MARSH

SOLUTIONS...DEFINED, DESIGNED, AND DELIVERED.

STORAGE TANK FIRES

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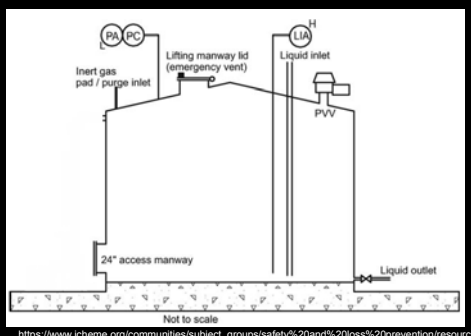
sr. consultant

MARSH & McLENNAN COMPANIES

CONE ROOF TANKS



https://www.icheme.org/communities/subject_groups/safety%20and%20loss%20prevention/resources/hazards%20archive/~/media/Documents/Subject%20Groups/Safety_Loss_Prevention/Hazards%20Archive/XIX/XIX-Paper-63.pdf

TANK DESIGN (1)

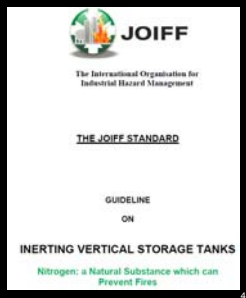
- Cone roof tank
  - Diameter <3 meter (no weak seam no ERV)
    Roof stays on tank – rocketing tank (video)
    Fixed system
  - Diameter ≥3 meter but <18 meter
    Weak seam, no ERV and no Nitrogen supply
    Roof can separate from tank – mobile response and fixed system are both possible
  - Diameter ≥3 meter but <18 meter
    With innerfloater – no mobile response

TANK DESIGN (2)

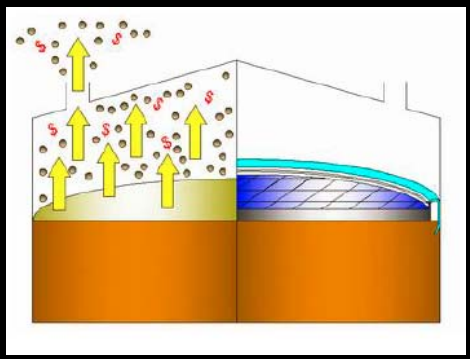
- Cone roof tank (continued)
  - Diameter > 18 meter with innerfloater
    Fixed system for rim seal fire or escalation scenario
    → full surface fire

TANK DESIGN (3)

- Cone roof tank (continued)
  - Diameter max 60 meter (also with innerfloater)
    Secure Nitrogen Blanketing
    NO FIRE
  - PFB Design – JOIFF Guideline
  - Tank venting requirements
    API 2000 venting design

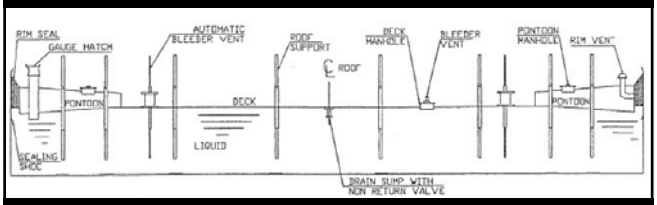


EFFECT FLOATING ROOF



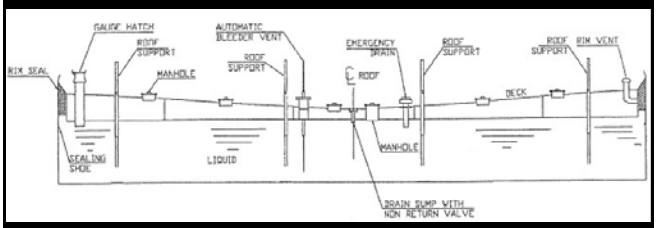
http://vapoloctemp.dynaglass.com/wp-content/uploads/2012/04/Brief-Information.pdf

