PETROLEUM STORAGE TANK FIRE PROTECTION
SECTION INDEX

Foam Application Method: Fixed Surface Systems

— (Design Reference NFPA 11) ................................................................. K2

Fixed, Full Surface Foam Application ........................................................................ K3-K4

BFC Series Custom Fitted Foam Chambers .......................................................... K5-K6

BFC-HC Series Custom Fitted Dual Agent Foam Chambers ................................. K7

Foam Chambers ........................................................................................................ K8-K10

Supplementary Foam Application in Diked Area -

Foam/Water Monitors ............................................................................................ K11

Foam Application Method: Seal Area Protection

— (Design Reference NFPA 11) .................................................................................. K12-K14

Standard LW Foam Makers - Typical Installations .................................................. K15

Spectrum LW9/WSDB, Foam Maker with Wind Shield/Discharge Board ............... K16

Standard LW Foam Makers .................................................................................. K17

Foam Application Method: Subsurface Foam Injection

— (Design Reference NFPA 11) .................................................................................. K18-K25

Supplementary Foam Application in Diked Area -

Foam/Water Monitors ............................................................................................ K26

High Back Pressure Foam Makers / Medium Flow - Brass .................................. K27

High Back Pressure Foam Makers / High Flow - Aluminum ............................... K28

High Back Pressure Foam Makers / Self Educting ............................................... K29
Foam Application Method: Fixed Surface Systems
(Design Reference NFPA 11)

General:
Fixed Surface Application Systems provide a potentially effective method of foam fire protection for vertical, atmospheric cone roof, internal floating roof, or open floating roof storage tanks containing hydrocarbon or alcohol (water miscible) liquids. For this application, discharge outlets are commonly referred to as “NFPA 11, Type II foam Chambers”. Foam Chambers can be sized and installed to provide either full surface fire protection, or seal protection only, when installed on floating roof tanks with foam dams.

In general, ThunderStorm® solution is proportioned and delivered into the system inlet piping which supplies one or more topside-mounted foam chambers. Upon entering the foam chamber, foam solution is then: introduced at the designed application rate through a calculated orifice and frangible vapor seal; aerated and expanded a nominal 8:1 with air; directed into the tank through a flanged penetration; deflected down the interior tank shell where it reaches the fuel surface; and (ultimately) delivered across the burning liquid surface to extinguish the fire.
Storage Tank Protection

Fixed, Full Surface Foam Application

Design Considerations

• Minimum Application Rates
  To determine the minimum application rate, use the following calculations (where tank diameter = D).

Minimum Application Rate =

\[(D \times D) \times 0.785 \times \text{Min. Application Density}\]

When Application Density is 0.1 Gpm per Sq. Ft:

\[(D \times D) \times 0.785 \times 0.1\]

Example for an 80' Diameter Crude Oil tank:

\[80 \times 80 \times 0.785 \times 0.1 = 503 \text{ gpm minimum application rate.}\]

When Application Density is 0.16 Gpm per Sq. Ft.:

\[(D \times D) \times 0.785 \times 0.16\]

Example for an 80' Diameter Ethanol tank:

\[80 \times 80 \times 0.785 \times 0.16 = 804 \text{ gpm minimum application rate.}\]

• Minimum Foam Application Durations.

Combustible liquids (flash point > 100 degree F.) - 30 minutes
Flammable liquids (flash point < 100 degrees F.) - 55 minutes
Crude oils - 55 minutes
Alcohols - 55 minutes

NFPA 11 Recommendation for Supplementary Foam Application in Diked Area -(Hose Streams)*.

Note:
NFPA 11 recommends the following minimum rates for “supplementary foam hose streams” to protect the diked area from small spills or fires. Minimum flow rates are based on 50 gpm per handline.

<table>
<thead>
<tr>
<th>Number of Hose Streams</th>
<th>Diameter of Largest Tank</th>
<th>Minimum No. of Hose Streams</th>
<th>Hose Stream Operating Times</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>up to 65’</td>
<td>1</td>
<td>Diameter of Largest tank</td>
</tr>
<tr>
<td></td>
<td>65’ to 120’</td>
<td>2</td>
<td>up to 35’</td>
</tr>
<tr>
<td></td>
<td>over 120’</td>
<td>3</td>
<td>35’ to 95’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>over 95’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minimum Operating Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

* Refer to Page K9 for Williams' recommendations regarding Dike Protection.
Storage Tank Protection

Fixed, Full Surface Foam Application

Design Considerations

• Minimum Foam Concentration Inventories

Calculation for minimum foam inventory:

\[ \pi r^2 \times \text{Application Rate} \times \% \text{ of Proportioning} \times \text{Application Duration} + \text{Supplemental Dike Protection (As per NFPA 11)} \]

Example for an 80’ Diameter Tank in Crude Oil Service:
(Foam Concentrate Inventory is ThunderStorm® ATC 1 x 3 AR/AFFF @ 1%)

\[
40 \times 40 \times 3.14 \times 0.1 \times 0.01 \times 55 + 60 = 889 \text{ gallons}
\]

Add for 100% Reserve Inventory (if required) + 889 gallons

Total Minimum Foam Inventory 1,778 gallons

Example for a 120’ diameter Tank in Ethanol Service:
(Foam Concentrate Inventory is ThunderStorm® ATC 1 x 3 AR/AFFF @ 3%)

\[
60 \times 60 \times 3.14 \times 0.16 \times 0.03 \times 55 + 135 = 6,104 \text{ gallons}
\]

Add for 100% Reserve Inventory (if required) + 6,104 gallons

Total Minimum Foam Inventory 12,208 gallons

• Discharge Outlets (Foam Chambers)

Minimum number of topside foam discharge outlets (chambers for full surface application is listed below). Where two or more outlets are used the foam chambers should be spaced equally around the tank and each should be designed to deliver foam at approximately the same discharge rate. Foam chambers should be installed at the top of the tank shell, located above the product’s highest level. Each chamber should be secured to the tank shell in a way that minimizes the possibility of damage, in the event that the tank’s roof is displaced by a vapor-air explosion. Each chamber should be equipped with a low pressure frangible vapor seal, as well as a suitable means for inspection.

