Tank Protection Best Practice and Lessons Learnt

Presenter: Martin Hough

8th International Conference

Hungary November 2015

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Tank protection

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Storage tank types

- Cone roof
  - Top pourers / foam chambers
  - Base injection / sub-surface
- Internal floating roof
  - Light or heavy decks
  - Top pourers
  - Geodesic pourers
- External floating roof
  - Rimseal pourers
  - Flotafoam
  - Full surface nozzles

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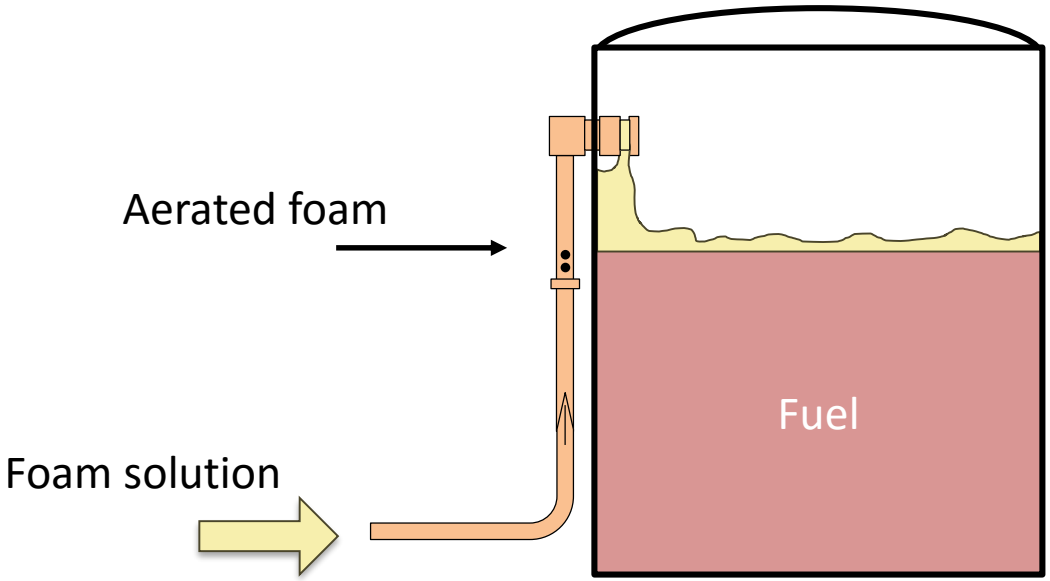
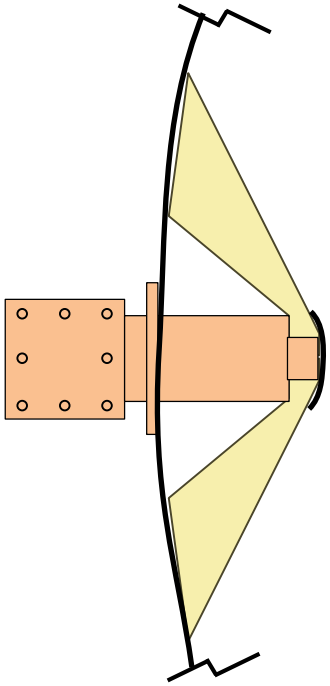
Cone roof tanks – top pourer schematic



View from above



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Cone roof tanks

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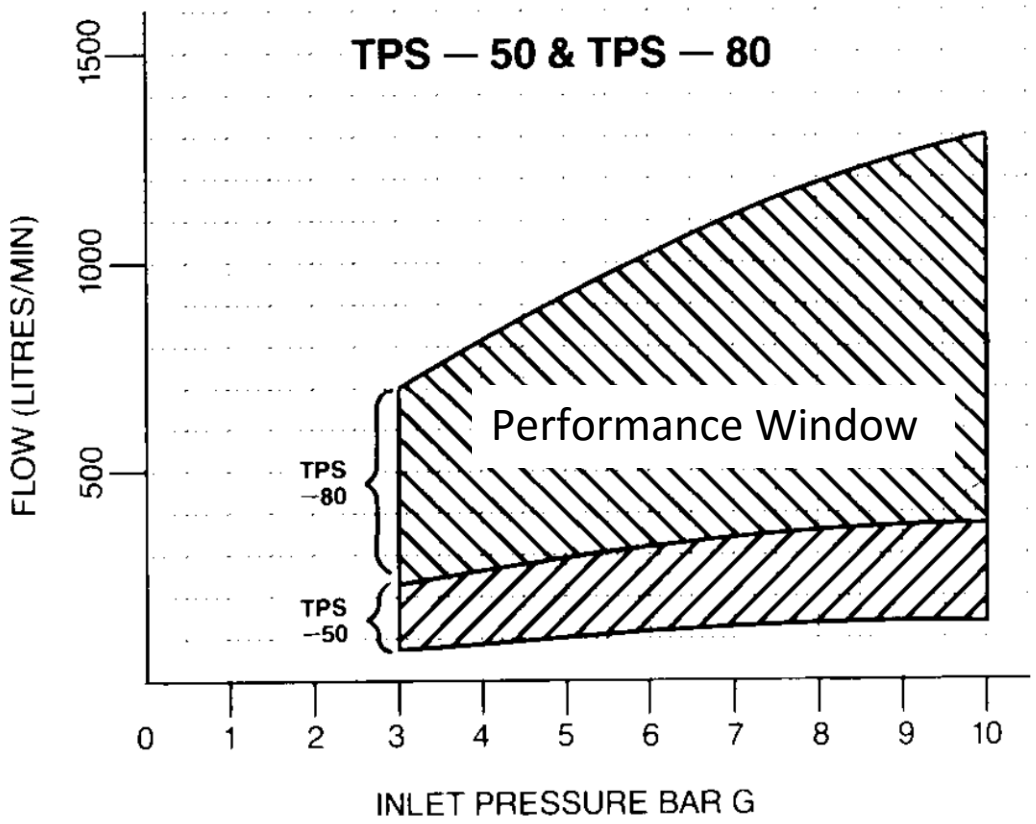
Top pourer performance



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Top pourer calculations – to NFPA 11

- Hydrocarbons: 4.1 L/min/m2 of the surface area
- Polar solvents: 10 L/min/m2 but also by advice
- Number of inlets:

Tank Diameter (m)	Minimum number of foam pourers
Up to 24	1
24 – 36	2
36 – 42	3
42 – 48	4
48 – 54	5
54 – 60	6
Over 60m add one inlet for each additional …	… 465 m^2 of exposed fuel surface

- System run-time
  - Hydrocarbons with flash point between 37.8°C and 93.3°C 30 minutes
  - Hydrocarbons with flash point below 37.8°C 55 minutes

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Foam slide rule

HYDROCARBON
Storage Tank Fires

FOAM APPLICATION ESTIMATOR

◀ Surface Area (m²)

◀ Tank Diameter (m)

TANKMASTER 3% FP @ 3% (Class EN 1A/2A)

Foam Solution (L/min) required	Foam CONCENTRATE (L/min) required	Total Foam Solution '000L required	Foam CONCENTRATE '000L required	WATER Demand '000L required
Litres/min required	TOTAL Kilolitres required			

Solution ratio: 3 parts concentrate to 97 parts water

TRIDOL ATF 1-3% AR-AFFF @ 1% (Class EN 1B/2B)

Foam Solution (L/min) required	Foam CONCENTRATE (L/min) required	Total Foam Solution '000L required	Foam CONCENTRATE '000L required	WATER Demand '000L required
Litres/min required	TOTAL Kilolitres required			

Solution ratio: 1 part concentrate to 99 parts water

NOTE: This estimator approximates resources necessary to combat flammable liquid fires of fuel in depth, based on semi-forceful monitor application, in accordance with EN13565-2:2009 recommendations. Consult Angus Fire for further information +44 (0)1844 293600.

