



Foam Suppression System Design

Storage Tank Protection – NFPA 11

Lecture 1

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Types Of Tanks

- ▶ Fixed (Cone) Roof Tank



Fixed roof tanks are defined as a vertical cylindrical tank with fixed roofs as a conical section and comply with the requirements of NFPA 30.

These tanks are designed with a weak seam at the junction of the vertical side and the roof.

In the event of an explosion, this seam separates, allowing the roof to blow off, thereby leaving the vertical wall intact to retain the contents of the tank.

► Open Top Floating Roof Tank

Open top roof tanks are defined as vertical cylindrical tanks without fixed roofs that have a double deck or pontoon type floating roof and comply with the requirements of NFPA 30.

The seal can be a mechanical shoe seal or tube seal. The tube seal can have a metal weather shield. Secondary seals of combustible or non-combustible materials may be installed.

Tanks with the following types of roofs do not fall under the design standards for protection of open top floating roof tanks;

- Roofs made of floating diaphragms
- Roofs made from plastic blankets
- Roofs made from plastic or other flotation material, even if encapsulated in metal or fiberglass
- Roofs that rely on floatation device enclosures that can be easily submerged if damaged
- Pan roofs

Although these types of tanks can experience a full surface fire in the event that the roof sinks, experience shows that the most common type of fire in these tanks is a seal fire. The authority having jurisdiction will normally determine the protection required, however, the typical protection is for the seal area only.



► Covered (Internal) Floating Roof Tank

Covered (internal) floating roof tanks are a combination of both the cone roof and the open top floating roof tanks. The tank has a cone roof but with the addition of an internal floating roof or pan that floats directly on the fuel surface.

The open vents in the tank sidewalls, just beneath the roof joints, can identify this type of tank. If the internal floating roof is other than a steel double deck or pontoon type, the fire protection system should be designed for full surface fires (similar to cone roof tanks).

For the double deck or pontoon internal roofs of steel construction, a design for the sealed area protection may be permitted (same as open floating roof tanks).



Fuels

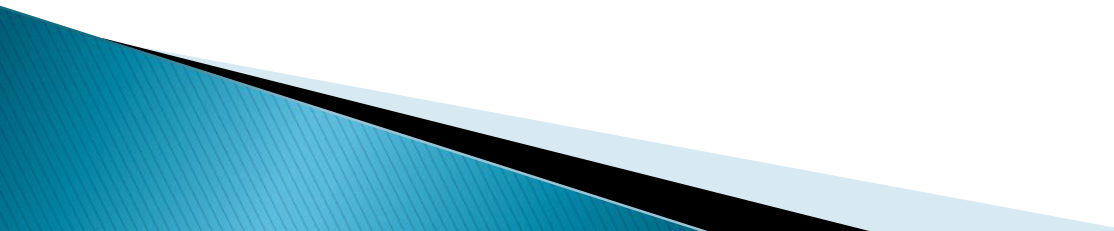
► Identify the Flammable Liquid

There are two basic classifications of flammable and combustible liquids;

- Hydrocarbons (non–water miscible)
- Polar Solvent (water miscible)

Hydrocarbons include non water soluble petroleum liquids such as crude oil, gasoline, jet fuels, fuel oil, etc.

Polar solvents include water soluble liquids such as alcohols, ketones, esters, etc.

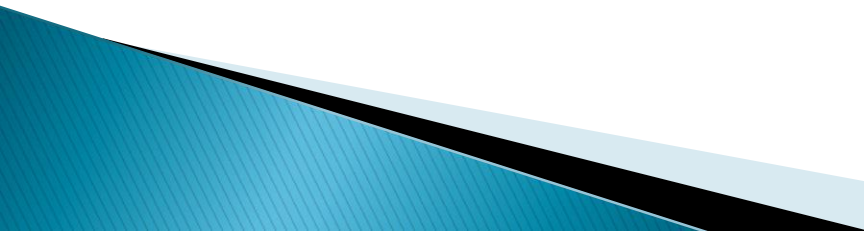


Flammable And Combustible Liquids Per NFPA 30

Flammable Liquid means a liquid having a flash point below 100°F and having a vapor pressure not exceeding 40 psi at 100°F shall be known as a Class I liquid. Class I liquids shall be subdivided as follows:

- Class IA includes those having flash points below 73°F (23°C) and having a boiling point below 100°F (38°C)
- Class IB includes those having flash points below 73°F (23°C) and having a boiling point above 100°F (38°C)
- Class IC includes those having flash points at or above 73°F (23°C) and below 100°F (38°C)