<table>
<thead>
<tr>
<th>Tank Diameter</th>
<th>Minimum No. of Discharge Outlets</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 80’</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 80’-120’</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 120’-140’</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 140’-160’</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 160’-180’</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 180’-200’</td>
<td>6</td>
</tr>
</tbody>
</table>
Storage Tank Protection

**Product:**

“BFC” SERIES CUSTOM FITTED FOAM CHAMBERS

**Description:**

Introducing the answer to a major potential storage tank problem, that is not given enough attention. Do to design, constant exposure to the elements, saline environments, and chemicals, Foam Chambers deteriorate, sometimes more rapidly than expected.

When an inspection reveals the need for replacements, then sourcing a superior replacement, that fits the existing piping and equipment arrangements, becomes a real problem. The Williams “BFC” Series Custom Foam Chamber will provide a cost effective, low maintenance, long-life solution, that will fit your equipment and needs. Williams offers field survey and recommendation services to help determine you needs, or the Client can provide dimensions required.

- A Foam Chamber that solves multiple retrofit problems! Relieves much of the concern about how much “it will really cost” to get the replacement completed, on time, and on budget.
- Optimized design building on years of experience as a Manufacturer.
- “BFC” Foam Chambers are manufactured at the Williams’ Mauriceville, Texas USA manufacturing facility, utilizing experienced local Craftsmen.
- Exclusive “No Blow” Re-usable, non-breakable Vapor Seal Available. Made from Stainless Steel or Composites. Several configurations available.
- Available in any inlet and outlet flange size, design, and arrangement required.
- Available in any nominal flow range between 40 GPM to 1000 GPM!
- Properly bored for sizing requirements, 316 Stainless Steel Orifice plates furnished for every Foam Chamber.
- Equipment Data Sheets provided with every project.
- A Foam Chamber that will quickly and easily fit and bolt into your existing piping.

**Options**

- Available in the BFC-“D” configuration, that incorporates a integral, built-in foam deflector, that directs the foam solution flow to the interior tank walls. No more missing interior deflectors or concerns!
- Other features may be available at your request. Let’s talk about your needs.

<table>
<thead>
<tr>
<th>Model</th>
<th>Operating Flow Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>BFC-9</td>
<td>30-150 gpm</td>
</tr>
<tr>
<td>BFC-17</td>
<td>100-280 gpm</td>
</tr>
<tr>
<td>BFC-30</td>
<td>190-600 gpm</td>
</tr>
<tr>
<td>BFC-55</td>
<td>400-1000 gpm</td>
</tr>
</tbody>
</table>
BFC SERIES FOAM CHAMBER W/DEFLECTOR
INLET AND OUTLET FLANGES ARE CLIENT SELECTABLE
DIMENSIONAL OUTLINE

3/16" DIAMETER WEEP HOLE

BFC SERIES FOAM CHAMBER W/DEFLECTOR
COMPONENT IDENTIFICATION
Storage Tank Protection

Product:
“BFC-HC” SERIES CUSTOM FITTED DUAL AGENT FOAM CHAMBERS

Description:

Introducing a Cutting Edge approach to a major potential storage Tank problem, involving interior floating roof storage tanks. Incorporating all of the features of the “BFC”- “D” option Foam Chambers, the “BFC-HC” model also provides a means of introducing a secondary agent into an internal floater storage tank.

Secondary agents may include steam, dry chemical, or any other suitable agent, as defined by the Client and/or applicable authority. The Williams “BFC-HC” Series DUAL AGENT Custom Foam Chamber will provide a cost effective, low maintenance, long-life solution, that will fit your equipment and needs. Williams offers field survey and recommendation services to help determine you needs, or the Client can provide dimensions required.

- A DUAL AGENT Foam Chamber that allows local or remote safe application of a variety of secondary agents, such as steam or dry chemical.
- Optimized design building on years of experience as a Manufacturer.
- “BFC-HC” Foam Chambers are manufactured at the Williams’ Mauriceville, Texas USA manufacturing facility, utilizing experienced local Craftsmen.
- Detailed Manufacturing Process Procedure to insure Quality and Value.
- Exclusive “No Blow” Re-usable, non-breakable Vapor Seal Available. Made from Stainless Steel or Composites.
- Available in any inlet and out flange size, design, and arrangement required.
- Available in any nominal flow range between 40 GPM to 1000 GPM!
- Properly bored for sizing requirements, 316 Stainless Steel Orifice plates furnished for every Foam Chamber.
- Equipment Data Sheets provided with every project.
- A DUAL AGENT Foam Chamber that will quickly and easily fit and bolt into your existing piping.

Options
- Available with the standard BFC-“D” configuration and features, that incorporates an integral, built-in foam deflector, with multiple optional nozzle configurations.
- Available with hot dip galvanized coating or painted exterior coat finish.
Storage Tank Protection

Product:
Foam Chambers

Description:
Spectrum Foam Chambers are discharge outlets defined by NFPA 11 as “Type II” top-side application devices. They are designed to meter foam flow, then gently expand and deliver foam directly onto the surface of a flammable or combustible liquid. Foam chambers are installed on the vertical wall of fuel storage tanks, above the product’s highest liquid level. Flow rates are sized for full surface application, or for protection of the annular seal area (only) of open floating roof tanks. Foam solution supply piping to the chamber can either be connected to a “fixed” foam storage and proportioning system, or tied into a dry pipe, “semi-fixed” system which receives foam solution from a mobile foam apparatus.

