Engineering Standard

SAES-B-018 29 June 2005

Air Foam Systems for Storage Tanks

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Revised paragraphs are indicated in the right margin

Primary contact: Esam A. Ashoor on 872-8431

1 Scope

This Standard defines the minimum mandatory requirements for the design and installation of fixed air foam fire protection systems for atmospheric storage tanks. Section 8 also includes requirements for fixed air foam systems that may be used in a variety of facilities such as offshore platforms and loading racks. Requirements for each type of atmospheric storage tank are summarized in Table 1 of SAES-B-019. The requirements for spacing and diking of onshore atmospheric tanks are covered in SAES-B-005.

Exception:

Where this Standard is in conflict with specialized requirements for offshore platforms, covered in SAES-B-009; for piers, wharves, sea islands, in SAES-B-060; and bulk plants/air fueling operations, in SAES-B-070, those Standards shall govern.

2 Conflicts and Deviations

2.1 Any conflicts between this Standard and other applicable Saudi Aramco Engineering Standards (SAESs), Saudi Aramco Materials System Specifications (SAMSSs), Saudi Aramco Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Loss Prevention Department of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from the Standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Loss Prevention Department of Saudi Aramco, Dhahran.

3 References

All referenced Specifications, Standards, Codes, Forms, Drawings, and similar material shall be considered part of this Standard to the extent specified herein and shall be of the latest issue (including all revisions, addenda, and supplements) unless stated otherwise.

3.1 Saudi Aramco References

Saudi Aramco General Instruction

GI-1781.001	*Inspection, Testing, and Maintenance of Fire Protection Equipment*

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-B-005	*Spacing and Diking for Atmospheric and Low-Pressure Tanks*
SAES-B-009	*Fire Protection and Safety Requirements for Offshore Production Facilities*
SAES-B-017	*Fire Water Systems*
SAES-B-019	*Portable Firefighting Equipment*
SAES-B-054	*Access, Egress, and Materials Handling for Plant Facilities*
SAES-B-060	*Fire Protection for Piers, Wharves and Sea Islands*
SAES-B-070	*Bulk Plants*
SAES-D-100	*Design Criteria of Atmospheric and Low-Pressure Tanks*
SAES-H-002	*Internal and External Coatings for Pipelines and Piping*
SAES-L-132	*Materials Selection of Piping Systems*
SAES-S-040	*Water Systems*

Saudi Aramco Materials System Specifications

21-SAMSS-011	*Fluroprotein Foam Concentrate for MTBE Hydrocarbon Fires*
32-SAMSS-005	*Manufacture of Atmospheric Tanks*

3.2 Industry Codes and Standards

National Fire Protection Association

NFPA 11	*Low Expansion Foam*
NFPA 16	*Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*
NFPA 1963	*Fire Hose Connections*

Underwriters Laboratories

UL 162 *Safety Foam Equipment and Liquid Concentrates*

4 Definitions

Air Foam: See **Foam**, below.

Deflector: On the discharge of the foam chamber, a plate or nozzle that deflects the foam downward as it exits the chamber outlet. See Figure 1.

Fixed System: A fixed foam system (when justified by special circumstances) providing foam concentrate storage, foam / water proportioning and foam solution pumping capability to the foam chambers of storage tanks.

Foam Dam: A metal retaining wall that keeps the foam near the seal area at the outer rim of the floating roof. See Figure 1.

Foam [Air Foam]: A foam concentrate that is a combination of fluorocarbon surfactants and protein foam concentrates suitable for fighting fires on crude oils and hydrocarbon fuels, gasoline-MTBE (methyl tertiary-butyl ether) blends, and pure MTBE (See material specification 21-SAMSS-011).

Foam Chamber (Foam Outlet Station per NFPA 11): A fixed foam discharge outlet, normally located at the top of the riser on a floating roof tank, designed to introduce foam to the seal area.

