

**FOAM/WATER
SPRINKLER SYSTEMS**

SPECIFICALLY

NFPA16: Standard for the
Installation of Foam-Water
Sprinkler and Foam-Water Spray
Systems
2007 edition

Where are they used?

- Chemical plant process and storage areas
- Food oil extraction plants
- Ethanol plants
- Flammable liquid storage areas
- Truck and rail load out racks
- Aircraft hangars

Design Decisions

- What is the hazard
 - What is the flammable liquid
 - What classification does the flammable liquid fall into
 - Hydrocarbon
 - Polar solvent

Hydrocarbons

- Essentially petroleum based liquids
- Density: .16 GPM/Sq Ft
- Area:
 - Closed head Wet: 5000 sq ft
 - Closed head Dry: 5000 sq ft
 - Closed head Pre-Action: 5000 sq ft
 - Deluge: Entire system area

Polar Solvents

- Water miscible liquids
 - Alcohols
 - *Ethanol*
 - Methanol
 - Ethers
 - Esters
 - Ketones

Polar Solvents

- Density: Based on manufacturer's listings
- Consult UL Directory or FM Approval Guide
- Density is concentrate specific
- Density is sprinkler/nozzle specific
 - Upright .24 GPM/Sq Ft
 - Pendent .22 GPM/Sq Ft

Concentrates

- Fuel: Hydrocarbon based
 - AFFF
 - Mid range cost per gallon
 - Standard sprinklers
 - AR-AFFF
 - Higher cost per gallon
 - Standard sprinklers
 - Better vapor suppression
 - Protein/Fluoroprotein
 - Low cost per gallon
 - Inexpensive tanks
 - Must use aspirating sprinklers
 - Mil Spec AFFF
 - High Expansion

Concentrates

- Fuel: Polar Solvent
 - MUST use AR-AFFF or AR-FFFP
 - AR-AFFF used extensively in the United States, Canada, Central and South America
 - AR-FFFP used extensively in Europe
 - Polar solvent fuels destroy standard AFFF foam blanket

System layout

- Follow NFPA13 rules regarding:
 - Spacing
 - Maximum 100 sq ft per head
 - Maximum 12' on center
 - Distance from walls
 - Distance from ceiling or roof

Hydraulic Calculations

- Same rules as NFPA13
- Use Hazen Williams formula for system piping
- Use D'Arcy formula for concentrate piping
- Balance flows within 15% on system
- Balance water/concentrate pressures within 2 PSI

Hydraulic Calculations

- Two sets of calculations required on closed head systems
 - Demand calculation
 - Most remote area
 - Supply calculation
 - Remote area nearest riser at full water supply

Need to Know Rules

- 5 pipe diameters straight piping above and below the ratio controller
- Bladder tank proximity to riser
 - Closer the better
 - Concentrate Pipe:
 - Black schedule 40 (NEVER USE GALVANIZED)
 - Stainless steel
 - Brass
- Sprinkler heads
 - AFFF: Standard sprinklers
 - AR-AFFF: Standard sprinklers
 - Protein/Fluoroprotein: Air aspirating sprinkler heads

Types of Foam Systems

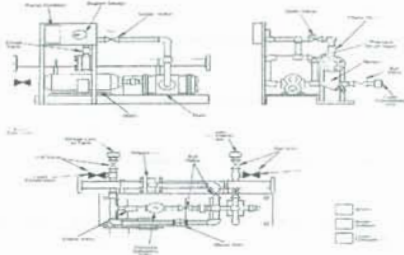
- Balanced Pressure Systems
 - Bladder Tanks
 - Balanced Pressure Pump Skids
- In-Line Balanced Pressure Systems
- Pre-mixed Systems
- Dual Agent Systems

System components: Bladder Tank



System Components: Balanced Pressure Skid

TYPICAL CONFIGURATION



System Components: Proportioners



System Components: Proportioners



SIZE	AR-AFFF (gpm (lpm))	AFFF (gpm (lpm))
2-1/2"	130-400 (492-1514)	48-400 (151-1514)
3"	245-700 (927-2649)	76-750 (284-2839)
4"	400-1500 (1514-5678)	200-1600 (757-6056)
6"	960-3000 (3633-11356)	300-3400 (1135-12870)
8"	1510-4500 (5715-17034)	500-5500 (1892-20819)

System Test

Typical process:

- **Gather and review system data**
 - Design criteria, plans & specifications.
 - Equipment data sheets and installation recommendations.
- **Preliminary visual inspection**
 - Entire system for errors & omissions.
- **Functional tests (component level)**
 - Pumps, motors, valves, etc.
- **Detection & alarms**
 - System activation & proper alarm response from all circuits.
 - note: Notify alarm center & fire department prior to start!
- **System flushing and preliminary water only flow tests**
 - Flush pipes, verify operating pressures.

