	209.5	207.9	206.3	205.3	204.3	200.5	196.7	190.4
5	215.1	213.7	211.9	210.3	208.7	207.6	206.5	202.7	198.8	192.5
5.25	217.6	216.2	214.4	212.7	211.0	209.9	208.8	204.9	201	194.7
5.5	220.1	218.7	216.8	215.1	213.4	212.2	211.0	207.1	203.2	196.8
5.75	222.7	221.1	219.2	217.5	215.8	214.5	213.2	209.3	205.3	198.9
6	225.2	223.6	221.7	219.9	218.1	216.8	215.5	211.5	207.5	201
6.25	227.7	226.1	224.1	222.3	220.5	219.1	217.7	213.7	209.6	203.1
6.5	230.2	228.6	226.6	224.7	222.9	221.4	219.9	215.9	211.8	205.2
6.75	232.7	231.1	229.0	227.1	225.2	223.7	222.2	218.1	214.0	207.3
7	235.2	233.6	231.4	229.5	227.6	226.0	224.4	220.3	216.1	209.5
7.25	237.8	236.0	233.9	231.9	230.0	228.3	226.6	222.5	218.3	211.6
7.5	240.3	238.5	236.3	234.3	232.3	230.6	228.9	224.7	220.4	213.7
7.75	242.8	241.0	238.8	236.7	234.7	232.9	231.1	226.9	222.6	215.8
8	245.3	243.5	241.2	239.1	237.1	235.2	233.4	229.1	224.8	217.9
8.25	247.8	246.0	243.6	241.5	239.4	237.5	235.6	231.3	226.9	220.0
8.5	250.3	248.4	246.1	243.9	241.8	239.8	237.8	233.5	229.1	222.2
8.75	252.9	250.9	248.5	246.3	244.2	242.1	240.1	235.7	231.3	224.3
9	255.4	253.4	251.0	248.8	246.5	244.4	242.3	237.8	233.4	226.4
9.25	257.9	255.9	253.4	251.2	248.9	246.7	244.5	240.0	235.6	228.5
9.5	260.4	258.4	255.8	253.6	251.3	249.0	246.8	242.2	237.7	230.6
9.75	262.9	260.9	258.3	256.0	253.7	251.3	249.0	244.4	239.9	232.7
10	265.5	263.3	260.7	258.4	256.0	253.6	251.2	246.6	242.1	234.8
10.25	268.0	265.8	263.1	260.8	258.4	255.9	253.5	248.8	244.2	237.0
10.5	270.5	268.3	265.6	263.2	260.8	258.2	255.7	251.0	246.4	239.1
10.75	273.0	270.8	268.0	265.6	263.1	260.5	257.9	253.2	248.5	241.2
11	275.5	273.3	270.5	268.0	265.5	262.8	260.2	255.4	250.7	243.3
11.25	278.0	275.8	272.9	270.4	267.9	265.1	262.4	257.6	252.9	245.4
11.5	280.6	278.2	275.3	272.8	270.2	267.4	264.6	259.8	255.0	247.5
11.75	283.1	280.7	277.8	275.2	272.6	269.7	266.9	262.0	257.2	249.6
12	285.6	283.2	280.2	277.6	275.0	272.0	269.1	264.2	259.3	251.8
12.25	288.1	285.7	282.7	280.0	277.3	274.3	271.3	266.4	261.5	253.9
12.5	290.6	288.2	285.1	282.4	279.7	276.6	273.6	268.6	263.7	256.0
12.75	293.1	290.7	287.5	284.8	282.1	278.9	275.8	270.8	265.8	258.1
13	295.7	293.1	290.0	287.2	284.4	281.2	278.0	273.0	268.0	260.2
13.25	298.2	295.6	292.4	289.6	286.8	283.5	280.3	275.2	270.1	262.3
13.5	300.7	298.1	294.9	292.0	289.2	285.8	282.5	277.4	272.3	264.5
13.75	303.1	300.5	297.3	294.4	291.5	288.1	284.7	279.6	274.5	266.6
14	305.4	302.9	299.7	296.8	293.9	290.4	287.0	281.8	276.6	268.7
14.25	307.7	305.2	302.1	299.2	296.3	292.7	289.2	284.0	278.8	270.8
14.5	310.1	307.6	304.4	301.5	298.6	295.0	291.4	286.2	280.9	272.9

APPENDIX E – WEIGHT CONVERSION TABLE (English Version)

180L Tank (Continued)

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
14.75	312.4	309.9	306.7	303.9	301	297.3	293.7	288.4	283.1	275.0
15	314.8	312.2	309.0	306.1	303.2	299.5	295.9	290.6	285.3	277.1
15.25	317.1	314.5	311.3	308.3	305.4	301.7	298.1	292.8	287.4	279.3
15.5	319.4	316.8	313.6	310.6	307.5	304.0	300.4	295.0	289.6	281.4
15.75	321.8	319.2	315.9	312.8	309.7	306.1	302.5	297.1	291.8	283.5
16	324.1	321.5	318.2	315.0	311.9	308.2	304.6	299.2	293.9	285.6
16.25	326.4	323.8	320.5	317.3	314.1	310.4	306.7	301.4	296.1	287.7
16.5	328.8	326.1	322.8	319.5	316.2	312.5	308.8	303.5	298.2	289.8
16.75	331.1	328.4	325.1	321.8	318.4	314.6	310.8	305.6	300.4	291.9
17	333.5	330.8	327.4	324.0	320.6	316.8	312.9	307.7	302.5	294.1
17.25	335.8	333.1	329.7	326.2	322.8	318.9	315.0	309.7	304.5	296.2
17.5	338.1	335.4	332.0	328.5	325.0	321.0	317.1	311.8	306.5	298.3
17.75	340.5	337.7	334.3	330.7	327.1	323.1	319.2	313.8	308.5	300.4
18	342.8	340.1	336.6	333.0	329.3	325.3	321.3	315.9	310.5	302.5
18.25	345.2	342.4	338.9	335.2	331.5	327.4	323.3	317.9	312.6	304.5
18.5	347.5	344.7	341.2	337.4	333.7	329.5	325.4	320.0	314.6	306.5
18.75	349.8	347.0	343.5	339.7	335.8	331.7	327.5	322.1	316.6	308.6
19	352.2	349.3	345.8	341.9	338.0	333.8	329.6	324.1	318.6	310.6
19.25	354.5	351.7	348.1	344.2	340.2	335.9	331.7	326.2	320.6	312.6
19.5	356.8	354.0	350.4	346.4	342.4	338.1	333.8	328.2	322.7	314.7
19.75	359.2	356.3	352.7	348.6	344.6	340.2	335.8	330.3	324.7	316.7
20	361.5	358.6	355.0	350.9	346.7	342.3	337.9	332.3	326.7	318.8
20.25	363.9	360.9	357.3	353.1	348.9	344.5	340.0	334.4	328.7	320.8
20.5	366.2	363.3	359.6	355.3	351.1	346.6	342.1	336.4	330.7	322.8
20.75	368.5	365.6	361.9	357.6	353.3	348.7	344.2	338.5	332.8	324.9
21	370.9	367.9	364.2	359.8	355.4	350.8	346.3	340.5	334.8	326.9
21.25	373.2	370.2	366.5	362.1	357.6	353.0	348.3	342.6	336.8	328.9
21.5	375.6	372.6	368.8	364.3	359.8	355.1	350.4	344.6	338.8	331.0
21.75	377.9	374.9	371.1	366.5	362.0	357.2	352.5	346.7	340.9	333.0
22	380.2	377.2	373.4	368.8	364.2	359.4	354.6	348.7	342.9	335.0
22.25	382.6	379.5	375.7	371.0	366.3	361.5	356.7	350.8	344.9	337.1
22.5	384.9	381.8	378.0	373.3	368.5	363.6	358.8	352.8	346.9	339.1
22.75	387.2	384.2	380.3	375.5	370.7	365.8	360.8	354.9	348.9	341.1
23	389.6	386.5	382.6	377.7	372.9	367.9	362.9	356.9	351.0	343.2
23.25	391.9	388.8	384.9	380.0	375.0	370.0	365.0	359.0	353.0	345.2
23.5	394.3	391.1	387.2	382.2	377.2	372.2	367.1	361.0	355.0	347.3
23.75	396.6	393.4	389.5	384.4	379.4	374.3	369.2	363.1	357.0	349.3
24	398.9	395.8	391.8	386.7	381.6	376.4	371.3	365.1	359.0	351.3
24.25	401.3	398.1	394.1	388.9	383.8	378.5	373.3	367.2	361.1	353.4
24.5	403.6	400.4	396.4	391.2	385.9	380.7	375.4	369.3	363.1	355.4
24.75	406.0	402.7	398.7	393.4	388.1	382.8	377.5	371.3	365.1	357.4
25	408.3	405.1	401.0	395.6	390.3	384.9	379.6	373.4	367.1	359.5
25.25			403.3	397.9	392.5	387.1	381.7	375.4	369.1	361.5
25.5			405.6	400.1	394.6	389.2	383.8	377.5	371.2	363.5
25.75			407.9	402.4	396.8	391.3	385.8	379.5	373.2	365.6
26					399.0	393.5	387.9	381.6	375.2	367.6
26.25					401.2	395.6	390.0	383.6	377.2	369.6
26.5					403.4	397.7	392.1	385.7	379.3	371.7
26.75					405.5	399.8	394.2	387.7	381.3	373.7

