FOAM-WATER SPRINKLER SYSTEMS

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1.0 SCOPE

This data sheet contains recommendations related to foam-water sprinkler systems, including guidelines for their design, installation, acceptance testing, inspection, and maintenance. Foam-water sprinkler systems are of the pre-primed wet-pipe, dry-pipe, deluge, or pre-action type. This data sheet applies only to these systems using low-expansion foam.

Foam-water sprinkler systems are more complex than standard sprinkler systems, particularly as regards the provision and arrangement of reliable foam-water solution proportioning and delivery systems. Great care must be taken to ensure the foam-water sprinkler system components are properly selected and the installation quality is high.

Foam-water sprinkler systems can provide effective fire protection for facilities whose operations involve the handling, processing, or transfer of ignitable liquid, or the storage of ignitable liquid in portable containers. Foam-water sprinkler systems are particularly appropriate for protecting facilities where the primary hazard is ignitable liquid floor-spill fire (i.e., a two-dimensional spill fire), such as aircraft hangars, ignitable-liquid truck-loading and unloading stations, and single-level ignitable-liquid product manufacturing/processing/storage facilities.

Foam-water sprinkler systems are not suitable for extinguishing three-dimensional fires such as cascading fuel or spray fires; however, with proper design and floor area containment, they can be of value in the control and extinguishment of resultant spill fires.

Low-expansion foam systems are **not** suitable for protecting the following:

- Chemicals, such as cellulose nitrate, that release sufficient oxygen or other oxidizing agents to sustain combustion
- Liquefied or compressed gas
- Energized, unenclosed electrical equipment
- Combustible metals, such as aluminum and magnesium
- Water-reactive metals, such as lithium, sodium, potassium, and sodium-potassium alloys
- Hazardous, water-reactive materials such as triethyl-aluminum and phosphorous pentoxide.

1.1 Changes

July 2020. Interim revision. The following changes were made:

A. Added guidance on an alternative proportioning test method assessed by FM Approvals.

B. Made minor editorial revisions.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

Foam-water sprinkler systems consist of specialized equipment connected to an automatic sprinkler system. Therefore, in addition to the specific recommendations in this document, adhere to the applicable guidelines in the following data sheets:

- Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
- Data Sheet 2-81, *Fire Protection System Inspection* (for inspection, testing, and maintenance guidelines)
- Data Sheet 3-0, *Hydraulics of Fire Protection Systems*
- Data Sheet 3-7, *Fire Protection Pumps* (for devices such as water and foam pumps, and water and foam motor controllers)
- Data Sheet 4-7N, *Low-Expansion Foam Systems* (for auxiliary discharge devices, such as foam monitors)

2.2 Construction and Location

2.2.1 General

2.2.1.1 Provide heating, ventilation, and air conditioning to maintain the operable temperature of the foam concentrate, pumps, control/actuating valves, and proportioning equipment components of the foam-water sprinkler system in accordance with their listings in the *Approval Guide*.

2.2.1.2 Locate the foam concentrate storage tank, pumps, control/ actuating valves, and proportioning equipment in a room separate from the protected area. If this is not possible, locate the equipment where it will not be exposed to the hazard it is intended to protect.

2.2.1.3 When the foam extinguishing system equipment is installed in a separate stand alone enclosure from normal building services, provide back-up power to the heating, ventilation, and air conditioning systems to maintain the equipment temperature of the foam fire extinguishing system. Or provide an alarm system for temperature control notification of impairment to the fire protection in accordance with the applicable recommendations in Data Sheet 5-40, *Fire Alarm Systems*.

2.2.1.4 Locate all operating devices of the foam-water sprinkler system so they are not subject to mechanical, chemical, climatic, or other conditions that can render them inoperative or susceptible to accidental damage or operation.

2.2.1.5 Locate all operating devices of the foam-water sprinkler system so they are fully accessible for inspection, testing, maintenance, and removal/ replacement without requiring the removal of any other equipment.

2.2.2 Containment

The following recommendations are intended to ensure the retention of the foam blanket in the area of a ignitable-liquid fire.

2.2.2.1 Provide containment in the ignitable liquid area adequate to handle the total flow of foam-water solution from the demand area of the foam-water sprinkler system(s), including auxiliary fixed foam-water discharge devices and the discharge from interior foam-water hose streams.

2.2.2.2 Provide a minimum of 2 in. (5 cm) freeboard for the retention of the low-expansion foam blanket over the area being protected.

2.2.2.3 In addition to these recommendations, design containment in accordance with the applicable occupancy-specific data sheet.

2.3 Protection

The recommendations in this section are intended to ensure the proper application of foam-water sprinkler systems.

Use FM Approved foam-water sprinklers and system components in accordance with their listings in the *Approval Guide*. (See Section 3.2)

2.3.1 Distribution and Discharge Devices

2.3.1.1 Use the appropriate foam-water sprinkler system (e.g., wet-pipe, preprimed, preaction, dry-pipe, or deluge) in accordance with the applicable occupancy-specific data sheet.

2.3.1.2 Use non-aspirating discharge devices for foam-water sprinkler systems with AFFF foam concentrates.

2.3.1.3 Use aspirating discharge devices for foam-water sprinkler systems with protein or fluoroprotein-based foam concentrates.

For foam-water deluge sprinkler systems, discharge devices may be aspirating or non-aspirating.

2.3.1.4 Arrange the system to deliver a foam-water solution from the four most remote sprinklers within 2 minutes of sprinkler operation. Use a pre-primed system if necessary to meet the 2 minute delivery time.

2.3.1.5 For pre-primed foam-water piping systems, use automatic sprinklers with a K-factor of K11.2 (K160) or greater when pendent automatic sprinklers are used. Otherwise, use upright automatic sprinklers.

When a wet-pipe, dry-pipe, or deluge system is used, refer to the applicable occupancy-specific data sheet to verify the foam-water solution delay time is acceptable for the given hazard.

Wet-Pipe, Pre-Primed, Preaction, Dry-Pipe, and Deluge Foam-Water Systems

- Arrange the distribution system in a tree or dead-end layout.

Pre-Primed Foam-Water Systems

- Pre-prime foam-water sprinkler system piping when recommended in the applicable occupancy-specific data sheet.
- Do not pre-prime foam-water sprinkler system piping with protein foam-water solution.
- Follow manufacturer's installation recommendations when pre-priming foam-water sprinkler system piping with alcohol-resistant foam-water solution.
- Provide flushing connections and valves on the cross mains and/ or branch lines of the distribution system. Flush with foam-water solution at the specified concentration.

2.3.2 Foam Concentrate

2.3.2.1 Use and store foam concentrates (including reserve and replacement supplies) in accordance with their listings in the *Approval Guide*.

2.3.2.2 When protecting hydrocarbon fuels, use one of the following types of foam concentrates:

- Protein
- Fluoroprotein
- Aqueous film-forming foam (AFFF)
- Film-forming fluoroprotein (FFFP)
- Alcohol-resistant (AR)

2.3.2.3 When protecting polar solvents, i.e., solvents with appreciable water solubility or water miscibility (e.g., methyl alcohol, ethyl alcohol, ethanol, and acetone), provide an alcohol-resistant foam concentrate. Film-forming foams will not form films over polar solvents.

2.3.2.4 Do not use wetting agents as a substitute for foam concentrates in foam-water sprinkler systems. There is no current testing that demonstrates that a wetting agent will provide protection equivalent to an FM Approved foam concentrate.

2.3.3 Water Supply

2.3.3.1 Provide a water supply for the foam-water sprinkler system at the design discharge rate and pressure for at least 60 minutes, or in accordance with the applicable occupancy-specific data sheet, whichever is longer.

2.3.4 Foam Concentrate Proportioning Methods

2.3.4.1 Use balanced-pressure or positive-pressure injection methods for the introduction of foam concentrates into the water flowing through the supply piping to the system.

Install one of the following balanced or positive-pressure injection methods:

(a) Bladder tank proportioning (Fig. 1)

(b) Balanced pressure proportioning (Fig. 2)

(c) In-line balanced proportioning (ILBP) (Figs. 3 and 4)

(d) Line proportioning, deluge applications only (Fig. 5)

(e) Positive displacement, water motor driven foam concentrate proportioner pump (Fig. 6)

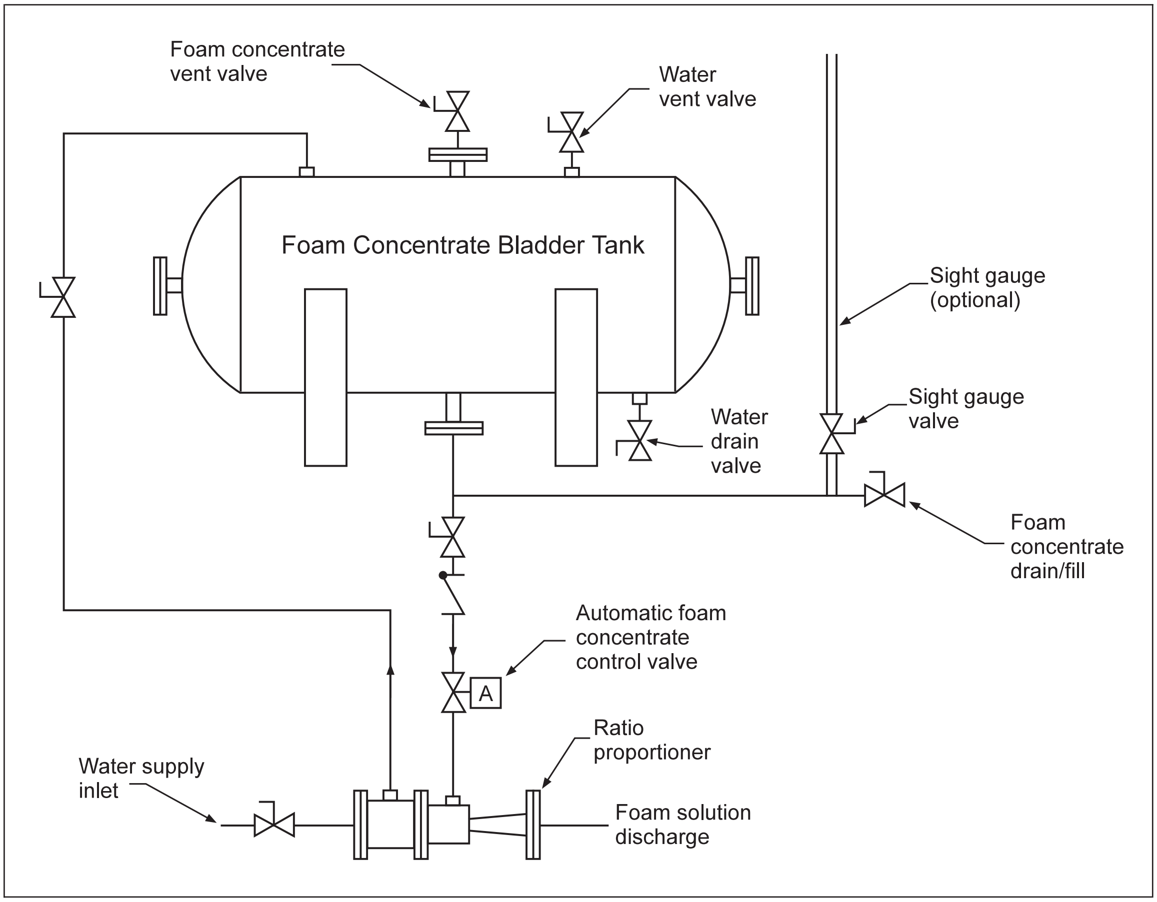


Fig. 1. Bladder tank proportioning

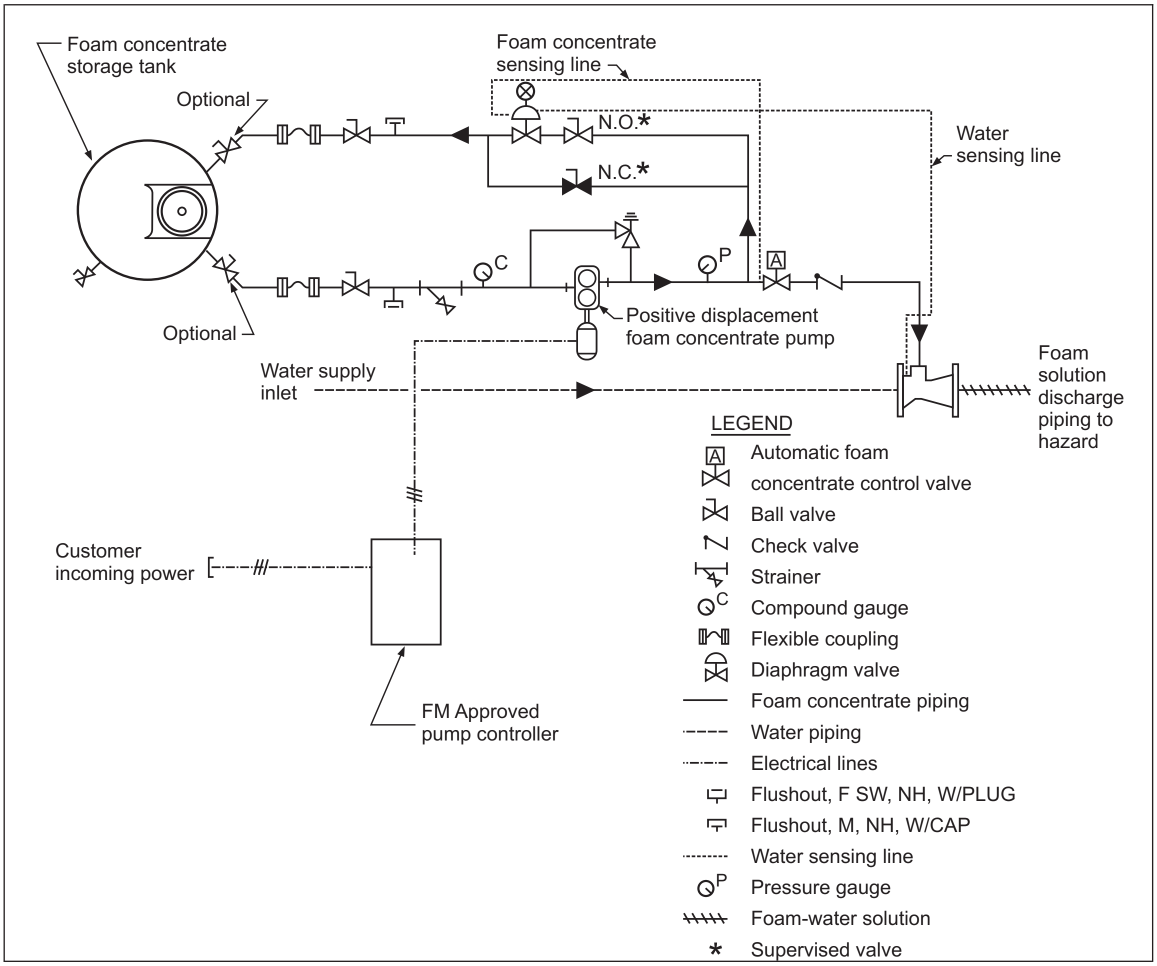


Fig. 2. Balanced pressure proportioning

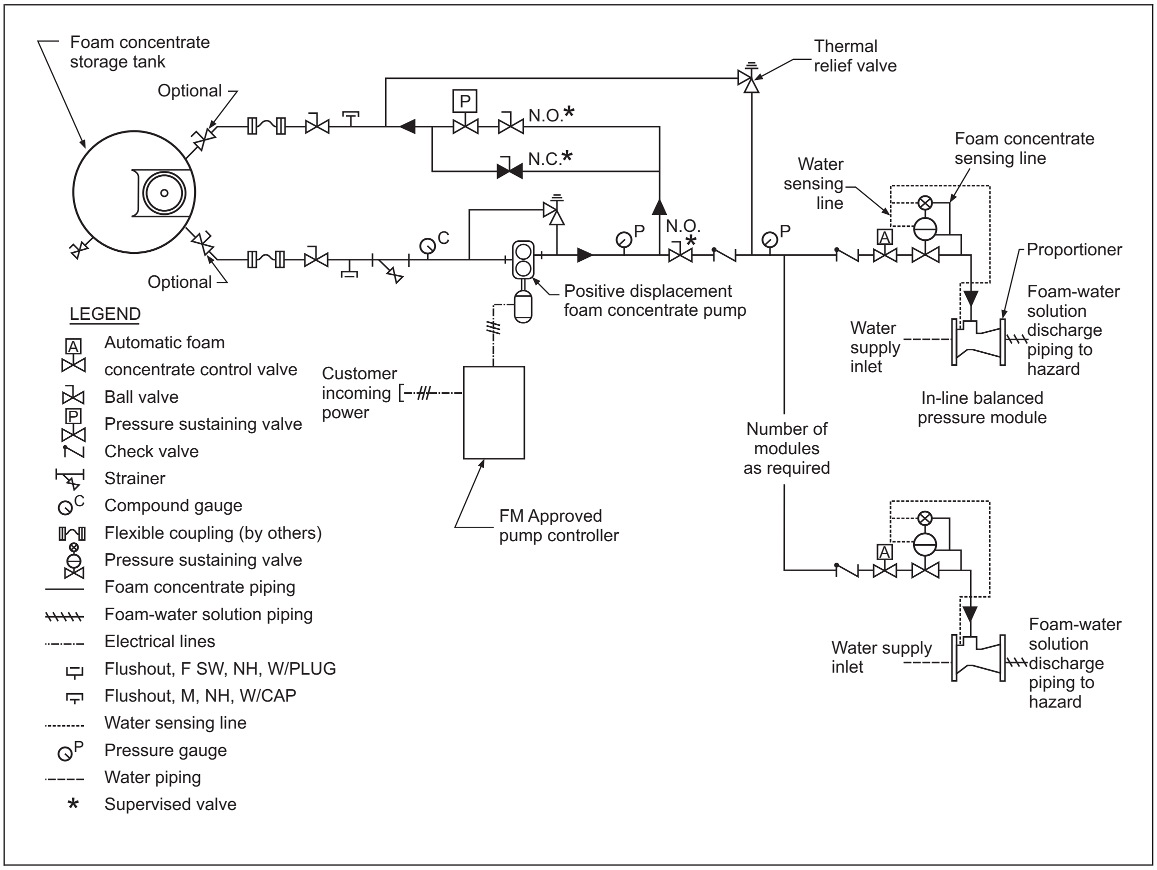


Fig. 3. In-line balanced proportioner (ILBP)