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POLAR SOLVENT
Spill & Bund Fires

FOAM APPLICATION ESTIMATOR

◀ Spill Size (m²)

NIAGARA 3-3% AR-FFFP @ 3% (Class EN1C)

Foam Solution (L/min) required	Foam CONCENTRATE (L/min) required	Total Foam Solution '000L required	Foam CONCENTRATE '000L required	WATER Demand '000L required
Litres/min required	TOTAL Kilolitres required			

Solution ratio: 3 parts concentrate to 97 parts water

TRIDOL ATF 3-3% AR-AFFF @ 3% (Class EN1B)

Foam Solution (L/min) required	Foam CONCENTRATE (L/min) required	Total Foam Solution '000L required	Foam CONCENTRATE '000L required	WATER Demand '000L required
Litres/min required	TOTAL Kilolitres required			

Solution ratio: 3 parts concentrate to 97 parts water

NOTE: This estimator approximates resources necessary to combat flammable liquid spill fires of greater than 25mm, based on gentle MEX Bund Pourer application, in accordance with EN13565-2:2009 recommendations. Application rates may vary depending on fuel (data consistent with Acetone/IPA). Consult Angus Fire for further information +44 (0)1844 293600.

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POLAR SOLVENT
Storage Tank Fires

FOAM APPLICATION ESTIMATOR

◀ Surface Area (m²)

◀ Tank Diameter (m)

ALCOSEAL 3-6% AR-FFFP @ 6% (Class EN1B)

Foam Solution (L/min) required	Foam CONCENTRATE (L/min) required	Total Foam Solution '000L required	Foam CONCENTRATE '000L required	WATER Demand '000L required
Litres/min required	TOTAL Kilolitres required			

Solution ratio: 6 parts concentrate to 94 parts water

TRIDOL ATF 1-3% AR-AFFF @ 3% (Class EN1B/1C)

Foam Solution (L/min) required	Foam CONCENTRATE (L/min) required	Total Foam Solution '000L required	Foam CONCENTRATE '000L required	WATER Demand '000L required
Litres/min required	TOTAL Kilolitres required			

Solution ratio: 3 parts concentrate to 97 parts water

NOTE: This estimator approximates resources necessary to combat flammable liquid fires of fuel in depth, based on Top Pourer application, in accordance with EN13565-2:2009 recommendations (Monitors are not suitable for water misdible fuels). Application rates may vary depending on fuel (data consistent with Acetone/IPA). Consult Angus Fire for further information +44 (0)1844 293600.

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HYDROCARBON
Spill & Bund Fires

FOAM APPLICATION ESTIMATOR

◀ Spill Size (m²)

TANKMASTER 3% FP @ 3% (Class EN1A/2A)

Foam Solution (L/min) required	Foam CONCENTRATE (L/min) required	Total Foam Solution '000L required	Foam CONCENTRATE '000L required	WATER Demand '000L required
Litres/min required	TOTAL Kilolitres required			

Solution ratio: 3 parts concentrate to 97 parts water

TRIDOL ATF 1-3% AR-AFFF @ 1% (Class EN1B/2B)

Foam Solution (L/min) required	Foam CONCENTRATE (L/min) required	Total Foam Solution '000L required	Foam CONCENTRATE '000L required	WATER Demand '000L required
Litres/min required	TOTAL Kilolitres required			

Solution ratio: 1 part concentrate to 99 parts water

NOTE: This estimator approximates resources necessary to combat flammable liquid spill fires of greater than 25mm, based on gentle MEX Bund Pourer application, in accordance with EN13565-2:2009 recommendations. Consult Angus Fire for further information +44 (0)1844 293600.

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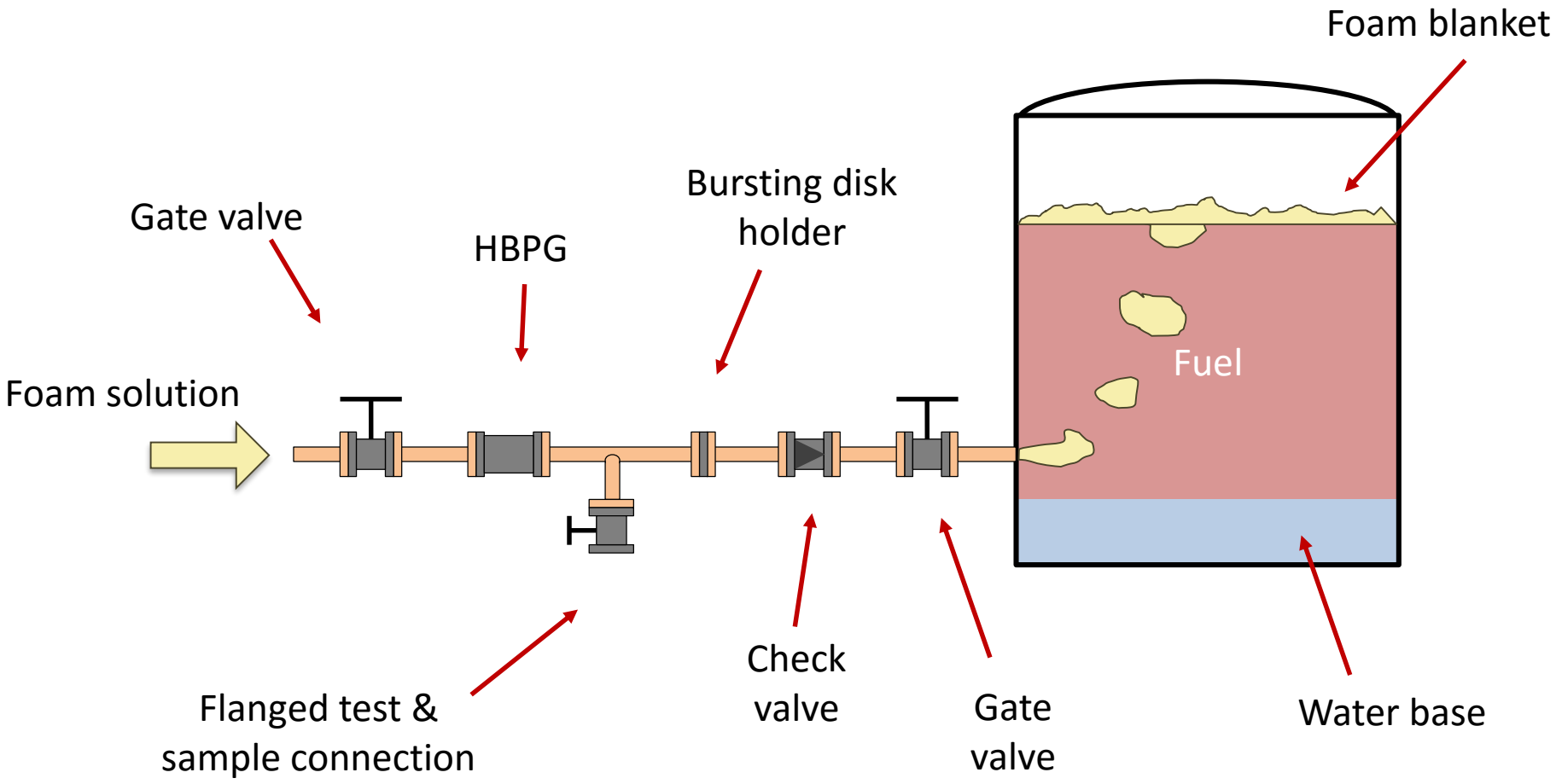
Base injection schematic