Foam Maker: A fixed foam device designed to aspirate air into foam solution. A foam maker is connected to a supply of pre-mixed foam solution. The maker introduces air and the turbulence downstream of the maker creates a stable foam capable of being directed to the hazard being protected.

Lateral Terminal: Location at the end of the horizontal run of pipe with a hose connection. The lateral connects to the riser. Refer to the top diagram of Figure 1.

Riser: A vertical pipe that runs up the side of the tank.

Seal area: The area around the outer seal of the floating roof, the most likely site for a fire on a floating roof tank.

Seal shield: A weather shield directly above the top rim seal of a floating roof tank. See Figure 1.

Semi-fixed System: A foam piping system that depends on a fire department tanker truck to connect to the piping and pump foam solution to the foam chambers at the

storage tank. This is the standard installation for storage tanks that require fire protection and is described in Section 7.

Wind girder: Stiffening ring around the top of a tank to help the tank withstand high winds. Wind girder access is a stairway up to the wind girder and a walking/working surface along the girder that meets SAES-B-054.

5 Fixed (Cone) Roof Tanks

No air foam system is required for fixed cone roof tanks. Refer to SAES-B-017 and SAES-B-019 for other fire protection requirements such as fire hydrants.

6 Covered or Internal Floating Roof Tanks

No air foam system is required for covered floating roof tanks. Refer to SAES-B-017 and SAES-B-019 for other fire protection requirements.

7 Open-Top Floating Roof Tanks

7.1 For tanks less than 38 m in diameter, air foam chambers are not required. However, all tanks with open-top floating roofs, regardless of diameter, shall have a foam dam installed around the seal rim on the roof. The foam dam height shall be not less than 600 mm (24 in). The foam dam shall extend at least 150 mm (6 in) above the seal's weather shield. See Figure 1.

7.2 Where a wind girder and wind girder access is provided and no air foam chambers are provided, a galvanized carbon steel, schedule 40 standpipe riser (minimum 75 mm or 3-inch NPS) shall be installed. The riser shall be fitted with a 64 mm (2½-inch) gated male hose connection at the top and a 64 mm (2½-inch) female gated hose connection at the riser bottom. See Figure 4.

Commentary Note:

The purpose of the riser is to aid the Fire Protection Department in extinguishing a seal rim fire on smaller tanks. The 2½-inch hose connection provides a location for FPD personnel to connect a Siamese adapter for two 1½-inch hoses that run along the wind girder. The riser avoids having to run a hose up the winding stairway. The gated valve at the top of the riser should be located at the top stairway platform, if provided. The Fire Protection Department's tactical plan allows deployment of attack lines for a maximum of 150 feet along the wind girder. For other access information, see SAES-B-054.

7.3 All hose connections shall be standard threaded fire hose couplings per NFPA 1963. Dust caps shall be provided for the couplings. The dust caps shall have a $\frac{1}{16}$-inch diameter vent hole.

7.4 Tanks 38 m (125 ft) and over in diameter shall have multiple fixed foam chambers and deflectors located at intervals not to exceed 24.4 m (80 ft), equally spaced around entire tank shell (see Figure 2 and NFPA 11). Foam chamber supply piping is shown in Figure 3. Wind girder access shall be provided and shall meet SAES-B-054.

Commentary Note:

For existing open-top floating roof tanks, retrofit of chambers or risers shall be done at the next tank turnaround.

7.5 Riser, lateral, and distribution piping (minimum 75 mm or 3-inch NPS) shall be galvanized carbon steel, schedule 40 piping sized to provide a pressure between the gauge pressure of 485 kPa to 690 kPa (70 psig to 100 psig) at each foam maker based on a foam generating truck discharge of approximately the gauge pressure of 1035 kPa (150 psig). The capacity of the foam system shall be based on 0.34 L/s/m² (0.5 gpm/ft²) of foam solution per area between the foam dam and tank shell or 5 L/s (80 gpm) per chamber at a gauge pressure of 520 kPa (75 psig).