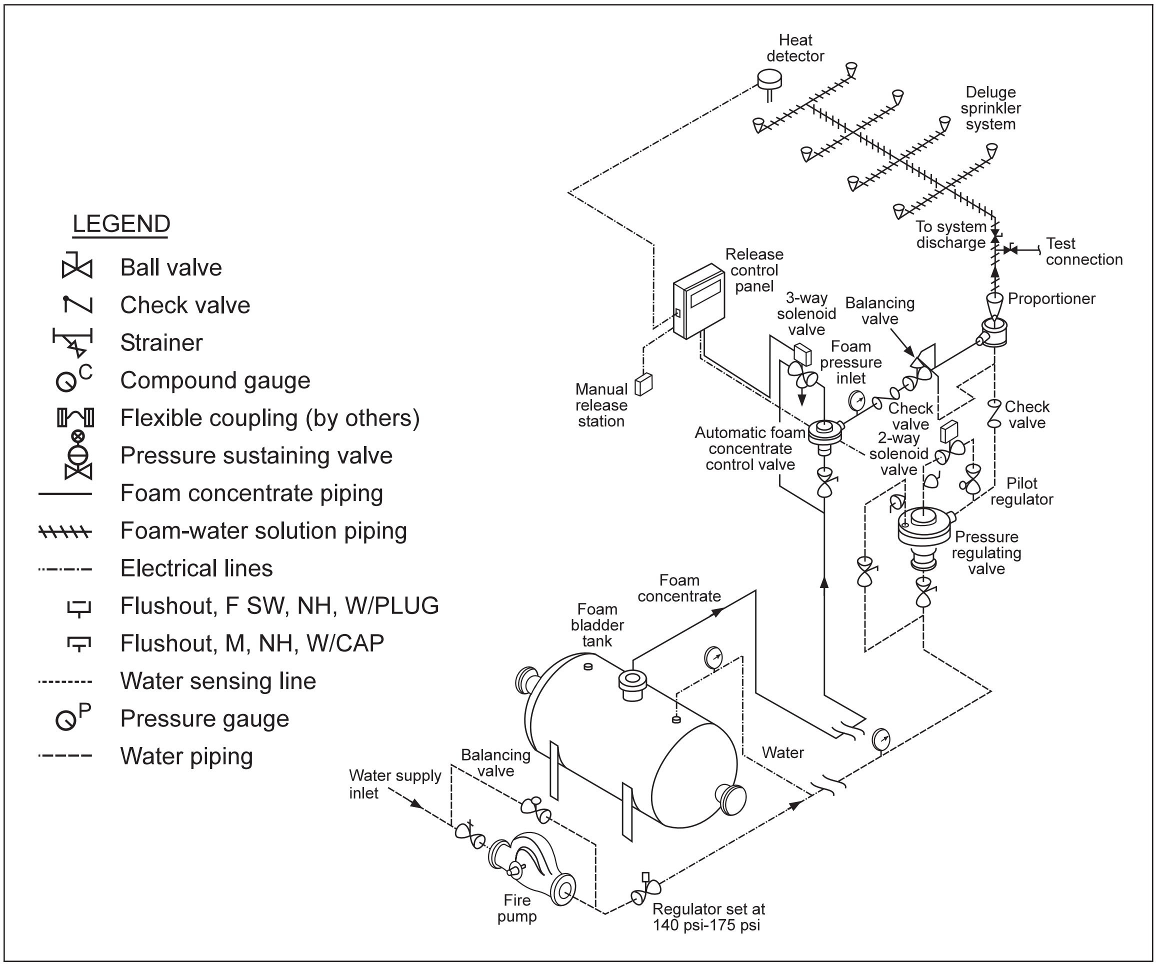


Fig. 4. In-line balanced proportioner (ILBP), deluge application

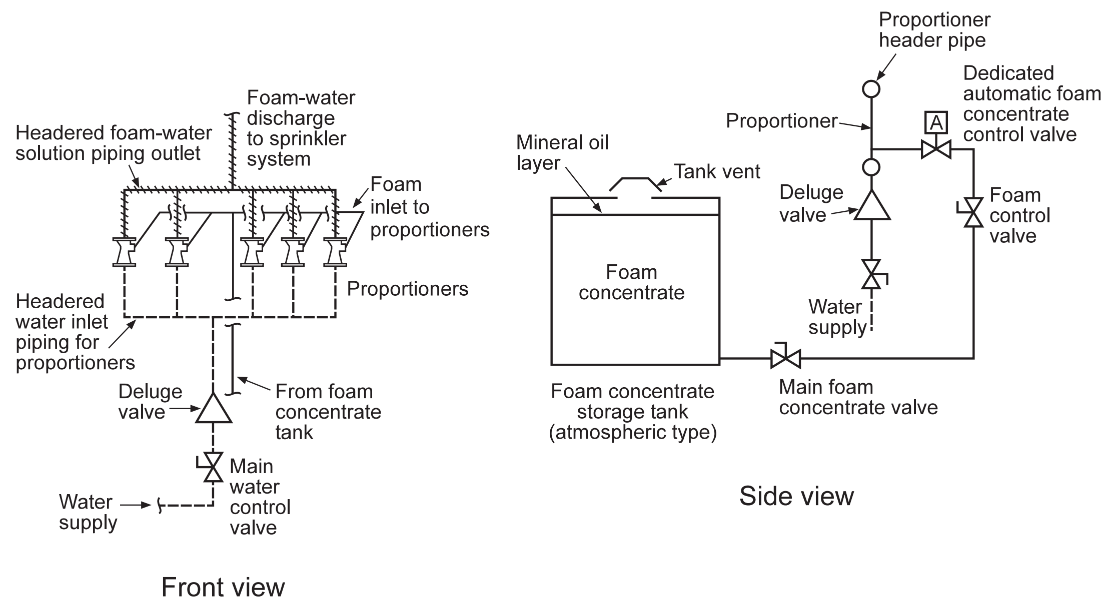
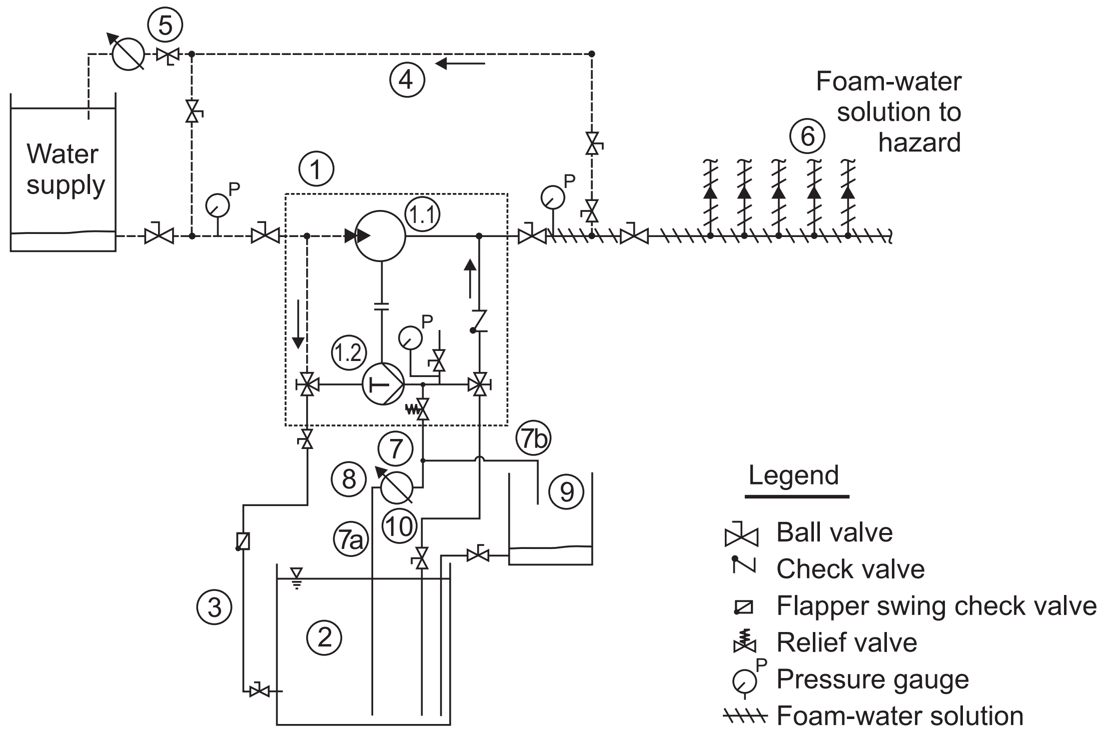


Fig. 5. Line proportioning, deluge application only



1 Positive displacement, water motor driven foam concentrate proportioner pump
1.1 Hydraulic drive
1.2 Foam concentrate pump
2 Foam concentrate tank
3 Foam concentrate suction line
4 Pump test line
5 Flow meter for water
6 Alarm valves
7 Test connection
7a Option a, flow meter
7b Option b, volumetric tank
8 Flow meter for foam concentrate
9 Foam concentrate measurement tank
10 Return line to foam concentrate supply

Fig. 6. Positive displacement, water motor driven foam concentrate proportioner pump

2.3.4.2 Provide permanently marked identification on the proportioning device with the following information:

- Flow direction
- Proportioning orifice diameter
- Applied foam concentration
- Working range of flow

2.3.4.3 Use a positive displacement foam concentrate pump and drive motor that will vary the foam concentrate pump output to match water flow rates while maintaining the correct percentage of foam concentrate for positive-pressure injection methods, e.g., balanced pressure and in-line balanced pressure proportioning.

2.3.5 Actuation

2.3.5.1 Provide automatic actuation of the foam-water sprinkler system.

2.3.5.2 Provide foam concentrate injection automatically by, or concurrently with, activation of the main water supply control alarm valve.

2.3.5.3 Provide manual actuation to supplement automatic actuation for deluge and preaction foam-water sprinkler systems. Ensure it is accessible at all times.

For large hazard areas and/ or where access may be limited, provide manual actuation devices both local to, and remote from, the actuating devices.

2.3.5.4 Use an FM Approved operating device to control actuation of the water and foam concentrate control valves.

2.3.5.5 Provide FM Approved indicating valves (e.g., OS&Y, indicating butterfly or post indicator) for water and foam solution lines.

2.3.5.6 Provide a separate sprinkler or deluge alarm valve on the water line to each proportioner inlet.

2.3.5.7 Provide supervision in accordance with the recommendations in Section 2.4.11.2.

2.3.5.8 Provide a reliable primary source of energy where operation is electrical. Also provide a source of backup power, and an emergency mechanical release or actuation device accessible from at least one remote location.

2.3.6 Design Criteria

2.3.6.1 Application Rate

2.3.6.1.1 Hydraulically design automatic or deluge foam-water sprinkler systems to provide the larger of the following:

(a) A minimum of 0.2 gpm/ft^2 (8 mm/min)

(b) The density recommended in the applicable occupancy-specific data sheet

(c) The minimum required density specified in the *Approval Guide* listing

2.3.6.1.2 Ensure the foam concentrate injection percentage is in accordance with the FM Approval listing for the concentrate being used.

2.3.6.2 Discharge Duration

2.3.6.2.1 Design the foam-water solution to discharge for the duration specified in the applicable occupancy-specific data sheet (if any), but in no case less than 10 minutes over one of the following:

(a) The entire system area for deluge foam-water sprinkler systems

(b) The demand area for automatic foam-water sprinkler systems

2.3.6.3 Demand Area

2.3.6.3.1 Use the full demand area recommended in the applicable occupancy-specific data sheet.

2.3.6.4 Foam Quantity

2.3.6.4.1 Base the foam concentrate supply on the required foam concentrate injection percentage for the foam-water sprinkler system, foam-water hose stream design, auxiliary discharge device requirements, and the recommendations in Section 2.3.6.1.

2.3.6.4.2 Determine the demand flow and pressure in accordance with Data Sheet 3-0, *Hydraulics of Fire Protection Systems*. Calculate the sprinkler demand with the minimum foam density/ application rate and minimum operating pressure specified for the foam-water sprinkler with the fuel and concentrate type.

2.3.6.4.3 Determine the quantity of foam concentrate needed for a foam-water sprinkler system design by adding the quantity of foam concentrate needed at the actual sprinkler discharge rate plus quantity of foam concentrate needed for foam hose lines plus quantity of foam concentrate needed to charge sprinkler piping in a pre-primed system. Use equation 1.

$$V_{FC} = [Q_{AA} \times t \times (C/100) \times PFF] + [Q_{FHS} \times t \times (C/100) \times PFF] + [V_{PP}] \qquad \text{(Equation 1)}$$

Where:

V_{FC} = Quantity of foam concentrate (gal [L])

Q_{AA} = Actual sprinkler flow demand at the point of connection to the foam concentrate proportioning device, (gpm, [L/min])

Q_{FHS} = Foam-hose or auxiliary discharge device (e.g., foam monitor) flow demand at the point of connection to the foam concentrate proportioning device, (gpm [L/min])

t = Foam discharge duration from applicable occupancy standard, (min)

C = Foam discharge concentration, (%)

PFF = Proportioner flow factor (See Table 1)

V_{PP} = (Volume of water in sprinkler system [gal or L] x foam discharge concentration [%]) + Volume of foam concentrate in feed line (gal or L) + Volume of foam concentrate in sediment pocket for atmospheric storage tanks (gal or L)

Table 1. Proportioner Flow Factors

Proportioner Type	*Delivered Flow of Proportioner for Demand Area*	*Proportioner Flow Factor, (PFF)*[1]
Variable	Minimum flow to maximum flow	1.15
Fixed ratio	Minimum flow to midrange flow	1.10
	Midrange flow to maximum flow	1.15
In-line balanced proportioner (ILBP)	Minimum flow to midrange flow	1.20
	Midrange flow to maximum flow	1.10
Positive displacement foam concentrate proportioner pump	Minimum flow to midrange flow	1.15
	Midrange flow to maximum flow	1.20

[1] PFF is a minimum value. If a manufacturer specifies a higher value, use that value to determine the quantity of foam concentrate.

2.3.6.5 Hydraulic Calculations for Wet-Pipe, Pre-Primed, Dry-Pipe and Preaction Foam-Water Systems

2.3.6.5.1 Calculate the pipe size carrying foam-water solution the same as carrying plain water. Perform hydraulic calculations in accordance with Data Sheet 3-0, *Hydraulics of Fire Protection Systems* and Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers.*

2.3.6.5.2 Include the pressure drop across the proportioner that is installed in the sprinkler water flow path in system hydraulic calculations.

2.3.6.5.3 Verify the selected FM Approved proportioner has a flow range that meets the calculated minimum and maximum system demand.

2.3.6.5.4 Verify the minimum inlet pressure requirement of the proportioner is met.

2.3.6.5.5 Verify the maximum pressure differential for the water and foam concentrate supply of an in-line balanced pressure proportioner does not exceed the manufacturer's specifications.

2.3.6.5.6 Calculate the friction loss in piping carrying a non-alcohol resistant foam concentrate using the Darcy-Weisbach formula (also known as the Fanning formula) from the foam concentrate supply to the proportioner.

2.3.6.5.7 Consult the foam concentrate manufacturers for friction loss characteristics in pipe carrying an alcohol resistant foam concentrate (non-Newtonian fluid) from the foam concentrate supply to the proportioner.

2.4 Equipment and Processes

2.4.1 Foam Concentrate

2.4.1.1 If foam concentrate piping to the foam-water sprinkler system proportioner(s) is run underground, or if it runs aboveground for more than 50 ft (15 m), ensure the piping is kept full. Provide a means of checking the integrity of the piping.

2.4.1.2 If piping integrity is checked by pressurization from a pressure-maintenance pump or similar means, ensure the system components and piping do not become over-pressurized. Provide a pressure-relief mechanism if necessary.

2.4.1.3 Maintain the temperature of the foam concentrate piping within the storage temperature limits specified for the foam concentrate in the *Approval Guide*.

2.4.2 Water Supply

2.4.2.1 Ensure the quality of the water supplied to the foam-water sprinkler system (e.g., hard or soft, fresh or salt, recycled or processed)is compatible with the foam concentrate being used.

2.4.2.2 Do not use recycled water, processed water, or grey water unless a competent evaluation for suitability of the water quality has been conducted to confirm adequate foam-production quality.

2.4.2.3 Provide water at temperatures between 40°F (4°C) and 100°F (38°C) to ensure optimum foam production.

2.4.2.4 Ensure no corrosion inhibitors, emulsion-breaking chemicals, or other additives are present unless they are listed in the *Approval Guide* as being compatible with the foam concentrate.

2.4.2.5 Provide water supplies of a capacity and pressure to maintain foam-water solution discharge, water discharge, or both, at the design rate for the required period of time over the entire demand area and/or area protected by systems expected to operate simultaneously.

2.4.2.6 When cross-connections exist to potable water, other external agencies may need to review the installation.

2.4.3 Foam Concentrate Proportioners

2.4.3.1 Provide a variable-flow proportioner for wet-pipe, pre-primed, dry-pipe, and preaction systems. If a variable-flow proportioner cannot be used, ensure the flow range of the ratio proportioner, in-line balanced proportioner or positive displacement water driven foam concentrate proportioner pump is adequate for the demand area.

2.4.3.2 Provide a fixed-ratio proportioner for deluge systems.

2.4.3.3 Provide a foam concentrate proportioner in the full foam-water solution range (minimum and maximum) of flow required for the hazard demand area.

2.4.3.4 Use the type of foam concentrate and injection percentage specified in the proportioner's listing in the *Approval Guide*.

2.4.3.5 Provide either (a) a minimum of five pipe diameters, or (b) the manufacturer's recommended amount of straight, unobstructed pipe on the inlet and discharge side of the proportioner.

2.4.3.6 Install the foam concentrate proportioner in the orientation (horizontal or vertical) specified in its *Approval Guide* listing.

2.4.3.7 Install the foam concentrate proportioner at an elevation at or above the foam concentrate bladder tank if an automatic foam concentrate control valve is not provided.

2.4.3.8 Install a spool piece of piping, grooved coupling, or union in the foam concentrate piping between the swing check valve and inlet at the proportioner to facilitate servicing either the orifice plate of the proportioner or proportioner itself.

2.4.3.9 If a pressure-reducing valve is used with an in-line balanced pressure proportioner, ensure it is correctly set and secured.

2.4.3.10 Ensure braided steel is used for the sensing line to the spool valve and duplex gauge.

2.4.3.11 Provide a swing-check valve on the foam concentrate piping from the foam concentrate supply after the automatic foam concentrate control valve, but prior to the proportioner.

2.4.3.12 Provide a label, tag, or nameplate with the proportioner to document the actual injection percentage of foam concentrate determined during the acceptance test.

2.4.4 Valves

2.4.4.1 Provide FM Approved indicating valves (e.g., OS&Y, post indicator, butterfly or ball) for water and foam solution lines.

2.4.4.2 Provide a separate alarm valve on the water line to each proportioner inlet.

2.4.4.3 Provide FM Approved valves on foam concentrate lines that are compatible for this service.

2.4.4.4 Install automatic foam concentrate control valve(s) in foam concentrate line(s) that are equipped with the following:

- Electrical supervision of operating position for remote annunciation
- Position indicator
- Emergency manual operation
- A manual reset
- A strainer in the actuation line
- A means to flush the actuation line after operation
- A minimum NEMA Type 1 or IP-10 housing/ enclosure, if electrically operated by solenoid

2.4.4.5 Ensure the water supply pressure meets the minimum operating pressure for the automatic foam concentrate control valve.

2.4.4.6 If the automatic foam concentrate control valve is actuated by water pressure upon foam-water sprinkler system flow, use a maximum of 24 in. (0.6 m) of braided stainless steel hose or pipe from the sprinkler valve trim to the water actuation line.

2.4.4.7 Do not use pressure-regulating valves in the actuation line for the automatic foam concentrate control valve. If the water supply pressure exceeds the operating pressure of the actuator for the automatic foam concentrate control valve, use a pressure relief valve set to the maximum operating pressure of the actuator body for the automatic foam concentrate control valve.

2.4.4.8 Do not use an automatic foam concentrate control valve with the positive displacement, water driven, foam concentrate proportioner pump.

2.4.4.9 Provide handles that can be secured or locked on all manual valves.

2.4.4.10 Equip the dry portion of the foam concentrate piping from the automatic concentrate control valve to the foam concentrate proportioner with flushing devices.

2.4.4.11 Provide nameplates in the immediate vicinity of valves and devices to identify their function and operating position.

2.4.4.12 Provide drain valves for premixed solution or foam concentrate piping at low points, whether below or above ground.

2.4.5 Test Connection

2.4.5.1 Provide a test connection in order to functionally verify the operability of the foam-water sprinkler system proportioning components (see Figure 7).

2.4.5.2 Size the foam-water sprinkler system test connection(s) to accommodate both the minimum design flow and the maximum anticipated flow through the proportioner. Multiple discharge outlet points from the test connection on the riser may be required to accommodate the range of flow.

2.4.5.3 Provide the test connection in the riser in a flow direction downstream of the proportioning device.

2.4.5.4 Provide a secured isolation valve(s) on the test connection outlet.

2.4.5.5 Provide a supervised isolation valve of equal dimension in the sprinkler riser to isolate the distribution/ discharge devices.