180L Tank (Continued)

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
27					407.7	402.0	396.3	389.8	383.3	375.8
27.25							398.3	391.8	385.3	377.8
27.5							400.4	393.9	387.3	379.8
27.75							402.5	395.9	389.4	381.9
28							404.6	398.0	391.4	383.9
28.25							406.7	400.0	393.4	385.9
28.5							408.8	402.1	395.4	388.0
28.75									397.4	390.0
29									399.5	392.0
29.25									401.5	394.1
29.5										396.1
29.75										398.1
30										400.2
30.25										402.2

APPENDIX E – WEIGHT CONVERSION TABLE (English Version)

343L Tank

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
7.75	356.4	354.7	352.4	350.2	347.9					
8.00	362.1	360.2	357.8	355.5	353.1					
8.25	367.7	365.7	363.3	360.8	358.3					
8.50	373.4	371.3	368.7	366.1	363.5					
8.75	379.0	376.8	374.1	371.4	368.6	361.4	354.1	346.8	339.5	332.2
9.00	384.6	382.4	379.5	376.7	373.8	366.5	359.2	351.8	344.5	337.2
9.25	390.3	387.9	384.9	382.0	379.0	371.6	364.2	356.8	349.5	342.1
9.50	395.9	393.4	390.4	387.3	384.2	376.7	369.3	361.9	354.4	347.0
9.75	401.6	399.0	395.8	392.6	389.4	381.9	374.4	366.9	359.4	351.9
10.00	407.2	404.5	401.2	397.9	394.5	387.0	379.4	371.9	364.3	356.8
10.25	412.8	410.1	406.6	403.2	399.7	392.1	384.5	376.9	369.3	361.7
10.50	418.5	415.6	412.0	408.5	404.9	397.2	389.6	381.9	374.3	366.6
10.75	424.1	421.1	417.4	413.8	410.1	402.3	394.6	386.9	379.2	371.5
11.00	429.7	426.7	422.9	419.0	415.2	407.5	399.7	392.0	384.2	376.4
11.25	435.4	432.2	428.3	424.3	420.4	412.6	404.8	397.0	389.2	381.4
11.50	441.0	437.8	433.7	429.6	425.6	417.7	409.9	402.0	394.1	386.3
11.75	446.7	443.3	439.1	434.9	430.8	422.8	414.9	407.0	399.1	391.2
12.00	452.3	448.9	444.5	440.2	435.9	428.0	420.0	412.0	404.1	396.1
12.25	457.9	454.4	450.0	445.5	441.1	433.1	425.1	417.0	409.0	401.0
12.50	463.6	459.9	455.4	450.8	446.3	438.2	430.1	422.1	414.0	405.9
12.75	469.2	465.5	460.8	456.1	451.5	443.3	435.2	427.1	419.0	410.8
13.00	474.9	471.0	466.2	461.4	456.6	448.5	440.3	432.1	423.9	415.7
13.25	480.5	476.6	471.6	466.7	461.8	453.6	445.3	437.1	428.9	420.7
13.50	486.1	482.1	477.1	472.0	467.0	458.7	450.4	442.1	433.8	425.6
13.75	491.8	487.6	482.5	477.3	472.2	463.8	455.5	447.1	438.8	430.5
14.00	497.4	493.2	487.9	482.6	477.3	468.9	460.6	452.2	443.8	435.4
14.25	503.0	498.7	493.3	487.9	482.5	474.1	465.6	457.2	448.7	440.3
14.50	508.7	504.3	498.7	493.2	487.7	479.2	470.7	462.2	453.7	445.2
14.75	514.3	509.8	504.2	498.5	492.9	484.3	475.8	467.2	458.7	450.1
15.00	520.0	515.3	509.6	503.8	498.0	489.4	480.8	472.2	463.6	455.0
15.25	525.6	520.9	515.0	509.1	503.2	494.6	485.9	477.2	468.6	459.9
15.50	531.2	526.4	520.4	514.4	508.4	499.7	491.0	482.3	473.6	464.9
15.75	536.9	532.0	525.8	519.7	513.6	504.8	496.0	487.3	478.5	469.8
16.00	542.5	537.5	531.2	525.0	518.7	509.9	501.1	492.3	483.5	474.7
16.25	548.2	543.0	536.7	530.3	523.9	515.0	506.2	497.3	488.5	479.6
16.50	553.8	548.6	542.1	535.6	529.1	520.2	511.3	502.3	493.4	484.5
16.75	559.4	554.1	547.5	540.9	534.3	525.3	516.3	507.4	498.4	489.4
17.00	565.1	559.7	552.9	546.2	539.4	530.4	521.4	512.4	503.3	494.3
17.25	570.6	565.1	558.3	551.4	544.6	535.5	526.5	517.4	508.3	499.2
17.50	576.0	570.5	563.6	556.7	549.8	540.7	531.5	522.4	513.3	504.1
17.75	581.4	575.8	568.9	561.9	555.0	545.8	536.6	527.4	518.2	509.1
18.00	586.8	581.2	574.2	567.1	560.1	550.9	541.7	532.4	523.2	514.0
18.25	592.2	586.5	579.5	572.4	565.3	556.0	546.7	537.5	528.2	518.9
18.50	597.6	591.9	584.7	577.6	570.4	561.1	551.8	542.4	533.1	523.8
18.75	603.0	597.2	590.0	582.7	575.5	566.1	556.8	547.4	538.1	528.7
19.00	608.4	602.5	595.2	587.8	580.5	571.1	561.8	552.4	543.0	533.6
19.25	613.8	607.8	600.4	593.0	585.5	576.1	566.7	557.3	547.9	538.5
19.50	619.2	613.2	605.6	598.1	590.6	581.2	571.7	562.3	552.9	543.4
19.75	624.6	618.5	610.9	603.3	595.6	586.2	576.7	567.3	557.8	548.4

343L Tank (Continued)