In operation, foam solution passes through an orifice plate which is sized to deliver the required flow rate at a specific inlet pressure. The metered flow of foam solution is then introduced into the foam maker, where it is aerated. The foam chamber inlet piping is fitted with a frangible vapor seal, which is designed to rupture at a predetermined pressure. The aerated foam solution enters the foam expansion chamber body, where additional expansion occurs, and the velocity of the foam is reduced. As the foam leaves the chamber body, it passes through the tank shell, and then impacts a foam deflector, which directs the foam down the tank wall and ultimately onto the fuel surface.

The foam chamber is accessible for inspection and service through a removable inspection hatch which is located on top of the chamber body. Foam deflectors are available in either solid, split, or shallow configurations. Solid style deflectors allow for installation when the shell is accessible from both inside and outside the tank (new tank installations). Split-style deflectors allow for installation when the shell is only accessible from outside the tank (existing tank installations). Standard finish, primed, with red epoxy exterior coating.

<table>
<thead>
<tr>
<th>Model</th>
<th>Nominal Flow @ 100 psi</th>
<th>Inlet Flange</th>
<th>Discharge Flange</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW-9</td>
<td>40-150 gpm</td>
<td>2.5”</td>
<td>4”</td>
</tr>
<tr>
<td>LW-17</td>
<td>100-280 gpm</td>
<td>3”</td>
<td>6”</td>
</tr>
<tr>
<td>LW-30</td>
<td>190-600 gpm</td>
<td>4”</td>
<td>8”</td>
</tr>
<tr>
<td>LW-55</td>
<td>400-1000 gpm</td>
<td>6”</td>
<td>10”</td>
</tr>
</tbody>
</table>
Storage Tank Protection

Foam Chamber Exploded View

Materials of Construction

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body, Maker &amp; Flanges</td>
<td>C</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Retainer Hatch</td>
<td>S</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Orifice Plate</td>
<td>S</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Retainer; Vapor Seal</td>
<td>B</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Gaskets</td>
<td>B</td>
<td>B</td>
<td>C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW-9</td>
<td>7.5</td>
<td>.75&quot;</td>
<td>4.75&quot;</td>
</tr>
<tr>
<td>LW-17</td>
<td>9.5&quot;</td>
<td>.875&quot;</td>
<td>6.625&quot;</td>
</tr>
<tr>
<td>LW-30</td>
<td>11.75&quot;</td>
<td>.875&quot;</td>
<td>8.75&quot;</td>
</tr>
<tr>
<td>LW-55</td>
<td>14.25&quot;</td>
<td>1&quot;</td>
<td>10.75&quot;</td>
</tr>
</tbody>
</table>
Storage Tank Protection

**Foam Chamber Schematic and Data**

![Foam Chamber Diagram]

**Foam Chamber Dimensional Data**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW-9</td>
<td>28.1875&quot;</td>
<td>8.125&quot;</td>
<td>9.8125&quot;</td>
<td>7&quot;</td>
<td>2.5&quot;</td>
<td>2.75&quot;</td>
<td>8&quot;</td>
<td>8&quot;</td>
<td>12&quot;</td>
<td>8&quot;</td>
<td>80 LBS.</td>
</tr>
<tr>
<td>LW-17</td>
<td>32.25&quot;</td>
<td>9.125&quot;</td>
<td>10.625&quot;</td>
<td>9&quot;</td>
<td>3&quot;</td>
<td>4.125&quot;</td>
<td>9.5&quot;</td>
<td>12&quot;</td>
<td>18&quot;</td>
<td>10&quot;</td>
<td>130 LBS.</td>
</tr>
<tr>
<td>LW-30</td>
<td>34.25&quot;</td>
<td>10.875&quot;</td>
<td>10.6875&quot;</td>
<td>10&quot;</td>
<td>4&quot;</td>
<td>5.5&quot;</td>
<td>11&quot;</td>
<td>16&quot;</td>
<td>24&quot;</td>
<td>12&quot;</td>
<td>200 LBS.</td>
</tr>
<tr>
<td>LW-55</td>
<td>42&quot;</td>
<td>12&quot;</td>
<td>13&quot;</td>
<td>12&quot;</td>
<td>6&quot;</td>
<td>6.5&quot;</td>
<td>12&quot;</td>
<td>20&quot;</td>
<td>30&quot;</td>
<td>16&quot;</td>
<td>350 LBS.</td>
</tr>
</tbody>
</table>

**Required Ordering Information**

Foam Chamber Model No. can be determined by providing the following:

1. Product in tank
2. Tank configuration
3. Tank diameter
4. Full surface or seal protection
5. Height of Foam Dam (Seal protection)
Storage Tank Protection

Supplementary Foam Application in Diked Area - Foam/Water Monitors

Foam/Water Monitors provide the following advantages over (as well as exceed) the recommendations of NFPA 11 for (50 gpm) supplemental hoselines.

Versatility
Firewater monitors are usually installed, or otherwise made available for exposure protection, as well as tank cooling in and around the tank farm. When employed for water application, they can also serve a dual purpose and be used for applying foam for vapor suppression and/or spill fire protection. Firewater monitors are easily converted to this dual “foam/water” application through the use of a separate/dedicated foam reservoir and a Hydro-Foam™ Nozzle installed on each monitor. As opposed to a central foam system, which charges a common line with foam solution, this configuration provides the versatility of allowing operators to selectively use each monitor for either foam or water.