2.4.5.6 Provide a secured isolation valve on the water supply line to the bladder tank. Ensure this connection is located prior to the proportioner.

2.4.5.7 Provide a secured isolation valve in the concentrate pipe upstream of the automatic foam concentrate control valve from the foam storage container.

2.4.5.8 Route the piping from the test connection to a drain area for easy disposal of the foam-water solution produced during either the acceptance test or annual testing of the foam-water sprinkler system.

2.4.5.9 When utilizing a test liquid or water equivalency method from a company assessed by FM Approvals for annual discharge testing, provide the connections and fittings in accordance with the configuration identified in their assessed manual for the appropriate proportioning method.

2.4.5.10 Keep isolation valves or three-way valve outlets for proportioning testing capped when not being used.

2.4.5.10.1 Provide a tethered end cap to the isolation valve or three-way valve.

2.4.5.10.2 Ensure a tee with an isolation valve is provided on the water supply riser upstream of the proportioner to allow for either water equivalency or test liquid testing.

2.4.5.10.3 Install a water-booster pump, permanently or temporarily, for water equivalency testing to provide the necessary pressure differential with an in-line balanced pressure proportioner with foam pump.

2.4.5.10.4 At the foam concentrate tank, provide a tee with isolation valve in the foam concentrate line, or replace isolation valves with a three-way valve to allow for either water equivalency testing or test liquid testing.

2.4.5.10.5 Install a pressure gauge on the water supply riser prior to the proportioner for measurement of water pressure.

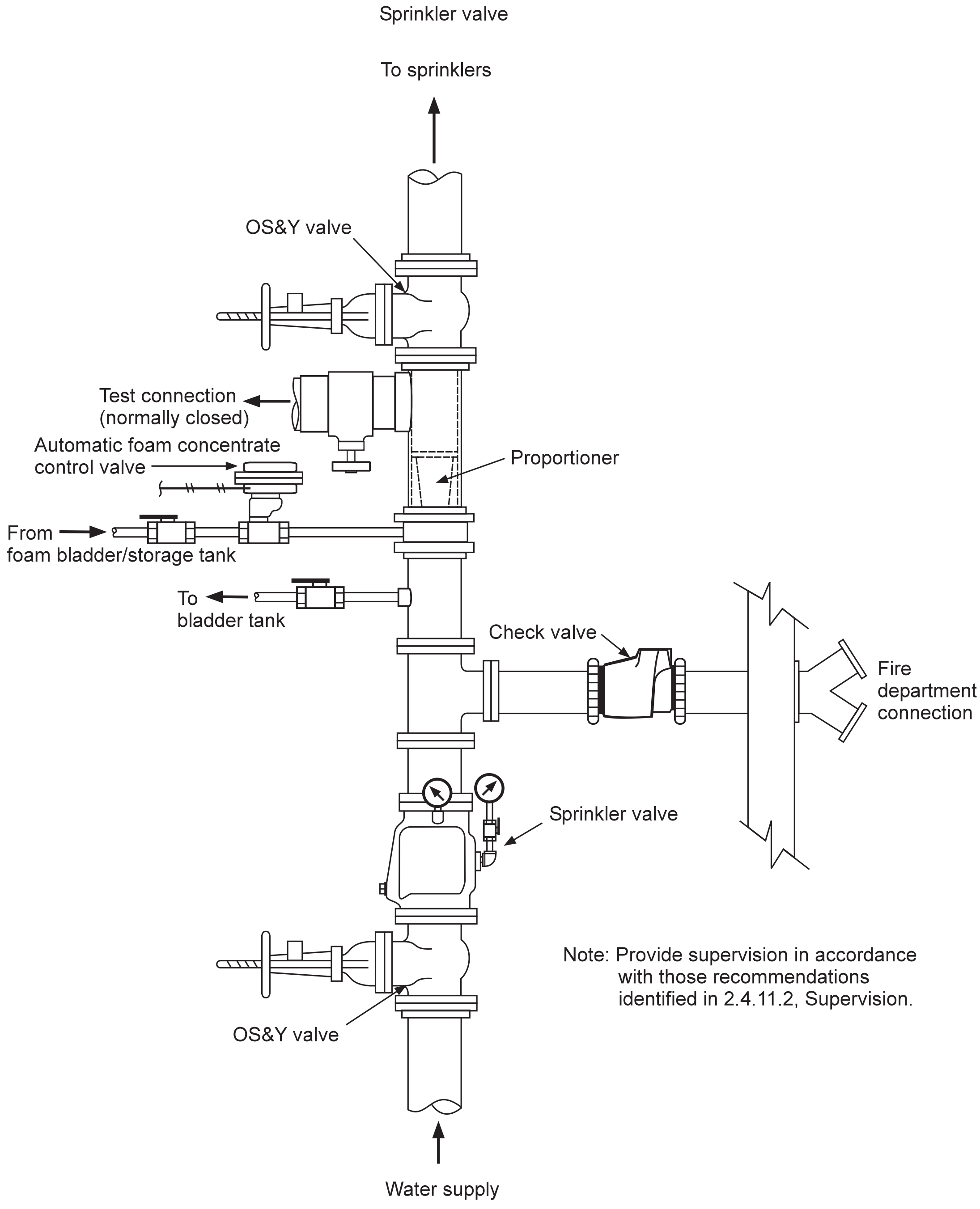


Fig. 7. Test connection

2.4.6 Concentrate Pump

2.4.6.1 Use a foam concentrate pump and drive motor that will vary the foam concentrate pump output to match water flow rates while maintaining the correct percentage of foam concentrate.

2.4.6.2 Arrange the foam concentrate piping so maximum foam concentrate demand can be supplied by any foam concentrate pump from either primary or reserve foam concentrate tanks.

2.4.7 Foam Concentrate Storage Tanks

2.4.7.1 General

2.4.7.1.1 Use foam concentrate storage tanks of either the atmospheric or bladder type.

2.4.7.1.2 Provide a foam concentrate storage tank with the capacity to hold the quantity of foam concentrate determined in Section 2.3.6.4.

2.4.7.1.3 Use atmospheric storage or bladder tanks constructed of materials compatible with the type of foam concentrate, and ensure they are solidly mounted and permanently located.

2.4.7.1.4 Do not store foam concentrates in galvanized steel tanks.

2.4.7.1.5 Locate storage tanks so the temperature will remain within the range specified in the *Approval Guide* for the foam concentrate. See Section 2.2 for recommendations on maintaining temperature.

2.4.7.1.6 Clearly mark foam concentrate storage tanks with the

- type of foam concentrate
- percentage (foam concentrate in the foam solution)
- manufacturer
- lot number
- purchase date

2.4.7.1.7 Provide a gauging device to determine the quantity of foam concentrate in the tank.

2.4.7.1.8 Provide a valve to isolate the gauging device used to determine the foam concentrate quantity during operation of the foam-water sprinkler system.

2.4.7.1.9 Use foam concentrate storage tanks that have a means of filling, draining, cleaning, and inspecting interior surfaces.

2.4.7.1.10 Use storage tanks that have filling and draining points close to the tank bottom.

2.4.7.1.11 Ensure the foam concentrate storage tank has sufficient ullage to accommodate thermal expansion of the foam concentrate based upon the manufacturer's specifications.

2.4.7.1.12 Provide nameplates/instructions in the immediate vicinity of valves and devices used with the foam concentrate storage tank to identify their functions and operating positions (e.g., foam concentrate fill, foam concentrate tank drain, foam concentrate tank vent).

2.4.7.1.13 Provide foam concentrate storage tanks with a pressure vacuum vent to prevent free exchange of air.

2.4.7.1.14 A single foam concentrate storage tank can supply multiple foam-water sprinkler systems by using a manifold concentrate supply system.

2.4.7.2 Bladder Tanks

2.4.7.2.1 Use a bladder tank equipped with a means of inspecting the interior surfaces and foam concentrate-holding bladder.

2.4.7.2.2 Use a bladder tank equipped with automatic pressure relief device(s) to prevent exceeding the design pressure of the tank.

2.4.7.2.3 Use a bladder tank stamped as meeting the requirements of the applicable pressure vessel code for the authority having jurisdiction.

2.4.7.2.4 Locate the water inlet line to the bladder tank for a single riser above the alarm check valve or system control valve.

2.4.7.2.5 Locate or configure the water inlet line(s) to the bladder tank for multiple risers to prevent hydraulic over-pressurization of the bladder in the set position.

2.4.7.2.6 Provide a valve to isolate the water inlet line to the bladder tank from the sprinkler system water supply.

2.4.7.3 Atmospheric Storage Tanks

2.4.7.3.1 Use an atmospheric storage tank equipped with overfill protection and automatic pressure/vacuum relief devices to prevent exceeding the design pressure of the tank.

2.4.7.3.2 Use an atmospheric storage tank with a connection for the foam concentrate suction pipe arranged above the tank bottom.

2.4.7.3.3 Do not use the volume below the connection of the suction pipe for the determination of the usable quantity of foam concentrate.

2.4.7.3.4 To prevent evaporation, seal alcohol-resistant foam concentrates (and other foam concentrates as required by the manufacturer) with a ¼ to ½ in. (6 to 13 mm) layer of mineral oil or manufacturer's proprietary equivalent.

2.4.7.3.5 Locate tank discharge outlets, if provided, to furnish a positive head on either the foam concentrate pump or positive displacement, water driven foam concentrate proportioner pump suction.

2.4.8 Pipe, Pipe Fittings, and Hangers

In addition to the following recommendations, provide pipe, valves, fittings, and hangers for foam-water solution and water in accordance with the recommendations in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers.*

2.4.8.1 Ensure the foam-water solution supply piping to foam discharge devices that protect a particular hazard in a given area does not pass over another hazard in the same area.

2.4.8.2 Use pipe, fittings, and valves of a material compatible with the foam-water solution.

2.4.8.3 With the foam concentrate, use pipe, fittings, and valves made of the following materials:

- Brass (red or naval)
- Bronze
- Stainless steel (304 or 316)
- FM Approved as compatible with the foam concentrate

In piping with dissimilar metals, insulate with dielectric components to reduce the possibility of galvanic corrosion.

2.4.8.4 Do not use galvanized steel pipe and fittings with foam concentrates.

2.4.8.5 Use grooved couplings and fittings with elastomeric seals that are compatible with the foam concentrate, foam-water solution, or water, as applicable.

2.4.8.6 Use Teflon tape or the foam concentrate manufacturer's compatible thread-locking compounds at pipe joints in the foam concentrate supply line.

2.4.8.7 Secure and restrain foam concentrate piping against movement, thrust, and vibration.

2.4.8.8 Install flushing and drainage valves/connections for foam concentrate piping that is dry in the standby condition. Provide the ability for complete drainage.

2.4.8.9 Provide a means of draining, and a minimum pitch towards the drain of 1 in 120 for draining all dry, preaction, and deluge foam-water solution distribution piping.

2.4.8.10 Do not insulate pipes against heat and cold or use antifreeze agents with wet or pre-primed foam-water sprinkler distribution systems.

2.4.8.11 Check the inside of all pipes for cleanliness prior to installation.

2.4.8.12 Flush the entire piping system after completion of the installation.

2.4.8.13 Provide pipes conveying foam-water solution that can withstand a pressure of 1.5 x p_{nom} (minimum 220 psi [15 bar]). See acceptance testing recommendations for further guidance.

2.4.8.14 Where a foam-water sprinkler system is pre-primed with foam-water solution, provide drain and flushing connections in accordance with the recommendations in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*

2.4.9 Strainers

2.4.9.1 Provide FM Approved strainers in the foam concentrate and water-actuation piping where solids of a size large enough to obstruct openings or damage equipment (e.g., foam pump, foam concentrate valve actuator) are present.

2.4.9.2 Provide strainers with perforations no larger than the smallest orifice in the foam-water sprinkler system, and no smaller than ⅛ in. (3.2 mm).

2.4.9.3 Install strainers for water-actuation and foam concentrate piping that are accessible for cleaning or flushing.

2.4.9.4 Install strainers for foam concentrate with a blow down/ off valve connection or similar outlet connection for cleaning (flushing) while maintaining system discharge during an emergency.

2.4.9.5 Install strainer(s) in the foam concentrate piping upstream of foam concentrate pump(s), except for high-viscosity, alcohol-resistant AFFF foam concentrates.

2.4.9.6 Follow the foam concentrate manufacturer's recommendations for using a strainer(s) in the foam concentrate piping upstream of foam concentrate pump(s) for high-viscosity, alcohol-resistant AFFF foam concentrates.

2.4.9.7 Install a compound gauge downstream of the strainer on a foam pump suction line to monitor potential blockage during operation.

2.4.10 Deluge Sprinklers

2.4.10.1 Where a foam-water sprinkler system will use deluge sprinklers in an atypical environment (e.g., heavy contamination) install them in accordance with the recommendations in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers.*

2.4.10.2 Install a weldolet on the riser downstream of the proportioner riser isolation valve to provide a test connection for determining if sprinklers are clogged. Plug the weldolet when it is not in use for inspection and testing.

2.4.11 Operation and Control of Systems

2.4.11.1 Actuation

2.4.11.1.1 Provide operating instructions that plainly indicate the location and purpose of the actuation controls.

2.4.11.1.2 In deluge or preaction systems, provide FM Approved detection and control equipment with an electrically compatible (voltage/current) interface/releasing module for the automatic actuation device (e.g., solenoid) of the water deluge valve(s) and other system-control equipment.

2.4.11.1.3 Provide manual release stations that are:

- clearly marked
- secure from unauthorized operation
- clearly identified as serving a specific area
- mounted 42 in. (1.1 m) above the finished floor

2.4.11.1.4 De-energize power/fuel supplies to the hazard being protected in accordance with the applicable occupancy-specific data sheet upon operation of the foam-water sprinkler system.

2.4.11.1.5 Provide emergency manual actuation of the hydraulic foam concentrate valve.

2.4.11.1.6 Provide signage on the proper shutdown sequence of valves and equipment after the foam-water sprinkler system has activated due to a fire or accidental discharge.

2.4.11.2 Supervision

2.4.11.2.1 Provide supervision of the operating position of water supply, water alarm check valve(s), and foam-water solution control valve(s) in accordance with the recommendations in Data Sheet 2-81, *Fire Protection System Inspection.*

2.4.11.2.2 Provide supervision to the operating position of foam concentrate valves in accordance with recommendations of Data Sheet 2-81, *Fire Protection System Inspection.*

2.4.11.2.3 Provide electrical supervision in accordance with the recommendations in Data Sheet 5-40, *Fire Alarm Systems*, for local, central station, proprietary, or remote station signaling, as applicable for each of the following:

- automatic foam concentrate control valve(s)
- foam concentrate pump isolation valve(s)
- foam concentrate pump regulating/diaphram by-pass valve(s)

2.4.11.2.4 Provide supervisory alarm signals that are different from fire alarm signals at the fire alarm control panel.

2.4.11.3 Detection

2.4.11.3.1 Provide automatic detection for foam-water preaction and deluge systems (whether pneumatic, hydraulic, optical, heat, or smoke) with complete supervision arranged so that failure of equipment, loss of supervising air pressure, or loss of electric energy results in clear notification of the abnormal condition. See Section 2.4.11.2 for further guidance.

2.4.11.3.2 Provide detection and actuation circuitry in accordance with the recommendations in Data Sheet 5-48, *Automatic Fire Detection*.

2.4.11.3.3 Provide detection for foam-water preaction and deluge systems in accordance with the recommendations in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

2.4.11.3.4 When used in a corrosive atmosphere, install detection devices made of materials not subject to corrosion, or that have been treated to resist corrosion.

2.4.11.3.5 When protecting hazardous areas, ensure electric automatic detection equipment and any auxiliary equipment has been specifically designed and rated for such areas.

2.4.11.4 Alarms

2.4.11.4.1 Provide audible and visual alarms that indicate locally and at a permanently manned location upon the following modes of foam-water sprinkler system operation:

- Release and/or actuation of each foam-water sprinkler system from the detection system or alarm check valve and automatic foam concentrate control valve
- Fault of the foam extinguishing/ monitoring system of the foam-water sprinkler system

2.4.11.4.2 Provide audible and visual alarms in accordance with Data Sheet 5-40, *Fire Alarm Systems*.

2.4.11.4.3 Provide fire alarm signals that are different from supervisory alarm signals at the fire alarm control panel.

2.4.11.4.4 Use alarms designed for indicating each foam-water sprinkler system separately.

2.4.11.4.5 Ensure fault alarms are distinctive from those indicating operation or hazardous conditions.

2.4.11.4.6 Arrange the detection system to alarm upon manual operation of the foam-water sprinkler system.

2.4.11.5 Power Supply and Controller

2.4.11.5.1 Provide a power supply and wiring for the drivers of foam concentrate pumps in accordance with the recommendations for electric motor-driven pumps and diesel engine-driven pumps in Data Sheet 3-7, *Fire Protection Pumps;* and/or any applicable local electrical codes.

2.4.11.5.2 Provide a power supply arranged so that disconnecting power from the protected facility during a fire will not disconnect the power supply to the foam concentrate pump feeder circuit.

2.4.11.5.3 Provide an FM Approved controller to govern the startup of foam concentrate pumps with electric drivers.

2.4.11.5.4 Provide a diesel engine fire pump controller to govern the startup of foam concentrate pumps with diesel engine drivers.

2.4.12 Manual Firefighting

2.4.12.1 Provide a means of manual firefighting using foam in accordance with the applicable occupancy-specific data sheet.

2.4.12.2 Provide fire hose(s) sufficient to reach any point within the hazard area.

2.4.12.3 Use a hose nozzle that is FM Approved for use with the foam concentrate and can provide the appropriate application density.

2.4.12.4 Ensure the water and foam concentrate supply for the hose stream is adequate for the operating time recommended in the applicable occupancy-specific data sheet.

2.4.12.5 Ensure the flow rate per hose stream is in accordance with the applicable occupancy-specific data sheet. Ensure the foam nozzle is capable of this flow rate.

2.4.12.6 Ensure the hose(s) are accounted for in (a) the hydraulic calculations of the foam-water sprinkler system, and (b) selection of the proportioner, due to the increased flow of foam-water solution. Or, provide a separate proportioner and distribution line for the hose(s).

2.4.13 Auxiliary Fixed Discharge Devices

2.4.13.1 If there is a recommendation for auxiliary fixed discharge devices (e.g., monitors, grate nozzles) to protect the occupancy, provide these devices in accordance with the recommendations in Data Sheet 4-7N, *Low Expansion Foam Systems*, and the applicable occupancy-specific data sheet.

2.4.13.2 Ensure the auxiliary fixed discharge devices are accounted for in (a) the hydraulic calculations of the foam-water sprinkler system, and (b) selection of the proportioner, due to the increased flow of foam-water solution. Or, provide a separate proportioner and distribution line for the devices.

2.4.13.3 Connect auxiliary fixed discharge devices to the water supply of the foam-water sprinkler system only if the necessary water supply and foam concentrate is available for the operating time.

2.4.14 Fire Service Connections

2.4.14.1 When a fire service connection is recommended, provide it on the supply side of the proportioner (see Fig. 7).

2.4.14.2 Ensure the following items are in accordance with the recommendations in this data sheet before installing or using the fire service connection:

(a) Pressure of the system components

(b) Balance of the proportioning equipment

(c) Dilution of the proportioned foam solution

(d) Disturbance of system accessory devices, including, but not limited to, the following:

- Pressure switches
- Hydraulic control valves
- Main control valve trim

(e) Pressures and flows of the foam system design capability

At the fire service connection, post the water demand pressure based on the items evaluated above.

2.4.14.3 Provide a fire service connection sized to the largest riser supplying the foam-water sprinkler system, auxiliary discharge devices, and/ or hose connections.

2.4.15 Plan Review

2.4.15.1 Ensure plans comply with the plan review recommendations in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, and the appropriate occupancy-specific data sheet.

