DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

ETL 1110-3-484

CEMP-ET

Technical Letter
No. 1110-3-484

26 September 1997

Engineering and Design
AIRCRAFT HANGAR FIRE PROTECTION SYSTEMS

Distribution Restriction Statement

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1. Purpose. This letter provides guidance for the design and construction of fire protection systems for hangars and similar facilities housing important and valuable military aircraft.

2. Applicability. This letter applies to all HQUSACE elements and USACE commands having military construction and design responsibility.

3. References. See Appendix A.

4. Distribution. Approved for public release; distribution is unlimited.

5. Objective. The objective of this letter is to provide a uniform approach to the design and construction of costly and complex fire protection systems required to be installed in aircraft hangars housing military aircraft.

6. Action. The guidance included in Appendix B to this technical letter will be used for planning, design and construction of fire protection features and systems for military facilities.

7. Implementation. This technical letter will have special application, as defined in paragraph 8c, ER 1110-345-100.

FOR THE COMMANDER:

2 Appendices
APP A - References
APP B - Aircraft Hangar
Fire Protection Systems

KISUK CHEUNG, P.E.
Chief, Engineering Division
Directorate of Military Programs

This ETL supersedes ETL 1110-3-411, dated 26 April 1990.

APPENDIX A

REFERENCES

GOVERNMENT PUBLICATIONS

Department of Defense

MIL-HDBK 1008C	Handbook, Fire Protection For Facilities, Engineering, Design and Construction

Department of the Army

CADD-93-1	U.S. Army Corps of Engineers, Waterways Experiment Station CADD Details Library, Report 2, Mechanical Details, April 1995,

Department of the Air Force

ETL 96-1	Engineering Technical Letter 96-1, Fire Protection Engineering Criteria - New Aircraft Facilities, 22 January 1997

National Institute of Standards and Technology (NIST)

Technical Note 1423	Analysis of High Bay Hangar Facilities For Fire Detector Sensitivity and Placement

NONGOVERNMENT PUBLICATIONS

National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269-9101

NFPA 13	Sprinkler Systems
NFPA 16A	Closed-Head Foam-Water Sprinkler Systems
NFPA 20	Centrifugal Fire Pumps

NFPA 22	Water Tanks For Private Fire Protection
NFPA 24	Private Fire Service Mains and Their Appurtenances
NFPA 72	National Fire Alarm Code
NFPA 409	Aircraft Hangers

APPENDIX B

AIRCRAFT HANGAR FIRE PROTECTION SYSTEMS

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AIRCRAFT HANGAR FIRE PROTECTION SYSTEMS

1. **GENERAL**. Fire protection systems are provided in aircraft hangars for protection against a potentially devastating fire and the loss of valuable military assets. Current state-of-the-art protection systems utilize aqueous film-forming foam (AFFF) to combat fuel spill fires that can occur in facilities housing fueled aircraft. Because of the critical nature and the inherent complexity associated with foam fire protection systems, it is essential that they be designed and installed by those with the required expertise and experience. Lessons learned have identified numerous installation and operational problems that can adversely affect system adequacy, reliability and maintainability. It is therefore imperative that attention be directed to the design and installation of these systems. The focus of this ETL is on *design*. Since there is a correlation between the adequacy of the design and the acceptability of the final installation, emphasis must be placed on producing designs that are technically correct and comply with applicable design criteria. To better assure system acceptability, it is essential to thoroughly and clearly define system requirements. This ETL establishes a number of procedures and technical direction to assist designers in achieving this objective.

2. **DESIGNER REQUIREMENTS**. Design of foam-water sprinkler systems for aircraft hangars requires specialized design knowledge and expertise. To assure adequacy of design, it is essential that such systems be designed and specified by engineers with extensive experience in this specialized area of fire protection system design. This is mandatory for Air Force projects covered by Air Force ETL 96-1, *Fire Protection Engineering Criteria-New Aircraft Facilities*.

3. **SUBMITTALS**. Each design submittal stage should address crucial considerations affecting the fire protection system design. This includes water supply systems, proposed types of sprinkler and nozzle systems, foam concentrate proportioning systems, fire detection and controls systems, etc. Of particular importance is the water supply system which must meet system demands. Lessons learned indicate the need for more comprehensive water demand and water supply analyses. After the initial design submittal, each succeeding submittal should be a further elaboration and refinement of what was previously submitted. For example, whereas the concept submittal may include only rough approximations of system water demand, the intermediate (preliminary) and final submittals need to include detailed hydraulic calculations to confirm that calculated system demands can in fact be met with the existing or proposed water system. This analysis should be correlated with the design to provide substantiation of pump selection, pipe sizes, nozzle selection, sprinkler discharges, etc. Specific requirements for design analysis, drawings and hydraulic calculations are described later in this document.