Combustible Liquid means liquid having a flash point at or above 100°F (38°C). Combustible liquids shall be subdivided as follows:

- Class II includes liquids with flash points at or above 100°F (38°C) and below 140°F (60°C)
 - Class IIIA includes liquids with flash points at or above 140°F (60°C) and below 200°F (93°C)
 - Class IIIB includes liquids with flash points at or above 200°F (93°C)
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Protection Of Storage Tanks

Fixed (Cone) Roof Tanks Protection

In accordance with NFPA 11, there are three accepted methods of the protection of fixed (cone) roof tanks:

- Surface (Foam Chamber) Method
- Subsurface Injection Method
- Portable Foam Nozzle and Monitor Method

Surface (Foam Chamber) Method

Foam chambers are considered Type II application devices which allow application of expanded foam onto the surface of the fuel with a minimal submergence of the foam and agitation of the fuel surface. The foam chamber is normally mounted on the vertical surface of the storage tank, approx. 8 in to 12 in (20 cm to 30.5 cm) below the roof line. Foam chambers can be used to protect storage tanks containing both hydrocarbon and polar solvent products.

When multiple foam chambers are required, they should be equally spaced on the vertical tank surface and should have the approximate flow rates. The foam solution piping should be installed in accordance with the requirements of NFPA 11 and any other applicable standards. Each foam chamber should be piped separately and contain a shut off valve located outside the diked area.

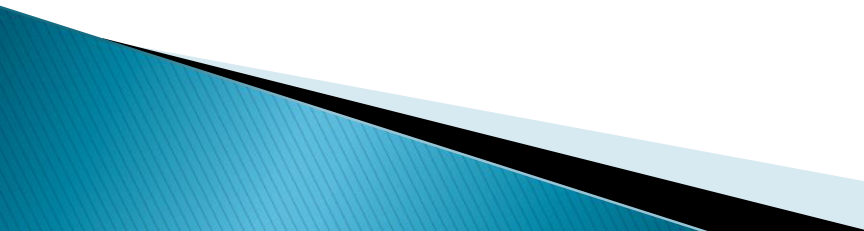


Chart "A" - Number of Foam Chambers Required Based on Tank Size

Tank Diameter	Minimum Number of Foam Chambers Required
Up to 80 ft (24.4 m)	1
Over 80 ft (24.4 m) to 120 ft (36.6 m)	2
Over 120 ft (36.6 m) to 140 ft (42.7 m)	3
Over 140 ft (42.7 m) to 160 ft (48.8 m)	4
Over 160 ft (48.8 m) to 180 ft (54.9 m)	5
Over 180 ft (54.9 m) to 200 ft (60.9 m)	6

For tanks over 200 ft (60.9 m) in diameter, one additional outlet foam chamber should be installed for each additional 5,000 sq ft (464.5 sq m) of surface area.



Chart "B" - Application Flow Rate and Discharge Time

Flash Fuel	Minimum* Point	Minimum Flow Rate	Discharge Time
Hydrocarbon	100°F to 140°F (38°C to 60°C)	0.10 gpm/sq ft (4.1 lpm/sq m)	30 minutes
Hydrocarbon	Below 100°F (38°C)	0.10 gpm/sq ft (4.1 lpm/sq m)	55 minutes
Crude Oil	Not Applicable	0.10 gpm/sq ft (4.1 lpm/sq m)	55 minutes
Polar Solvents	Not Applicable	See Solberg	55 minutes

Most hydrocarbon fuels meet the minimum application flow rate of 0.10 gpm/sq. ft. (4.1 lpm/sq. m). There are some hydrocarbons that require higher application flow rates. For polar solvents, NFPA does not establish a minimum flow rate. Although some polar solvents have a minimum flow rate of 0.10 gpm/sq ft (4.1 lpm/sq m), the minimum rate can vary for polar solvents. Consult Solberg for recommendations.

Supplemental Protection

In addition to the primary protection, supplemental hose streams are required for the protection of fixed roof tanks. They are intended for the protection of small spill fires. The minimum quantity of 50 gpm (189 lpm) hose streams required is shown in the following Chart "C". The number required is based on the size of the largest tank protected by the fire protection system. The proportioning equipment must be capable of flowing the required hoses simultaneously with the main protection system, as well as being able to operate the supplemental hoses without operating the tank systems.