In addition, provide the following information:

(a) The location and description of hazards protected by the foam-water sprinkler system

(b) An accurate and complete layout of the area to be protected, including drainage layout, if required

(c) Details of the foam concentrate:

- Type
- Injection percentage
- Quantity (active and reserve)
- Minimum anticipated temperature of the concentrate at the point of proportioning

(d) Discharge densities and the period of discharge

(e) Hydraulic calculations for:

- Foam-water solution
- Foam concentrate

(f) Details of mechanical foam–water solution injection equipment, including proportioner orifice size or model and test connection size

(g) Detailed data of the pumps (foam and/ or water), drivers, controllers, power supply, fittings, suction and discharge connections (acquire charts from the engineer or contractor showing head delivery, efficiency, and brake horsepower curves of pumps)

(h) Make and type of discharge devices, equipment, and foam concentrate to be installed

(i) Verification that the minimum operating pressure of discharge devices and equipment is provided from the water supply

(j) Location and spacing of discharge devices

(k) Review of foam-water sprinkler system components and design (items c to j) to:

- The *Approval Guide*, Fire Protection section
- Fixed extinguishing systems/ foam extinguishing systems
- Low-expansion foam (equipment)
- Foam-water sprinklers (discharge device)
- Manufacturer’s listed manual(s)
- Original equipment manufacturer (OEM) equipment specification sheets
- Applicable occupancy-specific data sheets

(l) Details of tests of the available water supply

(m) Details of proposed water supplies

(n) Laboratory test report to determine water quality and foam concentrate are compatible, where necessary (e.g., process water, grey water)

(o) Detailed layout of the piping, foam-water, and foam concentrate (include pitch of dry horizontal piping)

(p) Identification of the type of piping proposed for foam concentrate supply (brass/ bronze)

(q) Detailed layout of water supply piping, concentrate agent storage

(r) Pipe hanger and bracing location and installation details

(s) Installation layout of the actuation systems

- Layout of detection system for deluge and preaction foam-water sprinkler systems
- Details of the operating sequence of the detection/ alarm/ releasing device in coordination with the system control panel, as necessary

(t) Location of draft curtains, if applicable

(u) Location and spacing of supplementary or low-level discharge devices, showing the area of coverage

(v) Detailed layout of isolation valves for test connections and test header

(w) Tests to be conducted for commissioning

(x) Pre-treatment plan for disposal of effluent

(y) Detailed layout of pipe fittings and isolation valves to allow water equivalency testing by Foam Solutions LLC, test liquid discharge testing by Vector Fire Technology, Inc., or positive displacement water-driven proportioning pump operational testing.

2.4.15.2 Where field conditions necessitate any significant change from the submitted plan, provide revised "as installed" plans to the client and FM Global for review.

2.4.15.3 If alterations on protected sections have been carried out (e.g., structural changes), ensure the foam extinguishing system is adapted to the new conditions.

2.5 Commissioning of the Foam-Water Sprinkler System

2.5.1 Contract Fulfillment

2.5.1.1 Provide a complete step-by-step description of the proposed acceptance test procedure, identifying all devices, controls, and functions to be tested, and how the tests will be conducted prior to scheduling the acceptance test.

2.5.1.2 Ensure the installation companies have furnished a written statement and FM Global form(s) to the effect that the work covered by its contract has been completed and all specified flushing of underground, lead-in, and system piping has been successfully completed in accordance with the recommendations for system acceptance in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, together with specified hydrostatic pressure tests and system foam discharge tests for final approval by the authority having jurisdiction.

2.5.2 Visual Inspection

2.5.2.1 Verify the foam-water sprinkler system has been installed correctly to design drawing and specifications by conducting the following visual inspections:

- Confirm the foam extinguishing system components are FM Approved.
- Check the continuity of pipework.
- Ensure temporary blinds have been removed.
- Check that valves, controls, and gauges are accessible.
- Confirm discharge devices, proportioner(s), foam pumps, and associated hardware have been properly installed.

2.5.2.2 Provide a schematic of the operating valves and devices, identifying their set/normal operating position for the foam-water sprinkler system equipment.

2.5.2.3 Verify signage is provided on the proper shutdown sequence of valves and equipment for the foam-water sprinkler system(s) after activation due to fire or accidental false discharge.

2.5.2.4 Check operating valves and devices for proper identification, orientation of flow, operating position labeling, and operating instructions.

2.5.2.5 Inspect valves to verify they are set in the proper operating position (e.g., normally open or normally closed) in accordance with schematic.

2.5.2.6 Inspect all normally dry horizontal piping for proper drainage pitch.

2.5.3 Pipe Flushing

2.5.3.1 Thoroughly flush water-supply pipe work, both underground and above ground, at the maximum practicable rate of flow, before connection is made to foam-water sprinkler system piping.

2.5.3.2 Ensure all foam-water sprinkler system piping has been flushed after installation, using the system's normal water supply, unless the hazard cannot be subjected to water. Prior to flushing, close the foam concentrate or foam-water solution valve connections to isolate injection to the distribution piping. After flushing, reopen the valve connections to their normal operating position.

2.5.3.3 Ensure the flow is continued for a time to ensure thorough cleaning, allowing the water to run clear of foam-water solution or foam concentrate.

2.5.3.4 Where flushing cannot be accomplished, visually examine pipe interiors carefully for cleanliness during installation.

2.5.3.5 For deluge systems, pneumatically purge the sprinkler piping from the weldolet installed on the riser downstream of the proportioner riser isolation valve as a test connection.

2.5.4 Hydrostatic Pressure Tests

2.5.4.1 Ensure all piping, including foam concentrate piping and the foam-water sprinkler system distribution piping, has been hydrostatically tested at 200 psi (13.8 bar) or at 50 psi (3.4 bar) in excess of the maximum static pressure where the maximum static pressure exceeds 150 psi (10.3 bar).

2.5.4.2 Test foam concentrate piping using foam concentrate as the test medium.

2.5.4.3 Maintain the hydrostatic test pressure without a drop in gauge pressure or visual leakage for 2 hours.

2.5.4.4 Do not include bladder tanks in this hydrostatic pressure test.

2.5.5 Operation of Components

2.5.5.1 Check operation of all mechanical and electrical components of the foam-water sprinkler system and function of interconnected process equipment.

2.5.5.2 Arrange the foam-water sprinkler system to test the operational capability of all mechanical and electrical components of the foam-water sprinkler system without discharging foam-water solution to the distribution system piping.

2.5.5.3 Conduct operational tests to ensure the foam-water sprinkler system responds as designed, both automatically and manually, as applicable.

2.5.6 Acceptance Testing

- Ensure the hazard is fully protected by conducting an acceptance test to determine the flow pressures, actual discharge capacity, consumption rate of foam concentrate, staffing needs, and other operating characteristics.
- Ensure the completed foam-water sprinkler system is tested by qualified personnel in foam fire extinguishing systems to meet the approval of the authority having jurisdiction.
- Include the following tests:

  (a) Foam discharge from a single foam-water sprinkler system

  (b) Simultaneous foam discharge of the maximum number of foam-water sprinkler systems and auxiliary devices expected to operate on a single hazard.
- Continue the discharge for the time required to obtain stabilized discharge.

2.5.6.1 Proportioning System

2.5.6.1.1 Verify the operation of the proportioning equipment by flow tests of the foam concentrate or with the FM Approved test liquid designated for that foam concentrate.

When utilizing a test liquid or water equivalency method for subsequent annual testing, use a company assessed by FM Approvals in accordance with their Assessment Standard 5138, Assessment Standard for Proportioning Testing. Verifying the accuracy of an installed foam proportioning system without the actual foam concentrate is allowed subsequent to the Acceptance Test with a foam concentrate. Types of proportioning methods, ranges of flow, measurement techniques are limitations of the assessment. FM Approvals has assessed the following companies:

- Foam Solutions LLC, Columbus, OH, USA
- Vector Fire Technology, Inc., Coatesville, PA, USA

2.5.6.1.2 Ensure system pressures and flows remain as described in this section and meet manufacturer's system requirements and recommendations.

2.5.6.1.3 Compute the rate of foam solution discharge using hydraulic calculations with recorded inlet or end-of-system operating pressures, or both.

2.5.6.1.4 Determine the actual foam concentration percentage injected into the foam-water sprinkler system by calculation and empirical sampling from foam-water solution discharged from the test connection using digital refractometric means or a conductivity method.

2.5.6.1.5 Ensure flow tests of the proportioning equipment for pre-primed, wet-pipe, dry-pipe, and preaction systems are conducted at the minimum expected flow (four most remote sprinklers) and the maximum expected flow for the most remote design demand area.

2.5.6.1.6 For pre-primed, wet-pipe, dry-pipe, and preaction systems with a variable flow proportioner, ensure a flow test is conducted at the minimum flow equal to the flow of the most remote sprinkler, in lieu of the four most remote sprinklers.

2.5.6.1.7 For deluge systems, ensure a flow test is conducted using the full demand flow expected of the foam-water sprinkler system.

2.5.6.1.8 During the flow tests, ensure the pressure at the proportioning device(s) is:

(a) the design operating pressure of the foam-water sprinkler system or systems tested.

(b) At least equal to the highest anticipated water pressure of the foam-water sprinkler system or systems tested.

(c) the minimum anticipated water pressure of the foam-water sprinkler system or systems tested.

2.5.6.1.9 For an in-line balanced proportioner, ensure the proportioner is operating within the manufacturer's specified water and foam concentrate pressure differential from the duplex pressure gauge.

2.5.6.1.10 Ensure the foam-water solution meets the criteria in Table 2 for the percentage of concentrate injected.

Table 2. Foam-Water Solution Range

Proportioner Type	*Percentage of Concentrate*	*Minimum Percentage*	*Maximum Percentage*
Balanced pressure proportioner, positive pressure (with pump, bladder tank, in-line balanced pressure), variable flow proportioner, or positive displacement foam concentrate proportioner pump	1	1.0	1.3
	3	3.0	3.9
	6	6.0	7.0

2.5.6.1.11 For proportioner types not listed in Table 2, ensure the foam concentrate induction rate of the proportioner, expressed as a percentage of the foam solution flow (water plus foam concentrate), is between minus 0% to plus 30% of the induction rate specified in the *Approval Guide*, or 1 percentage point, whichever is less, at the recommended flow rates.

2.5.6.1.12 Ensure collection and disposal of the discharged foam-water solution is performed by the owner, the owner's representative, or the installing contractor in accordance with local and/ or national regulations and the authority having jurisdiction.

2.5.7 Alarm and Detection Devices

2.5.7.1 Test and inspect alarm and detection devices in accordance with the recommendations in Data Sheet 5-40, *Fire Alarm Systems*, and Data Sheet 5-48, *Automatic Fire Detection*.

2.5.7.2 Verify interlock devices function as intended when initiated by the fire alarm system.

2.5.8 System Restoration

2.5.8.1 After acceptance tests are completed, or following system discharge, restore the foam-water sprinkler system, alarms, and interlocks to operational condition.

2.5.8.2 Ensure piping that is charged only with water is flushed, and piping that is normally empty is flushed and drained, to remove foam concentrate or foam-water solution.

2.5.8.3 Ensure pre-primed foam-water sprinkler systems are flushed and re-primed with the specified design concentration of foam-water solution.

2.5.8.4 Do not flush those portions of the foam-water sprinkler system that normally contain foam concentrate when in service.

2.5.8.5 Flush foam concentrate pumps that do not normally contain foam concentrate when in service.

2.5.8.6 Ensure strainers are inspected, cleaned, and placed in operational condition.

2.5.8.7 Do not mix together different types and/ or brands of foam concentrates for use in storage tanks.

2.5.8.8 Ensure valves are restored to their operational position. This includes, but is not limited to, the following:

- Test connection valve – closed
- Flushing valves, water and foam concentrate — closed
- Riser OS&Y isolation valve – open
- Water feed valve from riser to bladder tank – open
- Foam concentrate fill valve — closed
- Water drain valve for shell of bladder tank – closed
- Foam concentrate isolation valve from bladder or storage tank to automatic foam concentrate control valve — open
- Automatic foam concentrate control valve closed/set to open
- Foam concentrate liquid level/ sight glass valve — closed

2.5.8.9 Follow the manufacturer's procedure(s) to restore the installed equipment to service.

2.5.9 Documentation

2.5.9.1 The installing contractor provides the following documents to the client, who keeps them on-site for reference:

- Manufacturer's literature describing the correct operation, inspection, and maintenance of the foam-water sprinkler system and its components
- Piping layout drawings, electrical schematics, and hydraulic calculations
- Schematic of the set position of operating valves and devices for the foam-water sprinkler system equipment
- Procedure(s) on the proper shutdown sequence of valves and equipment for the foam-water sprinkler system(s) after activation due to fire or accidental false discharge
- Test report documenting the results of the proportioning system discharge test with foam concentrate or alternative test method

2.6 Periodic Inspection and Testing

2.6.1 Inspect, test, and identify impairments to the foam-water sprinkler system in accordance with the applicable recommendations in Data Sheet 2-81, *Fire Protection System Inspection*.

2.6.2 Manage impairments caused by periodic inspections and testing in accordance with the recommendations in Data Sheet 2-81, *Fire Protection System Inspection*.

2.7 Maintenance

2.7.1 Maintain the foam-water sprinkler system in accordance with the applicable recommendations in Data Sheet 2-81, *Fire Protection System Inspection*.

2.7.2 Manage impairments caused by maintenance activities in accordance with the recommendations in Data Sheet 2-81, *Fire Protection System Inspection*.

2.7.3 Maintain the foam-water sprinkler system in accordance with the manufacturer's instructions.

2.7.4 Base maintenance intervals other than preventive maintenance on the results of visual inspections and operational tests.

2.8 Contingency Planning

2.8.1 Maintain a 100% reserve supply of foam concentrate, as determined from Section 2.3.6.4, Foam Quantity, in separate tanks, compartments, or drums on site, or ensure it is readily available so the system can be restored within 24 hours after operating.

2.8.2 If foam solution for hose streams is drawn from the foam-water sprinkler system, stock the necessary amount of additional foam concentrate.

2.9 Electrical

2.9.1 Test standby power for the foam-water sprinkler system in accordance with the applicable recommendations in DS 2-81, *Fire Protection System Inspection*.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Construction and Location

When considering the installation of a vertical bladder tank, provide either (a) enough space around the tank so it can be laid on its side, or (b) adequate overhead space in which to remove and replace the bladder from the tank. An area twice as long as the tank is tall will be required to remove the bladder.

Horizontal bladder tanks require sufficient horizontal clearance to remove and replace the piping and bladder. An area at least twice as long as the tank will be required at one end. Access through double doors, etc., is an acceptable alternative.

Foam concentrates that have been exposed to temperatures below their minimum storage/ usable temperature and subsequently thawed need to be checked for separation (especially alcohol-resistant foam concentrates). Contact the manufacturer of the foam concentrate for corrective action.

3.2 Protection

3.2.1 Where to Find Foam-Water Sprinkler Components in the *Approval Guide*

The following components are listed in the Foam-Water Sprinkler section of the *Approval Guide*:

- Automatic sprinklers
- Deluge sprinklers*
- Aspirated sprinklers
- Foam concentrates

* Deluge sprinklers are not listed as such in the *Approval Guide;* they are simply FM Approved automatic sprinklers that can be ordered in the open orifice (deluge) configuration from the manufacturer.

The following components are listed in the Low-Expansion Foam Systems section of the *Approval Guide*:

- Bladder tanks
- Pressure switches

- Variable flow proportioners
- Foam pumps
- Foam concentrate control valves
- Ratio proportioners
- In-line balanced proportioners (ILBPs)
- Positive displacement, water motor driven foam concentrate proportioner pump

The following components are listed in the Automatic Sprinklers section of the *Approval Guide*:

- Deluge sprinkler systems
- Pipe hangers
- OS&Y valves
- Strainers
- Automatic water control valves
- Water motor gongs
- Water flow detectors
- Pressure gauges
- Automatic releases for preaction and deluge sprinkler systems

The following components are listed in the Fire Pump Installation section of the *Approval Guide*:

- Pump controllers (water & foam)
- Diaphragm valves

3.2.2 Distribution and Discharge Devices

The following foam-water sprinkler systems are considered to be automatic:

- Wet-pipe
- Pre-primed pipe
- Foam-water dry-pipe
- Foam-water preaction

Factors to consider in the delay time of wet- and dry-pipe systems include the ignitable liquid fuel hazard, associated ordinary combustibles, storage configuration, probable fire growth rate, number of sprinklers expected to operate, and the involvement of commodities at the time of foam discharge. Fire growth factors include flash point of the fuel, water miscibility, container package, and storage height.

Deluge foam-water sprinkler systems are used in applications where an immediate application of foam solution over a large area involving ignitable liquids is desired, such as chemical process areas, truck loading racks, and aircraft hangars.

3.2.3 Pre-Primed Foam-Water Distribution Systems

Protein-based foam concentrate products are fairly rapid in biodegradability in their foam-water solution state and are not recommended for pre-primed distribution systems.

Fire testing conducted by FM Global to date to evaluate automatic sprinkler protection with AFFF foam-solution has involved freshly primed (i.e., foam solution in the piping from the riser to the sprinklers) sprinkler systems. This arrangement resulted in foam being discharged immediately upon operation of the automatic sprinklers with very rapid control and extinguishment of the ignitable liquid test fires. Consequently, pre-primed systems are normally preferred. Recognition of additional maintenance on such a system (e.g., periodic flushing and replacement of the foam solution) and the associated need to dispose of the foam solution must be considered in its operational cost.

Testing of AFFF foam-water solutions on an annual basis is recommended at least initially (during the first few years) to determine foam solution quality. This is due to environmental conditions, such as ceiling temperature and fluctuations of that temperature. Eventually, possible protocols can be established for replenishing with fresh foam-water solution at longer intervals.

3.2.4 Foam Concentrates

Some foam concentrates contain fluorochemicals, and their persistent degradation products have been found in living organisms. This has drawn the concern of environmental authorities worldwide and led to both regulatory and non-regulatory actions to reduce emissions. The focus of these actions has been on fluorochemicals that contain eight carbons (C8) or more, such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). The following environmental regulations are being enacted that involve fluorine-based foam concentrates:

- The United States Environmental Protection Agency (EPA) regulations do not restrict the use of existing stocks of PFOS-based foam concentrates. The only AFFF foam concentrates restricted were those manufactured by 3M, due to the electrochemical fluorination process and its effect on the environment.
- Rather than regulate emissions of PFOA, the EPA has developed a global stewardship program where fluorochemical manufacturers have voluntarily agreed to reduce emissions of PFOA, PFOA precursors, and higher homologue chemicals 95% by the end of 2010, and eliminate them altogether by the end of 2015. As a result, telomer-based fluorochemicals used in foam concentrates after 2015 are likely to contain only six carbons (C6) or fewer in order to comply with the EPA program.
- European Union (EU) member countries had to provide an inventory of PFOS-based foams to EC by December 2008. This is in accordance with Directive 2006/122/ECOF.
- EU regulations require existing stocks of PFOS-based foams to be removed from service by June 27, 2011. This is in accordance with Directive 2006/122/ECOF and Annex.
- Proposed regulations in Canada require existing stocks of PFOS-based AFFF to be removed from service 5 years after regulation is final (2013-2014).

As a result of these regulations, some foam concentrates will probably require reformulation, and therefore some type of re-certification for FM Approval, between 2010 and 2015.

3.2.5 Foam Concentrate Proportioning Methods

Balanced-pressure proportioning systems (i.e., those arranged to balance water and concentrate pressures at the proportioner inlet) are considered best suited for sprinkler applications, particularly automatic sprinkler systems, due to their ability to function properly over a wide range of flows and pressures.

Use balanced-pressure injection methods from one of the following:

(1) A balance-pressure proportioning system using a foam concentrate pump discharging through a metering orifice into a proportioning controller with the foam concentrate and water pressures automatically maintained as equal by the use of a pressure-balancing valve.