7.6 Fixed foam discharge outlets shall be designed to deliver fully aspirated foam directly to the annular seal area of open top floating roof storage tanks for fire protection, equivalent to National Model MCS-9 foam maker with a Type B foam chamber with the largest foam outlet orifice diameter listed per UL 162. All foam making equipment shall be listed per UL 162 or otherwise qualified per 8.1.

7.6.1 A mesh screen with 12 mm openings shall be installed over foam maker and deflector openings to prevent birds from nesting in the deflectors or foam chambers.

7.6.2 Foam makers shall be designed for flow-testing with foam in such a manner that foam entry into the protected tank is avoided.

7.7 Laterals shall run independently from each tank and terminate at a road on or outside the dike for the tank involved.

7.7.1 Lateral terminals shall be at a predominately upwind or crosswind location when practicable. Prevailing wind direction shall be based on a wind rose diagram via the Chief Environmental Engineer, Environmental Engineering Division of the Environmental Protection Department. These terminal locations preferably should be at the corner of the diked area between tanks. If terminal distance from the tank shell is less than one tank diameter, the design shall be approved by the Chief Fire Prevention Engineer.

7.7.2 Lateral terminals shall be situated on the road side of all pipelines and drainage ditches, near fire hydrants, with a maximum distance of 23 m from terminal to hydrant. Lateral terminals shall be fitted with signs to identify which tank and tank section they serve.

7.7.3 Hose connections on a lateral terminal should be spaced to allow maximum speed of opening. The number of 2½-inch hose connections on the lateral terminals shall be as follows:

Tank Diameter	No. of Connections
38 m to 48 m (100 ft to 160 ft)	2
48 m to 72 m (160 ft to 240 ft)	3
72 m to 96 m (240 ft to 320 ft)	4
96 m to 120 m (320 ft to 400 ft)	5
120 m to 146 m (400 ft to 480 ft)	6

7.7.4 The 2½-inch hose connections on the lateral terminals shall be female standard fire hose couplings per NFPA 1963. Dust caps shall be provided for the couplings. The dust caps shall have a $\frac{1}{16}$-inch diameter vent hole. Hose connections to put foam solution into the system shall have means to prevent back-flow through any hose connections. A manual block valve shall be installed on each lateral terminal connection.

7.7.5 Laterals shall be installed above ground to slope continuously with a slope of 1 in 100 towards the dike, without crossing through other tank dike areas. If practical, they should slope directly to outside the dike, terminating at a minimum height of 300 mm above grade. If continuous slope to the terminal connection is impractical due to grading, a carbon steel ¾ inch drain valve shall be installed at the low point near the dike.

7.7.6 Any foam system piping that runs underground or passes through a dike wall shall be protected against external corrosion in accordance with the requirements of SAES-H-002.

7.8 Foam Backboards

7.8.1 Foam backboards and dams shall be carbon steel, and capable of withstanding design wind pressure. Dam bracing shall be located outside the dam area, so as not to obstruct flow of foam.

7.8.2 Backboards shall be no less than 4 m wide. Backboards shall be mounted flush with the ID of the shell, and be of minimum height but high enough for the foam deflector to clear maximum travel of roof seal

protrusions when roof is at its highest position. See NFPA 11 for more information.

7.9 The ring supply piping to the multiple outlet foam chambers shall be installed above the wind girder, so that this equipment may be accessible for maintenance, inspection, and testing. Ring supply piping shall be either free-draining or shall be equipped with drain valves at low points. The ring supply piping shall be equipped with blind flanges to help assist in flushing the header (see Figure 2).

7.10 The top stair platform shall be located on the upwind side of the tank. Prevailing wind direction shall be based on a wind rose diagram via the Environmental Protection Department.

