A.5.2.4.3.2 If application results in foam submergence, the performance of alcohol-resistant foams usually deteriorates significantly, particularly where there is a substantial depth of fuel. The degree of performance deterioration depends on the degree of water solubility of the fuel (i.e., the more soluble, the greater the deterioration). Special alcohol-resistant foams are available for polar solvents in depths greater than 1 in. (25 mm) in both AFFF and SFFF.

N **A.5.2.4.4** Foam should not be used with monitors or handlines to plunge into polar solvents such as ethanol. Every effort should be made to apply the foam as gently as possible to the fuel surface. When using handlines, care should be exercised to gently apply the foam.

A.5.2.5.1 For this application, discharge outlets are commonly called foam chambers. Most foam chambers are of a Type II discharge outlet design, since they are normally suitable for use with modern foams.

Δ **A.5.2.5.2.1** It is recommended that, for tanks greater than 200 ft (61 m) in diameter, at least one additional discharge outlet should be added for each additional 5000 ft^2 (460 m^2) of liquid surface or fractional part thereof. Since there has been limited experience with foam application to fires in fixed-roof tanks greater than 140 ft (43 m) in diameter, requirements for foam protection on such tanks are based on the extrapolation of data from successful extinguishments in smaller tanks. Tests have shown that foam can travel effectively across at least 100 ft (30 m) of burning liquid surface. On fixed-roof tanks of over 200 ft (61 m) diameter, subsurface injection can be used to reduce foam travel distances for tanks containing hydrocarbons only. Unless subsurface foam injection is utilized, a properly sized flanged connection should be installed on all atmospheric pressure storage tanks, regardless of present intended service, to facilitate the future installation of an approved discharge outlet if a change in service should require such installation. Figure A.5.2.5.2.1(a) and Figure A.5.2.5.2.1(b) are typical fixed foam discharge outlets or foam chambers.

A.5.2.5.2.2 Type I discharge outlets are considered obsolete, and Type I outlets that are damaged effectively become Type II outlets. Minimum discharge times and application rates for Type I outlets currently installed are provided in Table 5.2.5.2.2 for fixed-roof tanks storing hydrocarbons and in Table 5.2.5.3.4 for flammable and combustible liquids requiring alcohol-resistant foams.

Δ **A.5.2.5.3** The system should be designed based on fighting a fire in one tank at a time. The rate of application for which the system is designed should be the rate computed for the protected tank considering both the liquid surface area and the type of flammable liquid stored. For example, the property contains a 40 ft (12 m) diameter tank storing ethyl alcohol and 35 ft (11 m) diameter tank storing isopropyl ether. The liquid surface area of a 40 ft (12 m) diameter tank equals 1257 ft^2 (117 m^2). Assuming the solution rate for ethyl alcohol is 0.1 gpm/ft^2 (4.1 mm/min), then 1257 gpm/ft^2 × 0.1 = 126 gpm (477 L/min). The liquid surface area of a 35 ft (11 m) diameter tank equals 962 ft^2 (89 m^2).

Assuming the solution rate for isopropyl ether is 0.15 gpm/ft^2 (6.1 mm/min), then 962 ft^2 × 0.15 gpm/ft^2 = 144 gpm. For SI units: Solution rate = 89 × 6.1 = 543 L/min. In this example, the smaller tanks storing the more volatile product require the higher foam-generating capacity. In applying this requirement, due consideration should be given to the future possibility of change to a more hazardous service requiring greater rates of application. Unfinished solvents or those of technical grade can contain quantities of impurities or diluents. The proper rate of application for these, as well as for mixed solvents, should be selected with due regard to the foam-breaking properties of the mixture.

A.5.2.5.3.2 Systems using these foams require special engineering consideration.

Δ **A.5.2.6.1** Experience with fuel storage tank firefighting has shown that the main problems are operational (i.e., difficulty in delivering the foam relatively gently to the fuel surface at an application rate sufficient to effect extinguishment). A properly engineered and installed subsurface foam system offers the potential advantages of less chance for foam-generation equipment disruption as a result of an initial tank explosion or the presence of fire surrounding the tank, and the ability to conduct operations a safe distance from the tank. Thus, the opportunity for establishing and maintaining an adequate foam application rate is enhanced. The following guidelines regarding fire attack are recommended. After necessary suction connections are made to the water supply and foam-maker connections are made to foam lines, foam pumping operations should be initiated simultaneously with opening of block valves permitting the start of foam flow to the tank. Solution pressure should be brought up to and maintained at design pressure.

When foam first reaches the burning liquid surface, there can be a momentary increase in intensity caused by the mechanical action of steam formation when the first foam contacts the heat of the fire. Initial flame reduction and reduc-

Δ **FIGURE A.5.2.5.2.1(a) Foam Chamber.**

Shaded text = Revisions. Δ = Text deletions and figure/table revisions. • = Section deletions. *N* = New material.

Δ FIGURE A.5.2.5.2.1(b) Foam Chamber Deflector.

tion of heat is then usually quite rapid, and gradual reduction in flame height and intensity will occur as the foam closes in against the tank shell and over the turbulent areas over foam injection points. If sufficient water supplies are available, cooling of the tank shell at and above the liquid level will enhance extinguishment and should be used. Care should be taken that water streams are not directed into the tank where they could disrupt the established foam blanket. After the fire has been substantially extinguished by the foam, some fire can remain over the point of injection. With flash points below 100°F (38°C) (Class IB and Class IC liquids), the fire over the turbulent area will continue until it is adequately covered by foam. With gasoline or equivalent liquids, when fire remains only over the area of injection, intermittent injection should be used so that foam will retrogress over the area during the time foam injection is stopped. Depending on local circumstances, it might be possible to extinguish any residual flickers over the turbulent area with portable equipment rather than continue the relatively high rate of application to the whole tank. If the tank contains a burning liquid capable of forming a heat wave, a slop-over can occur from either topside or subsurface injection of foam, especially if the tank has been burning for 10 minutes or longer. Slop-over can be controlled by intermittent foam injection or reduction in foam-maker inlet pressure until slop-over ceases. Once slop-over has subsided, and in the case of liquids that do not form a heat wave, the pump rate should be continuous. Figure A.5.2.6.1(a) and Figure

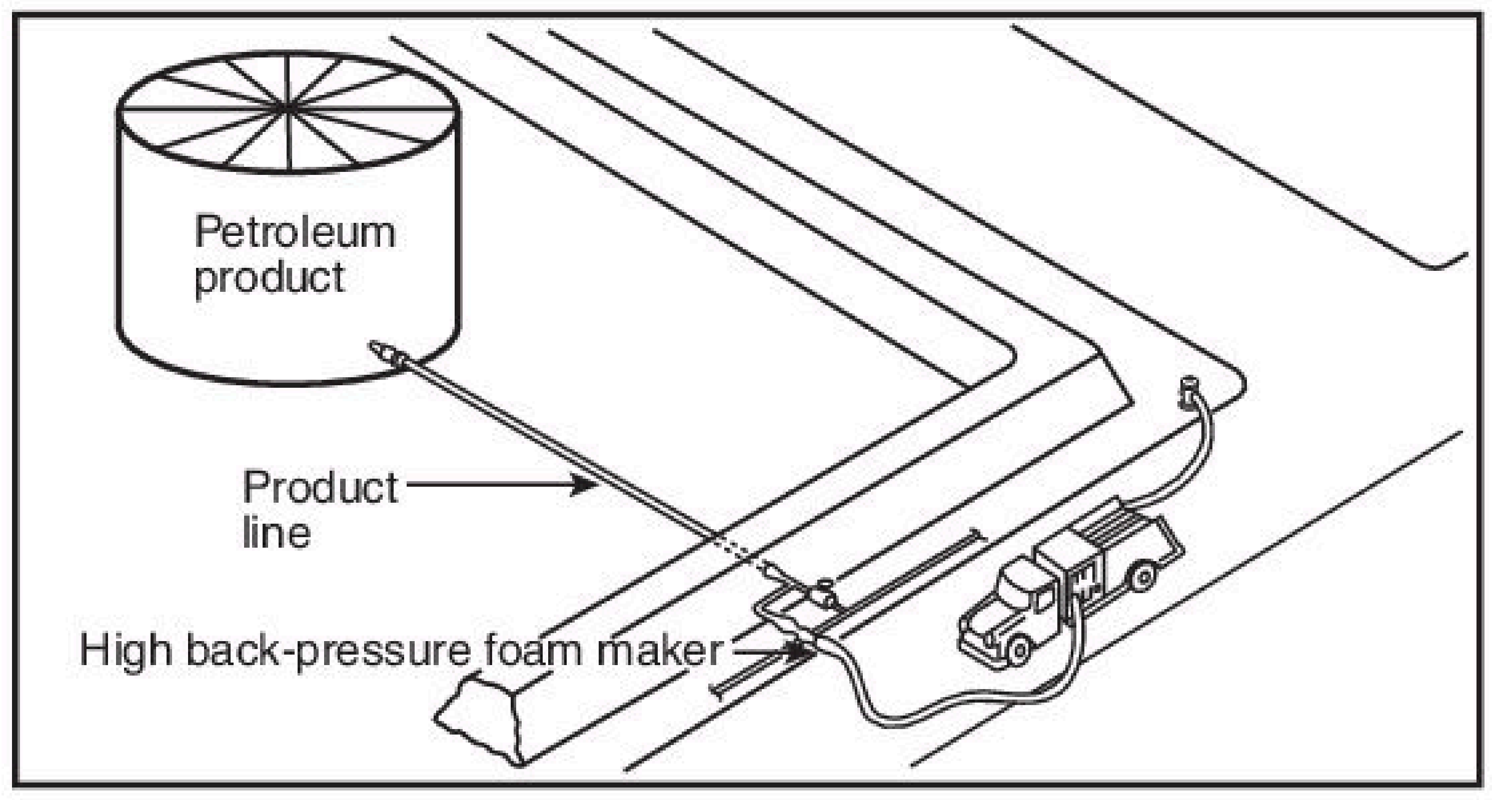


FIGURE A.5.2.6.1(a) Semifixed Subsurface Foam Installation.

