PDHonline Course M459 (5 PDH)

Fire Protection for USAF Aircraft Facilities

Instructor: Lawrence R. Eichner, PE

2020

PDH Online | PDH Center

5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
www.PDHonline.com

An Approved Continuing Education Provider

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

DEC 3 2002

FROM: HQ AFCESA/CES
139 Barnes Drive, Suite 1
Tyndall AFB, FL 32403-5319

SUBJECT: **Engineering Technical Letter (ETL) 02-15: Fire Protection Engineering Criteria - New Aircraft Facilities**

1. Purpose. This ETL provides fire protection criteria for protection of aircraft and facilities in the event of a fuel spill fire. Human intervention is required to minimize damage to incident aircraft.

2. Summary of Revisions. This ETL supersedes ETL 01-2, and includes the following changes: Deleted references to semi-hardened and hardened aircraft shelter now covered in ETL 01-4 (paragraph 3); clarified the aircraft type covered (paragraph 3.5); changed MIL-HDBK 1008C to UFC 3-600-01 (paragraph 4.3 and throughout the ETL); changed the UBC to the IBC (paragraph 4.8 and throughout the ETL); included the complete title and source for the Air Force Standard Design Details (paragraph 6 Note); clarified the requirements for electrical systems (paragraph A1.1.2.3.4); clarified the requirements for fire hydrants in or near airfield pavements (paragraph A1.1.2.4.2); included the use of stabilized landscaped surfaces (paragraph A1.2.1); clarified the meaning of unfueled aircraft (paragraph A1.3.1.1.1); revised the compensation factor for foam leakage loss (paragraph A1.3.3.3); added a note cautioning the designer to consider all transit voltage sources (paragraph A1.3.5.1.2.1 Note); added a requirement for locking manual stations (paragraph A1.3.5.5.1); added specific wording to place manual stations on a sign (paragraph A1.3.5.5.2); revised the graphic of the sign (Figure A5); clarified water source requirements (paragraphs A1.4.1 and A1.4.1.2); and added Figure A2.5 to Attachment 2.

3. Application: All types of aircraft facilities, including, but not limited to, maintenance, servicing, and storage hangars; corrosion control hangars; fuel cell repair hangars; depot overhaul facilities; research and development (R&D)/testing facilities housing aircraft; and all types of aircraft shelters (weather, alert). Compliance with this ETL should be considered for projects in active design beyond project definition (PD). Applying these criteria will result in reduced original construction and life-cycle maintenance costs, and increased overall reliability of the fire protection system. Compliance with this ETL is mandatory for:

- Projects that have not completed the PD phase.
- Projects beyond the PD phase, but not in active design status.

3.1. New Construction. Criteria within this ETL applies to the design and construction of all new aircraft facilities on Air Force installations or housing Air Force aircraft.

3.2. Existing Facilities. Criteria within this ETL applies to the design and construction of fire protection features for all existing aircraft facilities without installed fire suppression systems. Renovation, modification, or alteration of existing aircraft facilities without installed fire suppression systems will comply with the criteria contained in this ETL.

3.3. Occupancy Changes. Use of this ETL is mandatory during a major occupancy change, such as converting a former hangar currently being used as a warehouse back to an aircraft hangar. Change of aircraft does not constitute a change of occupancy; however, beddown of a new mission is not recommended in an existing hangar without a fire suppression system.

3.4. Integrated Combat Turn (ICT) Facilities. Criteria within this ETL apply to facilities for ICTs; however, compliance with this ETL is not authorization to conduct ICTs. ICT locations must be specifically evaluated and approved through the System Safety Engineering Program (AFI 91-202, *The US Air Force Mishap Prevention Program*).

3.5. Other Facilities. Facilities used exclusively for small aircraft (T-3, T-41, TG-3, TG-4, TG-7, TG-9, S-10), aero club aircraft, and similar aircraft within the size limitations for Group III hangars in National Fire Protection Association (NFPA) 409, *Standard on Aircraft Hangars*, will be protected with a fire suppression system complying with paragraph A1.3.1.1.4 and the other requirements of either NFPA 409 for Group III aircraft hangars or the requirements of this ETL. Mission aircraft such as T-1, T-6, T-37, T-38, and similar aircraft will be protected in accordance with the requirements of this ETL (paragraph A1.3.1.1.4 will not apply to these facilities).

3.6. Excluded Facilities. The following facilities are not addressed in this ETL:

- Aircraft shelters with two or fewer sides (including partial walls). These shelters will be treated as open ramps.
- Existing aircraft facilities with fire suppression systems in aircraft servicing areas. Fire protection modification/upgrade requirements will be addressed in a separate ETL.
- Protective aircraft shelters (PAS), hardened aircraft shelters (HAS), and semi-hardened aircraft shelters (HAS). These facilities are designed to provide a degree of survivability under combat conditions and or enemy attack. Refer to ETL 01-4.

3.7. Authority: AFI 32-1023, *Design and Construction Standards and Execution of Facility Construction Projects*.

3.8. Effective Date: Immediately.

3.9. Recipients: All major commands (MAJCOM) and Air Force activities.

3.10. Coordination: HQ USAF/ILEC, MAJCOM fire protection engineers, HQ NAVFAC, and USACE/CECP-TM.

Note: Criteria in this ETL assume fire department capabilities consistent with AFI 32-2001, *The Fire Protection Operations and Fire Prevention Program*, and a water supply and fire hydrant configuration at the hangar to support firefighting. Use of these criteria at other locations is not recommended without a complete risk analysis prepared by the base (or the project architect-engineer [A-E] for new construction) and accepted by the MAJCOM fire protection engineer (FPE) and the MAJCOM fire department operations (FDO) group.

4. Referenced Publications.

4.1. Air Force:

- AFI 32-1066, *Plumbing Systems*
- AFH(I) 32-1163, *Engineering Weather Data*
- AFI 32-2001, *The Fire Protection Operations and Fire Prevention Program*
- AFI 91-202, *The US Air Force Mishap Prevention Program*
- Technical Order 1-1-3, *Inspection and Repair of Aircraft Integral Tank and Fuel Cells*

4.2. U.S. Army Corps of Engineers (USACE):

- Engineer Technical Letter 1110-3-484, *Engineering and Design – Aircraft Hangar Fire Protection Systems*

4.3. Department of Defense (DOD):

- UFC 3-600-01, *Fire Protection for Facilities Engineering, Design, and Construction*

4.4. National Fire Protection Association (NFPA):

Note: The latest edition of an NFPA standard applies.

- NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*
- NFPA 13, *Installation of Sprinkler Systems*
- NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection*
- NFPA 24, *Installation of Private Fire Service Mains and their Appurtenances*
- NFPA 30, *Flammable and Combustible Liquids Code*
- NFPA 31, *Standard for the Installation of Oil-Burning Equipment*
- NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*

- NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids*
- NFPA 54, *National Fuel Gas Code*
- NFPA 70, *National Electrical Code®*
- NFPA 72, *National Fire Alarm Code®*
- NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*
- NFPA 101, *Life Safety® Code*
- NFPA 409, *Standard on Aircraft Hangars*

4.5. American Society for Testing and Materials (ASTM):

- ASTM A53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*
- ASTM A795, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*
- ASTM D2996, *Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe*

4.6. American National Standards Institute (ANSI):

- ASME/ANSI A13.1-1996, *Scheme for the Identification of Piping Systems*
- ASME/ANSI B31.3-1996, *Process Piping*

4.7. Underwriter's Laboratories (UL):

- UL 1449*, Standard for Safety Transient Voltage Surge Suppressors*, Second Edition
- UL 1283, *Electromagnetic Interference Filters,* latest edition

4.8. Private Industry:

- Factory Mutual (FM) Global Property Loss Prevention Data Sheet 1-22, *Criteria for Maximum Foreseeable Loss Fire Walls and Space Separation*
- FM Global Property Loss Prevention Data Sheet 1-23, *Protection of Openings*
- International Code Council, *International Building Code™ (IBC) 2000*

5. Acronyms and Terms:

AC	–	alternating current
A-E	–	architect-engineer
AFFF	–	aqueous film forming foam
DOD	–	Department of Defense
ETL	–	Engineering Technical Letter
FACP	–	fire alarm control panel
FDO	–	Fire Department Operations
FPE	–	Fire Protection Engineer
FSCP	–	foam system control panel
ft^2	–	square foot
ft^3	–	cubic foot

gpm	–	gallons per minute
HAS	–	hardened aircraft shelter
HVAC	–	heating, ventilation, and air conditioning
ICT	–	integrated combat turn
ILBP	–	in-line balanced pressure
kPa	–	kiloPascals
lpm	–	liters per minute
m^2	–	square meter
m^3	–	cubic meter
MAJCOM	–	major command
MILCON	–	military construction
NAVFACENGCOM	–	Naval Facilities Engineering Command
NCEE	–	National Council of Examiners for Engineering and Surveys
NDI	–	non-destructive inspection
NEC	–	National Electrical Code
NFPA	–	National Fire Protection Standard
OSHA	–	Occupational Safety and Health Administration
PAS	–	protective aircraft shelter
PD	–	project definition
PE	–	Professional Engineer
psi	–	pound per square inch
R&D	–	research and development
HAS	–	hardened or semi-hardened aircraft shelter
SIOH	–	supervision, inspection, and overhead
T.O.	–	Technical Order
TVSS	–	transient voltage surge suppression
IBC	–	Uniform Building Code
UL	–	Underwriters Laboratories
USACE	–	U.S. Army Corps of Engineers
UV/IR	–	ultraviolet/infrared
V	–	volt
Vac	–	volts alternating current

6. Specific Requirements. This ETL, in accordance with UFC 3-600-01, *Fire Protection for Facilities Engineering, Design, and Construction*, paragraph 1-3.4, takes precedence over UFC 3-600-01, section 4-15. This ETL is the Air Force alternative to NFPA Standard 409, and will be used except as noted. Attachment 1 provides criteria and technical guidance.