Fire Fighting Capability
Hydrocarbon spill fires require a minimum nominal foam application density of 0.1 gpm per sq. ft. Therefore, a 50 gpm handline has the capability of controlling and suppressing approximately 500 sq. ft. of flame surface area. Scaled up, a 500 (750, 1,000) gpm foam water monitor has the capability of controlling and suppressing 10 (15, 20) times the flame surface area versus that of a 50 gpm handline nozzle.

Operator Safety
Monitors flowing between 500 gpm and 1,000 gpm have an effective range which is about 3-4 times farther than that of a 50 gpm handline. This greater projection of foam or water translates proportionally into more safety for the operator. In addition, when the monitor nozzle is adjusted to the “full fog” position the higher volume of foam or water provides proportionally more cooling for the operator. Also, (as opposed to handlines) monitors can be set up and adjusted - then temporarily left unattended, if necessary.

Foam/Water Management
Individual/dedicated foam reservoirs at each monitor eliminate the possibility of depleting a central foam storage tank, in the event a single foam monitor is opened and then left unattended.
Storage Tank Protection

Foam Application Method: Seal Area Protection
(Design Reference NFPA 11)

General:
Annular Seal Area Protection of Open Top Floating Roof Tanks. “Top of Seal” method with foam dam, utilizing fixed discharge outlets (foam chambers).

• Design Criteria - Foam Dams:
Foam dams should be designed and constructed so that the expanded foam is retained between the dam and the tank shell, in sufficient quantities to adequately cover the seal area. Minimum recommended height of the foam dam is 12”, and should extend upward to a minimum of 2” above the secondary seal. Spacing between the foam dam and the tank shell should be a minimum of 12” and a maximum of 24”. The foam dam bottom should be slotted to allow drainage of rain water. However, the slots should also be designed and sized to prevent excessive loss of foam. Maximum recommended height of the slots is .375”. Slots should be sized on the basis of 0.4 sq. inches of slot area per sq. ft. of dam area.

• Maximum Spacing of Foam Chambers
Foam Chambers (Makers) are to be equally spaced around the tank per the following criteria:
- Tanks with Foam Dams < 24” High - Maximum spacing is every 40 linear ft.
- Tanks with Foam Dams 24” high or Greater- Maximum spacing is every 80 linear ft.

• Minimum Number of Foam Chambers
Calculation for Minimum Number of Foam Chambers (Makers)

Example Calculation for an 120’ Diameter Tank with 24” High Foam Dams:

Tank Circumference Calculation = (\pi \times D) / Maximum Spacing Between Devices

Example:

Tank Circumference Calculation = (3.1416 \times 120) = 377
Minimum Spacing of Discharge Devices = Every 80 ft.
Therefore Actual Number of Discharge Devices = 5
Storage Tank Protection

Foam Application Method: Seal Area Protection
(Design Reference NFPA 11)

• Area of Zone - Calculation of Seal Area

Example Calculation for a 120’ Diameter Tank:

\[(60 \times 60) \times 3.14 = 11,304 \text{ sq. ft.}\]
\[(58 \times 58) \times 3.14 = 10,563 \text{ sq. ft.}\]

\[11,304 - 10,563 = 741 \text{ sq. ft.}, \text{Area of Zone}\]

• Minimum Application Density of Foam Solution is 0.3 gpm per sq ft

• Minimum Application Rate (gpm) -
  Calculation for Minimum Application Rate =

\[\text{Area of Zone} \times \text{Minimum Application Density}\]

Example Calculation for a 120’ Diameter Tank:

\[\text{Area of Zone} = 741 \text{ Sq. Ft.}\]
\[\text{Minimum Application Density} = 0.3 \text{ Gpm per Sq. Ft.}\]
\[\text{Minimum Application Rate Calculation} = 741 \times 0.3\]
\[\text{Minimum Application Rate} = 223 \text{ Gpm}\]

• Minimum Application Rate per Foam Chamber (Maker)
  Calculation for Minimum Application Rate per Chamber =

\[\text{Minimum Application Rate} / \text{Minimum No. of Foam Chambers}\]

Example Calculation for an 120’ Diameter Tank:

\[\text{Minimum Application Rate} = 223 \text{ gpm}\]
\[\text{Minimum No. of Foam Chambers (Makers)} = 5\]
\[\text{Minimum Application Rate Per Foam Chamber} = \frac{223}{5} = 44.6 \text{ Gpm}\]

• Minimum Foam system Application Duration is 20 Minutes
  Minimum Foam Application into the Seal area is 20 minutes.
Storage Tank Protection

 Foam Application Method: Seal Area Protection
(Design Reference NFPA 11)

• NFPA Minimum recommendations for Supplementary Foam Application
  in Diked Area - (Hose Streams)*

NFPA 11 recommends the following minimums for supplementary foam hose streams to protect the diked area from small spills or fires. Minimum flow rates are based on 50 gpm per handline.

<table>
<thead>
<tr>
<th>Number of Hose Streams</th>
<th>Hose Stream Operating Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of Largest Tank</td>
<td>Minimum No. of Hose Streams</td>
</tr>
<tr>
<td>up to 65'</td>
<td>1</td>
</tr>
<tr>
<td>65' to 120'</td>
<td>2</td>
</tr>
<tr>
<td>over 120'</td>
<td>3</td>
</tr>
</tbody>
</table>

* Refer to page K9 for Williams’ recommendations regarding Dike Protection.