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Cone roof tanks

- Base Injection Systems
- High Back Pressure Generators

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Base injection calculation

- Minimum Application rate according to NFPA 11
  - 4.1 litres/min/m^2 of the surface area.
- Number of Generators:

Tank diameter (m)	Flash-point below 37.8°C	Flash-point 37.8°C or higher
Up to 24	1	1
24 – 36	2	1
36 – 42	3	2
42 – 48	4	2
48 – 54	5	2
54 – 60	6	3
Greater than 60m add one inlet for each additional …	… 465m^2 of exposed fuel	… 697m^2 of exposed fuel

- System run-time
  - Product flash point between 37.8°C and 93.3°C — 30 minutes
  - Product flash point below 37.8°C — 55 minutes

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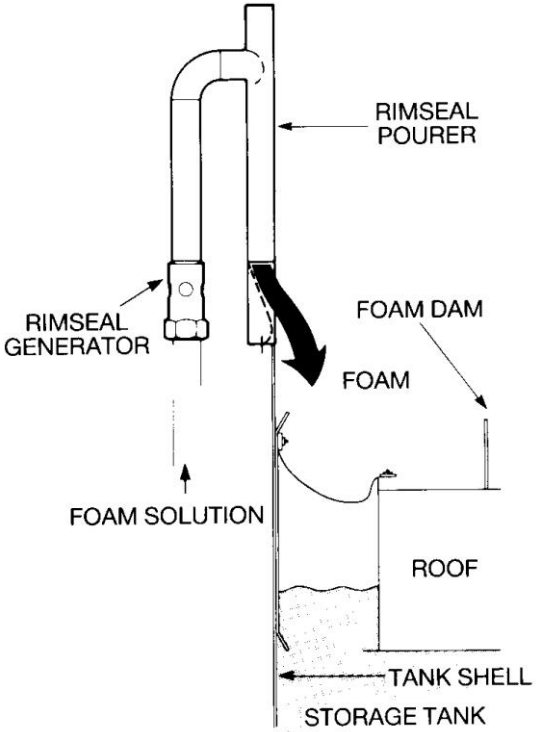
External floating roof tank

- Rimseal pourers



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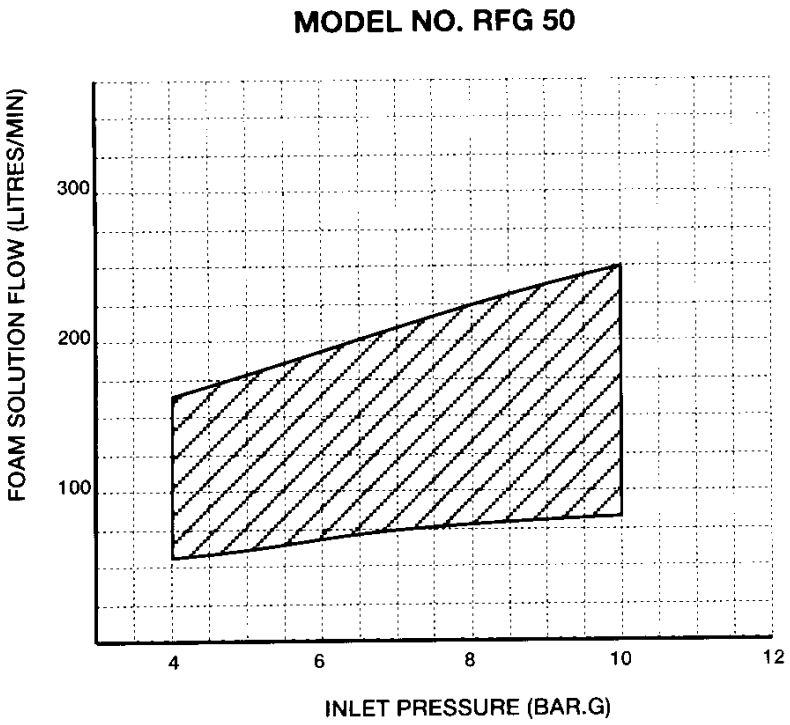
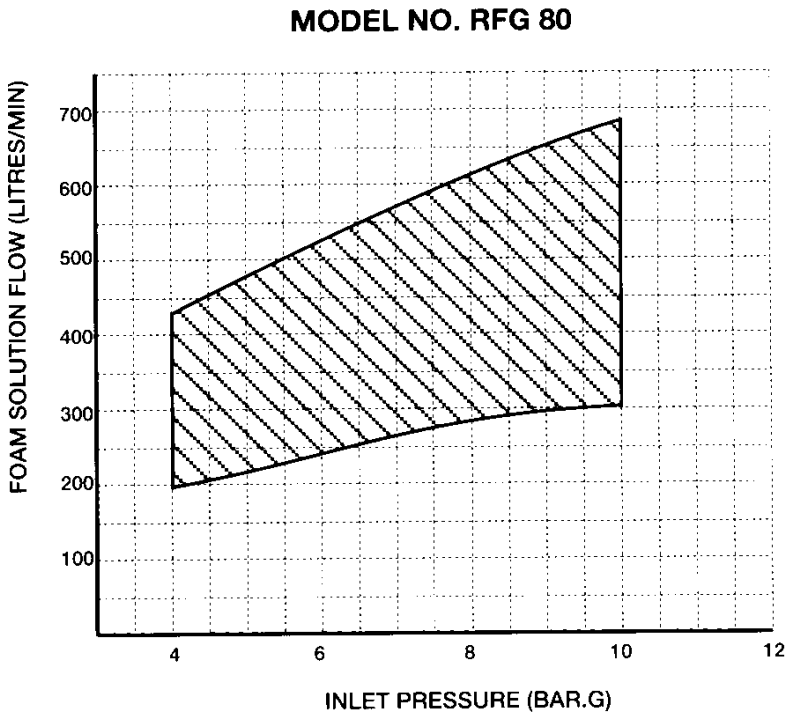
Rimseal pourer performance



