Supplying a Semi-Fixed Foam System, a Case Study

February 25, 2013
SFPE Chicago Chapter
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Supplying a Semi-Fixed Foam System, a Case Study

November 12, 2012
SFPE Greater Atlanta Chapter Meeting
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Learning Objectives

1. Understand the benefits and limitations of semi-fixed fire protection systems

2. Understand the specific issues associated with using Aircraft Rescue and Firefighting (ARFF) Vehicles to supply semi-fixed foam systems protecting bulk fuel storage tanks
Background

- Steve
- Rhett
- Don
- John

- How we all came together on this project
Semi-Fixed Systems are Common
Semi-Fixed CO₂
From NFPA 11
The usual supply vehicle
Proportioning, Water, Initial Foam
Proportioning, 3% AFFF
Foam Injection Piping
Fire Department Connection
Follow-on Foam
Sub-Surface Injection on Some Tanks
Air inlets, pumping 4:1 expanded solution
Expanded Foam Friction Loss
NFPA 11 and HFPE
Sub surface injection, not topside

Figure 4-5A.1. Foam friction losses—4:1 expansion (2½", 3", 4", 6", 8", and 10" pipe).
SPECIFICS
What we needed to know

- Tank and fuel characteristics
- Design foam solution flow rate and duration
- System demand flow and pressure (similar to DBOR)
- System k factor
- Actual flow at actual supply pressure
- Foam concentrate needed at actual flow
Tank and Fuel

- Cone roof tank
- Type II discharges
- Jet A, Class II liquid

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

<table>
<thead>
<tr>
<th>Hydrocarbon Type</th>
<th>Minimum Application Rate</th>
<th>Minimum Discharge Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L/min · m²</td>
<td>gpm/ft²</td>
</tr>
<tr>
<td>Flash point below 37.8°C (100°F) or liquids heated above their flash points</td>
<td>4.1</td>
<td>0.10</td>
</tr>
<tr>
<td>Crude petroleum</td>
<td>4.1</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Calculations

• Surface Area = 0.7854 X Diameter\(^2\)
• 80 foot diameter = 5027 ft\(^2\)
• 5027 ft\(^2\) X 0.1 gpm/ft\(^2\) = 502.7 gpm
• Actual demand = 505 gpm
• Foam concentrate = 505 gpm X 3% = 15.15 gpm
• 15.15 X 30 minutes = 454.5 gallons concentrate
• Supplementary hose to come from other vehicles
System Calculations, HFPE

For airport example, 505 gpm @ 115 psi
Calculations

- 505 gpm @ 115 psi
- $Q = k\sqrt{p}$
- $K = Q/\sqrt{p} = 47.1$
- At 150 psi @ FDC, flow = 577 gpm

Hose friction loss, $0.8Q^2$

- Actual foam @150 psi = 577 X 3% = 17.3 gpm
- = 519 gallons AFFF
- Crash truck carries 420 gallons/17.3 gpm = 24 min supply – need foam tanker
- Extra for over pressure and over proportioning – need foam tanker hooked up in 15 min – Striker empty in 18 minutes
Pressure Control

- Industrial foam pumpers can control pressure fairly easily, they are built for this.
- ARFF vehicle pumps discharge at 240 psi.
- Very hard to regulate to 150 psi through a quarter turn valve.
Pressure control

- "Structural kits" are available but are an expensive add-on, and not required for the crash rescue mission.
- The vehicle’s idle speed generates lower pressure but still adequate flow for these tanks.
  - Manage effect of pump curve flow < 1950 gpm
  - Application of the pump affinity laws
  - Actual 166 psi at FDC
Pump Affinity Laws - FPH

PUMP AFFINITY LAWS

The mathematical relationships among head, capacity, brake horsepower, and impeller diameter are called the pump affinity laws. Law 1 assumes constant impeller diameter with change of speed. Law 2 assumes constant speed with change in diameter of the impeller. These laws are expressed by proportion, as follows:

Law 1

\[
\frac{Q_1}{Q_2} = \frac{N_1}{N_2}, \quad \frac{H_1}{H_2} = \frac{N_1^2}{N_2^2}, \quad \frac{\text{bhp}_1}{\text{bhp}_2} = \frac{N_1^3}{N_2^3}
\]
Proportioning, 3% AFFF

- Somewhat iterative
- Estimate flow
  - idle rpm and resulting actual FDC pressure
  - k factor
- Set metering valve for that flow
- NFPA 11 range 3-3.9%
Proportioning, 3% AFFF
Simplified Around the Pump Proportioner

From NFPA 11
OPERATION
Water Resupply
Measurement

• Flow measurement
• Foam concentration measurement
The Result, Through The Manhole

- 606 gpm @ 166 psi (compare to 577 @ 150 psi and 505 @ 115)
- 4% initial proportioning
- Adjusted metering valve to 3.74% avge proportioning
  - Would have used 680 gpm AFFF over 30 min
  - Would have emptied ARFF tank in 18.5 min
Technical Issues

- These ARFF vehicles not designed for this task
- Had to be “tricked” into working this way
- Bypassed turret/handline proportioning valve
- Half of the vehicles had foam sensors in the structural outlets
  - As soon as foam flow was detected, the pump speed increased to provide 240 psi; is too high
- Prior to test, no one could verify that foam could be discharged from the structural outlets at idle
Attempt Using Quint

502 gpm  2.95% proportioning

Foam tank too small, foam system capacity too low
Not intended of this kind of task
Doing This Elsewhere

• Each type of vehicle has to be tested
• Low idle would not have been enough for larger tanks
  – remember pump affinity laws
• Pump takes suction from the 3000 gallon water tank
  – refill line not sized with this in mind
  – NFPA 414 requires two minute refill capability @ 80 psi inlet
  – K factor 168 for this vehicle
  – compare to refill source performance
• Full crash mode is very stressful on the engine
  – overheating during long duration in this mode
• Other types of proportioning systems
Going Forward

• Is 166 psi @ FDC acceptable? – Gauge on FDC will solve
• Atlanta is purchasing an industrial foam pumper
  – Purpose-built for this function
  – Existing Foam pumper was not evaluated
• Incident Commander now chief of special ops then city-wide shift commander

LA County FD Foam Unit Prototype for Atlanta
Thank you for your time.

Questions?

This concludes the educational content of this activity.