• Minimum Foam Concentrate Inventories

Calculation for Minimum Foam Inventory is (where tank diameter = D):

Minimum Foam Inventories =

(Seal Area) x (Application Density) x (% Proportioning) x (Application Duration) + (Supplemental Dike Protection)

Example Calculation for a 120' Diameter Tank in Gasoline Service:
(Foam Concentrate is 3% AFFF)

| Seal Area | 741 Sq. ft. |
| Application Density | 0.3 Gpm per Sq. Ft. |
| Proportioning | 3% |
| Application Duration | 20 minutes |
| Supplemental Protection | Two Handlines @ 50 gpm for 30 minutes |

741 x 0.3 x 0.03 x 20 = 134 gallons - Seal Protection (Foam Chambers) +
(50 +50) x 0.3 x 0.03 x 30 = 90 gallons - Supplemental Protection
Minimum Foam Concentrate Inventory = 224 gallons
Add for 100% Reserve inventory (if required) + 224 gallons
Total Minimum Foam Inventory 448 gallons
Storage Tank Protection

Standard LW Foam Makers - Typical Installations

Typical Storage Tank Protection

Typical Tank Dike Protection

Foam Maker Details

NOTES:
40 ft. max. foam maker spacing using 12 in. high min. foam dam.
80 ft. max. foam maker spacing using 24 in. high min. foam dam.
Storage Tank Protection

Product:
Spectrum LW9/WSDB, Foam Maker with Wind Shield/Discharge Board

Description:
The Spectrum LW9/WSDB Foam Makers are integrated systems providing NFPA 11 “Type II” foam application to the seal area of open floating roof tanks. It is designed to allow for installation without taking the tank out of service. They are designed to meter foam flow, then gently expand and deliver foam directly onto the seal area surface of flammable or combustible liquids. Foam solution supply piping to the system can either be connected to a “fixed” foam storage and proportioning system, or tied into a dry pipe, “semi-fixed” piping network, which receives and delivers foam solution from a mobile fire apparatus.

In operation, foam solution passes through an orifice plate which is sized to deliver the required flow rate at a specific inlet pressure. The metered flow of foam solution enters the interior of the discharge board, where additional aeration occurs as it impacts the deflector plates and passes through a wired mesh discharge opening.

The entire unit can be installed to the top of the storage tank shell without the need for welding, or any “hot work” by utilizing heavy duty galvanized mounting clamps secured with stainless steel machine bolts and jam nuts. Constructed of galvanized carbon steel, with 304 stainless steel mesh screen and trim.

<table>
<thead>
<tr>
<th>LW9/WSDB</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Inlet Pressures</td>
<td>75 - 125 psi</td>
</tr>
<tr>
<td>Min/Max Flows</td>
<td>25 - 100 gpm</td>
</tr>
<tr>
<td>K-Factor</td>
<td>2.5 - 10.0</td>
</tr>
<tr>
<td>Material of Construction</td>
<td>Piping &amp; Body - Galvanized Carbon Steel Wire Mesh Screen &amp; Deflector Trim - Stainless Steel</td>
</tr>
</tbody>
</table>
Foam Makers

Product:
Standard LW Foam Makers

Description:
Foam Makers are used to aerate foam solution “in-line” prior to application into the hazard area. They are ideal for dike or rim seal fire protection where low velocity foam streams are desired. In general, standard foam makers should be installed within 10 ft. of foam application points. Nominal foam expansion is from 5:1 to 8, depending on the type of foam as well as the size and configuration of the discharge piping and nozzle. Foam Makers are available in two basic configurations - threaded and flanged. Flanged Foam Makers are available with optional vapor seals.

<table>
<thead>
<tr>
<th>Model</th>
<th>Nominal flow @ 100 psi</th>
<th>A-Length</th>
<th>Inlet</th>
<th>Discharge</th>
<th>Recommended Size, Foam Delivery Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW 15D</td>
<td>10 to 40 gpm</td>
<td>16”</td>
<td>1.5” NPT (F)</td>
<td>1.25” NPT(M)</td>
<td>3”</td>
</tr>
<tr>
<td>LW 25D</td>
<td>40 to 140 gpm</td>
<td>20”</td>
<td>2.5” NPT (F)</td>
<td>2.5” NPT(M)</td>
<td>4”</td>
</tr>
<tr>
<td>LW-9D</td>
<td>30-150 gpm</td>
<td>24”</td>
<td>2.5” Flanged</td>
<td>2.5” Flanged</td>
<td>4”</td>
</tr>
<tr>
<td>LW-17D</td>
<td>100-280 gpm</td>
<td>30”</td>
<td>3” Flanged</td>
<td>3” Flanged</td>
<td>6”</td>
</tr>
<tr>
<td>LW-30D</td>
<td>175-600 gpm</td>
<td>36”</td>
<td>4” Flanged</td>
<td>4” Flanged</td>
<td>8”</td>
</tr>
</tbody>
</table>
Storage Tank Protection

Foam Application Method: Subsurface Foam Injection
(Design Reference NFPA 11)

General -
Subsurface injection is a potentially effective method of providing fixed (or semi-fixed) foam fire protection for vertical, atmospheric cone roof storage tanks containing hydrocarbon liquids. In general, ThunderStorm® ATC™ solution is expanded a nominal 4:1 with air and injected into the tank at its base through a High Back Pressure Foam Maker. The expanded foam is delivered to the tank’s base by directing its flow either through an existing product line or through dedicated foam distribution piping. In either case, the injection point(s) must be located above any potential water layer at the bottom of the tank.

Advantages of Subsurface Injection

Efficiency:
Expanded foam solution is delivered to the burning fuel surface with minimum exposure to heat and flame.

Survivability:
Piping and equipment is located at the tank’s base, in an area not as subject to damage from convected/conducted heat, vapor-air explosion and/or detonation.