(2) A balanced-pressure proportioning system using a pressure proportioning tank with a diaphragm or bladder to separate the water and foam concentrate discharging through a metering orifice into a proportioning controller.

(3) An in-line balanced-pressure proportioning system using a foam concentrate pump or bladder tank. A pressure-regulating device placed in the pump return line should maintain constant pressure in the foam concentrate supply line at all design flow rates. This constant pressure should be greater than the maximum water pressure under all operating conditions.

(4) Foam concentrate pump discharging through a metering orifice into the protection system riser with the foam pressure at the upstream side of the orifice exceeding the water pressure in the system riser by a specific design value.

(5) A positive displacement foam concentrate proportioner pump with fixed plunger driven by a direct-coupled positive displacement water motor. The positive displacement pump draws the foam concentrate from an atmospheric storage tank and feeds it into the water flow which passes through the drive unit. The ratio between the volumes transferred per rotation of the two devices determines the proportioning ratio. The mixing point is at the outlet to the drive unit. As a result, the proportioning ratio is little affected by flow rate or foam concentrate viscosity.

In many cases, bladder tank systems may be preferred as being simpler to operate and less costly (no pumps with their associated driver/controller needs, no power supply reliability issues, etc.), particularly for smaller systems. For multiple use-point systems (i.e., serving multiple risers/locations), in-line balanced pressure proportioners (ILBPs) typically use foam concentrate pumps, but may use bladder tanks. A positive displacement foam concentrate proportioner pump can be used for either single or multiple use-point systems.

3.2.6 Design Criteria

3.2.6.1 Application Rate

Foam-water sprinkler systems may have the capability to extinguish fires in various ignitable liquid occupancies at lower densities and open fewer sprinklers than with water sprinkler protection only. However, unless specifically proven to be adequate for a particular occupancy as determined through fire testing, and specifically recommended in the appropriate occupancy-specific data sheet, densities and areas of demand should be the same as those recommended for water sprinkler protection. This approach particularly applies where a foam-water sprinkler system is being accepted in lieu of adequate drainage.

The minimum density of 0.2 gpm/ ft^2(4 mm/min), is normally only acceptable for a floor spill (two-dimensional) fire involving a water insoluble hydrocarbon liquid protected by a foam-water sprinkler system.

Ignitable liquids that are polar, as well as some sprinkler combinations when used to protect non-polar ignitable liquids, may require higher foam solution densities than specified in this data sheet. The specific requirements in the *Approval Guide* under Fixed Extinguishing Systems should be used for any installation.

3.2.6.2 Demand Area

Where the specified areas of demand are selected close to the source of supply, the higher available pressures can increase the flow beyond the capacity of the foam proportioning equipment. This may lead to an injection of foam concentrate outside of the specified rate. See Section 2.3.6.5 for guidance.

3.2.6.3 Foam Quantity

The PFF multiplier is applied in the formula based on the proportioner being allowed to proportion the foam-water solution rich by up to a 30% tolerance of the injection rate. The multiplier is an average value based on a review of FM Approvals data for the various proportioner types, manufacturers, and foam concentrates. This multiplier will reduce the probability of an insufficient quantity of foam concentrate for the discharge duration and the injection characteristics of the type of proportioner.

3.2.6.4 Hydraulic Calculation of Foam-Water Solution for Wet-Pipe, Pre-Primed, Preaction, and Dry-Pipe Systems

Where excessive variations exist between calculated demand and available water supply, the actual excess discharge can exceed the capacity of the foam-water sprinkler system to operate for the recommended discharge duration time, minimum 10 minutes, or as recommended in the appropriate occupancy-specific data sheet. A verification calculation should be made as follows:

Multiply the actual predicted system flow by the foam concentrate percentage, then divide this answer into the foam quantity as determined in Section 2.2. The time indicated should be 10 minutes, the discharge duration time from the applicable occupancy-specific data sheet, or greater.

Friction Loss — Foam Concentrate

The friction loss in piping for foam concentrates is calculated using the Darcy-Weisbach formula (also known as the Fanning formula)

For U.S. customary units:

Darcy-Weisbach formula: $$\Delta P = 0.000216\left(\frac{fL\ \rho\ Q^2}{d^5}\right)$$

Reynolds number: $$Re = \frac{50.6\ Q\rho}{d\mu}$$

Where:

ΔP = friction loss (psi)
f = friction factor
L = length of pipe (ft)
ρ = weight density of foam concentrate (lb/ ft^3)
Q = flow (gpm)
d = pipe diameter (in.)

R = Reynolds number
μ = absolute (dynamic) viscosity of foam concentrate (cP)

For SI units:

Darcy-Weisbach formula: $\Delta P_m = 2.252 \left(\frac{fL \;\; \rho \; Q^2}{d^5} \right)$

Reynolds number: $R_e = 21.22 \left(\frac{Q\rho}{d\mu} \right)$

Where:
ΔP_m = friction loss (bar, kPa)
f = friction factor
L = length of pipe (m)
ρ = density of foam concentrate (kg/ m^3)
Q = flow (L/ min)
d = pipe diameter (mm)
R_e = Reynolds number
μ = absolute (dynamic) viscosity of foam concentrate (cP)

Select friction factors for use with the Darcy-Weisbach formula from the graphs shown in Figures 8 through 11.

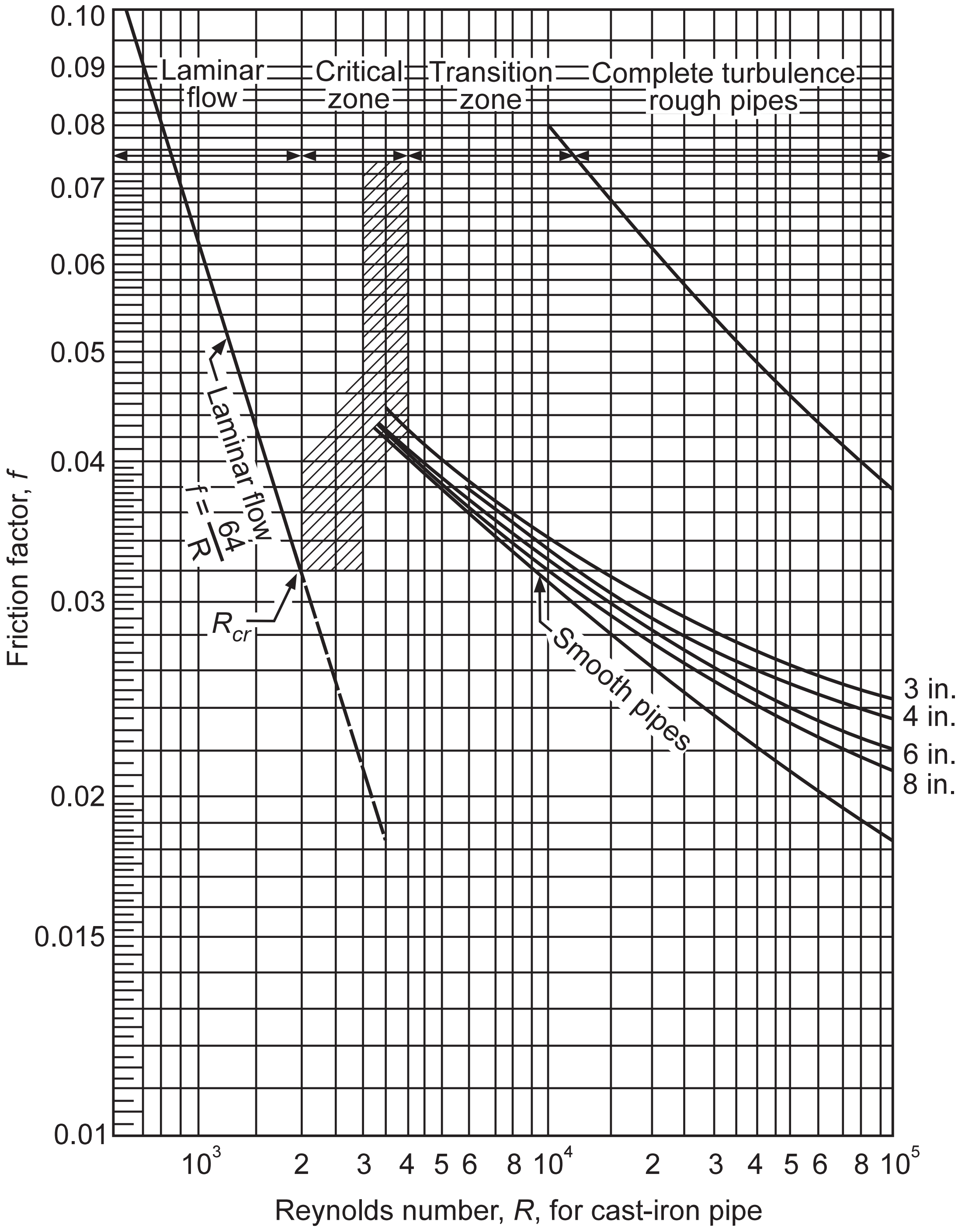


Fig. 8. Moody diagram for cast-iron pipe, $R \leq 10^5$

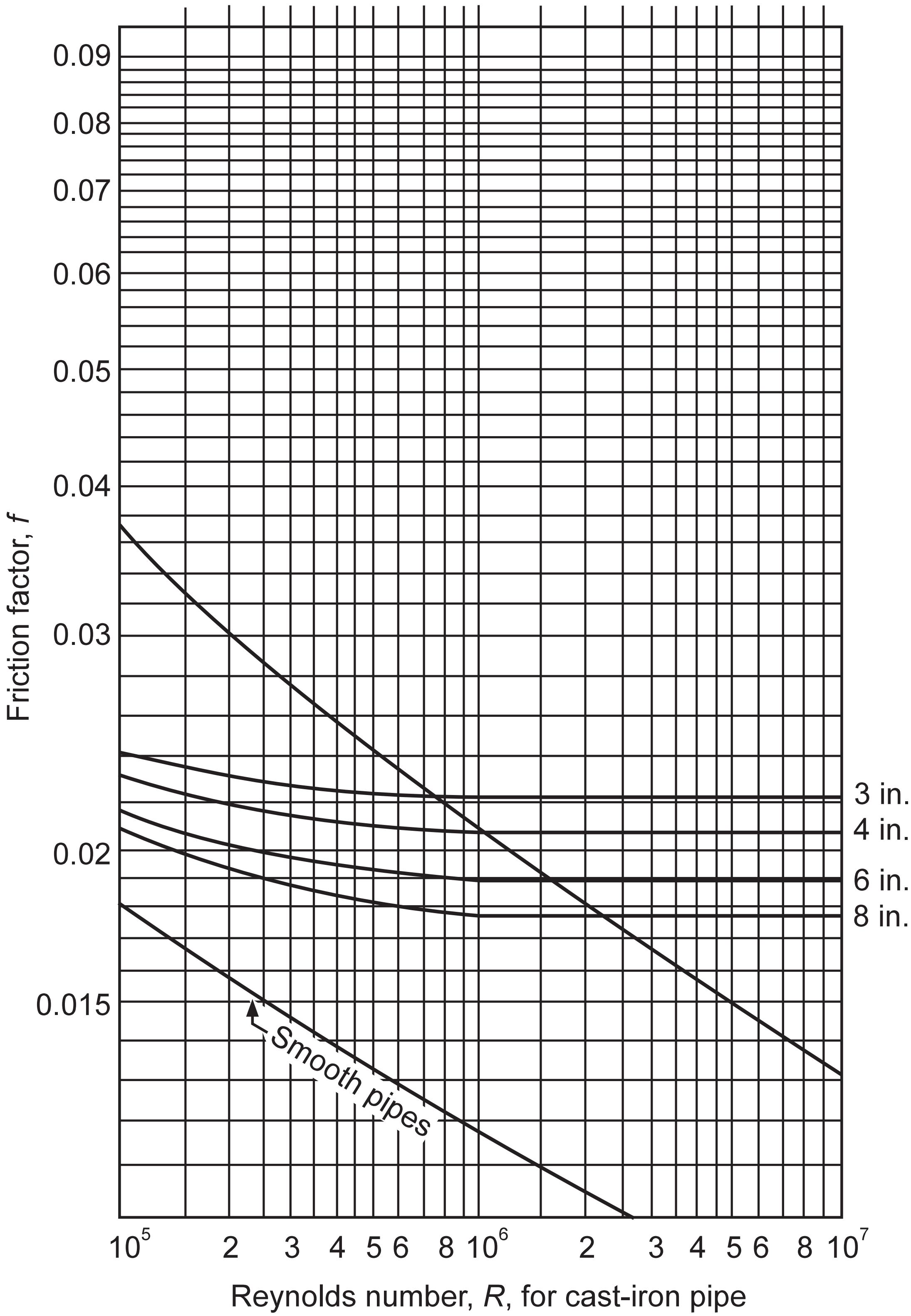


Fig. 9. Moody diagram for cast-iron pipe, $R \geq 10^5$

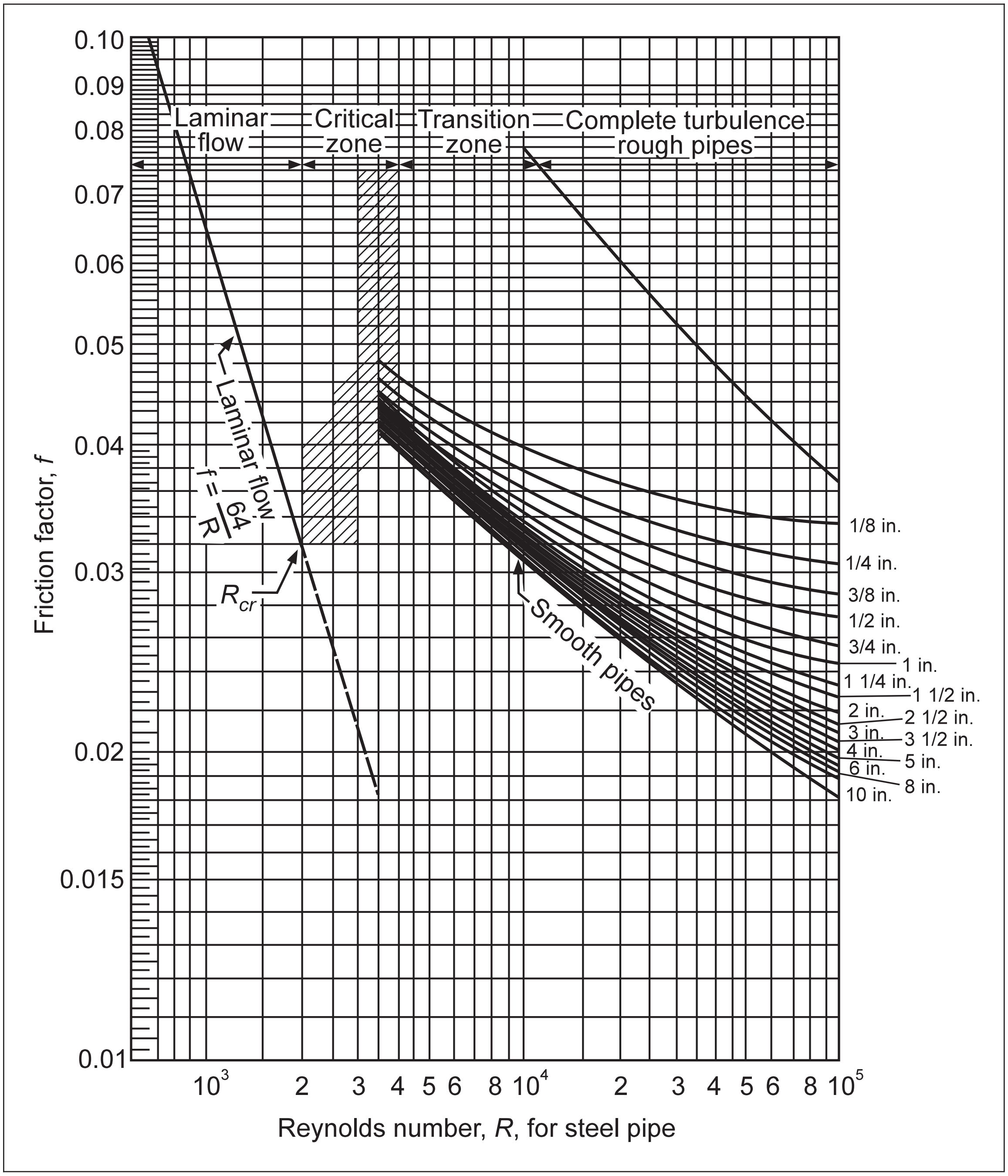


Fig. 10. Moody diagram for steel pipe, $R \leq 10^5$

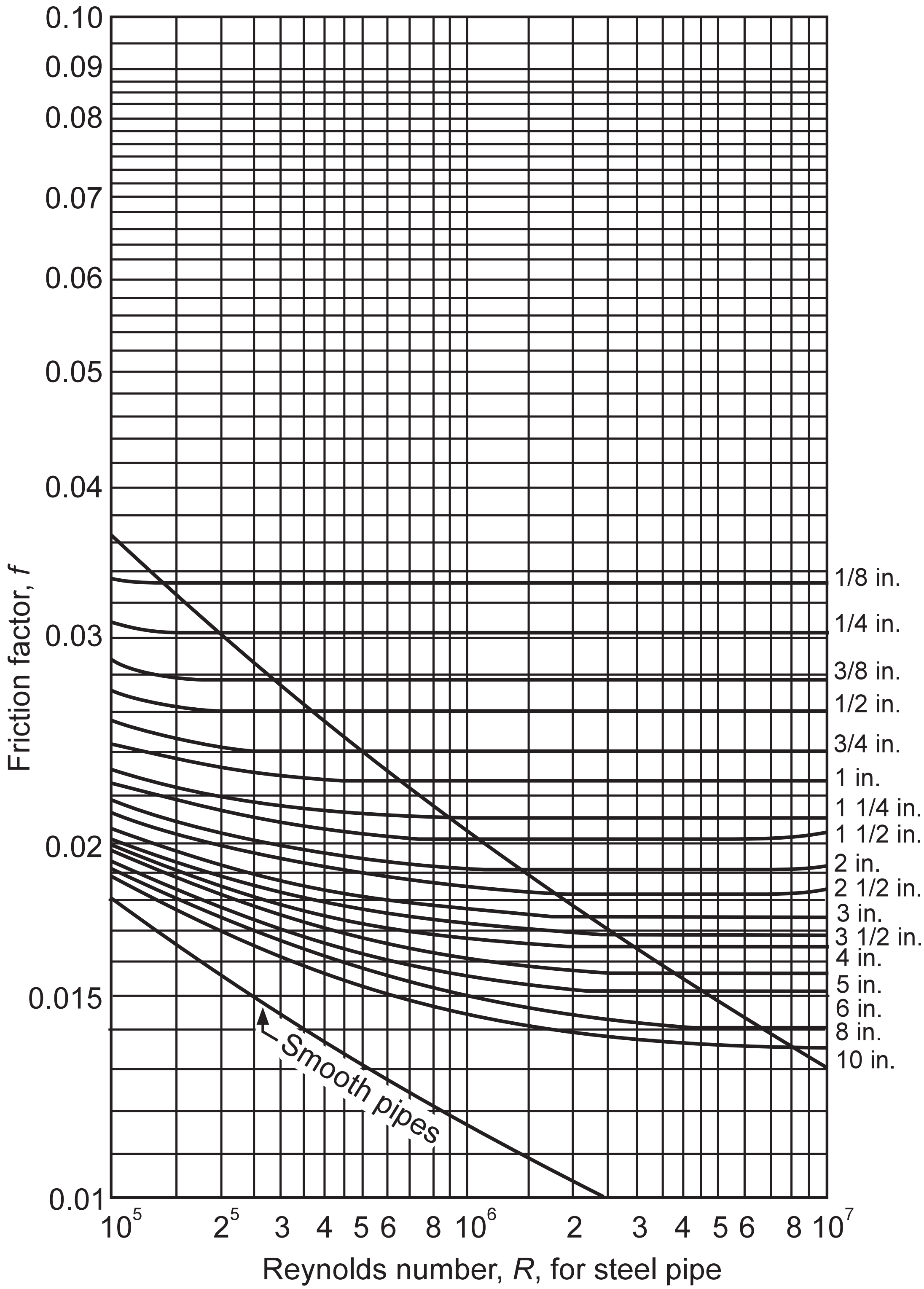


Fig. 11. Moody diagram for steel pipe, *R* ≥10^5

Calculate the Reynolds number for selecting friction factors from the graphs using the actual density (or specific gravity) of the foam concentrate.

