Foam System

Technical Manual for Operation, Maintenance, and Troubleshooting

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VIKING® | TECHNICAL DATA | FOAM SYSTEM

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NOTE: SPRINKLER SYSTEMS ARE ENGINEERED TO MEET THE STANDARDS OF NFPA 13, FM GLOBAL, LOSS PREVENTION COUNCIL (FOC), ASSEMBLEE PLENIERE, VERBAND DER SACHVERSICHERER (VDS) OR OTHER SIMILAR ORGANIZATIONS, AND WILL ALSO NEED TO COMPLY WITH THE PROVISIONS OF GOVERNMENTAL CODES, ORDINANCES, AND STANDARDS WHERE APPLICABLE. THE SYSTEM MUST BE DESIGNED BY QUALIFIED DESIGN PROFESSIONALS IN CONJUNCTION WITH INSURING BODIES. THE USER IS RESPONSIBLE FOR THE DESIGN AND CONFIGURATION OF THE SYSTEM, ITS APPROPRIATENESS FOR THE USE INTENDED AND ITS COMPLIANCE WITH ALL STANDARDS, CODES AND ORDINANCES. VIKING CORPORATION DOES NOT DESIGN SYSTEMS FOR SPECIFIC INSTALLATIONS AND MAKES NO REPRESENTATION OR WARRANTY CONCERNING WHETHER ANY SPECIFIC SYSTEM INSTALLATION WILL BE SUFFICIENT FOR THE INTENDED USE OR WILL COMPLY WITH ANY STANDARD, CODE, OR ORDINANCE. ANY SYSTEM DEPICTED IN THIS MANUAL IS SHOWN FOR ILLUSTRATIVE PURPOSES ONLY.

I. SYSTEM DESCRIPTION

A foam-water system is a special system of pipe connected to a source of foam concentrate and to a water supply. The system uses appropriate discharge devices to control and/or extinguish fires which require a smothering and cooling agent. The piping system is connected to the water supply through a control valve that is actuated by operation of automatic detection equipment that is installed in the same areas as the sprinklers. Foam-water systems are designed to distribute a foam-water solution to a specific hazard area for fire protection. *Examples:* extraction plants, aircraft hangars and areas where flammable-liquid spill fires may occur. 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, then foam for a specified period, and then followed by water until manually shut off. The type and potential size of the hazard determines the number of discharge devices, type of foam concentrate, and foam-water discharge rate and duration. Characteristics of some flammable products may require higher densities and special foam liquid concentrates. NFPA 11 contains requirements for foam-water systems, with requirements for foam systems also found in NFPA 13, NFPA 16, NFPA 30, NFPA 409, and NFPA 418.

II. TYPES OF FOAM-WATER SYSTEMS

Foam systems can be fixed, mobile, or portable systems:

Fixed System: A complete installation in which foam is piped from a central foam station, discharging through fixed delivery outlets to the hazard to be protected with permanently installed foam pumps or bladder tanks.

Semi-Fixed System: System where the hazard is equipped with fixed discharge outlets connected to piping that terminates at a safe distance.

Mobile System: Any type of foam-producing unit that is mounted on wheels and is self-propelled or towed by a vehicle and can be connected to a water supply or can utilize a premixed foam solution. Portable systems include foam-producing equipment, materials, hose, and so forth, that are transported by hand.

A. Wet Pipe Foam-Water Systems

The Viking Wet Pipe Bladder Tank Foam-Water System is a standard wet pipe automatic sprinkler system (Figure 1) capable of discharging a foam-water solution automatically through any sprinklers that operate. This system utilizes a hydraulically actuated Halar® deluge concentrate control valve (CCV) with a wet system alarm check valve complete with variable pressure trim, a concentrate controller proportioning device with appropriately sized orifice, a hydraulically actuated Halar® deluge valve, a foam concentrate bladder tank and trim and foam agent.

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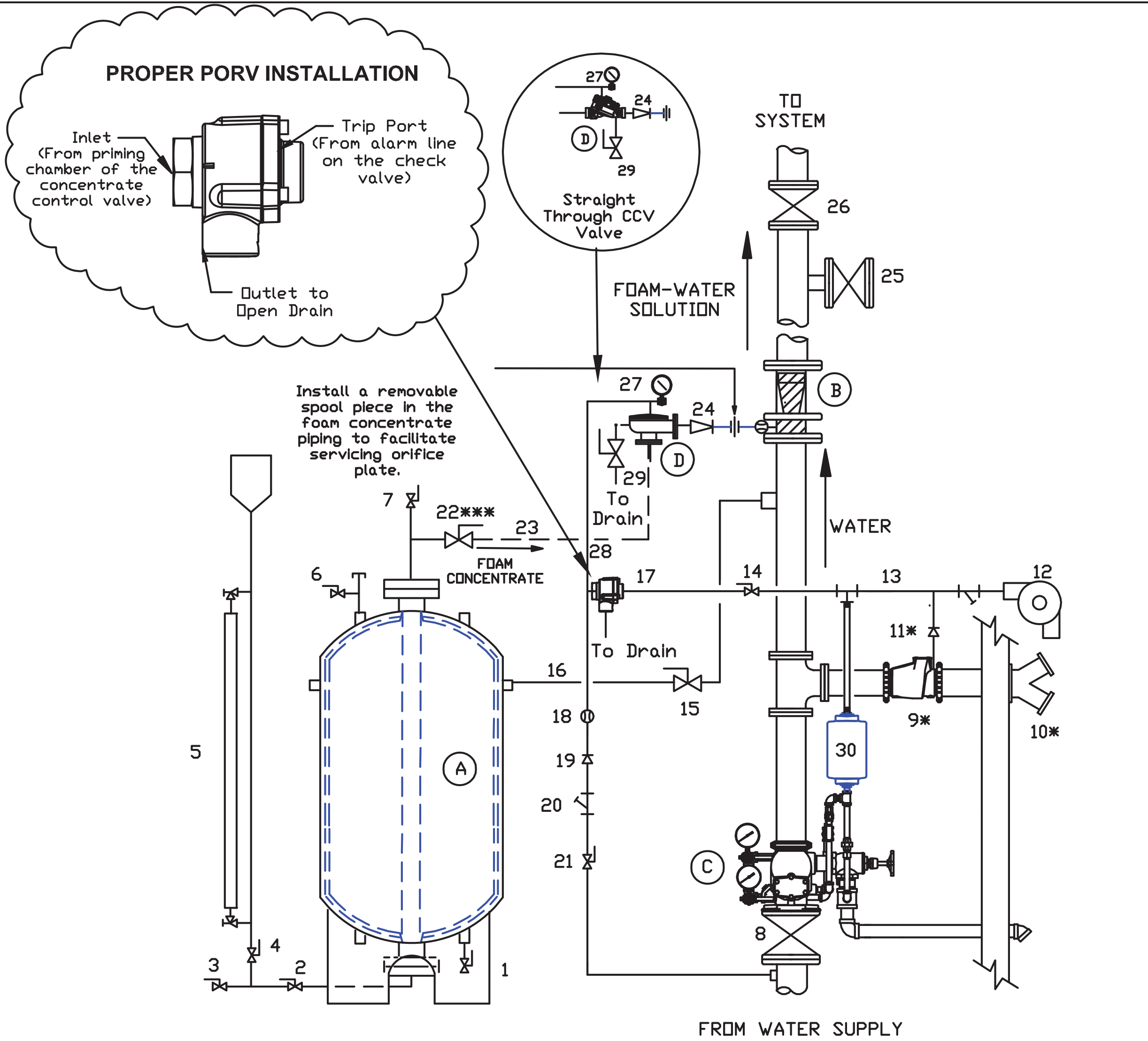

WET PIPE FOAM-WATER SYSTEM

A. Foam Concentrate Bladder Tank complete with Items 1-7
1. Water Drain/Fill Valve-NORMALLY CLOSED
2. Fill Line Master Shut-off Valve-NORMALLY CLOSED
3. Concentrate Drain/Fill Valve-NORMALLY CLOSED
4. Fill Cup/Sight Gauge Shut-off Valve-NORMALLY CLOSED
5. Sight Gauge Assembly - The trim for this assembly varies with the type of foam concentrate to be used. Refer to Tank Manufacturer's O & M Manual for specific details.
6. Tank Water Vent Valve-NORMALLY CLOSED
7. Diaphragm Concentrate Vent Valve-NORMALLY CLOSED

B. Proportioning Device - Concentrate Controller with Integral Orifice

C. Type of System - Alarm Check Valve with Variable Pressure Trim including Retard Chamber
8. Water Supply Control Valve - NORMALLY OPEN
12. Water Motor Alarm and Strainer or Alarm Pressure Switch with circuit closer vent trim

D. Concentrate Control Valve (CCV) - Hydraulically actuated Halar Coated Viking Angle Style Deluge Valve (*Angle Style and Straight Thru Style CCV available.)
14. 1/2" P.O.R.V. Water Supply Ball Valve-NORMALLY OPEN
17. P.O.R.V.
18. Restricted Orifice .125"
19. 1/2" Soft Seat Check Valve
20. 1/2" Strainer
21. 1/2" Ball Valve - NORMALLY OPEN
27. Water Pressure Gauge and 3 way valve and remainder of CCV special trim
29. 1/2" foam concentrate auxiliary drain valve

E. Accessory Trim - (Order each item separately)
9. Check Valve*
10. Fire Department Connection with Ball Drip Valve*
11. 1/2" Soft Seat Check Valve*
13. Alarm Line Piping
15. Tank Water Supply Control Valve-NORMALLY OPEN
16. Water Supply Piping to Bladder Tank
22. Concentrate Control Shut-off Valve-NORMALLY OPEN***
23. Foam Concentrate Discharge Piping
24. Foam Concentrate Swing Check Valve
25. Foam Solution Test Valve - NORMALLY CLOSED
26. System Isolation Valve - NORMALLY OPEN
28. 1/2" Priming Line

* Optional (Not required if a Fire Department Connection is located elsewhere)

*** Full Port Bronze Body with 316 Stainless Steel Trim and Ball (2" and under). Cast Iron Body OS & Y with Bronze Trim and seats (over 2")

Figure 1: Wet Pipe Foam-Water System

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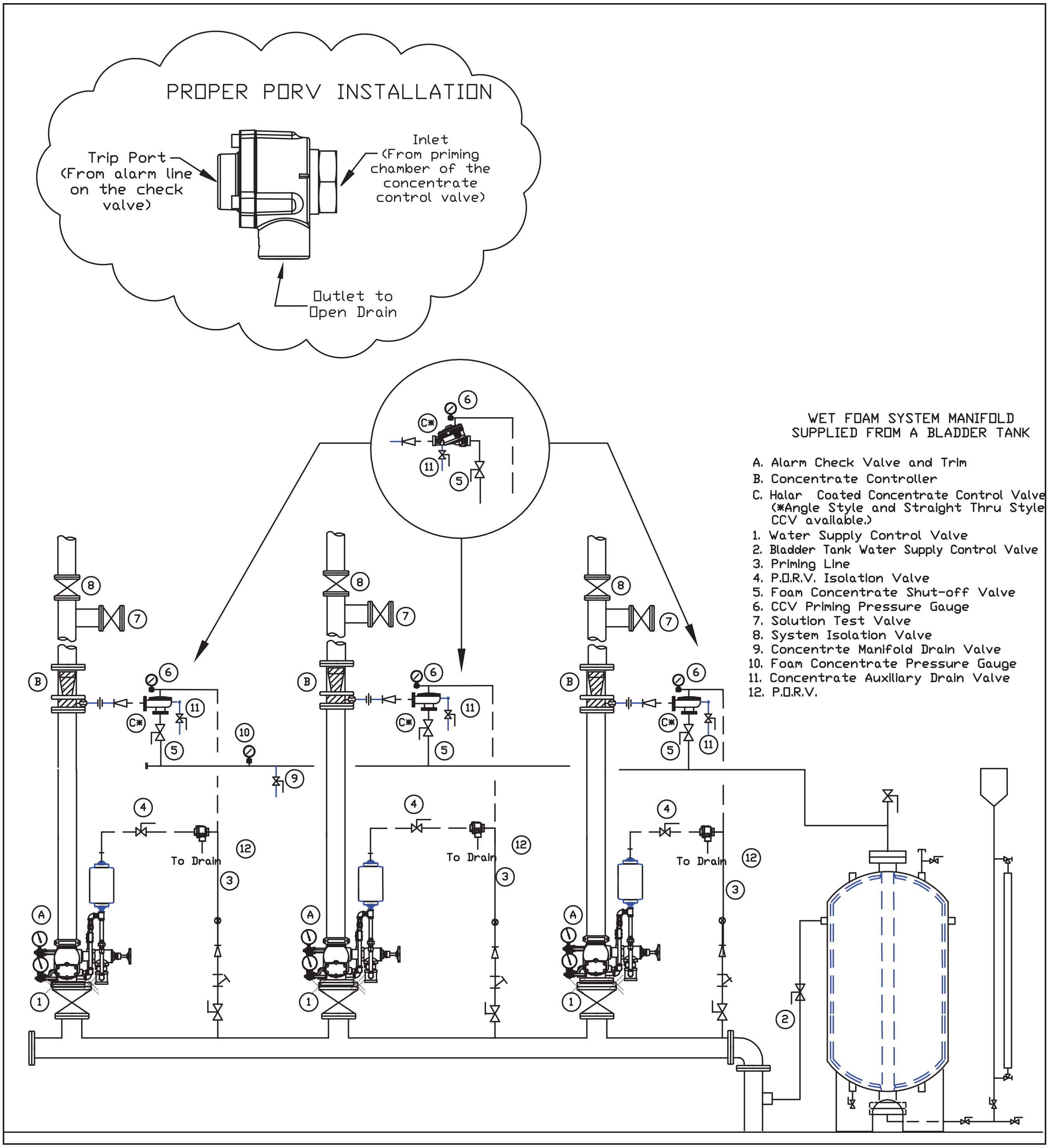

Figure 2: Wet Foam System Manifold Supplied From a Bladder Tank

With Viking's Multiple Wet Foam Systems Supplied by a Bladder Tank, multiple wet foam risers can be supplied from a single foam concentrate source (Figure 2). Where a bladder tank is used as the foam concentrate storage container and foam concentrate source, a manifold foam concentrate supply from the bladder tank to the individual risers is a cost-effective method of installing many foam risers without duplicating the foam concentrate supply for each different riser. The foam concentrate bladder tank will be sized by the most demanding system. It is important to remember that the most demanding system will also mean taking into account that the duration requirement per system may differ as well.

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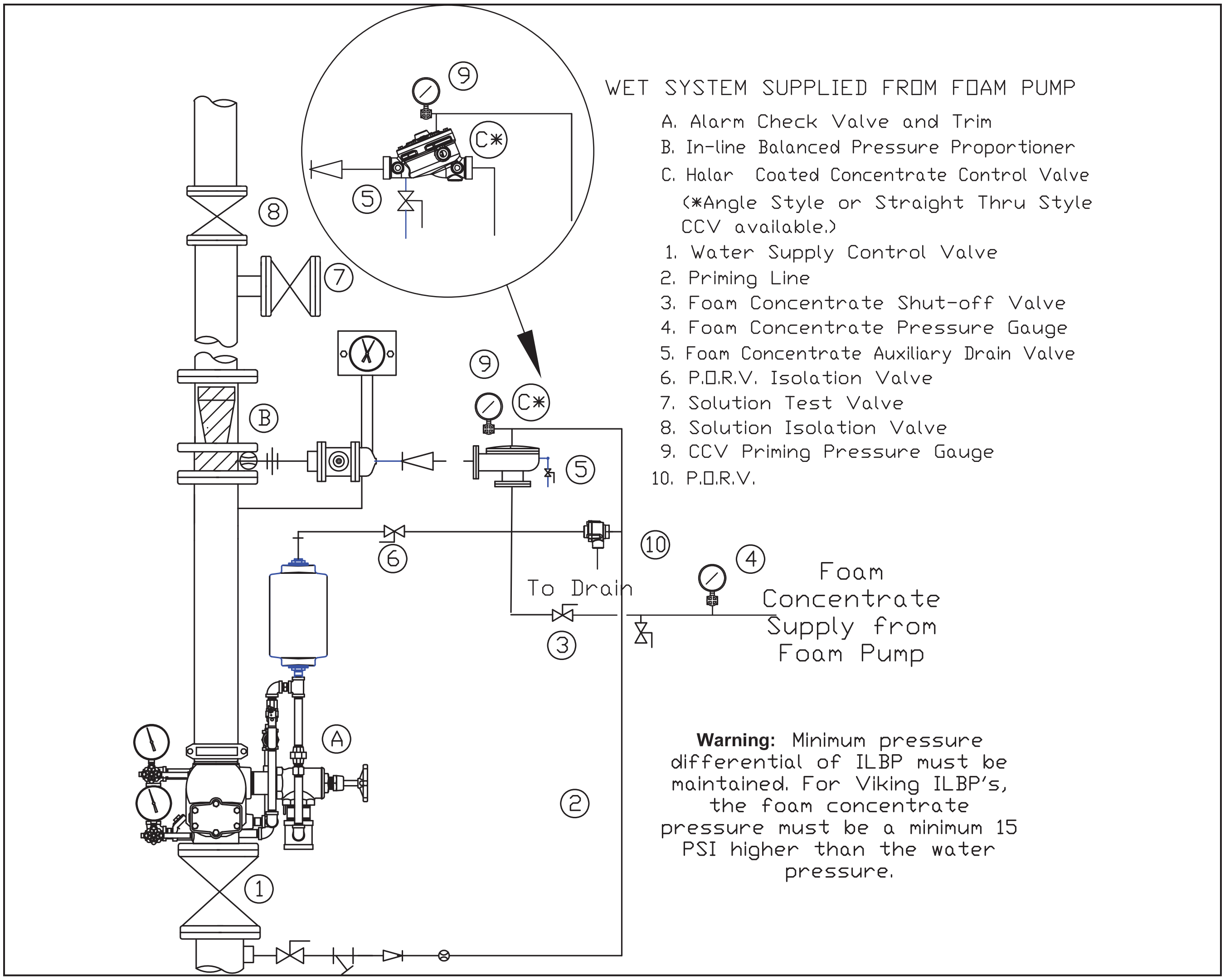

Figure 3: Wet System Supplied From Foam Pump

Multiple wet foam risers are supplied by a single bladder tank by a piping manifold installed from the discharge head of the bladder tank to each individual riser. The foam manifold will be sized for the most severe volume requirement and metered pressure drop requirement. At each riser location, a supply outlet will be provided from the concentrate manifold supply. The supply outlet will have a concentrate shut-off valve, a Halar® coated concentrate control valve, concentrate piping, a concentrate swing check valve, and a concentrate controller with integral metering orifice. The individual sprinkler riser will have a water supply control valve, Viking alarm check valve with variable pressure trim and retard chamber, sprinkler riser piping, concentrate controller, solution test valve and system isolation valve.

A manifold supply from a bladder tank to multiple wet risers allows for individual proportioning at each riser, allowing for different size risers. A manifold supply from a bladder tank to multiple wet risers also allows for individual system repair without completely losing foam protection for other areas.

A Viking Foam Wet System Supplied from a Foam Pump is a standard wet system capable of discharging foam-water solution automatically through any discharge device supplied from the wet system piping (Figure 3). A wet foam system with a hydraulically actuated Halar® coated concentrate control valve (CCV) consists of a Viking alarm valve complete with standard trim, an in-line balanced-proportioner assembly (ILBP), which includes a concentrate controller, listed orifice plate, spool balancing valve and swing check valve, hydraulically actuated Halar® coated concentrate control deluge

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valve (CCV) on foam concentrate line, a CCV priming connection, a foam concentrate atmospheric tank and trim, and foam concentrate agent.

With the Viking Wet Pipe Foam-Water Manifold System Supplied by Foam Pump, a foam pump can supply foam concentrate to an individual In-line Balanced Proportioning Assembly (ILBP) serving multiple risers in a manifold (Figure 4). A single proportioning device supplying multiple risers can be an economical method of providing foam risers.

The Viking Low-Flow Foam-Water Proportioning System consists of a standard wet pipe sprinkler system, using a Viking alarm check valve, complete with variable pressure trim and retard chamber, a factory assembled and tested Viking pilot operated pressure control valve, an in-line balanced pressure foam concentrate proportioning assembly (ILBP), bladder tank with trim, a hydraulic actuated Viking Halar® coated concentrate control deluge valve and foam agent (Figure 5).

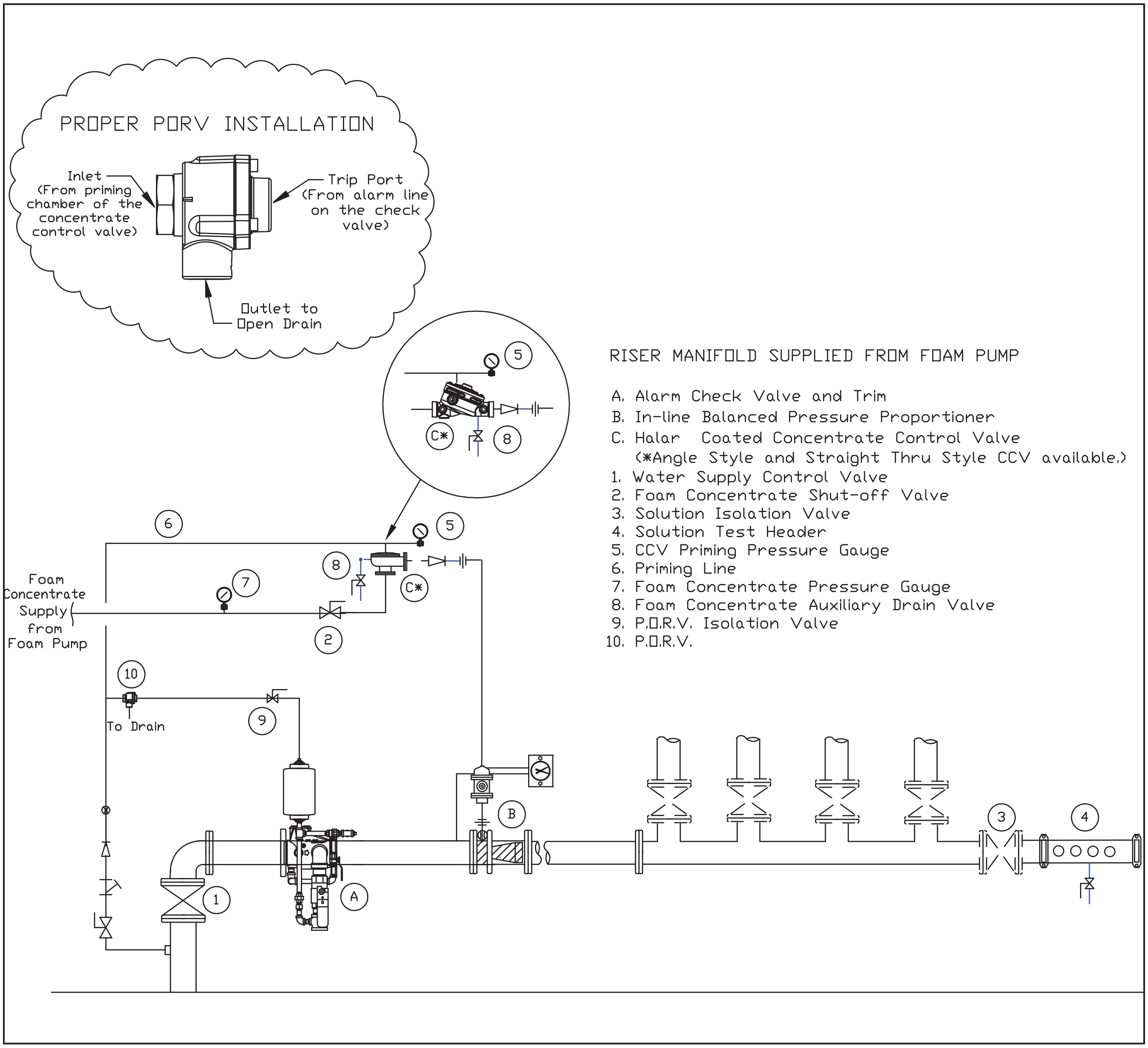

Figure 4: Riser Manifold Supplied From Foam Pump

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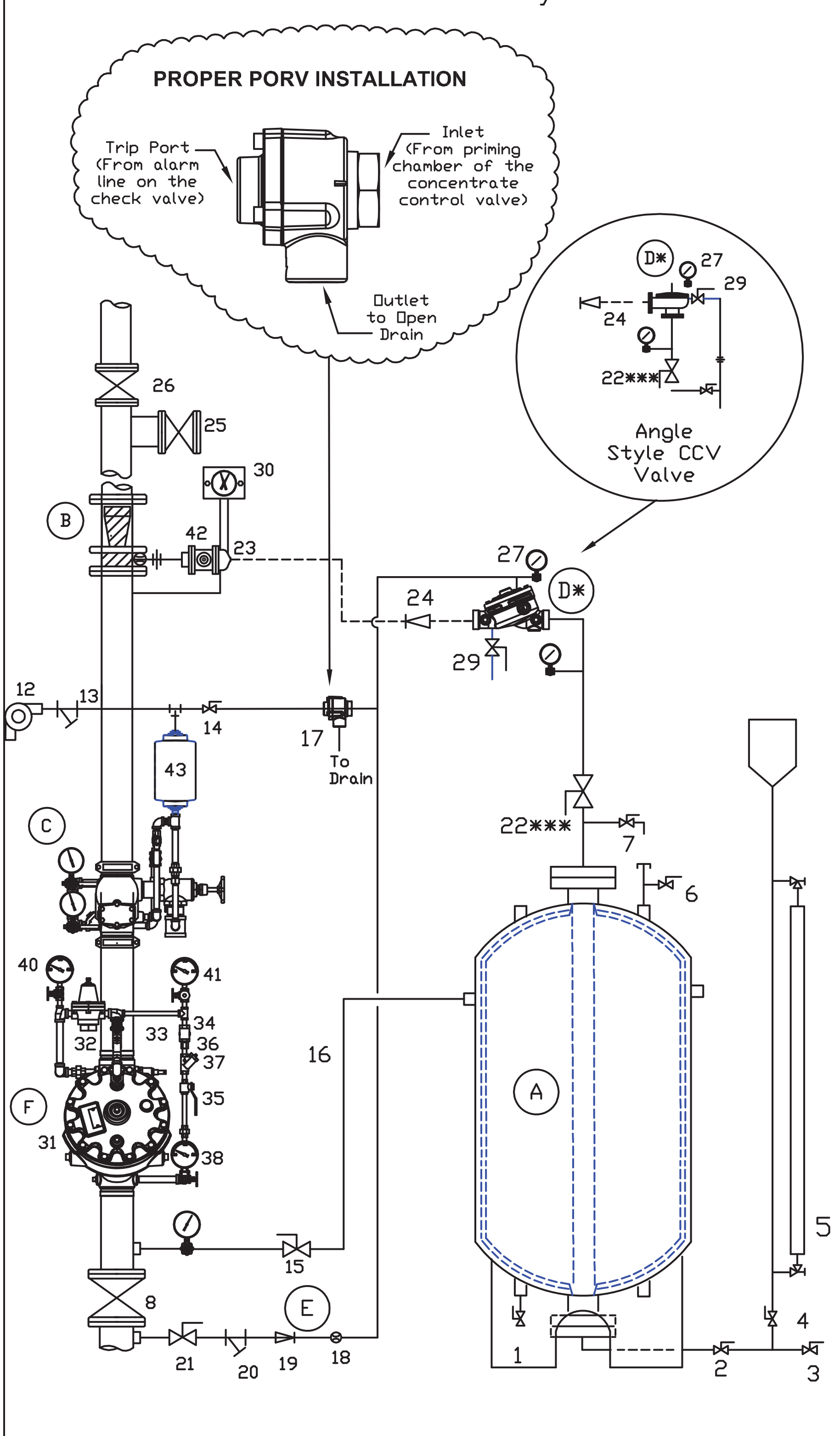
WET PIPE LOW FLOW FOAM SYSTEM
Vertical Straight Through Pilot Operated Pressure Control Valve Assembly w/CCV Valve



A. Foam Concentrate Bladder Tank (includes Items 1-7)
1. Water Drain/Fill Valve- NORMALLY CLOSED
2. Fill Line Master Shut-off Valve- NORMALLY CLOSED
3. Concentrate Drain/Fill Valve- NORMALLY CLOSED
4. Fill Cup/Sight Gauge Shut-off Valve- NORMALLY CLOSED
5. Sight Gauge Assembly-The trim for this assembly varies with the type of foam concentrates to be used. Refer to Tank Manufacturer's O & M Manual for specific details.
6. Tank Water Vent Valve- NORMALLY CLOSED
7. Diaphragm Concentrate Vent Valve- NORMALLY CLOSED

B. Viking In-line Balanced Pressure Proportioner Assembly (ILBP) Including Concentrate with Metering Orifice (Incl. Items 30 and 42)
30. Duplex Gauge
42. Spool Balancing Valve w/TFE lined stainless stainless braided hose and fitting- ΔP foam vs. water, min. 15 PSIG ILBP Piping Stainless Steel or Brass (order separately)

C. Type of System-Alarm Check Valve with Variable Pressure Trim
43. Retard Chamber (Order separately)
44. Circuit Closer Vent Trim (order separately)

D. Concentrate Control Valve (CCV)- Hydraulically actuated Halar Coated Viking Deluge Valve (*Angle Style or Straight Through Style CCV valve available) CCV Trim (includes items 27 & 29)
27. CCV Priming Pressure Gauge
29. 1/2" foam concentrate auxiliary drain valve

E. Priming Line Connection (Incl. Items 17-21)
17. P.O.R.V.
18. Restricted Orifice .125"
19. 1/2" Soft Seat Check Valve
20. 1/2" Strainer
21. 1/2" Ball Valve - NORMALLY OPEN

F. Factory assembled, tested Viking Model A or B Pilot Operated Pressure Control Assembly (includes items 31 through 41)
31. Viking Model H or J Flow Control Valve
32. Viking Model C-2 Pilot Pressure Reg. Valve
33. Viking Speed Control Assembly or Valve
34. Check Valve
35. Priming Valve
36. Restricted Orifice
37. Strainer
38. Water Supply Pressure Gauge
39. Drain Valve (Not shown)
40. Air Bleed Valve and Pressure Gauge
41. Downstream Pressure Gauge (Not Shown)

G. Accessory Trim-(Order each item separately)
8. Water Supply Control Valve-NORMALLY OPEN
12. Water Motor Alarm and Strainer
13. Alarm Line Piping
14. 1/2" P.O.R.V. Water Supply Ball Valve NORMALLY OPEN
15. Tank Water Supply Control Valve NORMALLY OPEN
16. Water Supply Piping to Bladder Tank
22. Concentrate Control Shut-off Valve NORMALLY OPEN***
23. Foam Concentrate Discharge Piping
24. Foam Concentrate Swing Check Valve
25. Foam Solution Test Valve NORMALLY CLOSED
26. System Isolation Valve NORMALLY OPEN
28. 1/2" Priming Line

*** Full Port Bronze Body with 316 Stainless Steel Trim and Ball (2" and under). Cast Iron Body OS&Y w/Bronze Trim and seats (over 2")

Figure 5: Wet Pipe Low-Flow Foam System Vertical Straight Through Pilot Operated Pressure Control Valve Assembly with Concentrate Control Valve

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This system was developed to provide an accurate foam-water solution at much lower flow ranges than what a conventional concentrate controller is capable of. The low flow foam system will also provide positive foam injection throughout the full range of system flows. It will provide a rich foam solution at low flows below the listed and approved minimum flow rates, which makes it ideal for use on closed head wet pipe sprinkler systems. Therefore, it is now possible to obtain the desired concentrate percentage at lower flows, which results in the operation of fewer sprinklers on the wet pipe systems, to achieve the desired foam-water solution percentage.