Product Surface Cooling:
Percolating foam bubbles rise to the hydrocarbon surface from the injection point(s) at the tank’s base. This process tends to cycle cooler product to the surface which can assist in reducing heat and flame intensity.

Installation Versatility:
Certain subsurface systems can be installed using procedures that do not require taking the tank out of service.
Storage Tank Protection

Subsurface Foam Injection

Design Considerations

• Limitations:

Subsurface injection should not be used on:

• Floating Roof Tanks (as the primary system).
• Tanks containing water miscible (alcohol) type flammable/combustible fuels.
• Tanks containing Class 1A hydrocarbon flammable liquids (i.e. those with a flash point < 73˚ F, and a boiling point < 80˚ F)

• Minimum Application Density/Rate:

The minimum foam solution application density for subsurface injection is 0.1 gpm per sq. ft. To determine the minimum application rate, use the following calculation (where tank diameter = D).

Minimum Application Rate =

\[(D \times D) \times 0.785 \times 0.1\]

• Minimum Application Durations:

Combustible Liquids (flash point > 100˚ F) - 30 minutes
Flammable Liquids (flash point < 100˚ F) - 55 minutes
Crude Oils - 55 minutes

• NFPA 11 Recommendation for Supplementary Foam application in Diked Area - (Hose Streams)*.

NFPA 11 recommends the following minimum rates for “supplementary foam hose streams” to protect the diked area from small spills or fires. Minimum flow rates are based on 50 gpm per handline.

<table>
<thead>
<tr>
<th>Number of Hose Streams</th>
<th>Diameter of Largest Tank</th>
<th>Minimum No. of Hose Streams</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>up to 65’</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>65’ to 120’</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>over 120’</td>
<td>3</td>
</tr>
</tbody>
</table>

Hose Stream Operating Times

Simultaneous operation of the required minimum number of hose streams discharging at a rate of 50 gpm.

<table>
<thead>
<tr>
<th>Diameter of Largest Tank</th>
<th>Minimum Operating Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 35’</td>
<td>10 minutes</td>
</tr>
<tr>
<td>35’ to 95’</td>
<td>20 minutes</td>
</tr>
<tr>
<td>over 95’</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>
Storage Tank Protection

Subsurface Foam Injection

Design Considerations

• **Minimum Foam Concentration Inventories**
  Calculation for minimum 3% foam inventory is (where D = tank diameter):

  \[(D \times D) \times 0.785 \times 0.1 \times 0.3 \times \text{(Application Duration)} + \text{Supplemental Dike Protection}\]

  Example for an 80' Diameter Tank in Crude Oil Service:
  (Foam Inventory is 3% ThunderStorm® ATC™)

  \[
  80 \times 80 \times 0.785 \times 0.1 \times 0.03 \times 55 + 60 = 889 \text{ gallons}
  \]

  Add for 100% Reserve Inventory (if required) +

  \[
  889 \text{ gallons}
  \]

  Total Minimum Foam Inventory = 1,778 gallons

• **Expanded Foam Rates & Velocities**

  Maximum (expanded foam inlet velocities should not exceed 10 ft. per second (fps) for flammable liquids and 20 fps for combustible liquids. To determine the expanded foam rate, use the minimum application rate (established previously) and multiply by four (4), which is the maximum anticipated foam expansion (4:1) through the high back pressure foam maker. Refer to the adjacent chart to determine minimum (schedule 40) pipe sizes.

**Maximum Allowable Back Pressure**

a) **Maximum Allowable Back Pressure = 40% of Inlet Pressure.**

When using Spectrum High Back Pressure Foam Makers, the total allowable system back pressure should not exceed 40% of foam solution inlet pressure or:

\[
\text{Maximum Allowable Back Pressure} = \text{Inlet Pressure} \times 0.4
\]

Spectrum High Back Pressure Foam Makers are rated 150 psi (standard inlet pressure).

Therefore:

\[
\text{Maximum Allowable Back Pressure} = 150 \times 0.4
\]

\[
\text{Maximum Allowable Back Pressure} = 60 \text{ psi}
\]
Storage Tank Protection

Subsurface Foam Injection

Design Considerations

• Maximum Allowable Back Pressure (cont'd.)

The maximum allowable back pressure increases (decreases) proportionally with the inlet pressure into the foam maker. K Factors are provided in this catalog for each Spectrum High Back Pressure Foam Maker, or refer to the following formula for determining the adjusted flow through the Foam Maker for pressures other than 150 PSI:

Example, HPB Foam Maker # HBFM - 250B @ 150 psi:

Standard Flow Rate = 250 gpm @ 150 psi.
K factor* = 20.4
Adjusted Inlet Pressure = 160 psi.
Flow = K x *P
Flow = 20.4 x 160
Flow = 20.4 x 12.65
Flow = 258 gpm

b) Maximum Allowable Back Pressure < 40 % of -
(Maximum Friction Loss + Static Head Pressure of Stored Material)

To determine static head by using the adjacent chart, first locate the highest possible level of the product in the storage tank, then locate the line representing the specific gravity of the stored product.

Specific Gravity

A = 1.00 (Water)
B = 0.90 (Oils)
C = 0.84 (Fuel Oil)
D = 0.72 (Gasoline)
E = 0.68 (Heptane)

• Back Pressure Calculation

Maximum Allowable Back Pressure < 40% of Inlet Pressure
Back Pressure (PSIG) < X + Static Head / 2.3

Maximum Allowable Back Pressure < 40% of Inlet Pressure
Storage Tank Protection

Subsurface Foam Injection

Design Considerations

- **Determining Expanded Foam Friction Loss in Pipe**

  Subtract the static head pressure (derived from chart in section B) from maximum allowable back pressure for the higher back pressure foam maker. The remaining figure is the maximum allowable friction loss in pipe. Calculate the length of total delivery pipe needed and establish a pipe size so that pressure drop in the system does not exceed the maximum allowable friction loss. Assume a 4:1 foam expansion rate for calculation purposes (flow rate x 4).
### Storage Tank Protection

#### Subsurface Foam Injection

**Design Considerations**

- **Number of Discharge Outlets**
  Minimum number of subsurface foam discharge outlets are listed in the adjacent table.