SINGLE DECK PONTOON FLOATING ROOF



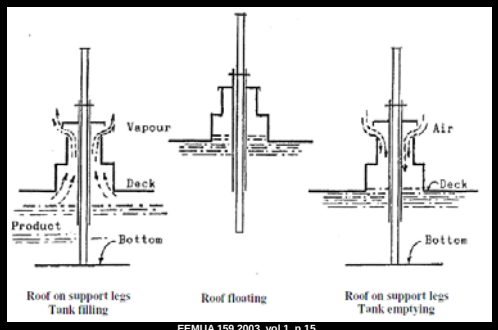
EEMUA 159: 2003, vol.1, p.15

DOUBLE DECK FLOATING ROOF TANK



EEMUA 159 2003, vol.1, p.15

ROOF POSITION



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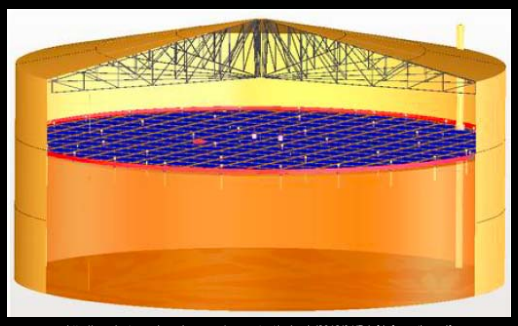
ALUMINIUM FLOATING ROOF

http://www.atecotank.com/product/floating_roof/alumax_ultimate_internal_floating_roof.html

FULL CONTACT GRE FLOATING ROOF TANK



http://vapoloctemp.dynaglass.com/wp-content/uploads/2012/04/Brief-Information.pdf

TANK DESIGN (4)

- Floating roof tank
  - Rim seal fire – fixed system
  - Escalation scenario – full surface fire
    Fixed or mobile system
    Diameter > 60 meter – consider mutual aid

TANK DESIGN (5)

- Floating roof tank with Aluminum geodesic dome roof felted and non felted
  - Fixed system for full surface fire for single full contact Aluminum deck and full contact GRE floating roof (may change in next version NFPA 11)
  - Fixed system for rim seal fire for other floating roofs

DESIGN OF TANK (6)

- Tank height
  - Very large tanks used to have L/D ratios of 0.5 or less with max height of 23 meter (API 650). Space limitations can dictate a larger height up to 44 meter – cylinder stiffening (API 620)
  - Small diameter tall tanks for vapour control like heated tarmac
  - Never use fixed system on tanks heated > 100 ºC

DESIGN OF TANK (7)

- Insulated tanks
  - Type of insulation and weather shield
  - Insulation – no credits heat exposure
  - Program – Corrosion Under Insulation (CUI) in place
- Heated tanks
  - Hot water coil
  - Steam coil
  - Electrical coil

DESIGN OF TANK (8)

- Temperature measurement/control liquid in tank
- Mixers
- Vapor control system
- Venting provisions
  - Inbreathing
  - Outbreathing
  - Standard calculation sheet JOIFF website

DESIGN OF TANK (9)

- Practical life of carbon steel storage tanks

Whatever comes first:

- 30 years, or
- 1,300 full empty movements

- EEMUA 159 – keeping tank fit for purpose, life can be extended to 100 years

TANK FIRE SCENARIO (1)

- Cone roof tank full surface fire
  - Roof separates from cylinder – intense fire
  - Functional weak seam but did not fully seperate from roof of tank – roof will partially lift from cylinder at intervals (video)
  - ERV with contra weight – mild fire
  - ERV without contra weight – more intense fire
  - With innerfloater and ventilation opening at top of cylinder – roof will partially lift from cylinder at intervals

TANK FIRE SCENARIO (2)

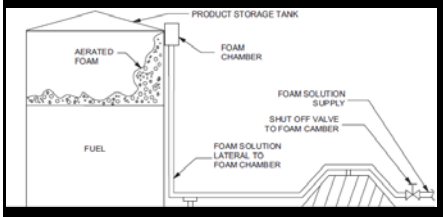
- Floating roofs
  - Rim seal fire
  - Full surface fire when floating capacity of floating roof is compromised
  - Pontoon chamber fire/explosion

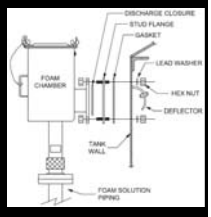
TANK FIRE SCENARIO (3)

- Floating roofs with geodesic Aluminum dome roof – felted and non felted
  - Rim seal fire
  - Full surface fire
  - Tank failure when Aluminum roof crashes in cylinder

FOAM EXTINGHUISMENT OPTIONS (1)