Note: Aircraft Hangar Standards. All design and construction packages will use the Air Force aircraft hangar standardized design details, *Aircraft Hangar Fire Protection Systems, Standard Design Elements, CAD Drawings and Specifications Version 2001.01 1 July 2001* (available from Mr. Fred Walker; refer to paragraph 7 for contact information).

6.1. U.S. Army Corps of Engineers (USACE) Center of Expertise for Aircraft Hangar Fire Protection.

Note: Services of the Center of Expertise are provided on a cost reimbursable basis between the USACE district designing and constructing the project and USACE. This service is expected to be covered in the standard design management fee, and supervision, inspection, and overhead (SIOH) paid on the project. This service should not result in additional costs or fees to the project.

6.1.1. For all hangar military construction (MILCON) projects on which USACE is the design agent, the USACE Center of Expertise will review all project designs to ensure compliance with this ETL. This review is mandatory at all design review stages, and all formal review comments issued by the Center of Expertise will be implemented to the satisfaction of the Air Force in accordance with USACE Engineer Technical Letter 1110-3-484, *Engineering and Design – Aircraft Hangar Fire Protection Systems.*

6.1.2. For all hangar MILCON projects on which USACE is the construction agent, the Center of Expertise will review all contractor shop submittals to ensure compliance with this ETL. All review comments issued by the Center of Expertise will be implemented by the USACE contracting officer to the satisfaction of the Air Force. An FPE at the Center of Expertise will perform the final acceptance testing of all hangar fire protection systems. The MILCON project will not be accepted by the USACE contracting officer until the Center of Expertise has accepted the fire protection systems.

6.3. Naval Facilities Engineering Command (NAVFACENGCOM) Division FPE.

6.3.1. For all hangar MILCON projects on which NAVFACENGCOM is the design agent, the division FPE will review all project designs to ensure compliance with this ETL. This review is mandatory at all design review stages, and all formal review comments issued will be implemented to the satisfaction of the Air Force.

6.3.2. For all hangar MILCON projects, the division FPE will review all contractor shop submittals to ensure compliance with this ETL. The contracting officer will implement all review comments to the satisfaction of the Air Force. An FPE will perform the final acceptance testing of all hangar fire protection systems.

7. Point of Contact. Fire protection criteria for aircraft facilities must evolve concurrently with technical developments in fire science, data generated in fire testing programs, and the availability of new fire protection equipment or methodologies. Recommendations for improvements to this ETL are encouraged and should be furnished to Mr. Fred Walker, HQ AFCESA/CESM, 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32408-5319, DSN 523-6315, commercial (850) 283-6315, FAX DSN 523-6219, Internet: fred.walker@tyndall.af.mil.

MICHAEL J. COOK, Colonel, USAF
Technical Director

3 Atchs
1. Technical Criteria
2. Low-Level High-Expansion Foam System Views
3. Distribution List

TECHNICAL CRITERIA
AIR FORCE AIRCRAFT HANGAR FIRE PROTECTION

A1.1. Construction Requirements.

A1.1.1. Structural Requirements. All new aircraft hangars will be exclusively noncombustible construction in accordance with the International Code Council, *International Building Code* 2000™ (IBC) requirements for any category of Type I or Type II construction.

Note: Additional protection of structural members (columns, beams, trusses, joists) above that established in the IBC for Type I or Type II construction is not required in a facility protected by an approved fire suppression system in compliance with this ETL.

A1.1.1.1. Exceptions:

A1.1.1.1.1. Tension fabric structures on metal structural frames when sited in accordance with paragraph A1.1.1.4.3 and protected in accordance with paragraph A3.

A1.1.1.1.2. Facilities used exclusively for small aircraft (T-3, T-41, TG-3, TG-4, TG-7, TG-9, S-10), aero club aircraft, and similar aircraft meeting the space requirements of NFPA 409 for Group III structures. These facilities must comply with criteria in NFPA 409 for Group III hangars and paragraph A1.3.1.1.4.

A1.1.1.2. Internal Fire-Rated Separations. To allow the greatest operational flexibility in hangars covered by this ETL, fire-rated walls and partitions are not required between adjacent aircraft servicing areas when the nature of the occupancy is similar in both bays. Operations such as fuel cell maintenance, ICT, and indoor refueling must be separated from general maintenance areas by walls of masonry construction, having not less than a one-hour fire rating with 45-minute opening protection. Such walls will extend from the floor to the underside of the roof deck.

A1.1.1.2.1. All operations outside the aircraft servicing area must be isolated from the aircraft servicing area by a masonry wall having a fire resistance rating of at least one hour. This wall will extend from the concrete floor to the roof. All openings in this wall will be automatic closing or self-closing and will be rated for at least 45 minutes. These areas outside the aircraft servicing area must have full sprinkler coverage in accordance with this ETL.

A1.1.1.2.2. Air Force operational aircraft assets will be isolated from the non-Department of Defense (DOD) areas by four-hour rated firewalls when Air Force aircraft assets are co-located in a facility with non-DOD operations that are beyond the control of the DOD activity. Penetrations of such firewalls must be minimized. Any necessary door, window, and other penetration must be protected in accordance with Factory

Mutual Global Property Loss Prevention Data Sheets 1-22*, Criteria for Maximum Foreseeable Loss Fire Walls and Space Separation*, and 1-23, *Protection of Openings*.

A1.1.1.3. Allowable Floor Area.

A1.1.1.3.1. The allowable floor area of a facility is unlimited when all of the following conditions are met:

- 100 percent of the facility has full sprinkler coverage in accordance with this ETL.
- Water supply to the sprinkler systems is in compliance with the criteria in this ETL.
- Separations from adjacent structures complies with paragraphs A1.1.4. through A1.1.4.3.
- Internal separation walls comply with paragraph A1.1.1.2.

A1.1.1.3.2. Facilities not meeting the conditions in paragraph A1.1.1.3.1 will be limited to the floor areas contained in the latest edition of the IBC for occupancy type S-1, except facilities used for fuel cell maintenance, ICT, or indoor refueling/defueling, which will be occupancy type H-3.

A1.1.1.4. Siting/Separation. No separation is required between any combination of Type I or Type II construction hangars protected by approved fire suppression systems.

A1.1.1.4.1. Separation Between Type I and Type II Hangars and Hangars of Other Construction Types. The minimum separation distance between adjacent hangars is 12 meters (40 feet). This may be reduced to 7.6 meters (25 feet) if one of the hangars has a one-hour exposure wall and protected 45-minute openings (e.g., windows, doors), or if both hangars have approved fire suppression systems. This may be further reduced to 3 meters (10 feet) if both hangars have one-hour exposure walls and protected 45-minute openings.

A1.1.1.4.2. Separation Between Hangars and Other Buildings. Minimum separation between hangars and other buildings is 12 meters. Reductions in this distance must conform to the IBC.

A1.1.1.4.3. Separation Between Tension Fabric Hangars and All Other Structures. Minimum separation between tension fabric structures and other structures will be 30 meters (100 feet), with a clear zone of 15 meters (50 feet) immediately adjacent to the tension fabric structure. The clear zone cannot be used for storage and must be clear of vegetation (maintained lawn is permitted). The clear zone may be used as a street or driveway, but not for vehicle parking.

A1.1.1.5. Draft Curtains.

A1.1.1.5.1. Provide draft curtains surrounding each sprinkler system, or up to 1400 square meters (15,000 square feet), whichever is less, for all hangars. Extend draft curtains down from the roof (or ceiling) not less than one-eighth of the distance from the roof (or ceiling) to the floor. When roof structural supports extend below the roof or ceiling, suspend draft curtains to the lowest member of the structural supports, or one-eighth the distance from the roof or ceiling, whichever is greater.

A1.1.1.5.2. Install draft curtains to form rectangular roof pockets whenever possible. Install draft stops on exposed structural roof supports whenever possible.

A1.1.2. Utility Systems.

A1.1.2.1. Floor and Ramp Drainage.

A1.1.2.1.1. Outside the Hangar. Aprons and the approach into the hangar must be sloped away from the hangar with a grade of not less than one-half of one percent (0.3:60 meters [1:200 feet]) to preclude a ramp fuel spill from entering. If the required grade cannot be achieved, provide an appropriately sized trench drain across the entire apron side of the hangar with a discharge to a remote safe location.

A1.1.2.1.2. Inside the Hangar. Floor elevations within the hangar must be arranged to prevent a liquid spill within the aircraft servicing area from flowing into adjacent areas.

A1.1.2.2. HVAC Systems.

A1.1.2.2.1. Install heating equipment in accordance with NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*; NFPA 31, *Standard for the Installation of Oil-Burning Equipment*; or NFPA 54, *National Fuel Gas Code* and this section.

A1.1.2.2.2. Heating devices with a flame or glowing element open to the atmosphere in the aircraft servicing area are not permitted.

A1.1.2.2.3. Where radiant heating is used, install only overhead radiant tube systems.

A1.1.2.2.4. Forced- or recirculated-air HVAC systems will not draw air from the aircraft servicing area below 3 meters (10 feet).

A1.1.2.2.5. Exhaust systems discharging to the exterior of the facility may draw air at any level.

A1.1.2.3. Electrical Systems.

A1.1.2.3.1. Install electrical equipment in general maintenance aircraft hangars in accordance with NFPA 70, *National Electrical Code®* (NEC), Article 513.

Note: Most operational aircraft use on-board fuel for a heat sink/dissipater. Many hangar maintenance activities, including avionics and hydraulic operations, will cause heating of the fuel on these aircraft. Fuel temperatures above 71 °C (160 °F) are operationally acceptable; therefore, NFPA 70, Article 513 requirements for combustible fuel above its flash point must be followed.