7.11 Testing

All tests shall be witnessed by designated representatives of Loss Prevention and Fire Protection prior to mechanical completion acceptance of the fire system. The performance flow test shall meet NFPA 11. A copy of the performance flow test shall sent to the Chief Fire Prevention Engineer (CFPE), Loss Prevention Department and General Supervisor, Planning and Technical Services Division, Fire Protection Department.

Testing of the air foam system shall be done during the initial hydrostatic testing of the tank (Refer to SAES-D-100 and 32-SAMSS-005). The roof shall be floating at a level no higher than 50% and no lower than 25% of its maximum height during the test of the foam system. The installed foam system shall be performance tested with a gauge pressure of 1035 kPa (150 psig) at the foam proportioning truck. The seal area shall be covered within 10 minutes of foam flow from the chamber to the extent as follows:

a. For tanks with a single foam chamber, 12 m from the chamber along the seal in both directions.

b. For tanks with multiple fixed foam chambers and deflectors, the entire seal area.

Commentary Notes:

Performance testing the air foam system during the initial filling for hydrotest will help avoid product contamination that might occur if the test was done later.

Also note that the test times for covering the seal will be far faster than what is required in NFPA 11 due to the oversized outlet orifice (see 7.6). This will not adversely affect the effectiveness of the foam.

7.12 Frequency of maintenance, inspection, and testing of fire protection equipment shall meet GI-1781.001.

8 Fixed Foam Systems and Storage

Commentary Note:

Normally, foam is supplied to onshore atmospheric open-top floating roof storage tanks using a mobile foam system provided and operated by the fire department brigade, as specified above. If a permanent built-in air foam system is justified by special circumstances, the following requirements shall apply:

8.1 Fixed foam-water fire protection systems, if specified, shall be designed and installed in accordance with the applicable requirements of NFPA 11, NFPA 16, SAES-B-017, and this Standard. Design, drawings, and hydraulic calculations shall be done by or directly supervised by a registered professional engineer in the specialty of fire protection who has at least five years of experience in foam fire-suppression and related system design. All drawings shall bear the seal of that registered engineer. Drawings and calculations shall be submitted to the Chief Fire Prevention Engineer (CFPE) or his representative for review.

8.2 The fixed foam concentrate supply system (also referred to as a foam skid) shall be a balanced-pressure proportioning system with foam concentrate pumps and storage tank. The foam skid design shall be based on in-line balance proportioning or balanced-pressure backpressure philosophy as illustrated by NFPA 16, Appendix A, Figure 5.4.2(e) or (g).

8.2.1 A fire department connection on the outside of the foam skid building or shelter shall be provided on the supply side of the proportioner (header with multiple 2½ inch angle valves and one 5-inch connection) per NFPA 16. Configuration, number and type of fittings to be approved by the General Supervisor, Planning and Technical Services Division, Fire Protection Department.

8.2.2 Equipment for the foam skid shall be UL listed for use with the specified type and manufacturer of foam.

8.2.3 Bladder type foam systems shall not be used.

8.3 Foam concentrate piping (undiluted, wet service in continuous contact with the concentrate) shall be 316 stainless steel (pipe wall thickness schedule 80 or greater). Piping handling foam concentrate shall be kept to the minimum.

Commentary Note:

The piping for foam concentrate shall not be galvanized or be made of any other

material that will degrade the foam concentrate. For onshore areas, concentrate piping runs should be kept to a minimum to avoid exposing the foam concentrate to high temperatures.

8.4 Piping downstream of the proportioner that carries foam solution (where foam solution = 3% concentrate, 97% water) shall meet the material, coating, and sizing requirements of SAES-L-132 for either sea or utility water [Water, Fire Control, (sea or utility), Table 1].

Exception:

For above grade small (<75 mm) steel pipe sizes where FBE or cement internal lining is impractical, galvanized carbon steel or black carbon steel pipe is allowable as an alternative. Other recently developed fire-resistant nonmetal alternatives may also be used with approval by the Chief Fire Prevention Engineer or his representative.