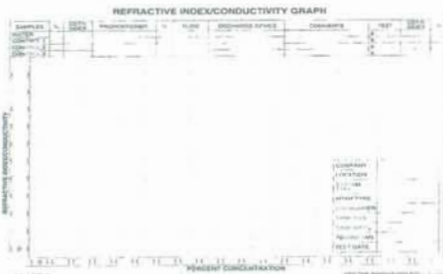
- Typical process
continued

- **Foam flow test**
 - Verify proper proportioning under operating conditions
- **Flush and drain system**
 - Where appropriate
- **Refill foam tank to design level**
- **Reset / restore to normal standby condition**
- **Record and file system performance data**

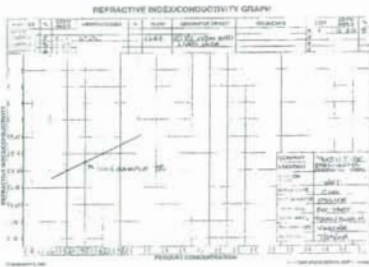
Foam Flow Test

- Mix base line samples
 - 3% foam mix 2%, 3% and 4%
 - Plot on graph paper
- Obtain sample from system trip test
 - Take from test header drain
- Compare to base line
 - Must fall at or above concentrate ratio and below 1% higher

Typical test Graph Sheet



Sample Graph



High Expansion Foam Systems

- In-Depth coverage of solid fuel fires
- Flooding of large enclosed areas
 - High rack storage protection
 - Basements and underground passages
 - LNG and LPG
 - Vapor protection
 - Wind will affect outdoor application

Calculation Formula

- $R = ((V/T) + R_s) \times C_n \times C_L$
- R = Application rate in CFM
- V = Area x Depth
- T = Submergence Time
- R_s = Breakdown Rate by sprinklers cubic ft/min
- C_n = Shrinkage Factor (1.15)
- C_L = Leakage Factor

Aircraft Hangar Protection

- Design Criteria based on:
 - NFPA 409
 - USAF ETL 02-15
 - ANG ETL 03-04
 - US Army ETL TL1110-3-484 (Aircraft)

NFPA 409 (Group I)

- Entire area covered to 3' depth
- 1 minute time allowed
- R_s .17/15,000 sq ft
- Breakdown per test data
- Leakage (C_L) 1.0 to 1.2
- 12 Minute Duration
- Outside Air Required
- Supplemental Hand Lines Required (2 @ 60/20 min)
- Concentrate Redundancy Required

Extinguishing Methods

- Prevents movement of air required for continuous combustion
- Converts to steam which reduces oxygen concentration by dilution of air
- Conversion to steam is an effective cooling mechanism
- Lowers surface tension of water for better penetration of class A materials
- Reduces radiation feedback on LNG fires

Redundancy Requirement NFPA 409

- Connected reserve foam tank
 - Manually operated control valves
 - No doubling primary tank size allowed
 - Same fill quantity as Primary tank
- No secondary pump required

USAF ETL 02-15

- Entire area covered to 1 meter (3.28 ft)
- 4 Minute time allowed
- Rs 2/5000 sq ft
- Breakdown = 10
- Leakage (CL):
 - <15000 sq ft = 2.0
 - >15000 sq ft < 30000 sq ft = 2.5
 - >30000 sq ft = 3.0
- 15 Minute Duration
- No Outside Air
- No Hand Lines
- No Concentrate redundancy

Redundancy USAF ETL

- No reserve tank allowed
- No reserve foam supply on site required by ETL
- Back up pump with controller required if Balanced Pressure or In-line Balanced Pressure skids are used

Total Flooding Systems

- Require permanent enclosure around hazard
- Leakage considerations
- Venting requirements
- Submergence volume
- Minimum fill depth not less than 1.1 times the storage height
- In no case less than 2 feet over the hazard

Maintenance of Submergence Volume

- To ensure adequate control or extinguishment the submergence volume shall be maintained for at least 60 minutes for unsprinklered locations and 30 minutes for sprinklered locations
- Where only flammable liquids are involved this period may be reduced.

Typical Calculation Example

- Hazard Area 100' x 100' x 25'
- Storage Height 13'
- Construction Unprotected steel non-sprinklered
- Hazard Low density combustibles (rolled tissue)
- Minimum Fill 13' + 2' = 15'
- Submergence Volume $100 \times 100 \times 15 = 150000$ Cu Ft.
- Submergence Time 3 minutes (Table 8.13.4)
- Discharge Rate $150000 / 3 \times 1.15 \times 1.2 = 69000$ CFM

- Determine number of generators required
- Select generator from product data sheet for best CFM, Pressure and solution flow based on volume calculation