A1.1.2.3.2. Install electrical equipment in hangars for fuel system maintenance operations involving combustible fuels, including JP-8, in accordance with NFPA 70, Article 513, for flammable fuels or combustible fuels above their flash point.

Note: Technical Order (T.O.) 1-1-3, *Inspection and Repair of Aircraft Integral Tank and Fuel Cells*, additionally requires all outlets in the aircraft servicing area to be Class I Division 2 rated. This is an aircraft maintenance (user) safety requirement, not a fire safety issue. Additional information on this requirement is available from the command fuels system maintenance office or the T.O. manager at Warner Robins Air Logistics Center.

A1.1.2.3.3. Install electrical equipment in hangars with the following operations in accordance with paragraphs A1.1.2.3.3.1 and A1.1.2.3.3.2:

- Refueling or defueling, regardless of fuel type (other than that associated with fuel system maintenance).
- ICTs, regardless of fuel type.
- Fuel system maintenance operations with flammable fuels.

A1.1.2.3.3.1. Electrical equipment above the floor in the aircraft servicing area up to the height of the highest hangar door must satisfy NEC criteria for Class I Division 2 locations.

A1.1.2.3.3.2. Electrical equipment outside the classified area in the aircraft maintenance area, including lights, must conform to NFPA 70, Article 513.

A1.1.2.3.4. In hangars where the rate of spray paint application exceeds 0.9 liter (1 quart) per hour, or the cumulative application of more than 3.7 liters (1 gallon) over an eight-hour period, install Class I Division 1 or Class I Zone 1 electrical equipment throughout in accordance with NFPA 33, *Spray Applications Using Flammable or Combustible Materials,* for an enclosed spray room or booth. Spray area definitions do not apply to aircraft hangars constructed as painting facilities. Installed overhead mounted moveable platforms must be individually evaluated, but all controls, switches, and motors must be Class I Division 1 or Class I Zone 1.

A1.1.2.4. Fire Hydrants.

A1.1.2.4.1. Hydrants protecting aircraft hangars will be located at 91-meter (300-foot) maximum intervals, and there will be at least one hydrant within 30 meters of each corner of the hangar. When the aircraft parking apron pavement comes within 11 meters (35 feet) or less of the hangar wall at the hydrant location, the hydrants protecting hangars will be located not more than 3 meters from the hangar wall. When the aircraft parking apron pavement is 11 meters or more away from the hangar wall at the hydrant location, the hydrants protecting hangars will be located not less than 7.6 meters from the pavement edge.

A1.1.2.4.2. Hydrants installed through the airfield pavement must be low-profile, conventional hydrants, not higher than 0.7 meter (2.5 feet) above the pavement surface. Flush-mounted hydrants in the pavement are not permitted.

A1.1.2.4.3. Hydrants installed in unpaved areas adjacent to the airfield pavement must be no higher than 0.7 meter (2.5 feet) above the pavement surface.

A1.1.2.4.4. Hose threads on hydrants must match those used by the base fire department.

A1.1.2.4.5. Fire hydrants will be supplied from the domestic (potable) water system around the hangar in accordance with UFC 3-600-01, Section 3-7.3. Install water mains supplying hydrants in accordance with UFC 3-600-01. Hydrants will not be supplied by the hangar fire protection water system.

A1.1.2.5. Foam-Water Retention Systems. Retention systems are not required for facilities or systems designed and constructed in accordance with this ETL. Foam-water retention is not required in any of the following cases:

- Testing discharges of any systems discussed in this ETL (test headers/connections are required on all new foam-water systems allowing controlled discharge into a tank or other portable collection device, so no fixed permanent retention capability is required). In geographic regions where there is little or no open water, streams, or wetlands, and no high-ground water table (solar evaporation is an appropriate disposal method).
- Low-level high-expansion foam systems, since the highly expanded foam contains little liquid and is impractical to control.
- Catastrophic events, such as actual fires. Foam discharge associated with a fire is not a “most probable worst case” event. A fire in a hangar is a catastrophic event. Designing a containment system for a catastrophic event is impractical due to the number of associated variables and the mass of fire debris generated.

A1.1.2.5.1. Unplanned Accidental Events. Current environmental guidance for management of unplanned accidental foam discharges:

- Formally documented response plan by the installation spill team and/or off-base contractors to contain, collect, and dispose of discharged foam.

- Direct release to a government-operated sanitary or industrial waste treatment facility, if the foam-water solution is less than 50 parts per million of the plant influent.
- In geographic regions where there is little or no open water, streams, or wetlands, and no high-ground water table, solar evaporation is an appropriate disposal method.

A1.1.2.5.2. Other Retention Issues. For additional guidance or information on foam retention and management, consult with HQ USAF/ILEV and or MAJCOM/CEV.

A1.2. Accessibility for Firefighting:

A1.2.1. Exterior Firefighting. Provide fire apparatus access on at least two complete sides of every hangar. Suitable access surfaces include ramps, aircraft parking aprons, automotive parking areas, fire apparatus access roads, and stabilized landscaped areas.

A1.2.1.1. Automotive parking areas used for fire department access must include at least one aisle 5.4 meters (18 feet) wide, with adequate turning radius for fire department apparatus.

A1.2.1.2. Fire department access roads must be at least 5.4 meters wide, designed to support imposed loads of fire apparatus, and provide all-weather driving capabilities. Where mowed lawns cover fire department access roads, use bollards to mark the limits of the supporting surface. Fire department access roads over 45 meters (150 feet) long must allow fire apparatus to drive through or turn around. Fire department access roads must not be used for any other purpose, and should be secured with gates, bollards, or similar devices to restrict use.

A1.2.2. Interior Firefighting.

A1.2.2.1. Hangar aircraft doors must operate under emergency conditions.

A1.2.2.1.1. Configure hangar doors for manual operation without special tools or disassembly.

A1.2.2.1.2. Use door track heaters in areas subject to freezing to prevent accumulated snow and ice from impeding operation of hangar doors.

A1.2.2.1.3. The electrical supply for power-operated doors must be independent of the building power supply to permit isolation of power to the facility during a fire without interrupting power to door motors.

A1.2.2.1.4. Provide a key-operated or other access-controlled switch on the exterior of the facility for operation of power-operated doors.

A1.2.2.2. Personnel doors satisfying requirements of the Life Safety Code, *Industrial Occupancies* chapter, *Special Provisions for Aircraft Servicing Hangars* section (NFPA 101, *Life Safety® Code*), will provide adequate access into the hangar for normal structural firefighting operations.

A1.3. Fire Suppression Systems.

A1.3.1. General Requirements.

A1.3.1.1. Applicable Design Standards and Criteria. Provide automatic sprinkler protection in all areas of aircraft facilities, including shop and administration. Sprinkler protection must be designed for the occupancy hazard present in accordance with this ETL, UFC 3-600-01, NFPA 33, and the following NFPA standards (if there is a conflict between this ETL and any provisions of an NFPA standard or code, this ETL will take precedence):

- NFPA 13, *Installation of Sprinkler Systems*
- NFPA 30, *Flammable and Combustible Liquids Code*
- NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids*

A1.3.1.1.1. Protect areas used exclusively for unfueled aircraft (drained and purged in accordance with T.O. 1-1-3) with conventional wet-pipe sprinkler systems designed for Ordinary Hazard Group 2 occupancy (8.0 lpm/m^2 over 270 square meters [0.2 gpm/ft^2 over 3000 square feet]).

Note: An unfueled aircraft is not one which has been simply defueled; defueled aircraft are considered fueled aircraft for the purposes of fire protection safety. An unfueled aircraft has had fuel removed from all tanks, engines and piping such that less than 0.5% of fuel remains in the aircraft (using the procedures in T.O. 1-1-3).

A1.3.1.1.2. Protect areas used for fueled aircraft with a conventional wet-pipe sprinkler system (8.0 lpm/m^2 over 465 square meters [0.2 gpm/ft^2 over 5000 square feet]) and a low-level high-expansion foam system.

A1.3.1.1.3. Protect dedicated single-aircraft facilities used exclusively for non-destructive inspection (NDI) (e.g., x-raying) of fueled or unfueled aircraft with no aircraft maintenance or servicing operations with conventional wet-pipe sprinkler systems designed for Extra Hazard Group 1 occupancy (12.0 lpm/m^2 over 270 square meters [0.3 gpm/ft^2 over 3000 square feet]).

A1.3.1.1.4. Protect NFPA Group III hangars used exclusively for small aircraft (T-3, T-41, TG-3, TG-4, TG-7, TG-9, S-10), aero club aircraft, and similar aircraft with conventional wet-pipe or dry-pipe sprinkler systems designed for Extra Hazard Group 1 occupancy (12 lpm/m^2 over 270 square meters [0.3 gpm/ft^2 over 3000 square feet]).

A1.3.1.2. Manual Foam-Water/Water Fire Hose Stations. Do not provide interior or exterior hose stations or fire hose connections.

A1.3.1.3. Fire Department Connections. Do not provide fire department connections on foam-water systems.

A1.3.1.4. Strainers. Provide basket-type strainers upstream of risers on all foam-water systems.

A1.3.1.5. Test Header. Provide a test header for all overhead and low-level nozzle foam-water systems. Locate the header inside the aircraft servicing area as near as practicable to an outside door. Configure the test header to permit each proportioner to be individually tested. Each test header must have at least four valved 2.5-inch (no equal metric standard) hose fittings.

A1.3.1.6. Underground Piping. Install underground piping systems, including piping in fire pump systems, in accordance with NFPA 24, *Installation of Private Fire Service Mains and their Appurtenances*, and the following:

A1.3.1.6.1. Provide ductile iron pipe or other pipe (high-density polyethylene or filament-wound fiberglass) listed by Underwriters Laboratories (UL) or approved by Factory Mutual for buried fire service application for all underground uses.