8.5 Mixed solution foam piping system that is above grade shall be designed to be self-draining to a low point drain valve(s) and shall be designed so that it can be flushed with fresh water and drained of all fluids after each use. If the main fire water supply is sea water, a potable water supply shall be used for flushing the system.

8.6 Materials for water supply piping to the skid shall meet SAES-S-040.

8.7 On tanks that are protected by a fixed foam skid, a pressure tap and valve for a pressure gauge shall be installed in the wind girder ring main near the foam chambers.

Commentary Note:

This is provided to allow temporary installation of a pressure gauge to facilitate performance testing.

8.8 The foam concentrate storage tanks shall be made of a material that is compatible with the type of foam, as recommended by the foam manufacturer. Manufacturer-supplied polyethylene atmospheric storage tanks are allowable and are usually recommended for the storage of most foam concentrates. Stainless steel shall not be used for the storage of fluoroprotein foam concentrate.

Commentary Note:

However, using 316 stainless for foam skid piping is allowable provided that the wall thickness is schedule 80 or greater (for corrosion allowance).

8.9 Atmospheric metal foam concentrate storage tanks shall not have an internal coating or lining. Foam storage tanks shall be kept full, with liquid level up

inside the expansion dome, to avoid contamination from moisture condensation. A thin layer of mineral oil may be added to the top of the foam concentrate to help limit contact with moist air.

8.10 Foam concentrate tanks and associated equipment shall be located to the extent practical in areas free of potential fire exposure and sized to deliver foam for 20 minutes at 3% of water flow.

8.11 Atmospheric concentrate tanks, if provided, shall be equipped with the following:

a. Expansion dome

b. Chrome plated 2½-inch pressure-vacuum vent

c. Liquid Supply line: 2½-inch

d. Liquid Return line: 2½-inch

e. Drain with forged steel valve

f. Two ¾-inch fill connections

g. One readily accessible 2-inch bulk fill line

h. Sight glass

i. Low Level switch

Exception:

Exceptions are permitted with the concurrence of the Chief Fire Prevention Engineer or his representative.

8.12 Foam concentrate storage tanks shall be provided with a sunshade or air-conditioned shelter (where justified).

8.13 Air foam systems protecting floating roof tanks shall be designed to deliver foam solution to the most remote point of use within 5 minutes or less from start of pumping. Other fixed air foam systems shall deliver foam solution within 1 minute unless a longer time is approved by the Chief Fire Prevention Engineer or his representative.

8.14 Concentrate pumps shall be rotary gear or similar technology pumps, capable of injecting several specified concentrate quantities up to full flow at the operating pressure of the water supply at those respective flows. A 100% installed spare concentrate pump with a separate electrical source shall be provided. The concentrate pump power supply shall be from the most reliable available bus and shall otherwise meet the same requirements as fire water controllers and pumps in SAES-P-116.

Commentary Note:

Concentrate pump selection should be based on the foam manufacturer's recommendation. Since this is such a limited market and the pumps are very precise, most foam suppliers can provide an acceptable pump for the skid or make referrals to alternative manufacturers of acceptable pumps.

8.15 A self-priming foam transfer pump (20 gpm minimum) shall be installed on foam skids. The transfer pump shall be one especially designed for this foam concentrate, i.e., it shall be designed to not agitate or aspirate the foam concentrate.