Use the dynamic viscosity of the foam concentrate at its lowest anticipated storage temperature.

Table 3. Characteristics of Foam Concentrates

Manufacturer	*Foam Concentrate[1]*	*Temperature Range °F (°C)*	*Density[2] lb/ft^3 (kg/m^3)*	*Specific Gravity*	*Dynamic Viscosity[2] (cp)*
Ansul	3 protein	20 to 120 (-6.7 to 49)	71.3 (1142)	-	Note 3
	3 (AFC-3A) AFFF	35 to 120 (2 to 49)	64.0 (1025)	-	Note 3
	Premium 3 (AFC-5A) AFFF	35 to 120 (2 to 49)	63.9 (1024)	-	Note 3
	Premium 6 (AFC-5) AFFF	35 to 120 (2 to 49)	63.4 (1016)	-	Note 3
	3x3 low-viscosity AR-AFFF	35 to 120 (2 to 49)	63.7 (1020)	-	1500 ±500
	ARC 3 or 6 AR-AFFF	35 to 120 (2 to 49)	62.4 (1000)	-	2525 ±700
Buckeye	Platinum 1 AFFF	35 to 120 (2 to 49)	-	1.020 - 1.040	6.5–10.5 @ 68 (20)
	Platinum 3 AFFF	35 to 120 (2 to 49)	-	1.007 - 1.009	Note 3
	Platinum 3×3 AR-AFFF	35 to 120 (2 to 49)	-	1.015 - 1.055	Note 3
Chemguard	3 AFFF C302				
	Ultraguard 3 AR-AFFF	35 to 120 (2 to 49)	-	1.020	3000–3200
National Foam	Universal Gold 3 AFFF	35 to 120 (2 to 49)	-	1.025	2500
	Aer-O-Lite 3 AFFF	20 to 120 (-7 to 49)	-	1.03	
	Aer-O-Water 3EM 3 AFFF	35 to 120 (2 to 49)	-	1.04	
	Aer-O-Water 1 AFFF	20 to 120 (-6.7 to 49)	-	1.08	

[1] These foam concentrates may be FM Approved for use with other manufacturer's foam-water sprinkler systems as specified in their *Approval Guide* listings.

[2] At a temperature of 77°F (25°C), unless specified otherwise.

[3] These manufacturers have friction loss data for various pipe diameters in the form of charts/graphs for their foam concentrates. Contact the manufacturer for this friction loss data.

Non-Newtonian (e.g., alcohol-resistant) foam concentrates have viscosities that increase as their flow rate (shear rate) decreases, and viscosities that increase as temperatures decrease. In view of these properties, special care and attention should be taken when designing distribution piping for them. In particular, minimize the lengths of piping that are filled with non-Newtonian foam concentrates under no-flow conditions.

3.3 Equipment and Processes

3.3.1 Foam Concentrate Proportioners

An in-line balanced pressure proportioner typically uses a spool valve or diaphragm balancing valve which is reliant upon being installed in the proper orientation as specified by the manufacturer for proper operation.

3.3.2 Valves

Typically, when a concentrate storage tank is provided, the foam concentrate supply is isolated from the water/ solution in the sprinkler riser by an automatic foam concentrate control valve. The need for this valve has been questioned, but it is necessary to ensure the foam concentrate supply is not contaminated/ diluted by water. The operation of this valve is essential to providing foam concentrate, and consequently, foam solution to the sprinkler system. This is also the basis for the recommendation that the automatic foam concentrate valve be supervised. If actuated by water pressure upon sprinkler system flow, the water actuation line should be piped from the sprinkler valve trim (i.e., not tubing, which could be subject to bending or crimping). An advantage to this arrangement is that the automatic foam concentrate control valve can be functionally tested when an alarm test is conducted.

3.3.3 Foam Concentrate Storage Tanks

Filling foam concentrate from the bottom of the storage tank prevents the formation of aerated foam.

3.3.4 Atmospheric Storage Tanks

Atmospheric storage tanks need to be constructed from a material that is compatible with the foam concentrate, such as:

- Stainless steel – 304L or 316 grades
- High-density cross-linked polyethylene
- Fiberglass with isophthalic-based polyester and an internal layer (50–100 mils minimum) of vinyl ester resin in contact with foam concentrate

Verify the acceptability of the material with the manufacturer (e.g., some fluoroprotein foam concentrates are not compatible with stainless steel).

A layer of mineral oil or a manufacturer’s proprietary sealer oil is added to seal an alcohol-resistant foam concentrate, when used in an atmospheric tank, to minimize the effect of evaporation. Other foam concentrates may require a sealer, as well, per the manufacturer.

3.3.5 Piping

Provide standard-weight steel pipe conforming to one of the following standards (Schedule 40 through nominal 12 in. diameter):

- ASTM A 135
- ASTM A 53
- ASTM A 795
- BS 3601
- DIN 2440 – screwed
- DIN 2448 – flanged/coupling

Provide standard-weight pipe fittings conforming to one of the following:

- ANSI B16.1
- ANSI B16.3
- ANSI B16.4
- ANSI B16.5
- ANSI B16.9
- ANSI B16.11
- ANSI B16.25
- ASTM A 234

- BS 143
- BS 1256
- BS 1560
- BS 1640
- BS 1740
- BS 3799

Materials for pipe and fittings used with the foam concentrate, as specified by the foam manufacturer, may include:

- Stainless steel – 304L or 316 grades
- Brass or bronze
- Black steel (not recommended for alcohol-resistant foam concentrates)

Ensure no galvanic corrosion occurs between piping, fittings, and different materials of construction.

Check with the manufacturer of the foam concentrate to ensure the acceptability of the material (e.g., some fluoroprotein foam concentrates are not compatible with stainless steel).

When selecting pipe wall thickness, anticipate internal pressure, internal and external pipe wall corrosion, and mechanical bending requirements.

Use corrosion-resistant materials or finishes where the pipe may be subjected to corrosive atmospheres.

Use Teflon tape or the foam concentrate manufacturer's thread locker compounds at pipe joints. Foam concentrates are harsh detergents and may wash or dissolve other pipe joint compounds (pipe dope) out of the joint.

Foam-water solution will form sediment and can deteriorate when stored in system piping. Not all foam concentrates are suitable for storage as a foam-water solution and the manufacturer's advice should be sought and followed. High storage temperatures may accelerate deterioration due to aging of the foam-water solution. Therefore, the effectiveness may be reduced until the degraded, preprimed, foam-water solution is flushed out and fresh foam-water solution reaches the open sprinklers.

Drain and flushing connections enable the foam-water solution in the mains to be removed and replenished with fresh foam-water solution to minimize this effect. The foam-water solution drained from the system should be disposed of using environmentally responsible means.

3.3.6 Strainers

Concentrate strainers should be capable of removing all solids of a size that would obstruct system components.

3.3.7 Flushing

For all foam-water sprinklers systems (especially in-line proportioner designs), it is very important that a means is provided to flush all of the concentrate supply piping from just downstream of the foam tank outlet through the discharge of the proportioner following any testing or activation of the system. Failure to accomplish this flushing will likely result in foam concentrate being left in the piping/ proportioner orifice, where it will deteriorate and possibly cause partial or total impairment of the system.

To prevent the risk of water damage in the case of a break, use a small-capacity pump to maintain pressure during the test period.

Longevity of the foam solution in the distribution piping is related to water quality. Generally speaking, foam-water solution quality is expected to last two to three years. Testing on an annual basis is recommended at least initially (during the first few years) to determine foam solution quality. Eventually, possible protocols can be established for replenishing with fresh solution at longer intervals.

3.3.8 Operation and Control of Systems

3.3.8.1 Actuation

For large hazard areas and/ or where access may be limited, manual release devices both local to and remote from the operating devices are recommended.

3.3.8.2 Supervision

Many valves in the foam proportioning system, if left in an incorrect position, can compromise or even disable the foam proportioning system. Examples of valves critical to proper operation of the foam proportioning system that are intended to be supervised include, but are not limited to, valves in the supply from the foam concentrate storage tank, valves in the return to the foam concentrate storage tank, storage tank drain valves, liquid-level valve for the foam concentrate storage tank, strainer blow-off valves, foam concentrate pump supply and discharge valves, bypass valves around diaphragm valves or pressure-regulating valves, and valves at the inlet to the proportioner.

3.3.9 Fire Service Connection

Install a sign that states the following or similar information at the fire service connection:

FIRE SERVICE CONNECTION
THIS CONNECTION FEEDS A FOAM-WATER SPRINKLER SYSTEM.

DO NOT PUMP AT PRESSURES
EXCEEDING [*insert design pressure*] UNTIL FOAM
LIQUID SUPPLY IS EXHAUSTED.
IF INCIDENT IS CONTROLLED BY FOAM BLANKET,
DO NOT DESTROY FOAM BLANKET BY EXCESSIVE APPLICATION OF WATER

Provide the fire service connection to the foam-water sprinkler system connection separate from the normal building sprinkler system whenever practical. Identify this condition in the signage for the fire service connection of the foam-water sprinkler system.

3.4 Acceptance Testing

In order to guarantee the system is designed and installed properly for the application for which it was intended, it is imperative that verification is made that the foam-water solution being discharged meets the intent of the system and the listed performance of the product. Most foam-water sprinkler system proportioning equipment is installed at the job site. In order to make sure all correct equipment and proper foam concentrate for the protection has been installed properly and in the correct arrangement, an acceptance test must be performed that indicates performance and operability as specified under the listings of the products. Also, this makes sure all components are installed in their proper orientation and pressure settings. It is advisable to note the performance of the system at its commissioning and then compare the results of annual testing to flag any potential problems.

Use these tests to confirm that the foam-water sprinkler system has been properly installed, and functions as intended.

Many jurisdictions require the collection and waste treatment of foam solution discharges, which can have a significant impact on the cost and extent of acceptance testing and subsequent maintenance procedures for foam-water sprinkler system installations.

Prevent discharge from entering ground water, surface water, or storm drains, even though most foam concentrates are biodegradable. With advanced notice, some foam-water solutions can be treated by local biological sewage treatment systems. Manufacturer’s Material Safety Data Sheets (MSDSs) and/or foam concentrate specification data sheets typically identify the biological oxygen demand (BOD) and chemical oxygen demand (COD), which will aid in determining their ability to process the effluent. Further dilution of foam-water solution may be needed to allow processing and meter the foam solution at a specified rate to avoid overloading/ shocking the wastewater treatment facility. Otherwise, a waste hauler may have to be hired to collect and transport the foam solution to a treatment plant.

Consider the usage of antifoam agents in the foam-water solution discharge from the acceptance testing. Use those antifoam agents recommended by the foam concentrate manufacturer for the specific foam concentrate.

Record the following data, as applicable, to document the performance specifications of the foam-water sprinkler system:

- Static water pressure
- Residual water pressure at the control valve and at a remote reference point in the system
- Actual discharge rate
- Consumption rate of foam-producing material
- Concentration of the foam solution
- Pressure differential on duplex gauge for in-line balanced proportioners of water and foam concentrate in manufacturers specified range (foam pressure to be higher)

Thirty to 60 seconds after the foam appears from the test connection valve, take a sample of the foam-water solution discharge.

Evaluating the foam quality from the discharge device is recommended if the discharge device is not FM Approved. Visual inspection and evaluation (expansion and one-quarter drain time) to the manufacturer's specification or data is recommended to ensure the foam blanket produced is satisfactory for the purpose intended.

See Appendix E for a job aid to assist in determining the foam-water solution concentration. The method used for measuring the foam-water solution should consider the type of foam concentrate, water supply quality, and precision of the instrumentation.

For alcohol-resistant foam-water solutions, it may be preferable to use the conductivity method over the refractive index method due to the precision of the instrumentation needed to differentiate between the standard foam-water solutions.

4.0 REFERENCES

4.1 FM Global

Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance* and Other Loss Prevention Inspections
Data Sheet 3-0, *Hydraulics of Fire Protection Systems*
Data Sheet 3-7, *Fire Protection Pumps*
Data Sheet 3-10, *Installation and Maintenance of Private Fire Service Mains and Their Appurtenances*
Data Sheet 4-0, *Special Protection Systems*
Data Sheet 4-7N, *Low-Expansion Foam Systems*
Data Sheet 5-40, *Fire Alarm Systems*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 7-29, *Flammable Liquid Storage in Portable Containers*
Data Sheet 7-32, *Flammable Liquid Operations*
Data Sheet 7-93, *Aircraft Hangars, Aircraft Manufacturing and Assembly Facilities, and Protection of Aircraft Interiors During Assembly*

4.1.1 FM Approvals

Class 5130, *Approval Standard for Foam Extinguishing Systems*

4.2 Other

British Standards Institute (BSI). *Fire Extinguishing Installations and Equipment on Premises*. Part 6: Foam Systems, Section 6.1 Specification for Low-Expansion Foam Systems. BS 5306-6.1:1988.

European Committee for Standardization (CEN). *Fixed Firefighting Systems*. Part 2: Design, Construction and Maintenance (Draft). prEN 13565-2.

National Fire Protection Association (NFPA). *Standard for Low-, Medium-, and High-Expansion Foam*. NFPA 11, 2005.

National Fire Protection Association (NFPA). *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. NFPA 25, 2008.

National Fire Protection Association (NFPA). *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*. NFPA 16, 2007.

VdS Schadenverhütung GmbH. *Guidelines for Foam Extinguishing Systems—Planning and Installation*. VdS 2108en: 2005-09

APPENDIX A GLOSSARY OF TERMS

Note: See Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, for sprinkler-related terms.

Alcohol-Resistant (AR) Foam Concentrate: A concentrate used for fighting fires on water-soluble material and other fuels destructive to regular, AFFF, or FFFP foams, as well as for fires involving hydrocarbons. Alcohol-resistant foam concentrates are generally used at 1%, 3%, or 6% concentration on water miscible fuels, and at 1%, 3%, or 6% concentration on hydrocarbon fuels.

Approval Guide: An online resource of FM Approvals, the *Approval Guide* provides access to a fully searchable, Web-based database of the most up-to-date information on approximately 50,000 FM Approved fire protection products, building materials, electrical equipment, and services that conform to the highest property protection standards.

Aqueous Film-Forming Foam Concentrate (AFFF): A concentrate based on fluorinated surfactants plus foam stabilizers to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors. AFFF foam concentrates are generally used at 1%, 3%, or 6% concentration.

Automatic Foam Concentrate Control Valve: A valve controlling the flow of foam concentrate to the proportioner. The valve is automatically actuated by hydraulic, pneumatic, or electric means. Supervision is provided to the position of the valve.

Balanced-Pressure Bladder Tank: A foam concentrate tank fitted with an internal bladder that uses water flow through a modified venturi-type proportioner to control the foam concentrate injection rate by displacing the foam concentrate within the bladder with water outside the bladder.

Deluge Sprinkler: A piece of fire protection equipment used as a discharge device through which water is discharged with the intent of controlling or suppressing a fire. A deluge sprinkler typically consists of two main components: the sprinkler frame and the deflector.

Discharge Device: A device designed to discharge water or foam-water solution in a predetermined, fixed, or adjustable pattern. This may be a standard (non-aspirated) sprinkler, deluge-type sprinkler, nozzle, or foam-water (aspirated) sprinkler.

Expansion Ratio: The ratio of volume of foam formed to the volume of foam-solution used to generate the foam. For example, a 7:1 expansion ratio equates to 700 gals of finished foam from 100 gals of foam-water solution.

Film-Forming Fluoroprotein Foam Concentrate (FFFP): A protein foam concentrate that uses fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors. The foam is more fluid than both protein and standard fluoroprotein foams. *FFFP* foam concentrates are film-forming on some liquid hydrocarbon fuel surfaces and are generally used at 3% or 6% concentration.

Fluoroprotein Foam Concentrate: A protein foam concentrate with added fluorinated surface active agents. The foam is generally more fluid than protein foam, gives faster control and extinction of fire, and has a greater ability to reseal if the foam blanket is disturbed. Inhibitors are included that protect against freezing, corrosion, and bacterial decomposition. Fluoroprotein foam is resistant to contamination by hydrocarbon liquids, is generally used at 3% or 6% concentration, and may be compatible with dry chemical extinguishing agents.

Foam: A stable aggregation of bubbles which are of lower density than ignitable liquids or water. Exhibits a tenacity for covering horizontal surfaces to form a continuous barrier between the ignitable vapors and air/oxygen.

Foam-Water Density: The unit rate of foam-water solution application to an area, expressed in gpm/ft^2 (L/min•m^2).

Foam Solution: See foam-water solution.

Foam-Water Solution: A homogeneous mixture of water and foam concentrate in the correct proportions.

Foam-Water Sprinkler System: A sprinkler system that is pipe-connected to a source of foam concentrate and to a water supply. The system is equipped with appropriate discharge devices for foam-water solution discharge and for distribution over the area to be protected. The piping system is connected to the water supply through an alarm check valve that usually is actuated by operation of automatic detection equipment that is installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system, foam concentrate is proportioned (injected) into the water, and the resulting foam-water solution discharging through the discharge devices generates and distributes "foam." Upon exhaustion of the foam concentrate supply, water discharge follows and continues until shut off manually. Systems can be used for discharge of water first, followed by discharge of foam-water solution for a specified period, and then followed by water until manually shut off. Existing deluge sprinkler systems that have been converted to the use of aqueous film-forming foam or film-forming fluoroprotein foam are classified as foam-water sprinkler systems.

Foam-Water Deluge Sprinkler System: A foam-water sprinkler system employing open orifice discharge devices, which are attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system, which is installed in the same areas as the discharge devices. When this valve opens, water flows into the piping system and out of all attached discharge devices.

Foam-Water Dry-Pipe Sprinkler System: A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry-pipe valve. The foam-water solution then flows into the piping system and out the opened sprinkler(s).

Foam-Water Preaction Sprinkler System: A sprinkler system employing automatic sprinklers attached to a piping system containing air that may or may not be under pressure, with a supplemental detection system installed in the same area as the sprinklers. Actuation of the detection system opens a valve that permits foam-water solution to flow into the sprinkler piping system and to be discharged from any sprinklers that have activated.

FM Approved: The term ''FM Approved'' is used to describe a product or service that has satisfied the criteria for Approval by FM Approvals. Refer to the *Approval Guide* for a complete list of products and services that are FM Approved.

Ignitable Liquid: Any liquid or liquid mixture that is capable of fueling a fire, including flammable liquids, combustible liquids, inflammable liquids, or any other reference to a liquid that will burn. An ignitable liquid must have a fire point.

Open-type sprinkler: See deluge sprinkler.

Preprimed System: A wet-pipe system containing foam-water solution.

Proportioning: The continuous introduction of foam concentrate at the recommended ratio into the water stream to form foam solution.

Balanced Pressure Pump Proportioning. A foam proportioning system that uses a foam pump and valve(s) to balance foam and water pressures at a modified venturi-type proportioner located in the foam solution delivery piping; a foam concentrate metering orifice is fitted in the foam inlet section of the proportioner.