4. **TECHNICAL CENTER OF EXPERTISE (TCX)**. A TCX for Aircraft Hangar Fire Protection was established to provide technical assistance to those involved in the design, installation, and testing of aircraft hangar foam fire suppression systems. The TCX will provide,

on a cost reimbursable basis, technical guidance and assistance to those tasked to design hangar fire protection systems. The office requesting services will provide funding to cover TCX costs associated with each project. Costs are directly related to the size and complexity of the project and the quality of the design submittal. Arrangements should be made by contacting Mr. Ed Lockwood at (540) 665-3919 (voice) and (540) 665-3628 (facsimile). Correspondence and submittal packages should be sent as follows:

U.S. Postal Service:	***Federal Express or UPS***
U.S. Army Corps of Engineers	U.S. Army Corps of Engineers
Transatlantic Programs Center	Transatlantic Programs Center
ATTN: CETAC-EC-TM (Lockwood)	ATTN: CETAC-EC-TM (Lockwood)
P.O. Box 2250	201 Prince Frederick Drive
Winchester, Virginia 22604-1450	Winchester, Virginia 22602

4.1 **Required Design Reviews**. As mandated by U.S. Air Force ETL 96-1, aircraft facility fire protection designs will be submitted for technical review by the TCX. Comments will be incorporated to the satisfaction of the Air Force. For other than Air Force designs, Corps offices are encouraged to utilize the TCX for technical assistance and to submit designs for review. This will serve to assure technical adequacy of the design and conformance to the requirements of this ETL.

4.2 **Submittal Procedures.** Corps offices tasked to design projects with aircraft facility fire protection systems will contact the TCX as early as possible during the design process to discuss required services, design schedule, and funding requirements. To assure timely reviews by the TCX, the requesting office should transmit required funds as early as possible, but in no case less than 10 work days prior to submission of the first submittal. A submittal schedule should be provided to the TCX to facilitate workload management. All design submittals, i.e., concept, intermediate (preliminary) and final, will be submitted to the TCX for review. Documents will include all drawings, design analyses, calculations, specifications, confirmation notices, meeting minutes, and other related documentation associated with the project. As soon as possible following their submission, technical comments provided by the TCX will be annotated with the action taken and returned to the TCX reviewer. Comments to which exception is taken will be discussed and resolved prior to continuation of the design process and submission of the next submittal.

5. **DESIGN ANALYSIS.**

5.1 **Narrative**. Provide a Fire Protection narrative separately from other disciplines. Prepare a comprehensive design analysis in accordance with MIL-HDBK-1008C. Clearly indicate the basis of design and application of specific design criteria. Describe the overall fire protection system proposed for the facility including types and arrangement of all systems and subsystems. This includes sprinkler, nozzle, detection, control, AFFF concentrate, proportioning, and etc. Include detailed descriptions of sprinkler systems in terms of applicable sprinkler types, spacing limitations, and etc. As applicable, include reference to other disciplines where related systems are described. For example, refer to applicable civil site utility portions of the analysis for description of water storage, distribution, and etc.

5.2 **Water Supply/Demand Analysis**. Hangar fire protection systems typically have high water demands, in terms of water quantity and pressure. It is not unusual for such systems to have water demands for sprinklers and nozzles in excess of 18925 L/min (5000 gpm) at pressures of 862 kPa (125 psi). To assure adequacy of water supply to meet such demands, the designer must perform a detailed hydraulic analysis. This will compare the system demand with the supply and identify system adjustments necessary to assure that all applicable design parameters will be met. Include an exterior hose stream demand of 1893 L/min (500 gpm) where the water supply for the building sprinklers and nozzles also supplies hydrants available for use by the fire department.

5.3 **Hydraulic Calculations**. Calculations in the absence of a specific design will constitute, at best, rough approximations. While such approximations may suffice for the concept submittal, subsequent submittals need to include calculations based upon an actual layout of discharge devices and corresponding piping configuration.