Graph 3.3 Angus RFG50 Performance



Graph 3.3.1 Angus RFG 80 Performance

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Rimseal pourers

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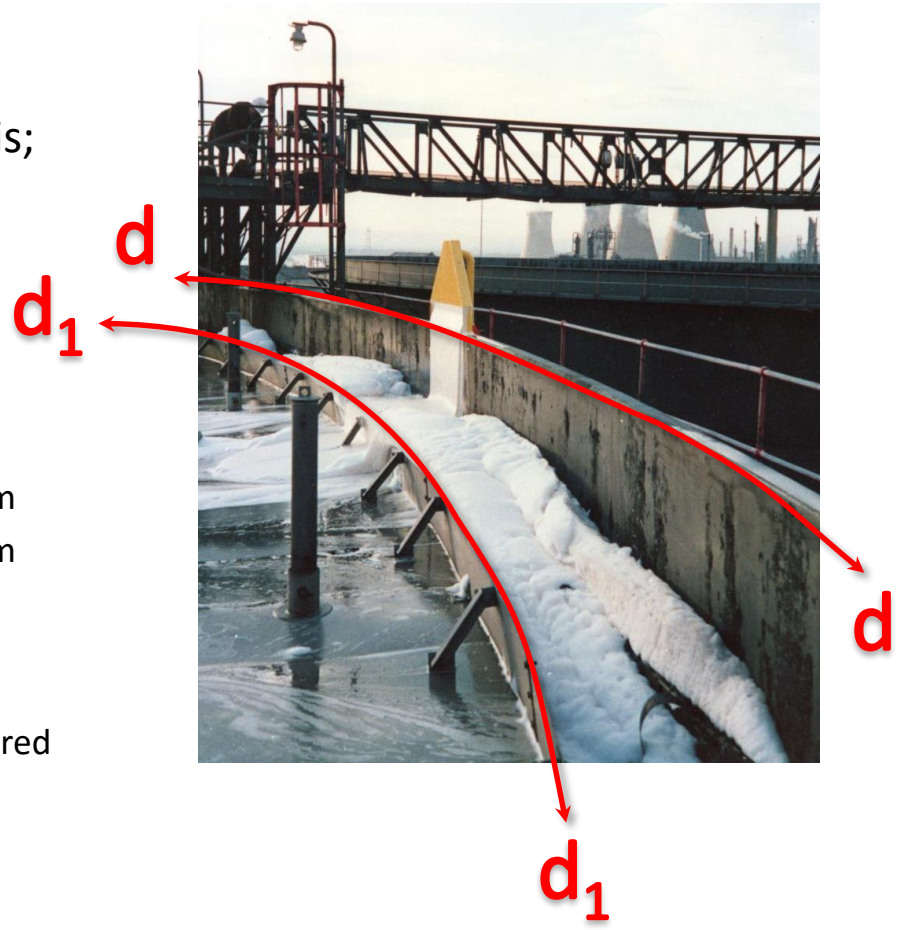
External floating roof tank

- Calculation for protection = $\frac{\pi d^2}{4} - \frac{\pi d_1^2}{4}$

- NFPA 11 minimum Foam Application rate is;
  - Where d is the tank diameter and
  - Where d1 is the foam dam diameter
  - Application rate is 12.2 L/min/m^2

- Number Of Pourers
  - Dam height: 0.3m high, maximum spacing 12.2m
  - Dam height: 0.6m high, maximum spacing 24.4m

- Running Time.
  - Sufficient foam for 20 minutes operation is required



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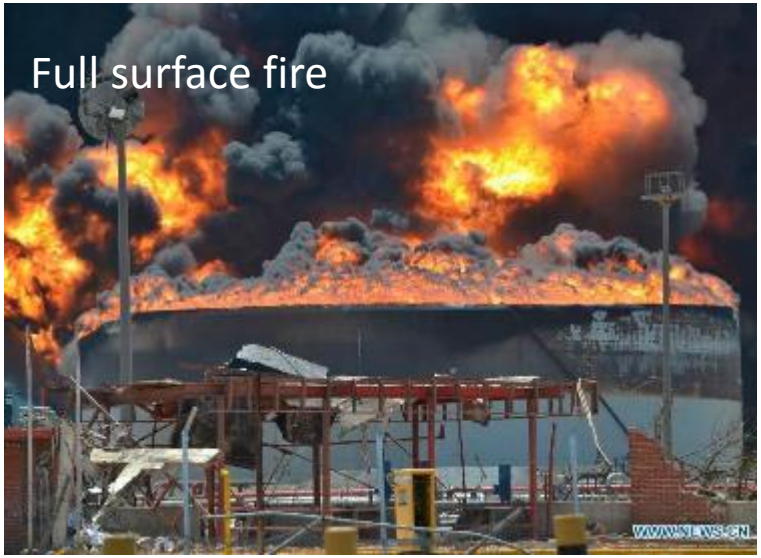
Floating Roof Tank – Full Surface Fire



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Reference Project – Abu Dhabi crude oil (ADCOP)

Rimseal pourer (left), full surface pourer (right)

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Reference Project – Abu Dhabi crude oil (ADCOP)

Full surface nozzle

© Angus Fire 2015

Reference Project – Abu Dhabi crude oil (ADCOP)

Foam Pourers

Hook Lift Trucks

12” Fire Hose

Fire Trucks

Foam Tankers

Water Monitors

Hydrants

RIV’s

Foam Proportioning

Hose Deployment

Cabinets

Big Flow Monitors

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Big Flow Monitors

Large resource requirement but flexible, scalable, future-proof

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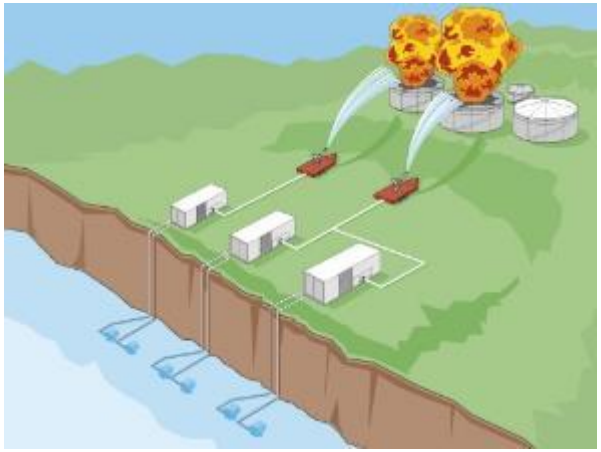
Big Flow System

Neptune	Dominator	Iron Man
Submersible pump	Booster pump	Monitor



- System design EN 13565-2
- Base application rate 4 Lpm/m^2 plus "*factors*"
- 100m dia. tank application rate is 12 Lpm/m^2
- Total flow rate: $94{,}200\ Lpm$

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EN 13565-2 Foam Systems Standard

DIAMETER	HANDLINES	MONITORS	TOP POURING
Less than 10m	2.5 t: 60 min	-	-
Less than 45m	-	2.5 t: 60 min	1.0 t: 60 min
45m to 60m	-	2.75 t: 90 min	1.25 t: 60 min
More than 60m	-	3.0 t: 90 min	1.5 t: 60 min

Consideration may have to be given to foam application to the centre on large tanks.

Source: EN13565-2 System Standard

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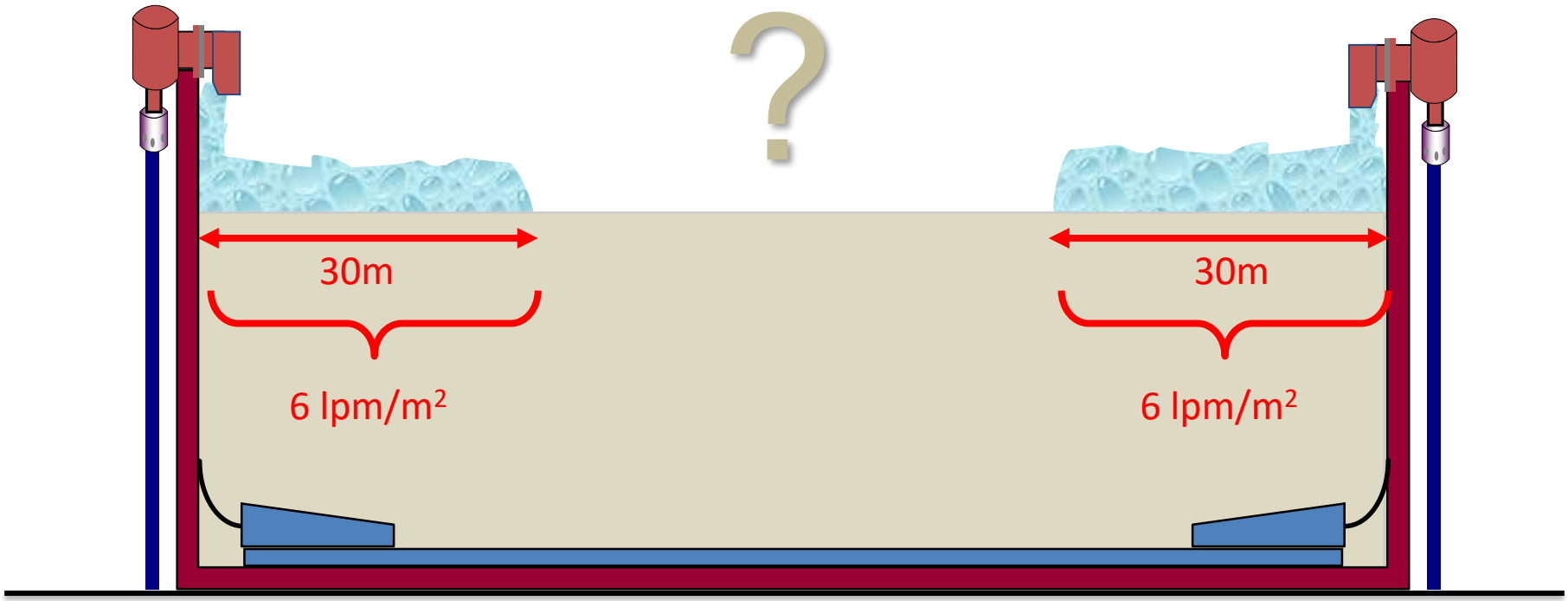
Full Surface Pourers – 100m Diameter Tank