A.5.2.6.1(b) illustrate typical arrangements of semifixed subsurface systems.

N **A.5.2.6.1.2** The expansion ratios for subsurface injection are typically between 2:1 and 4:1. Limited testing with SFFFs applied with subsurface form injection systems suggests that, for some fuels, some SFFFs can be applied using subsurface foam injection systems. However, the user should check with the specific foam manufacturer to confirm that it has been tested for that use.

Δ **A.5.2.6.2** Figure A.5.2.6.2(a) through Figure A.5.2.6.2(c) should be used to determine foam velocity. Expanded foam flow rate, adjusted to the supply curve, should be used for this calculation; that is, multiply the supply calculation flow rate by the maximum expansion ratio of 4:1. Expanded foam velocity also can be calculated by using the following formulas:

[A.5.2.6.2a]

$$\text{English velocity (ft/sec)} = \frac{\text{Expanded foam (gpm)}}{KA}$$

where:
gpm = gallons per minute
K = constant 449
A = area of ID of the injection pipe (ft^2)

or

[A.5.2.6.2b]

$$V = \frac{\text{gpm foam}}{d^2} \times 0.4085$$

where:
d = pipe ID (in.)

[A.5.2.6.2c]

$$\text{Metric velocity (m/sec)} = \frac{\text{L/min foam}}{d^2} \times 21.22$$

where:
d = pipe ID (mm)

Figure A.5.2.6.2(d) illustrates optional arrangements for multiple subsurface discharge outlets.

N **A.5.2.6.2.4** Fire tests have proven that most types of firefighting foam applied by monitors, fixed foam appliances, and compressed air foam appliances can and will travel over a burning fuel surface greater than 100 ft (30 m). Test results show that travel of 130 ft (40 m) to as much as 150 ft (46 m) is possible. See *LASTFIRE Ongoing Testing of New Generation Foams DFW Large Scale Extended Flow Test Report* for supporting test data.

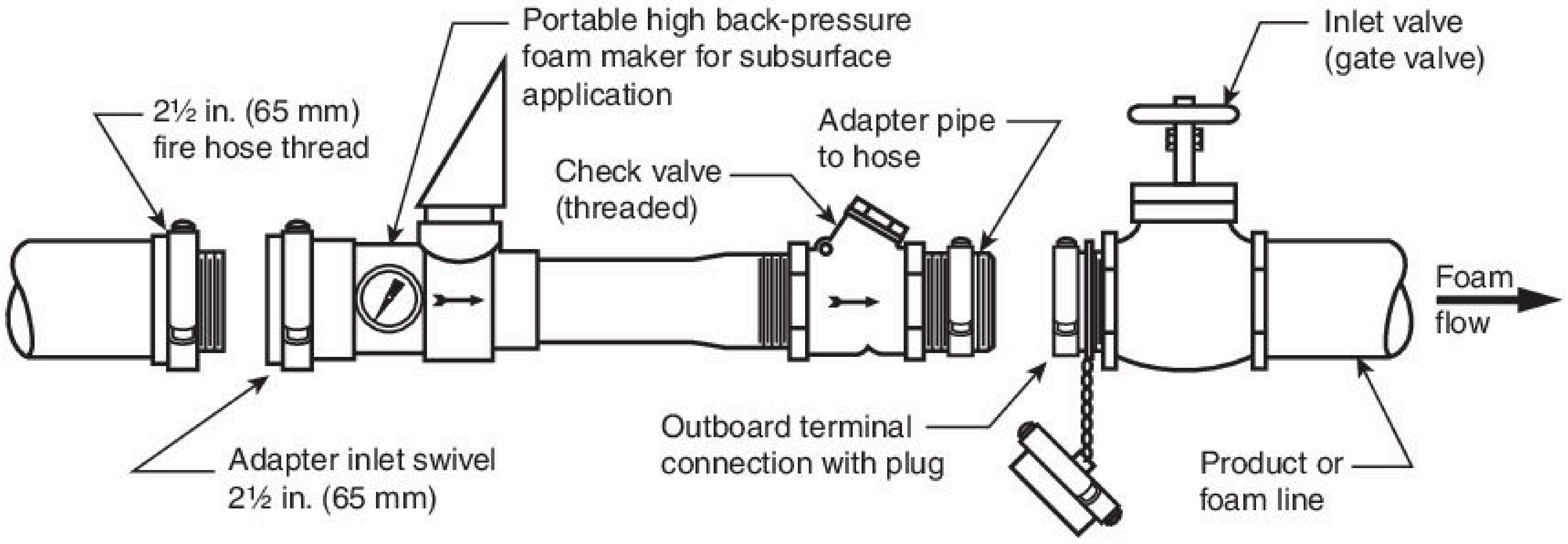
A.5.2.6.3 Figure A.5.2.6.3 illustrates a typical foam inlet tank connection.

A.5.2.6.3.1 Liquid hydrocarbons that contain foam-destructive products might require higher application rates. Some foams might fail to extinguish fires in gasolines containing oxygenates where subsurface discharge is used at the usually required rate. Optimum fluoroprotein foam, AFFF, and FFFP characteristics for subsurface injection purposes should have expansion ratios between 2 and 4. *[See Figure A.5.2.6.3.1(a) and Figure A.5.2.6.3.1(b).]*

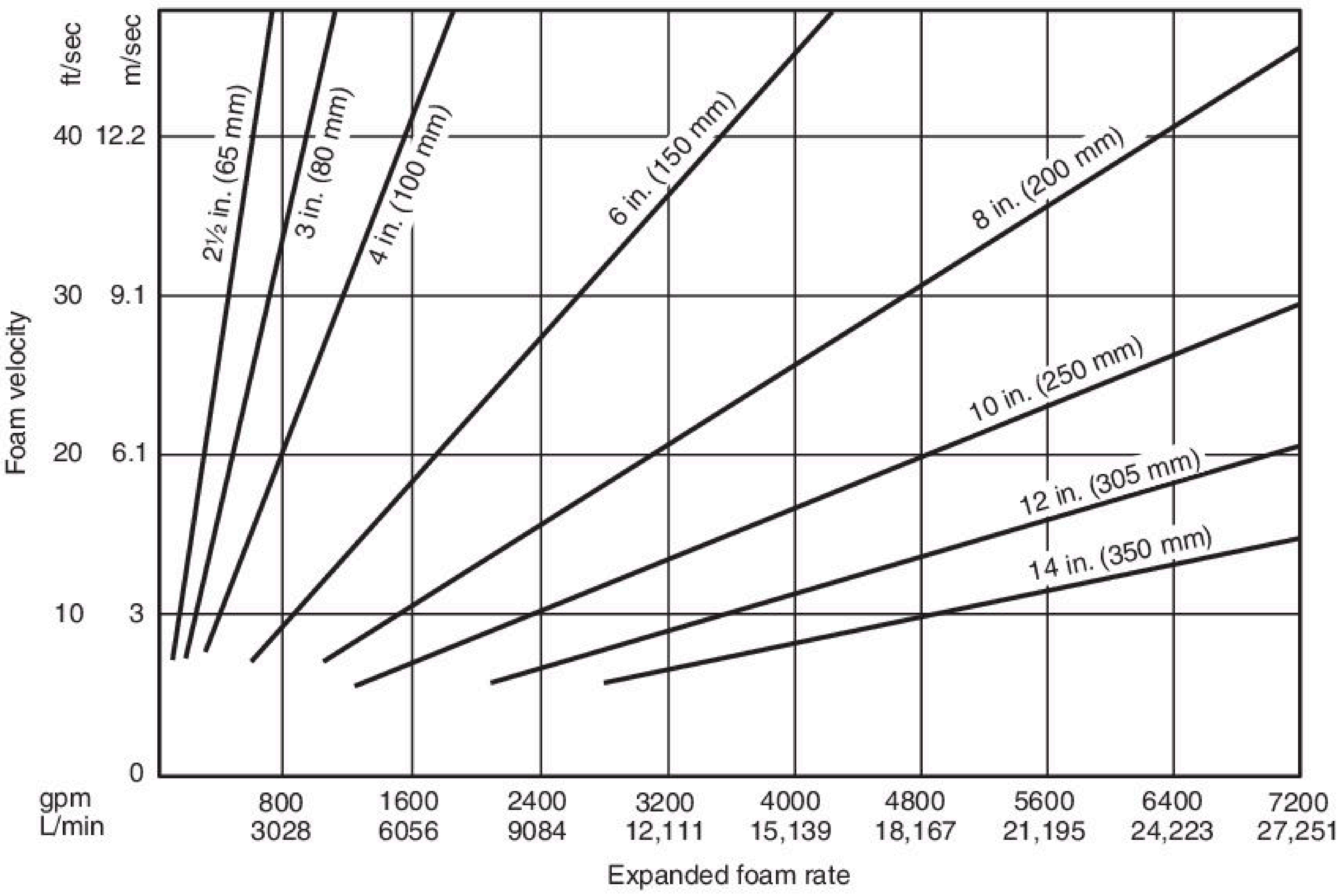
A.5.2.6.4 The back pressure consists of the static head plus pipe friction losses between the foam maker and the foam inlet to the tank. The friction loss curves, as shown in Figure A.5.2.6.4(a) and Figure A.5.2.6.4(b), are based on a maximum foam expansion of 4, which is the value to be used for friction loss and inlet velocity calculations.

A.5.2.6.5.2 Liquid hydrocarbons that contain foam-destructive products might require higher application rates. Some foams might fail to extinguish fires in gasolines containing oxygenates where subsurface discharge is used at the usually required rate.