<table>
<thead>
<tr>
<th>Tank Diameter</th>
<th>Flash Point &lt;100º</th>
<th>Flash Point &gt;100º</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 80'</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>80' - 120'</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>120' - 140'</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>140' - 160'</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>160' - 180'</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>180' - 200'</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>over 200'</td>
<td>One outlet for each additional 500’ sq.ft.</td>
<td>One outlet for each additional 7500’ sq. ft.</td>
</tr>
</tbody>
</table>

- **Configuration of Discharge Outlets**
  Where two or more outlets are required, they should be located so that the horizontal foam travel on the fuel surface does not exceed approximately 80 ft. Each outlet should be sized to deliver foam at approximately the same flow rate. Foam outlet(s) can either be connected directly to the tank shell, or can be supplied through a pipe manifold within the tank from a single shell connection.

#### Typical Configurations

**Pipe Manifold Configuration**

- **2 Outlets**

**Tank Shell Configuration**

- **3 Outlets**

- **4 Outlets**
Storage Tank Protection

Subsurface Foam Injection - Schematics

Typical Flow Diagrams

Dedicated Line - Foam Injection

Product Line Foam Injection
Single Inlet - Dual Outlet Manifold
Storage Tank Protection

Subsurface Foam Injection -
Recommended Foam Piping Inlet Configurations

STRAIGHT IN

HORIZONTAL ELL

HORIZONTAL TEE
Storage Tank Protection

Supplementary Foam Application in Diked Area - Foam/Water Monitors

Foam/Water Monitors provide the following advantages over (as well as exceed) the recommendations of NFPA 11 for (50 gpm) supplemental hoselines.

Versatility
Firewater monitors are usually installed, or otherwise made available for exposure protection, as well as tank cooling in and around the tank farm. When employed for water application, they can also serve a dual purpose and be used for applying foam for vapor suppression and/or spill fire protection. Firewater monitors are easily converted to this dual “foam/water” application through the use of a separate/dedicated foam reservoir and a Hydro-Foam™ Nozzle installed on each monitor. As opposed to a central foam system, which charges a common line with foam solution, this configuration provides the versatility of allowing operators to selectively use each monitor for either foam or water.

Fire Fighting Capability
Hydrocarbon spill fires require a minimum nominal foam application density of 0.1 gpm per sq. ft. Therefore, a 50 gpm handline has the capability of controlling and suppressing approximately 500 sq. ft. of flame surface area. Scaled up, a 500 (750, 1,000) gpm foam water monitor has the capability of controlling and suppressing 10 (15, 20) times the flame surface area versus that of a 50 gpm handline nozzle.

Operator Safety
Monitors flowing between 500 gpm and 1,000 gpm have an effective range which is about 3-4 times farther than that of a 50 gpm handline. This greater projection of foam or water translates proportionally into more safety for the operator. In addition, when the monitor nozzle is adjusted to the “full fog” position the higher volume of foam or water provides proportionally more cooling for the operator. Also, (as opposed to handlines) monitors can be set up and adjusted - then temporarily left unattended, if necessary.

Foam/Water Management
Individual/dedicated foam reservoirs at each monitor eliminate the possibility of depleting a central foam storage tank, in the event a single foam monitor is opened and then left unattended.
Foam Makers

Product:
High Back Pressure Foam Makers
Medium Flow - Brass

Description:
High Back Pressure Foam Makers are used for “in-line” foam expansion and delivery into foam fire protection distribution systems that are subjected to discharge head pressure. They are typically designed for subsurface foam injection into flammable (combustible) hydrocarbon fuels, stored in vertical cone roof atmospheric tanks. In subsurface applications, expanded foam is injected directly into the fuel, then gently rises to form a foam blanket at the fuel surface. Maximum allowable back pressure for the HBFM series High Back Pressure Foam Makers is 40% of foam solution inlet pressure. Flow rates are available from 100 gpm to 300 gpm @ 150 psi inlet pressure. Nominal foam expansion is 4:1. SAE 40, cast brass construction, with stainless steel trim.

For fixed subsurface injection foam system installations, design considerations should address the following (per NFPA 11): application density rate; quantity and configuration of foam injection points; maximum back-pressure allowance; foam injection velocity.

<table>
<thead>
<tr>
<th>Model</th>
<th>Flow Rate @ 150 psi</th>
<th>K-Factor</th>
<th>Standard Inlet</th>
<th>Optional Inlet</th>
<th>Standard Discharge</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBFM-100B</td>
<td>100 gpm</td>
<td>8.2</td>
<td>2.5&quot; NPT(M)</td>
<td>2.5&quot;NH(F)</td>
<td>2.5&quot;NPT(M)</td>
<td>Brass</td>
</tr>
<tr>
<td>HBFM-150B</td>
<td>150 gpm</td>
<td>12.2</td>
<td>2.5&quot; NPT(M)</td>
<td>2.5&quot;NH(F)</td>
<td>2.5&quot;NPT(M)</td>
<td>Brass</td>
</tr>
<tr>
<td>HBFM-200B</td>
<td>200 gpm</td>
<td>16.3</td>
<td>2.5&quot; NPT(M)</td>
<td>2.5&quot;NH(F)</td>
<td>2.5&quot;NPT(M)</td>
<td>Brass</td>
</tr>
<tr>
<td>HBFM-250B</td>
<td>250 gpm</td>
<td>20.4</td>
<td>2.5&quot; NPT(M)</td>
<td>2.5&quot;NH(F)</td>
<td>2.5&quot;NPT(M)</td>
<td>Brass</td>
</tr>
<tr>
<td>HBFM-300B</td>
<td>300 gpm</td>
<td>24.5</td>
<td>2.5&quot; NPT(M)</td>
<td>2.5&quot;NH(F)</td>
<td>2.5&quot;NPT(M)</td>
<td>Brass</td>
</tr>
</tbody>
</table>
Foam Makers