LLI	"Temperature, Degrees F"									
Inches	32	40	50	60	70	80	90	100	110	120
	"Weight of FM-200, pounds"									
20.00	630.0	623.8	616.1	608.4	600.7	591.2	581.7	572.2	562.7	553.3
20.25	635.4	629.1	621.3	613.5	605.7	596.2	586.7	577.2	567.7	558.2
20.50	640.8	634.5	626.6	618.7	610.8	601.2	591.7	582.2	572.6	563.1
20.75	646.2	639.8	631.8	623.8	615.8	606.2	596.7	587.1	577.6	568.0
21.00	651.6	645.1	637.0	628.9	620.8	611.1	601.4	591.7	582.0	572.2
21.25	657.0	650.4	642.3	634.1	625.9	616.0	606.1	596.3	586.4	576.5
21.50	662.4	655.8	647.5	639.2	630.9	620.9	610.9	600.8	590.8	580.7
21.75	667.8	661.1	652.7	644.3	636.0	625.8	615.6	605.4	595.2	585.0
22.00	673.2	666.4	658.0	649.5	641.0	630.7	620.3	609.9	599.6	589.2
22.25	678.6	671.7	663.2	654.6	646.1	635.5	625.0	614.5	604.0	593.5
22.50	684.0	677.1	668.4	659.8	651.1	640.4	629.7	619.1	608.4	597.7
22.75	689.4	682.4	673.6	664.9	656.1	645.3	634.5	623.6	612.8	602.0
23.00	694.8	687.7	678.9	670.0	661.2	650.2	639.2	628.2	617.2	606.2
23.25	700.2	693.0	684.1	675.2	666.2	655.1	643.9	632.8	621.6	610.5
23.50	705.6	698.4	689.3	680.3	671.3	660.0	648.6	637.3	626.0	614.7
23.75	711.0	703.7	694.6	685.4	676.3	664.8	653.4	641.9	630.4	618.9
24.00	716.4	709.0	699.8	690.6	681.4	669.7	658.1	646.5	634.8	623.2
24.25	721.8	714.3	705.0	695.7	686.4	674.6	662.8	651.0	639.2	627.4
24.50	727.2	719.7	710.3	700.9	691.4	679.5	667.5	655.6	643.6	631.7
24.75	732.6	725.0	715.5	706.0	696.5	684.4	672.3	660.1	648.0	635.9
25.00	738.0	730.3	720.7	711.1	701.5	689.3	677.0	664.7	652.4	640.2
25.25	743.4	735.6	726.0	716.3	706.6	694.1	681.7	669.3	656.8	644.4
25.50	748.8	741.0	731.2	721.4	711.6	699.0	686.4	673.8	661.3	648.7
25.75	754.2	746.3	736.4	726.5	716.7	703.9	691.2	678.4	665.7	652.9
26.00	759.6	751.6	741.6	731.7	721.7	708.8	695.9	683.0	670.1	657.2
26.25	765.0	756.9	746.9	736.8	726.7	713.7	700.6	687.5	674.5	661.4
26.50	770.4	762.3	752.1	741.9	731.8	718.6	705.3	692.1	678.9	665.6
26.75	775.8	767.6	757.3	747.1	736.8	723.4	710.1	696.7	683.3	669.9
27.00	781.2	772.9	762.6	752.2	741.9	728.3	714.8	701.2	687.7	674.1
27.25	786.6	778.2	767.8	757.4	746.9	733.2	719.5	705.8	692.1	678.4
27.50					752.0	738.1	724.2	710.4	696.5	682.6
27.75					757	743.0	728.9	714.9	700.9	686.9
28.00					762.0	747.9	733.7	719.5	705.3	691.1
28.25					767.1	752.7	738.4	724.0	709.7	695.4
28.50					772.1	757.6	743.1	728.6	714.1	699.6
28.75					777.2	762.5	747.8	733.2	718.5	703.8
29.00					782.2	767.4	752.6	737.7	722.9	708.1
29.25					787.3	772.3	757.3	742.3	727.3	712.3
29.50					792.3	777.2	762.0	746.9	731.7	716.6
29.75					797.3	782.0	766.7	751.4	736.1	720.8
30.00					802.4	786.9	771.5	756.0	740.5	725.1
30.25					807.4	791.8	776.2	760.6	744.9	729.3
30.50					812.5	796.7	780.9	765.1	749.3	733.6
30.75					817.5	801.6	785.6	769.7	753.8	737.8
31.00					822.6	806.5	790.4	774.3	758.2	742.1
31.25										746.3
31.50										750.5
31.75										754.8
32.00										759.0

APPENDIX E – WEIGHT CONVERSION TABLE (Metric Version)

106L Tank

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
19.5											
20	50.8	50.6	50.3								
20.5	51.6	51.4	51.1	50.6	50.1						
21	52.5	52.2	52.0	51.5	50.9	50.6	50.3				
21.5	53.3	53.1	52.8	52.3	51.7	51.4	51.0	50.7	50.3		
22	54.2	53.9	53.6	53.1	52.6	52.2	51.8	51.4	51.0	50.3	
22.5	55.1	54.8	54.5	53.9	53.4	53.0	52.6	52.2	51.8	51.0	
23	55.9	55.6	55.3	54.7	54.2	53.8	53.4	53.0	52.5	51.8	
23.5	56.8	56.4	56.1	55.5	55.0	54.5	54.2	53.7	53.2	52.5	
24	57.6	57.3	56.9	56.4	55.8	55.3	54.9	54.5	54.0	53.2	50.8
24.5	58.5	58.1	57.8	57.2	56.6	56.1	55.7	55.2	54.7	53.9	51.5
25	59.3	59.0	58.6	58.0	57.4	56.9	56.5	56.0	55.5	54.6	52.2
25.5	60.2	59.8	59.4	58.8	58.2	57.7	57.3	56.8	56.2	55.4	52.9
26	61.0	60.6	60.3	59.6	59.0	58.5	58.1	57.5	56.9	56.1	53.7
26.5	61.9	61.5	61.1	60.5	59.8	59.3	58.8	58.3	57.7	56.8	54.4
27	62.7	62.3	61.9	61.3	60.6	60.1	59.6	59.0	58.4	57.5	55.1
27.5	63.6	63.2	62.7	62.1	61.5	60.9	60.4	59.8	59.1	58.3	55.8
28	64.4	64.0	63.6	62.9	62.3	61.7	61.2	60.6	59.9	59.0	56.5
28.5	65.3	64.8	64.4	63.7	63.1	62.5	62.0	61.3	60.6	59.7	57.2
29	66.1	65.7	65.2	64.6	63.9	63.3	62.7	62.1	61.4	60.4	57.9
29.5	67.0	66.5	66.1	65.4	64.7	64.1	63.5	62.9	62.1	61.2	58.6
30	67.8	67.4	66.9	66.2	65.5	64.9	64.3	63.6	62.8	61.9	59.3
30.5	68.7	68.2	67.7	67.0	66.3	65.7	65.1	64.4	63.6	62.6	60.0
31	69.5	69.0	68.5	67.8	67.1	66.5	65.9	65.1	64.3	63.3	60.7
31.5	70.4	69.9	69.4	68.6	67.9	67.3	66.6	65.9	65.1	64.1	61.4
32	71.2	70.7	70.2	69.5	68.7	68.1	67.4	66.7	65.8	64.8	62.1
32.5	72.1	71.6	71.0	70.3	69.5	68.9	68.2	67.4	66.5	65.5	62.8
33	73.0	72.4	71.9	71.1	70.4	69.7	69.0	68.2	67.3	66.2	63.5
33.5	73.8	73.2	72.7	71.9	71.2	70.5	69.8	68.9	68.0	67.0	64.2
34	74.7	74.1	73.5	72.7	72.0	71.3	70.5	69.7	68.7	67.7	65.0
34.5	75.5	74.9	74.3	73.6	72.8	72.0	71.3	70.5	69.5	68.4	65.7
35	76.4	75.8	75.2	74.4	73.6	72.8	72.1	71.2	70.2	69.1	66.4
35.5	77.2	76.6	76.0	75.2	74.4	73.6	72.9	72.0	71.0	69.8	67.1
36	78.1	77.4	76.8	76.0	75.2	74.4	73.7	72.8	71.7	70.6	67.8
36.5	78.9	78.3	77.6	76.8	76.0	75.2	74.5	73.5	72.4	71.3	68.5
37	79.8	79.1	78.5	77.6	76.8	76.0	75.2	74.3	73.2	72.0	69.2
37.5	80.6	80.0	79.3	78.5	77.6	76.8	76.0	75.0	73.9	72.7	69.9
38	81.5	80.8	80.1	79.3	78.4	77.6	76.8	75.8	74.7	73.5	70.6
38.5	82.3	81.6	80.9	80.1	79.2	78.4	77.6	76.6	75.4	74.2	71.3
39	83.1	82.4	81.7	80.9	80.1	79.2	78.4	77.3	76.1	74.9	72.0
39.5	84.0	83.2	82.5	81.7	80.8	80.0	79.1	78.1	76.9	75.6	72.7
40	84.8	84.1	83.3	82.5	81.6	80.8	79.9	78.8	77.6	76.4	73.4
40.5	85.6	84.9	84.1	83.3	82.4	81.6	80.7	79.6	78.4	77.1	74.1
41	86.5	85.7	84.9	84.1	83.2	82.3	81.5	80.4	79.1	77.8	74.8
41.5	87.3	86.5	85.7	84.9	84.0	83.1	82.2	81.1	79.8	78.5	75.5
42	88.1	87.3	86.5	85.6	84.8	83.9	83.0	81.9	80.6	79.3	76.3
42.5	89.0	88.1	87.3	86.4	85.6	84.7	83.8	82.6	81.3	80.0	77.0
43	89.8	89.0	88.1	87.2	86.4	85.5	84.5	83.4	82.0	80.7	77.7
43.5	90.6	89.8	88.9	88.0	87.1	86.2	85.3	84.1	82.8	81.4	78.4

106L Tank (Continued)