The Viking low-flow foam system combines the advantages of a conventional foam pump/ILBP system, but without the additional maintenance or cost of a foam pump.

With the Viking Wet Pipe Low-Flow Manifold System, multiple risers can be supplied from a single proportioning device (Figure 6). A riser manifold is installed with various riser types and sizes that are to supply foam solution to their hazard areas.

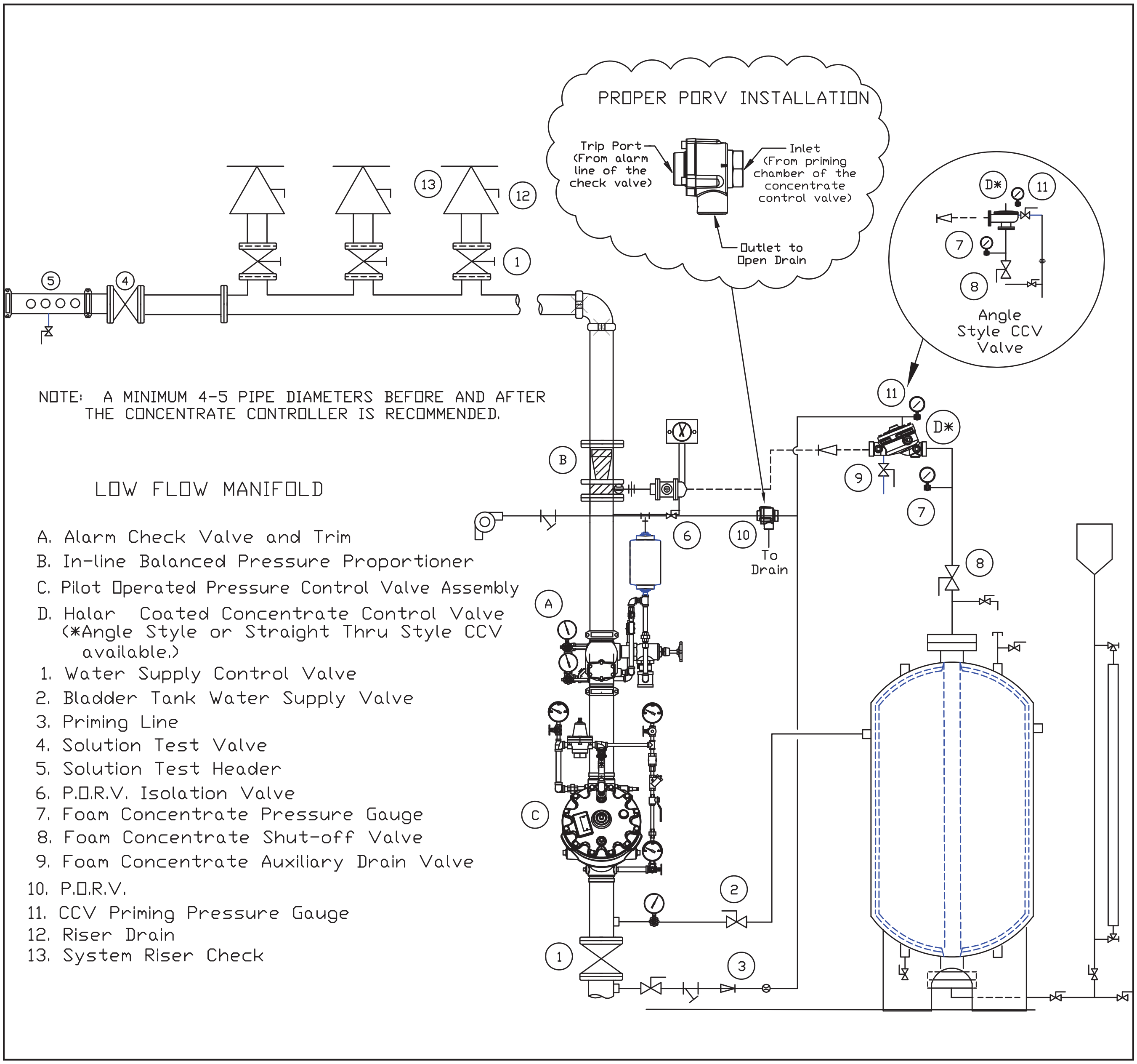

Figure 6: Wet Pipe Low-Flow Manifold System

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B. Preaction Foam-Water Systems

Preaction systems are used when faster response is desired (versus a dry system). All sprinklers are closed and normally there is no water in the piping. When a fire occurs, a supplementary detection system senses the fire and automatically opens a water control valve before the sprinkler(s) operate. Water then flows in the sprinkler piping and discharges from individual sprinklers as they open. Note that pre-priming foam solution is not needed as foam will be proportioned into the piping during operation.

The Viking Preaction Bladder Tank Foam-Water System is a standard preaction system capable of discharging a foam-water solution automatically through any sprinklers that operate (Figure 7). A preaction bladder tank foam-water system with a hydraulically actuated Halar® coated Viking deluge concentrate control valve consists of a standard preaction system using a Viking deluge valve complete with full standard preaction trim, detection and releasing devices on the water supply line, a concentrate controller-proportioning device with appropriately sized orifice, a hydraulically actuated Viking Halar® coated concentrate control deluge valve on foam concentrate line, a foam concentrate bladder tank and trim and foam agent.

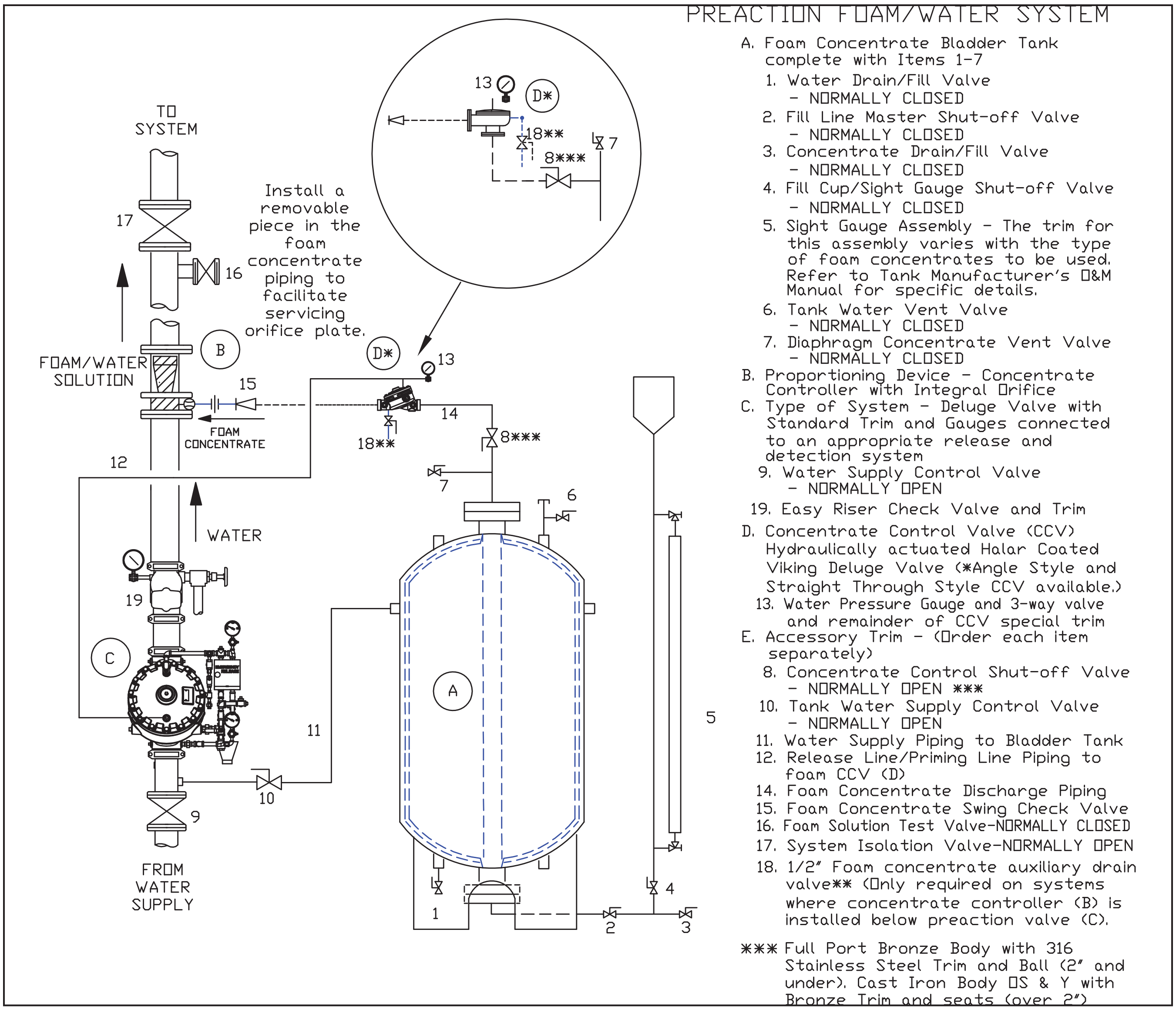

Figure 7: Preaction Bladder Tank Foam-Water System

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A Viking Foam Preaction System Supplied from a Foam Pump is a standard preaction system capable of discharging foam-water solution automatically through any discharge device supplied from the preaction system piping (Figure 8). A preaction foam-water system with a hydraulically actuated Halar® coated concentrate control valve consists of a Viking deluge valve complete with standard deluge trim, riser check valve, supervisory air supply, detection and releasing devices on the water supply line, an In-line Balanced Proportioner Assembly (proportioning device) which includes a concentrate controller, listed orifice plate, spool balancing valve and swing check valve, hydraulically actuated Halar® coated concentrate control valve on foam concentrate line, a foam concentrate atmospheric tank and trim and foam concentrate agent.

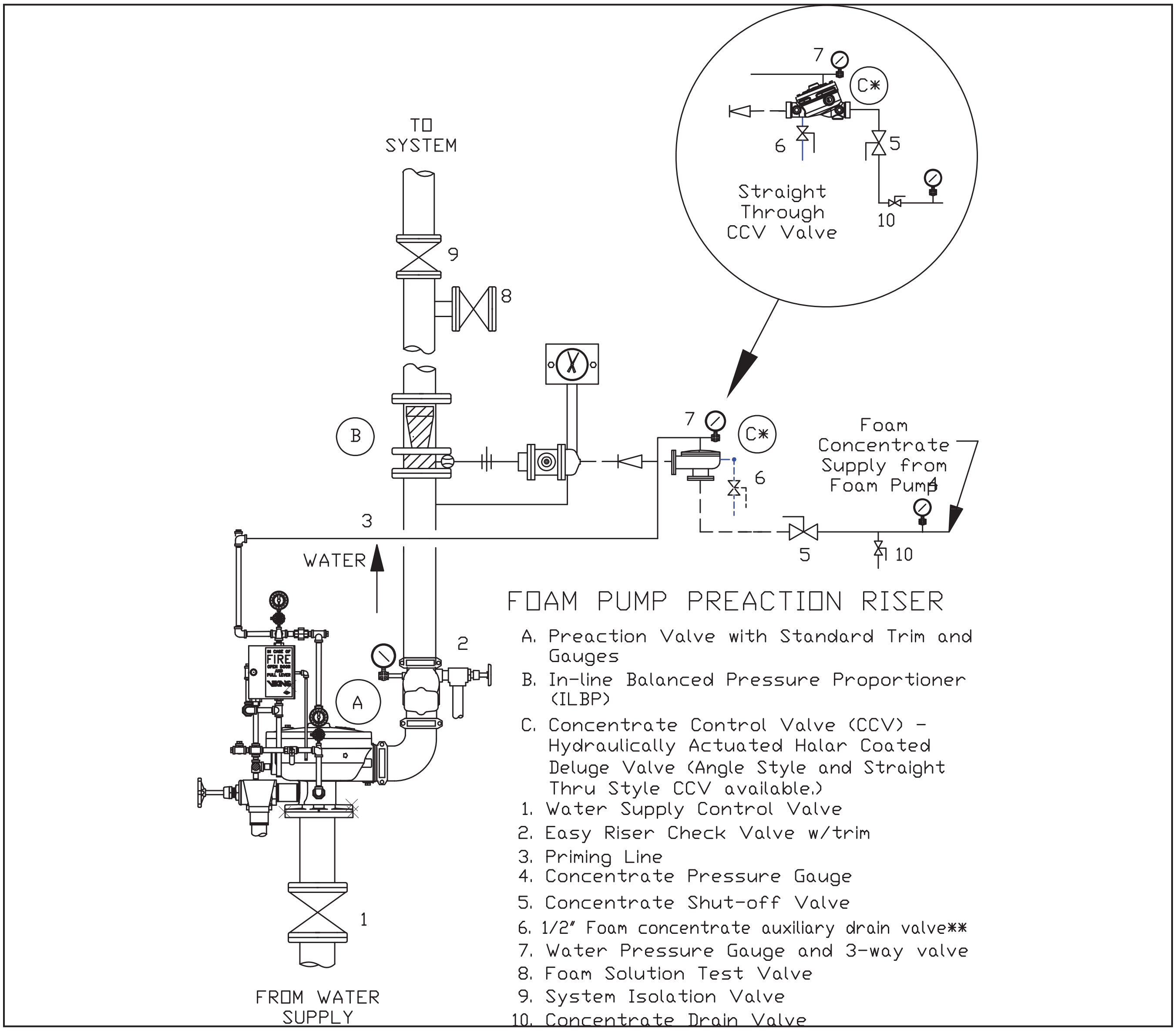

Figure 8: Foam Pump Preaction Riser

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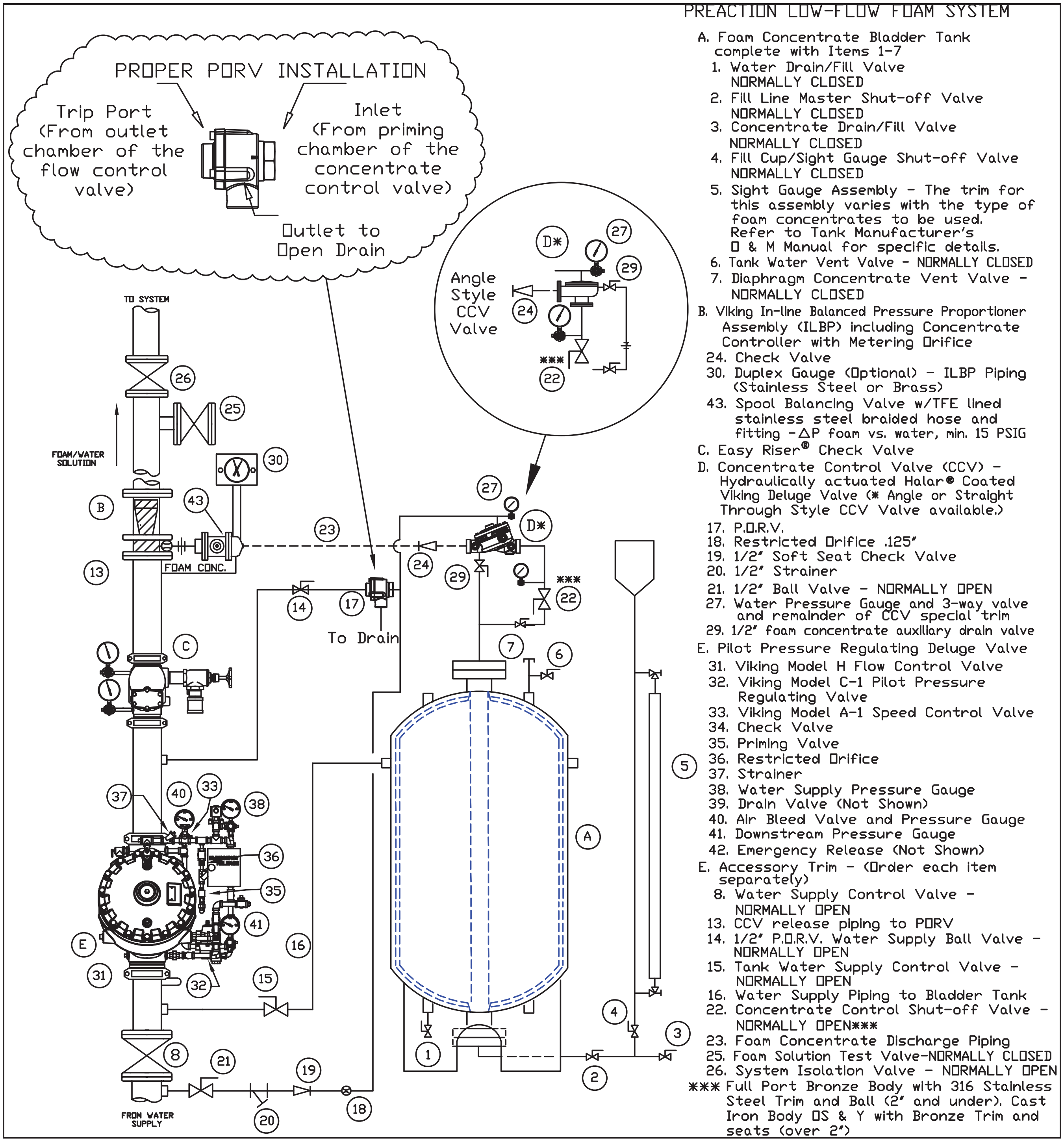

Figure 9: Preaction Low-Flow Foam-Water Proportioning System

The Viking Preaction Low-Flow Foam-Water Proportioning System (Figure 9) consists of the following: A standard single-interlocked preaction sprinkler system using a Viking flow control valve with pressure regulating deluge trim, Viking Easy Riser® Check Valve, release module for the supplemental detection system, an in-line balanced-pressure foam concentrate proportioning assembly (ILBP), hydraulically actuated Viking Halar® coated concentrate control valve, and foam concentrate that is UL Listed and FM Approved for use with the Viking system.

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This system was developed to provide an accurate foam-water solution at much lower flow ranges than a conventional concentrate controller. The low-flow foam system will also provide positive foam injection throughout the full range of system flows. It will provide a rich foam solution at low flows, which makes it ideal for use on closed-head preaction sprinkler systems. Therefore, it is now possible to obtain the desired concentrate percentage at lower flows, which results in the operation of fewer sprinklers on the pre-action system to achieve the desired foam-water solution percentage. The Viking low-flow foam system combines the advantages of a conventional foam pump/ILBP system, but without the additional maintenance or cost of a foam pump. Although the system cannot be re-filled while it is in operation, it requires less service than a foam pump system, while maintaining the dependability of a bladder tank system.

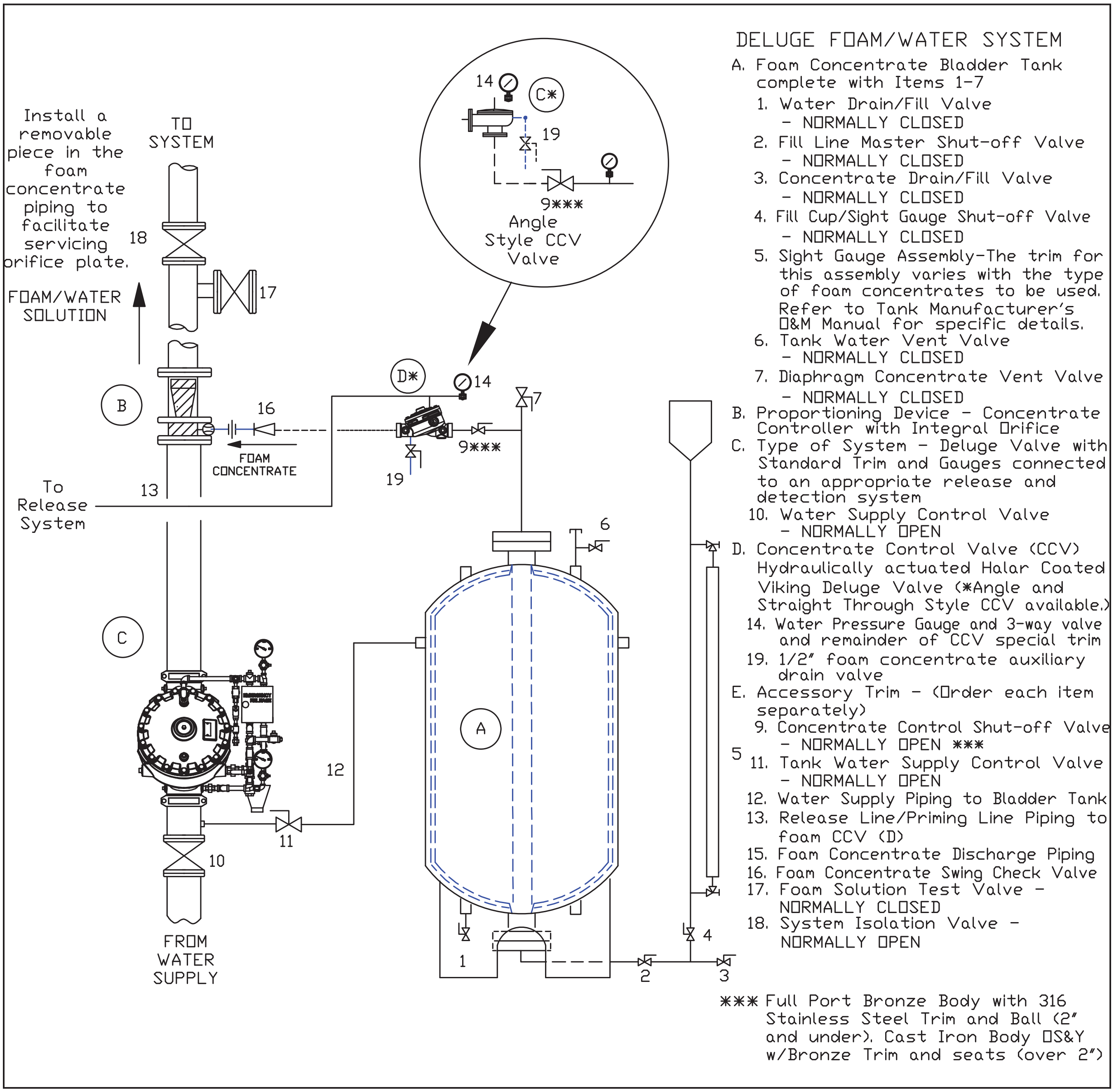

Figure 10: Deluge Bladder Tank Foam-Water System

The Viking preaction low-flow foam system also allows for the use of multiple foam discharge points with variable pressure. It is capable of sizing the proportioner specifically for the area of application, while using only a single source of foam concentrate supply. Water supply pressure to the bladder tank must be provided from an upstream source, preceding the pilot regulating control valve and preferably near a main fire water source, pump, or centrally located bladder tank.

C. Deluge Foam-Water Systems

A Viking Deluge Bladder Tank Foam-Water System is a standard deluge system capable of discharging a foam-water solution automatically through open sprinklers, spray nozzles, monitor nozzles, and other discharge devices (Figure 10). With a hydraulically actuated Viking Halar® coated concentrate control deluge valve, this system consists of a standard deluge system using a Viking Deluge Valve complete with full standard trim and detection and releasing devices, a concentrate controller-proportioning device with appropriately sized orifice, a hydraulically actuated Viking Halar® coated concentrate control deluge valve on foam concentrate line, a foam concentrate bladder tank and trim and foam agent.

With the Viking Multiple Foam-Water Deluge Systems Supplied by a Bladder Tank, multiple deluge foam risers can be supplied from a single foam concentrate source (Figure 11). Where a bladder tank is used as the foam concentrate storage container and foam concentrate source, a manifold foam concentrate supply from the bladder tank to the individual risers is a cost effective method of installing many foam risers without duplicating the foam concentrate supply for each different riser. The foam concentrate bladder tank will be sized by the most demanding system. It is important to remember that the most demanding system will also mean taking in account that the duration requirement per system may differ as well.

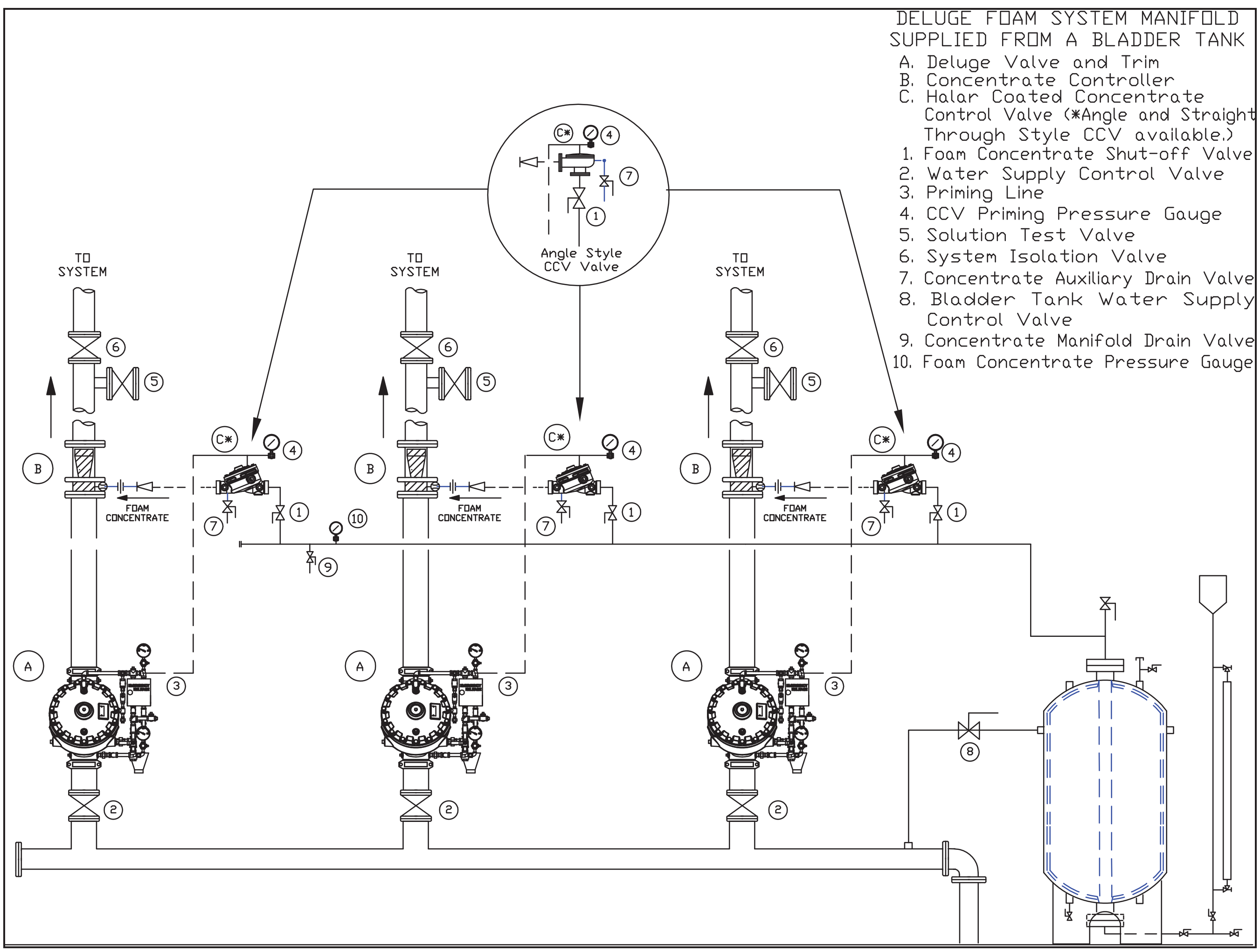

Figure 11: Deluge Foam System Manifold Supplied From a Bladder Tank

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Multiple deluge foam risers can be supplied by a single bladder tank when a concentrate manifold from the discharge head of the bladder tank is installed to each individual riser. The foam concentrate manifold will be sized for the most severe volume requirement and metered pressure drop requirement. At each riser location, a supply outlet will be provided from the concentrate manifold supply. The supply outlet will have a concentrate shut-off valve, a Halar® coated concentrate control valve, concentrate piping, a concentrate swing check valve, and a concentrate controller with integral metering orifice.