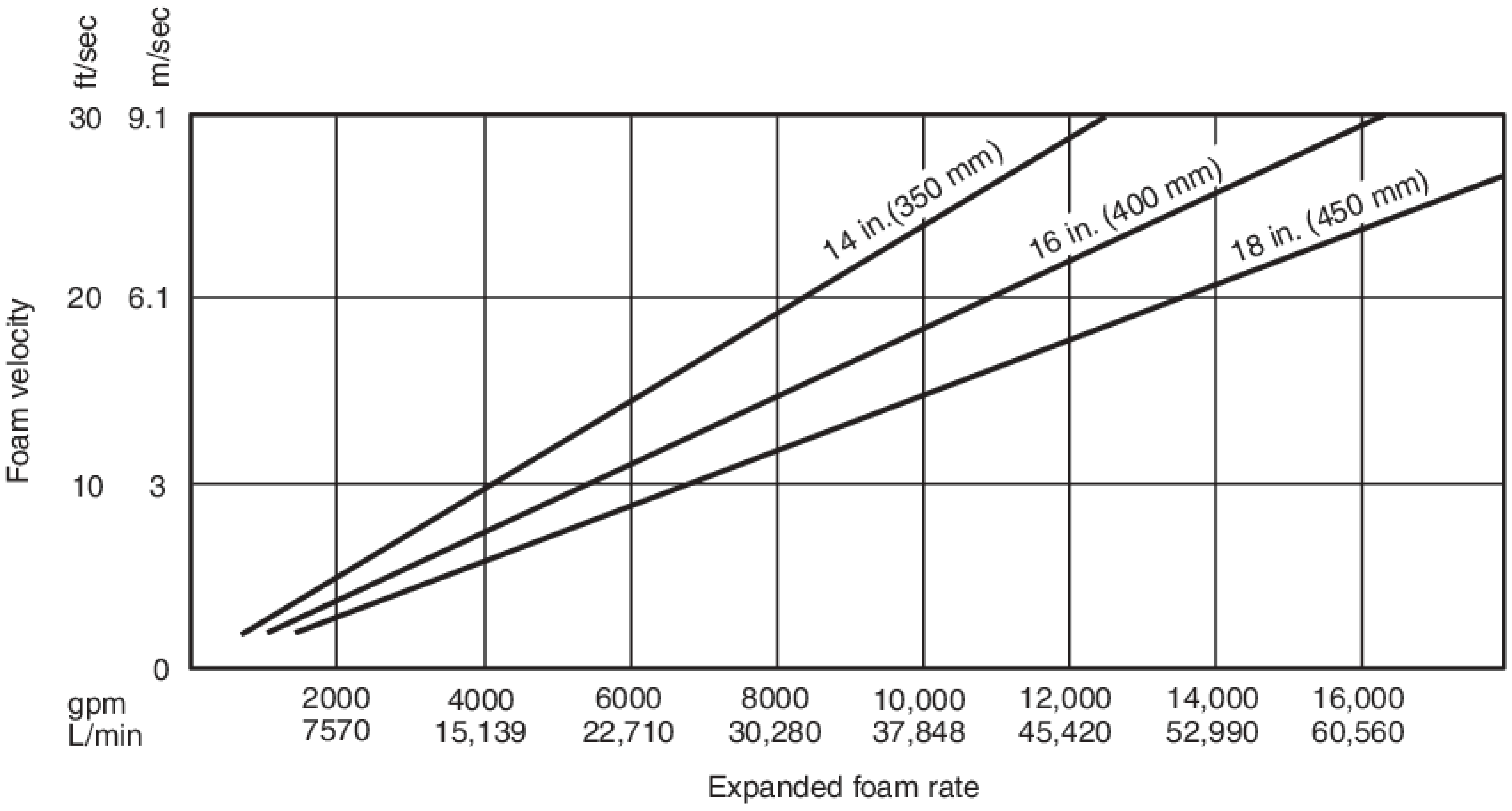
Δ **A.5.2.7** This section describes the design criteria that are applicable to systems used to apply foam to the surface of fixed-roof (cone) storage tanks via a flexible hose rising from the base of the tank. Manufacturer recommendations should be followed for the design and installation of such systems. For semisubsurface system arrangement, see Figure A.5.2.7.



Δ **FIGURE A.5.2.6.1(b) Typical Connection for Portable High Back-Pressure Foam Maker for Subsurface Application in Semifixed System.**



Δ **FIGURE A.5.2.6.2(a) Foam Velocity vs. Pipe Size [2 ½ in. (65 mm), 3 in. (80 mm), 4 in. (100 mm), 6 in. (150 mm), 8 in. (200 mm), 10 in. (250 mm), and 12 in. (305 mm)] — Standard Schedule 40 Pipe.**



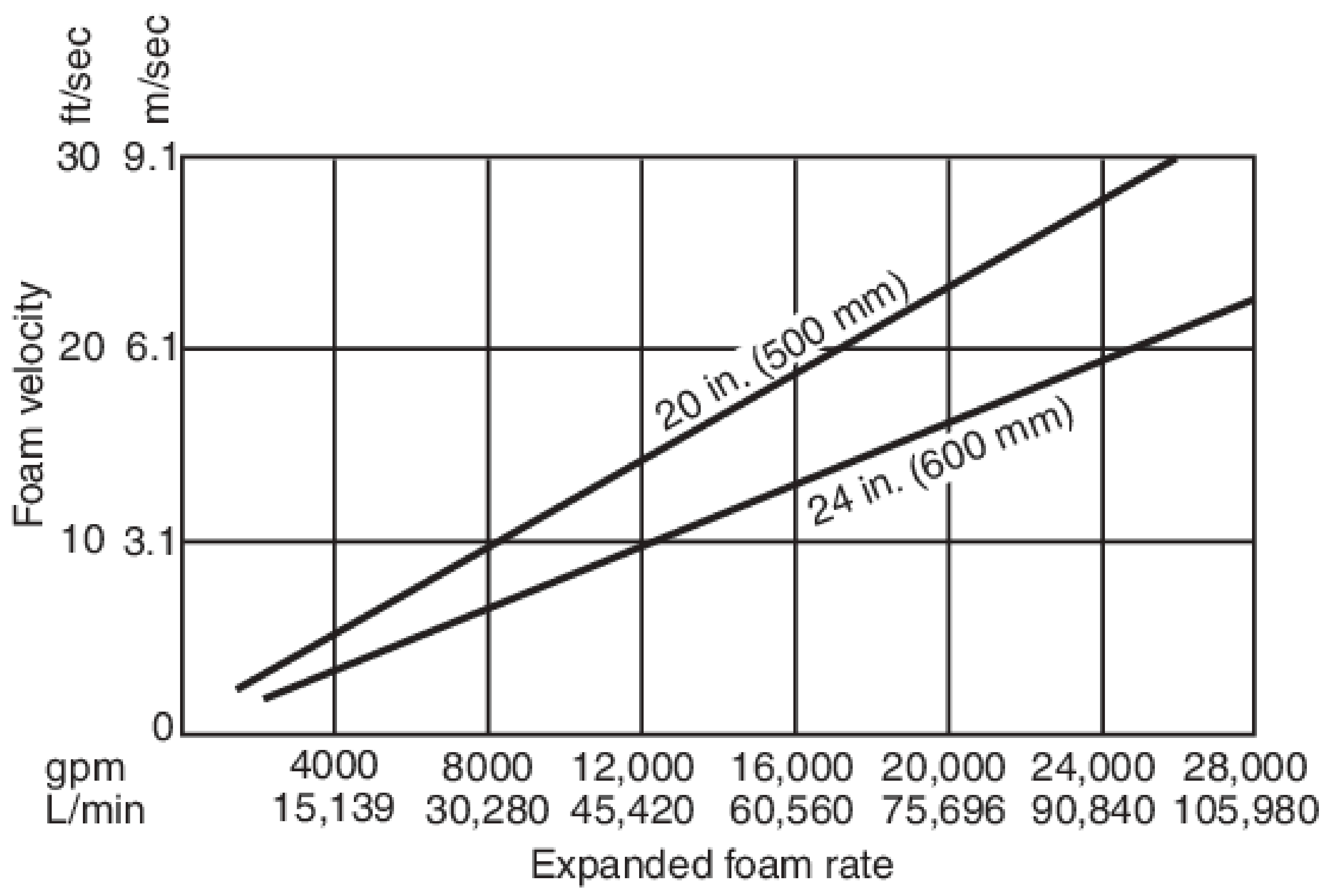
Δ FIGURE A.5.2.6.2(b) Foam Velocity vs. Pipe Size [14 in. (350 mm), 16 in. (400 mm), and 18 in. (450 mm)] — Standard Schedule 40 Pipe.

These systems are not considered appropriate for floating roof tanks with or without a fixed roof because the floating roof prevents foam distribution. The flexible foam delivery hose is contained initially in a sealed housing and is connected to an external foam generator capable of working against the maximum product head. When operated, the hose is released from its housing, and the hose floats to the surface as a result of the buoyancy of the foam. Foam then discharges through the open end of the hose directly onto the liquid surface.

Consideration should be given to the following factors when selecting this type of system:

(1) The total foam output should reach the surface of the burning liquid.
(2) With large tanks, the semisubsurface units can be arranged to produce an even distribution over the fuel surface.
(3) Any type of concentrate suitable for gentle surface application to the particular fuel can be used.
(4) Foam-generating equipment and operating personnel can be located at a distance from the fire.
(5) The system can be used for the protection of foam destructive liquids, provided the flexible hose is not affected by them.
(6) Certain high-viscosity fuels might not be suitable for protection by this type of system.
(7) There is no circulation of the cold fuel and, therefore, no assistance in extinguishment.
(8) The system can be difficult to check, test, and maintain.
(9) The high back-pressure foam generator has to produce foam at a pressure sufficient to overcome the head pressure of fuel as well as all friction losses in the foam pipework. Friction losses with foam differ from those with foam solution.