A1.3.1.6.2. Do not install any piping under hangar/facility floor slabs. If piping must be located below the floor line, use concrete trenching with open steel grating. Provide drains to sanitary sewer from any trenches. Do not install any piping, including the fire protection water service entrance into the building, that allows pressurization of the space below the floor slab. Minimize piping under paved operational surfaces (taxiways and aircraft parking).

A1.3.1.6.3. Size underground mains to ensure the maximum flow velocity does not exceed 3 meters per second.

A1.3.1.6.4. Use flanged or welded fittings (Figures A1.1 and A1.2) to transition the fire protection water service entrance from horizontal to vertical as it enters the building. Do not use gasketed compression fittings (including locking type), or flange fittings with setscrews.

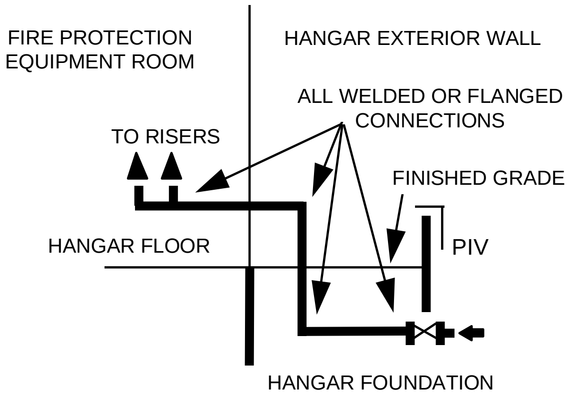

Figure A1.1 Water Supply Pipe Entry

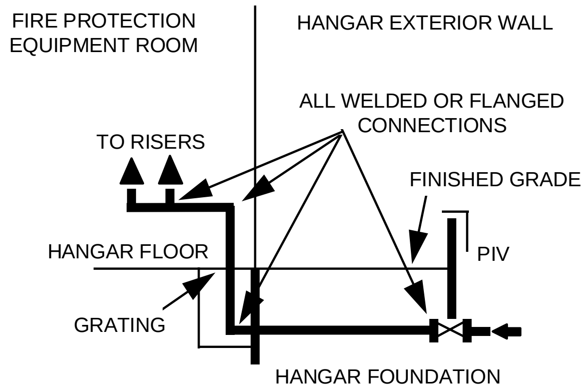

Figure A1.2 Water Supply Pipe Entry

A1.3.1.6.5. Provide corrosion protection on underground fire mains in the same manner as required for domestic water and other buried piping at the location.

A1.3.1.6.6. Do not install piping carrying foam concentrate or foam-water solution underground.

A1.3.1.7. Backflow Prevention. Install backflow prevention devices at connections to domestic water distribution systems. Backflow prevention is not required in dedicated non-potable water distribution systems. Valves that are part of a backflow prevention assembly will be the indicating type and will be supervised. Omit post indicator valves when backflow preventers are located outside. Locate backflow preventers inside the protected buildings when freeze protection is required. Do not use heat tapes or tracings to provide freeze protection; however, in locations where simple insulation will provide adequate freeze protection, the backflow preventer may be located outside (see AFI 32-1066, *Plumbing Systems).*

A1.3.1.7.1. Connections between potable water systems and systems containing chemical fire suppression agents or additives will use reduced-pressure backflow preventers.

A1.3.1.7.2. Connections between potable water systems and systems that do not contain chemicals (e.g., wet pipe systems) will use double-check valve assemblies unless otherwise required by local health and or water authorities.

A1.3.1.7.3. Install backflow prevention on the discharge side of pumps supplied directly from domestic water systems.

A1.3.1.8. Interior Piping Systems.

A1.3.1.8.1. Limit maximum flow velocity in interior facility piping to 6 meters per second (20 feet per second) or less.

A1.3.1.8.2. For water systems, use standard-weight pipe conforming to ASTM A795, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use,* or ASTM A53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*.

A1.3.1.8.3. For foam-water systems, use one of the following:

- Standard-weight pipe conforming to ASTM A795 (exception: do not use galvanized pipe) or ASTM A53.
- Filament-wound fiberglass pipe conforming to ASTM D2996, *Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe,* designation code "RTRP-11 FF-3121."

Note: Filament-wound fiberglass pipe must be installed in accordance with ASME/ANSI B31.3-1996, *Process Piping.*

A1.3.1.8.4. Use threaded, flanged, or grooved fittings. Do not use fittings which couple plain-end pipe. Do not use welded sprinkler fittings or outlets for foam-water solution.

A1.3.1.8.5. Paint all exposed interior piping (color will be the same as the walls and or ceiling, or a complementing color). Do not paint exposed interior fire protection piping red. Exposed piping in the fire protection equipment room and mechanical rooms may be left unpainted. Stainless steel piping may be cleaned and left unpainted.

A1.3.1.8.6. Mark all exposed interior piping, at 8-meter (26-foot) intervals, with plastic wraparound-type pipe labels conforming to ASME/ANSI A13.1-1996, *Scheme for the Identification of Piping Systems*, indicating the type of fluid carried and direction of flow. Labels are not required on sprinkler system branch lines and pipes less than 51 millimeters (2 inches) in nominal size. The following legends are required:

- FIRE PROTECTION WATER - Used on dedicated potable and non-potable fire protection water supply lines.
- FOAM CONCENTRATE - Used on high-expansion foam concentrate lines.
- FIRE SPRINKLER or SPRINKLER FIRE - Used on standard water-only sprinkler systems.
- HIGH EXPANSION FOAM - Used on lines supplying low-level high-expansion foam generators.

A1.3.2. Automatic Sprinkler System.

A1.3.2.1. Use a wet-pipe automatic sprinkler system in all heated areas of the hangars other than the aircraft servicing area. Use a wet-pipe automatic sprinkler system in the aircraft servicing area in geographic locations having a 99.6% dry bulb temperature greater than -17.7 °C (0 °F) (per AFH[I] 32-1163, *Engineering Weather Data*). See paragraph A1.5.4, pertaining to building temperature supervision, when the 99.6% dry bulb temperature is less than 0.5 °C (33 °F) (per AFH[I] 32-1163).

A1.3.2.2. Risers will be provided with riser check valves and vane-type water flow switches rather than alarm check valves and associated trim.

A1.3.2.3. Provide a pressure relief trim device above the riser check valve. These devices typically are available in standard trim packages in the range of 1.2 to 1.3 MPa (175 to 185 psi). Discharge from these devices will be directed to sanitary waste collection.

A1.3.2.4. When multiple systems are required in an aircraft servicing area, all overhead systems will cover essentially equal floor areas.

A1.3.2.5. Provide upright quick-response sprinklers at the roof or ceiling level with temperature ratings of 79.4 °C (175 °F). In areas where extremely high temperatures normally occur, upright quick-response sprinklers at the roof or ceiling level with temperature ratings of 93.3 °C (200 °F) may be used.

A1.3.2.6. Provide a surge arrester (expansion tank) of not less than 38-liter (10-gallon) capacity for each separate wet pipe riser above the riser check valve. Tanks must be listed/approved as a surge arrester with a rated working pressure of not less than 1895 kPa (275 psi).

A1.3.2.7. Connect all drains to an appropriately sized sanitary drain.

A1.3.2.8. Use a pre-action automatic sprinkler system activated by a roof- or ceiling-level thermal detection system, as described in paragraph A1.3.5.2, in the aircraft servicing area in geographic locations having a 99.6% dry bulb temperature less than -17.7 °C (0 °F) (per AFH[I] 32-1163).

A1.3.2.8.1. Provide externally resettable (without opening the valve assembly and without use of special tools) automatic water control (deluge) valves for pre-action systems. Maximum valve size is 150 millimeters (6 inches).

A1.3.2.8.2. Do not provide supervisory air on pre-action sprinkler systems in aircraft servicing areas.

A1.3.2.8.3. Provide a surge arrester (expansion tank) of not less than 38-liter capacity for each separate pre-action riser below the riser indicating valve. Provide a surge arrester (expansion tank) of not less than 95-liter (25-gallon) capacity for each set of multiple pre-action risers below the riser indicating valves on the header. Tanks must be listed/approved as a surge arrester with a rated working pressure of not less than 1895 kPa (275 psi).

A1.3.3. Low-Level High-Expansion Foam Systems. Low-level high-expansion foam systems are designed in accordance with NFPA 11A, *Standard for Medium and High Expansion Foam Systems.*

A1.3.3.1. Installation. Locate low-level high-expansion foam generators so that foam discharge falls close to, but not directly on, the aircraft fuselage or wings. Mount generators in the overhead roof support structure and/or high on the walls just below the roof support structure. Initial discharge of foam must protect the underaircraft and underwing area and then spread to the remaining hangar floor area.

A1.3.3.1.1. Low-level high-expansion foam generators may be designed to use either outside or inside air. Air from inside the hazard can be employed successfully and requires no additional increase in foam discharge rates.

A1.3.3.1.2. Provide a surge arrester (expansion tank) of not less than 38-liter (10-gallon) capacity for each separate high-expansion riser below the deluge valve. Tanks must be listed/approved as a surge arrester with a rated working pressure of not less than 1895 kPa (275 psi).

A1.3.3.2. Performance Requirements. Failure to achieve these requirements during acceptance testing will indicate a design failure. Performance is greatly affected by the physical shape of the aircraft servicing area and the placement of the generators.

A1.3.3.2.1 Low-level high-expansion foam systems must cover 90 percent of the aircraft silhouette area projected on the floor in one minute or less. (Note: Wall mounted generators alone in larger rectangular/square shaped hangars cannot normally achieve this performance requirement.) The area under engines extending beyond the wing edge and under rear elevators does not have to be considered in the aircraft's silhouette area.

A1.3.3.2.2 Low-level high-expansion foam systems must cover the aircraft servicing area and adjacent accessible areas to a depth of one meter (3.2 feet) in four minutes or less.