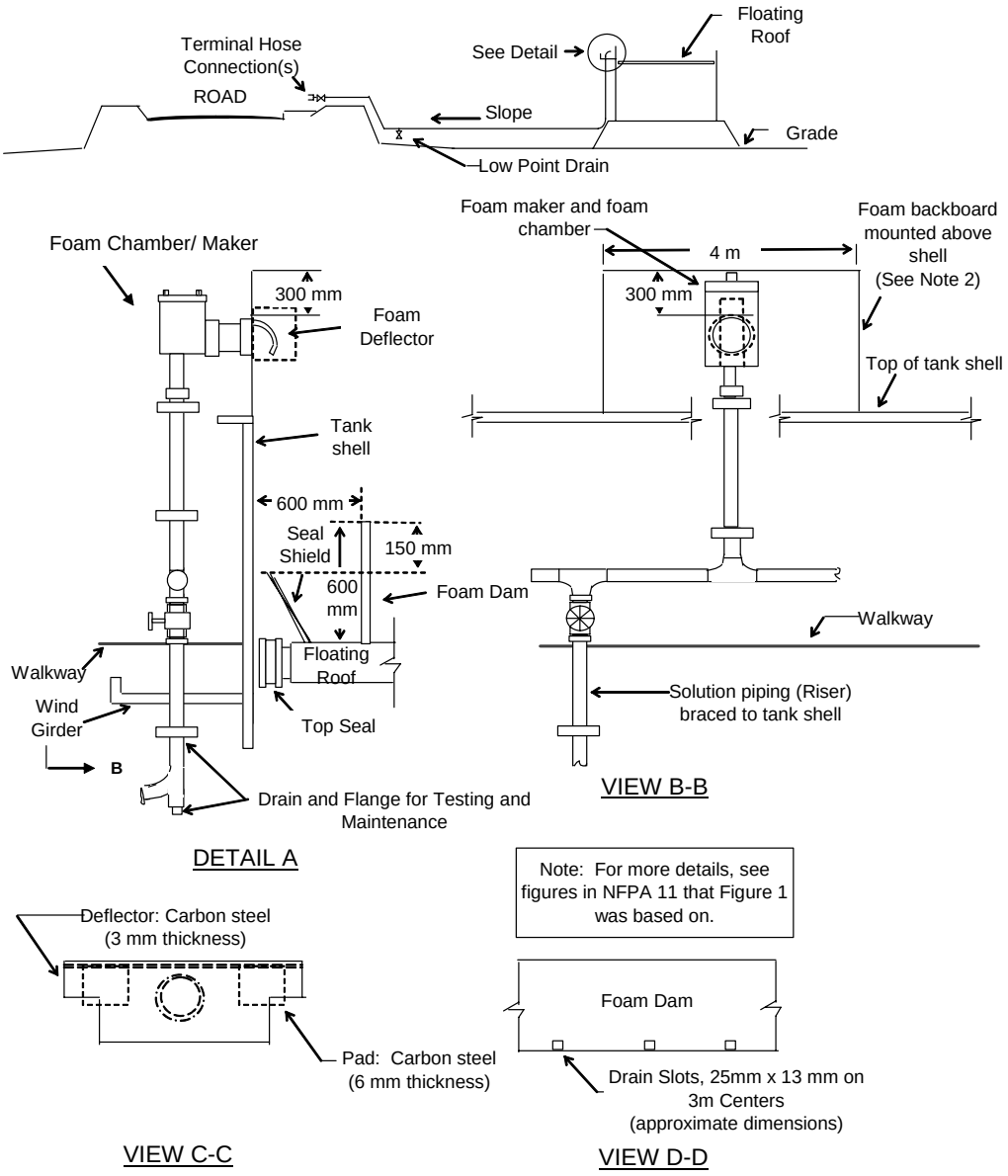

Figure 1 – Typical Foam Outlet Station
Layout of Foam Chamber and Solution Piping

Notes:

1) Hose connection at top stairway platform is not shown. See Figure 3.
2) Minimum height of backboard depends on the top position of the roof.
3) Riser and lateral pipe size shall be a minimum nominal diameter of 75 mm (3-inch NPS).