Design application rates and discharge times for hydrocarbons are typically the same as for Type II topside application systems [i.e., 0.1 gpm/ft^2 (4.1 mm/min)]. Manufacturers should be consulted for appropriate application rates and design recommendations to be followed for protection of products requiring the use of alcohol-resistant foams.



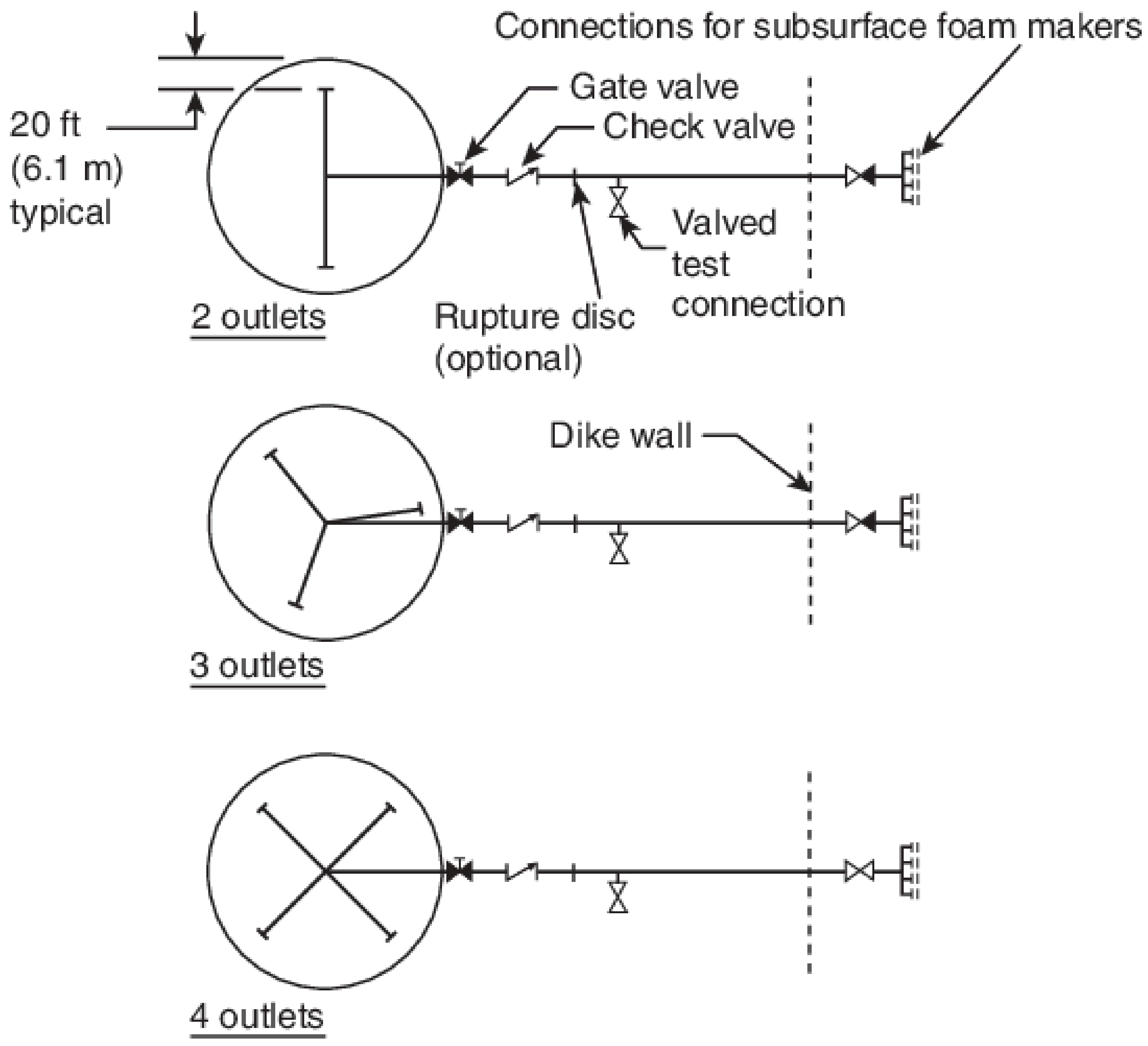
Δ FIGURE A.5.2.6.2(c) Foam Velocity vs. Pipe Size [20 in. (500 mm) and 24 in. (600 mm)] — Standard Schedule 40 Pipe.

Duration of discharge should be in accordance with Table A.5.2.7(a).

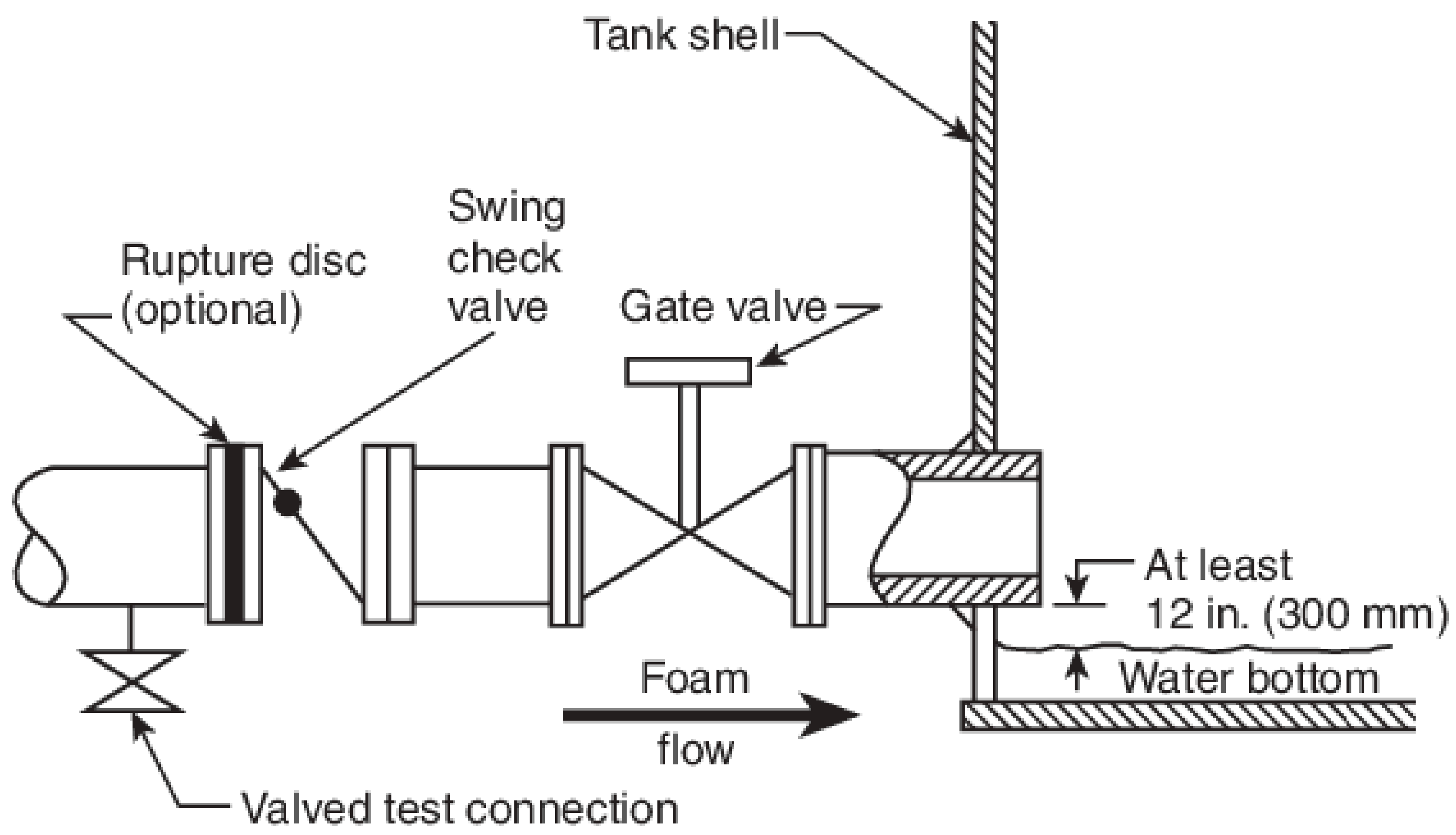
Semisubsurface foam units should be spaced equally, and the number of units should be in accordance with Table A.5.2.7(b).

A.5.3 Within the scope of this standard, open-top floating roof tanks are defined as vertical cylindrical tanks without fixed roofs that have double-deck or pontoon-type floating roofs and are constructed in accordance with the requirements of NFPA 30. The seal can be a mechanical shoe seal or tube seal. The tube seal can be equipped with a metal weather shield. Secondary seals of combustible or noncombustible materials can also be installed. *[See Figure 5.3(a) through Figure 5.3(d).]*

N **A.5.3.1.2(3)** LASTFIRE has developed testing protocols. Examples of other tank construction include full liquid surface contact, metallic sandwich panels and full liquid surface contact, and composite sandwich roof/seal systems, designed



Δ **FIGURE A.5.2.6.2(d) Typical Arrangement of Semifixed Subsurface System.**



Δ **FIGURE A.5.2.6.3 Typical Tank Foam-Maker Discharge Connection for Subsurface Injection.**

in accordance with the performance criteria in Appendix H, "Internal Floating Roofs," of API STD 650.