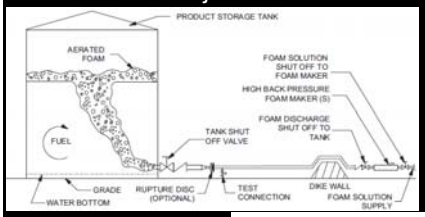
- Monitors – radiant heat exposure responders
- Foam chamber (various foam chambers available)

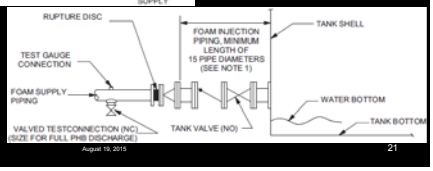




FOAM EXTINGHUISMENT OPTIONS (2)

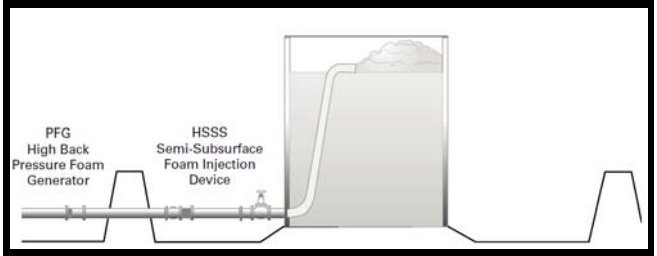
- Sub-surface injection





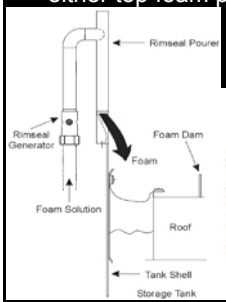
FOAM EXTINGHUISMENT OPTIONS (3)

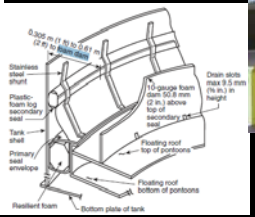
- Semi sub-surface injection



FOAM EXTINGHUISMENT OPTIONS (4)

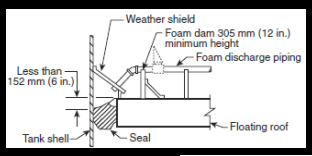
- Top foam pourers with foam dam foam delivered by either top foam pourer or flexible hose in tank (video)

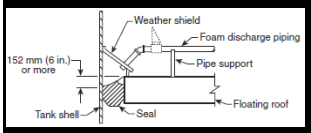


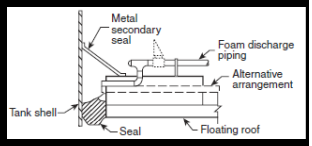


FOAM EXTINGHUISMENT OPTIONS (5)

- Foam between or below the seals







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FIXED FOAM SYSTEM – NUMBER OF POURERS (1)

Table 5.2.5.2.1 Number of Fixed Foam Discharge Outlets for Fixed-Roof Tanks Containing Hydrocarbons or Flammable and Combustible Liquids Requiring Alcohol-Resistant Foams

Tank Diameter (or Equivalent Area)		Minimum Number of Discharge Outlets
m	ft	
Up to 24	Up to 80	1
Over 24 to 36	Over 80 to 120	2
Over 36 to 42	Over 120 to 140	3
Over 42 to 48	Over 140 to 160	4
Over 48 to 54	Over 160 to 180	5
Over 54 to 60	Over 180 to 200	6

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FIXED FOAM SYSTEM – NUMBER OF POURERS (1)

Table 5.2.6.2.8 Minimum Number of Subsurface Foam Discharge Outlets for Fixed-Roof Tanks Containing Hydrocarbons

Tank Diameter		Minimum Number of Discharge Outlets	
m	ft	Flash Point Below 37.8°C (100°F)	Flash Point 37.8°C (100°F) or Higher
Up to 24	Up to 80	1	1
Over 24 to 36	Over 80 to 120	2	1
Over 36 to 42	Over 120 to 140	3	2
Over 42 to 48	Over 140 to 160	4	2
Over 48 to 54	Over 160 to 180	5	2
Over 54 to 60	Over 180 to 200	6	3
Over 60	Over 200	6	3
		Plus 1 outlet for each additional 465 m^2 (5000 ft^2)	Plus 1 outlet for each additional 697 m^2 (7500 ft^2)