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
44	91.5	90.6	89.7	88.8	87.9	87.0	86.1	84.9	83.5	82.1	79.1
44.5	92.3	91.4	90.5	89.6	88.7	87.8	86.9	85.6	84.2	82.9	79.9
45	93.2	92.2	91.3	90.4	89.5	88.6	87.6	86.4	85.0	83.6	80.6
45.5	94.0	93.0	92.1	91.2	90.3	89.4	88.4	87.2	85.7	84.3	81.3
46	94.8	93.9	92.9	92.0	91.1	90.1	89.2	87.9	86.4	85.0	82.0
46.5	95.7	94.7	93.7	92.8	91.9	90.9	89.9	88.7	87.1	85.7	82.8
47	96.5	95.5	94.5	93.6	92.7	91.7	90.7	89.4	87.9	86.5	83.5
47.5	97.3	96.3	95.3	94.4	93.4	92.5	91.5	90.2	88.6	87.2	84.2
48	98.2	97.1	96.1	95.1	94.2	93.3	92.3	90.9	89.3	87.9	84.9
48.5	99.0	97.9	96.9	95.9	95.0	94.0	93.0	91.7	90.1	88.6	85.7
49	99.8	98.8	97.7	96.7	95.8	94.8	93.8	92.4	90.8	89.4	86.4
49.5	100.7	99.6	98.5	97.5	96.6	95.6	94.6	93.2	91.5	90.1	87.1
50	101.5	100.4	99.3	98.3	97.4	96.4	95.3	93.9	92.3	90.8	87.9
50.5	102.4	101.2	100.1	99.1	98.2	97.1	96.1	94.7	93.0	91.5	88.6
51	103.2	102.0	100.8	99.9	99.0	97.9	96.9	95.5	93.7	92.2	89.3
51.5	104.0	102.8	101.6	100.7	99.7	98.7	97.7	96.2	94.5	93.0	90.0
52	104.9	103.7	102.4	101.5	100.5	99.5	98.4	97.0	95.2	93.7	90.8
52.5	105.7	104.5	103.2	102.3	101.3	100.3	99.2	97.7	95.9	94.4	91.5
53	106.5	105.3	104.0	103.1	102.1	101.0	100.0	98.5	96.6	95.1	92.2
53.5	107.4	106.1	104.8	103.9	102.9	101.8	100.7	99.2	97.4	95.8	93.0
54	108.2	106.9	105.6	104.7	103.7	102.6	101.5	100.0	98.1	96.6	93.7
54.5	109.0	107.7	106.4	105.4	104.5	103.4	102.3	100.7	98.8	97.3	94.4
55	109.9	108.5	107.2	106.2	105.2	104.2	103.1	101.5	99.6	98.0	95.1
55.5	110.7	109.4	108.0	107.0	106.0	104.9	103.8	102.2	100.3	98.7	95.9
56	111.5	110.2	108.8	107.8	106.8	105.7	104.6	103.0	101.0	99.5	96.6
56.5						106.5	105.4	103.8	101.8	100.2	97.3
57						107.3	106.1	104.5	102.5	100.9	98.1
57.5							106.9	105.3	103.2	101.6	98.8
58								106.0	104.0	102.3	99.5
58.5								106.8	104.7	103.1	100.2
59									105.4	103.8	101.0
59.5									106.2	104.5	101.7
60									106.9	105.2	102.4
60.5										106.0	103.1
61										106.7	103.9
61.5										107.4	104.6
62											105.3
62.5											106.1
63											106.8

APPENDIX E – WEIGHT CONVERSION TABLE (Metric Version)

147L Tank

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
26											
26.5	70.8	70.6	70.4	69.8							
27	71.7	71.5	71.3	70.7	70.1	69.6					
27.5	72.6	72.4	72.1	71.5	70.9	70.5	70.0				
28	73.5	73.3	73.0	72.4	71.8	71.3	70.8	70.1			
28.5	74.4	74.1	73.9	73.2	72.6	72.1	71.6	70.9	69.9		
29	75.3	75.0	74.7	74.1	73.5	72.9	72.4	71.6	70.7		
29.5	76.2	75.9	75.6	74.9	74.3	73.7	73.2	72.4	71.5	69.8	
30	77.1	76.8	76.5	75.8	75.1	74.6	74.0	73.2	72.2	70.6	
30.5	78.0	77.7	77.3	76.6	76.0	75.4	74.8	74.0	73.0	71.4	
31	78.9	78.6	78.2	77.5	76.8	76.2	75.6	74.8	73.8	72.1	
31.5	79.8	79.4	79.1	78.4	77.6	77.0	76.4	75.6	74.6	72.9	
32	80.7	80.3	79.9	79.2	78.5	77.8	77.2	76.3	75.3	73.7	
32.5	81.6	81.2	80.8	80.1	79.3	78.6	78.0	77.1	76.1	74.4	
33	82.5	82.1	81.7	80.9	80.2	79.5	78.8	77.9	76.9	75.2	70.0
33.5	83.4	83.0	82.5	81.8	81.0	80.3	79.6	78.7	77.6	76.0	70.8
34	84.3	83.8	83.4	82.6	81.8	81.1	80.4	79.5	78.4	76.7	71.6
34.5	85.2	84.7	84.3	83.5	82.7	81.9	81.2	80.3	79.2	77.5	72.4
35	86.1	85.6	85.1	84.3	83.5	82.7	82.0	81.0	80.0	78.3	73.1
35.5	87.0	86.5	86.0	85.2	84.3	83.6	82.8	81.8	80.7	79.0	73.9
36	87.9	87.4	86.9	86.0	85.2	84.4	83.6	82.6	81.5	79.8	74.7
36.5	88.8	88.3	87.7	86.9	86.0	85.2	84.4	83.4	82.3	80.6	75.5
37	89.7	89.1	88.6	87.7	86.9	86.0	85.2	84.2	83.0	81.3	76.2
37.5	90.6	90.0	89.5	88.6	87.7	86.8	86.0	85.0	83.8	82.1	77.0
38	91.5	90.9	90.3	89.4	88.5	87.6	86.8	85.7	84.6	82.9	77.8
38.5	92.4	91.8	91.2	90.3	89.4	88.5	87.6	86.5	85.3	83.6	78.6
39	93.3	92.7	92.1	91.1	90.2	89.3	88.4	87.3	86.1	84.4	79.3
39.5	94.2	93.6	92.9	92.0	91.0	90.1	89.2	88.1	86.9	85.2	80.1
40	95.1	94.4	93.8	92.8	91.9	90.9	90.0	88.9	87.7	85.9	80.9
40.5	96.0	95.3	94.7	93.7	92.7	91.7	90.8	89.7	88.4	86.7	81.7
41	96.9	96.2	95.5	94.5	93.5	92.6	91.6	90.4	89.2	87.5	82.4
41.5	97.8	97.1	96.4	95.4	94.4	93.4	92.4	91.2	90.0	88.2	83.2
42	98.7	98.0	97.3	96.3	95.2	94.2	93.2	92.0	90.7	89.0	84.0
42.5	99.6	98.9	98.1	97.1	96.1	95.0	94.0	92.8	91.5	89.8	84.8
43	100.4	99.7	99.0	98.0	96.9	95.8	94.8	93.6	92.3	90.5	85.5
43.5	101.3	100.6	99.9	98.8	97.7	96.6	95.6	94.4	93.1	91.3	86.3
44	102.2	101.5	100.8	99.7	98.6	97.5	96.4	95.1	93.8	92.1	87.1
44.5	103.1	102.4	101.6	100.5	99.4	98.3	97.2	95.9	94.6	92.8	87.9
45	104.0	103.3	102.5	101.4	100.2	99.1	98.0	96.7	95.4	93.6	88.6
45.5	104.9	104.1	103.4	102.2	101.1	99.9	98.8	97.5	96.1	94.4	89.4
46	105.8	105.0	104.2	103.1	101.9	100.7	99.5	98.3	96.9	95.1	90.2
46.5	106.7	105.9	105.1	103.9	102.8	101.6	100.3	99.0	97.7	95.9	91.0
47	107.6	106.8	106.0	104.8	103.6	102.4	101.1	99.8	98.4	96.7	91.7
47.5	108.5	107.7	106.8	105.6	104.4	103.2	101.9	100.6	99.2	97.4	92.5
48	109.4	108.6	107.7	106.5	105.3	104.0	102.7	101.4	100.0	98.2	93.3
48.5	110.3	109.4	108.6	107.3	106.1	104.8	103.5	102.2	100.8	99.0	94.1
49	111.2	110.3	109.4	108.2	106.9	105.6	104.3	103.0	101.5	99.7	94.8
49.5	112.1	111.2	110.3	109.0	107.8	106.5	105.1	103.7	102.3	100.5	95.6
50	112.9	112.0	111.1	109.9	108.6	107.3	105.9	104.5	103.1	101.3	96.4