Δ **A.5.3.3** Open-top floating roof tanks can be subject to two distinct types of fires: a seal fire or a full surface area fire (as a result of the floating roof sinking). Experience indicates that the most frequent type of fire involves only the seal of the floating roof tank. Prior to selection of the method of protection, the type of fire that will serve as the basis for design should be defined. *(See NFPA 30 for fire protection requirements.)*

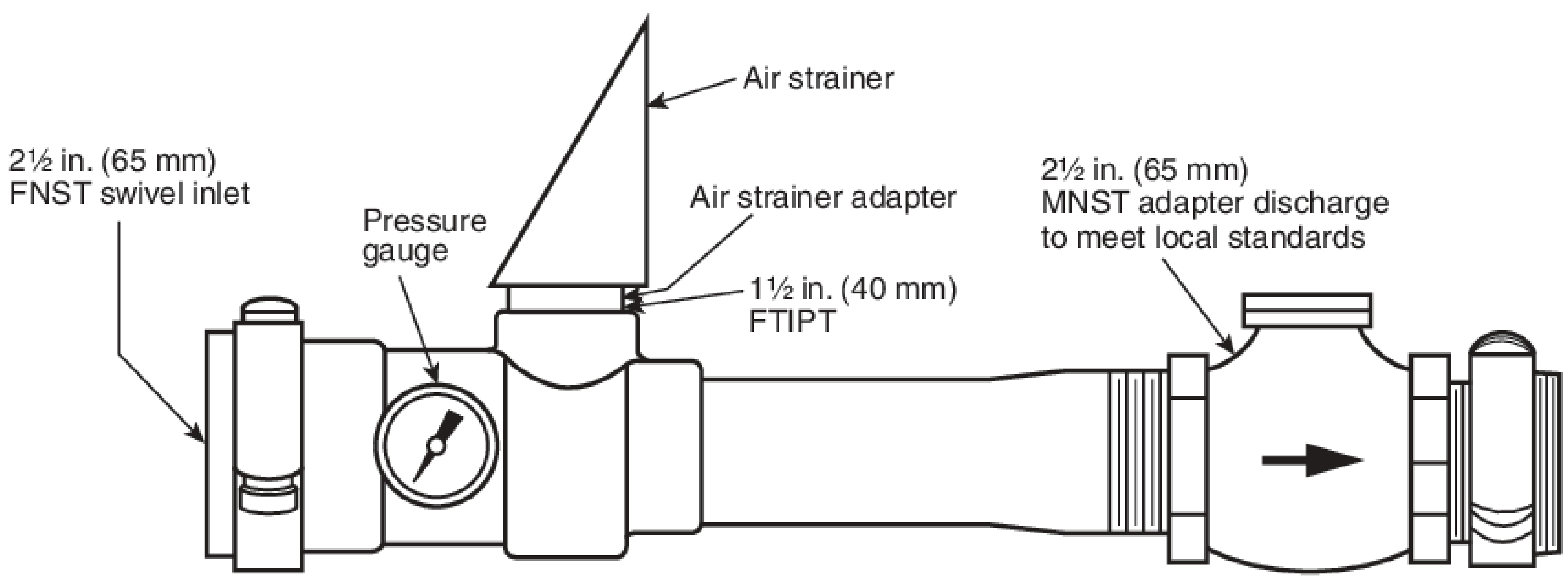
Most fires in open-top floating roof tanks occur in the seal areas, and these fires can be extinguished with the foam systems described in Chapter 5. However, some fires involve the full surface area when the roof sinks. These fires are very infrequent and normally do not justify a fixed system to protect for this risk. Plans should be made to fight a full surface fire in a floating roof tank with portable or mobile equipment. Large capacity foam monitor nozzles with capacities up to 6000 gpm (22,700 L/min) are currently available. If foam-proportioning devices are not provided with the foam monitors, additional foam-proportioning trucks might be required through mutual aid. Generally, the number of foam-proportioning trucks available at any location is not sufficient to fight a sunken floating roof fire, and outside assistance is required.

Generally, the fire water systems available in floating roof tank areas are not designed to fight a full surface fire, so additional water is required. Therefore, relay pumping with municipal or mutual aid water pumpers might be required to obtain enough water for foam generation.

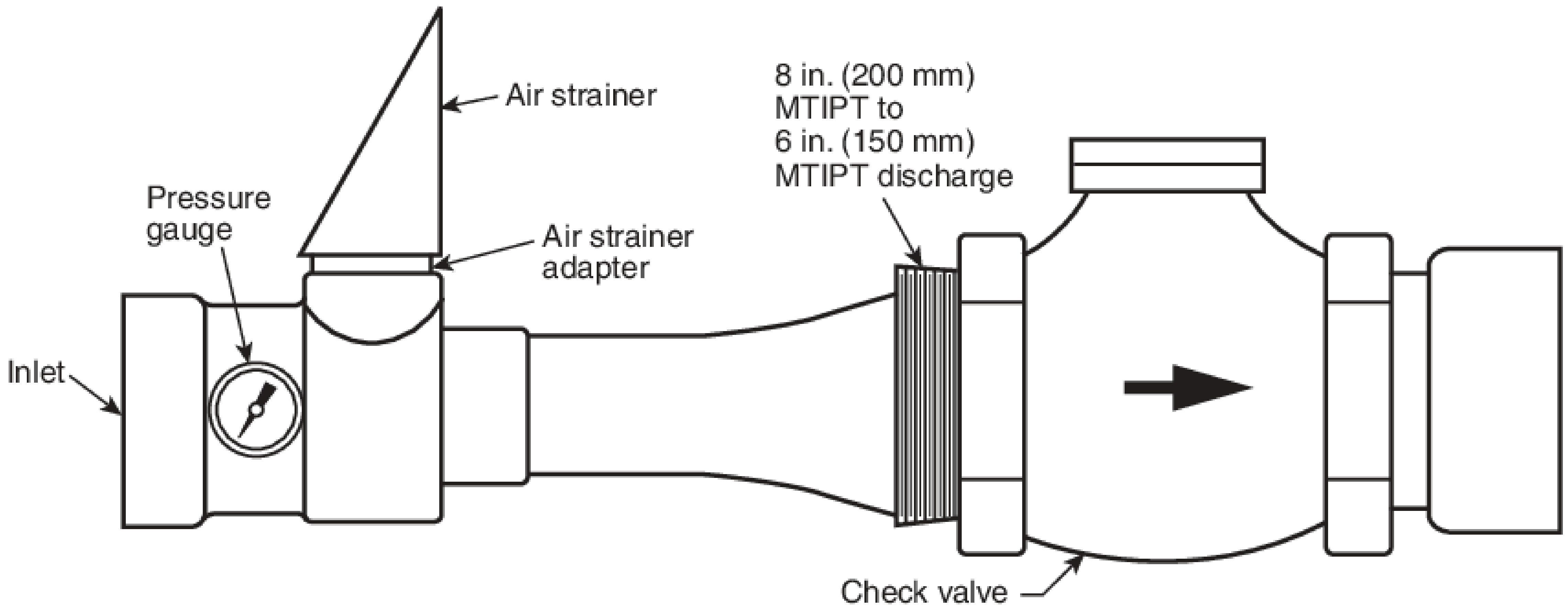
Another aspect to consider is the amount of foam concentrate available. The foam application rate of 0.16 gpm/ft^2 (6.5 mm/min) of surface area listed in Chapter 5 might have to be increased for very large tanks. Therefore, the amount of foam concentrate available through mutual aid should be established prior to the fire. In some cases, it can be necessary to increase the on-site foam storage if mutual aid supplies are limited.

If it is decided to fight a fire in a tank with a sunken roof instead of protecting the adjacent facilities and allowing a controlled burnout, the most important aspect is to have planned ahead and held simulated drills. Coordinating the efforts of many different organizations and various pumping operations required for fighting potentially catastrophic fires requires well-developed plans and plenty of practice.

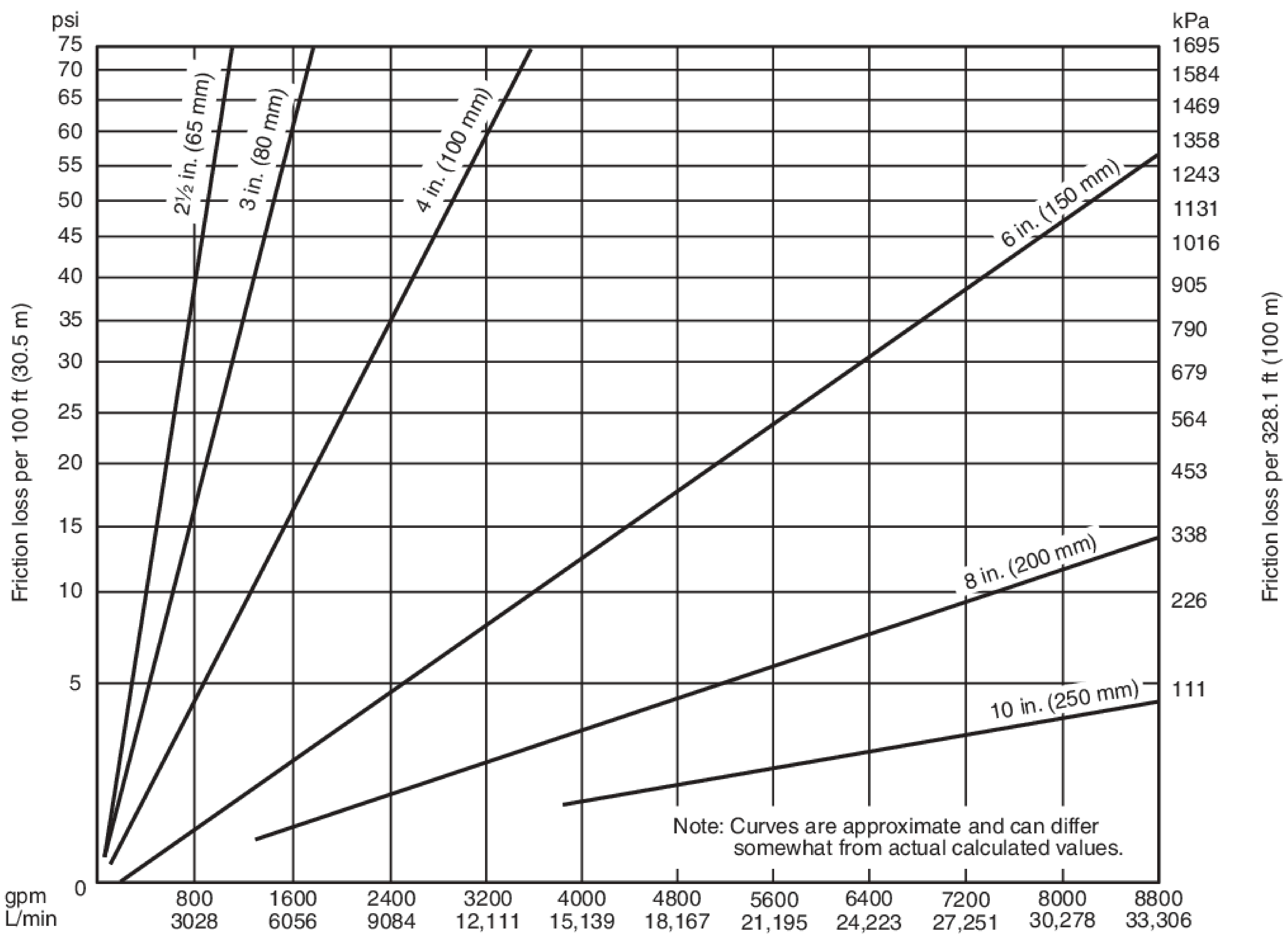
N **A.5.3.4.1(3)** It should be recognized that overapplication of foam to a seal area can cause roof tilt and escalate the fire.