The individual deluge riser will have a water supply control valve, Viking deluge valve with deluge trim, riser piping, concentrate controller, solution test valve and system isolation valve.

A manifold supply from a bladder tank to multiple deluge risers allows for individual proportioning at each riser, allowing for different size risers. A manifold supply from a bladder tank to multiple deluge risers also allows for individual system repair without completely losing foam protection for other areas.

A Viking Foam Deluge System Supplied by a Foam Pump is a standard deluge system capable of discharging foam-water solution automatically through any discharge device supplied from the deluge system piping (Figure 12).

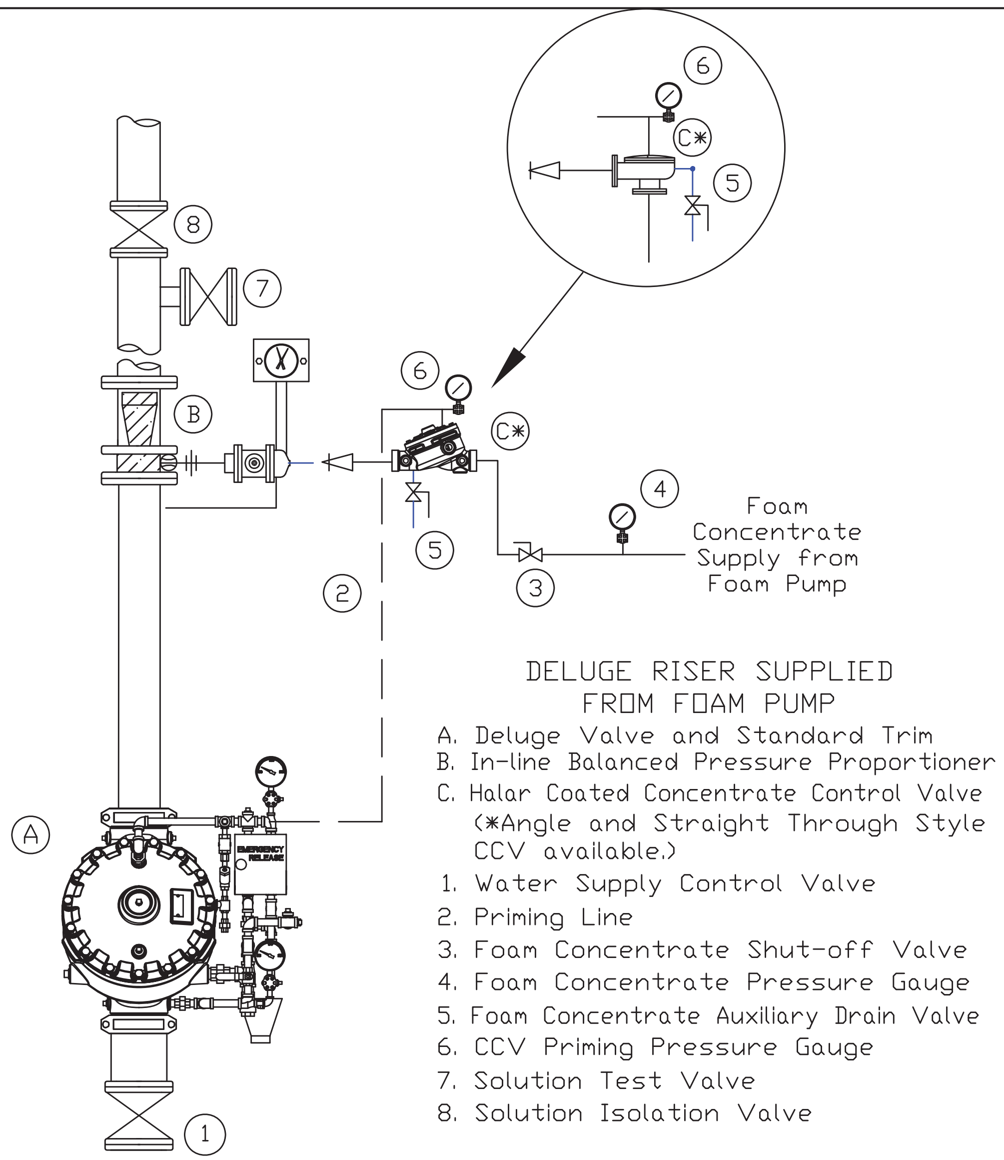

Figure 12: Deluge Riser Supplied From Foam Pump

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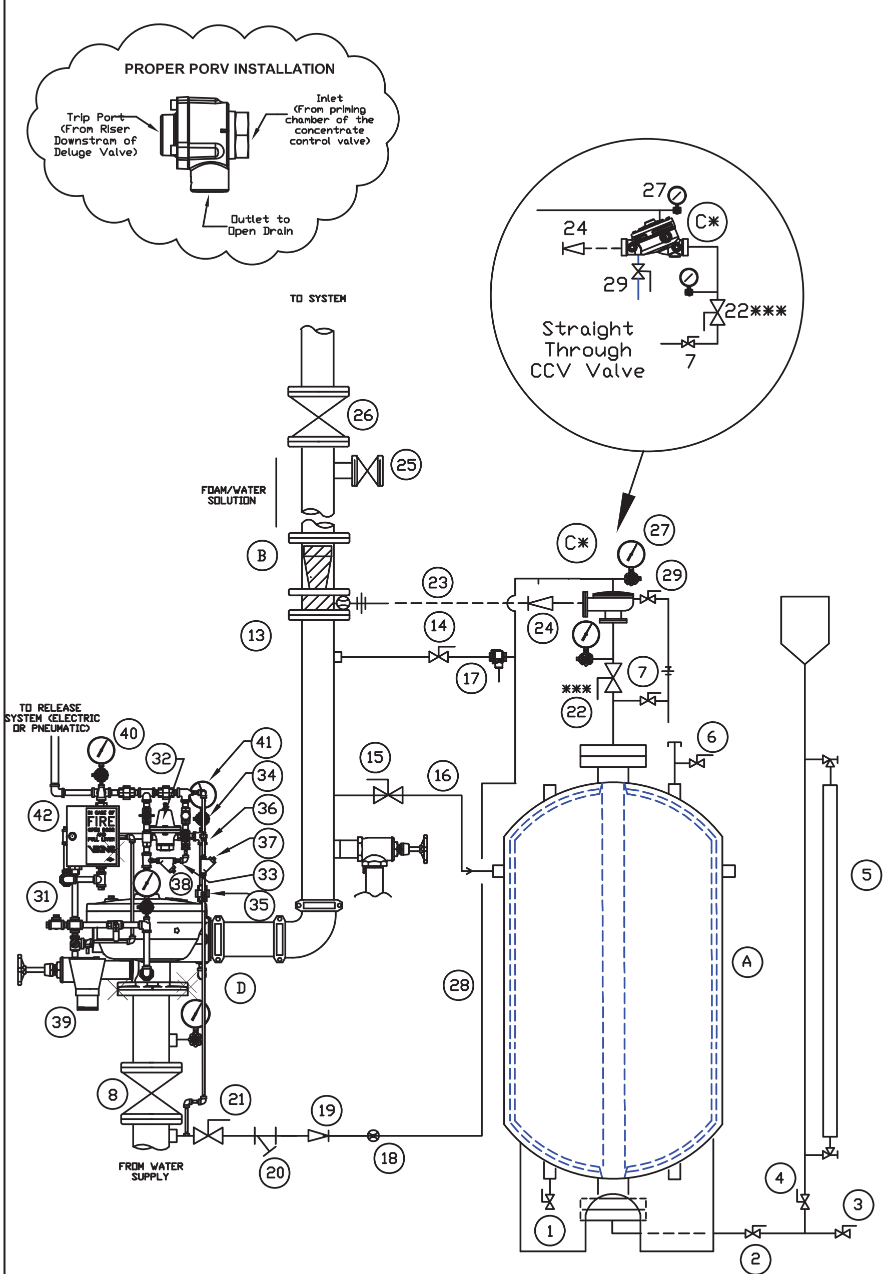
A deluge foam-water system with a hydraulically actuated Halar® coated concentrate control valve consists of a Viking deluge valve complete with standard deluge trim, detection and releasing devices on the water supply line, an In-line Balanced Proportioner Assembly (proportioning device), which includes a concentrate controller, listed orifice plate, spool balancing valve and swing check valve, hydraulically actuated Halar® coated concentrate control valve on foam concentrate line, a foam concentrate atmospheric tank and trim and foam concentrate agent.



FOAM/WATER DELUGE SYSTEM
PILOT PRESSURE REGULATING

A. Foam Concentrate Bladder Tank complete with Items 1-7
1. Water Drain/Fill Valve - NORMALLY CLOSED
2. Fill Line Master Shut-off Valve - NORMALLY CLOSED
3. Concentrate Drain/Fill Valve - NORMALLY CLOSED
4. Fill Cup/Sight Gauge Shut-off Valve- NORMALLY CLOSED
5. Sight Gauge Assembly - The trim for this assembly varies with the type of foam concentrates to be used. Refer to Tank Manufacturer's O & M Manual for specific details.
6. Tank Water Vent Valve - NORMALLY CLOSED
7. Diaphragm Concentrate Vent Valve- NORMALLY CLOSED

B. Concentrate Controller with Metering Orifice
23. Check Valve

C. Concentrate Control Valve (CCV) - Hydraulically actuated Halar Coated Viking Deluge Valve (*Angle and Straight Through CCV available.)
17. P.O.R.V.
18. Restricted Orifice .125"
19. 1/2" Spring Loaded Check Valve
20. 1/2" Strainer
21. 1/2" Ball Valve - NORMALLY OPEN
27. Water Pressure Gauge and 3-way valve and remainder of CCV special trim
28. 1/2" Priming Line
29. 1/2" foam concentrate auxiliary drain valve

D. Pilot Pressure Regulating Deluge Valve
31. Viking Model H Flow Control Valve
32. Viking Model C-2 Pilot Pressure Regulating Vavle
33. Viking Model A-2 Speed Control Assembly
34. Check Valve
35. Priming Valve
36. Restricted Orifice
37. Strainer
38. Water Supply Pressure Gauge
39. Drain Valve
40. Air Bleed Valve and Pressure Gauge
41. Downstream Pressure Gauge
42. Emergency Release

E. Accessory Trim - (Order each item separately)
8. Water Supply Control Valve NORMALLY OPEN
13. CCV Release Piping to PORV
14. 1/2" P.O.R.V. Water Supply Ball Valve NORMALLY OPEN
15. Tank Water Supply Control Valve- NORMALLY OPEN
16. Water Supply Piping to Bladder Tank
22. Concentrate Control Shut-off Valve- NORMALLY OPEN ***
23. Foam Concentrate Discharge Piping
24. Foam Concentrate Swing Check Valve
25. Foam Solution Test Valve-NORMALLY CLOSED
26. System Isolation Valve-NORMALLY OPEN

*** Full Port Bronze Body with 316 Stainless Steel Trim and Ball (2" and under). Cast Iron Body OS&Y with Bronze Trim and seats (over 2")

Figure 13: Pilot Pressure Regulating Foam-Water Deluge System

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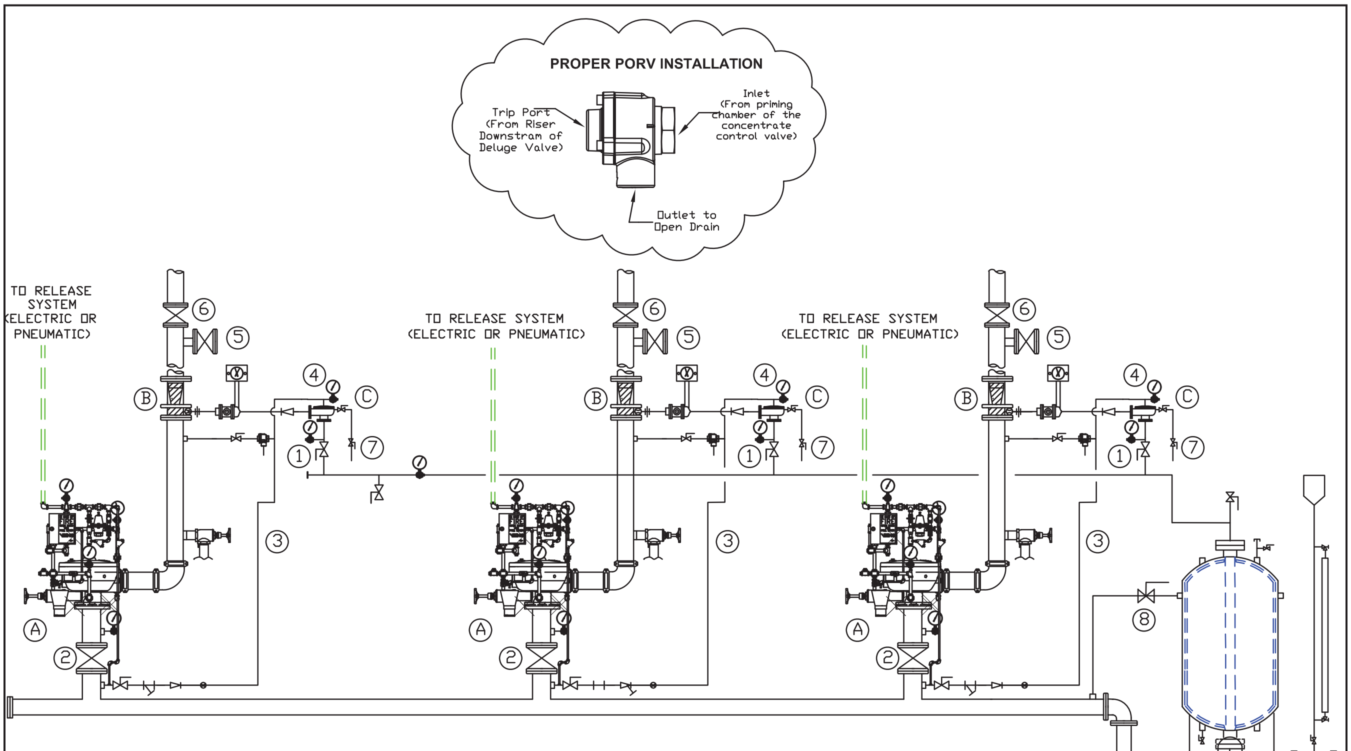
D. Pilot Pressure Regulated Deluge Foam-Water Systems

The Viking Pressure Regulating Deluge Foam Water Proportioning System (Figure 13) consists of a standard deluge sprinkler system, using a Viking flow control valve with pressure regulating deluge trim, a release module for the supplemental detection system, a concentrate controller, a hydraulically actuated Viking Halar® coated concentrate control valve, and foam concentrate.

This system was developed to provide constant discharge rates to eliminate over-discharge on deluge systems. It will provide constant pressure and water flow past the concentrate controller enabling the foam concentrate to be determined by the demand flow. The Viking pressure regulating foam-water deluge system combines the advantages of a conventional foam deluge system, but without the required supply hydraulic calculation to provide for the over-discharge past the concentrate controller, which would deplete the concentrate supply prior to the required time duration. Water supply pressure to the bladder tank must be provided from a down stream source, after the pilot pressure regulating deluge valve, preferably between the discharge outlet of the flow control valve and the concentrate controller. The listed pressure differential for the pressure regulating trim is 20 PSIG (1.38 bar). This means that the inlet pressure at the desired flow rate to the pressure regulating deluge system has to be 20 PSI higher than the desired pressure on the discharge side of the deluge valve.

To obtain the pressure differential between foam-water solution and supply water pressure, the pilot pressure regulating valve on the pressure regulating deluge trim must be adjusted to reduce the water pressure past the discharge side of the flow control valve. For best results the pilot pressure regulating



MULTIPLE PILOT PRESSURE REGULATING FOAM SYSTEMS SUPPLIED FROM BLADDER TANK

A. Flow Control Valve and Pressure Regulating Trim
B. In-line Balanced Pressure Proportioner
C. Halar® Coated Concentrate Control Valve
(*Angle Style or Straight Thru Style CCV available.)
1. Foam Concentrate Shut-off Valve
2. Water Supply Control Valve
3. Priming Line
4. CCV Priming Pressure Gauge
5. Solution Test Valve
6. System Isolation Valve
7. Concentrate Auxiliary Drain Valve
8. Bladder Tank Water Supply Control Valve
9. Concentrate Manifold Drain Valve
10. Foam Concentrate Pressure Gauge

Figure 14: Multiple Pilot Pressure Regulating Foam Systems Supplied From a Bladder Tank

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deluge valve should be set using the downstream pressure gauge of the pilot pressure regulating deluge valve and the water pressure gauge. For existing sprinkler systems which are restricted in flow and pressure capacity, this system should not be used without supplementing the available supply pressure.

With Viking Multiple Pilot Pressure Regulating Foam-Water Deluge Systems Supplied by a Bladder Tank, multiple pilot pressure regulating foam risers can be supplied from a single foam concentrate source (Figure 14). Where a bladder tank is used as the foam concentrate storage container and foam

concentrate source, a manifold foam concentrate supply from the bladder tank to the individual risers is a cost-effective method of installing many foam risers without duplicating the foam concentrate supply for each different riser. The foam concentrate bladder tank will be sized by the most demanding system. It is important to remember that the most demanding system will also require taking into account that the duration requirement per system may differ as well.

Multiple pilot pressure regulating foam risers can be supplied by a single bladder tank when a concentrate manifold from the discharge head of the bladder tank is installed to each individual riser. The foam concentrate manifold will be sized for the most severe volume requirement and metered pressure drop requirement. At each riser location, a supply outlet will be provided from the concentrate manifold supply. The supply outlet will have a concentrate shut-off valve, a Halar® coated concentrate control valve, concentrate piping, a concentrate swing check valve, and an in-line balanced pressure proportioner (ILBP).

The individual pilot pressure regulating riser will have a water supply control valve, Viking flow control valve with pressure regulating deluge trim, riser piping, solution test valve and system isolation valve.

A manifold supply from a bladder tank to multiple pilot pressure regulating risers allows for individual proportioning at each riser, allowing for different size risers. A manifold supply from a bladder tank to multiple pilot pressure regulating risers also allows for individual system repair without completely losing foam protection for other areas.

E. Grate Nozzle Systems

The Viking Grate Nozzle System with Pilot Pressure Regulation Supplied by Bladder Tanks (Figure 15) is a low-level fire suppression system that provides fire extinguishing capabilities equal to or better than existing systems with high-flow monitors, provides total floor area coverage including even flow distribution, minimal effect regarding obstructions, low-profile spray pattern at low pressure, and provide coverage up to 25 ft (7.6 m) radius. The nozzle has no moving parts and structurally supports loads due to aircraft or maintenance vehicles passing over nozzle assembly.

F. High-Expansion Foam Systems

A Viking High-Expansion Foam System (Figure 16) is a standard deluge system capable of discharging a foam-water solution automatically through open hi-ex generators. With a hydraulically actuated Halar® coated deluge concentrate control valve, this system consists of a standard deluge system using a deluge valve complete with full standard trim and detection and releasing devices on the water supply line, a concentrate controller-proportioning device with appropriately sized orifice, a hydraulically actuated Halar® coated deluge concentrate control valve on foam concentrate line, a foam concentrate bladder tank with trim, and foam agent.

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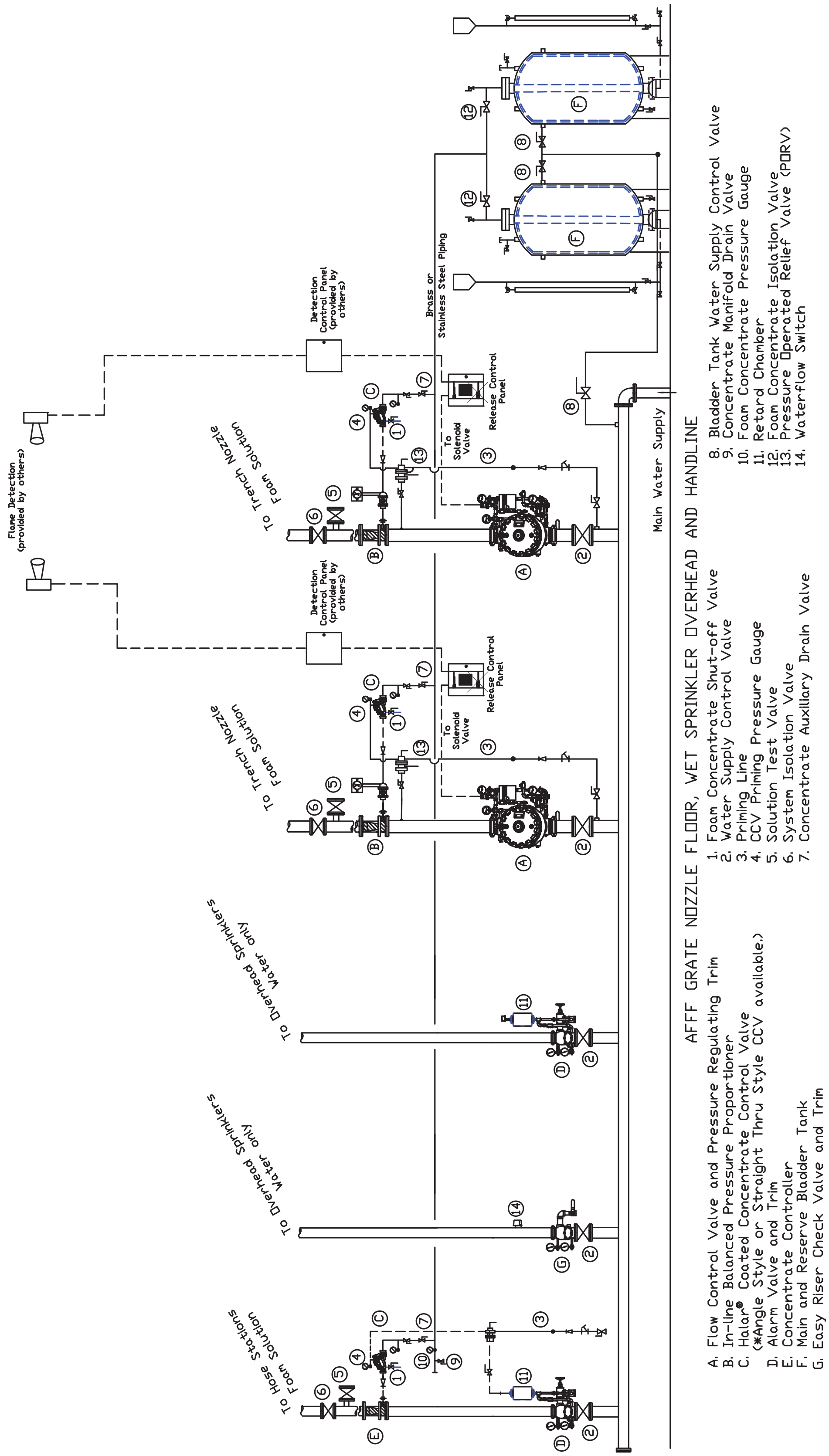

Figure 15: Grate Nozzle System with Pilot pressure Regulation Supplied by Bladder Tanks

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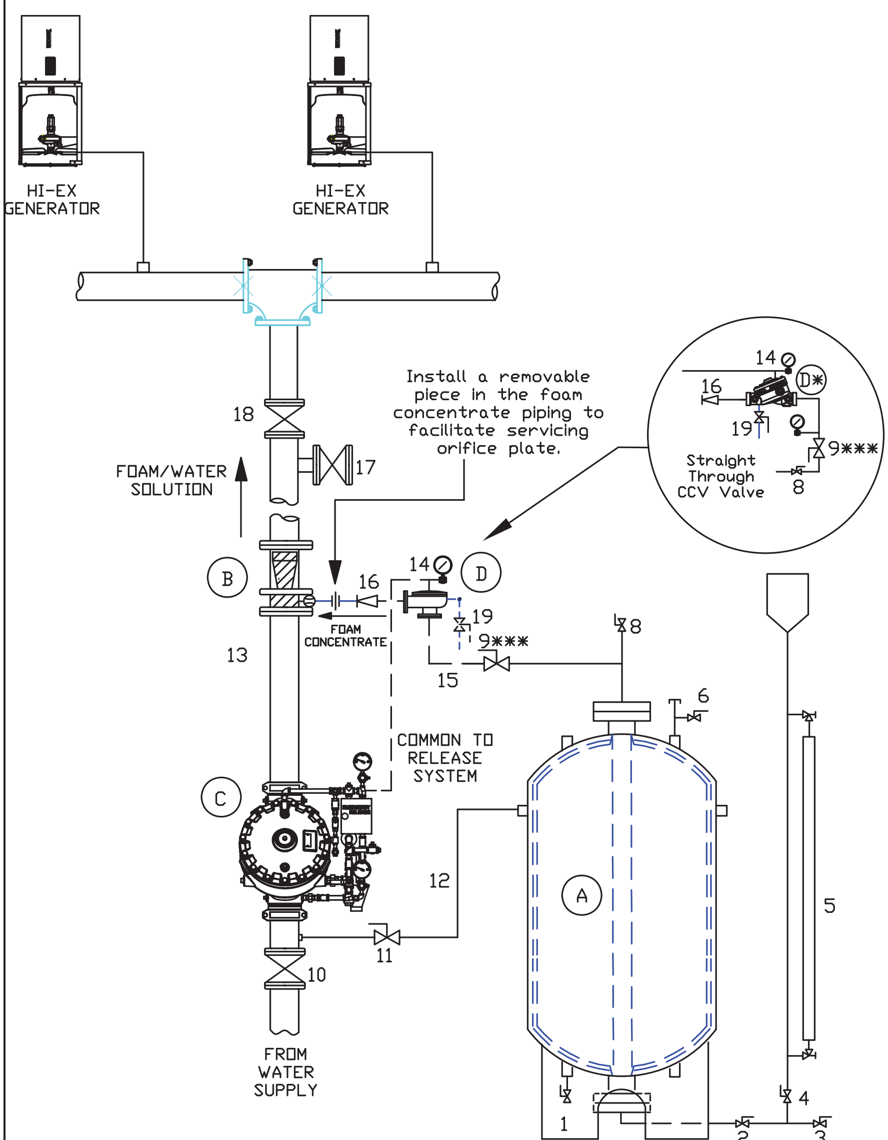

A. Foam Concentrate Bladder Tank complete with Items 1-8
1. Water Drain/Fill Valve - NORMALLY CLOSED
2. Fill Line Master Shut-off Valve - NORMALLY CLOSED
3. Concentrate Drain/Fill Valve - NORMALLY CLOSED
4. Fill Cup Sight Gauge Shut-off Valve - NORMALLY CLOSED
5. Sight Gauge Assembly-The trim for this assembly varies with the type of foam concentrate to be used. Refer to Tank Manufacturer's O&M Manual for specific details.
6. Tank Water Vent Valve - NORMALLY CLOSED
7. Hydrostatic Relief Valve
8. Diaphragm Concentrate Vent Valve - NORMALLY CLOSED

B. Proportioning Device-Concentrate Controller with Integral Orifice

C. Type of System - Deluge Valve with Standard Trim and gauges connected to an appropriate release and detection system
10. Water Supply Control Valve - NORMALLY OPEN

D. Foam Concentrate Control Valve CCV-Hydraulically actuated Halar® coated Viking Deluge Valve (Angle or Straight Through Style Available)
14. Water Pressure Gauge and 3 way valve and remainder of CCV special trim
19. 1/2" Foam Concentrate Auxillary Drain Valve

E. Accessory Trim - (Order each item separately)
9. Concentrate Control Shut-off Valve - NORMALLY OPEN ***
11. Tank Water Supply Control Valve - NORMALLY OPEN
12. Water Supply Piping to Bladder Tank
13. Release Line/Priming Line Piping to foam CCV (D)
15. Foam Concentrate Discharge Piping
16. Foam Concentrate Swing Check Valve
17. Foam Solution Test Valve - NORMALLY CLOSED
18. System Isolation Valve - NORMALLY OPEN

*** Full Port Bronze Body with 316 Stainless Steel Trim and Ball (2" and under) for AFFF & ARC. Cast Iron Body OS & Y with bronze Trim and Seats (over 2") for AFFF only.