147L Tank (Continued)

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
50.5	113.7	112.8	111.9	110.7	109.4	108.1	106.7	105.3	103.8	102.0	97.2
51	114.6	113.7	112.8	111.5	110.3	108.9	107.5	106.1	104.6	102.8	97.9
51.5	115.4	114.5	113.6	112.3	111.1	109.7	108.3	106.9	105.4	103.6	98.7
52	116.3	115.3	114.4	113.1	111.9	110.5	109.1	107.7	106.2	104.3	99.5
52.5	117.1	116.1	115.2	113.9	112.7	111.3	109.9	108.4	106.9	105.1	100.3
53	118.0	117.0	116.0	114.7	113.5	112.1	110.7	109.2	107.7	105.9	101.0
53.5	118.8	117.8	116.8	115.5	114.3	112.9	111.5	110.0	108.5	106.6	101.8
54	119.7	118.6	117.6	116.3	115.1	113.7	112.3	110.8	109.2	107.4	102.6
54.5	120.5	119.5	118.4	117.1	115.8	114.4	113.0	111.5	110.0	108.2	103.3
55	121.4	120.3	119.2	117.9	116.6	115.2	113.8	112.3	110.8	108.9	104.1
55.5	122.2	121.1	120.0	118.7	117.4	116.0	114.5	113.1	111.5	109.7	104.9
56	123.1	121.9	120.8	119.5	118.2	116.8	115.3	113.8	112.3	110.4	105.7
56.5	123.9	122.8	121.6	120.3	119.0	117.6	116.1	114.6	113.0	111.2	106.5
57	124.7	123.6	122.4	121.1	119.8	118.3	116.8	115.3	113.7	111.9	107.3
57.5	125.6	124.4	123.2	121.9	120.6	119.1	117.6	116.1	114.5	112.7	108.1
58	126.4	125.2	124.0	122.7	121.4	119.9	118.4	116.8	115.2	113.4	108.9
58.5	127.3	126.1	124.8	123.5	122.1	120.7	119.1	117.6	115.9	114.1	109.6
59	128.1	126.9	125.6	124.3	122.9	121.4	119.9	118.3	116.7	114.9	110.4
59.5	129.0	127.7	126.4	125.1	123.7	122.2	120.7	119.1	117.4	115.6	111.1
60	129.8	128.5	127.2	125.9	124.5	123.0	121.4	119.8	118.1	116.3	111.9
60.5	130.7	129.4	128.0	126.7	125.3	123.8	122.2	120.6	118.9	117.1	112.6
61	131.5	130.2	128.8	127.5	126.1	124.5	122.9	121.3	119.6	117.8	113.4
61.5	132.4	131.0	129.7	128.3	126.9	125.3	123.7	122.1	120.3	118.5	114.2
62	133.2	131.8	130.5	129.1	127.7	126.1	124.5	122.8	121.1	119.3	114.9
62.5	134.1	132.7	131.3	129.9	128.5	126.9	125.2	123.6	121.8	120.0	115.7
63	134.9	133.5	132.1	130.7	129.2	127.7	126.0	124.3	122.6	120.7	116.4
63.5	135.7	134.3	132.9	131.5	130.0	128.4	126.8	125.1	123.3	121.5	117.2
64	136.6	135.1	133.7	132.2	130.8	129.2	127.5	125.8	124.0	122.2	117.9
64.5	137.4	136.0	134.5	133.0	131.6	130.0	128.3	126.6	124.8	122.9	118.7
65	138.3	136.8	135.3	133.8	132.4	130.8	129.1	127.3	125.5	123.7	119.4
65.5	139.1	137.6	136.1	134.6	133.2	131.5	129.8	128.1	126.2	124.4	120.2
66	140.0	138.4	136.9	135.4	134.0	132.3	130.6	128.8	127.0	125.1	120.9
66.5	140.8	139.3	137.7	136.2	134.8	133.1	131.4	129.6	127.7	125.9	121.7
67	141.7	140.1	138.5	137.0	135.6	133.9	132.1	130.3	128.4	126.6	122.4
67.5	142.5	140.9	139.3	137.8	136.3	134.6	132.9	131.1	129.2	127.3	123.2
68	143.4	141.7	140.1	138.6	137.1	135.4	133.6	131.8	129.9	128.1	123.9
68.5	144.2	142.6	140.9	139.4	137.9	136.2	134.4	132.6	130.6	128.8	124.7
69	145.1	143.4	141.7	140.2	138.7	137.0	135.2	133.3	131.4	129.5	125.4
69.5	145.9	144.2	142.5	141.0	139.5	137.7	135.9	134.1	132.1	130.3	126.2
70	146.8	145.0	143.3	141.8	140.3	138.5	136.7	134.8	132.8	131.0	126.9
70.5	147.6	145.9	144.1	142.6	141.1	139.3	137.5	135.6	133.6	131.7	127.7
71	148.4	146.7	144.9	143.4	141.9	140.1	138.2	136.3	134.3	132.5	128.4
71.5	149.3	147.5	145.8	144.2	142.6	140.9	139.0	137.1	135.1	133.2	129.2
72	150.1	148.3	146.6	145.0	143.4	141.6	139.8	137.8	135.8	133.9	129.9
72.5	151.0	149.2	147.4	145.8	144.2	142.4	140.5	138.6	136.5	134.7	130.7
73	151.8	150.0	148.2	146.6	145.0	143.2	141.3	139.3	137.3	135.4	131.4
73.5	152.7	150.8	149.0	147.4	145.8	144.0	142.0	140.1	138.0	136.1	132.2
74	153.5	151.6	149.8	148.2	146.6	144.7	142.8	140.8	138.7	136.9	132.9
74.5	154.4	152.5	150.6	149.0	147.4	145.5	143.6	141.6	139.5	137.6	133.7

APPENDIX E – WEIGHT CONVERSION TABLE
(Metric Version)

147L Tank (Continued)

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
75						146.3	144.3	142.3	140.2	138.3	134.4
75.5						147.1	145.1	143.1	140.9	139.1	135.2
76						147.8	145.9	143.8	141.7	139.8	135.9
76.5							146.6	144.6	142.4	140.5	136.7
77							147.4	145.3	143.1	141.3	137.4
77.5								146.1	143.9	142.0	138.2
78								146.8	144.6	142.7	138.9
78.5								147.6	145.3	143.5	139.7
79									146.1	144.2	140.4
79.5									146.8	144.9	141.2
80									147.6	145.7	141.9
80.5										146.4	142.7
81										147.1	143.5
81.5										147.8	144.2
82											145.0
82.5											145.7
83											146.5
83.5											147.2