Δ **FIGURE A.5.2.6.3.1(a) Portable High Back-Pressure Foam Maker for Semifixed Systems.**



Δ **FIGURE A.5.2.6.3.1(b) Fixed High Back-Pressure Foam Maker for Fixed Systems.**



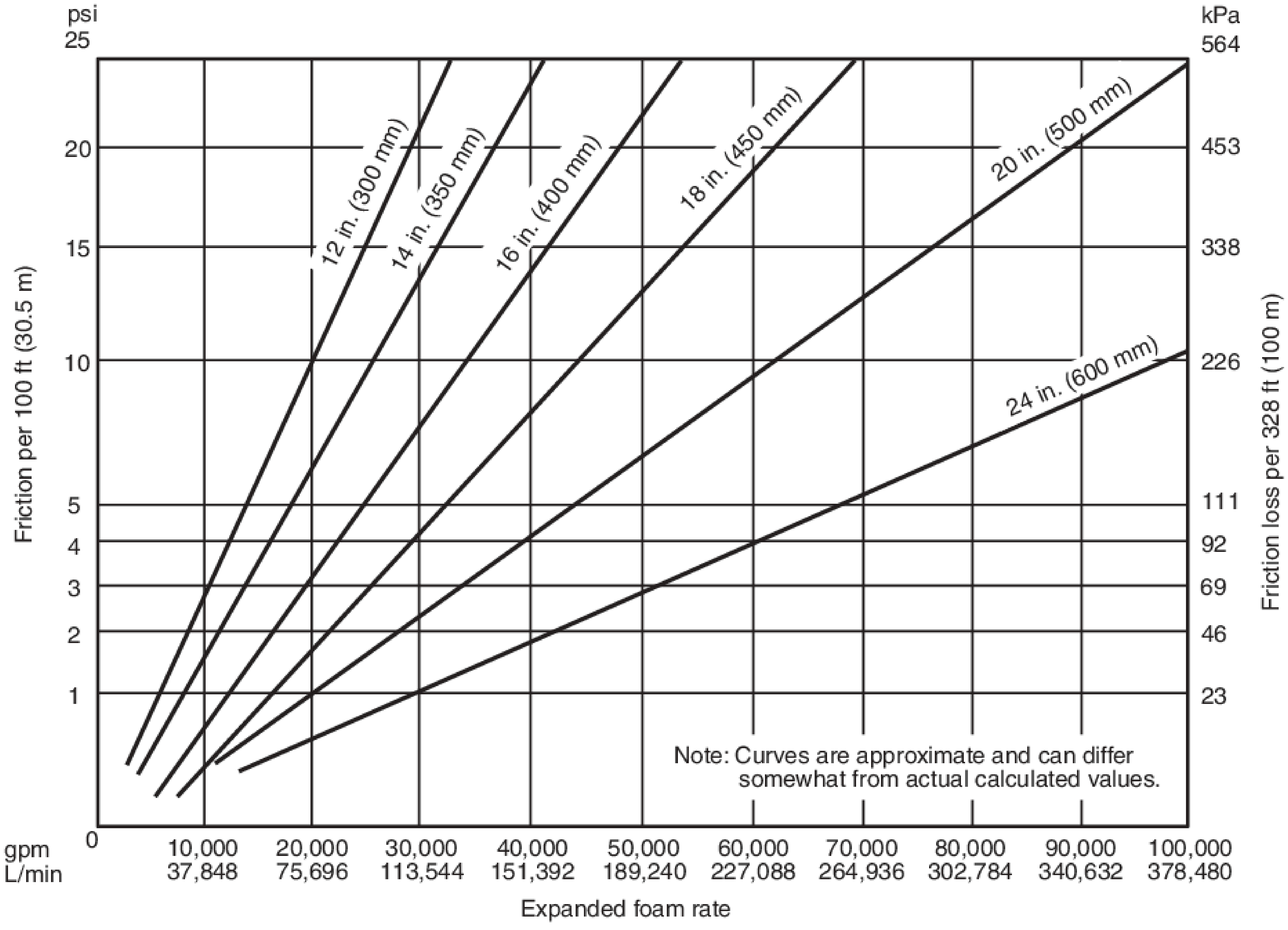
Δ **FIGURE A.5.2.6.4(a) Foam Friction Losses — 4 Expansion [2 ½ in. (65 mm), 3 in. (80 mm), 4 in. (100 mm), 6 in. (150 mm), 8 in. (200 mm), and 10 in. (250 mm)] — Standard Schedule 40 Pipe.**

A.5.3.4.3 The requirements given in this section are based on extrapolations of test experience and appropriate listings and reflect the limitations known to date. Foam can fail to seal against the tank shell as a result of prolonged free burning prior to agent discharge. If adequate water supplies are available, cooling of the tank shell is recommended.

A.5.3.5.2 See Figure A.5.3.5.2(a) and Figure A.5.3.5.2(b).

A.5.3.5.2.3 Since all the discharge outlets are supplied from a common (ring) foam solution main, some vapor seal devices might not rupture due to pressure variations encountered as the system is activated. *[See Figure A.5.3.5.2(a) and Figure A.5.3.5.2(b).]*

A.5.3.5.4.5 Excessive dam openings for drainage should be prohibited to prevent loss of foam through the drainage slots.



Δ FIGURE A.5.2.6.4(b) Foam Friction Losses — 4 Expansion [12 in. (300 mm), 14 in. (350 mm), 16 in. (400 mm), 18 in. (450 mm), 20 in. (500 mm), and 24 in. (600 mm)] — Standard Schedule 40 Pipe.

Δ **A.5.3.6** Use of foam handlines for the extinguishment of seal fires should be limited to open-top floating roof tanks of less than 250 ft (76 m) in diameter. The following design information applies to foam handline protection methods:

(1) A foam dam should be installed in accordance with 5.3.5.4.
(2) To establish a safe base for operation at the top of the tank, a single fixed foam discharge outlet should be installed at the top of the stairs. This fixed foam discharge outlet is supplied to provide coverage of the seal area for approximately 40 ft (12 m) on both sides of the top of the stairs.
(3) The fixed foam discharge outlet should be designed to discharge at least 50 gpm (190 L/min).
(4) To permit use of foam handlines from the wind girder, two 1.5 in. (40 mm) diameter valved hose connections should be provided at the top of the stairs in accordance with Figure A.5.3.6. The wind girder should be provided with a railing for the safety of the firefighters.

A.5.4 Within the scope of this standard, covered (internal) floating roof tanks are defined as vertical cylindrical tanks with a fixed metal roof (cone or geodesic dome) equipped with ventilation at the top and containing a metal double-deck or pontoon-type floating roof or a metal floating cover supported by liquidtight metal flotation devices. They are constructed in accordance with the requirements of NFPA 30. *(See Figure 5.4.)*

N **A.5.4.2** The decision to provide rim seal and/or full surface protection foam systems should include consideration of the tank roof and seal structure and the relative risk associated with potential fire scenarios. See Annex I for additional information on the rim seal fire test protocol.