Figure 16: High Expansion Foam System

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III. FOAM/WATER DISCHARGE DEVICES

The devices specifically designed to discharge water or foam-water solution in a predetermined, fixed, or adjustable pattern. Examples include sprinklers, spray nozzles, and hose nozzles, and other devices. Methods of generating air foam include hose stream, foam nozzle, and medium- and high-expansion generators, foam makers, pressure foam makers, or foam monitor stream.

A. Foam Makers

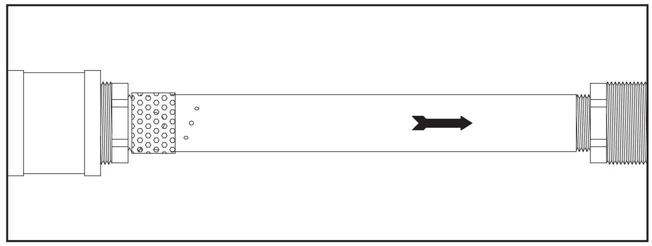

Figure 17: Foam Maker

Chemguard and Viking foam makers (Figure 17) are designed as air-aspirating discharge devices used principally for the protection of open floating roof storage tanks and dike protection systems. These devices are used in various types of proportioning systems such as bladder tanks, balanced pressure pump proportioning systems or line proportioners. The foam maker is normally installed in the line of a semi-fixed or fixed foam fire protection system. Foam makers incorporate an orifice, air inlet and mixing barrel. The body and orifice are corrosion resistant brass. The air inlet screen is corrosion resistant stainless steel.

An orifice is provided at the inlet to the foam maker and designed to provide the required flow rate of foam solution at a specified inlet pressure. The air inlet provides uniform distribution of air into the foam solution stream to generate expanded foam. The air inlet screen conforms to the body of the foam maker and prevents damage by the entrance of foreign material.

B. Standard Spray Sprinklers

Foam/water sprinklers generate air aspirated foam by drawing air into the foam solution stream. The sprinkler distributes a nearly uniform pattern of water or expanded foam over a given area. The solution strikes the deflector and is broken into a circular pattern of distribution. Occupancy classification of the area is used to determine maximum sprinkler spacing.

This spacing results in overlapping patterns for uniform coverage and effective control. In addition, hydraulic calculations are performed to determine an adequate water supply and uniform distribution from the sprinklers. Refer to data page 130a-d for listed and approved Viking sprinklers for use with foam concentrates, along with density and minimum pressure requirements when protecting various fuels.

C. Directional Foam Spray Nozzles

Directional foam spray nozzles are different from open foam-water sprinklers with regards to the discharge patterns. They deliver a special directional pattern specific to the design of the particular nozzle.

D. Discharge Outlets

Fixed Foam Discharge Outlet: A device permanently attached to a tank, dike, or other containment structure, designed to introduce foam. Chemguard Model FC 2.5, 3.0, 4.0 & 6.0 Foam Chambers consist of a foam expansion chamber and an integral foam maker. The foam chamber is installed on a flammable liquid storage tank just below the roof joint. The foam solution is piped to the chamber from outside the hazard area. Upon entering the chamber, the foam solution is expanded and then discharged against a deflector inside the storage tank. The deflector directs the foam against the inside wall of the storage tank. This reduces the submergence of the foam and agitation of the fuel surface (NFPA Type II Application).

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Foam chambers are compatible with all types of foam concentrate; protein, fluoroprotein, AFFF, and AR-AFFF.

Type I Discharge Outlet: An approved discharge outlet that conducts and delivers foam gently onto the liquid surface without submergence of the foam or agitation of the surface.

Type II Discharge Outlet: An approved discharge outlet that doesn't deliver foam gently onto the liquid surface; it is designed to lessen submergence of the foam and agitation of the surface. Viking foam chambers (Figure 18) are an example of a Type II Discharge Outlet.

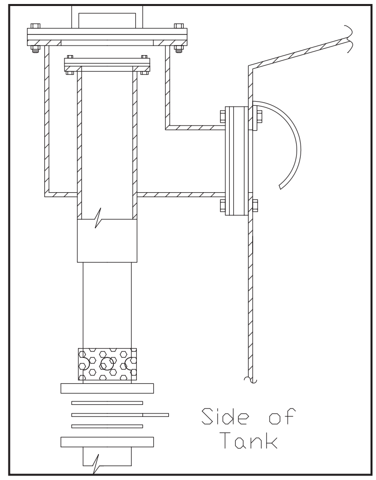

Figure 18: Foam Chamber

E. Eductors

Fixed eductors present a simple method of proportioning foam concentrate and water at the proper percentage. Fixed eductors are constant flow devices that produce accurate proportioning of foam concentrate at a specified flow and pressure. See Figure 19. Fixed eductors are typically used in fixed systems where simple and cost effective foam proportioning is required. Other than flowing water, no external power supplies are required to operate fixed eductors.

Figure 19: Fixed Eductor

F. Monitors

Viking has several types of monitors available. The basic monitors have 360° rotation and are suitable for use with water and all types of foam solutions, and may be used for marine, offshore, industrial or other corrosive environments. The water powered oscillating monitors (Figure 20) are designed to automatically discharge over a specific design area upon system activation. These are suitable for use in high risk areas such as tank farm facilities, aircraft hangars, offshore, refineries, chemical plants, and heliports.

The Viking Brahma can be used as a single waterway monitor when not installed on the oscillating mechanism.

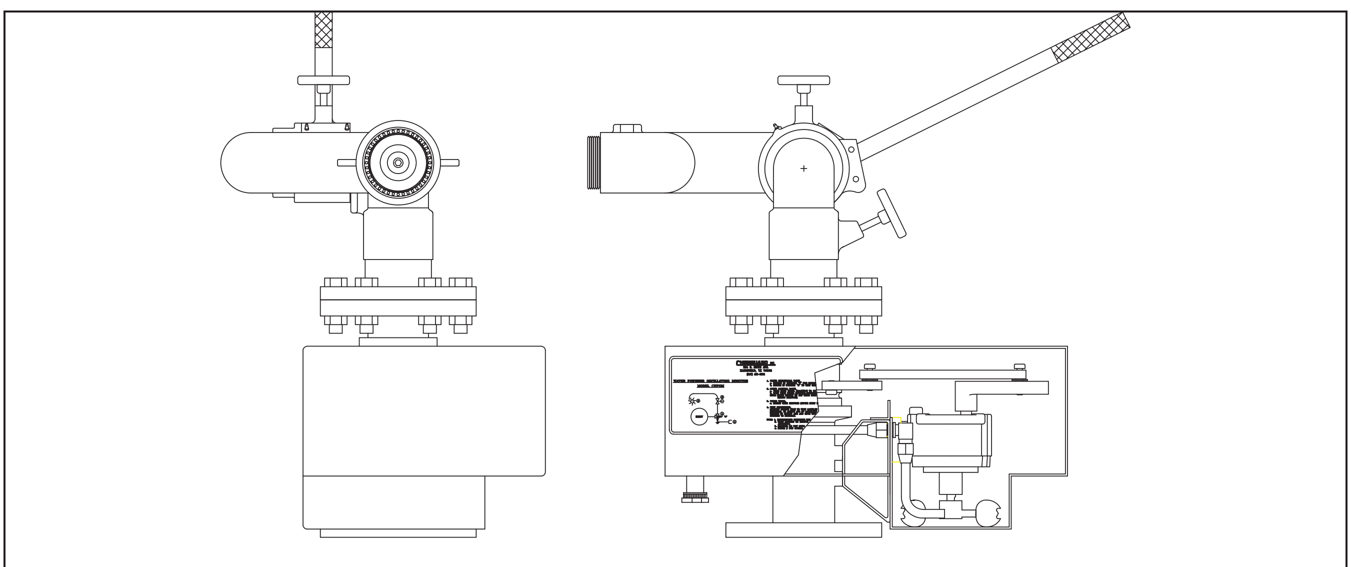

Figure 20: Oscillating Monitor

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The Viking "Rattler" is a hand wheel monitor with a full 3" (76 mm) single waterway that allows flow up to 1,250 gpm (4,732 lpm) with low friction loss. It features full 360 degree rotation and is easily adjustable in horizontal plane then locked in position by a locking mechanism, for manual and fixed operation. Vertical travel is controlled by adjustable hand wheel.

Viking Brahma Monitors and Rattler Hand Wheel Monitors are suitable for use with water and all types of foam solutions, and may be used for marine, offshore, industrial or other corrosive environments.

G. Hose Reels

Viking's foam hose reel station (Figure 21) is a self- contained unit that relies only on water flow and pressure to place the system into operation. It is designed to be installed in a fixed location such as Helidecks, offshore processing, storage or handling areas where it is used to control fires or spills of flammable or combustible liquids.

The continuous flow hose reel (Figure 22) is equipped with booster hose and hand line nozzle. It allows instant, single-person operation; only unreel the amount of hose required and manually rewind.

Figure 21: Hose Reel Station

Figure 22: Continuous Flow Hose Reel

H. Handlines and Other Portable Dispensing Devices

The Chemguard Mobile Foam Cart (Figure 23) is a very effective fire-fighting unit for flammable liquid fires due to its ease of handling and mobility. A length of 1½" fire hose from a suitable water supply source is connected to the in-line eductor inlet. Note: The in-line eductor design point is 95 gpm at 200 psi. Any reduction in pressure at the in-line eductor inlet will create a corresponding decrease in flow. The tank is manufactured of reinforced fiberglass, which makes the unit suitable for use with all types of foam concentrates and environments. It is designed to hold 36 gallons of fire fighting foam concentrate and contains a 95-gpm in-line eductor, a 95-gpm handline nozzle and 50 feet of 1½" rubber lined single jacket fire hose.

The Viking handline eductor features a variable removable metering valve, a large, easy to read metering dial; ball check valve prevents back flow into foam concentrate. The handline eductor must be used with a nozzle of equivalent flow rate. Normal inlet operating pressure at eductor is 200 psi; however, the eductor can be used at lower inlet pressures with a corresponding reduction in flow rates. Maximum hose lay between eductor and nozzle on level ground using 1½" (3.8 cm) hose is 150 ft. (46 m). Maximum hose lay between eductor and nozzle on level ground using 2" (5 cm) hose is 300 ft. (91 m).

Figure 23: Mobile Foam Cart

I. Grate Nozzles

Viking 90° and 180° grate nozzles (Figure 24) are discharge devices specifically designed for the protection of helicoptor helipads, however they can also be used for aircraft hangars. Grate nozzles are AFFF foam discharge devices located at the floor level of an aircraft hangar, in trench drains, so they do not take any floor space. They are designed to provide uniform discharge foam solution in a 90° (GN200/090), and 180° (GN200/180) radius, respectively. The companion Model 1120 and Model 1126 trench drain grate is specially engineered to receive the grate nozzle and serve as a cover for the drain trench.

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Grate nozzles are used to spread AFFF foam solution over the burning liquid faster than conventional overhead deluge foam systems or oscillating monitors. This is because they are located where the flammable liquid spill will happen, at the floor of an aircraft hangar.

Viking 360° grate nozzles (Figure 25) is designed to discharge foam solution in a 360° (GN200/360) pattern or to direct in a single direction. The 360° grate nozzle is designed to provide uniform discharge over a maximum area of 1250 sq. ft. (116 sq. meters) and allows for less discharge nozzles in trench drain grate than other 180° discharge devices.

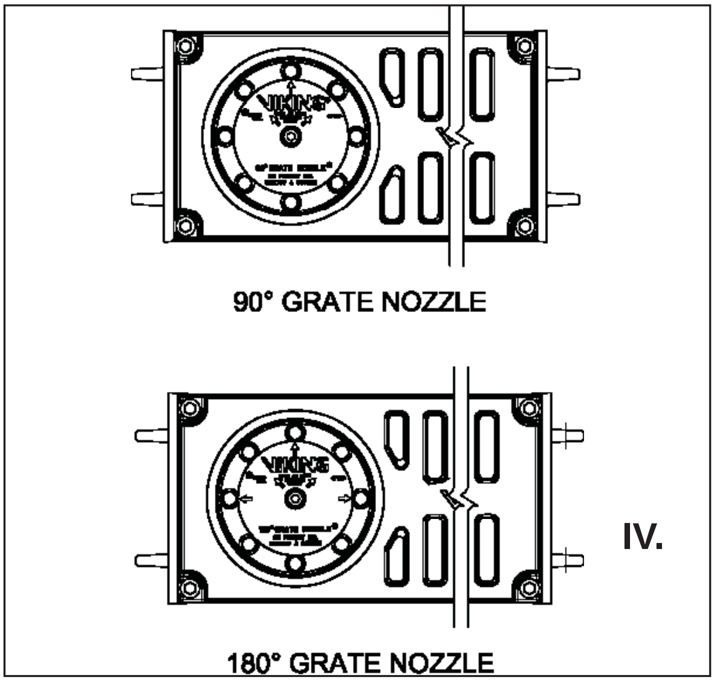

Figure 24: 90° and 180° Grate Nozzles

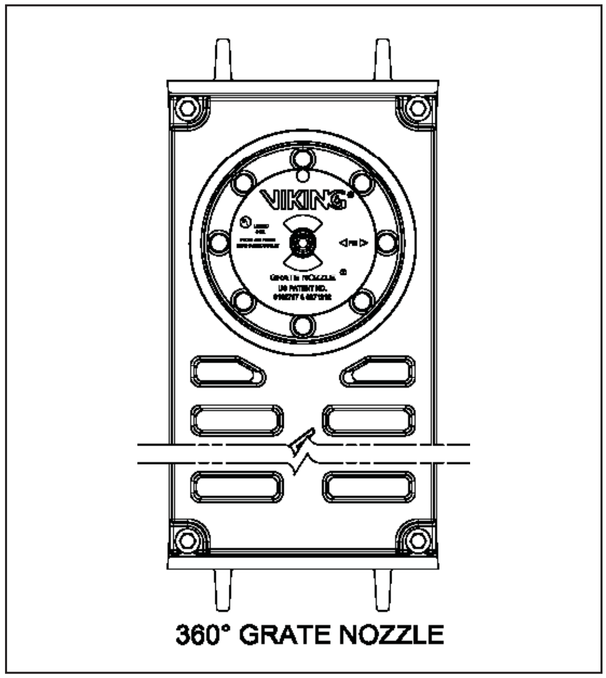

Figure 25: 360° Grate Nozzle

Viking Grate Nozzles are only to be installed with the companion Viking trench drain grate. Refer to Figure 26. Installation of Grate Nozzles or trench drain grates require that adequate trench drain sizing has been accounted for. The Grate Nozzle is provided with a 2” grooved inlet for ease of installation and removal.

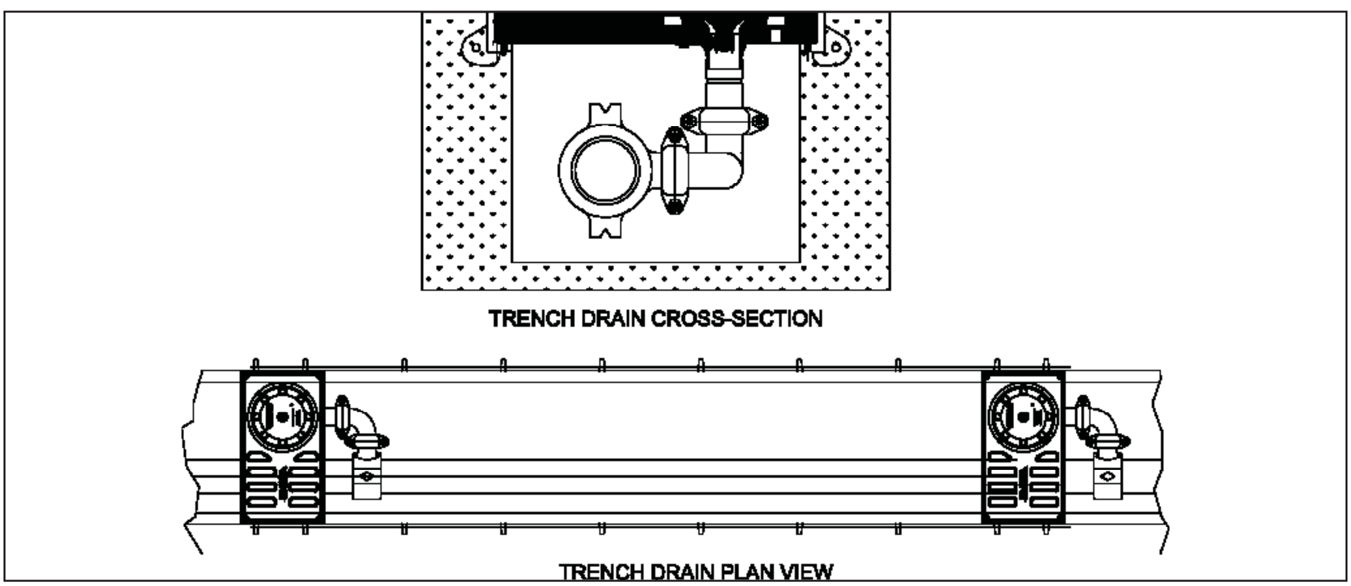

Figure 26: Trench Drains

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Supply piping must be located in the trench; a 2” supply pipe should be piped horizontally from the supply main located in the trench, and then vertically to the Grate Nozzle.

Standard practice is to locate the Grate Nozzles so that the maximum distance between nozzles in a trench is 25’ and so that trench drains are not located in excess of 50’ on center, (25’ maximum from walls). Configurations other than this may be acceptable, contact Viking for designs other than what is indicated. A typical hangar layout with grate nozzles is shown in Figure 27.

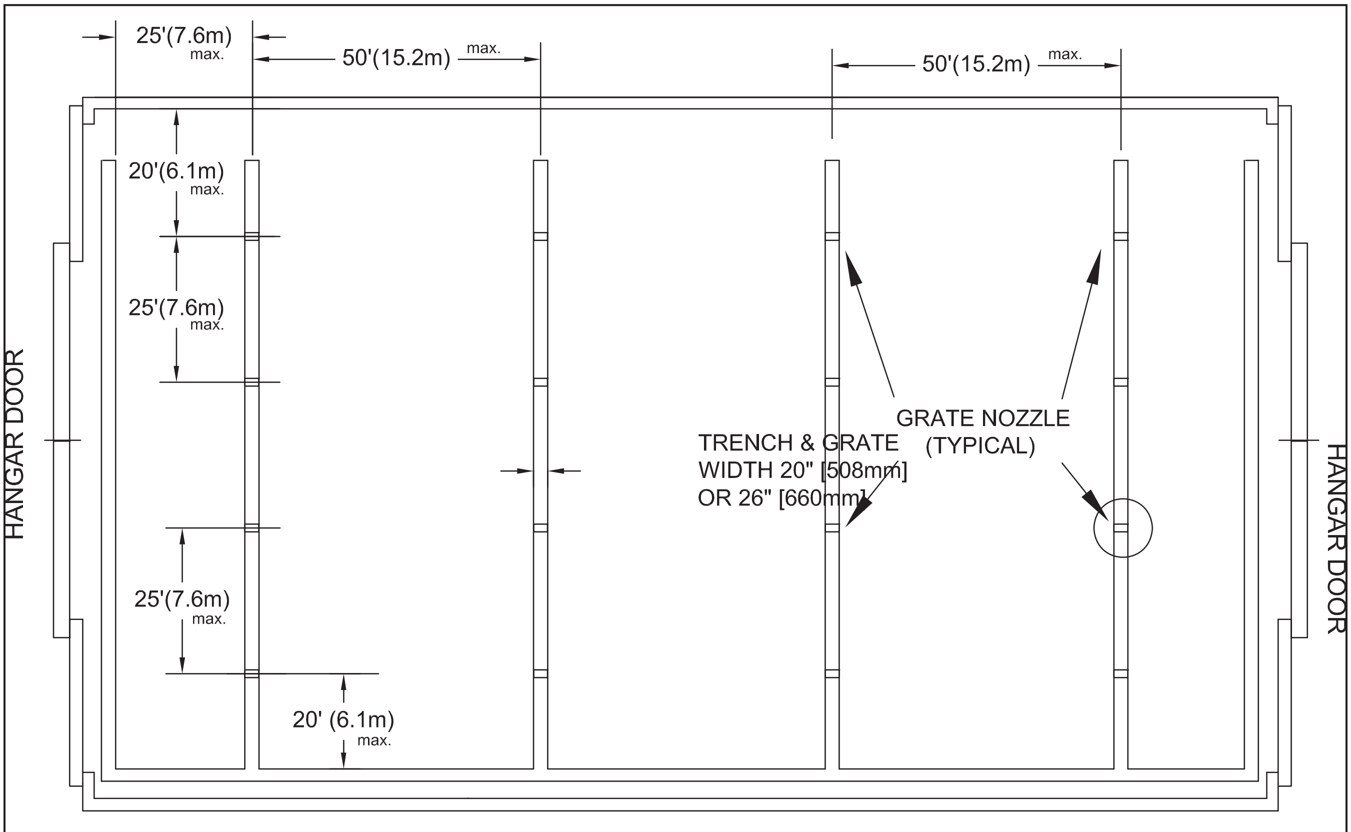

Figure 27: Typical Aircraft Hangar Layout with Grate Nozzles

FOAM CONCENTRATES

Foam is defined as a stable mass of small air-filled bubbles that have a lower in density than oil, gasoline, or water. When mixed in the correct proportions, this mixture of water, foam concentrate, and air form a homogeneous foam blanket with a tenacity for covering horizontal surfaces.

Foam Solution is a solution of water and foam concentrate after they have been mixed together in the correct proortions.

Foam Concentrate is liquid concentrate supplied from the manufacturer; when mixed with water in the correct proportion, forms a foam solution.

Finished Foam is foam solution as it exits a discharge device, having been aerated.

Expansion Rate is the volume of finished foam divided by the volume of foam solution used to create the finished foam; i.e., a ratio of 5 to 1 would mean that one gallon of foam solution after aeration would fill an empty 5-gallon container with the expanded foam mass.

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A. Types of Foam Concentrates

Aqueous Film-Forming Foam Concentrate (AFFF): AFFF foams extinguish hydrocarbon flammable liquid fires. An aqueous film is formed on the surface of the flammable liquid by the AFFF foam solution as it drains from the foam blanket. This film is very fluid and floats on the surface of most hydrocarbon fuels. This speeds fire control and knockdown when used on a typical hydrocarbon spill fire. In certain circumstances, it is possible to notice the fire being extinguished by the “invisible” film before there is complete foam blanket coverage over the surface of the fuel.

Alcohol-Resistant Aqueous Film Forming Foam Concentrate (AR-AFFF): AR-AFFF is available in 3%-6% or 3%-3% type concentrate. Fires in flammable liquids that readily mix with water are more difficult to extinguish than hydrocarbon fires. Polar solvent/alcohol liquids destroy any foam blanket that has been generated using standard AFFF or fluoroprotein type concentrates. Water in the generated foam blanket mixes with alcohol, causing the foam blanket to collapse and disappear until the fuel surface is completely exposed again. AR-AFFF type concentrates were developed to overcome this problem. Using plain AFFF concentrate as a base material, a high molecular weight polymer is added during the manufacturing process. When AR-AFFF is used on a polar solvent fuel fire, the polar solvent fuel tries to absorb water from the foam blanket. A polymer precipitates out, forming a physical membrane/barrier between the fuel surface and foam blanket. This barrier now protects the generated foam blanket from destruction by the alcohol fuel.

Synthetic/Detergent (High-Expansion) Foam Concentrate: Normally used at a concentrate rate between 1.5% to 2.5%. this type of foam concentrate is manufactured from a combination of hydrocarbon surfactants and solvents. High-expansion foam solution is normally used through devices that give high expansion ratios such as the high-expansion foam generators.

B. Foam Agent Limitations

1. Foams are typically not suitable for extinguishing fires involving gases, liquefied gases (having boiling points below ambient temperatures such as butane, butadiene, propane, etc), or cryogenic liquids. There are a few exceptions where high expansion foams may be considered.
2. Three-dimensional flowing liquid fires such as overhead tank leakage or pressure leaks, are not easily extinguishable with foams.
3. Foams are not to be used with fires involving materials that react violently with water, such as metallic sodium and metallic potassium.
4. Foam conducts electricity and cannot be used on Class C energized electrical fires.
5. Judgement must be used in applying foams to hot oils, burning asphalts, or burning liquids that are above the boiling point of water. This is due to the water contacting the very hot fuel, immediately turns to steam.
6. Foams, except for the alcohol-resistant concentrate type, are not suitable for water soluble or polar-solvent liquids.

C. Selecting the Correct Foam Concentrate

Selecting the correct foam concentrate requires a hazard analysis to identify the type of combustibles, the quantity of combustibles, and the configuration of combustibles. Generally, foam concentrates are used for Class B fires where flammable or combustible liquids are transported, stored, processed, or used. Due to their water content, foam concentrates can also be used for protecting Class A fuels such as paper, wood, cloth, and some plastics. Usually one or two foam concentrate types may be considered for protecting a specific hazard, however the foam concentrate(s) are required to be listed for use on the specific flammable or combustible liquid to be protected.

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D. Hydrocarbons and Polar Solvents

These fuels are the two basic classifications of flammable or combustible liquids. Hydrocarbon liquids are NOT water soluble and consist of petroleum products such as heptane, kerosene, diesel, gasoline, fuel oil, jet fuel, and crude oil. Polar solvent liquids such as alcohol, ketone, ether, aldehyde, and ester, are water miscible (mix readily with water). Protein foams, fluoroprotein foams, and AFFF foam are all suitable for hydrocarbon liquid protection. Because the foam types mentioned above break down or are destroyed rapidly when used or exposed to polar solvent type liquids, an alcohol resistant foam must be used for polar solvents.

E. Flammable and Combustible Liquids

Flammable liquids are defined by NFPA 11 as any liquid having a flash point below 100 °F (38 °C) and having a vapor pressure not exceeding 40 PSI (276 bar) (absolute) at 100 °F (38 °C). Flammable liquids shall be subdivided as follows:

CLASS I LIQUIDS: Includes those having a flash point below 100 °F (38 °C) and may be subdivided as follows:

Class IA: Includes those having a flash point below 73 °F (23 °C) and a boiling point below 100 °F (38 °C).

TABLE 1a

Example Class IA	Flash Point	Boiling Point	Water Soluble
Acetic Aldehyde	-38 °F (-39 °C)	70 °F (21 °C)	Yes
Dimethyl Sulfide	0 °F (-18 °C)	99 °F (37 °C)	Slight
Furan	32 °F (0 °C)	88 °F (31 °C)	No

Class IB: Includes those having a flash point below 73 °F (23 °C) and a boiling point above 100 °F (38 °C).

TABLE 1b

Example Class IB	Flash Point	Boiling Point	Water Soluble
Ethyl Alcohol	55 °F (13 °C)	173 °F (78 °C)	Yes
Gasoline-92 Octane	-36 °F (-38 °C)	100-400 °F (38-204 °C)	No
Cyclohexane	-4 °F (-20 °C)	179 °F (82 °C)	No

Class IC: Includes those having a flash point at or above 73 °F (23 °C) and below 100 °F (38 °C).

COMBUSTIBLE LIQUIDS: Defined by NFPA 11 as any liquid having a flash point at or above 100 °F (38 °C) and may be subdivided as follows:

Class II Liquids: Includes those having flash points at or above 100 °F (38 °C) and below 140 °F (60 °C).

TABLE 1c

Example Class II	Flash Point	Boiling Point	Water Soluble
Diesel Fuel Oil (No. 1-D/2-D/4-D)	100-130 °F (38-54 °C)	173 °F (78 °C)	No
Glacial Acetic Acid	103 °F (39 °C)	100-400 °F (38-204 °C)	Yes
Jet Fuel (A & A-1)	110 °F (43 °C)	179 °F (82 °C)	No

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Class IIIA Liquids: Includes those having flash points at or above 140 °F (60 °C) and below 200 °F (93 °C).

TABLE 1d		
Example Class IIIA	**Flash Point**	**Water Soluble**
Creosote Oil	165 °F (74 °C)	No
Butyl Carbitol	172 °F (78 °C)	Yes
Fuel Oil No. 4	142-240 °F (61-116 °C)	No

Class IIIB Liquids: Includes those having flash points at or above 200 °F (93 °C).