Notes:
(1) Liquids with flash points below 22.8°C (73°F), combined with boiling points below 37.8°C (100°F), require special consideration.
(2) Table 5.2.6.2.8 is based on extrapolation of fire test data on 7.5 m (25 ft), 27.9 m (93 ft), and 34.5 m (115 ft) diameter tanks containing gasoline, crude oil, and hexane, respectively.
(3) The most viscous fuel that has been extinguished by subsurface injection where stored at ambient conditions [15.6°C (60°F)] had a viscosity of 2000 SSU (440 centistokes) and a pour point of –9.4°C (15°F). Subsurface injection of foam generally is not recommended for fuels that have a viscosity greater than 440 centistokes (2000 SSU) at their minimum anticipated storage temperature.
(4) In addition to the control provided by the smothering effect of the foam and the cooling effect of the water in the foam that reaches the surface, fire control and extinguishment can be enhanced further by the rolling of cool product to the surface.

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APPLICATION RATE & TIME NFPA RECOMMANDATION (1)

Table 5.2.4.2.2 Foam Handline and Monitor Protection for Fixed-Roof Storage Tanks Containing Hydrocarbons

Hydrocarbon Type	Minimum Application Rate		Minimum Discharge Time (minutes)
	L/min · m²	gpm/ft²	
Flash point between 37.8°C and 60°C (100°F and 140°F)	6.5	0.16	50
Flash point below 37.8°C (100°F) or liquids heated above their flash points	6.5	0.16	65
Crude petroleum	6.5	0.16	65

Notes:
(1) Included in this table are gasohols and unleaded gasolines containing no more than 10 percent oxygenated additives by volume. Where oxygenated additives content exceeds 10 percent by volume, protection is normally in accordance with 5.2.4.3. Certain nonalcohol-resistant foams might be suitable for use with fuels containing oxygenated additives of more than 10 percent by volume. The manufacturer should be consulted for specific listings or approvals.
(2) Flammable liquids having a boiling point of less than 37.8°C (100°F) might require higher rates of application. Suitable rates of application should be determined by test. Flammable liquids with a wide range of boiling points might develop a heat layer after prolonged burning and then can require application rates of 8.1 L/min · m² (0.2 gpm/ft²) or more.
(3) Care should be taken in applying portable foam streams to high-viscosity materials heated above 93.3°C (200°F). Good judgment should be used in applying foam to tanks containing hot oils, burning asphalts, or burning liquids that have a boiling point above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate, it can also cause violent frothing and "slop-over" of the tank's contents.

APPLICATION RATE & TIME NFPA RECOMMANDATION (2)

Table 5.2.5.2.2 Minimum Discharge Times and Application Rates for Type II Fixed Foam Discharge Outlets on Fixed-Roof (Cone) Storage Tanks Containing Hydrocarbons

Hydrocarbon Type	Minimum Application Rate		Minimum Discharge Time (minutes)
	L/min · m²	gpm/ft²	
Flash point between 37.8°C and 60°C (100°F and 140°F)	4.1	0.10	30
Flash point below 37.8°C (100°F) or liquids heated above their flash points	4.1	0.10	55
Crude petroleum	4.1	0.10	55

Notes:
(1) Included in this table are gasohols and unleaded gasolines containing no more than 10 percent oxygenated additives by volume. Where oxygenated additives content exceeds 10 percent by volume, protection is normally in accordance with 5.2.5.3. Certain nonalcohol-resistant foams might be suitable for use with fuels containing oxygenated additives of more than 10 percent by volume. Consult manufacturer for specific listings or approvals.
(2) Flammable liquids having a boiling point of less than 37.8°C (100°F) might require higher rates of application. Suitable rates of application should be determined by test.
(3) For high-viscosity liquids heated above 93.3°C (200°F), lower initial rates of application might be desirable to minimize frothing and expulsion of the stored liquid. Good judgment should be used in applying foams to tanks containing hot oils, burning asphalts, or burning liquids that have boiling points above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such liquids at a slow rate, it can also cause violent frothing and "slop-over" of the tank's contents.
(4) Type I discharge outlets are considered obsolete, and those currently installed become Type II outlets if damaged. Refer to A.5.2.5.2.2 for additional information and minimum discharge times for existing Type I outlets.