A1.3.3.3. Rate of Discharge. The minimum rate of discharge or total generator capacity will be calculated in accordance with NFPA 11A; however, it will never be less than 0.8 m^3min/m^2 (2.6 ft^3min/ft^2). Application rates in the range of 0.8 to 1.2 m^3min/m^2 (2.6 to 4 ft^3min/ft^2) are required to meet the performance requirements

A1.3.3.3.1. The minimum rate of discharge or total generator capacity will be calculated from the following formula:

$$R = ([V/T] + R_S) \times C_N \times C_L$$

where:

R = Rate of discharge in m^3/min (ft^3/min)
V = Submergence volume in m^3 (ft^3) determined by the following formula:

$$V = A \times D$$

where:

A = Area of the aircraft servicing floor and adjacent floor areas not cut off from the aircraft servicing floor m^2 (ft^2)
D = Depth = 1 meter (3.28 feet) (see paragraph A1.3.3.2) which is greater than the 0.6-meter (2-foot) minimum foam depth over the hazard required in NFPA 11A

T = Submergence time in minutes = 4 (see paragraph A1.3.3.2)
R_S = Rate of foam breakdown by sprinklers in ft^3/min (m^3/min) determined by the following formula:

$$R_S = S \times Q$$

where:

S = Foam breakdown from sprinkler discharge = 0.0748 cubic meters per minute • L/min (10 cubic feet per minute • gpm)
Q = Estimated total discharge from maximum number of sprinklers expected to operate in L/min (gpm).

C_N = Compensation for normal foam shrinkage = 1.15. This is an empirical factor based on average reduction in foam quantity from solution drainage, fire, wetting of surfaces, and absorbency of stock.
C_L = Compensation for loss of foam due to leakage around doors and windows and through unclosable openings determined by the design engineer after proper evaluation of the structure. This factor for Air Force hangars cannot be less than 2.0 for hangars less than 1394 square meters (15,000 square feet), 2.5 for hangars less than 2787 square meters (30,000 square feet), and 3.0 for all other hangars.

A1.3.3.4. Concentrate and Water Supply. Concentrate and water supply will permit continuous operation of the system to generate four times the submergence volume, but for not less than 15 minutes. No additional foam is required for maintenance of the submergence volume beyond 15 minutes. Do not provide a connected reserve concentrate supply.

A1.3.3.5. Power Supply. Low-level high-expansion foam generators may be either hydraulically (water) or electrically powered. Electrically powered low-level high-expansion foam generators should be supplied ahead of the building disconnect and do not require a secondary power source when the power source meets the reliability requirements in paragraph A1.4.3.3.

A1.3.3.6. Activation. The following will activate the low-level high-expansion foam systems:

- Manual foam activation stations located at main exits from aircraft servicing area.
- Water flow signal in overhead sprinkler systems.
- Roof- or ceiling-level heat detection systems associated with pre-action systems (when installed).

A1.3.4. Foam Proportioning Systems.

A1.3.4.1. Listing. All components and assemblies used in this fire protection subsystem must be specifically listed/approved for their intended use by a nationally recognized testing organization whose listing/approval process includes follow-up factory inspections to ensure that products comply with the listing/approval conditions.

A1.3.4.2. High-Expansion Concentrate. Use only high-expansion foam (Hi-Ex®) concentrate listed/approved for use with the foam generators installed.

A1.3.4.3. Location. For high-expansion foam, provide independent concentrate storage and proportioning systems for each aircraft hangar facility. Locate foam concentrate storage, foam proportioning, foam injection, and system risers in a dedicated fire protection equipment room isolated from the aircraft servicing area by construction rated for at least one hour. These rooms must have direct exterior access.

A1.3.4.3.1. The foam equipment room will be large enough to accommodate all required equipment. All equipment will be fully accessible for inspection, testing, maintenance, and removal/replacement without the removal of any other equipment.

A1.3.4.3.2. If any equipment and or valves requiring access for maintenance, periodic testing, or re-servicing are located more than 2.4 meters (8 feet) above the floor, provide an open steel grate mezzanine, with a permanent ladder, at that equipment level. All platforms and ladders must be in compliance with Occupational Safety & Health Administration (OSHA) requirements.

A1.3.4.4. Proportioning.

A1.3.4.4.1. Proportioners will be limited to 152 millimeters (6 inches) or less.

A1.3.4.4.2. Use in-line balanced-pressure (ILBP) proportioners on all pumped concentrate systems. Do not use ILBP proportioners on bladder tank systems. ILBP proportioners must be factory assembled and tested by the manufacturer, and the entire ILBP proportioner assembly must be listed/approved by a recognized laboratory. Disassembly, reassembly, and or modification by the installing contractor will be prohibited.

A1.3.4.4.3. Use pressure proportioners for all bladder systems.

A1.3.4.5. Control Valve. Provide water-powered ball valves as foam concentrate control valves. The valve must be operated by connection to the alarm line of the automatic water control valve or alarm valve. Provide a retard chamber in the line to the water-powered ball valve on wet pipe foam water systems.

A1.3.4.6. Application Time.

A1.3.4.6.1. For foam-water sprinklers and foam-water nozzles, provide a connected foam concentrate supply sized for a single 10-minute application of foam, based on the actual system flow in the least hydraulically demanding area.

A1.3.4.6.2. For low-level high-expansion generators, provide a connected foam concentrate supply sized for a single 15-minute application (or four times the submergence volume, whichever is greater) of foam.

A1.3.4.7. Concentrate Storage. Atmospheric foam storage tanks must be either plastic or fiberglass construction and listed/approved for the storage of foam concentrate. Pressure tanks for bladder tank systems must be steel and listed/approved for the storage of foam concentrate.

A1.3.4.7.1. Do not provide back-up supply of foam concentrate in the facility, either as a connected reserve or bulk reserve.

A1.3.4.7.2. Provide clear space at one end of a horizontal bladder tanks, at least equal to the length of the tank, to permit bladder replacement. Doors to the outside or adjacent open space at the end of the tank are an acceptable alternative. Provide clear space above vertical bladder tanks and permanent personnel access and work area, to permit re-servicing and bladder replacement.

A1.3.4.8. Foam Concentrate Pipe. Foam concentrate pipe must satisfy the following criteria:

- Grooved, welded, or flanged stainless steel.
- Filament-wound fiberglass conforming to ASTM D2996, designation code “RTRP-11 FF-3121,” installed in accordance with ASME/ANSI B31.3-1996.

A1.3.5. Foam System Detection and Controls. Design all foam system detection and controls in accordance with NFPA 72, *National Fire Alarm Code®*, and the following criteria.

A1.3.5.1. Foam System Control Panel (FSCP).

A1.3.5.1.1. Locate all FSCPs in the fire protection equipment room, in a clean environment having temperature and humidity control, in accordance with the unit's listing/approval.

A1.3.5.1.2. Transient Voltage Surge Suppression (TVSS).

A1.3.5.1.2.1. All FSCPs must have TVSS on all fire alarm circuits entering and leaving the facility, including, but not limited to, the power supply circuits to the FSCP, circuits interfacing with fire pumping stations outside the facility, and circuits interfacing with the fire alarm receiving station (e.g., communication circuits, antenna systems).

NOTE: The TVSS required in A1.3.5.1.2.1 may not provide complete protection from transient voltage surges. A comprehensive evaluation of other transient voltage entry points must be conducted and appropriate TVSS installed where needed, e.g., the building service entrance, communication entry points, any building-mounted antenna, and other points of special interest.

A1.3.5.1.2.2. Alternating Current (ac) Power TVSS Devices. These devices will have been tested in accordance with UL 1449*, Standard for Safety Transient Voltage Surge Suppressors*, Second Edition, and UL 1283, *Electromagnetic Interference Filters,* latest edition, by a nationally recognized testing laboratory. The TVSS devices must provide normal sine wave tracking, with Category A1 ring wave suppression (2000 volts [V], 67 amperes, 180 degrees) of less than 50 V for nominal 120 V alternating current (Vac) legs. The TVSS will provide independent, distinct, and dedicated circuitry for each possible protection mode (i.e., line-to-line, line-to-neutral, line-to-ground, neutral-to-ground). TVSS device circuitry must be fully encapsulated for protection of the circuitry and to provide longer life expectancy.

A1.3.5.1.2.3. Data, Signal, and Control Wire TVSS Devices. The TVSS devices must be designed by the same manufacturer as the ac power TVSS devices to ensure overall compatibility and system reliability. The TVSS manufacturer will provide the TVSS devices based on evaluation of individual system parameters, including: conductor size and length, number of conductors, shield type, peak current and voltage, signal type, signal baud rate, frequency bandwidth, maximum attenuation, maximum standing-wave ratio, and maximum reflection coefficient. TVSS device circuitry must be fully encapsulated for protection of the circuitry and to provide longer life expectancy.

A1.3.5.1.3. Provide an FSCP for all suppression and detection functions in the aircraft area. The FSCP must be fully compatible with the base fire alarm receiving system without field modifications to any system hardware or software.

A1.3.5.1.3.1. The FSCP must transmit a separate and distinctive fire signal to the fire department upon activation of any portion of the foam-water system. Separate fire alarm transmitters/receivers will be permitted when they are fully compatible with the FSCP and the base fire alarm receiving system without field modifications to the FSCP.

A1.3.5.1.3.2. The specific number of alarm signals (e.g., fire, supervisory, tamper) to be transmitted must be defined in the system matrix (Figures A1.3 and A1.4).