180L Tank

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
6											
6.5	86.5										
7	87.4	86.9	86.3								
7.5	88.3	87.8	87.2	86.6							
8	89.2	88.6	88.0	87.5	86.9	86.6	86.4				
8.5	90.1	89.5	88.9	88.4	87.8	87.5	87.2	86.2			
9	91.0	90.4	89.8	89.2	88.6	88.3	88.0	87.0			
9.5	91.9	91.3	90.7	90.1	89.5	89.1	88.8	87.8			
10	92.9	92.2	91.5	90.9	90.3	90.0	89.6	88.6	86.9		
10.5	93.8	93.1	92.4	91.8	91.2	90.8	90.4	89.4	87.7		
11	94.7	94.0	93.3	92.7	92.0	91.6	91.3	90.2	88.5	86.5	
11.5	95.6	94.9	94.2	93.5	92.9	92.5	92.1	90.9	89.2	87.3	
12	96.5	95.7	95.0	94.4	93.7	93.3	92.9	91.7	90.0	88.1	
12.5	97.4	96.6	95.9	95.3	94.6	94.1	93.7	92.5	90.8	88.8	
13	98.3	97.5	96.8	96.1	95.5	94.9	94.5	93.3	91.6	89.6	
13.5	99.2	98.4	97.7	97.0	96.3	95.8	95.3	94.1	92.4	90.4	
14	100.1	99.3	98.5	97.8	97.2	96.6	96.1	94.9	93.1	91.1	
14.5	101.0	100.2	99.4	98.7	98.0	97.4	96.9	95.7	93.9	91.9	86.8
15	101.9	101.1	100.3	99.6	98.9	98.3	97.7	96.5	94.7	92.7	87.5
15.5	102.8	102.0	101.2	100.4	99.7	99.1	98.5	97.3	95.5	93.4	88.2
16	103.7	102.9	102.0	101.3	100.6	99.9	99.4	98.1	96.3	94.2	89.0
16.5	104.6	103.7	102.9	102.2	101.4	100.8	100.2	98.9	97.0	95.0	89.7
17	105.5	104.6	103.8	103.0	102.3	101.6	101.0	99.7	97.8	95.7	90.5
17.5	106.4	105.5	104.7	103.9	103.1	102.4	101.8	100.5	98.6	96.5	91.2
18	107.3	106.4	105.5	104.7	104.0	103.3	102.6	101.3	99.4	97.3	91.9
18.5	108.2	107.3	106.4	105.6	104.8	104.1	103.4	102.1	100.2	98.0	92.7
19	109.1	108.2	107.3	106.5	105.7	104.9	104.2	102.8	100.9	98.8	93.4
19.5	110.0	109.1	108.2	107.3	106.5	105.8	105.0	103.6	101.7	99.6	94.2
20	110.9	110.0	109.0	108.2	107.4	106.6	105.8	104.4	102.5	100.4	94.9
20.5	111.8	110.8	109.9	109.1	108.2	107.4	106.6	105.2	103.3	101.1	95.6
21	112.7	111.7	110.8	109.9	109.1	108.3	107.5	106.0	104.1	101.9	96.4
21.5	113.6	112.6	111.6	110.8	109.9	109.1	108.3	106.8	104.9	102.7	97.1
22	114.5	113.5	112.5	111.6	110.8	109.9	109.1	107.6	105.6	103.4	97.8
22.5	115.4	114.4	113.4	112.5	111.6	110.7	109.9	108.4	106.4	104.2	98.6
23	116.3	115.3	114.3	113.4	112.5	111.6	110.7	109.2	107.2	105.0	99.3
23.5	117.2	116.2	115.1	114.2	113.3	112.4	111.5	110.0	108.0	105.7	100.1
24	118.1	117.1	116.0	115.1	114.2	113.2	112.3	110.8	108.8	106.5	100.8
24.5	119.0	117.9	116.9	116.0	115.0	114.1	113.1	111.6	109.5	107.3	101.5
25	119.9	118.8	117.8	116.8	115.9	114.9	113.9	112.4	110.3	108.0	102.3
25.5	120.8	119.7	118.6	117.7	116.7	115.7	114.7	113.2	111.1	108.8	103.0
26	121.7	120.6	119.5	118.5	117.6	116.6	115.6	114.0	111.9	109.6	103.8
26.5	122.6	121.5	120.4	119.4	118.4	117.4	116.4	114.7	112.7	110.3	104.5
27	123.5	122.4	121.3	120.3	119.3	118.2	117.2	115.5	113.4	111.1	105.2
27.5	124.4	123.3	122.1	121.1	120.1	119.1	118.0	116.3	114.2	111.9	106.0
28	125.3	124.2	123.0	122.0	121.0	119.9	118.8	117.1	115.0	112.6	106.7
28.5	126.2	125.0	123.9	122.8	121.8	120.7	119.6	117.9	115.8	113.4	107.4
29	127.1	125.9	124.8	123.7	122.7	121.6	120.4	118.7	116.6	114.2	108.2
29.5	128.0	126.8	125.6	124.6	123.5	122.4	121.2	119.5	117.3	114.9	108.9
30	128.9	127.7	126.5	125.4	124.4	123.2	122.0	120.3	118.1	115.7	109.7

APPENDIX E – WEIGHT CONVERSION TABLE
(Metric Version)

180L Tank (Continued)

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
30.5	129.8	128.6	127.4	126.3	125.2	124.0	122.8	121.1	118.9	116.5	110.4
31	130.7	129.5	128.3	127.2	126.1	124.9	123.7	121.9	119.7	117.2	111.1
31.5	131.6	130.4	129.1	128.0	126.9	125.7	124.5	122.7	120.5	118.0	111.9
32	132.5	131.3	130.0	128.9	127.8	126.5	125.3	123.5	121.2	118.8	112.6
32.5	133.4	132.2	130.9	129.7	128.6	127.4	126.1	124.3	122.0	119.5	113.4
33	134.3	133.0	131.7	130.6	129.5	128.2	126.9	125.1	122.8	120.3	114.1
33.5	135.2	133.9	132.6	131.5	130.3	129.0	127.7	125.9	123.6	121.1	114.8
34	136.1	134.8	133.5	132.3	131.2	129.9	128.5	126.6	124.4	121.8	115.6
34.5	137.0	135.7	134.4	133.2	132.0	130.7	129.3	127.4	125.1	122.6	116.3
35	137.9	136.5	135.2	134.1	132.9	131.5	130.1	128.2	125.9	123.4	117.0
35.5	138.7	137.4	136.1	134.9	133.7	132.4	130.9	129.0	126.7	124.1	117.8
36	139.5	138.3	137.0	135.8	134.6	133.2	131.8	129.8	127.5	124.9	118.5
36.5	140.4	139.1	137.8	136.6	135.4	134.0	132.6	130.6	128.3	125.7	119.3
37	141.2	139.9	138.6	137.4	136.3	134.9	133.4	131.4	129.0	126.5	120.0
37.5	142.0	140.7	139.4	138.3	137.1	135.7	134.2	132.2	129.8	127.2	120.7
38	142.9	141.6	140.3	139.1	137.9	136.5	135.0	133.0	130.6	128.0	121.5
38.5	143.7	142.4	141.1	139.9	138.7	137.3	135.8	133.8	131.4	128.8	122.2
39	144.5	143.2	141.9	140.7	139.5	138.0	136.6	134.6	132.2	129.5	123.0
39.5	145.4	144.1	142.7	141.5	140.2	138.8	137.4	135.4	132.9	130.3	123.7
40	146.2	144.9	143.6	142.3	141.0	139.6	138.1	136.1	133.7	131.1	124.4
40.5	147.1	145.7	144.4	143.1	141.8	140.4	138.9	136.9	134.5	131.8	125.2
41	147.9	146.5	145.2	143.9	142.6	141.1	139.6	137.6	135.2	132.6	125.9
41.5	148.7	147.4	146.0	144.7	143.4	141.9	140.4	138.4	136.0	133.4	126.6
42	149.6	148.2	146.8	145.5	144.2	142.7	141.1	139.1	136.8	134.1	127.4
42.5	150.4	149.0	147.7	146.3	144.9	143.4	141.9	139.9	137.6	134.9	128.1
43	151.2	149.9	148.5	147.1	145.7	144.2	142.6	140.6	138.3	135.6	128.9
43.5	152.1	150.7	149.3	147.9	146.5	145.0	143.4	141.4	139.0	136.4	129.7
44	152.9	151.5	150.1	148.7	147.3	145.7	144.1	142.1	139.8	137.1	130.5
44.5	153.7	152.3	151.0	149.5	148.1	146.5	144.9	142.9	140.5	137.9	131.3
45	154.6	153.2	151.8	150.3	148.9	147.3	145.6	143.6	141.2	138.6	132.1
45.5	155.4	154.0	152.6	151.1	149.6	148.0	146.4	144.3	141.9	139.3	132.9
46	156.2	154.8	153.4	151.9	150.4	148.8	147.1	145.1	142.7	140.0	133.6
46.5	157.1	155.7	154.2	152.7	151.2	149.6	147.9	145.8	143.4	140.8	134.3
47	157.9	156.5	155.1	153.5	152.0	150.3	148.6	146.5	144.1	141.5	135.1
47.5	158.8	157.3	155.9	154.3	152.8	151.1	149.4	147.3	144.8	142.2	135.8
48	159.6	158.2	156.7	155.1	153.6	151.9	150.1	148.0	145.6	142.9	136.5
48.5	160.4	159.0	157.5	155.9	154.3	152.6	150.9	148.8	146.3	143.7	137.3
49	161.3	159.8	158.4	156.7	155.1	153.4	151.7	149.5	147.0	144.4	138.0
49.5	162.1	160.6	159.2	157.5	155.9	154.2	152.4	150.2	147.8	145.1	138.7
50	162.9	161.5	160.0	158.3	156.7	154.9	153.2	151.0	148.5	145.8	139.5
50.5	163.8	162.3	160.8	159.1	157.5	155.7	153.9	151.7	149.2	146.6	140.2
51	164.6	163.1	161.6	159.9	158.2	156.5	154.7	152.5	149.9	147.3	140.9
51.5	165.4	164.0	162.5	160.8	159.0	157.2	155.4	153.2	150.7	148.0	141.7
52	166.3	164.8	163.3	161.6	159.8	158.0	156.2	153.9	151.4	148.7	142.4
52.5	167.1	165.6	164.1	162.4	160.6	158.8	156.9	154.7	152.1	149.5	143.1
53	168.0	166.4	164.9	163.2	161.4	159.5	157.7	155.4	152.8	150.2	143.9
53.5	168.8	167.3	165.8	164.0	162.2	160.3	158.4	156.1	153.6	150.9	144.6
54	169.6	168.1	166.6	164.8	162.9	161.1	159.2	156.9	154.3	151.6	145.3
54.5	170.5	168.9	167.4	165.6	163.7	161.8	159.9	157.6	155.0	152.4	146.1