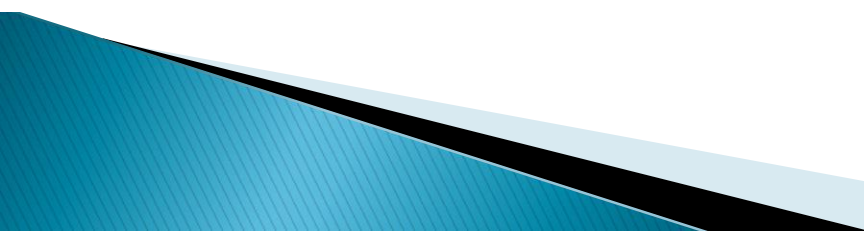
Chart "C" - Supplemental Hose Streams Required

Diameter of Tank	Number of Hose Streams
Up to 65 ft (19.8 m)	1
65 ft to 120 ft (19.8 m to 36.6 m)	2
Over 120 ft (36.6 m)	3

Chart "D" - Operating Time for Supplemental Hose Streams

Diameter of Tank	Minimum Operating Time
Up to 35 ft (10.7 m)	10 minutes
35 ft. to 95 ft (10.7 m to 28.9 m)	20 minutes
Over 95 ft (28.9 m)	30 minutes

System Design

- 1** Determine the fuel in the storage tank
 - 2** Determine the type of foam concentrate
 - 3** Determine the application flow rate required
 - 4** Determine the surface area to be protected
 - 5** Determine the amount of foam solution required
 - 6** Determine the quantity and size of the foam chambers required
 - 7** Determine the required discharge time
 - 8** Determine the number of supplementary hose streams required
 - 9** Determine the total quantity of foam concentrate required
 - 10** Select the proper proportioning equipment
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Design Example

Tank Type:	Cone Roof
Tank Diameter:	120 ft. (36.6 m)
Fuel:	Crude Oil
Available Water:	1,400 gpm (5,300 lpm) at 110 psi (7.6 bar)

1. Determine the Fuel In the Storage Tank

The fuel is crude oil

2. Determine the Type of Foam Concentrate

3% AFFF has been chosen

3. Determine the Application Flow Rate Required

Based on the above flow rate Chart "B", the required application flow rate for crude oil is 0.10 gpm/sq ft (4.1 lpm/sq m).

4. Determine the Surface Area To Be Protected

The tank diameter is 120 ft (36.6 sq m) which = 11,310 sq ft (1,051 sq m) ($\text{Radius}^2 \times \text{PI}$) = 60 ft (18.3 m) x 60 ft (18.3 m) x 3.1416 = 11,310 sq ft (1,051 sq m).

5. Determine the Amount of Foam Solution Required

11,310 sq ft (1,051 sq m) of surface area x 0.10 gpm/sq. ft. (4.1 lpm/sq. m) = 1,131 gallons (4,281 l) of foam solution required.

6. Determine the Quantity and Size of the Foam Chambers Required

Based on the Chart A, a 120 ft (36.6 m) diameter tank requires 2 foam chambers. The total foam solution required for this tank is 1,131 gallons (4281 l). To determine the size of the foam chambers required, divide the gallons of foam solution by the number of foam chambers required. 1,131 gallons (4281 l) divided by 2 = 566 gpm (2140 lpm) per foam chamber. Select the required foam chamber that will provide the necessary flow at the available water pressure.

7. Determine the Required Discharge Time

Based on the Chart B, crude oil requires a discharge time of 55 minutes.

8. Determine the Number of Supplementary Hose Streams Required

Based on the supplementary hose stream Chart C, a 120 ft (36.6 m) diameter tank requires 2 hose streams, each flowing at 50 gpm (189 lpm). The hose stream must operate for a minimum of 30 minutes.

9. Determine the Total Quantity of Foam Concentrate Required

The total quantity of foam concentrate required must include the quantity required for the foam chambers and the hose streams.

Solution rate for tank x % of injection x time = foam concentrate required for storage tank.

Solution rate for Hose Streams x % of injection x time = foam concentrate required for hoses.

Tank- 1,131 gpm (4281 l) x 0.03 x 55 minutes = 1,866 gallons (7064 l).

Hose Streams – 100 gpm (378 lpm) x 0.03 x 30 minutes = 90 gallons (341 l).

1,866 gallons (7064 l) for tank

+ 90 gallons (341 l) for two hose streams

1,956 total gallons (7404 l) of foam concentrate required

To be Continued...