TABLE 1e		
Example Class IIIB	**Flash Point**	**Water Soluble**
Fuel Oil No. 4	142-240 °F (61-116 °C)	No
Mineral Oil	380 °F (193 °C)	No
Olive Oil	437 °F (225 °C)	No

V. SYSTEM APPLICATIONS

This section covers foam system requirements for some common hazards. This section is sub-divided into the following:

A. Storage Tank Protection
B. Aircraft Hangar Protection
C. Truck Loading Rack Protection
D. Heliport Protection
E. Spill Fire Protection
F. High-Expansion Foam Systems

Sections A through D and F contain flow charts for the foam and hardware selection process. Section F has guidelines for applications where spill fire protection is required only or in combination with other systems. Detection and control systems are also required for many applications. For detection and control recommendations or for foam system applications not covered in this manual contact Viking Technical Services.

A. Storage Tank Protection

Protection Options: Special consideration should be given to large volume storage of flammable or combustible liquids when providing fire protection for the fuel and surrounding area. There are various tank styles and liquid types as well as a variety of foam fire protection systems.

The three basic types of protection for storage tanks are Subsurface Injection; Surface Application (cone roof, with or without internal floater, or floating roof); and Dike Protection (Figure (5B-1).

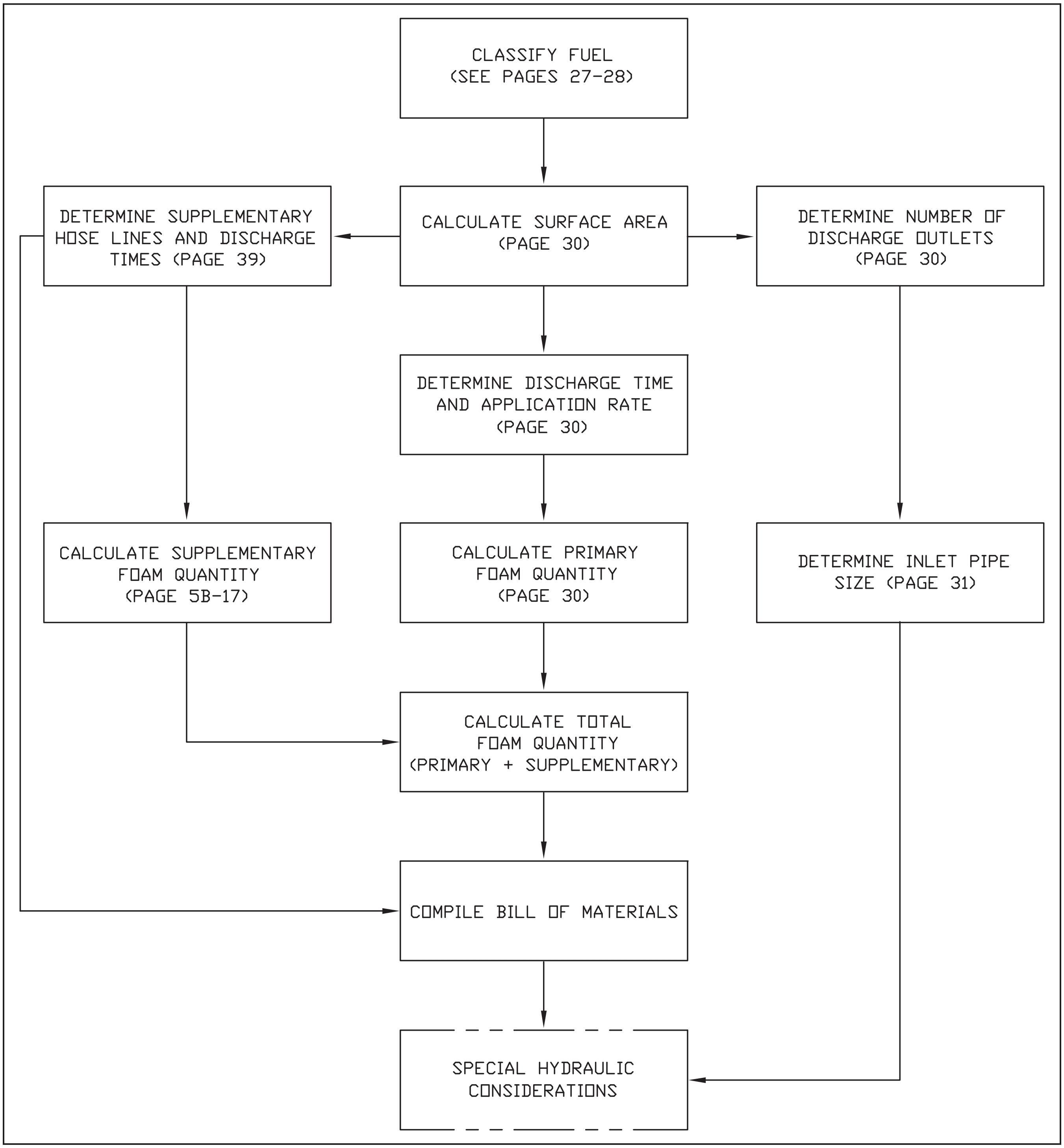
1. **Subsurface Injection:** This method can be used on hydrocarbon fuels stored in cone roof tanks. Subsurface injection is NOT acceptable for protecting floating roof tanks (open or covered), cone roof tanks with internal floaters, or any tank containing polar solvent liquid.

   A low expanded foam, having an expansion ratio between 2 and 4, must be injected at the base of the tank above the water layer. A high back-pressure foam maker is required in the foam supply line to assure proper flow and expansion. The foam can be injected into an existing product line or through a separate inlet dedicated to fire protection.

The expanded foam must be injected into the fuel contained in the tank, at least 1'-0" above the highest water level that may be present on the bottom. Injection into the water layer would destroy the finished foam.

NOTE: Be sure the system does NOT exceed the maximum foam inlet velocity.

Refer to the Subsurface Injection Flow Chart for the steps for designing subsurface injection systems:



Subsurface Injection Flow Chart

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Calculating Surface Area When Protecting a Single Storage Tank: Use the following formula:

SURFACE AREA = πr2

Calculating Surface Area When Protecting Multiple Storage Tanks: Calculate the surface area of the tank that is the most severe hazard. When all tanks contain the same fuel, the largest tank is the most severe hazard because it will require the most foam concentrate.

When tanks contain different fuels, determine the surface area, discharge time, and application rate for each tank and then use the tank that requires the most foam concentrate for primary protection.

Determining Discharge Time and Application Rate: Discharge time and application rate are determined according to the type of fuel in the storage tank (see Table 2 below.) NOTE: Protein foam concentrate is not acceptable due to fuel pickup of the expanded foam.

TABLE 2: DETERMINING DISCHARGE TIME & APPLICATION RATE SUBSURFACE INJECTION SYSTEMS

Fuel Protected	Foam Concentrate	Application Rate		
		gpm/ft²	(Lpm/m²)	Discharge Time
Hydrocarbon Flash point between 100 °F and 200 °F (38 °C and 93 °C)	AFFF	0.10	(4.1)	30 minutes
Hydrocarbon Flash point below 100 °F (38 °C) or liquid heated above flash point	AFFF	0.10	(4.1)	55 minutes
Crude Petroleum	AFFF	0.10	(4.1)	55 minutes

Calculating Primary Foam Quantity: First, use this formula to determine Foam Solution Discharge Rate which is required to determine proportioner size:

FOAM SOLUTION DISCHARGE RATE = SURFACE AREA X APPLICATION RATE

Then calculate the foam concentrate quantity using the following formula:

QUANTITY = FOAM SOLUTION DISCHARGE RATE X DISCHARGE TIME X CONCENTRATE %*

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

Determining Number of Discharge Outlets: The number of discharge outlets is based on tank diameter and flash point of fuel (Refer to Table 3 below).

TABLE 3: DETERMINING NUMBER OF DISCHARGE OUTLETS - SUBSURFACE INJECTION SYSTEMS

Tank Diameter		Number of Discharge Outlets Required	
feet	(m)	Flash Point Below 100 °F (38 °C)	Flash Point 100 °F (38 °C) or Higher
Up to 80	(24)	1	1
80 to 120	(24-36)	2	1
120 to 140	(36-42)	3	2
140 to 160	(42-48)	4	2
160 to 180	(48-54)	5	2
180 to 200	(54-60)	6	3
Over 200	(60)	One outlet for each additional 5000 sq. ft. (465 m²)	One outlet for each additional 7000 sq. ft. (697 m²)
NOTE: Information in this table is found in NFPA 11-2005 edition (Table 5.2.6.2.8).			

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Determining Inlet Pipe Size: NFPA 11 limits foam velocity at the point of discharge into the tank to a maximum of 10 ft. per second (3 m/sec) for Class IB liquids, or 20 ft. per second (6.1 m/sec) for other liquids, unless actual tests prove higher velocities are satisfactory.

The inlet pipe for subsurface injection must be sized adequately so that the expanded foam flow doesn't exceed the maximum inlet velocity. Adequate inlet size can be found by multiplying the flow rate needed for the tank by 4 (maximum expansion expected) to get the expanded foam rate, and then comparing this with Tables 4a-4c for the appropriate pipe size.

To use Table 4, find Foam Velocity at the left side of the tables. Read across the tables to intersection with Expanded Foam Rate. Choose the Inlet Pipe Size from the curve either at or below the intersection.

Note: Table is based on Standard Schedule 40 Pipe.

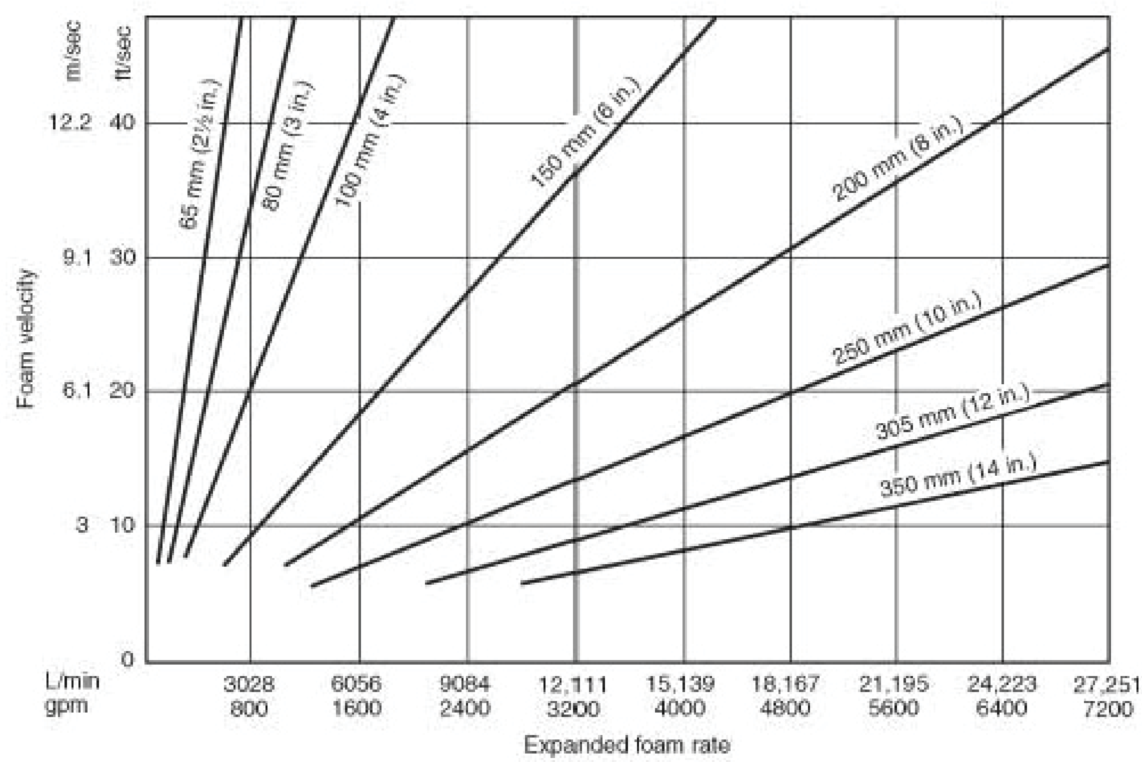

Table 4: Foam Velocity vs. Pipe Size (2-1/2" through 14")

(This table is found in NFPA 11-2005 edition [Figure A.5.2.6.2 (a)]

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Determining Static Head Pressure: Use Table 5 by finding Static Head (maximum height of liquid) at the left side. Read across the table to intersection with Specific Gravity curve for fuel in tank. The Static Head Pressure is the measurement at the bottom of the table directly below the intersection.

Note: Table is based on Standard Schedule 40 Pipe.

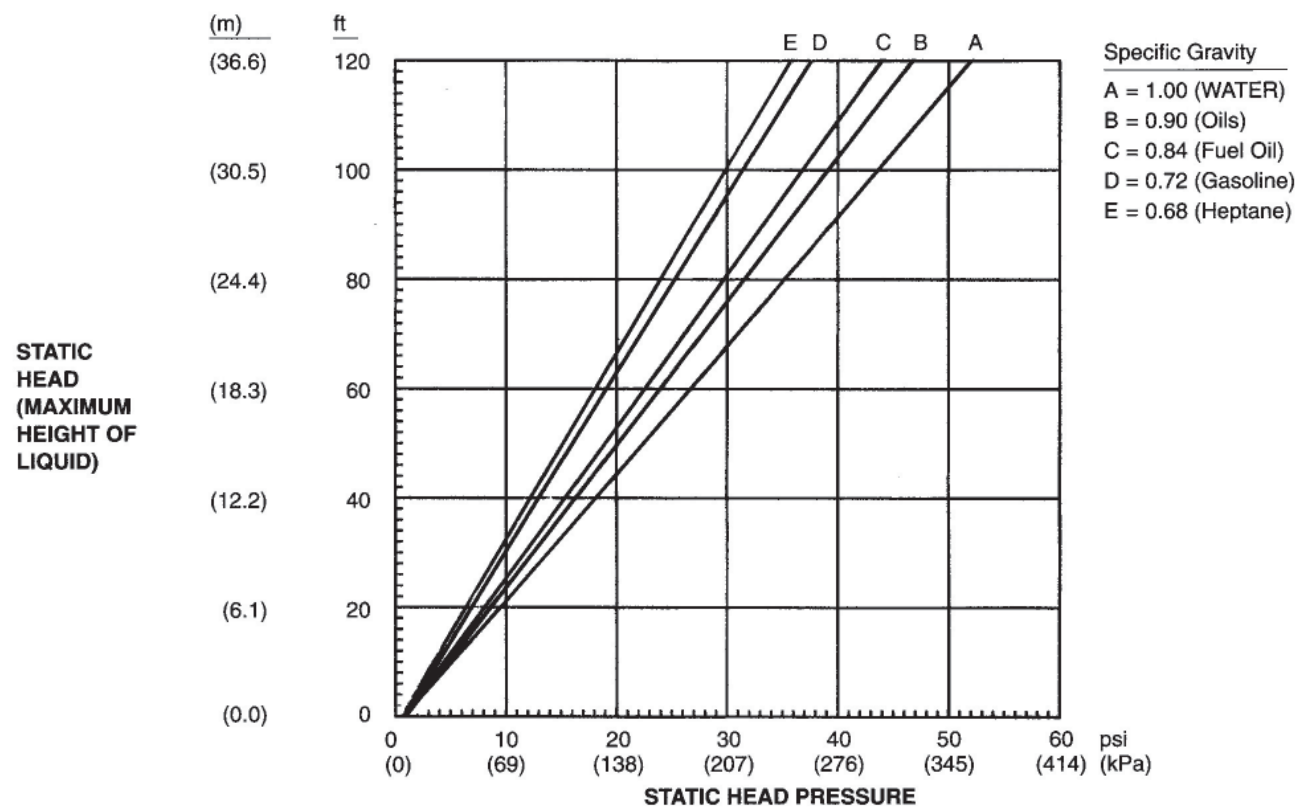

Table 5: Static Head Pressure

Determining Expanded Foam Friction Losses Vs. Pipe Size: To use Tables 6, first determine Maximum Allowable Friction Loss and Expanded Foam Rate using the following formulas:

MAXIMUM ALLOWABLE FRICTION LOSS	=	MAXIMUM ALLOWABLE BACK PRESSURE	-	STATIC HEAD PRESSURE
EXPANDED FOAM	=	FOAM SOLUTION DISCHARGE RATE	X	EXPANSION (4) RATIO

Next, find the Expanded Foam Rate at the bottom of the table. Read up the table until intersectioning with minimum pipe size that is under Maximum Allowable Friction Loss.

Note: Table is based on Standard Schedule 40 Pipe.

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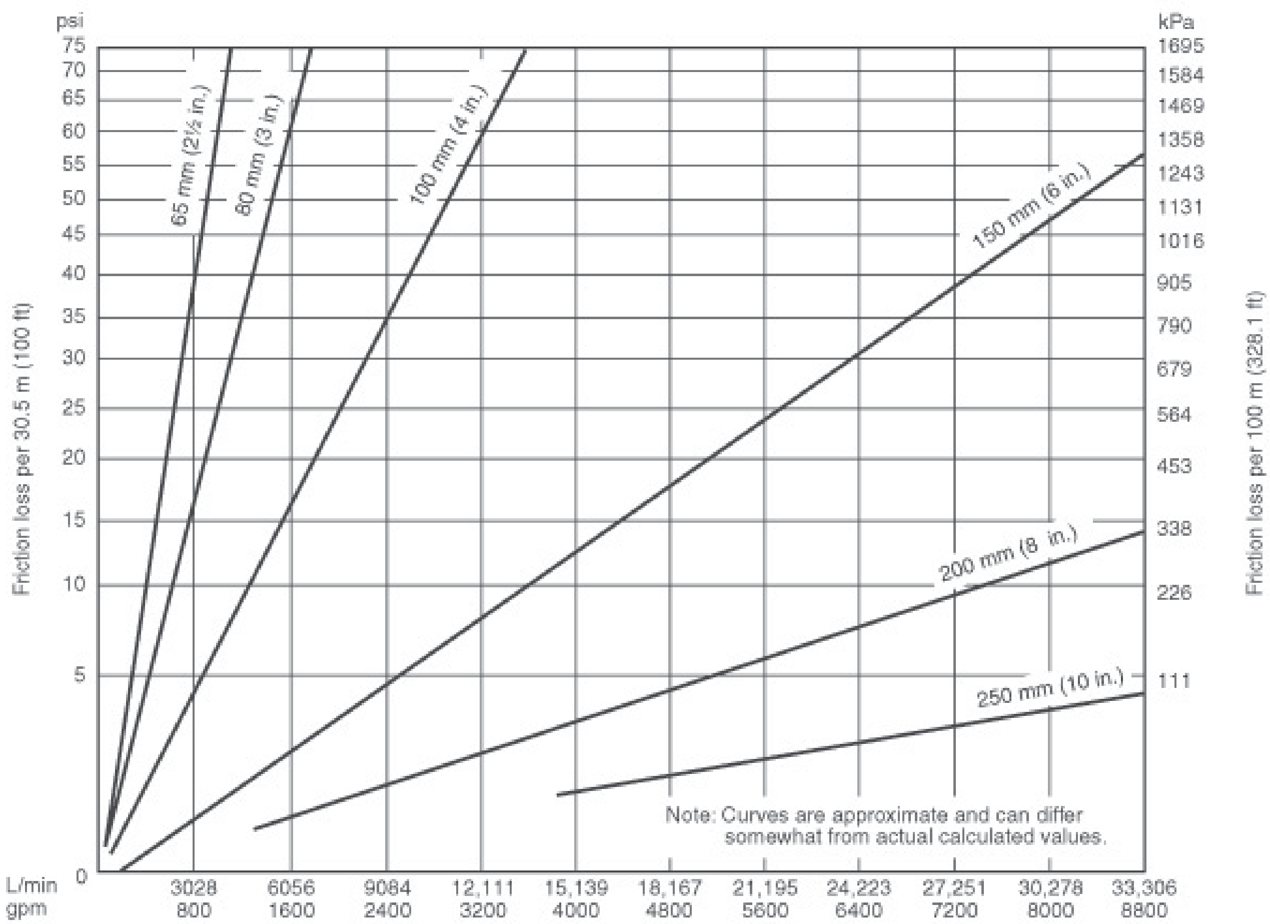

Table 6: Expanded Foam Friction Losses vs Pipe Size (2-1/2" through 10")

(This table is found in NFPA 11-2005 edition [Figure A.5.2.6.4 (a)]

2. **Surface Application:** This can be accomplished by several methods including foam chambers, floating roof foam makers, monitors, or handlines. The type of surface application required depends on tank style and diameter, with cone roof and floating roof tanks being the most common. Both devices are air-aspirating and direct the stream down the inside wall of the tank.

   Cone Roof Tanks (with or without internal floaters): Require the use of foam chambers for surface application, which prevent the entrance of flammable vapors into the supply piping. Unlike foam chambers, floating roof foam makers don't contain water vapor seals, and so they cant be used with cone roof tanks.

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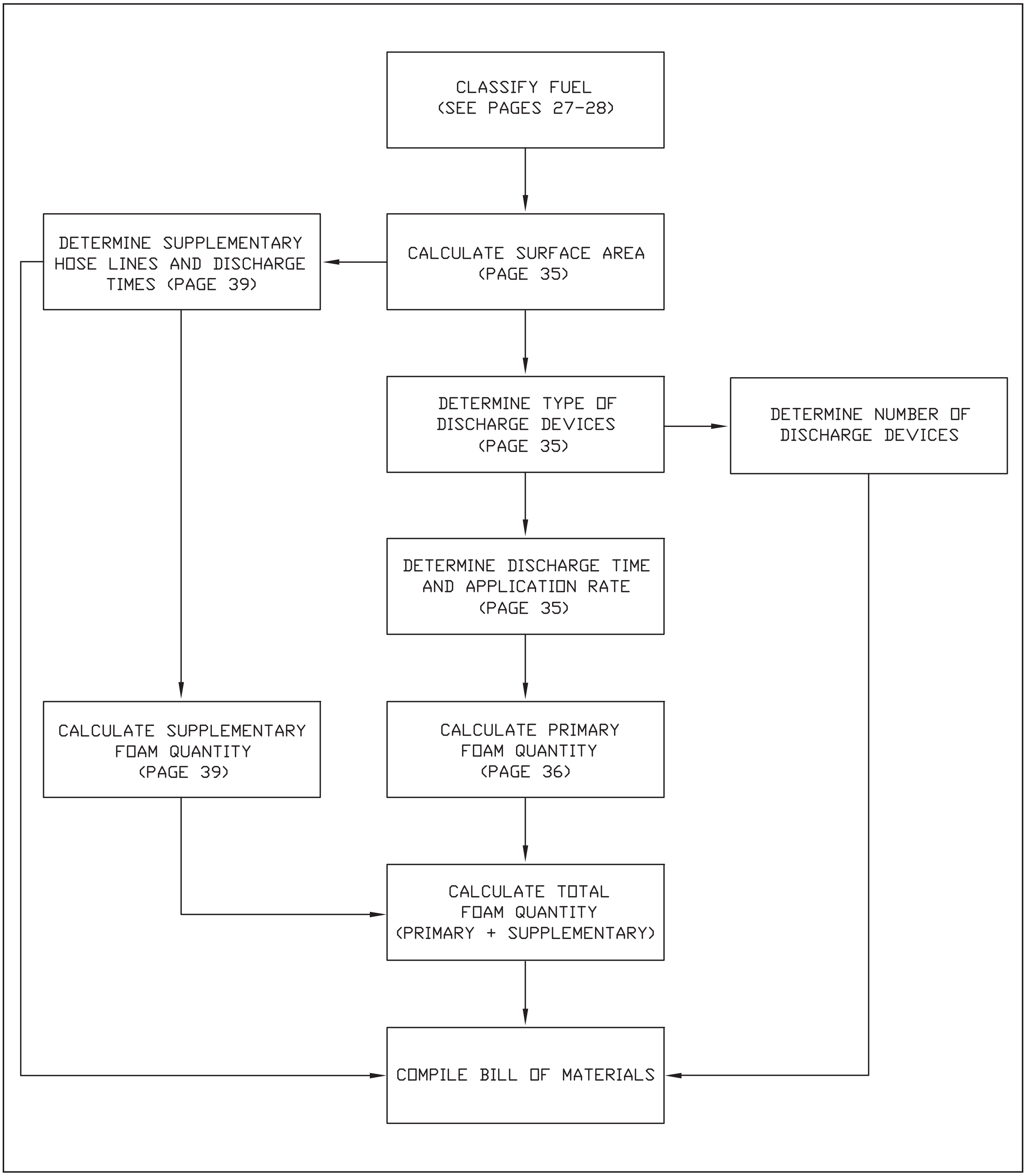
Refer to the Flow Chart - Cone Roof Surface Application for cone roof surface application systems:



Cone Roof Surface Application Flow Chart

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Calculating Surface Area When Protecting a Single Storage Tank: Calculate the surface area using this formula:

SURFACE AREA = πr^2

Calculating Surface Area When Protecting Multiple Storage Tanks: Calculate the surface area of the most severe hazard, which is the storage tank that will require the most foam concentrate for protection. When all tanks contain the same fuel, consider the largest tank to be the most severe hazard.

When tanks contain different fuels, determine the surface area, discharge time, and application rate for each tank and then select the tank that requires the most foam concentrate for primary protection.

Determining Type of Discharge Devices: Typically, foam chambers are used to protect cone roof storage tanks. However, for smaller tanks, foam monitors or hand hose lines may be used. The use of hand hose lines or monitors as primary foam protection is subject to the following conditions:

- Hand hose lines shall NOT be considered for cone roof tanks over 30 ft,. (9 m) diameter nor when tanks are over 20 ft. (6 m) high.
- Monitors shall NOT be considered for cone roof tanks over 60 ft. (18 m) diameter.

When using hand hose lines or monitors for primary protection, the application rates and discharge times are greater than those for foam chambers, and therefore, more foam concentrate is required. This is due to adverse conditions that may arise when applying the foam stream to the fuel surface through he damaged roof. When applying foam to polar solvent fuels using monitors or handlines, direct the streams at the internal tank sidewall to avoid plunging the foam into the fuel.

Determining Discharge Time and Application Rate: Discharge time and application rate are determined according to the type of fuel in the storage tank (see Table 7 below).

TABLE 7: DETERMINING DISCHARGE TIME AND APPLICATION RATE - FOAM CHAMBERS AND MONITORS/HANDLINES ON CONE ROOF TANKS

Fuel Protected	Foam Concentrate	Foam Chambers as Primary Protection			Monitors/Hand Hose Lines as Primary Protection		
		Application Rate		Discharge Time	Application Rate		Discharge Time
		gpm/ft^2	(Lpm/m^2)		gpm/ft^2	(Lpm/m^2)	
Hydrocarbon Flash point between 100 °F and 200 °F (38 °C and 93 °C)	AFFF	0.10	(4.1)	30 minutes	0.16	(6.5)	50 minutes
Hydrocarbon Flash point below 100 °F (38 °C) or liquid heated above flash point	AFFF	0.10	(4.1)	55 minutes	0.16	(6.5)	65 minutes
Crude Petroleum	AFFF	0.10	(4.1)	55 minutes	0.16	(6.5)	65 minutes

NOTE: Information in this table is found in NFPA 11-2005 edition (Tables 5.2.4.2.2 and 5.2.5.2.2).

(continued on next page)

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TABLE 7 *(continued)*: DETERMINING DISCHARGE TIME AND APPLICATION RATE - TYPE 1 AND TYPE II FIXED FOAM DISCHARGE OUTLETS ON CONE ROOF TANKS

Fuel Protected	Foam Concentrate	Application Rate		Discharge Time	
		gpm/ft²	(Lpm/m²)	Type I Foam Discharge Outlet	Type II Foam Discharge Outlet
Flammable and Combustible Liquids	Alcohol-Resistant Foams (Refer to specific data sheets for type of foam concentrate or consult the manufacturer for listings on specific fuels.)			30 minutes	55 minutes

NOTE: Information in this table is found in NFPA 11-2005 edition (Table 5.2.5.3.4).

Calculating Primary Foam Quantity: First, use this formula to determine Foam Solution Discharge Rate which is required to determine proportioner size:

FOAM SOLUTION DISCHARGE RATE = SURFACE AREA X APPLICATION RATE

Then calculate the foam quantity using the following formula:

QUANTITY = FOAM SOLUTION DISCHARGE RATE X DISCHARGE TIME X CONCENTRATE %*

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

Determining Number of Foam Chambers: If foam chambers are selected as primary protection, the number required depends on tank diameter as shown in Table 8.

TABLE 8: DETERMINING NUMBER OF FOAM CHAMBERS - CONE ROOF TANKS

Tank Diameter		Minimum Number of Foam Chambers
feet	(m)	
Up to 80	(24)	1
80 to 120	(24-36)	2
120 to 140	(36-42)	3
140 to 160	(42-48)	4
160 to 180	(48-54)	5
180 to 200	(54-60)	6
Over 200	(60)	One chamber for each additional 5000 sq. ft. (465 m²)

NOTE: Information in this table is found in NFPA 11-2005 edition (Table 5.2.5.2.1).