Δ Table A.5.2.7(a) Duration of Discharge for Semisubsurface Systems

Product Stored	Foam Type Minimum	Discharge Time (minutes)
Hydrocarbons with flash point below 100°F (38°C)	Protein, AFFF, fluoroprotein, FFFP, and alcohol-resistant AFFF or FFFP	55
Flash point at or above 100°F (38°C)	All foams	30
Liquids requiring alcohol-resistant foams	Alcohol-resistant foams	55

A.5.4.2(4) Important fire-resistive properties of these roof/seal systems include:

(1) Conductive top and bottom surfaces to prevent the buildup of static charge
(2) Flame spread Class A rating of the top laminate
(3) Buoyancy in accordance with API STD 650, Appendix H
(4) Noncombustible material covering the vapor space will limit the spread of a potential rim-seal fire

Δ Table A.5.2.7(b) Minimum Number of Subsurface Units

Tank Diameter		Minimum Number of Semisubsurface Units
ft	m	
Up to 80	Up to 24	1
Over 80 to 120	Over 24 to 37	2
Over 120 to 140	Over 37 to 43	3
Over 140 to 160	Over 43 to 49	4
Over 160 to 180	Over 49 to 55	5
Over 180 to 200	Over 55 to 61	6
Over 200	Over 61	6 Plus 1 outlet for each additional 5000 ft^2 (465 m^2)

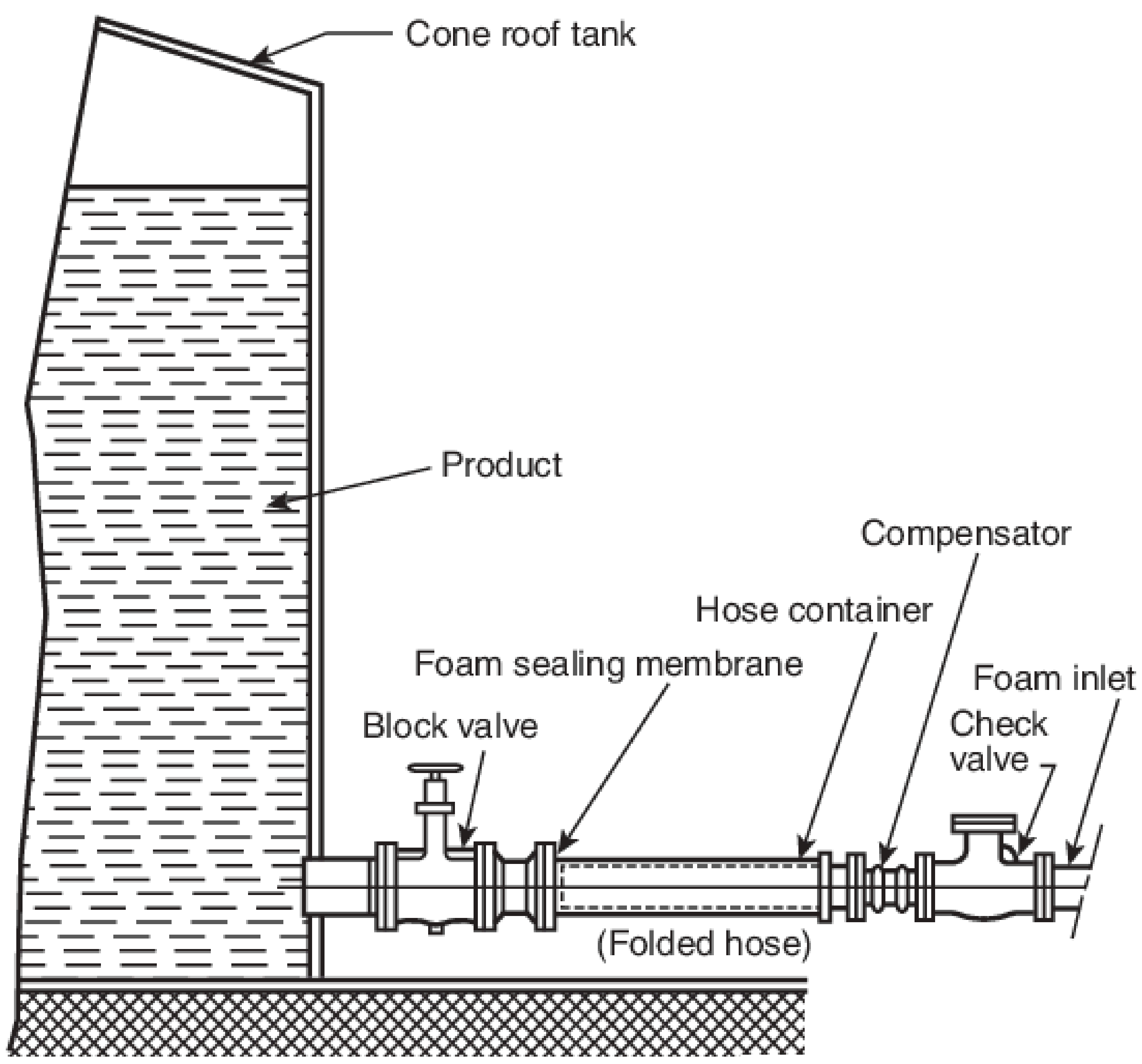


FIGURE A.5.2.7 Semisubsurface System Arrangement.

(5) Seamless construction with chemical bonds will ensure the roof system maintains its integrity in an explosion, preventing a full-surface fire

A.5.4.2.3.4 The hazard requiring the highest foam solution flow rate does not necessarily dictate the total amount of foam concentrate required. The requirements given in this section are based on extrapolations of test experience and appropriate listings and reflect the limitations known to date. Foam can fail to seal against the tank shell as a result of prolonged free burning prior to agent discharge. If adequate water supplies are available, cooling of the tank shell is recommended.

A.5.5.1 For other types of indoor hazards, see the design criteria requirements of NFPA 16.

A.5.5.4.1 Systems using these foams require special engineering consideration.

A.5.6 To minimize life and property loss, automation of foam systems protecting a truck loading rack should be taken into account. NFPA 16 states "Foam-water deluge and preaction systems shall be provided with automatic and auxiliary manual tripping means." [**16:**4.1.1]

Manual operation only can be provided where acceptable to the AHJ.

There are two methods of automating foam monitor systems for this application:

(1) Completely automatic detection and actuation *(See applicable sections of NFPA 72 for design criteria.)*
(2) Actuation by push-button stations or other means of manual release.

The speed of system operation is always critical in minimizing life and property loss.

A.5.6.5.1 The correct choice of each monitor location is a very important factor in designing a foam monitor system. Traffic patterns, possible obstructions, wind conditions, and effective foam nozzle range affect the design. The appropriate monitors and nozzles should be located so that foam is applied to the entire protected area at the required application rate. Consult the manufacturer of the monitor nozzle for specific performance criteria related to stream range and foam pattern, discharge capacity, and pressure requirements. Manufacturers also should be consulted to confirm applicable listings and/or approvals.

•

A.5.7 Generally, portable monitors or foam hose streams or both have been adequate in fighting spill fires in diked areas. In order to obtain maximum flexibility due to the uncertainty of location and the extent of a possible spill in process areas and tank farms, portable or trailer-mounted monitors are more practical than fixed foam systems in covering the area involved. The procedure for fighting diked area spill fires is to extinguish and secure one area and then move on to extinguish the next section within the dike. This technique should be continued until the complete dike area has been extinguished.

N **A.5.7.3.2** When using SFFF, the user should refer to Annex H and the manufacturer's recommendations to determine application rates.

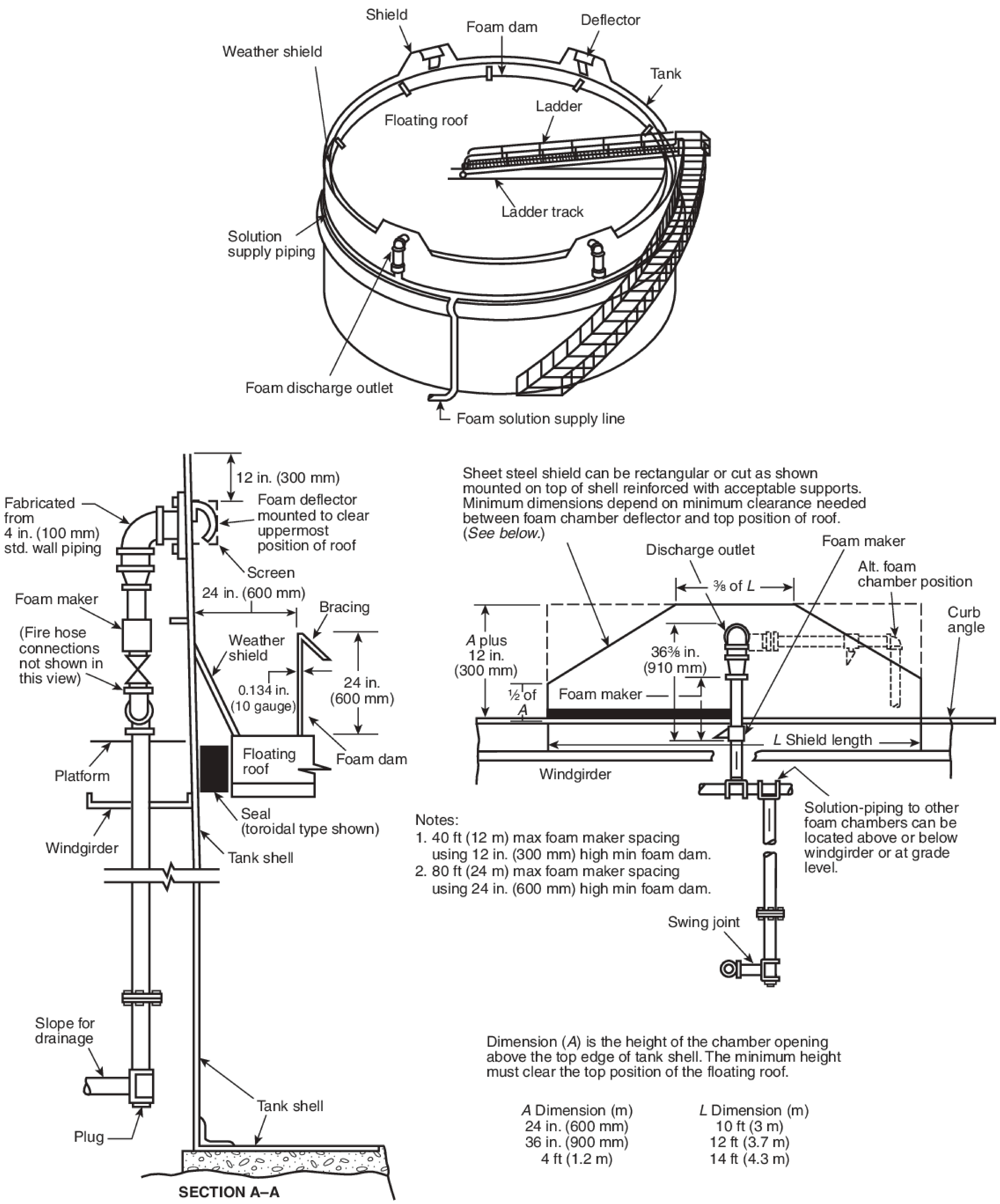
A.5.7.3.3 Fixed foam discharge outlets vary considerably in capacity and range area of coverage.