	SYSTEM INPUTS	ANNUNCIATION AT LOCAL PANELS				FIRE SUPPRESSION SYSTEM FUNCTIONS				TRANSMIT SIGNALS TO FIRE DEPARTMENT						AUXILIARY FUNCTIONS		EVACUATION SIGNALS	
		Audio-Visual Fire Alarm Indication by Zone	Audio-Visual Trouble Indication by Zone	Audio-Visual Common Trouble Indication	Audio-Visual Alarm Indication by Device	Transmit Pump Start Signal to Pumphouse	Open Pre-Action Sprinkler Valves	Open Low Level Spill Fire Suppression System Valve	Divert Drain Flow from Separators to Containment	Common Trouble Signal Per Building	Common Supervisory Signal Per Building	Common Fire Alarm Per General Area	Sprinkler Water Flow Per General Area	Low-Level Optical Detectors Per General Area	Foam-Water Discharge Per General Area	Shut Down All Supply & Recirculating Fans	Release magnetically Held Smoke Doors	Facility Fire Evacuation Audio-Visual Signal	Foam System Signal Blue Strobe/Beacon
	FIRE ALARMS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Manual Fire Alarm Stations																		
2	Spot-Type Smoke Detectors																		
3	Fixed Temp & Rate-of-Rise Type Heat Detectors																		
4	In-Duct Smoke Detectors																		
5	Rate-Compensated Type Heat Detectors on Hangar Ceiling																		
6	Water Flow Switches - Wet or Dry-Pipe Sprinkler Systems in Adjacent Areas																		
7	Water Flow Switches - Wet-Pipe Sprinkler Systems	X				X		X	X						X	X	X	X	X
8	Water Switches - Low Level System	X						X	X						X	X	X	X	X
9	Manual Foam Discharge Station for Low-Level	X				X		X	X						X	X	X	X	X
10	Low Level Optical Fire Detector				X									X				X	
	SUPERVISORY SIGNALS																		
11	Valve Supervisory Switch - Wet or Dry-Pipe Sprinklers in Adjacent Areas																		
12	Valve Supervisory Switches - Sprinklers		X								X								
13	Valve Supervisory Switches - Low-Level High-Expansion System		X								X								
14	Valve Supervisory Switches - Water Supply Entrance		X								X								
15	Hi-Lo Pressure Switches - Dry-Pipe Sprinklers																		
16	Temperature Monitoring System				X						X								
17	Low-Level Optical Fire Detector Trouble		X								X								
18	Control Component Common Trouble Condition		X								X								
19	Low Level Auto Disable Switch		X								X								
	TROUBLE CONDITIONS																		
20	Low Battery Voltage			X						X									
21	Circuit Fault		X	X						X									
22	Supervised Component Failure			X						X									
23	AC Power Failure			X						X									

NOTES:

1. Fire alarm signals and supervisory alarm signals shall be clearly differentiated at the fire alarm control panel(s).
2 General area means the specific bay, dock, mezzanine, office area, or mechanical area. System zoning shall be sufficient to direct responding firefighters directly to the fire area.
3, This sample matrix shows the basic requirements and is expected to be tailored to each individual project.

Figure A1.3. Sample Wet-Pipe & Low-Level High-Expansion System Functional Matrix

	SYSTEM INPUTS	ANNUNCIATION AT LOCAL PANELS				FIRE SUPPRESSION SYSTEM FUNCTIONS				TRANSMIT SIGNALS TO FIRE DEPARTMENT						AUXILIARY FUNCTIONS		EVACUATION SIGNALS	
		Audio-Visual Fire Alarm Indication by Zone	Audio-Visual Trouble Indication by Zone/Middle	Audio-Visual Common Trouble Indication	Audio-Visual Alarm Indication by Device	Transmit Pump Start Signal to Pumphouse	Open Pre-Action Sprinkler Valves	Open Low Level Spill Fire Suppression System Valves	Divert Drain Flow from Separators to Containment	Common Trouble Signal Per Building	Common Supervisory Signal Per Building	Common Fire Alarm Per General Area	Sprinkler Water Flow Per General Area	Low-Level Optical Detectors Per General Area	Foam Discharge Per General Area	Shut Down All Supply & Recirculating Fans	Release magnetically Held Smoke Doors	Facility Fire Evacuation Audio-Visual Signal	Foam System Signal Blue Strobe/Beacon
	FIRE ALARMS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Manual Fire Alarm Stations																		
2	Spot-Type Smoke Detectors																		
3	Fixed Temp & Rate-of-Rise Type Heat Detectors																		
4	In-Duct Smoke Detectors																		
5	Rate-Compensated Type Heat Detectors on Hangar Ceiling	X				X	X	X	X						X	X	X	X	X
6	Water Flow Switches - Wet or Dry-Pipe Sprinkler Systems in Adjacent Areas																		
7	Water Flow Switches - Pre-Action Sprinkler Systems	X				X		X	X						X	X	X	X	X
8	Water Switches - Low Level System	X						X	X						X	X	X	X	X
9	Manual Foam Discharge Station for Low-Level	X				X	X	X	X						X	X	X	X	X
10	Low Level Optical Fire Detector				X									X				X	
	SUPERVISORY SIGNALS																		
11	Valve Supervisory Switch - Wet or Dry-Pipe Sprinklers in Adjacent Areas																		
12	Valve Supervisory Switches - Sprinklers		X								X								
13	Valve Supervisory Switches - Low-level High Expansion		X								X								
14	Valve Supervisory Switches - Water Supply Entrance		X								X								
15	Hi-Lo Pressure Switches - Dry-Pipe Sprinklers																		
16	Temperature Monitoring System																		
17	Low-Level Optical Fire Detector Trouble		X								X								
18	Control Component Common Trouble Condition		X								X								
19	Low Level System Auto Disable Switch		X								X								
	TROUBLE CONDITIONS																		
20	Low Battery Voltage			X						X									
21	Circuit Fault		X	X						X									
22	Supervised Component Failure			X						X									
23	AC Power Failure			X						X									

NOTES:

1. Fire alarm signals and supervisory alarm signals shall be clearly differentiated at the fire alarm control panel(s).

2 General area means the specific bay, dock, mezzanine, office area, or mechanical area. System zoning shall be sufficient to direct responding firefighters directly to the fire area.

3, This sample matrix shows the basic requirements and is expected to be tailored to each individual project.

Figure A1.4. Sample Pre-Action & Low-Level High-Expansion System Functional Matrix

A1.3.5.1.4. Control panels activating deluge, pre-action, or nozzle systems must be listed/approved as releasing panels. All releasing panels must be specifically listed/approved for use with the automatic water control valves/solenoid release valves specified for the fire suppression system. Provide a switch within the lockable control panel to disable the releasing functions of the panel while leaving all detection and other functions of the panel operational. Activation of this switch will transmit a trouble signal to the fire alarm center.

A1.3.5.2. Thermal Fire Detectors.

A1.3.5.2.1. Provide one of the following automatic fire detection systems at the underside of the roof of the aircraft servicing area to activate pre-action suppression systems:

- Rate-compensated fire detector having a temperature rating between 71 °C (160 °F) and 76 °C (170 °F). Maximum spacing between detectors is 12 meters, or the detectors' listed spacing, whichever is less.
- Linear thermistor (line-type electrical conductivity) fire detector having a temperature setting of 76 °C (170 °F). Maximum spacing between detection lines is 9 meters (30 feet). The manufacturer must verify the detector response setting by an approved test method after installation. On steeply sloped or curved roofs, thermistor detectors must be installed perpendicular to the slope or arc (along the axis of the curve).

A1.3.5.2.2. The area covered by the fire detection system must correspond with its affiliated roof-level sprinkler system bound by draft curtains. The activation of any heat detection device in the sprinkler zone will immediately:

- Send a start signal to the fire pumping system (if any).
- Activate all low-level fuel spill fire suppression systems in the aircraft servicing area of fire origin.
- Actuate the appropriate suppression system valves (e.g., pre-action valves, foam concentrate valves) for the floor area covered by the detection system.
- Activate the facility fire evacuation alarm system and the foam system annunciation signal.
- Transmit a fire alarm signal to the base fire alarm communications center (fire department). The number and type of signals transmitted to the fire department will be locally determined based on the current fire alarm receiving equipment and planned upgrades.

A1.3.5.3. Optional Low-Level Optical Fire Detectors. The MAJCOM may establish an additional requirement for low-level optical detection.

A1.3.5.3.1. Connect low-level optical fire detectors to the FSCP. Arrange for alarm notification only; do not use optical detection systems to activate any fire suppression system.

A1.3.5.3.2. Use one of the following types of detectors:

A1.3.5.3.2.1. Combination or dual-spectrum ultraviolet/infrared (UV/IR) type optical detectors, listed/approved by a nationally recognized laboratory. Additionally, the manufacturer must provide a copy of the test report prepared by a nationally recognized laboratory certifying the listed/approved unit will detect a fully developed 3 meter by 3 meter JP-4, JP-8, or JET-A fuel fire at a minimum distance of 45 meters, within 5 seconds.

A1.3.5.3.2.2. Multi-spectrum optical detectors complying with the NAVFACENGCOM guide specification. The detectors must be listed/approved by a nationally recognized laboratory and the manufacturer must provide a copy of the test report prepared by a nationally recognized laboratory certifying the listed/approved unit fully meets the NAVFACENGCOM guide specification requirements.

A1.3.5.3.3. Install a sufficient number of optical detectors such that a fire at any position under an aircraft will be within the range and cone-of-vision of at least one optical detector.

A1.3.5.3.4. Mount optical detectors approximately 3 meters above the hangar floor level; however, specifics of each design must take into account facility construction, aircraft configuration and positioning, fixed and mobile equipment within the aircraft servicing area, and all other relevant factors. Do not mount optical detectors in inaccessible locations such as under roofs or on roof trusses.

A1.3.5.3.5. Optical detectors will be of a latching design. Fire detection by any optical detector will immediately:

- Activate the facility fire evacuation alarm system.
- Transmit a fire alarm signal to the fire department. The number and type of signals transmitted to the fire department will be locally determined based on the current fire alarm receiving equipment.

A1.3.5.4. Water Flow Detecting Devices. Provide water flow detecting devices on all fire protection risers with a built-in adjustable retard (not less than 0 to 90 seconds) on all sprinkler systems. Water flow will cause the FSCP to:

- Activate the low-level high-expansion fire suppression systems.
- Activate the facility fire evacuation alarm system and the foam system annunciation signal.
- Transmit a fire alarm signal to the fire department. The number and type of signals transmitted to the fire department will be locally determined based on the current fire alarm receiving equipment.