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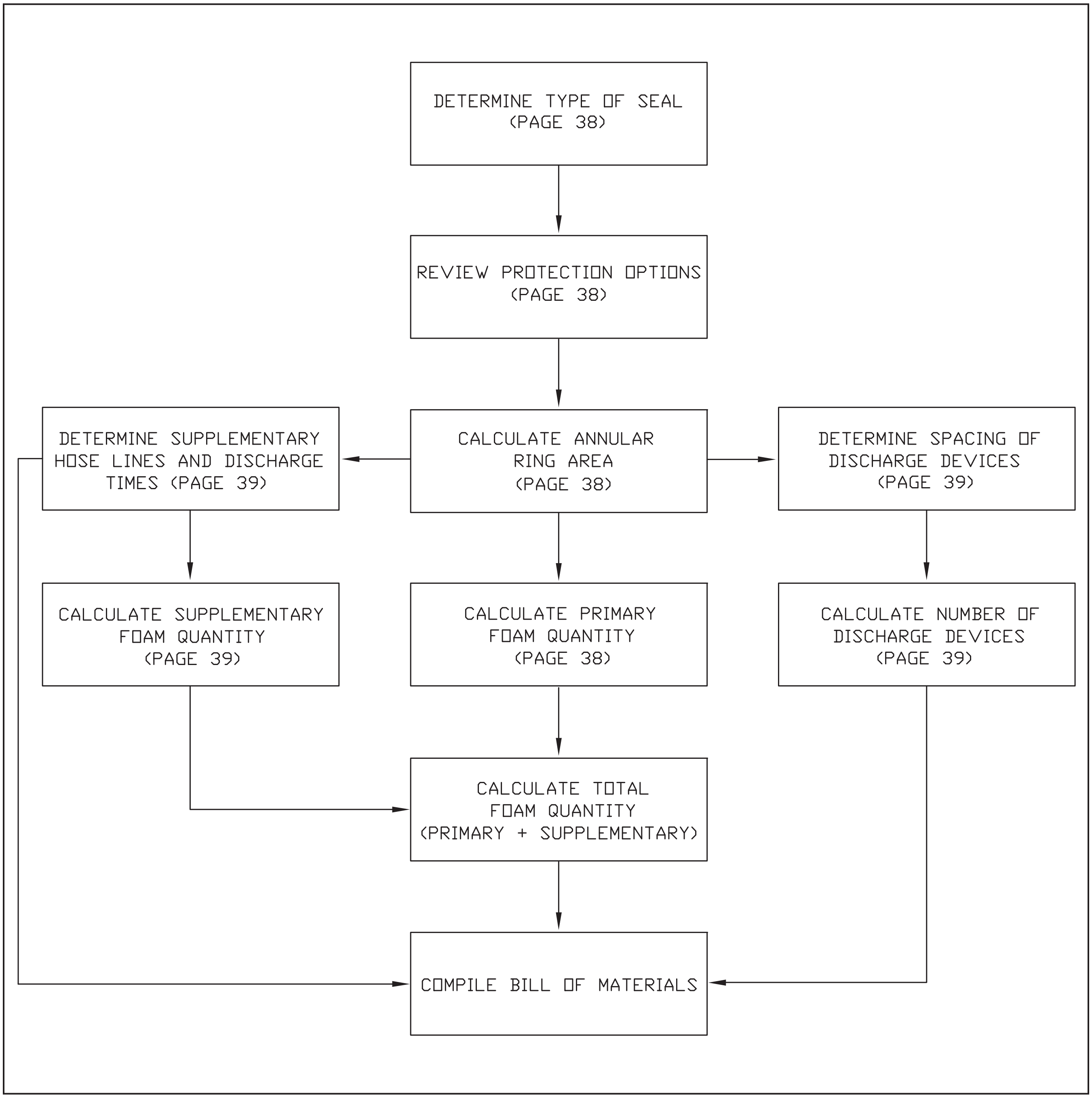
Determining Number of Monitor/Hose Lines for Primary Protection: The number required must be adequate to provide the required application rate for those devices. Additional devices may be added to accomodate normal wind direction or obstructions that may affect stream pattern and coverage.

Floating Roof Tanks: Can be protected with either floating roof foam makers or foam chambers. Flammable vapors are minimized and a vapor seal is not required because piping from the floating roof foam maker is above the floating roof of the tank and open to atmosphere.

See the Flow Chart - Floating Roof Surface Application below:



Floating Roof Tank Flow Chart

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Determinining Type of Seal (Floating Roof Tanks): There are 2 general types of ring seals according to NFPA 11: pantograph (mechanical shoe) seal and tube seals:

Pantograph: Typically contains a fabric seal that is anchored to the top of the roof and rides on the inside of the tank wll. A pantograph or mechanical shoe system is attached below the fabric seal to keep the roof aligned within the tank.

Tube Seals: Typically constructed of a urethane foam contained within a durable envelope. The seal is connected to the edge of the floating roof around the entire circumference of the tank. A weather shield or secondary seal is installed above the tube seal.

Protection Options: There are 2 protection options for floating roof tank systems: top of seal protection and below seal protection:

Top of Seal Protection: Uses either floating roof foam makers or foam chambers connected to the tank shell above the seal. When this type of protection is used, a foam dam is required to contain the foam in the seal area. The foam dam is typically 12 or 24 inches (30 or 60 cm) high.

Below Seal Protection: Accomplished using a floating roof foam maker mounted on the floating roof. Pipe is run from the foam maker and is injected through the fabric seal, secondary seal, or weather shield. Because the foam maker is mounted on the floating roof, a special catenary distribution network is required. (Contact Viking Technical Services for catenary system requirements.)

TABLE 9

Type of Seal	Top of Seal Protection	Below Seal Protection
Pantograph	Floating roof foam makers or foam chambers. Foam dam required.	Floating roof foam makers. Foam dam NOT required.
Tube Seal (top of seal MORE than 6” (152 mm) from top of roof deck)	Floating roof foam makers or foam chambers. Foam dam required.	Floating roof foam makers. Foam dam NOT required.
Tube Seal (top of seal LESS than 6” (152 mm) from top of roof deck)	Floating roof foam makers or foam chambers. Foam dam required.	Floating roof foam makers. Foam dam required.

Calculating Annular Ring Area: For tanks with foam dams, the annular ring is the area between teh foam dam and the tank wall. For tanks without foam dams the annular ring is the area between the tank wall and the inside base of the secondary seal. It is calculated by subtracting the unprotected roof area from the total surface area of the tank as follows:

ANNULAR = TOTAL SURFACE AREA (πr^2) - UPROTECTED ROOF AREA (πr^2)

Calculating Primary Foam Quantity: Top of seal protection requires a discharge time of 20 minutes and an application rate of 0.30 gpm/ft^2 (12.2 Lpm/m^2). Below seal protection requires a discharge time of 10 minutes and an application rate of 0.50 gpm/ft^2 (20.1 Lpm/m^2). Using these requirements, the primary foam quantity is calcuated.

First, use the following formula to determine Foam Solution Discharge Rate, which is required to determine proportioner size:

FOAM SOLUTION DISCHARGE RATE = ANNULAR RING AREA X APPLICATION RATE

Now, calculate the foam concentrate quantity using the following formula:

QUANTITY = FOAM SOLUTION DISCHARGE RATE X DISCHARGE TIME X CONCENTRATE %

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

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Determining Spacing of Discharge Devices: The spacing between floating roof makers or foam chambers for top of seal protection is based on the height of the foam dam; below seal protection is based on the type of seal. Refer to Table 10 below.

TABLE 10: DETERMINING SPACING OF DISCHARGE DEVICES - FLOATING ROOF TANKS

Type of Seal	Maximum Discharge					
	Height of Foam Dam		Top of Seal		Below Seal	
	Inches	(mm)	Inches	(m)	Inches	(m)
Pantograph	No Dam		--	--	130	(39.6)
	12	(305)	40	(12.2)	--	--
	24	(610)	80	(24.4)	--	--
Tube Seal (top of seal MORE than 6” (152 mm) from top of roof deck	No Dam		--	--	60	(18.3)
	12	(305)	40	(12.2)	--	--
	24	(610)	80	(24.4)	--	--
Tube Seal (top of seal LESS than 6” (152 mm) from top of roof deck	12	(305)	40	(12.2)	60	(18.3)
	24	(610)	80	(24.4)	60	(18.3)

Calculating Number of Discharge Devices: The number of discharge devices is determined as follows:

$$\text{NUMBER OF DISCHARGE DEVICES} = \frac{\text{CIRCUMFERENCE OF TANK } (\pi d)}{\text{MAX. SPACING BETWEEN DEVICES}}$$

Determining Supplementary Hose Lines and Discharge Times: In addition to the primary protection system, a minimum number of foam hose lines are required as protection for small spill fires. This supplementary protection may be either fixed or portable hose lines with a minimum flow rate of 50 gpm (189 Lpm) per nozzle.

Minimum number of hose streams and their discharge times (as they relate to tank size) are as shown in Table 11:

TABLE 11: MINIMUM NUMBER OF HOSE STREAMS AND DISCHARGE TIMES

Tank Diameter		Minimum Number of Hose Lines	Minimum Discharge Time
feet	(m)		
Up to 35	(Up to 11)	1	10 minutes
35 to 65	(11-20)	1	20 minutes
65 to 95	(20-29)	2	20 minutes
95 to 120	(29-37)	2	30 minutes
Over 120	(Over 37)	3	30 minutes

Calculating Supplementary Foam Quantity: Minimum discharge times are based on simultaneous operation of the minimum number of hose lines required.

To calculate the quantity of foam concentrate required for supplementary protection, use the following formula. Foam hose streams can be incorporated into the primary system or can be set up as a separate self-contained syatem.

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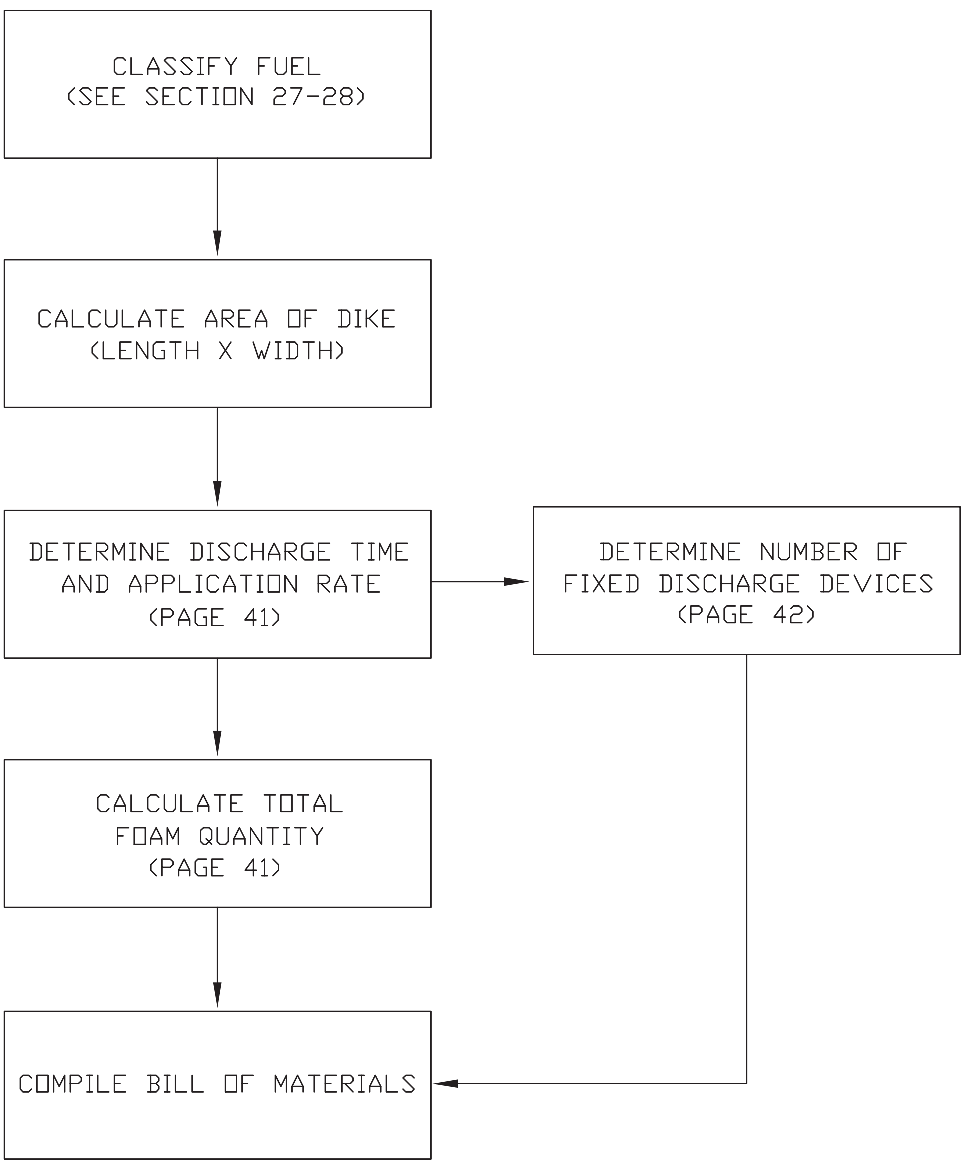
QUANTITY = NUMBER OF HOSE LINES X 50 GPM X DISCHARGE TIME X CONCENTRATE %

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

3. **Dike Protection:** Generally required for small diameter vertical tanks or horizontal tanks, dike protection can use floating roof foam makers, spray nozzles, or foam monitors. The diked area, rather than the individual storage tanks, may be considered the hazard to be protected and a fixed foam system using monitors or floating roof foam makers is required.

See the Flow Chart - Dike Protection below:



Dike Protection Flow Chart

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Determining Discharge Time and Application Rate: Discharge time and application rate are determined according to the type of fuel contained in the storage tank being protected. Refer to Table 12:

TABLE 12: DETERMINING DISCHARGE TIME AND APPLICATION RATE FIXED DISCHARGE DEVICES

Fuel Protected	Type of Foam Discharge Outlet	Application Rate		
		gpm/ft²	(Lpm/m²)	Discharge Time
Class I Hydrocarbon Flash point between 100 °F and 200 °F (38 °C and 93 °C)	Low-Level Foam Discharge Outlets	0.10	(4.1)	30 minutes
	Foam Monitors	0.16	(6.5)	30 minutes
Class II Hydrocarbon Flash point below 100 °F (38 °C) or liquid heated above flash point	Low-Level Foam Discharge Outlets	0.10	(4.1)	20 minutes
	Foam Monitors	0.16	(6.5)	20 minutes
Alcohols				
Methanol	Refer to specific data sheets for type of foam concentrate being used or consult the manufacturer.			30 minutes
				30 minutes
Ethanol				30 minutes
				30 minutes
Isopropanol				30 minutes
				30 minutes
Ketones				
Methyl Ethyl Ketone	Refer to specific data sheets for type of foam concentrate being used or consult the manufacturer.			30 minutes
				30 minutes
Acetone				30 minutes
				30 minutes
Carboxylic Acids				30 minutes
				30 minutes
Aldehydes*				30 minutes
				30 minutes
Esthers (Ethyl Tertiary Butyl Ether)				30 minutes
				30 minutes
*Consult Chemguard Foam data sheets for other specific fuels.				

Calculating Total Foam Quantity: First, use the following formula to determine Foam Solution Discharge Rate, which is required to determine proportioner size:

FOAM SOLUTION DISCHARGE RATE = DIKE AREA X APPLICATION RATE

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

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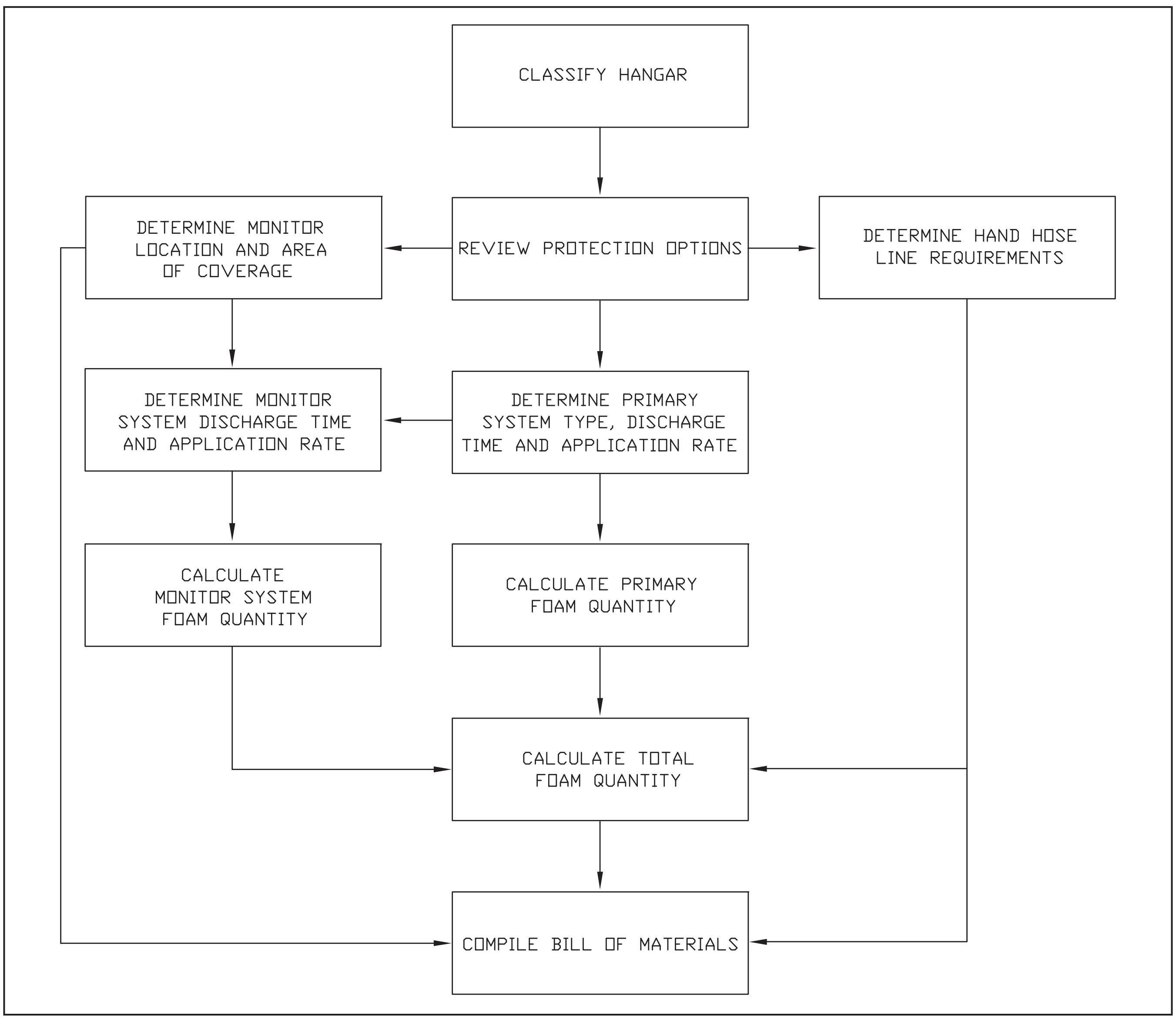
Determining Number of Fixed Discharge Devices: If monitors are used, a minimum of 2 is recommended. This allows for overlapping spray patterns, which helps to ensure complete coverage of the area protected. Additional monitors may be required to accomodate normal wind direction or obstructions that may affect stream pattern and coverage.

When floating roof foam makers are used, the maximum recommended spacing between discharge outletsis 30 ft (9.1 m) at 60 gpm (227.1 Lpm) flow or less*. For flows that exceed 60 gpm (227.1 Lpm), spacing may be increased to a maximum of 60 ft (18.3 m)*.

B. Protecting Aircraft

Fixed foam systems are required to protect housed aircraft in many commercial and military aircraft hangars. Variable factors that affect system design and component selection include hangar floor area, type of hangar construction, aircraft access door height, type and size of housed aircraft, aircraft quantity and parking arrangement, and floor drainage details. Additional information on aircraft hangar protection is covered in NFPA 409 "Standard on Aircraft Hangars."

Refer to the following flow chart for a logical sequence for designing aircraft hangar systems:



Aircraft Hangar Protection Flow Chart

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Classification of Hangars: The hangar must be classified to determine the fire protection requirements. The following hangar groups are defined in NFPA 409.

Group I: Hangar with at least one of the following conditions:

- An access door height over 28 ft (8.5 m)
- A single fire area no larger than 40,000 ft^2 (3716 m^2), but equal to or greater than those specified in NFPA 409, Table 4.1.2 for specific types of construction.
- Housing strategically important aircraft as determined by the Department of Defense.

Group II: A hangar with both of the following conditions:

- An aircraft access door height of 28 ft (8.5 m) or less.
- A single fire area not larger than 40,000 ft^2 (3716 m^2), but equal to or greater than those specified in NFPA 409, Table 4.1.2 for specific types of construction.

Group III: May be a freestanding individual unit for a single aircraft, a row hangar having a common structural wall and roof system and housing multiple aircraft as well as having door openings for each aircraft, or an open bay hangar capable of housing multiple aircraft, and having both of the following conditions:

- An aircraft access door height of 28 ft (8.5 m) or less.
- A single fire area up to the maximum permitted for specific types of construction as defined in NFPA 409, Table 4.1.3.

Group IV: A membrane-covered, ridged, steel frame structure.

Protection Options: Once the aircraft hangar classification has been determined, fire protection requirements can be established.

There are four types of foam systems available for aircraft hangars:

- Primary Foam-Water Sprinkler Systems
- Foam Monitor Systems
- High-Expansion Foam Systems
- Foam-Water Hand Hose Line Systems

Primary foam-water sprinkler systems are normally deluge systems or preaction systems. Nonaspirated sprinkler heads may be used with AFFF agents.

Monitor systems consist of oscillating monitors or fixed monitors. Oscillating monitors are capable of being pre-adjusted for arc and rate of oscillation and are equipped with manual override. The number of monitors, location, flow rates, and nozzle stream performance must be capable of covering the areas as specified by the hangar "group" requirements.

High-expansion foam systems use a high expansion generator to mix foam concentrate with air and water creating large volumes of foam for an effective foam blanket.

Foam-water hand hose line systems are designed to provide personnel a manual fire fighting capability.

Group I Hangar Protection: Three options are recommended for protecting Grouup I hangars:

Option 1: The hangar must contain an overhead foam-water deluge system as primary protection. When the hangar contains aircraft with wing areas exceeding 3000 ft^2 (279 m^2), the hangar must be provided with a monitor system. A monitor system is also recommended when the hangar stores several aircraft with wing areas less than 3000 ft^2 (279 m^2) each. The minimum design density for this monitor system is to cover the center fuselage and wing area at a density of 0.10 gpm/ft^2.

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Option 2: The hangar must contain a water sprinkler system (wet pipe or preaction) AND a foam monitor system. The water system is based on 0.17 gpm/ft^2 (6.9 Lpm/m^2) application rate over any 15,000 ft^2 (465 m^2) area. The high expansion foam system has a minimum required foam depth of 3 ft (0.9 m) in one minute over the entire hangar floor area. See design requirements as shown on system calculation form.

Group II Hangar Protection: Four options are recommended for protecting Group II hangars:

Option 1: The hangar must contain an overhead foam-water deluge system as primary protection. When the hangar contains aircraft with wing areas exceeding 3,000 ft^2 (279 m^2), the hangar must be provided with a monitor system. A monitor system is also recommended when the hangar stores several aircraft with wing areas less than 3,000 ft^2 (279 m^2) each. The minimum design density for this monitor system is to cover the center fueslage and wing area at a density of 0.10 gpm/ft^2.

Option 2: The hangar must contain a wet pipe or preaction water sprinkler system AND a foam monitor system. The water sprinkler system is to be based on 0.17 gpm/ft^2 (6.9 Lpm/m^2) application rate over any 5,000 ft^2 (465 m^2) area. The foam monitor system is based on covering the entire hanger floor area. See monitor system requirements.

Option 3: The hangar must contain a wet pipe or preaction water sprinkler system AND a high expansion foam system. The water sprinkler system is to be based on 0.17 gpm/ft^2 (6.9 Lpm/m^2) application rate over any 5,000 ft^2 (465 m^2) area. The high expansion foam system has a minimum required foam depth of 3 ft (0.9 m) in one minute over the entire hangar floor area. See design requirements as shown on system calculation form.

Option 4: The hangar must contain a closed-head foam-water sprinkler system based on the same design requirements of Option 1.

Group III Hangar Protection: Foam protection is not usually required for Group III hangars. However, Group III hangars are to be protected as Group II hangars when hazardous operations (fuel transfer, welding, torch cutting and soldering, doping, spray painting) are performed. If Group III hangars exceed one story, they shall be protected as Group II hangars.

Group IV Hangar Protection: Foam protection is not usually required for Group IV hangars. However, Group IV hangars having a fire area greater than 12,000 ft^2 housing fueled aircraft shall have a foam system in accordance with the following options.

Option 1: The hangar must contain a monitor system or low level discharge nozzles to cover the entire hangar floor area. See monitor system requirements.

Option 2: The hangar must contain a high-expansion system to cover the entire hangar floor area. See design requirements as shown on system calculation form. Note: R_s may not be required.

* Overhead sprinklers are not required when a foam system is used. Foam systems are not required if the aircraft are unfueled, but a water only sprinkler system is required. With exceptions as modified above, these foam systems when required will be designed like a Group II Hangar.

All Deluge Systems: The maximum deluge zone size is 15,000 ft^2.

All zones within 100 ft radius of any point in protected area must be included in agent quantity calculation.

All Closed Head Systems: The maximum closed-head zone size is 52,000 ft^2. Exception: 15,000 ft^2 if meeting closed-head requirements of option IV for Group II hangars.

All Systems: A directly-connected, equal reserve supply of concentrate in a separate, manually-operated tank is required by NFPA 409. However, the authority having jurisdiction may take exception if a supply of concentrate is available within 24 hours. (This does not pertain to Hand Hose Line Systems).

In addition to the previous fire protection, hand portable and wheeled extinguishers must be provided in all hangars in accordance with NFPA 10.

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Determining Primary System Discharge Time and Application Rate (AFFF Systems): Primary protection using deluge systems requires a discharge time of 10 minutes for foam and a water supply sufficient for 45 minutes. The required foam application rates required are listed in Table 13. The number of sprinklers required for overhead foam protection is usually based on 10 ft (3.1 m) maximum centers.

TABLE 13: REQUIRED FOAM APPLICATION RATES - AIRCRAFT HANGARS (AFFF SYSTEMS)		
Hangar Group	Non-Aspirated AFFF	
	gpm/ft²	(Lpm/m²)
I	0.16	(6.5)
II	0.16	(6.5)

Calculating Primary Foam Quantity: First, use the following formula to determine Foam Solution Discharge Rate, which is required to determine proportioner size:

FOAM SOLUTION DISCHARGE RATE = FLOOR AREA X APPLICATION RATE

Now, calculate the foam concentrate quantity using the following formula:

QUANTITY = FOAM SOLUTION DISCHARGE RATE X 10 MINUTES X CONCENTRATE %* X 1.15 (15% OVERAGE) - SEE NOTE NO. 1

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

Note 1: The foam concentrate supply must be based upon two separate calculations (demand calculation and supply calculations) and the supply calculation is not normally available at the preliminary system design stage. It is recommended that a 15% overage be included to compensate for this unknown factor. (The 15% overage is based upon the maximum variance allowed between the lowest density and highest density sprinkler within an individual sprinkler zone.)

Wing Areas of Various Aircraft: Monitor systems are required for hangars housing aircraft with wing areas exceeding 3,000 ft² (279 m²). Table 14 lists the wing areas of various large transport aircraft.

TABLE 14: WING AREAS OF VARIOUS LARGE TRANSPORT AIRCRAFT				
Aircraft	Gross Wing Area		Overall Height	
	ft²	(m²)	ft-in	(m)
Airbus A-3xx*			79-0	(24.1**)
Antonov An-124*	6760	(628.0**)	69-2	(21.0**)
Lockheed L-500-Galaxy	6200	(576.0**)	65-1	(19.8**)
Boeing 747*	5825	(541.1**)	63-8	(19.4**)
Airbus A-340-500, -600*	4703	(437.0**)	54-11	(16.7*)
Boeing 777*	4605	(427.8**)	60-9	(18.5**)
Ilyushin Il-96*	4215	(391.6**)		
DC-10-120, 30*	3958	(367.7**)	58-1	(17.7**)
Airbus A-340-200, -300, A-330-200, -300*	3892	(361.6**)	54-11	(16.7**)
DC-10-10*	3861	(358.7**)	58-1	(17.7**)
(Continued on next page.)				