180L Tank (Continued)

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
55	171.3	169.8	168.2	166.4	164.5	162.6	160.7	158.4	155.8	153.1	146.8
55.5	172.1	170.6	169.0	167.2	165.3	163.4	161.4	159.1	156.5	153.8	147.5
56	173.0	171.4	169.9	168.0	166.1	164.1	162.2	159.8	157.2	154.5	148.3
56.5	173.8	172.2	170.7	168.8	166.9	164.9	162.9	160.6	157.9	155.3	149.0
57	174.6	173.1	171.5	169.6	167.6	165.7	163.7	161.3	158.7	156.0	149.7
57.5	175.5	173.9	172.3	170.4	168.4	166.4	164.4	162.1	159.4	156.7	150.5
58	176.3	174.7	173.2	171.2	169.2	167.2	165.2	162.8	160.1	157.4	151.2
58.5	177.1	175.6	174.0	172.0	170.0	168.0	165.9	163.5	160.9	158.2	151.9
59	178.0	176.4	174.8	172.8	170.8	168.7	166.7	164.3	161.6	158.9	152.7
59.5	178.8	177.2	175.6	173.6	171.6	169.5	167.4	165.0	162.3	159.6	153.4
60	179.7	178.1	176.4	174.4	172.3	170.3	168.2	165.8	163.0	160.3	154.1
60.5	180.5	178.9	177.3	175.2	173.1	171.0	168.9	166.5	163.8	161.1	154.9
61	181.3	179.7	178.1	176.0	173.9	171.8	169.7	167.2	164.5	161.8	155.6
61.5	182.2	180.5	178.9	176.8	174.7	172.6	170.4	168.0	165.2	162.5	156.4
62	183.0	181.4	179.7	177.6	175.5	173.3	171.2	168.7	165.9	163.2	157.1
62.5	183.8	182.2	180.6	178.4	176.3	174.1	171.9	169.4	166.7	164.0	157.8
63	184.7	183.0	181.4	179.2	177.0	174.9	172.7	170.2	167.4	164.7	158.6
63.5	185.5	183.9	182.2	180.0	177.8	175.6	173.4	170.9	168.1	165.4	159.3
64	186.3	184.7	183.0	180.8	178.6	176.4	174.2	171.7	168.9	166.1	160.0
64.5	187.2	185.5	183.8	181.6	179.4	177.2	174.9	172.4	169.6	166.9	160.8
65	188.0	186.3	184.7	182.4	180.2	177.9	175.7	173.1	170.3	167.6	161.5
65.5	188.9	187.2	185.5	183.2	181.0	178.7	176.5	173.9	171.0	168.3	162.2
66	189.7	188.0	186.3	184.0	181.7	179.5	177.2	174.6	171.8	169.0	163.0
66.5	190.5	188.8	187.1	184.8	182.5	180.2	178.0	175.4	172.5	169.8	163.7
67						181.0	178.7	176.1	173.2	170.5	164.4
67.5						181.8	179.5	176.8	173.9	171.2	165.2
68						182.5	180.2	177.6	174.7	171.9	165.9
68.5							181.0	178.3	175.4	172.7	166.6
69							181.7	179.0	176.1	173.4	167.4
69.5							182.5	179.8	176.9	174.1	168.1
70								180.5	177.6	174.8	168.8
70.5								181.3	178.3	175.6	169.6
71								182.0	179.0	176.3	170.3
71.5								182.7	179.8	177.0	171.0
72									180.5	177.7	171.8
72.5									181.2	178.5	172.5
73									182.0	179.2	173.2
73.5									182.7	179.9	174.0
74										180.6	174.7
74.5										181.4	175.4
75										182.1	176.2
75.5										182.8	176.9
76											177.6
76.5											178.4
77											179.1
77.5											179.8
78											180.6
78.5											181.3
79											182.0
79.5											182.8

APPENDIX E – WEIGHT CONVERSION TABLE (Metric Version)

343L Tank

LLI cm	"Temperature, Degrees C" 0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
15											
15.5											
16											
16.5											
17											
17.5											
18											
18.5											
19											
19.5											
20											
20.5	165.2	164.2	163.3	162.3							
21	167.2	166.2	165.2	164.2	163.2						
21.5	169.3	168.2	167.1	166.1	165.0	162.5					
22	171.3	170.2	169.1	168.0	166.9	164.3					
22.5	173.3	172.2	171.0	169.9	168.7	166.2	163.2				
23	175.3	174.1	173.0	171.8	170.6	168.0	165.0	162.0			
23.5	177.3	176.1	174.9	173.7	172.5	169.9	166.8	163.8			
24	179.3	178.1	176.8	175.6	174.3	171.7	168.7	165.6	162.6		
24.5	181.4	180.1	178.8	177.5	176.2	173.5	170.5	167.4	164.4		
25	183.4	182.1	180.7	179.4	178.1	175.4	172.3	169.3	166.2	163.1	
25.5	185.4	184.0	182.7	181.3	179.9	177.2	174.1	171.1	168.0	164.9	
26	187.4	186.0	184.6	183.2	181.8	179.1	176.0	172.9	169.8	166.7	163.6
26.5	189.4	188.0	186.5	185.1	183.6	180.9	177.8	174.7	171.6	168.4	165.3
27	191.5	190.0	188.5	187.0	185.5	182.7	179.6	176.5	173.3	170.2	167.1
27.5	193.5	192.0	190.4	188.9	187.4	184.6	181.4	178.3	175.1	172.0	168.8
28	195.5	193.9	192.4	190.8	189.2	186.4	183.3	180.1	176.9	173.8	170.6
28.5	197.5	195.9	194.3	192.7	191.1	188.3	185.1	181.9	178.7	175.5	172.3
29	199.5	197.9	196.2	194.6	193.0	190.1	186.9	183.7	180.5	177.3	174.1
29.5	201.6	199.9	198.2	196.5	194.8	191.9	188.7	185.5	182.3	179.1	175.8
30	203.6	201.9	200.1	198.4	196.7	193.8	190.5	187.3	184.1	180.8	177.6
30.5	205.6	203.8	202.1	200.3	198.5	195.6	192.4	189.1	185.9	182.6	179.3
31	207.6	205.8	204.0	202.2	200.4	197.5	194.2	190.9	187.6	184.4	181.1
31.5	209.6	207.8	206.0	204.1	202.3	199.3	196.0	192.7	189.4	186.1	182.9
32	211.7	209.8	207.9	206.0	204.1	201.1	197.8	194.5	191.2	187.9	184.6
32.5	213.7	211.8	209.8	207.9	206.0	203.0	199.7	196.3	193.0	189.7	186.4
33	215.7	213.7	211.8	209.8	207.9	204.8	201.5	198.1	194.8	191.5	188.1
33.5	217.7	215.7	213.7	211.7	209.7	206.7	203.3	199.9	196.6	193.2	189.9
34	219.7	217.7	215.7	213.6	211.6	208.5	205.1	201.7	198.4	195.0	191.6
34.5	221.8	219.7	217.6	215.5	213.4	210.3	206.9	203.6	200.2	196.8	193.4
35	223.8	221.7	219.5	217.4	215.3	212.2	208.8	205.4	201.9	198.5	195.1
35.5	225.8	223.6	221.5	219.3	217.2	214.0	210.6	207.2	203.7	200.3	196.9
36	227.8	225.6	223.4	221.2	219.0	215.9	212.4	209.0	205.5	202.1	198.6
36.5	229.8	227.6	225.4	223.1	220.9	217.7	214.2	210.8	207.3	203.8	200.4
37	231.8	229.6	227.3	225.0	222.8	219.5	216.1	212.6	209.1	205.6	202.1
37.5	233.9	231.6	229.2	226.9	224.6	221.4	217.9	214.4	210.9	207.4	203.9
38	235.9	233.5	231.2	228.8	226.5	223.2	219.7	216.2	212.7	209.2	205.6
38.5	237.9	235.5	233.1	230.7	228.3	225.1	221.5	218.0	214.5	210.9	207.4
39	239.9	237.5	235.1	232.6	230.2	226.9	223.3	219.8	216.2	212.7	209.1