A1.3.5.5. Manual Foam Discharge Stations for Low-Level High-Expansion Fire Suppression Systems.

A1.3.5.5.1. Provide manual foam discharge stations inside the aircraft servicing area at exits to actuate the low-level high-expansion fire suppression systems. Manual foam discharge stations must be the locking type that when activated, require a key to be reset.

A1.3.5.5.2. Manual foam discharge stations must be yellow and distinctively different from the manual fire alarm stations, and will have distinctive signage at each device stating "START FOAM SYSTEM" in red lettering not less than 76 millimeters (3 inches) high on a yellow or lime-yellow background. The manual foam discharge station must be mounted directly on the sign.

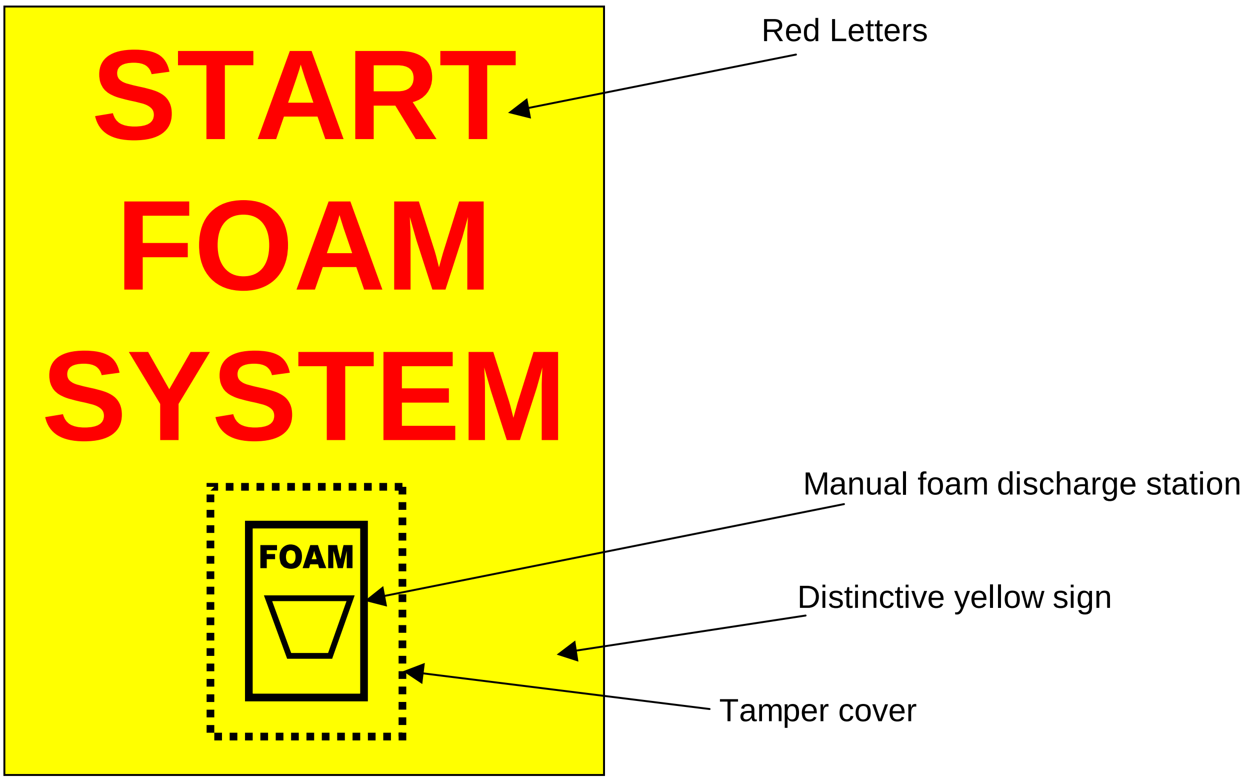

Figure A1.5. Manual Foam Discharge Station, Tamper Cover, and Signage

A1.3.5.5.3. Manual foam discharge stations must be housed within a clear plastic tamper cover that must be lifted prior to actuating the station. Any colored portions of the tamper covers must be yellow and any lettering on the cover must be "FOAM"; the words "fire" or "fire alarm" will not appear on the cover.

A1.3.5.5.4. Actuation of any manual foam discharge stations will cause the FSCP to:

- Activate foam discharge through the low level high-expansion generators.

- Activate the facility fire evacuation alarm and the foam system annunciation signal.
- Transmit a fire alarm signal to the fire department. The number and type of signals transmitted to the fire department will be locally determined based on the current fire alarm receiving equipment.

A1.3.5.6. Foam System Signals. Provide blue visual alarm signals (strobes or rotating beacons) within the aircraft servicing area to indicate foam system activation. When the base has adopted a standard audio-visual signal for foam system activation, the signals in the facility will comply fully with that base standard.

A1.4. Fire Protection System Water Supply.

A1.4.1. Requirement. Use the base domestic water system for hangar fire protection systems whenever adequate capacity (flow rate, pressure, and storage capacity) is available. The A-E is responsible for testing and determining the capability of the existing distribution systems and integrating those systems with the new systems being designed. New hangar fire protection systems will not be connected to exiting non-potable fire protection water supply systems simply because they already exist; connection to existing non-potable systems will be permitted only where the base domestic water system is inadequate.

A1.4.1.1. Provide booster fire pumps in accordance with paragraph A1.4.3 when the water flow rate and storage capacity is adequate but pressure is inadequate to meet system pressure demands.

A1.4.1.2. Provide a separate dedicated fire protection system water supply when the available domestic flow rate is not sufficient to meet the system flow rate demands. When improvements in the existing water distribution system will correct the flow rate deficiency, a cost analysis will be conducted to determine the least expensive option between constructing a separate dedicated fire protection system water supply and improving the existing domestic distribution system.

A1.4.2. Fire Protection Water Storage System.

A1.4.2.1. Provide water storage tanks in accordance with NFPA 24. Provide corrosion protection when steel water tanks and associated piping are used.

A1.4.2.2. Use a single water storage system, when practical, for multiple aircraft facilities. Limit water supply distribution mains from a fire pump station to less than 450 meters (1500 feet). As an exception, the MAJCOM FPE may approve a greater length when justified by specific physical situations. Such longer systems are subject to hydraulic surge (water hammer). Surge suppression must be provided at each end point of the system and at the pump station.

A1.4.2.3. Provide storage capacity equal to 120 percent of the maximum demand for 30 minutes. Divide the required storage capacity between two equal-sized water tanks, each storing one-half of the required volume. The piping configuration must allow water to be supplied by both reservoirs, and either of the reservoirs if the other is out of service.

A1.4.2.4. Provide each tank with a low-water-level alarm and a low-temperature alarm, each transmitting back to the fire department as separate supervisory signals. In areas with a 90% dry bulb temperature less than 0 °C (32 °F), provide appropriate freeze protection.

A1.4.2.5. Provide an external visual water-level gauge on each tank.

A1.4.2.6. Provide automatic refill from the base water distribution system.

A1.4.3. Fire Protection Water and Foam Pump Systems.

A1.4.3.1 Design and install pumping installations in accordance with NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection.* Use a single water pumping station for multiple aircraft facilities, when practical.

A1.4.3.2. Provide one redundant pump for every water and foam pump system.

A1.4.3.3. Pumps must have electric motor drivers conforming to NFPA 20, supplied by a single reliable power source. Use dual power sources when a single reliable power source is not available. Use diesel engine drivers only when the installation electrical service fails to meet the reliable standard and dual power sources are not available. (For pump systems with one primary and one redundant pump, provide one electric and one diesel if the electrical service fails to meet the reliability standard and dual power sources are not available.) The A-E is responsible for determining and documenting the reliability of the existing power sources. A power source is considered reliable when the following are not exceeded:

- Forced downtime, excluding scheduled repairs, 8 consecutive hours for any one incident over the previous 3 years;
- 24 cumulative hours of downtime during the previous year.

A1.4.3.4. Use "soft start" or variable frequency pump controllers when electric-driven pumps are installed.

A1.4.3.5. Limit the maximum rated pump size to 9.463 m^3pm (9463 lpm) (2500 gpm) at 862 kPa (8.5 bar) (125 psi).

A1.4.3.6. Ensure the pumping system will have capacity to meet the maximum demand when the largest capacity pump is out of service.

A1.4.3.7. Provide pressure maintenance pumps ("jockey pumps") to maintain normal operating pressure on the system and to compensate for normal system leakage. See NFPA 20 for jockey pump flow requirements. The jockey pump's rated pressure must be sufficient for the startup and shutdown pressures specified in NFPA 20. Set jockey pump controllers to automatically start and stop in accordance with NFPA 20, paragraph A-11-2.6. Provide run timers to ensure that the jockey pump will operate for at least the minimum time recommended by the manufacturer of the jockey pump's motor.

A1.4.3.8. Arrange multiple-pump installations for sequential starting at 10-second intervals until the operating pumps maintain the required pressure. The starting sequence will begin automatically as follows:

- Pump start signal transmitted from the foam system control panel in the protected facility.
- Drop in system water pressure in accordance with NFPA 20.

A1.4.3.9. Provide connection through the installation fire reporting system to notify the fire department of pump running signals, pump system trouble, tamper and supervisory signals provided by the pump controllers. Pump running signals will be transmitted as a "fire" signal.