Product:
High Back Pressure Foam Makers
High Flow - Aluminum

Description:
High Back Pressure Foam makers are used for “in-line” foam expansion and delivery into foam fire protection distribution systems that are subjected to discharge head pressure. They are typically designed for subsurface foam injection into flammable (combustible) hydrocarbon fuels stored in vertical cone roof atmospheric tanks. In subsurface applications, expanded foam is injected directly into the fuel, then gently rises to form a foam blanket at the fuel surface. Maximum allowable back pressure for the HBFM series High Back Pressure Foam Makers is 40% of inlet pressure. Flow rates are from 300 gpm to 550 gpm @ 150 psi inlet pressure. Nominal foam expansion is 4:1. T-6 tempered and hardcoat anodized aluminum with stainless steel trim.

For fixed subsurface injection foam system installations, design considerations should address the following (per NFPA 11): application density rate; quantity and configuration of foam injection points; maximum back-pressure allowance; foam injection velocity.

<table>
<thead>
<tr>
<th>Model</th>
<th>Flow Rate @150 PSI</th>
<th>K-Factor</th>
<th>Standard Inlet</th>
<th>Optional</th>
<th>Discharge Inlet</th>
<th>Optional Discharge</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBFM-300A</td>
<td>300 gpm</td>
<td>23.7</td>
<td>4” Flange</td>
<td>2.5”, 3.5” NH (F)</td>
<td>6” Flange</td>
<td>6”NPT (N)</td>
<td>Aluminum</td>
</tr>
<tr>
<td>HBFM-350A</td>
<td>350 gpm</td>
<td>27.7</td>
<td>4” Flange</td>
<td>2.5”, 3.5” NH (F)</td>
<td>6” Flange</td>
<td>6”NPT (N)</td>
<td>Aluminum</td>
</tr>
<tr>
<td>HBFM-400A</td>
<td>400 gpm</td>
<td>31.6</td>
<td>4” Flange</td>
<td>2.5”, 3.5” NH (F)</td>
<td>6” Flange</td>
<td>6”NPT (N)</td>
<td>Aluminum</td>
</tr>
<tr>
<td>HBFM-450A</td>
<td>450 gpm</td>
<td>35.6</td>
<td>4” Flange</td>
<td>2.5”, 3.5” NH (F)</td>
<td>6” Flange</td>
<td>6”NPT (N)</td>
<td>Aluminum</td>
</tr>
<tr>
<td>HBFM-500A</td>
<td>500 gpm</td>
<td>39.6</td>
<td>4” Flange</td>
<td>2.5”, 3.5” NH (F)</td>
<td>6” Flange</td>
<td>6”NPT (N)</td>
<td>Aluminum</td>
</tr>
<tr>
<td>HBFM-550A</td>
<td>550 gpm</td>
<td>43.5</td>
<td>4” Flange</td>
<td>2.5”, 3.5” NH (F)</td>
<td>6” Flange</td>
<td>6”NPT (N)</td>
<td>Aluminum</td>
</tr>
</tbody>
</table>
Foam Makers

Product:
High Back Pressure Foam Makers
Self Educting

Description:
Proportions foam concentrate at 1% or 3%, then aspirates the foam solution. Capable of discharging expanded foam against considerable back pressure, not exceeding 25% of foam solution inlet pressure. For use in either atmospheric systems or for subsurface injection. Designed to operate at inlet pressures from 100 to 250 psi. Flow rates are based on 150 psi inlet pressure. Standard material or construction is SAE 356 cast anodized aluminum, heat treated to T6 temper and hard coat anodized to Mil. A-8625, Type III. Also available (special order) in SAE 40 cast brass red.

<table>
<thead>
<tr>
<th>Model</th>
<th>Flow Rate @150 psi</th>
<th>K-Factor</th>
<th>Standard Inlet</th>
<th>Standard Discharge</th>
<th>Optional Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEFM-LB300</td>
<td>300 gpm</td>
<td>24.5</td>
<td>4&quot; 150# Flg.</td>
<td>6&quot; 150# Flg.</td>
<td>6&quot;NPT(M)</td>
</tr>
<tr>
<td>SEFM-LB400</td>
<td>400 gpm</td>
<td>32.7</td>
<td>4&quot; 150# Flg.</td>
<td>6&quot; 150# Flg.</td>
<td>6&quot;NPT(M)</td>
</tr>
<tr>
<td>SEFM-LB500</td>
<td>500 gpm</td>
<td>40.8</td>
<td>4&quot; 150# Flg.</td>
<td>6&quot; 150# Flg.</td>
<td>6&quot;NPT(M)</td>
</tr>
<tr>
<td>SEFM-LB565</td>
<td>565 gpm</td>
<td>46.1</td>
<td>4&quot; 150# Flg.</td>
<td>6&quot; 150# Flg.</td>
<td>6&quot;NPT(M)</td>
</tr>
</tbody>
</table>