Standards suggest that 30m is maximum foam flow
More is possible but not documented from a formal series of tests



Source: Niall Ramsden

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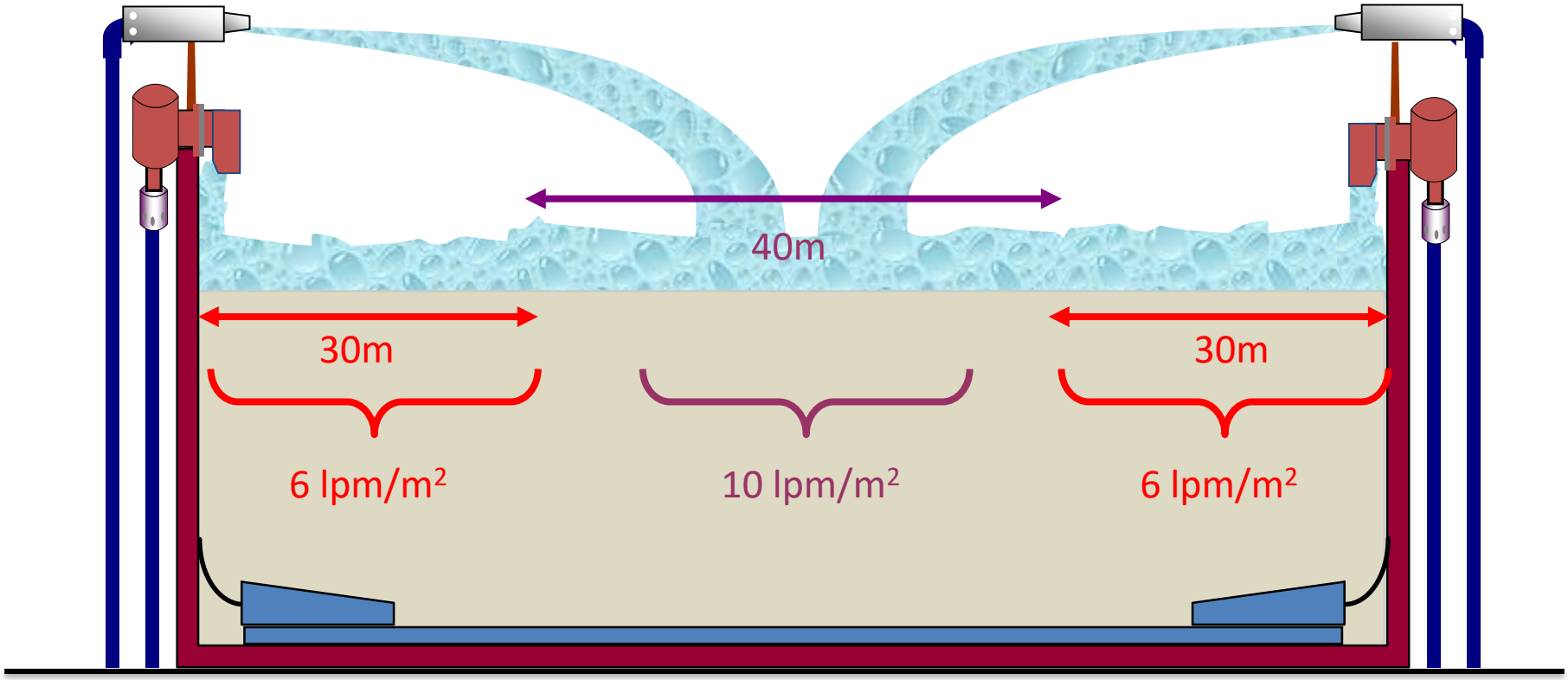
Full Surface Pourers – 100m Diameter Tank



Source: Niall Ramsden

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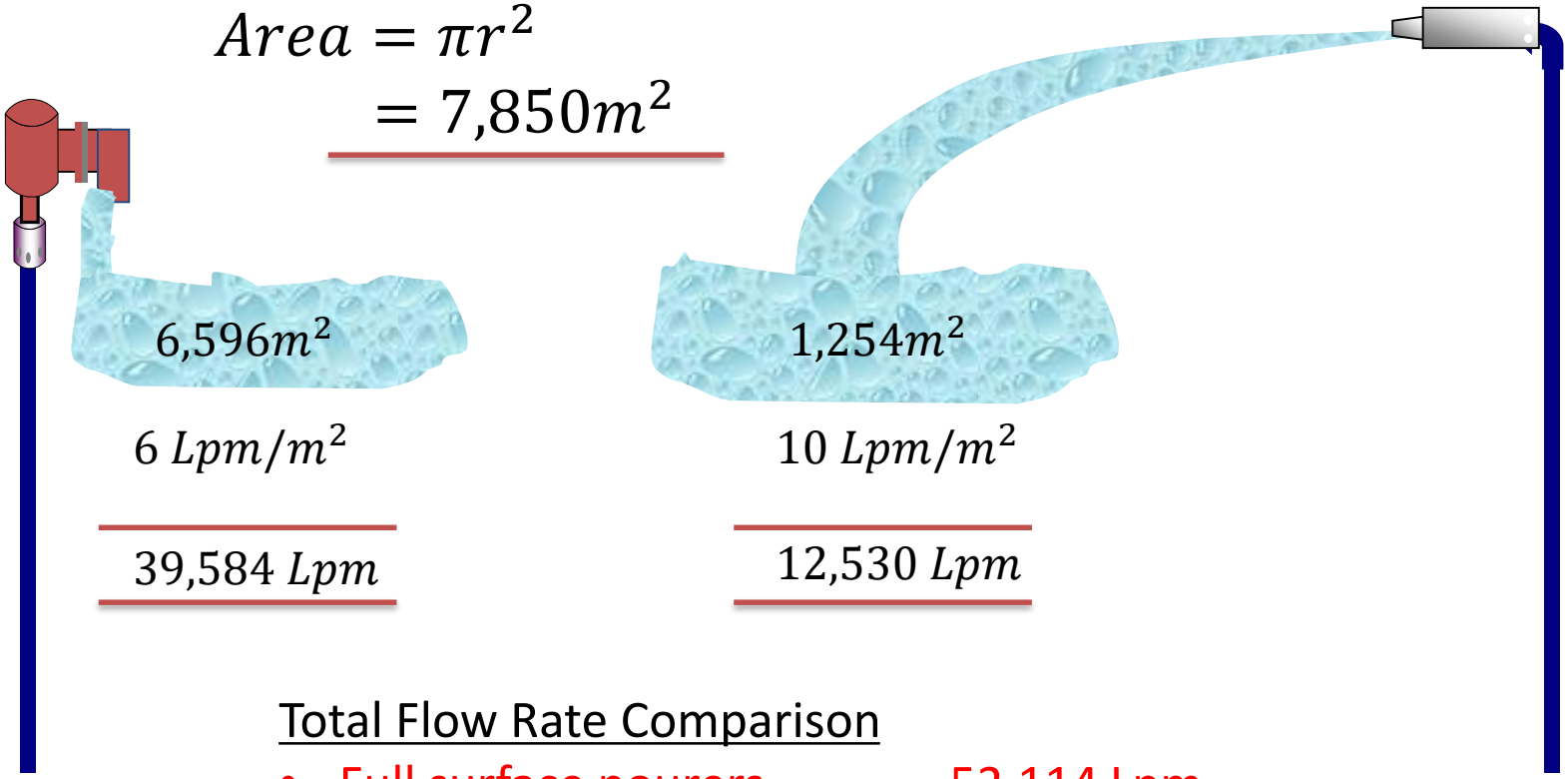
A little bit of maths …