APPLICATION RATE & TIME NFPA RECOMMANDATION (3)

Table 5.2.5.3.4 Minimum Application Rates and Discharge Times for Fixed-Roof (Cone) Tanks Containing Flammable and Combustible Liquids Requiring Alcohol-Resistant Foams

Application Rate for Specific Product Stored	Minimum Discharge Time (minutes)
	Type II Foam Discharge Outlet
Consult manufacturer for listings on specific products	55

Notes:
(1) Most currently manufactured alcohol-resistant foams are suitable for use with Type II fixed foam discharge outlets. However, some older alcohol-resistant foams require gentle surface application by Type I fixed foam discharge outlets. Consult manufacturers for listings on specific products.
(2) Type I discharge outlets are considered obsolete, and those currently installed become Type II outlets if damaged. Refer to A.5.2.5.2.2 for additional information and minimum discharge times for existing Type I outlets.

APPLICATION RATE & TIME NFPA RECOMMANDATION (4)

Table 5.2.6.5.1 Minimum Discharge Times and Application Rates for Subsurface Application on Fixed-Roof Storage Tanks

Hydrocarbon Type	Minimum Application Rate L/min · m²	Minimum Application Rate gpm/ft²	Minimum Discharge Time (minutes)
Flash point between 37.8°C and 60°C (100°F and 140°F)	4.1	0.1	30
Flash point below 37.8°C (100°F) or liquids heated above their flash points	4.1	0.1	55
Crude petroleum	4.1	0.1	55

Notes:
(1) The maximum application rate shall be 8.1 L/min · m² (0.20 gpm/ft²).
(2) For high-viscosity liquids heated above 93.3°C (200°F), lower initial rates of application might be desirable to minimize frothing and expulsion of the stored liquid. Good judgment should be used in applying foams to tanks containing hot oils, burning asphalts, or burning liquids that are heated above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such liquids at a slow rate, it can also cause violent frothing and "slop-over" of the tank's contents.

APPLICATION RATE & TIME NFPA RECOMMANDATION (5)

Table 5.3.5.3.1 Top-of-Seal Fixed Foam Discharge Protection for Open-Top Floating Roof Tanks

Seal Type	Applicable Illustration Detail	Minimum Application Rate L/min · m²	Minimum Application Rate gpm/ft²	Minimum Discharge Time (minutes)	Maximum Spacing Between Discharge Outlets with 305 mm (12 in.) Foam Dam m	305 mm (12 in.) Foam Dam ft	610 mm (24 in.) Foam Dam m	610 mm (24 in.) Foam Dam ft
Mechanical shoe seal	A	12.2	0.3	20	12.2	40	24.4	80
Tube seal with metal weather shield	B	12.2	0.3	20	12.2	40	24.4	80
Fully or partly combustible secondary seal	C	12.2	0.3	20	12.2	40	24.4	80
All metal secondary seal	D	12.2	0.3	20	12.2	40	24.4	80

Note: Where the fixed foam discharge outlets are mounted above the top of the tank shell, a foam splashboard is necessary due to the effect of winds.

APPLICATION RATE & TIME NFPA RECOMMANDATION (6)

Table 5.3.5.3.6.1 Below-the-Seal Fixed Foam Discharge Protection for Open-Top Floating Roof Tanks

Seal Type	Applicable Illustration Detail	Minimum Application Rate L/min · m²	Minimum Application Rate gpm/ft²	Minimum Discharge Time (minutes)	Maximum Spacing Between Discharge Outlets
Mechanical shoe seal	A	20.4	0.5	10	39 m (130 ft) — Foam dam not required
Tube seal with more than 152 mm (6 in.) between top of tube and top of pontoon	B	20.4	0.5	10	18 m (60 ft) — Foam dam not required
Tube seal with less than 152 mm (6 in.) between top of tube and top of pontoon	C	20.4	0.5	10	18 m (60 ft) — Foam dam required
Tube seal with foam discharge below metal secondary seal*	D	20.4	0.5	10	18 m (60 ft) — Foam dam not required

*A metal secondary seal is equivalent to a foam dam.

CONTROLLED BURN

Controlled burn can be considered for very toxic products when safe discharge after the incident from primary containment might be compromised.

Controlled burn for crude is not recommended

RISK OF BOILOVER
(video)

QUESTIONS

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