In-Line Balanced-Pressure Proportioning. A foam proportioning system using either a foam concentrate pump or a bladder tank in conjunction with a pressure-reducing valve. At all design flow rates, the constant foam concentrate pressure is greater than the maximum water pressure at the inlet to the in-line balanced-pressure proportioner. A pressure-balancing valve is integral to the in-line balanced proportioner to regulate foam concentrate pressure to be balanced with incoming water pressure.

Direct Injection Variable Pump Output Proportioning. A direct injection proportioning system that uses flowmeters for foam concentrate and water in conjunction with a variable output foam pump control system.

Pump Proportioner *(Around-the-Pump Proportioner)*. A system that uses an eductor installed in a bypass line between the discharge and suction side of a water pump and suitable variable or fixed orifices to induct foam concentrate from a tank or container into the pump suction line.

Positive Displacement, Water Motor Driven Foam Proportioning Pump. A foam proportioning system that uses a positive displacement proportioner pump with fixed plunger driven by a direct-coupled positive displacement water motor. The positive displacement pump draws the foam concentrate from an atmospheric storage tank and feeds it into the water flow which passes through the drive unit.

Proportioner Flow Factor (PFF). A safety factor for the injection tolerance of the proportioner, based on the type, flow range and data from FM Approvals testing.

Protein Foam Concentrate: Concentrate consisting primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise ensure readiness for use under emergency conditions. Protein foam concentrates are generally used at 3% and 6% concentration.

Test liquid: A non-foaming liquid that replicates the viscosity, specific gravity, and other relevant properties of the foam concentrate used in a system. It is used to test the accuracy of proportioners and similar devices in installed systems.

Test liquid proportioning testing: A method of evaluating the proportioning accuracy of an installed foam fire extinguishing system using a test liquid in lieu of the foam concentrate. This method minimizes the difficulties in disposing of the discharge required in testing a foam system.

Water equivalency proportioning testing: A method of evaluating the proportioning accuracy of an installed foam fire extinguishing system using water in lieu of the foam concentrate. This method minimizes the difficulties in disposing of the discharge required in testing a foam system.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

July 2020. Interim revision. The following changes were made:

A. Added guidance on an alternative proportioning test method assessed by FM Approvals.

B. Made minor editorial revisions.

April 2020. Interim Revision. Minor editorial changes were made.

January 2020. Interim revision. Minor editorial changes were made.

October 2017. Interim revision. Reference to NFPA 409, *Standard on Aircraft Hangars*, was deleted in Section 2.7, *Maintenance,* since this guidance is covered in Data Sheet 7-93, *Aircraft Hangars, Aircraft Manufacturing and Assembly Facilities, and Protection of Aircraft Interiors During Assembly.*

January 2017. Interim revision. Minor editorial changes were made.

January 2013 (Interim revision). Minor editorial changes were made for this revision.

October 2011. Inclusion of Proportioning Testing Assessment by FM Approvals, clarification on general recommendation, minor editorial revisions.

July 2011. Minor editorial changes were made for this revision. Figure 2, 3, and 6 were revised.

September 2010. Minor editorial changes were made for this revision.

January 2010. This is the first publication of this document.

APPENDIX C COMPARISON WITH OTHER FOAM INSTALLATION STANDARDS

There is relative agreement between this data sheet and the following standards:

- NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*
- BS 5306-6.1*, Fire Extinguishing Installations and Equipment on Premises. Part 6: Foam Systems*
- European Standard pr13565-2, *Fixed Firefighting Systems—Foam Systems. Part 2: Design, Construction and Maintenance*

- VdS 2108en: *Foam Extinguishing Systems—Planning and Installation*

One significant area of disagreement is with the foam concentrate supply. The standards listed above do not account for the allowable injection tolerance of the proportioner in the discharge duration of the foam concentrate. The foam concentrate supply in this data sheet is adjusted with a “proportioner flow factor” for the injection tolerance based on the type and flow range of proportioner and data from FM Approvals testing.

Also, the standards listed above do not recommend the supervision of the automatic foam concentrate control valve as identified in this data sheet.

APPENDIX D FORMS

The following forms may be used to assist in the commissioning of the foam-water sprinkler system:

D.1 Contractor's Checklist for Commissioning of Foam-Water Sprinkler Systems Installation (for FM Global clients)

CONTRACTOR'S CHECKLIST FOR COMMISSIONING OF FOAM-WATER SPRINKLER SYSTEM INSTALLATION

JOB OR CONTRACT NUMBER	DATE	FM GLOBAL OPERATIONS CENTER
INDEX NUMBER	ACCOUNT NUMBER:	☐ New System ☐ Existing System
LOCATION:		
HAZARD:		

Instructions:

1. The contractor will fill out "Part A" and send, along with 1 print of all drawings (including a wiring diagram when applicable), to the FM Global Operations Center serving the facility in which the system is to be installed. A separate application should be submitted for each system to be installed.
2. The FM Global office will retain information and 1 print of each drawing and return a copy with "acknowledgement" of "Part A" indicated.
3. The FM Global field engineer visiting the plant will complete "Part B" and will return it to the FM Global office for its files.
4. Final "acceptance" of the foam-water sprinkler system will be indicated in separate correspondence with the FM Global client. Any deficiencies preventing final acceptance will be addressed directly with that client.

NOTE: If additional completed copies of this application or prints are needed for contractor or customer requirements, they should be submitted along with these required copies and prints, and they will follow the outlined procedure. All additional copies of the application submitted will be returned by the FM Global office to the submitter after completion of "Part A".

It is understood that the representative of the purchaser placing their name in "Part B" as a result of witnessing a turn-over test in no way prejudices any claim which the purchaser may have against the installer for faulty material, poor workmanship or failure to comply with the requirements of FM Global or Local Ordinances. It simply indicted who was present at the test.

FINAL ACKNOWLEDGEMENT OF THE INSTALLATION CANNOT BE GRANTED UNTIL THE FORM WITH "PARTS A, AND B PROPERLY COMPLETED HAS BEEN RECEIVED.

Parts A and B appear on the following pages:

 1
FM7615 (January 2010) Engineering

Fig. D.1 Contractor's checklist for commissioning of foam-water sprinkler system installation

CONTRACTOR'S CHECKLIST FOR COMMISSIONING OF FOAM-WATER SPRINKLER SYSTEM INSTALLATION

FM Global

Part A

Plans and Specifications

NAME OF CUSTOMER	STREET ADDRESS
CITY/STATE/PROVINCE/POSTAL CODE & COUNTRY	DRAWINGS SUBMITTED (NOS.)
NAME & ADDRESS OF EQUIPMENT CONTRACTOR	
NAME AND ADDRESS OF EQUIPMENT MANUFACTURER	

Type of System:

☐ Automatic ☐ Deluge ☐ Supplementary Protection		

Hazard:

Location Building Name or Number	Story	Sprinkler Elevation Ft. (m)	Temperature Variation at Hazard Min °F(C) Max °F(C)
Description:			
Flammable Liquids? ☐ Yes ☐ No	In Open Tank? ☐ Yes ☐ No	If "Yes", Freeboard In.	

Component	Manufacturer	Model	FM Approved System Component	Miscellaneous
Foam Concentrate			☐ Yes ☐ No	☐ 1% ☐ 3% ☐ 6% ☐ AFFF ☐ AFFF-AR ☐ Protein ☐ Fluoroprotein ☐ Film-forming Fluoroprotein
Proportioner			☐ Yes ☐ No	☐ Variable Flow ☐ Ratio ☐ ILBP ☐ Pos. Displace Proportioner Pump
Sprinkler			☐ Yes ☐ No	Unobstructed Discharge? ☐ Yes ☐ No
Automatic Foam Concentrate Control Valve			☐ Yes ☐ No	Supervised? ☐ Yes ☐ No NEMA Type I or IP-10 housing if Electrical? ☐ Yes ☐ No
Foam Storage Tank			☐ Yes ☐ No	☐ Bladder ☐ Atmospheric
Check Valve (s)			☐ Yes ☐ No	
Strainer(s)			☐ Yes ☐ No	
Foam Concentrate Pump			☐ Yes ☐ No	
Diaphragm Valve			☐ Yes ☐ No	
Pressure Reducing Valve/Regulator-Foam Concentrate			☐ Yes ☐ No	
Pump Controller (Water & Foam)			☐ Yes ☐ No	
Control Panel			☐ Yes ☐ No	Alarms: ☐ 1st Detector ☐ 2nd Detector
Detectors			☐ Yes ☐ No	Cross-Zoned? ☐ Yes ☐ No Supervised? ☐ Yes ☐ No
Manual Actuation (Deluge/Preaction)			☐ Yes ☐ No	
			☐ Yes ☐ No	

Abort Switch? ☐ Yes ☐ No System Isolated? ☐ Yes ☐ No	Alarm? ☐ Yes No System Operational? ☐ Yes ☐ No	☐ Yes ☐ No
Time Delay Setting: Sec.	Emergency Mechanical Manual Release? ☐ Yes ☐ No	Control Panel? ☐ Yes ☐ No
Reserve Supply of Foam Concentrate? ☐ Yes ☐ No	Connected? ☐ Yes ☐ No	Changeover: ☐ Auto ☐ Manual ☐ DNA
Interlocks: ☐ Yes ☐ No (See Below)		Electrical Shutdown? ☐ Yes ☐ No
Alarm to Manned Location? ☐ Yes ☐ No		
Panel Location *(Describe)*:		
Foam Concentrate Storage Tank & Equipment Location *(Describe)*:		

FM7615 (January 2010) Engineering 2

Fig. D.1 Continued

CONTRACTOR'S CHECKLIST FOR COMMISSIONING OF FOAM-WATER SPRINKLER SYSTEM INSTALLATION

Plans Submitted? ☐ Yes ☐ No	Foam Concentrate Calculations Submitted? ☐ Yes ☐ No	Plans/Calculations reviewed By:
Pipe Conforms to Standard #: ☐ Yes ☐ No	Fittings Conform to Standard #: ☐ Yes ☐ No	
Test Connection Provided? ☐ Yes ☐ No		

Interlocked Associated Equipment:

Process Pumps ☐ Yes ☐ No	Fans ☐ Yes ☐ No	Drive Motors ☐ Yes ☐ No	Dampers ☐ Yes ☐ No	Door - Closer ☐ Yes ☐ No	Other ☐ Yes ☐ No
If "Yes", Enumerate and Describe:					
Are they interlocked with the system? ☐ Yes ☐ No	If not interlocked, explain:				

Part "A" Acknowledged:
Subject to any changes recommended below or noted on drawings by:

Engineers Name / FM Global Office (Printed)   Date:

Recommended Changes & Remarks to Above:

PART "B" – INSTALLER'S TURN-OVER TEST / FM GLOBAL FIELD EXAMINATION OF COMPLETED INSTALLATION

Instructions: The turn-over tests should be made by the contractor and witnessed by a representative of the purchaser and FM Global. Names of the representative of both the installer and the purchaser should be indicated in "Part B" on all copies. Insofar as possible, all defects discovered during these tests should be corrected immediately.

SUMMARY - REFERENCE "CONTROL MATRIX" FORM FOR DETAILS

How Tested: ☐ Foam Discharge ☐ Foam Discharge & Proxy concentrate ☐ Foam Discharge & Water Equivalency	
Discharge? ☐ Yes ☐ No ☐ Not Tested	Functional Test? ☐ Yes ☐ No
Manual Release Operated Satisfactorily for Deluge? ☐ Yes ☐ No	Alarms Operated Satisfactorily? ☐ Yes ☐ No
Pressure Operated Trips and Switches Operated Satisfactorily? ☐ Yes ☐ No	Interlocked Equipment Functioned Satisfactorily? ☐ Yes ☐ No
Electrical & Mechanical Connections Installed? ☐ Yes ☐ No	Electrical and Mechanical Controls Operated Satisfactorily? ☐ Yes ☐ No
Detection Devices: Test at least one farthest from the release ☐ Yes ☐ No	Time delay Device Operated Satisfactorily Where Provided ☐ Yes ☐ No Delay of Discharge Sec.

SUMMARY – REFERENCE "ACCEPTANCE TESTING FOR FOAM INJECTION PERCENTAGE" FORM FOR DETAILS

SYSTEM DISCHARGE SAMPLE				
FLOW ☐ GPM ☐ LPM	PRESSURE ☐ psi ☐ bar	METER READING	PERCENT FOAM SOLUTION	RESULT

Foam Concentrate Storage Tank Properly Labeled? ☐ Yes ☐ No	Foam Concentrate Storage Tank Provided? ☐ Filling ☐ Drainage ☐ Cleaning ☐ Inspection	Bladder Tank Stamped as Pressure Vessel? ☐ Yes ☐ No
Foam Concentrate Storage Tank Pressure Vacuum Vent? ☐ Yes ☐ No	Foam Proportioner Properly Labeled? ☐ Yes ☐ No	Containment for Foam Blanket? ☐ Yes ☐ No

 3

Fig. D.1 Continued

CONTRACTOR'S CHECKLIST FOR COMMISSIONING OF FOAM-WATER SPRINKLER SYSTEM INSTALLATION

FM Global

Foam Concentrate Control Valve(s) Electrically Supervised Position? ☐ Yes ☐ No	Foam Concentrate Control Valve Position Indicated ☐ Yes ☐ No Emergency Manual Operation ☐ Yes ☐ No	Foam Concentrate Control Valve Manual Reset ☐ Yes ☐ No Flushing Capability ☐ Yes ☐ No
Valves Supervised? ☐ Yes ☐ No	If Yes, ☐ Sealed ☐ Locked ☐ Supervisory Switch	Proper Piping Material for Foam Concentrate ☐ Yes ☐ No
Valves Identified with Nameplates ☐ Yes ☐ No	Operating Position of Valve Identified ☐ Yes ☐ No	"Shut-down" Procedure Signage Provided ☐ Yes ☐ No
Test Connection Isolation Valve Supervised ☐ Yes ☐ No	If Yes, ☐ Sealed ☐ Locked ☐ Supervisory Switch	Hydrostatic Pressure Test of Piping ☐ Yes ☐ No
Fire Department Connection ☐ Yes ☐ No	Proper Signage with Information Provided? ☐ Yes ☐ No	Reserve Foam Concentrate Supply Available? ☐ Yes ☐ No
"Acceptance Test" Witnessed By FM Global Representative? ☐ Yes ☐ No	Results Acceptable? ☐ Yes ☐ No	Subject to Comments? ☐ Yes ☐ No
Final Acknowledgement by FM Global Field Engineer? ☐ Yes ☐ No		

Variations from Drawings or Information in Parts "A" or "B" in Completed Installation:

Other Deficiencies or Remarks:

Part "B" Completed

This system, except as noted, is now in good operating condition And charged with required supply	Date:
Contractor (print name):	Test Witnessed By: (Representative For Purchaser, print name)

Any Deficiencies Noted Above Have Been Corrected, and the Installation is Acknowledged by FM Global; for Property Insurance Purposes Only.

Field Engineer Examining Completed Installation (Print name):	Date:

NOTE: If the installation is deficient in any way, list variations and deficiencies above and return to the FM Global office. Include a statement in your report, giving the name of the manufacturer of the equipment, the name of the installer, identifying the hazard and its location, commenting upon the acceptability of the installation, along with suitable recommendations for making the system "acceptable", if necessary.

If deficiencies are listed above, they will be checked by succeeding field consultant, and when all have been corrected or completed, the field consultant will indicate acknowledgement of the system , where "Part B" is completed and return them to the FM Global office. Include a statement in your report indicating the deficiencies that have been corrected, and that the installation is now acceptable.

THE LIABILITY OF FM GLOBAL IS LIMITED TO THAT COVERED BY ITS INSURANCE POLICIES. NO OTHER LIABILITY IS ASSUMED BY REASON OF THE APPLICATION FOR ACKNOWLEDGEMENT.

Fig. D.1 Continued

D.2 Control Matrix for Commissioning

CONTROLS MATRIX

		ANNUNCIATION AT LOCAL PANELS				FIRE SUPPRESSION SYSTEM FUNCTIONS					TRANSMIT SIGNALS TO MANNED STATION/CENTRAL STATION/FIRE						AUXILIARY FUNCTIONS		EVACUATION SIGNALS	
		Audio-Visual Fire Alarm Indication by Zone	Audio-Visual Trouble Indication by Zone/Middle	Audio-Visual Common Trouble Indication	Audio-Visual Alarm Indication by Device	Transmit Pump Start Signal for Water Supply	Transmit Pump Start Signal for Foam Concentrate	Open Pre-Action Sprinkler Valves	Divert Drain Flow from Separators to		Common Trouble Signal Per Building	Common Supervisory Per Building	Common Fire Alarm Per Hazard Area	Sprinkler Water Flow Per Hazard Area	UV/IR Flame/Heat Detector Per Hazard Area	Foam Discharge Per Hazard Area	Shut Down All Supply & Recirculating Fans	Release Magnetically Held Smoke Doors	Facility Fire Evacuation Audio-Visual Signal	Foam System Discharge Audio-Visual Signal
	SYSTEM INPUTS FIRE ALARMS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Manual Fire Alarm Stations																			
2	Spot-Type Smoke Detectors																			
3	Fixed Temp & Rate-of Rise Type Heat Detector																			
4	In-Duct Smoke Detector																			
5	Water Flow Switches - Pre-primed, Wet or Dry-Pipe Sprinkler System																			
6	Water Flow Switches - Pre-Action Foam-Water Sprinkler System																			
7	Water Switches - Low Level System																			
8	Manual Foam Discharge Station for Low Level																			
9	Low Level Optical Fire Detector																			
10																				
	SUPERVISORY SIGNALS																			
11	Valve Supervisory Switch - Foam-Water Sprinklers																			
12	Valve Supervisory Switch - Automatic Foam Concentrate Control Valve																			
13	Valve Supervisory Switches - Supplementary Discharge Device(s)																			
14	Valve Supervisory Switches - Water Supply Entrance																			
15	Hi-Lo Pressure Switches - Dry-Pipe Foam-water Sprinkler																			
16	Temperature Monitoring System																			
17	UV/IR Flame/Heat/Smoke Detector Trouble																			
18	Control Component Common Trouble Condition																			
19	Low Level System Auto Disable Switch																			
20																				
	TROUBLE CONDITIONS																			
21	Low Battery Voltage																			
22	Circuit Fault																			
23	Supervised Component Failure																			
24	AC Power Failure																			

NOTES:

A. Fire alarm signals and supervisory alarm signals are to be clearly differentiated at the fire alarm control panel(s).

B. This sample matrix shows the basic requirements and is expected to be tailored to each individual project.

C. In electronic format, typing "1" will shade the cell "yellow" to identify it as a check point in tailoring and preparation for Commissioning. The form can be printed and the cell can then be "√" for compliance during Commissioning.