343L Tank (Continued)

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
39.5	241.9	239.5	237.0	234.5	232.1	228.7	225.2	221.6	218.0	214.5	210.9
40	244.0	241.5	238.9	236.4	233.9	230.6	227.0	223.4	219.8	216.2	212.6
40.5	246.0	243.4	240.9	238.3	235.8	232.4	228.8	225.2	221.6	218.0	214.4
41	248.0	245.4	242.8	240.2	237.7	234.3	230.6	227.0	223.4	219.8	216.2
41.5	250.0	247.4	244.8	242.1	239.5	236.1	232.5	228.8	225.2	221.5	217.9
42	252.0	249.4	246.7	244.0	241.4	237.9	234.3	230.6	227.0	223.3	219.7
42.5	254.1	251.4	248.7	245.9	243.2	239.8	236.1	232.4	228.8	225.1	221.4
43	256.1	253.3	250.6	247.8	245.1	241.6	237.9	234.2	230.5	226.9	223.2
43.5	258.1	255.3	252.5	249.7	247.0	243.5	239.8	236.0	232.3	228.6	224.9
44	260.0	257.2	254.4	251.6	248.8	245.3	241.6	237.9	234.1	230.4	226.7
44.5	262.0	259.1	256.3	253.5	250.7	247.1	243.4	239.7	235.9	232.2	228.4
45	263.9	261.1	258.2	255.4	252.5	249.0	245.2	241.5	237.7	233.9	230.2
45.5	265.8	263.0	260.1	257.3	254.4	250.8	247.0	243.3	239.5	235.7	231.9
46	267.8	264.9	262.0	259.1	256.3	252.7	248.9	245.1	241.3	237.5	233.7
46.5	269.7	266.8	263.9	261.0	258.1	254.5	250.7	246.9	243.1	239.2	235.4
47	271.6	268.7	265.8	262.9	259.9	256.3	252.5	248.7	244.8	241.0	237.2
47.5	273.6	270.6	267.7	264.7	261.7	258.1	254.3	250.4	246.6	242.8	238.9
48	275.5	272.5	269.5	266.5	263.6	259.9	256.1	252.2	248.4	244.5	240.7
48.5	277.4	274.4	271.4	268.4	265.4	261.7	257.9	254.0	250.2	246.3	242.5
49	279.4	276.3	273.3	270.2	267.2	263.5	259.6	255.8	251.9	248.1	244.2
49.5	281.3	278.2	275.1	272.1	269.0	265.3	261.4	257.6	253.7	249.8	246.0
50	283.2	280.1	277.0	273.9	270.8	267.1	263.2	259.3	255.5	251.6	247.7
50.5	285.2	282.0	278.9	275.7	272.6	268.9	265.0	261.1	257.2	253.4	249.5
51	287.1	283.9	280.8	277.6	274.4	270.7	266.8	262.9	259.0	255.1	251.2
51.5	289.0	285.8	282.6	279.4	276.2	272.5	268.6	264.7	260.8	256.9	253.0
52	291.0	287.7	284.5	281.3	278.0	274.3	270.4	266.5	262.6	258.6	254.7
52.5	292.9	289.6	286.4	283.1	279.8	276.1	272.2	268.2	264.3	260.4	256.5
53	294.8	291.5	288.2	285.0	281.7	277.9	273.9	270.0	266.0	262.1	258.1
53.5	296.8	293.4	290.1	286.8	283.5	279.6	275.6	271.6	267.6	263.6	259.6
54	298.7	295.3	292.0	288.6	285.3	281.4	277.3	273.3	269.2	265.2	261.1
54.5	300.6	297.2	293.9	290.5	287.1	283.1	279.0	274.9	270.8	266.7	262.6
55	302.6	299.1	295.7	292.3	288.9	284.9	280.8	276.6	272.4	268.3	264.1
55.5	304.5	301.0	297.6	294.2	290.7	286.7	282.5	278.3	274.1	269.9	265.7
56	306.4	302.9	299.5	296.0	292.5	288.4	284.2	279.9	275.7	271.4	267.2
56.5	308.4	304.8	301.3	297.8	294.3	290.2	285.9	281.6	277.3	273.0	268.7
57	310.3	306.8	303.2	299.7	296.1	292.0	287.6	283.2	278.9	274.5	270.2
57.5	312.2	308.7	305.1	301.5	297.9	293.7	289.3	284.9	280.5	276.1	271.7
58	314.2	310.6	307.0	303.4	299.8	295.5	291.0	286.6	282.1	277.7	273.2
58.5	316.1	312.5	308.8	305.2	301.6	297.3	292.7	288.2	283.7	279.2	274.7
59	318.0	314.4	310.7	307.0	303.4	299.0	294.5	289.9	285.3	280.8	276.2
59.5	320.0	316.3	312.6	308.9	305.2	300.8	296.2	291.6	286.9	282.3	277.7
60	321.9	318.2	314.4	310.7	307.0	302.5	297.9	293.2	288.6	283.9	279.2
60.5	323.8	320.1	316.3	312.6	308.8	304.3	299.6	294.9	290.2	285.5	280.7
61	325.8	322.0	318.2	314.4	310.6	306.1	301.3	296.5	291.8	287.0	282.2
61.5	327.7	323.9	320.1	316.2	312.4	307.8	303.0	298.2	293.4	288.6	283.8
62	329.6	325.8	321.9	318.1	314.2	309.6	304.7	299.9	295.0	290.1	285.3
62.5	331.6	327.7	323.8	319.9	316.0	311.4	306.4	301.5	296.6	291.7	286.8
63	333.5	329.6	325.7	321.8	317.9	313.1	308.2	303.2	298.2	293.3	288.3
63.5	335.4	331.5	327.5	323.6	319.7	314.9	309.9	304.9	299.8	294.8	289.8

APPENDIX E – WEIGHT CONVERSION TABLE
(Metric Version)

343L Tank (Continued)

LLI	"Temperature, Degrees C"										
cm	0	5	10	15	20	25	30	35	40	45	50
	"Weight of FM-200, kilograms"										
64	337.4	333.4	329.4	325.4	321.5	316.7	311.6	306.5	301.4	296.4	291.3
64.5	339.3	335.3	331.3	327.3	323.3	318.4	313.3	308.2	303.1	297.9	292.8
65	341.2	337.2	333.2	329.1	325.1	320.2	315.0	309.8	304.7	299.5	294.3
65.5	343.1	339.1	335.0	331.0	326.9	321.9	316.7	311.5	306.3	301.1	295.8
66	345.1	341.0	336.9	332.8	328.7	323.7	318.4	313.2	307.9	302.6	297.3
66.5	347.0	342.9	338.8	334.6	330.5	325.5	320.1	314.8	309.5	304.2	298.8
67	348.9	344.8	340.6	336.5	332.3	327.2	321.9	316.5	311.1	305.7	300.4
67.5	350.9	346.7	342.5	338.3	334.1	329.0	323.6	318.1	312.7	307.3	301.9
68	352.8	348.6	344.4	340.2	336.0	330.8	325.3	319.8	314.3	308.9	303.4
68.5	354.7	350.5	346.3	342.0	337.8	332.5	327.0	321.5	315.9	310.4	304.9
69	356.7	352.4	348.1	343.9	339.6	334.3	328.7	323.1	317.6	312.0	306.4
69.5	358.6	354.3	350.0	345.7	341.4	336.1	330.4	324.8	319.2	313.5	307.9
70	360.5	356.2	351.9	347.5	343.2	337.8	332.1	326.5	320.8	315.1	309.4
70.5						339.6	333.8	328.1	322.4	316.7	310.9
71						341.3	335.6	329.8	324.0	318.2	312.4
71.5						343.1	337.3	331.4	325.6	319.8	313.9
72						344.9	339.0	333.1	327.2	321.3	315.4
72.5							340.7	334.8	328.8	322.9	317.0
73							342.4	336.4	330.4	324.5	318.5
73.5							344.1	338.1	332.0	326.0	320.0
74								339.7	333.7	327.6	321.5
74.5								341.4	335.3	329.1	323.0
75								343.1	336.9	330.7	324.5
75.5								344.7	338.5	332.3	326.0
76									340.1	333.8	327.5
76.5									341.7	335.4	329.0
77									343.3	336.9	330.5
77.5									344.9	338.5	332.0
78										340.1	333.6
78.5										341.6	335.1
79										343.2	336.6
79.5										344.7	338.1
80											339.6
80.5											341.1
81											342.6
81.5											344.1