A1.4.3.10. Provide surge arresters to moderate the potentially destructive effects of pressure surges or water hammer due to pump starting and stopping and valve opening and closing. These hydropneumatic devices absorb pressure surges into a precalculated volume of captive gas and return the absorbed water volume to the system in a controlled fashion. Surge arresters are installed on the system side of the fire pump discharge check valve and as close to the valve as possible. At least one arrester will be provided for each pump and each must be listed/approved as a surge arrester for fire protection piping, with a volume of not less than 378.4 liters (100 gallons) and a rated working pressure not less than 1724 kPa (250 psi). Provide each arrester with an indicating valve to isolate it from the system. Supervision is not required. Because of the complex effects of system variables on satisfactory performance, the manufacturer should engineer each surge arrester installation.

A1.5. Facility Fire Detection and Alarm System. Design all facility fire detection and alarm systems in accordance with NFPA 72 and the following criteria.

A1.5.1. Fire Alarm Control Panel (FACP).

A1.5.1.1. Locate all FACPs in a clean environment with temperature and humidity control in accordance with the unit's listing/approval.

A1.5.1.2. FACPs will have TVSS on all fire alarm circuits entering and leaving the facility, including, but not limited to, the power supply circuits to the FACP, circuits interfacing with fire pumping stations outside the facility, and circuits interfacing with the fire alarm receiving station (e.g., communication circuits, antenna systems). TVSS devices must comply with the requirements of paragraph A1.3.5.1.2.

A1.5.1.3. Provide a single FACP for all detection alarm functions in the facility that are not part of the foam-water fire suppression system. The FACP must be fully compatible with the base fire alarm receiving system without field modifications to any system hardware or software.

A1.5.1.4. Separate fire alarm transmitters/receivers are permitted when they are fully compatible with the FACP and the base fire alarm receiving system without field modifications to the FACP.

A1.5.1.5. The specific number of alarm signals to be transmitted will be defined in the system matrix (Figure A1.6).

A1.5.2. Manual Fire Alarm Stations (Pull Stations).

A1.5.2.1. Provide pull stations throughout the facility at all exit doors. Provide additional pull stations when required by NFPA 101.

A1.5.2.2. Ensure all manual alarm activation stations are identical throughout the facility. If the base has established a formal base-wide standard for manual pull stations, the pull stations in facilities governed by this ETL will comply fully with that standard.

A1.5.2.3. Actuation of any manual alarm activation stations will immediately cause the FACP to:

- Activate the facility fire evacuation alarm signal throughout the facility.
- Transmit a fire alarm signal to the base fire department.

A1.5.3. Fire Alarm Notification. Provide audio-visual alarm notification devices. When the base has a standard for audible sound (e.g., slow whoop, bell) and visual signal (red, white), the devices in the facility will comply fully with the base standards. No other system (hangar doors, alert signal) will be permitted to use these signals. The fire alarm must be distinctive in high-noise areas.

A1.5.4. Temperature Monitoring System.

A1.5.4.1. Provide a system of temperature sensors for the aircraft servicing area in all geographic areas having a 99.6% dry bulb temperature less than -1 °C (30 °F) when wet-pipe sprinkler systems are present. The temperature sensors will be located at the same level as the sprinkler piping and spaced not more than 60 meters (200 feet) apart. Provide this temperature monitoring to ensure a warning when freezing temperatures endanger sprinkler piping.

A1.5.4.2. This facility temperature monitoring system will be tied into the FACP as a dedicated supervisory zone, and this supervisory signal will be transmitted to the fire department in the same manner as all fire-related supervisory signals in the facility.

	SYSTEM INPUTS	ANNUNCIATION AT LOCAL PANELS				FIRE SUPPRESSION SYSTEM FUNCTIONS				TRANSMIT SIGNALS TO FIRE DEPARTMENT						AUXILIARY FUNCTIONS		EVACUATION SIGNALS	
		Audio-Visual Fire Alarm Indication by Zone	Audio-Visual Trouble Indication by Zone/Middle	Audio-Visual Common Trouble Indication	Audio-Visual Alarm Indication by Device	Transmit Pump Start Signal to Pumphouse	Open Pre-Action Sprinkler Valves	Open All Low-Level High-Expansion	Divert Drain Flow from Separators to Containment	Common Trouble Signal Per Building	Common Supervisory Signal Per Building	Common Fire Alarm Per General Area	Sprinkler Water Flow Per General Area	Low-Level Optical Detectors Per General Area	Foam-Water Discharge Per General Area	Shut Down All Supply & Recirculating Fans	Release magnetically Held Smoke Doors	Facility Fire Evacuation Audio-Visual Signal	Foam System Signal Blue Strobe/Beacon
	FIRE ALARMS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Manual Fire Alarm Stations	X										X					X	X	
2	Spot-Type Smoke Detectors	X										X				X	X	X	
3	Fixed Temp & Rate-of-Rise Type Heat Detectors	X										X					X	X	
4	In-Duct Smoke Detectors	X										X				X	X	X	
5	Rate-Compensated Type Heat Detectors on Hangar Ceiling																	X	
6	Water Flow Switches - Wet or Dry-Pipe Sprinkler Systems in Adjacent Areas	X											X			X	X	X	
7	Water Flow Switches - Pre-Action Sprinkler Systems																	X	
8	Water Switches - Low-level High-expansion System																	X	
9	Manual Foam Discharge Station for Low-Level																	X	
10	Low Level Optical Fire Detector																	X	
	SUPERVISORY SIGNALS																		
11	Valve Supervisory Switch - Wet or Dry-Pipe Sprinklers in Adjacent Areas		X								X								
12	Valve Supervisory Switches - Sprinklers																		
13	Valve Supervisory Switches - Low-Level High-Expansion System																		
14	Valve Supervisory Switches - Water Supply Entrance																		
15	Hi-Lo Pressure Switches - Dry-Pipe Sprinklers		X								X								
16	Temperature Monitoring System				X						X								
17	Low-Level Optical Fire Detector Trouble																		
18	Control Component Common Trouble Condition		X								X								
19	Under-Aircraft Foam-Water System Auto Disable Switch																		
	TROUBLE CONDITIONS																		
20	Low Battery Voltage			X						X									
21	Circuit Fault		X	X						X									
22	Supervised Component Failure			X						X									
23	AC Power Failure			X						X									

NOTES:

1. Fire alarm signals and supervisory alarm signals shall be clearly differentiated at the fire alarm control panel(s).
2 General area means the specific bay, dock, mezzanine, office area, or mechanical area. System zoning shall be sufficient to direct responding firefighters directly to the fire area.
3, This sample matrix shows the basic requirements and is expected to be tailored to each individual project.

Figure A1.6. Sample Facility Fire Detection and Alarm System Functional Matrix

A1.6. Design and Construction Management.

A1.6.1. A-E Qualifications.

A1.6.1.1. It is mandatory that design organizations (whether the design is accomplished by an in-house design agent or an outside A-E firm) use a qualified FPE, experienced in the design of aircraft hangars, for the design of the fire protection systems in all Air Force projects covered by this ETL.

A1.6.1.1.1. "Qualified FPE" does not have a universal definition and is defined differently among various government agencies. For this ETL, one of the following credentials is required to meet the criteria for "qualified FPE":

- Bachelor of Science or Master of Science degree in fire protection engineering from an accredited university, plus a minimum of 5 years' work experience in fire protection engineering.
- Professional Engineer (PE) registration by examination, National Council of Examiners for Engineering and Surveys (NCEE) fire protection engineering written examination.
- Qualification as a GS/GM 804-series FPE.
- PE registration in a related discipline with a minimum of 5 years' work experience in fire protection engineering.

A1.6.1.1.2. For Air Force aircraft hangars, the design agent will confirm that:

- Designer complies with the definition of "qualified FPE."
- FPE has substantial experience in the design and construction of aircraft hangar fire protection systems of similar complexity.

A1.6.1.2. The Commerce Business Daily announcement for the project design will specifically include the requirement for a qualified FPE on the A-E design team.

A1.6.2. System Testing and Acceptance:

A1.6.2.1. Preliminary Testing.

A1.6.2.1.1. Testing of the fire protection system is critical. The entire fire protection system must be tested in accordance with the specification to ensure that all equipment, components, and subsystems function as intended. In addition to establishing written confirmation of all test results, all preliminary tests will be videotaped to record the methods and equipment employed to conduct the tests.

A1.6.2.1.2. A copy of the videotape must be submitted with a copy of the proposed test plan to the USACE Center of Expertise or NAVFACENGCOM FPE before the request for a final acceptance test is made. All preliminary tests must be completed prior to scheduling the final acceptance test.

A1.6.2.2. Final Acceptance Test. The final test will be a repeat of all preliminary tests, except that flushing and hydrostatic tests will not be repeated. Tests must be witnessed by the USACE Center of Expertise or NAVFACENGCOM FPE. All system failures or other deficiencies identified during the testing must be corrected and retested in the presence of the USACE Center of Expertise or NAVFACENGCOM FPE.

LOW-LEVEL HIGH-EXPANSION FOAM SYSTEM VIEWS

Figure A2.1. Low-Level High-Expansion Foam Wall-Mounted (Adjacent Leading Wing Edge) Generators' Initial Discharge

Figure A2.2. Low-Level High-Expansion Foam After Three-Minute Discharge

Figure A2.3. Low-Level High-Expansion Ceiling-Mounted Generators' Foam Discharge

Figure A2.4. Low-Level High-Expansion Foam After 15-Minute Discharge

Figure A2.5. Low-Level High-Expansion Foam After 7-Minute Discharge

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Defense Commissary Service (1)
Director of Facilities
Bldg 8400
Lackland AFB TX 78236-5000

Defense Technical Information Center (1)
ATTN: DTIC-FDA
Alexandria VA 22034-6145

AAFES/ATTN: CFE (1)
PO Box 660320
Dallas TX 75266-0320

SPECIAL INTEREST ORGANIZATIONS

IHS (A.A. DeSimone) (1)
1990 M Street NW, Suite 400
Washington DC 20036

Construction Criteria Database (1)
National Institute of Bldg Sciences
1201 L Street NW, Suite 400
Washington DC 20005