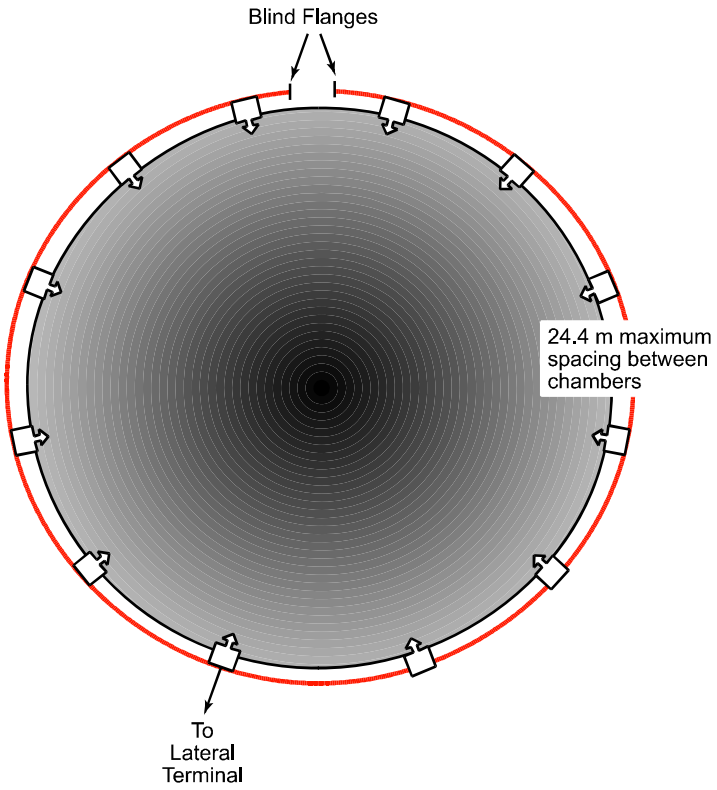

Figure 2 - Multiple Foam Chamber Locations
Tanks Over 38m (125 ft) Diameter - Typical Layout Of Foam Chambers

Notes:

1) One 2½-inch hose connection, per Figure 3, is required at top of tank stairs by the platform with supply piping located upstream of riser block valve.

2) For tanks that require multiple chambers, the number of chambers (based on one chamber per 24.4 m [80 ft] of circumference) are as follows:

Tank Diameter (m)	(ft)	Number Of Chambers	Solution Flow Rate L/S	(GPM)
38 - 46	(125 - 150)	6	30.28	(480)
46 - 53	(151 - 175)	7	35.33	(560)
54 - 61	(176 - 200)	8	40.38	(640)
61 - 69	(201 - 225)	9	45.4 2	(720)
69 - 78	(226 - 255)	10	50.52	(800)
78 - 85	(256 - 280)	11	60.57	(880)
85 - 93	(281 - 306)	12	65.61	(960)
93 - 101	(306 - 330)	13	65.61	(1040)
101 - 108	(331 - 355)	14	70.66	(1120)
108 - 116	(356 - 380)	15	75.71	(1200)
116 - 124	(381 - 406)	16	80.75	(1280)
124 - 146	(407 - 430)	17	85.80	(1360)