- Calculation for 100m diameter tank, full surface solution

$$Area = \pi r^2$$
$$= 7{,}850m^2$$



Total Flow Rate Comparison

- Full surface pourers 52,114 Lpm
- Monitors 94,200 Lpm

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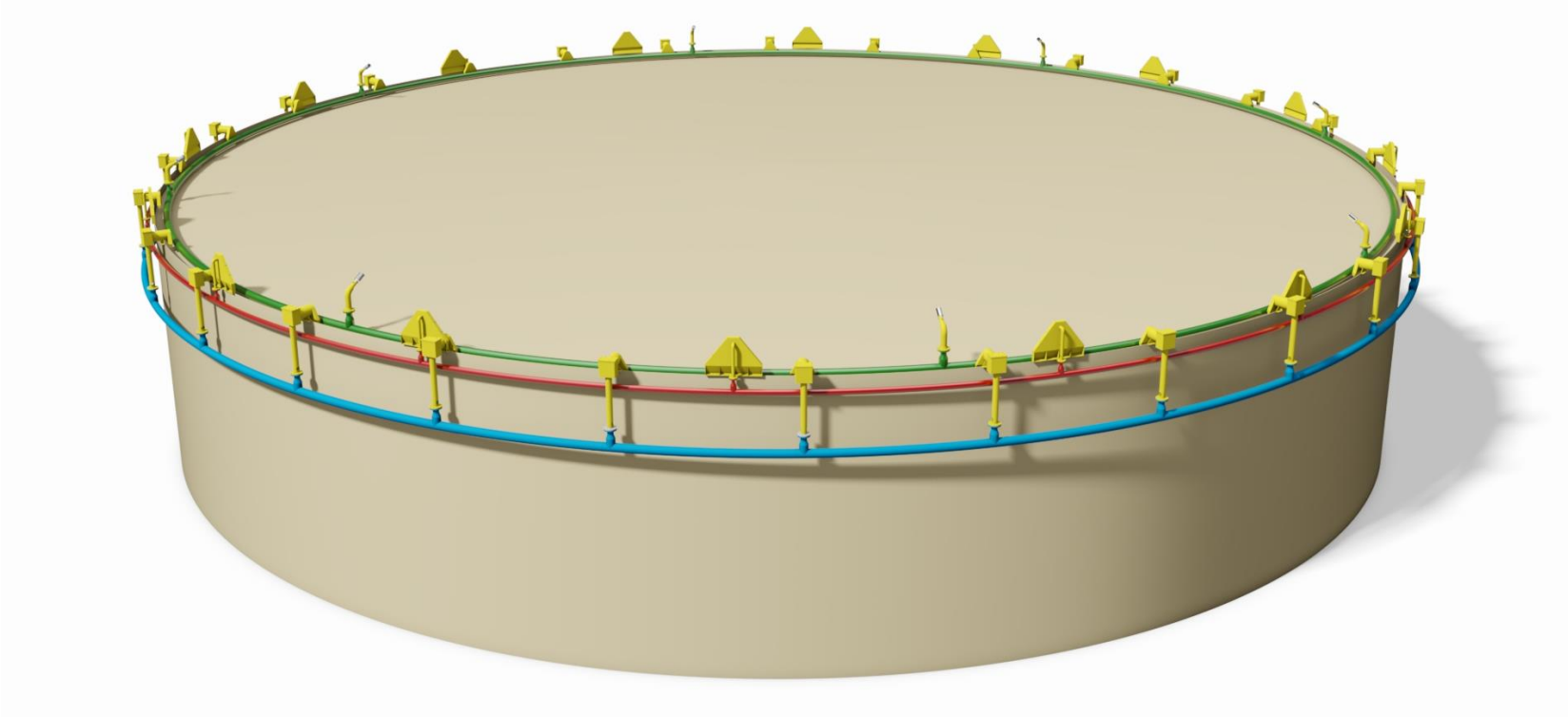
Angus Model Reference 100m dia Tank

Rimseal protection -	16
Full surface pourers -	28
Full surface nozzles -	8



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Full surface nozzles in operation

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Fixed Equipment Developments

- Full Surface Monitor
  - Angus long throw nozzle
  - Fixed jet (no moving parts)
  - Stainless steel (316) construction
  - Heat resistant
  - Supplied complete with elbow (carbon steel)
  - Nominal flow of 2,120 Lpm at 6.5 bar
  - Range = 50m

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Fixed Equipment Developments

- Full surface pourer
  - Existing design
  - Carbon steel body
  - Thermoplastic coated for durability
  - Fire resistant components
  - Multiple units in service
  - Nominal flow of; 1,650 Lpm at 6 bar