A.5.7.3.4.2 Overhead application by foam-water sprinklers or nozzles could require supplementary low-level foam application to provide coverage below large obstructions. Overhead pipework can be susceptible to damage by explosion. Overhead application by foam-water sprinklers or nozzles might require supplementary low-level foam application to provide coverage below large obstructions. Overhead pipework can be susceptible to damage by explosion.

A.5.7.3.5.3 Low-level foam discharge outlets might require supplementary overhead foam spray application to provide coverage or cooling for overhead structures or for tank surfaces.

Δ **A.5.8** For the purpose of this standard, nondiked spill areas are areas where a flammable or combustible liquid spill can occur, uncontained by curbing, dike walls, or walls of a room or building.

In such cases it is assumed that any fire would be classified as a spill fire [i.e., one in which the flammable liquid spill has an average depth not exceeding 1 in. (25 mm) and is bounded only by the contour of the surface on which it is lying].



Δ FIGURE A.5.3.5.2(a) Typical Foam Splash Board for Discharge Devices Mounted Above the Top of the Shell.

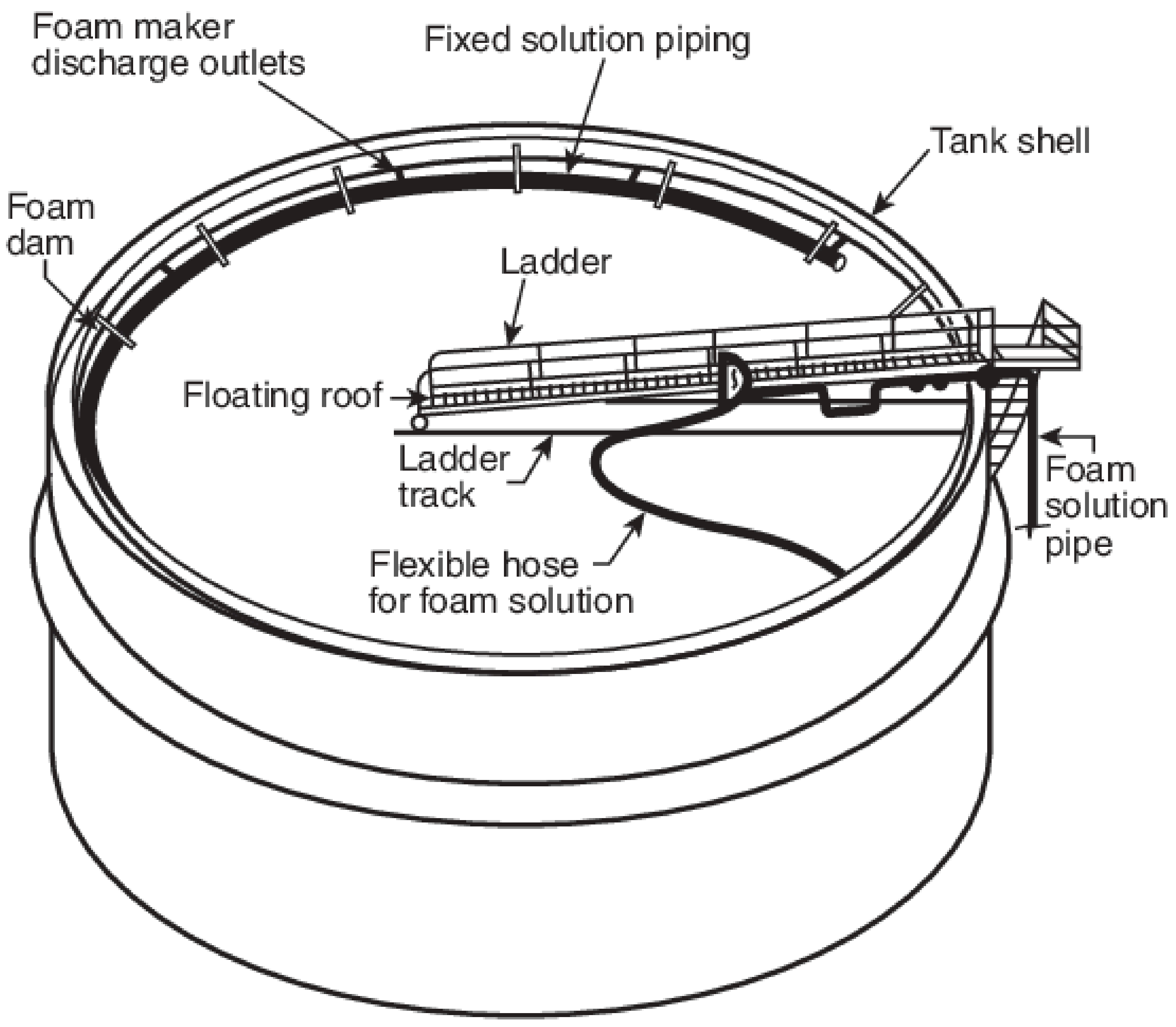


FIGURE A.5.3.5.2(b) Fixed Foam Discharge Outlets Mounted on the Periphery of the Floating Roof.

Δ **A.5.9** Auxiliary foam hose streams can be supplied directly from the main system protecting the tanks (e.g., centralized fixed pipe system) or can be provided by additional equipment. The supplementary hose stream requirements provided herein are not intended to protect against fires involving major fuel spills; rather, they are considered only as first aid–type protection for extinguishing or covering small spills involving areas in square feet (square meters) equal to those covered by about six times the rated capacity [in gpm (L/min)] of the nozzle. Permanently installed foam hydrants, where used, should be located in the vicinity of the hazard protected and in safe and accessible locations. The location should be such that excessive lengths of hose are not required. Limitations on the length of hose that can be used depend on the pressure requirements of the foam nozzle.

N **A.6.1.2** The uses of foam (or mechanical foam, as it was first called) for fire protection have increased greatly since it was first used in the 1930s. Original applications of this agent utilized a proteinaceous-type foam-forming liquid concentrate delivered in water solution to a turbulence-producing foam generator or nozzle that then directed the mechanically formed foam to a burning fuel tank or area of burning flammable fuel. (Details of these and similar applications are found in NFPA 402 and NFPA 403.) As the technology for using this agent developed over the years, new systems and new devices for applying the foam to the hazard being protected and new foam-forming liquid concentrates were proven useful for fire protection purposes. The application of foam from overhead sprinkler-type systems using specially designed foam-making nozzles capable of either forming a foam from protein-type foam concentrate solutions or delivering a satisfactory water discharge pattern where supplied with water only was an early development (circa 1954) in foam fire protection. Protein, fluoroprotein, and aqueous film-forming concentrates or film-forming fluoroprotein foam concentrates are suitable for use with foam-water sprinklers. This latter type of foam concentrate also has been found to be suitable for use with standard sprinklers of the type referred to in NFPA 13 where the system is provided with the necessary foam concentrate proportioning equipment. Care should be exercised to ensure that the choice of concentrate and discharge device are listed for use together.

NFPA 11 is based on available test data and design experience concerning the design information, installation recommendations, operating methods, and maintenance needs for the types of foam-water sprinkler systems previously described and foam-water spray systems utilizing protein, fluoroprotein, or aqueous film-forming foam or film-forming fluoroprotein foam concentrates. These systems possess the common ability to either discharge foam in a spray form or discharge water in a satisfactory pattern for fire protection purposes.

N **A.6.1.3.1** Caution should be exercised when auxiliary extinguishing equipment is used with these systems. Some extinguishing agents are incompatible with some foams. The manufacturers should be consulted.

Most foams are not considered suitable extinguishing agents on fires involving liquefied or compressed gases (e.g., butane, butadiene, propane), on materials that will react violently with water (e.g., metallic sodium) or that will produce hazardous materials by reacting with water, or on fires involving electrical equipment where the electrical nonconductivity of the extinguishing agent is of first importance.

N **A.6.1.3.4** Several AFFF and FFFP concentrates have been listed with standard sprinklers for use on nonmiscible hydrocarbons such as heptane, gasoline, fuel oil, crude oils, and so forth, and therefore can be permitted to be used on these products. Polar solvents in depth, such as acetone, methyl ethyl ketone, methyl isobutyl ketone, methanol, ethanol, and isopropanol, have been successfully extinguished with special alcohol-type foam concentrates and standard sprinklers. In all cases, the agent to be used should be determined to be effective on the particular hazardous product by means of listing tests or special testing by the manufacturer where necessary. Application rates can be higher than the required 0.16 gpm/ft^2 (6.5 mm/min) for some specific polar solvents.

N **A.6.2.4** The purpose of a reserve supply of concentrate is to have the means available for returning systems to service-ready condition following system operation.

N **A.6.2.5** Most test work conducted with closed-head sprinklers has been performed with preprimed systems or systems where foam solution is discharged very quickly — in less than 1 minute. The inherent design philosophy is that foam solution is discharged rapidly on the fuel hazard. Where only water is in the sprinkler piping, the designer and the AHJ should satisfy themselves that the foam solution delay time is acceptable for the given hazard. Factors to consider include the combustible/flammable liquid fuel hazard, associated ordinary combustibles, probable fire growth rate, number of sprinklers expected to operate, and the involvement of commodities at the time of foam discharge. Fire growth factors include flash point of the fuel, water miscibility, container package, and storage height.

Foam concentrate manufacturers generally do not recommend prepriming with foam solution where alcohol-type concentrates are used. The foam concentrate manufacturers should be consulted. The factors cited in the preceding paragraph should then be considered if the system is not preprimed with foam solution. *(See A.3.3.17.2.1 for draining and flushing guidance.)*

N **A.6.4.3** Foam concentrates meeting the requirements of 6.4.3 are available in 3 percent and 6 percent concentrations. Some