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TABLE 14 *(continued)*: **WING AREAS OF VARIOUS LARGE TRANSPORT AIRCRAFT**

Aircraft	Gross Wing Area		Overall Height	
	ft²	(m²)	ft-in	(m)
Concorde*	3856	(358.2**)	40-0	(12.2**)
Boeing MD-11*	3648	(339.9**)	57-9	(17.6**)
Boeing MD-17*	3800	(353.0**)	55-1	(16.8**)
L-1011*	3456	(321.1**)	55-4	(16.8**)
Ilyushin IL-76*	3229	(300.0**)	48-5	(16.8**)
Boeing 767*	3050	(283.4**)	52-0	(16.8**)
Ilyushin IL-62*	3030	(281.5**)	40-6	(16.8**)
DC-10 MD-10	2932	(272.4)		
DC-8-63, 73	2927	(271.9)		
DC-8-62, 72	2926	(271.8)		
DC-8-61, 71	2883	(267.8)		
Airbus A-300	2799	(260.0**)	54-3	(16.5**)
Airbus A-310	2357	(218.9**)	51-10	(15.8**)
Tupolev TU-154	2169	(201.5**)	37-4	(11.4**)
Boeing 757	1994	(185.2**)	44-6	(13.5**)
Tupolev Tu-204	1963	(182.4**)	45-7	(13.9**)
Boeing 727-200	1700	(157.9**)	34-0	(10.4**)
Lockheed L-100J Hercules	1745	(162.1**)	38-3	(11.6**)
Yakovlev Yak-42	1614	(150.0**)	32-3	(9.3**)
Boeing 737-600, -700, -800, -900	1345	(125.0**)	43-3	(12.5**)
Airbus A-318, A-319, A320, A-321	1319	(122.6**)	38-8	(11.8**)
Boeing MD-8	1209	(112.3**)	29-7	(9.0**)
Boeing MD-90	1209	(112.3**)	30-7	(9.3**)
Gulfstream V	1137	(105.6**)	25-10	(7.9**)
Boeing 737-300, -400, -500	1135	(105.4**)	36-6	(11.1**)
Tupolev Tu-334, Tu-354	1076	(100.0**)	30-9	(9.4**)
BAC 1-11-500	1031	(95.8**)	24-6	(7.5**)
NAMC YS-11	1020	(94.8**)	29-5	(8.9**)
Fokker 100, 70	1006	(93.5**)	27-10	(8.5**)
BAC 1-11-300, 400	1003	(93.2**)	24-6	(7.5**)
Boeing 717	1001	(93.0**)	29-1	(8.8**)
DC-9-30	1001	(93.0**)	27-6	(8.4**)
Boeing 737-200	980	(91.0**)	37-0	(11.3**)
Gulfstream IV	950	(88.3**)	24-5	(7.4**)
DC 9-10	934	(86.8**)	27-6	(8.4**)
BAe 146, RJX-70, -85, 100	832	(77.3**)	28-3	(8.6**)

(Continued on next page.)

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TABLE 14 *(continued)*: **WING AREAS OF VARIOUS LARGE TRANSPORT AIRCRAFT**

Aircraft	Gross Wing Area		Overall Height	
	ft^2	(m^2)	ft-in	(m)
Fokker 50, 60	753	(70.0**)	27-3	(2.7**)
Canadiar RJ-700	738	(68.6**)	24-10	(7.6**)
Dash 8 Q400	679	(63.0**)	24-7	(7.5**)
ATR 72	656	(61.0**)	25-1	(7.6**)
Airtech CN-235	636	(59.1**)	26-10	(8.2*)
Saab 2000	600	(55.7**)	25-4	(7.7**)
Canadiar RJ-100, 200	587	(54.5**)	20-5	(6.2**)
ATR 42	586	(42.5**)	24-10	(7.6**)
Dash 8 Q100, 200	585	(54.3**)	24-7	(7.5**)
Embaraer ERJ-135, 145	550	(51.1**)	22-1	(6.9**)
Cessna 750	527	(48.9**)	18-11	(5.8**)
Cessna 680	516	(47.9**)	19-2	(5.5**)
Saab 340	450	(41.8**)	22-1	(6.9**)
Embaraer EMB-120	424	(39.4**)	20-10	(6.3**)
Bell Boeing V-22	382	(39.5**)	21-9	(6.6**)
Britten-Norman BN2	325	(30.2**)	13-8	(4.2**)
Cessna 650	312	(28.9**)	16-9	(5.1**)
Beach 1900	310	(28.8**)	15-6	(4.7**)
Beech King Air C90	294	(27.3**)	14-3	(4.3**)

*Aircraft with wing areas in excess of 3000 ft^2 (279 m^2)
**Jane's All the Worlds Aircraft, Editions, Jane's Information Group Limited, Sentinel House, 163 Brighton Road, Coulsdon, Surrey, CR5 2YH, UK

Determining Monitor Location and Area of Coverage: First, locate the monitors based on customer-aproved mounting locations. Next, determine the required range (radius) and arc of oscillation (degrees) in order to cover the underwing and center fuselage area of the aircraft from the customer-approved locations. Finally, calculate the area of coverage for each monitor using the following formula. Note that each monitor may have a different area of coverage based on its range and arc of oscillation.

$$\text{AREA OF COVERAGE} = \frac{(\pi R2)\ (\text{ARC OF OSC})}{360}$$

Determining Monitor System Discharge Time and Application Rate: The discharge time for monitor systems is 10 minutes. Protein or fluoroprotein foam with an aspirating nozzle requires an application rate of 0.16 gpm/ft^2 (6.5 Lpm/m^2). AFFF agents with aspirating or nonaspirating nozzles require an application rate of 0.10 gpm/ft^2 (4.1 Lpm/m^2).

Calculating Monitor System Foam Quantity: First, use the following formula to determine Foam Solution Discharge Rate for each monitor in order to select the proper monitor and nozzle:

FOAM SOLUTION DISCHARGE RATE = AREA OF COVERAGE X APPLICATION RATE

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Next, determine the Total Foam Solution Discharge Rate, which is the combined discharge rates of all monitors. This is required to determine proportioner size.

TOTAL FOAM SOLUTION DISCHARGE	=	MONITOR #1 DISCHARGE RATE	+	MONITOR #2 DISCHARGE RATE	+	ETC.

Finally, calculate the foam concentrate quantity using the following formula:

QUANTITY = TOTAL FOAM SOLUTION DISCHARGE RATE X 10 MINUTES X CONCENTRATE %* X 1.15 (15% OVERAGE) -- SEE NOTE NO. 1

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

Note 1: The foam concentrate supply must be based upon two separate calculations (demand calculation and supply calculations) and the supply calculation is not normally available at the preliminary system design stage. It is recommended that a 15% overage be included to compensate for this unknown factor. (The 15% overage is based upon the maximum variance allowed between the lowest density and highest density sprinkler within an individual sprinkler zone.)

Hand Hose Line Requirements: The hand hose lines must be situated with a sufficient length of hose to provide water or foam on each side and into the interior of the aircraft. The supply of foam concentrate must be sufficient to supply two hand hose lines for a period of 20 minutes at a discharge rate of 60 gpm (227 Lpm) each. (Two hand hose lines are minimum; customer preference may dictate additional hose lines to cover additional areas of the hangar.)

First, use the following formula to determine Foam Solution Discharge Rate, which is required to determine proportioner size:

FOAM SOLUTION DISCHARGE RATE = 60 GPM X NO. OF HAND HOSE LINES

Now, calculate the foam concentrate quantity using the following formula:

QUANTITY = Foam Solution Discharge Rate X 20 Minutes X Concentrate %*

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

The supply for the hand hose lines may be incorporated into the primary system supply and connected to the sprinkler system header, or it may be desirable to have a separate supply for hand hose lines so that the primary system does not require recharge when only the hand hose lines are used.

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HANGAR HIGH EXPANSION SYSTEM CALCULATION FORM

- Design Per NFPA 409 Exception: the use of Inside Air as recognized by Ansul Incorporated, and many AHJ's.

Hangar floor area = ________________ ft^2 x 3 cfm / ft^2 = __________________ **cfm**

Sprinkler breakdown factor (R_S)

Refer to the technical data page for the specific breakdown factor, depending on which Chemguard generator is being used.

Therefore;

(________________ cfm + ________________ breakdown cfm) x 1.15 (shrinkage) x 1.2 (inside air)

= ________________ cfm of high expansion foam is required.

Assuming that ______________ **psi** is available at each generator, the ____________________ model generator will generate ______________ cfm each (flowing ___________ gpm each).

Note: Minimum inlet pressure to generators must be 0 psi.

________________ cfm required / ________________ cfm per generator

= ___________ or (round up) ______________ **Generators are required for the system.**

Concentrate required is then calculated:

_________ generators x ________ gpm each

= ____________ gpm x 12 minute duration = ______________ gal. of foam solution

x 0.02

= ______________ **gal. of 2% Chemguard High Expansion Concentrate**

x 15% overage = ______________ gal of Chemguard High Expansion Concentrate in main system tank with connected reserve of equal capacity

Required Sprinkler Demand

0.17 gpm / ft^2 x ________ ft^2 = _________ gpm

Required Foam-Water Hose Demand

2 handline x 60 gpm = 120 gpm

Minimum flow requirements for all Systems

________ gpm (generators) + ______________ (sprinklers) gpm + 120 gpm =

______________ **gpm***

**Note: This does not include any overage allowance or outside hose steam requirements.*

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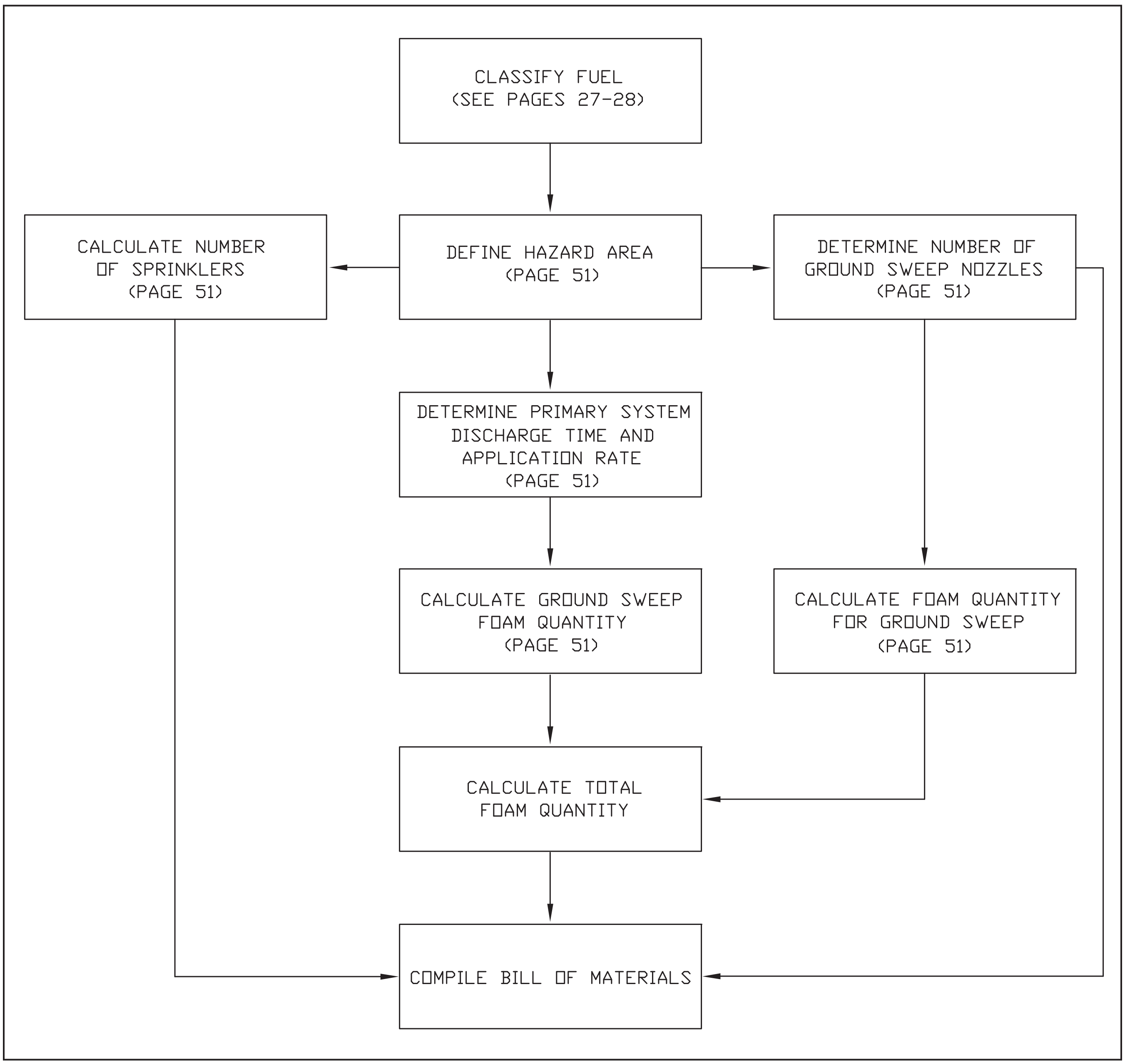
C. Truck Loading Rack Protection

The transfer of highly flammable fuels at truck loading racks presents a variety of fire protection problems. The fuel could be transferred from storage tanks or pipeline, under pressure or by gravity. Therefore, the potential fire could be ground spill, three dimensional gravity fed, or three dimensional fuel-under-pressure.

The type of foam system used for loading rack protection consists of a foam-water deluge system, and if desired, a supplementary ground sweep nozzle or “under truck” system. Monitor systems may also be used as primary protection.

Refer to the following flow chart for a logical sequence for designing truck loading rack systems:



Truck Loading Rack Protection Flow Chart

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Defining Hazard Area: A loading rack is normally surrounded by a low-profile dike or curb, or a drainage system, which will contain a fuel spill. If no containment is provided, the area under the roof or canopy is usually considered the hazard area to be protected. However, the overall length of the truck and trailer may extend the fire area and must also be considered (see Figure 5D-2).

When no canopy or containment area is provided, the hazard area must be defined by the customer or the authority having jurisdiction.

Determining Primary System Discharge Time and Application Rate: The discharge time for primary loading rack systems is 10 minutes. The application rate depends on the type of fuel and foam agent used as shown in Popular Sprinkler/Concentrates Data Sheet in Section IV. In addition to Overhead Foam-Water Sprinklers, ANSUL recommends using "Ground Sweep" nozzles for faster fire knockdown under the areas shielded by the vehicle.

Calculating Number of Sprinklers: The number of sprinklers required for overhead foam protection is based on 10 ft (3.1 m) maximum centers. Therefore, to estimate the number of sprinklers required to protect the hazard area, use the following formula:

$$\text{NUMBER OF SPRINKLERS} = \frac{\text{HAZARD LENGTH}}{10} \times \frac{\text{HAZARD WIDTH}}{10}$$

Fractions or decimals must be rounded up to the nearest whole number before multiplying.

Calculate Primary Foam Quantity: First, use the following formula to determine Foam Solution Discharge Rate, which is required to determine proportioner size:

FOAM SOLUTION DISCHARGE RATE = AREA OF HAZARD X APPLICATION RATE X 10 MINUTES X CONCENTRATE %*

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

Determining Number of Ground Sweep Nozzles: Ground sweep nozzles are recommended as additional protection especially for bottom loading and open-sided racks. These nozzles will increase the spread of foam under the truck, thereby reducing the fire exposure to the truck and surrounding structure. Typically, two or four nozzles are recommended per bay depending on customer requirements. Typically, ANSUL would recommend that an additional 0.1 gpm/ft^2 minimum is provided by these nozzles. As this is additional protection, the area covered cannot be deducted from the overhead calculations.

Calculating Ground Sweep Foam Quantity: The foam quantity for ground sweep protection is in addition to sprinkler system foam requirements. This application rate depends on the flow rate of the nozzle used. The discharge time is the same as for the sprinkler system: 10 minutes.

First, use the following formula to determine Foam Solution Discharge Rate, which is required to determine proportioner size:

FOAM SOLUTION DISCHARGE RATE = NOZZLE FLOW RATE X NO. OF NOZZLES

Now, calculate the foam concentrate quantity using the following formula:

QUANTITY = FOAM SOLUTION DISCHARGE RATE X 10 MINUTES X CONCENTRATE %*

*Concentrate % is expressed as: .01 for 1% concentrates
.03 for 3% concentrates
.06 for 6% concentrates

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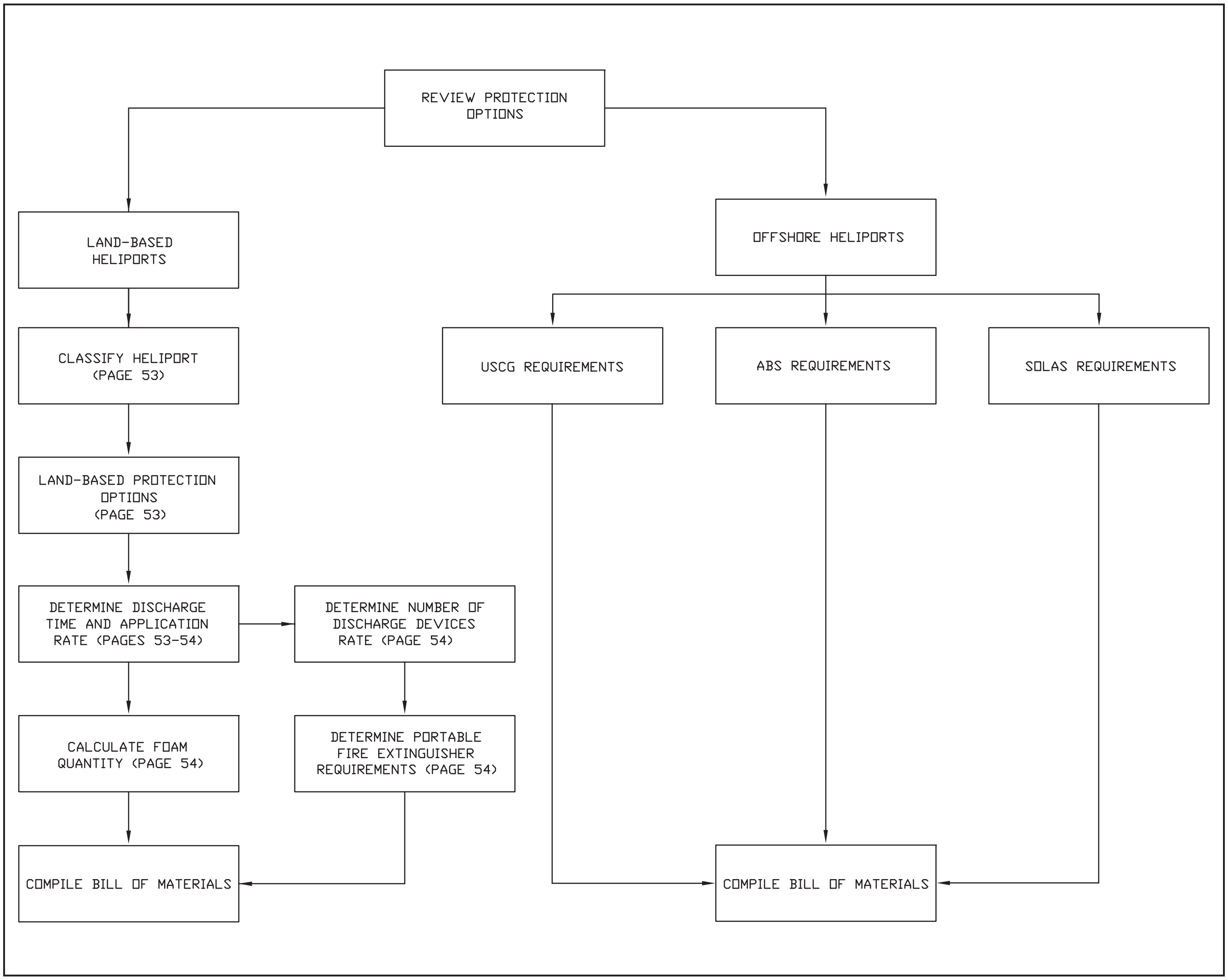
D. Heliport Protection

With increasing demands for rapid transportation to areas that are difficult to reach quickly, helicopter transportation has been on the uprise in business and the emergency medical fields. This has also increased the demand for fire protection at facilities that accomodate helicopters.

Fire protection at heliports consists generally of foam application using hand hose lines, oscillating monitors, or fixed nozzles depending on the authority having jurisdiction.

Refer to the following flow chart for a logical sequence for designing heliport systems:



Heliport Protection Flow Chart

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Protection Options: The codes and standards for protecting heliports vary depending on the authority having jurisdiction. Heliport protection is divided into two basic categories: land-based and offshore.

Land-Based Heliports: NFPA 418 “Standard for Heliports” addresses minimum fire protection requirements for land-based heliport facilities. This standard also addresses protection requirements for rooftop landing facilities.

Offshore Heliports: NFPA 418 “Standard for Heliports” also covers offshore heliports, which can be either fixed or mobile installations. These heliports shall be approved by the authority having jurisdiction, which may be the United States Coast Guard (USCG) Title 46, American Bureau of Shipping (ABS) Mobile Offshore Drilling Units, and the International Convention for the Safety of Life at Sea (SOLAS).

Classifying Heliports: The degree of fire protection recommended is determined by the “practical critical fire area”, which has been compiled from factors such as aircraft size, passenger load, fuel capacity, etc. The three categories of heliports are defined by NFPA 418 as follows:

H-1 Heliports: Helicopter overall length* up to, but not including, 50 ft (15 m) with a practical critical fire area of 375 ft^2 (34.8 m^2).

H-2 Heliports: Helicopter overall length* from 50 ft (15 m) up to, but not including, 80 ft (24.4 m) with a practical critical fire area of 840 ft2 (78 m2).

H-3 Heliports: Helicopter overall length* from 80 ft (24 m) up to, but not including, 120 ft (36.6 m) with a practical critical fire area of 1440 ft^2 (133.8 m^2).

* Helicopter length, including the tail boom and the rotors.

Land-Based Protection Options: NFPA 418 requires semi-fixed hand hoseline systems for H-1, H-2, and H-3 heliport protection. Fixed foam systems may be used to satisfy the requirement for hand hoselines and may be desirable especially where refueling operations are performed. In addition to foam requirements, at least one portable fire extinguisher for each takeoff and landing area, parking area, and fuel storage area shall be provided.

Other Fire Protection Requirements:

- The water supply for the foam system shall be from a reiable source, approved by the authority having jurisdiction.
- The foam components shall be installed in a readily accessible area of the heliport and not penetrated the approach, departure, or transitional areas.
- Fixed foam system components utilizing deck level nozzles and/or oscillating monitors shall be listed or approved.
- Where freezing is possible, adequate freeze protectin shall be provided.
- Where buildings are provided with a fire alarm system, a manual pull station shall be provided for each designated means of egress from the roof.

Determining Discharge Time and Application Rate:

Hand Hoselines: The discharge rates and minimum amounts of water for foam production for semi-fixed systems are listed in Table 15.

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TABLE 15: DETERMINING DISCHARGE TIME AND APPLICATION RATE - HAND HOSELINES

Heliport Category			1/2 O.L. of Largest Helicopter	Fuselage Width Tripled	Practical Critical Fire Area	Application Rate	Q_1	Q_2	Q
	(ft)	(ft)	(ft)	(ft)	(ft^2)	(gpm/ft^2)	(gal)		(gal)
H-1	0 < 50		25	X 15	= 375	X 0.10	= 37.5	+ 100%	= 75
H-2	50 < 80		40	X 21	= 840	X 0.10	= 84	+ 100%	= 168
H-3	80 < 120		60	X 24	= 1440	X 0.10	= 144	+ 100%	= 288

O.L.: Overall length, measured from tip of main rotor fully extended to tip of tail rotor fully extended. Fuselage width: Actual fuselage width (does not include gear) measured from outside of cabin.

Q1: Water to control within 1 minute. Q2: Reserve to extinguish. Q: Total water to extinguish.

Fixed Nozzles/Monitors: The minimum required discharge time for fixed nozzles/monitors is 5 minutes. When AFFF is supplied, the required minimum application rate is 0.10 gpm/ft^2 (4.1 Lpm/m^2).

Calculating Foam Quantity: Fixed Nozzles/Monitors: To calculate the minimum foam concentrate quantity for fixed nozzles and/or monitors, use the following formula to determine Foam Solution Discharge Rate, which is required to determine proportioner size and nozzle quantity:

FOAM SOLUTION DISCHARGE RATE = AREA OF LANDING DECK X APPLICATION RATE

Note: For some heliport installations, an allowance should be made to account for adverse site conditions which may effect foam distribution.

Now, calculate the foam concentrate quantity using the following formula:

QUANTITY = FOAM SOLUTION DISCHARGE RATE X 5 MINUTES X CONCENTRATE %

E. Spill Fire Protection

Spill fire protection may be considered for areas where flammable liquids are processed, stored, handled, or transported. Because spill fire size and shape are often unpredictable, spill fire protection should not be considered a replacement for those systems previously discussed. The area to be protected should be studied carefully, and the actual system provided must be approved by the end-user and the authority having jurisdiction.

Notice: Spill fire protection should not be confused with dike protection requirements where fuel-in-depth fires from the failure of a large storage tank are possible.

The largest potential spill area must be carefully considered to determine the number, type, and location of discharge devices; as well as the quantity of foam concentrate required. Factors that must be considered include:

1. Amount, source, and type of potential flammable liquid spill.
2. Physical characteristics of the flammable liquids, such as viscosity, that may limit or aid the spread of a spill.
3. Presence of dikes, curbs, drainage systems, etc., that may contain a spill.
4. Type of ground surface (such as sand, clay, asphalt, concrete, etc.) that may limit or aid the spread of a spill.
5. The surface grade or slope of the areas that may limit, aid, or redirect the spread of a spill.

Protection Options: Protection for a flammable liquid spill fire may be a fixed system such as an oscillating monitor prepiped to a bladder tank and proportioner, or portable equipment such as hand hose lines supplied from an eductor with a pick-up tube and 5 gal. concentrate containers.

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Determining Discharge Time and Application Rate: The amount of foam concentrate must be sufficient for a discharge time of 15 minutes with fixed systems and 15 minutes with portable equipment. The application rates are as follows:

TABLE 17: DETERMINING DISCHARGE TIME & APPLICATION RATE - SPILL FIRE PROTECTION

Fuel Protected	Foam Concentrate	Application Rate	
		gpm/ft²	(Lpm/m²)
Hydrocarbon (Water Insoluble)	AFFF	0.10	(4.1)
Alcohols			
Methanol	Refer to specific data sheets for type of foam concentrate being used or consult the manufacturer.		
Ethanol			
Isopropanol			
Ketones			
Methyl Ethyl Ketone	Refer to specific data sheets for type of foam concentrate being used or consult the manufacturer.		
Acetone			
Carboxylic Acids			
Aldehydes*			
Esters			
Esthers (Ethyl Tertiary Butyl Ether)			

*Consult Chemguard foam data sheets for other specific fuels. Rates are based on Type II discharge devices but can be used for Type III provided the fuel depth does not exceed 1” (25.4 mm). If fuel depth exceeds 1”, and Type III application technique is used, above application rates should be increased by 60%.

F. High-Expansion Foam Systems

Where traditional foam or water extinguishing agents are unable to reach the source of the fire, such as with hazardous toxic chemicals, medium- and high-expansion foam systems are are used. These systems offer a fire extinguishing procedure that will automatically seek out and extinguish the fire at the source in applications such as warehouses, storage buildings, basements, tunnels, etc. The foam blanket that is produced by this system transports water to the fire, suffocates and cools the fire, suppresses escaping vapors and encapsulates the toxic vapors and particulate.

Hazards Protected: This section outlines the requirements found in NFPA 11 “Standard for Low-, Medium-, and High-Expansion Foam”. NFPA 11 permits medium- and high-expansion foam systems to protect the following:

- Ordinary combustibles
- Flammable and combustible liquids
- Combinations of the above 2
- Liquefied natural gas (high-expansion foam only)

Refer to NFPA 11 for more detailed information. Note that this standard refers to minimum application rates of expanded foam as cubic feet per minute (cfm) (cubic meters per minute (m^3/m)), NOT as a solution in gpm (Lpm).

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System Requirements:

Safety and Training of Personnel: All personnel likely to use foam system equipment shall be properly trained in its operation and in the necessary fire-fighting techniques. Procedures for personnel evacuation should be implemented before and during system actuation in accordance with NFPA 11.

Electrical Clearances: There is a limited amount of moisture in foam, so it should be used with caution around exposed electrical equipment. It should NOT be used near high voltages. Refer to Table 6.6.2.1 in NFPA 11 for minimum clearance requirements.

System Devices, Operation, and Control: NFPA 11 requires listed or approved methods or devices for automatic detection and indication of heat, smoke, or flame, and they shall be installed in accordance with NFPA 72. Note: Removal of automatci detection is permitted when approved by the AHJ. Supervision shall be provided and audible alarms installed to indicate system operation, to alert personnel, and indicate failure of any supervised device or equipment. Alarms shall indicate operation or hazardous conditions shall be distinctive from failure of supervised equipment or devices.