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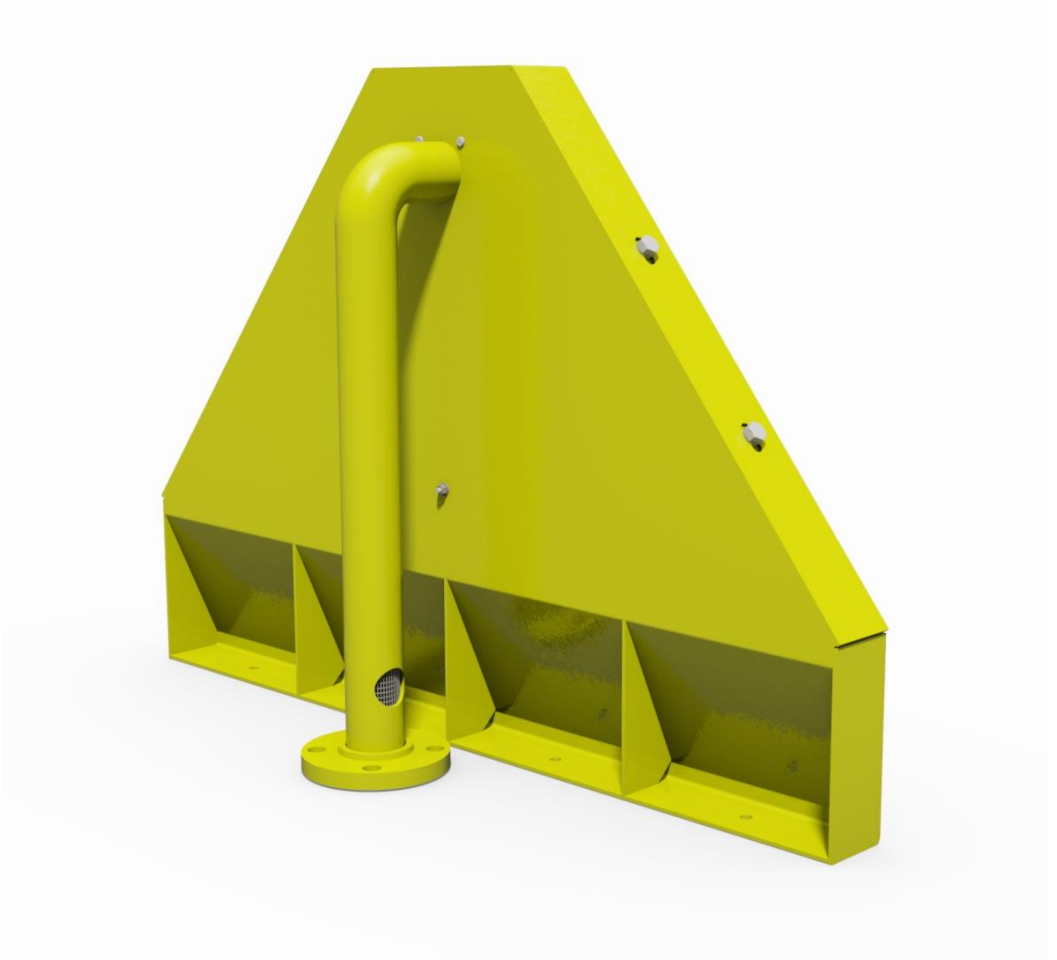
Fixed Equipment Developments

- Rimseal pourer
  - Existing design
  - Carbon steel body
  - Thermoplastic coated for durability
  - Fire resistant components
  - Multiple units in service
  - Nominal flow of; 220 Lpm at 4 bar



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Fire Test Procedures

- Test protocol approved by RPI (Resource Protection International)
- Accredited by ISO 9001 and 14001
- Pourer foam properties and monitor nozzle throw checked after 2 hour fire exposure.
- All equipment tested for 2 hours

FM 595473

EMS 576644

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Video of live fire tests

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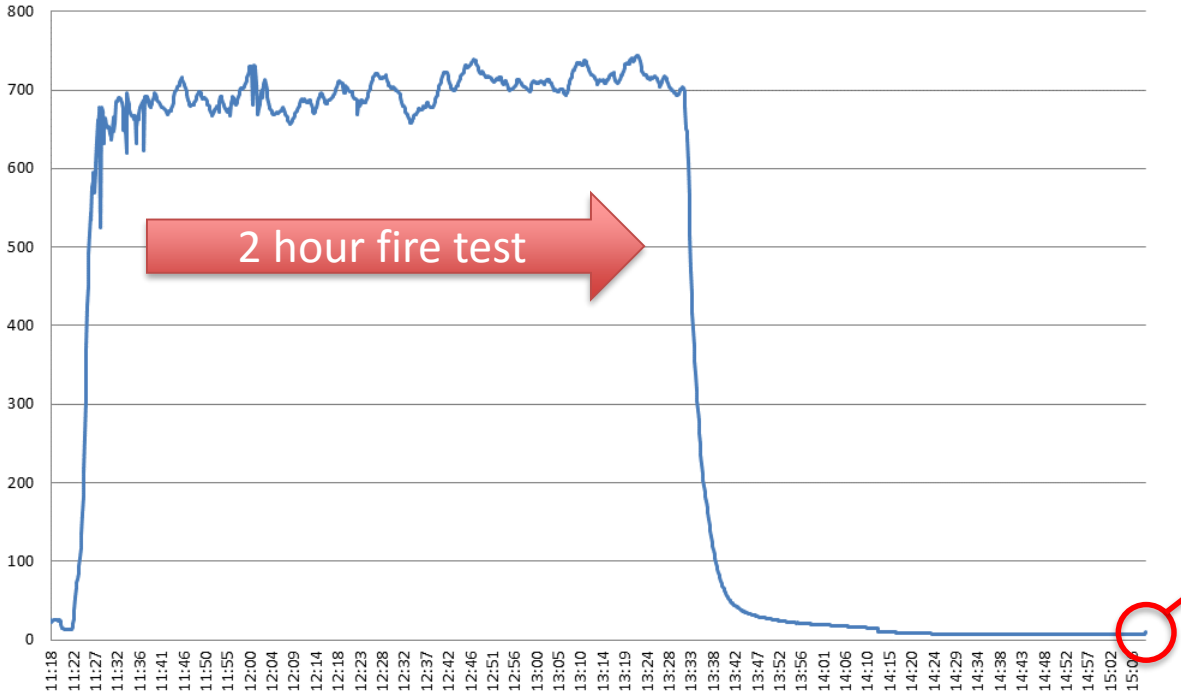
Finished Foam Properties



Multiple Test Results	Expansion ratio (ave.)	25% drainage time (ave.)
Pre burn test	9.8	2 min 13 sec
Post burn test	10.55	2 min 24 sec
RESULT	**PASS**	**PASS**

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Floatafoam systems

- First strike protection on floating roof tanks
- Puts foam directly into the seal area
- Self Contained

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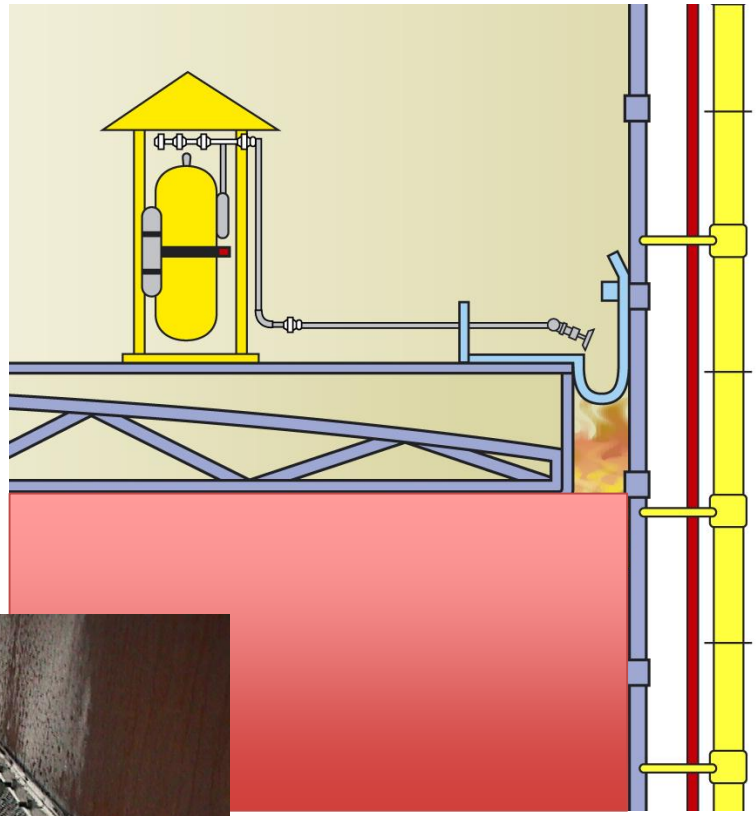
Floatafoam systems

- Includes detection; self-contained
- Replacement for gas systems
- Cools/Extinguishes
- Post-fire security
- Time to make decisions