Fig. D.2 Control matrix for commissioning

D.3 ″Acceptance Test″ for Percent Injection of Foam Concentrate

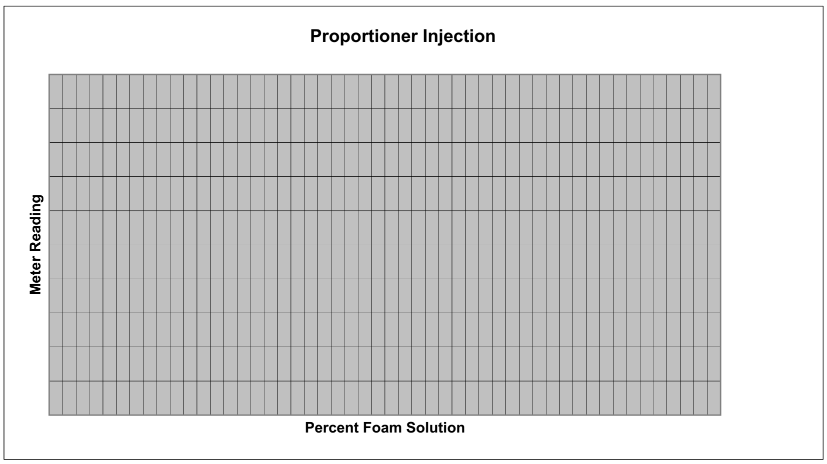
"ACCEPTANCE TEST" FOR PERCENT INJECTION OF FOAM CONCENTRATE

JOB or CONTRACT NUMBER	DATE	FM GLOBAL OPERATIONS CENTER
INDEX NUMBER	ACCOUNT NUMBER	
LOCATION :		
HAZARD:		

NAME OF CUSTOMER	STREET ADDRESS	
CITY/STATE/PROVIDENCE/POSTAL CODE & COUNTRY		DRAWINGS SUBMITTED
NAME & ADDRESS OF EQUIPMENT CONTRACTOR:		
NAME OF EQUIPMENT MANUFACTURER:		

FOAM CONCENTRATE TYPE	LOT NUMBER	PERCENT INJECTION
METER TYPE: CONDUCTIVITY	REFRACTOMETER	
MANUFACTURER	MODEL	

CALIBRATION STANDARDS[1,2]			METER READING[4]
FOAM CONCENTRATE			
WATER	0	%	
PRE-MIX #1		%	
PRE-MIX #2		%	
PRE-MIX #3		%	



SYSTEM DISCHARGE SAMPLE

FLOW	PRESSURE	METER READING[6]	PERCENT FOAM SOLUTION[7]	RESULT[8]

**** Values included only for example***

NOTES:

1. Identify foam concentrate being used 1%, 3% or 6%.
2. Use Pre-mix solutions recommended in Appendix E for the appropriate foam concentrate injection
3. Identify those pre-mix solutions in the "yellow" cell for the Calibration Standard
4. Identify the meter reading, either conductivity or refractive index, in the "tan" cell for respective cell.
5. Graph
6. Identify "Meter Reading" into "blue" cells for System Discharge Samples.
7. Identify "Percent Foam Solution" from "blue" cells for System Discharge Samples.
8. Determine if Results either "Pass" or "Fail"

1%	1.0 to 1.3%
3%	3.0 to 3.9%
6%	6.0 to 7.0%

Fig. D.3 Acceptance Test for Percent Injection of Foam Concentrate

APPENDIX E JOB AIDS

DETERMINATION OF FOAM-WATER SOLUTION CONCENTRATION FROM PROPORTIONER INJECTION

The following is guidance for conducting acceptance testing of foam-water sprinkler systems. These are key elements to be considered in the recommended step-by-step procedure to be submitted by the installing contractor and in agreement with the foam equipment manufacturer's manuals.

The following equipment, or similar, is needed for testing:

(a) Test Connection Valve Header

1. Fifty ft (15 m) lengths, 2½ in. (65 mm) lined hose

2. Smooth-bore nozzles (Underwriters' play pipes) as needed to flow required volume of water (where a calibrated and reliable in-line test flow meter is provided, these may not be needed)

(b) Test instruments of high quality that are accurate and in good repair.

1. Test pressure gauges

2. Pitot tube with gauge (for use with hose and nozzle)

(c) Test instrumentation that has been calibrated within the previous 12 months.

To limit the amount of foam-water solution discharge, adjust the water flow first from the test connection discharge valves for the recommended foam-water sprinkler system test flows prior to the actual testing of the proportioner for proper injection of the foam concentrate. Conduct this operation for each of the recommended test flows.

Communication is critical between personnel involved in the acceptance testing. Several people may be required to coordinate operations between the water control valve, automatic concentrate control valve, test connection discharge valve, and sample point to minimize the amount of foam concentrate used. Communication devices such two-way radios may be needed due to the distance between these operational points.

When a containment tank/tanker is used, the pretreatment of the hoses subsequent to the sample point and tank/tanker with antifoaming agent is recommended. This will prevent nuisance foaming during the acceptance test. The amount of antifoam agent depends on the volume of foam-water solution being discharged.

Antifoam agents may be obtained from one of the following suppliers, but only after the manufacturer has confirmed they are compatible with the foam concentrate:

- Dow Chemical
- General Electric
- Henkel
- Union Carbide
- Wacker Silicones

Ensure the proper containment and disposal of the foam-water solution discharge has been arranged to meet the requirements of the client and the authority having jurisdiction.

There are two acceptable methods for measuring foam concentrate percentage in water. Both methods are based on comparing foam solution test samples with pre-measured solutions, which are plotted on a baseline graph of percent concentration versus instrument reading.

1. Conductivity Method

This method is based on changes in electrical conductivity as foam concentrate is added to water. A conductivity meter is used to measure the conductivity of foam solutions in microsiemens units. Conductivity is a very accurate method, provided there are substantial changes in conductivity as foam concentrate is added to the water in relatively low percentages (i.e., 1 percent, 3 percent, or 6 percent). Since salt or brackish water is very conductive, this method might not be suitable due to small conductivity changes as foam concentrate is added, relative to the conductivity of the water.

It will be necessary to make foam-water solutions in advance to determine if adequate changes in conductivity can be detected if the water source is salty or brackish.

Equipment Required

Prepare a base (calibration) curve using the following apparatus:

- Four 1000 ml plastic bottles with caps*
- One 60 ml measuring pipette or 60 cc syringe
- One 1000 ml graduated cylinder or beaker
- Three plastic-coated magnetic stirring bars
- One temperature-compensated conductivity meter:
  - Range (minimum): 0 to 2000 S
  - Accuracy: ± 40 S
  - Resolution: 2 S
- Standard graph paper or electronic graphing
- Ruler or other straightedge

* Minimum size bottles and graduated cylinder. Larger sample volumes (2000 or 3000 ml) may reduce the possible error in mixing of samples. This is should be considered for 1% foam concentrate and if the band of error for instrumentation is being considered.

Procedure

Using the water from the water supply and foam concentrate from the system to be tested, make up a minimum of three standard foam-water solutions using the 1000 ml graduated cylinder. These samples should include the nominal intended percentage of injection, the nominal percentage plus 1 or 2 percentage points, and the nominal percentage minus 1 or 2 percentage points.

Typical premix solutions are as follows:

Foam Concentrate	*Sample #1*	*Sample #2*	*Sample #3*
1	0.5	1.0	1.5
3	2.0	3.0	5.0
6	4.0	6.0	8.0

It may also be advisable to prepare samples that identify the band of error for the instrumentation being used.

Foam Concentrate	*Sample #4*	*Sample #5*
1	0.9	1.4
3	2.9	4.0
6	5.9	7.0

Place the water in the 1000 ml graduated cylinder (leaving adequate space for the foam concentrate) and then carefully measure the foam concentrate samples into the water using the syringe. Use care not to pick up air in the foam concentrate samples. Pour each measured foam solution from the 1000 ml graduated cylinder into a 1000 ml plastic bottle. Each bottle should be marked to indicate the percent solution it contains. Add a plastic stirring bar to the bottle, cap it, and shake thoroughly to mix the foam solution.

After making the three foam solutions in this manner, measure the conductivity of each solution. Refer to the instructions that come with the conductivity meter to determine proper procedures for taking readings. It will be necessary to switch the meter to the correct conductivity range setting to obtain a proper reading. Most synthetic-based foams used with freshwater will result in foam solution conductivity readings of less than 2000 microsiemens. Protein-based foams will generally produce conductivity readings in excess of 2000 in freshwater solutions. Due to the temperature compensation feature of the conductivity meter, it can take a short time to obtain a consistent reading.

Once the solution samples have been measured and recorded, set the capped bottles aside for control sample references.

Over long tests, i.e., multiple tests lasting all day, it may be necessary to mix new samples as the base water conductivity can change enough over this period (or due to evaporation if the bottles are not capped) to affect the conductivity reading of the standard solutions.

The conductivity readings should then be plotted on the graph paper or equivalent electronic method. (See Appendix D - Forms, ″Acceptance Test″ for percent Injection of Foam) It is most convenient to plot the foam solution percentage on the horizontal (X) axis and conductivity readings on the (Y) vertical axis (See Fig E.1).

It might not be possible to hit all three points with a straight line, but they should be very close. If they are not, repeat the conductivity measurements and, if necessary, make new control sample solutions until all three points plot in a nearly straight line. This plot will serve as the known base (calibration) curve to be used for the test series.

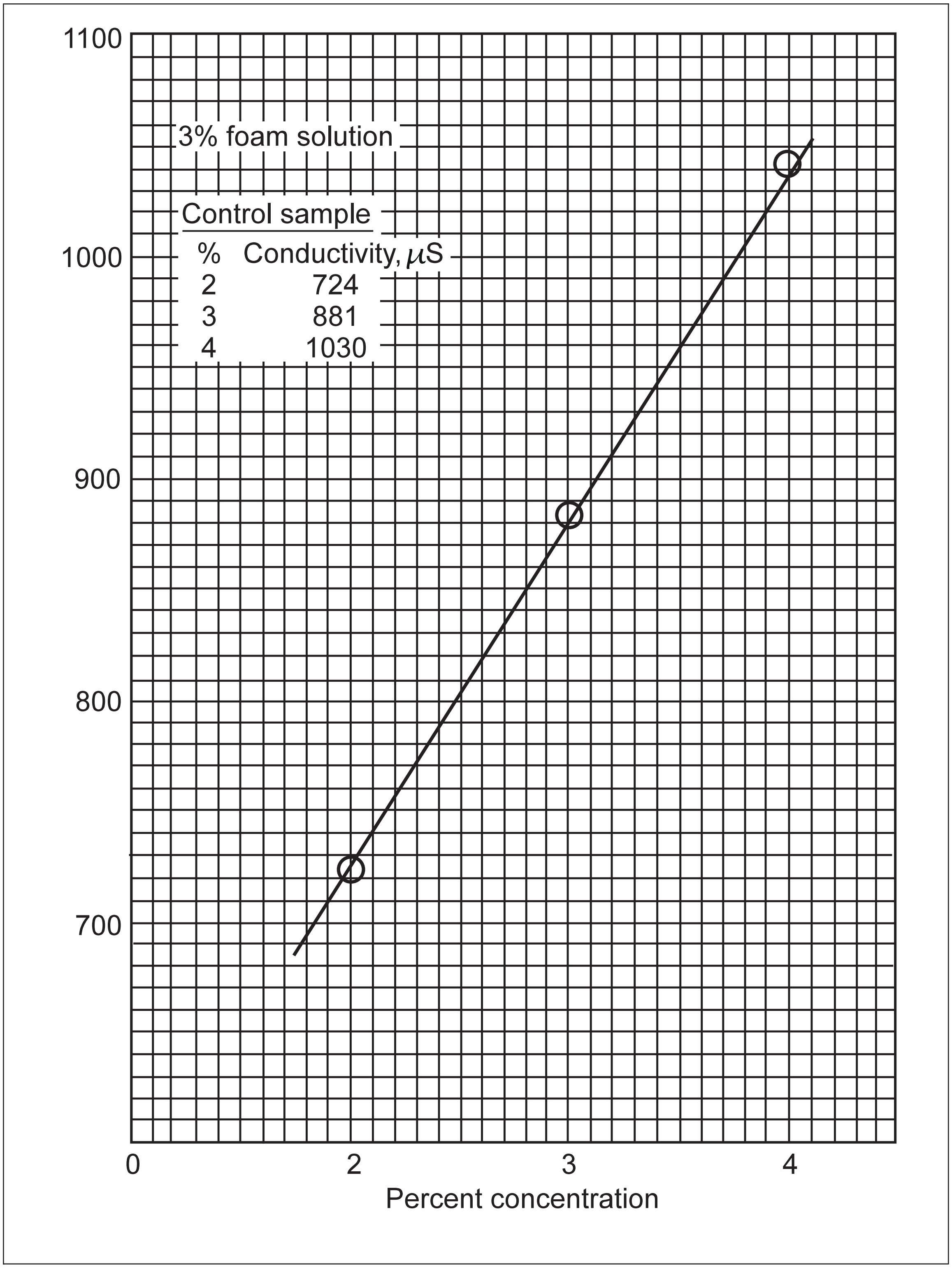


Fig. E.1 Determining foam concentrate percentage using the conductivity method

2. Refractive Index Method

A digital refractometer is used to measure the refractive index of the solution samples. This method is not particularly accurate for AFFF or alcohol-resistant foams, since they typically exhibit very low refractive index readings. For this reason, the conductivity method might be preferred when these products are used.

Equipment Required

A base (calibration) curve is prepared using the following apparatus:

- Four 1000 ml plastic bottles with caps*
- One 60 ml measuring pipette or 60 cc syringe
- One 1000 ml graduated cylinder* or beaker
- Three plastic-coated magnetic stirring bars
- One digital refractometer:
  - Refractive Index Scale (Minimum): 1.3330 – 1.3700
  - Scale Division: 0.0001
  - Accuracy: ±0.0001
- Standard graph paper or electronic graphing
- Ruler or other straightedge

* Minimum size bottles and graduated cylinder. Larger sample volumes (2000 or 3000 ml) may reduce the possible error in mixing of samples. This is should be considered for 1% foam concentrate and if band of error for instrumentation is being considered.

Procedure

Using the water from the water supply and foam concentrate from the system to be tested, make up a minimum of three standard solutions using the 1000 ml graduated cylinder. These samples should include the nominal intended percentage of injection, the nominal percentage plus 1 or 2 percentage points, and the nominal percentage minus 1 or 2 percentage points.

Typical premix solutions are as follows:

Foam Concentrate	*Sample #1*	*Sample #2*	*Sample #3*
1	0.5	1.0	1.5
3	2.0	3.0	4.0
6	4.0	6.0	8.0

It may be also advisable to prepare samples that identify the band of error for the instrumentation used.

Foam Concentrate	*Sample #4*	*Sample #5*
1	0.9	1.4
3	2.9	4.0
6	5.9	7.0

Place the water in the 1000 ml graduated cylinder (leaving adequate space for the foam concentrate) and then carefully measure the foam concentrate samples into the water using the syringe. Use care not to pick up air in the foam concentrate samples. Pour each measured foam solution from the 1000 ml graduated cylinder into a 1000 ml plastic bottle. Each bottle should be marked to indicate the percent solution it contains. Add a plastic stirring bar to the bottle, cap it, and shake thoroughly to mix the foam solution.

After thoroughly mixing the foam solution samples, take a refractive index reading of each percentage foam solution sample. This is done by placing a few drops of the solution on the refractometer prism, closing the cover plate, and observing the scale reading at the dark yield intersection. Since the refractometer is temperature compensated, it can take 10 to 20 seconds for the sample to be read properly. It is important to take all refractometer readings at ambient temperatures of 50°F (10°C) or above.

Once the solution samples have been measured and recorded, set the capped bottles aside for control sample references.

Over long tests, i.e., multiple tests lasting all day, it may be necessary to mix new samples as the base water conductivity can change enough over this period (or due to evaporation if the bottles are not capped) to affect the conductivity reading of the standard solutions.

Using standard graph paper or equivalent electronic graphing method, (See Appendix D - Forms, ″Acceptance Test″ for Percent Injection of Foam) plot the refractive index readings on the vertical (Y) axis and the percent concentration on the horizontal (X) axis. The resulting plotted curve will serve as the known baseline for the test series. Set the solution samples aside in the event the measurements need to be checked. (See Fig. E.2).

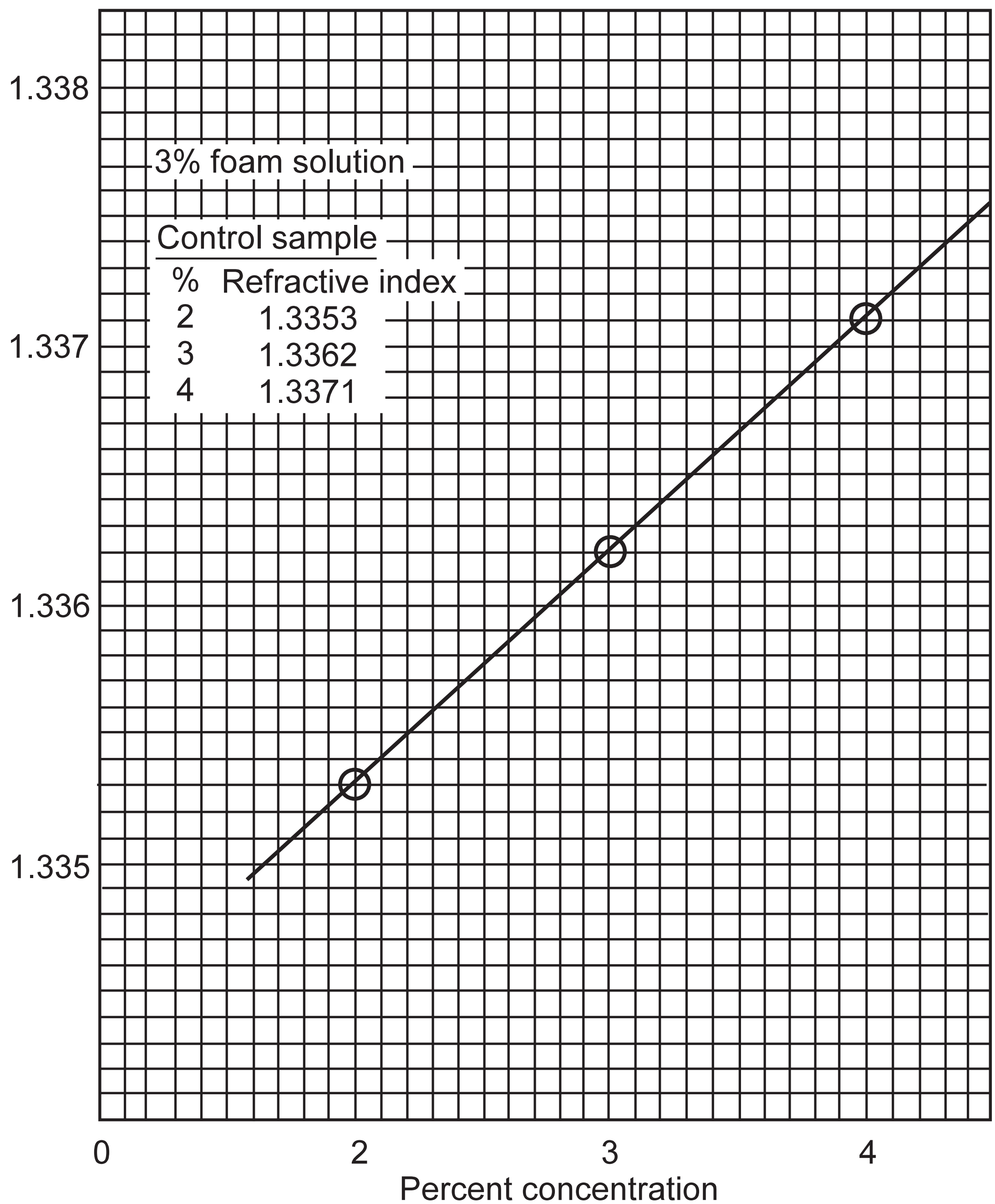


Fig. E.2 Determining foam concentrate percentage using the refractive index method

Sampling and Analysis

Collect foam-water solution samples from the proportioning system, using care to ensure the sample is taken at an adequate distance downstream from the proportioner being tested. Using foam-water solution samples that are allowed to drain from expanded foam can produce misleading conductivity readings.

Thirty to 60 seconds after the foam appears from the test valve, take a sample of the foam-water solution discharge.

Once one or more samples have been collected, read their conductivity or refractive index and find the corresponding percentage from the plotted base curve prepared from the control sample solutions.

Foam Solution Concentration Determination

This test is used to determine the percent concentration of a foam in the water being used to generate foam-water solution. It is typically used as a means of determining the accuracy of a system's proportioning equipment. If the level of foam concentrate injection varies widely from design, it could abnormally influence the expansion and drainage foam quality values, which could influence the foam's performance during a fire.

APPENDIX F BIBLIOGRAPHY

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