Operating Devices: Include Foam generators, valves, proportioners, eductors, discharge controls, and shutdown equipment. Operation shall be controlled by listed or approved mechanical, electrical, hydraulic, or pneumatical means. A reliable source of energy shall be used; the power supply for electrically operated systems is required to be as reliable as a fire pump circuit in accordance with NFPA 20.

All operating devices shall be suitable for the service they will encounter and shall not be readily rendered inoperable or susceptible to accidental operation. Devices must be located, installed, or suitably protected so that they are not subject to mechanical, chemical, climatic, or other conditions that would render them inoperative. Equipment shall be provided with emergency manual operation as described in NFPA 11*.

All required door and window closers, vent openers, and electrical equipment shutdown devices are required to be integral parts of the system and function simultaneously with system operation.

Provisions shall be made to protect piping that is normally filled with liquid from freezing.

Foam Concentrate: The foam concentrate must be listed for use with the equipment and the quality shall be tested.

Air Supply: Air from outside the hazard area must be used for foam generation unless there is specific data (as described in NFPA 11) showing air can be used from inside the hazard. Vents from the fire area must be located to avoid recirculation of combustion products or materials that would negatively affect the formation of foam into foam generator air inlets.

Foam Generator Location: Foam generating equipment must be located as close as possible to the hazard being protected, while not being exposed to a fire or explosion. Protection from fire exposure for the duration of the fire must be provided in accordance with NFPA 11*.

Distribution Systems: Piping and fittings shall conform to the requirements of Chapter 4 in NFPA 11.

Arrangement and Installation of Piping and Fittings: A listed strainer suitable for use with the proportioner and foam generator shall be provided in the water line upstream of the water valve.

Ducts: Foam distribution and air inlet ducts must NOT be subject to undue mechanical, chemical, or other damage as well as undue turblence. Duct closures are required to be the quick-opening type, to allow free passage of foam, and care should be taken to ensure positive operation when subjected to fire or heat exposure. The actual foam discharge rate shall be tested or determined as appropriate to the AHJ.

*NFPA 11-2005 edition.

TECHNICAL DATA

FOAM SYSTEM

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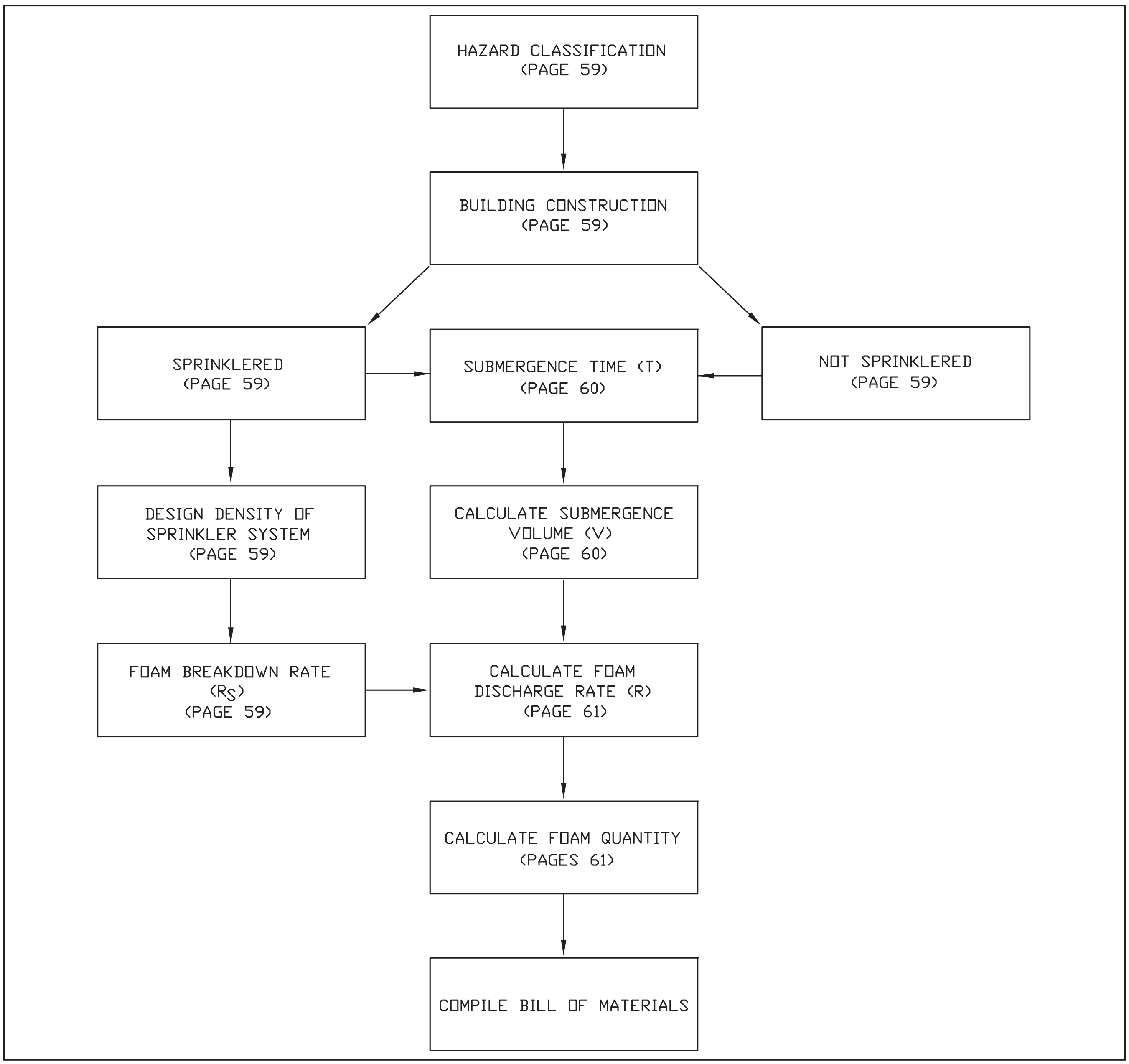
Types of High-Expansion Foam Systems: There are three types of High-Expansion Foam Systems:

- Total Flooding Systems
- Local Application Systems
- Portable Foam-Generating Devices

1. *Total Flooding High-Expansion Foam Systems:* High-expansion foam generators typically deliver expansion ratios between 200:1 and 1000:1. High-expansion foam is capable of totally flooding large rooms and enclosures, so it can be carried to the source of the fire. These systems are permitted to be used where there is an adequate permanent enclosure around the hazard. Refer to enclosure specifications in NFPA 11; foam must accumulate to a certain depth above the hazard and be maintained for a period of time. Allowing the foam to dissipate helps minimize water damage to the enclosure and its contents. High-expansion foam effectively controls Liquefied Natural Gas (LNG) fires by blocking heat feed-back from the flames to the LNG, reducing the vaporization rate.

   The following chart shows a logical sequence for designing Total Flooding Systems:



Total Flooding High-Expansion Foam System Flow Chart

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The minimum application rate of expanded foam necessary to extinguish or control a fire depends on several factors that include hazard classification, building construction, whether there is a sprinkler system, submergence time and volume, and foam generator selection.

Hazard Classification: This is based on the products to be stored, used, or moved in and out of the protected area. When more than one type of product is present, the most severe hazard must be the one considered for determining hazard classification. An example is Low-Density Combustibles (such as foam rubber, foam plastics, rolled tissue, or crepe paper). Refer to Table 18 for classifications.

Building Construction: There are two classifications:

- Light or unprotected steel construction, or
- Heavy, protected, or fire-resistive construction.

Building construction is one factor used to determine submergence time in Table 18.

TABLE 18: SUBMERGENCE TIME FOR HIGH-EXPANSION FOAM

Type of Hazard	Light or Unprotected Steel Construction		Heavy or Protected or Fire Resistant Construction	
	Sprinklered	Not Sprinklered	Sprinklered	Not Sprinklered
Flammable Liquids (Flash Points below 100 °F (38 °C) having a vapor pressure not exceeding 40 PSI (27 bar)	3 minutes	2 minutes	5 minutes	3 minutes
Combustible Liquids (Flash Points at or above 100 °F (38 °C)	4 minutes	3 minutes	5 minutes	3 minutes
Low Density Combustibles (i.e., Foam Rubber, Plastics, Rolled Tissue)	4 minutes	3 minutes*	6 minutes	4 minutes*
High Density Combustibles (i.e., Rolled Paper, Kraft or Coated-Banded)	7 minutes	5 minutes*	8 minutes	6 minutes*
High Density Combustibles (i.e., Rolled Paper, Kraft or Coated-Unbanded)	5 minutes	4 minutes*	6 minutes	5 minutes*
Rubber Tires	7 minutes	5 minutes*	8 minutes	6 minutes*
Combustibles, in cartons, bags, fiber drums	7 minutes	5 minutes*	8 minutes	6 minutes*

*These submergence times may not be directly applicable to high-piled storage above 15 ft (4.6 m) or where fire spread through combustible contents is very rapid.

Table from NFPA 11-2005 edition.

Sprinkler Systems and Foam Breakdown Rate (Rs): If the hazard area has a sprinkler system, the foam breadown rate from spraying sprinklers must be calculated. The amount of destroyed foam is shown on the technical data page for the specific Chemguard generator being used. There should be a design information sign at the sprinkler system alarm valve, dry valve, or preaction valve location that contains sprinkler design density and floor area. The following formula is used to calculate the foam breakdown rate:

FOAM BREAKDOWN RATE (R_S) = FOAM DESTROYED X SPRINKLER DESIGN DENSITY X FLOOR AREA

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For example, when using the Chemguard Model 3000WP Generator:

R_S = 6.4 cfm/gpm x 0.30 gpm/ft^2 x 3000 ft^2

R_S = 5,760 cfm (161.28 m^3/m)

Submergence Time (T): After determining the type of hazard, building construction, and calculating foam breakdown (where a sprinkler system is present), select the appropriate value for the minimum submergence time (T) from Table 18. Submergence time is is based on a maximum of 30 seconds delay between fire detection and start of foam discharge. Any delays in excess of .0 seconds must be deducted from the times. Polar solvents are not included in the table.

Minimum Submergence Volume (V): To calculate this, multiply the floor areea of the hazard to be protected by the minimum fill depth. The minimum total depth of foam shall be no less than 1.1 times the height of the highest hazard, but in no case less than 2 ft (0.6 m) over this hazard. To determine the minimum fill depth of foam, find the height of the highest hazard and use that height in one of the following formulas:

If hazard height is less than 20 ft (6.1 m), use this formula:

MINIMUM FILL DEPTH = HEIGHT + 2 FEET (0.6 m)

If hazard height is at least 20 ft (6.1 m), use this formula:

MINIMUM FILL DEPTH = HEIGHT X 1.1

Then, calculate the minimum submergence volume using this formula:

MINIMUM SUBMERGENCE VOLUME (V) = FLOOR AREA X MINIMUM FILL DEPTH

Note: Fractions or decimals should be rounded up to the nearest whole number.

For flammable or combustible liquids, the foam depth is allowed to be significantly greater and must be a minimum depth as determined by tests that duplicate the anticipated fire event in the protected area (refer to NFPA 11).

TYPICAL CALCULATION
EXAMPLE ONE: HEIGHT IS LESS THAN 20 FT (6.1 m)
Floor Area = 100 ft x 30 ft = 3,000 ft^2 (279 m^2)
Hazard Height = 12 ft (3.7 m)
Minimum Fill Depth = 12 ft + 2 ft = 14 ft (4.3 m)
Minimum Submergence Volume (V) = 3,000 ft^2 x 14 ft = 42,000 ft^3 (1,189 m^3)
EXAMPLE TWO: HEIGHT IS 20 FT (6.1 m) OR MORE
Floor Area = 100 ft x 30 ft = 3,000 f^{t2} (279 m^2)
Hazard Height = 25 ft (7.6 m)
Minimum Fill Depth = 25 ft x 1.1 = 27.5 ft (8.4 m)
Minimum Submergence Volume (V) = 3,000 ft^2 x 27.5 ft = 82,500 ft^3 (2,336 m^3)

For unsprinklered rooms of combustible construction or finish, submergence volume must be based on the entire volume, including concealed spaces. Note that the volume occupied by permanently located equipment does not need to be included, while the volume occupied by stored material must be included.

Compensation for Foam Shrinkage (C_N = 1.15): This factor takes into account average expanded foam losses due to drainage, fire, wetting of surfaces, etc. This factor is 1.15 unless otherwise specified.

Compensation for Foam Leakage (C_L): This factor accounts for expected foam loss from leakage around doors, windows and other openings that can't be closed (vents, etc.). For a completely sealed area, C_L equals 1. However, the factor most often used is 1.2 for a building with all openings normally closed, depending on foam expansion ratio, sprinkler operation, and foam depth.

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Calculate Foam Discharge Rate (R): Use information from above to calculate foam discharge rate (R) using this formula:

$R = (V/T + R_S) \times C_N \times C_L$

Where:

R = minimum rate of foam discharge in cfm (m^3/m)

V = minimum submergence volume in ft^3 (m^3)

T = time to achieve submergence volume (minutes)

R_S = rate of foam breakdown by sprinklers in cfm (m^3/m)

C_N = compensation for normal foam shrinkage (%)

C_L = compensation for normal foam leakage (%)

Calculate Foam Quantity: To calculate the amount of foam for operating a total flooding system, several steps are required. First, choose a foam generator from Table 19. Determine the values for foam output and solution flow according to generator inlet pressure.

TABLE 19: HIGH EXPANSION FOAM GENERATORS - TYPICAL DISCHARGE CHARACTERISTICS

Genterator Part Number/ Chemguard Model No.	Generator Inlet Pressure		Generator Output		Solution Flow		Foam Breakdown	Expansion
	PSI	(bar)	cfm	(m^3/m)	GPM	(Lpm)		
F15105/3000WP	40	2.76	2950	83	46	175	6.4	?/1
	60	4.14	3825	107	57	216		
	80	5.5	4300	121	66	17.5		
F15106/6000WP	60	4.14	4875	137	75	285	6.4	?/1
	70	4.8	5450	153	84	319		
	80	5.5	5925	166	139	527		
F15108/15000WP	50	2.76	10750	301	110	417	5.1	?/1
	75	5.17	14800	415	231	876		
	100	6.9	17000	476	153	580		
F15109/18000WP	40	2.76	12600	353	178	675	2.8	?/1
	60	4.14	15300	429	204	774		
	80	5.5	19000	532	240	910		
F15110/25000WP	40	2.76	19063	534	179	679	5.1	?/1
	60	4.14	23440	657	210	796		
	80	5.5	26200	734	235	891		

Use the following formula to calculate the number of generators needed:

NUMBER OF GENERATORS = DISCHARGE RATE (R) / GENERATOR FOAM OUTPUT

Note: Any fractions should be rounded up to the next whole number.

System flow rate is the total flow of water and concentrate per minute for the total number of generators.

Calculate system flow rate with this formula:

SYSTEM FLOW RATE = NUMBER OF GENERATORS X SOLUTION FLOW

The proportion rate for Chemguard C2 or CX High Expansion Foam Concentrate is 2% (2 gallons of concentrate to 98 gallons of water). It is expressed as 0.02 in the formulas.

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The operating time for the system's foam concentrate and water supply shall be sufficient to:

Continually operate the system for 25 minutes, or

To generate four times the submergence volume

(Whichever is less, but in no case less than enough for 15 minutes of full operation.)

One of the previous requirements must be met to determine the quantity of foam concentrate required for the system. The formulas for each option are as follows:

1. QUANTITY = SYSTEM FLOW RATE X 25 MIN X PROPORTION RATE
2. QUANTITY = [(4 X SUBMERGENCE VOLUME (V) / GENERATOR FOAM OUTPUT] X SOLUTION FLOW X PROPORTION RATE.
3. QUANTITY = SYSTEM FLOW RATE X 15 MIN X PROPORTION RATE

The lesser quantity from formula 1 or 2 may be used for the system unless that value is less than the quantity for formula 3, then the value for 3 must be used.

A reserve supply of foam concentrate shall be readily available to return the system to service after operation. This supply must be in separate storage tanks or original shipping containers on the premises, or available from an approved source within 24 hours.

TYPICAL CALCULATION

HAZARD AREA = 125 ft x 180 ft x 30 ft x 30 ft high (38 m x 55 m x 9 m high)

MAXIMUM STORAGE HEIGHT = 25 ft (7.6 m)

CONSTRUCTION = Light Steel, and No Sprinkler System

TYPE OF HAZARD = High Density Combustible (Rolled Paper, Coated-Unbanded)

MINIMUM FILL DEPTH = 25 ft x 1.1 = 27.5 ft (8.4 m)

SUBMERGENCE VOLUME (V) = (125 ft x 180 ft) x 27.5 ft = 618,750 ft^3 (17521 m^3)

SUBMERGENCE TIME (T) = 4 minutes (from Table 18)

FOAM DISCHARGE RATE (R) = (618,750 ft^3 / 4 min) x 1.15 x 1.2 = 213,469 cfm (6045 m^3/m)

The Chemguard Model ? is selected as the generator to be used and there is a minimum of 75 PSI inlet pressure to the generators.

FROM TABLE 19:

GENERATOR FOAM OUTPUT = 18,000 cfm

SOLUTION FLOW = 231 gpm

NUMBER OF GENERATORS = 213,469 cfm / 18,000 cfm = 12 (11.86 rounded up)

SYSTEM FLOW RATE = 12 x 231 gpm = 2772 gpm (10,506 Lpm)

The choices for foam quantity are:

1. Quantity = 2772 gpm x 25 min x 0.02
   = 1386 gal (5250 L) of Chemguard C2 or CX Concentrate
2. Quantity = [(4 x 618,750 ft^3) / 18,000 cfm] x 231 gpm x 0.02
   = 635 gal (2407 L) of Chemguard C2 or CX Concentrate
3. Quantity = 2772 gpm x 15 min x 0.02
   = 831 gal (3150 L) of Chemguard C2 or CX Concentrate

The quantity of concentrate for four times the submergence volume (formula 2) is less than the 25 minute duration (formula 1) but is also less than the 15 minute minimum requirement. Therefore, the quantity of concentrate required for this system would be the value from formula 3, which is 831 gal (3150 L).

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Maintenance of Submergence Volume: For adequate fire control or extinguishment, the submergence volume must be maintained for at least 60 minutes for unsprinklered locations and 30 minutes for sprinklered locations. *Exception:* Where the hazard consists of flammable or combustible liquids in noncombustible containers, the time is permitted to be reduced.

Method: The submergence volume may be maintained by continuous or intermittent operation of any or all of the generators provided. Means for maintaining submergence volume without waste of foam concentrate that might be needed shall be provided in case of reignition

Overhaul: Procedures must be preplanned to prevent loss of control by submergence of the hazard.

Distribution: The foam generators shall be located to discharge a relatively even amout of foam throughout the protected area.

2. *Local Application Systems:* In hazard areas where a high expansion total flooding system is not feasible and the hazard is not totally enclosed, the local application system may be more useful.

   These systems are used for protecting relatively flat surfaces such as confined spills, curbed areas, pits, trenches, etc with flammable or combustible liquids liquefied natural gas (LNG), and ordinary Class A combustibles. When protecting multi-level or three dimensional hazards, an acceptable method of foam containment is required.

   The volume of medium expansion foam solution is expanded to between 20:1 and 200:1. The foam generator creates a foam blanket that prevents the release of fuel vapor while the higher water content provides additional cooling. Medium-expansion foam works well in outdoor applications because the foam is less affected by wind conditions than high-expansion foam.

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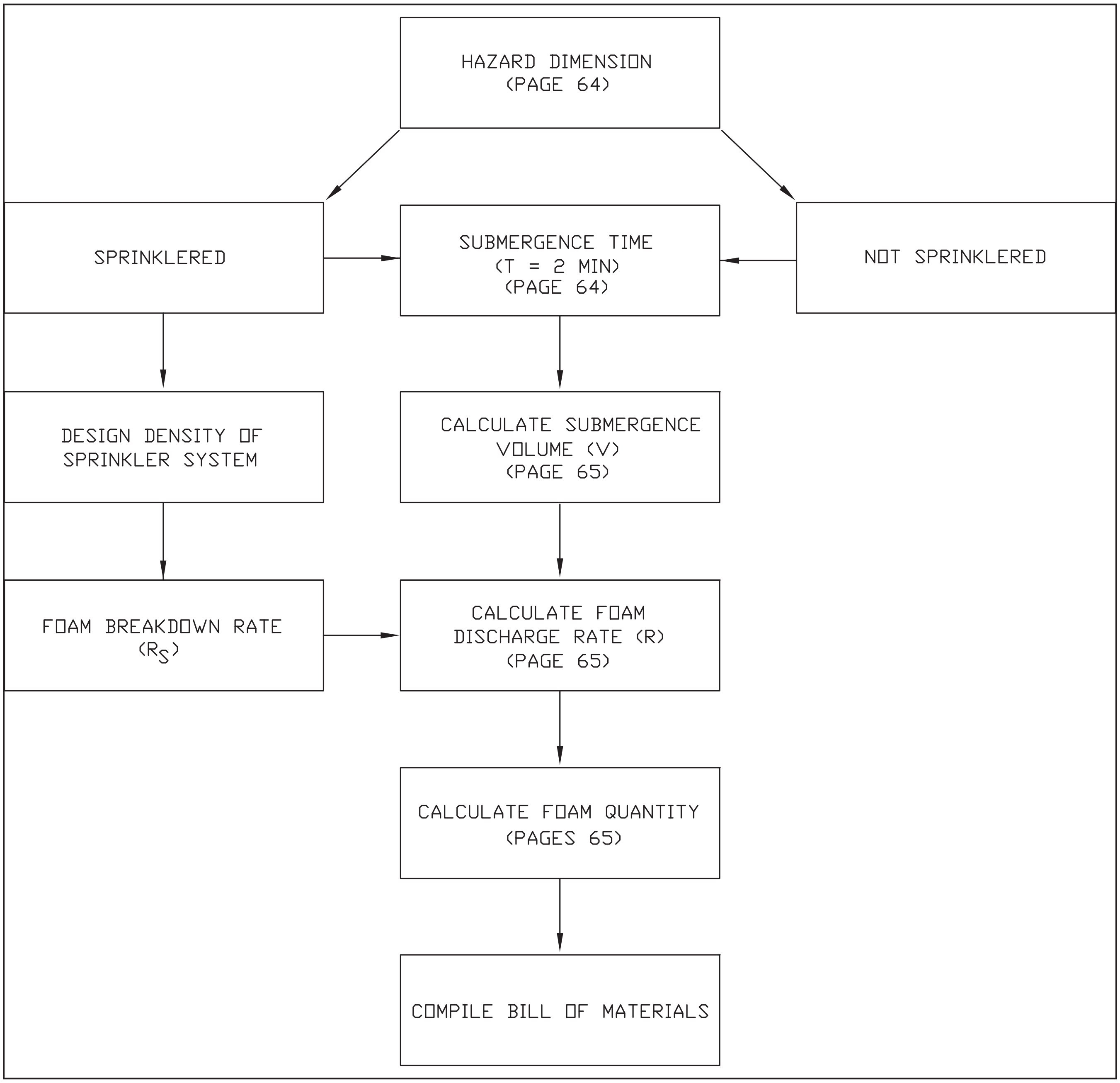
The following chart shows a logical sequence for designing Local Application Systems:



Local Application Systems Flow Chart

Hazard Dimension: The protected hazards may be located indoors, partially sheltered, or entirely outdoors. Containment of foam to the hazard must be considered along with compensating for weather effects such as wind.

Sprinkler Systems and Foam Breakdown Rate (Rs): If the hazard area has a sprinkler system, use the guidelines and formula for sprinkler systems on page 58 for the total flooding system.

Submergence Time (T = 2 Minutes): The design criteria for a local application medium/high expansion foam system is to discharge a sufficient quantity of expanded foam to cover the hazard at least 2 ft (0.6 m) deep within 2 minutes.

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Minimum Submergence Volume (V): The area of protection shall include all areas to where the fire may spread with a minimum required depth of foam to at least 2 ft (0.6 m) over the hazard.

MINIMUM SUBMERGENCE VOLUME = HAZARD AREA X (HAZARD HEIGHT + 2 FT (0.6 m))

Calculate Foam Discharge Rate (R): Use the design formula for total flooding systems on page 60. Include the standard values for C_N (1.15) and C_L (1.2).

Calculate Foam Quantity: After the minimum foam discharge rate (R) has been calculated, choose a foam generator from Table 19. Determine the number of generators needed for the system using the following formula:

NUMBER OF GENERATORS = DISCHARGE RATE (R) / GENERATOR FOAM OUTPUT

The system flow rate is the total flow of water and concentrate per minute for the total number of generators required. Calculate the system flow rate with this formula:

SYSTEM FLOW RATE = NUMBER OF GENERATORS X SOLUTION FLOW

The proportion rate for Chemguard C2 or CX High Expansion Foam Concentrate is 2% (2 gallons of concentrate to 98 gallons of water). A medium expansion foam is usually used at a rate of 2%. The rate is expressed as 0.02 in the formulas.

The system's foam concentrate and water supply must be sufficient to allow continuous operation of the system for at least 12 minutes. Therefore, the quantity of foam concentrate required for a local application system is calculated as follows:

QUANTITY = SYSTEM RATE X 12 MIN X PROPORTION RATE

A reserve supply of foam concentrate and water supply must be sufficient for 12 minutes of continuous foam system operation. The quantity of required foam concentrate for a local application system is calculated as:

QUANTITY = SYSTEM FLOW RATE X 12 MIN X PROPORTION RATE

A reserve supply of foam concentrate must be available to return the system to service after operation. The supply may be in original shipping containers on the premisis or in separate storage tanks, or available from an approved source within 24 hours.

Note: Per NFPA 11, a local application system requires a minimum duration of discharge of 12 minutes. Specific hazard analysis may require additional agent to extend discharge and/or protection time by cycling system on/off for maintaining the minimum required foam depth.

VI. PLACING THE SYSTEM IN SERVICE

(Refer to technical data.)

VII. SYSTEM INSPECTIONS, TESTS, AND MAINTENANCE

NOTICE: THE OWNER IS RESPONSIBLE FOR MAINTAINING THE FIRE PROTECTION SYSTEM AND DEVICES IN PROPER OPERATING CONDITION. FOR MINIMUM MAINTENANCE AND INSPECTION REQUIREMENTS, REFER TO RECOGNIZED STANDARDS SUCH AS THOSE PRODUCED BY NFPA, LPC, AND VDS WHICH DESCRIBE CARE AND MAINTENANCE OF SPRINKLER SYSTEMS. IN ADDITION, THE "AUTHORITY HAVING JURISDICTION" MAY HAVE ADDITIONAL MAINTENANCE, TESTING AND INSPECTION REQUIREMENTS WHICH MUST BE FOLLOWED.

WARNING: ANY SYSTEM MAINTENANCE OR TESTING WHICH INVOLVES PLACING A CONTROL VALVE OR DETECTION SYSTEM OUT OF SERVICE MAY ELIMINATE THE FIRE PROTECTION OF THAT SYSTEM. PRIOR TO PROCEEDING, NOTIFY ALL AUTHORITIES HAVING JURISDICTION. CONSIDERATION SHOULD BE GIVEN TO EMPLOYMENT OF A FIRE PATROL IN THE AFFECTED AREA.

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It is imperative that the system be inspected and tested on a regular basis in accordance with NFPA 11, NFPA 16, and NFPA 25. The following recommendations are minimum requirements. The frequency of the inspections may vary due to contaminated or corrosive water supplies and corrosive atmospheres. In addition, the alarm devices or other connected equipment may require more frequent inspections. Refer to the technical data, system description, applicable codes and Authority Having Jurisdiction for minimum requirements. Prior to testing the equipment, notify appropriate personnel.

Refer to the Warnings and General Notes on page 2a-d in the Design section of the Viking Foam Data Book.

A. Alarm Test - Please refer to the Special Notes in the technical data page for the particular foam system used, before performing an alarm test, otherwise, an unwanted release of foam concentrate will occur. At least quarterly, test all connected alarm devices by opening the remote inspectors test valve.

B. Riser Flow Test - Please refer to Special Notes in the technical data page for the particular foam system used, before performing the riser flow test, otherwise, an unwanted release of foam concentrate will occur. At least quarterly, perform a riser flow test. Observe and record the supply pressure gauge reading. Open the main drain valve fully. Again, observe and record the supply pressure gauge reading. Close the main drain valve. If the readings vary significantly from those previously established or from normal, check the main supply line for obstructions or closed valves and correct any problems found.

C. General - Visually inspect the valve, trim, piping, alarm devices and connected equipment for physical damage, freezing, corrosion or other conditions that may inhibit the proper operation of the system.

VIII. TROUBLESHOOTING

1. For operating and maintenance instructions pertaining to Viking manufactured equipment, refer to the appropriate section of the Viking Engineering and Design Data Book.
2. For operating and maintenance instructions pertaining to foam equipment manufactured for Viking, refer to the appropriate section of the Viking Foam Data Book.
3. For operation and maintenance instructions for all other equipment, refer to appropriate equipment data.

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