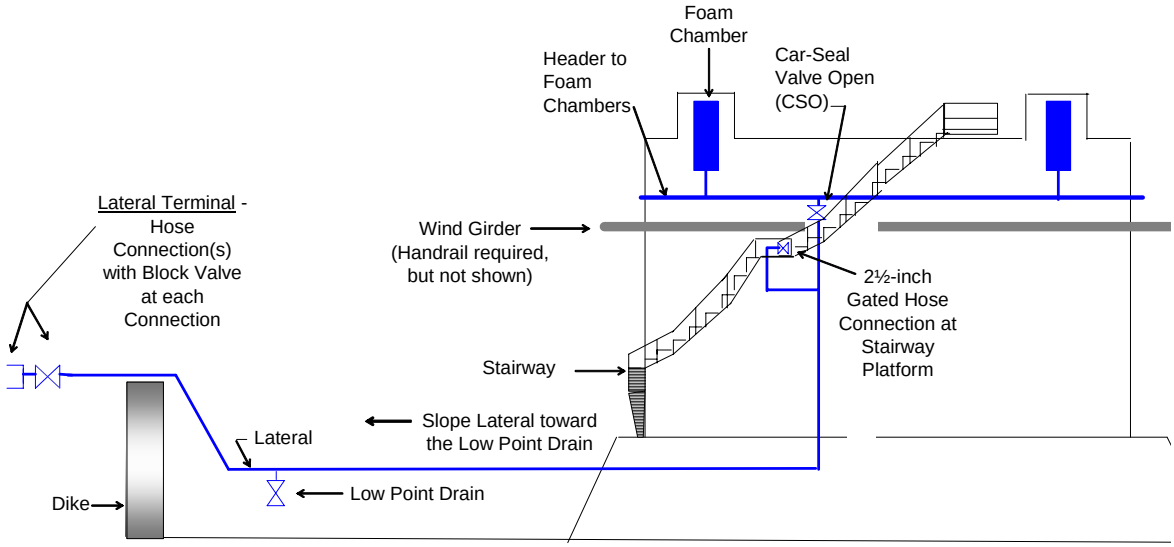

Figure 3 - Layout of Supply Piping to 2½-Inch Hose Connections and Multiple Foam Makers

Notes:

1) One 2½-inch male hose connection shall be accessible from top stairway platform.

2) Foam deflectors and foam backboards shall be offset from the wind girder walkway to avoid blocking entrance to floating roof.

3) Block valve(s) in lateral and riser to be car-sealed open (CSO).

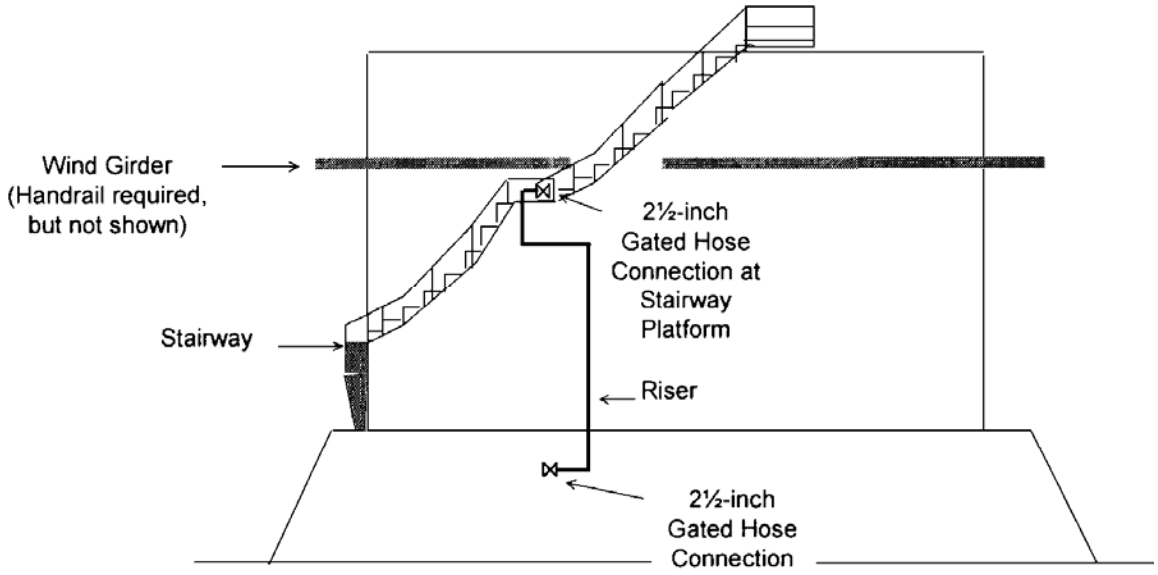

Figure 4 - Layout of Riser with 2½-Inch Hose Connections (see 7.2)

Revision Summary

29 June 2005 Major revision.