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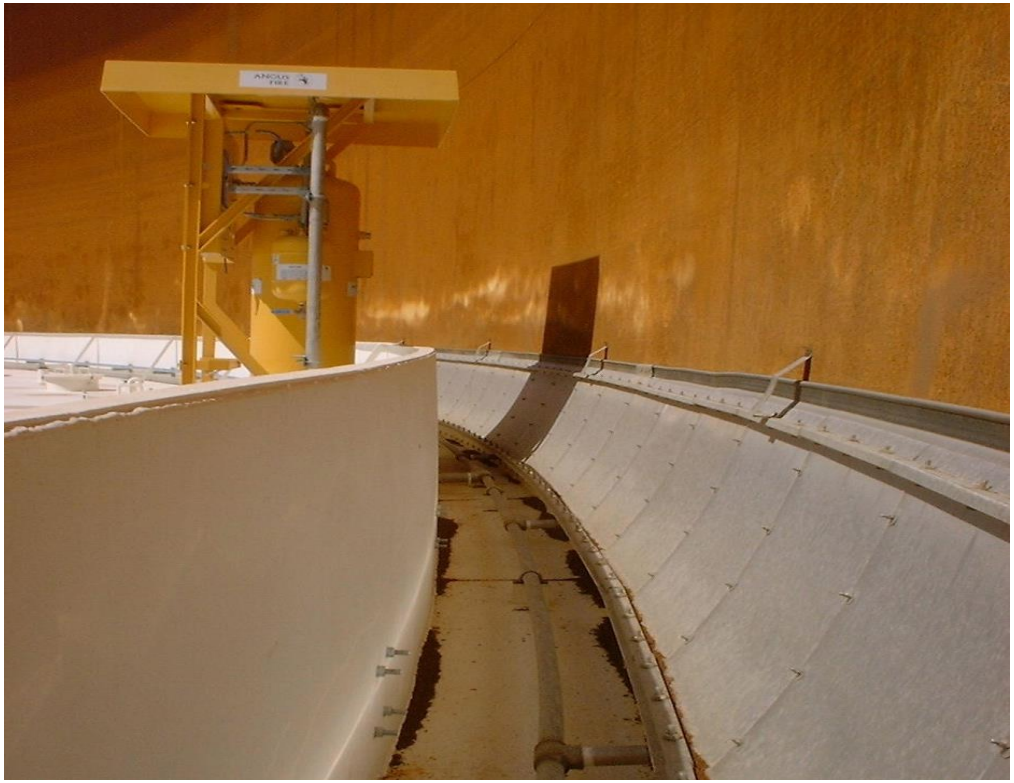
Floatafoam system installed



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Internal floating roof tanks

"Geodesic Dome" tanks can have two options for floating decks

1. Lightweight.
   - Use Top Pourers, and calculate as a Cone roof tank.

2. Heavyweight with foam dam.
   - Use Geodesic Pourers and calculate as an Open Top Floating roof tank

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Geodesic pourer

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Summary

- Full surface fires can result in a total loss of product and tank
- Full surface pourers may not protect centre of tank on >60m dia.
- Full surface nozzles do offer protection for the tank centre
- “Belt and braces” approach to fire protection ensures reliability

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Considerations for Bund Protection

- Size of bund/separating walls
- Bund construction
- Distance of foam travel/obstructions
- Fuels Stored
- Water supplies available – May not be possible to apply foam over full surface area

Foam Branch Pipe

- Typically 225 to 900 lpm
- Foam expansion 6-8:1 (Low) 40:1 (Med)
- Ideal for small spill fire – Limited throw
- Supplementary Protection (NFPA 11)

Standard Foam Monitors

- Typical application rate 6.5 lpm/m2 (Hydrocarbon)
- Up to 10,000 lpm
- Foam expansion 2-6:1
- Throws up to 70m

Big Flow Monitors

- Typical application rate 6.5 lpm/m2 (Hydrocarbon)
- Up to 40,000 lpm
- Foam expansion 2-6:1
- Throws up to 140m
- Long set up time

Fixed Low Expansion or Medium Expansion Pourers

- Typical application rate 4 lpm/m2 (Hydrocarbon), 6.5 lpm/m2 Polar solvents
- Up to 1,800 lpm flow
- Foam expansion 8:1 (Low) 40:1 (Medium)
- Quick/safe operation

Design Standards

EN 13565-2 - Base Application Rate 4 lpm/m2

HAZARD	FUEL TYPE	HANDLINES		MONITORS		FIXED FOAM POURING SYSTEMS	
		Low Exp.	Medium Exp.	Non-aspirated	Aspirated – Low Exp.	Low Exp.-pouring	Medium Exp.-pouring
Spill fires (<25mm fuel depth)	WI-V	<400m² **1.0 t: 15 min** >400m² **NA**	<400m² **1.0 t: 15 min** >400m² **NA**	**1.5 t: 30min**	**1.5 t: 30 min**	**0.75 t: 15 min**	**0.75t: 15 min**
Bund/Dike fuel in depth fires (>25mm fuel depth) Process /Loading areas - increased splashing and escalation risk	WI-V	<400m² **1.0 t: 30 min** >400m² **NA**	<400m² **1.0 t: 30 min** >400m² **NA**	< 400m² **1.5 t: 30min** >400 <2000m² **2.25 t: 45min** >2,000m² **2.5 t: 60 min**	< 400m² **1.5 t: 30 min** >400<2,000m² **2.0 for 45 min** > 2,000m² **2.25 t: 60 min**	< 400m² **1.0 t: 20 min** >400<2 000m² **1.00 t: 45 min** >2,000m² **1.25 t: 45min**	< 400m² **1.0 t: 15 min** >400 <2000m² **1.00 t: 30 min** >2,000m² **1.25 t: 30min** [b]
Bund/Dike fuel in depth (>25mm fuel depth) Process /Loading areas - increased splashing and escalation risk	WM	<400m² **1.0 * t: 30 min** (AR foams only) >400m² **NA**	<400m² **1.5 * t: 20 min** (AR foams only) >400m² **NA**	**NA**	**NA**	< 400m² **1.0* t: 20 min** (AR foams only) >400 <2000m² **1.0* t: 45 min** (AR foams only) >2,000m² **1.25 t: 45 min**	< 400m² **1.0* t: 15 min** (AR foams only) >400 <2000m² **1.0* t: 30 min** (AR foams only) >2,000m² **1.25 t: 30 min** [a b]

Fire Ground

- 83m External floating roof tank
- No automatic detection
- Visual alert Tuesday 19th August

- Split re-circulating hose at the base of the tank
- Extensive bund fire
- Running fuel fire
- Rimseal fire
- Pumped off most of the fuel

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Ignition of tank

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River of fire

© Angus Fire 2015

Tank cooling

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Early attempts at firefighting

- Rimseal pourers
  - Failed
  - Single riser
  - Proportioner damaged
- No manual attempts at this stage

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Early attempts at tank firefighting

- Vehicle monitors
  - Foam quality ok
  - Poorly directed
  - Majority fell in centre of roof

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The fire ground at night

© Angus Fire 2015

Successful attack

- Colossus monitor 15,000 L/min @ 8 bar
- Dominator pump 20,000 L/min @ 8 bar
- 5” hose
- FP70 fluoroprotein foam

- Result:

Control and extinction in 37 minutes

© Angus Fire 2015

Successful attack

Colossus sweeping the rimseal

© Angus Fire 2015

Successful attack

Extinction !

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Thank you, are there any questions?

Presenter: Martin Hough

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8th International Conference

Hungary November 2015

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