5.3.1 Computer Software. Perform hangar fire protection system hydraulic calculations using recognized fire protection software. The “HASS” (*Hydraulic Analyzer of Sprinkler Systems*) is a recognized hydraulics program used by many contractors and fire protection design firms. This program is taught in PROSPECT Course, “*Fire Extinguishing System Design*”and should be used by Corps of Engineers offices performing or specifying fire protection systems for aircraft hangars.

5.3.2 System Sketch**.** Include in the design analysis (*not the contract drawings*) a sketch representative of the overall fire protection system. It should show all pipes and nodes in the sprinkler, nozzle and underground water distribution systems. Assure that the sketch corresponds to what is indicated on the project drawings as well as in the hydraulic calculations.

5.3.3 Hydraulic Reference Points. Identify all hydraulic reference points (nodes) in the piping system being calculated. Include elevation and pressure at each node in the system. For discharging nodes, indicate the k-factor and flow.

5.3.4 Pipe Segments. Identify all pipes in the system and indicate the two nodes to which each pipe is connected. Include the diameter, length, number and type fittings, equivalent length, friction loss per foot, flow, velocity, total friction loss in the pipe segment, Hazen-Williams coefficient, and etc. As permitted by computer software used, label pipe segments as “strainer,” "proportioner," "fire pump," "backflow preventer," and others as appropriate to identify the specific system components with special features and friction loss characteristics.

5.4 **Manufacturer's Catalog Data**. Include in the design analysis catalog information for all major items of equipment upon which the design is based. This includes, but is not limited to, fire pumps, jockey pumps, foam concentrate tanks, foam pumps, foam proportioners, automated foam concentrate valves, nozzles, automatic water control valves, sprinklers, and etc.

6. FIRE PROTECTION DRAWINGS

6.1 **Fire Protection Piping**. Prepare separate "FP" drawings to indicate all fire protection equipment and devices associated with the fire protection system. Provide complete fire protection system design including sizes and locations of all equipment and piping. Determine pipe sizes using computer software developed specifically for design of fire protection systems. Since the fire protection system design will be provided as part of the contract drawings, do *not* include design criteria on the drawings or in the specifications. This is apt to be misinterpreted by the contractor as an invitation to redesign the system.

6.1.1 Sprinkler and Piping Plan. Prepare a separate "FP" drawing showing the overall arrangement of the sprinkler system. Assure that the scale is adequate to clearly show sprinklers, branch lines, crossmains, riser nipples, feed mains, risers and other major components. A drawing scale of 1:100 (1/8"= 1'-0") is recommended. Indicate routing of all piping and identify pipe sizes, but do *not* indicate lengths of pipe segments. Leave this for the contractor to determine and provide for review and approval as part of shop drawing submittal.

6.1.2 Nozzle System Plan. Prepare a separate "FP" drawing showing nozzle system piping, automatic control valves as well as nozzles. Where possible, position nozzles so as to direct the foam discharge *toward the hangar door*. Nozzle system design should strive for gentle application of foam solution into the protected area. Keep in mind that the discharge velocity will carry the foam beyond the area of nozzle stream impact on the floor. Nozzle discharges should *not* overlap those from opposing or converging nozzles. Such arrangements will result in undesirable turbulence, particularly in the under-aircraft area and is apt to adversely affect fire control or extinguishment. Show the approximate area to be covered by each nozzle. Include a detail of each nozzle type required. Where possible, use nozzles with the same discharge characteristic as this will simplify installation and maintenance as well as design. Indicate, on the drawings, the k-factor for each nozzle. Where a number of different k-factors are involved, include a nozzle schedule to clearly convey design intent and requirements.

6.2 **Fire Detection and Control System**. Prepare separate "FP" drawings identifying each device connected to the foam system control panel (FSCP). Develop unique symbols for identifying the various components comprising the foam system. Clearly identify each symbol and omit any which is not used for a specific design. Assure that symbols are dissimilar to those used in the fire alarm or other building systems. Provide unique identification of each such device using a subscript indicating the applicable zone number and a sequentially allocated *device number* for each specific circuit. For example, if Zone 3 includes four manual actuation stations, identify them with subscripts of "3-1," "3-2," "3-3," and "3-4." If Zone 4, for example, has twenty (20) rate compensated heat detectors, identify them "4-1".......thru "4-20." Use this device numbering scheme for floor plans and riser diagrams.

6.2.1 Foam System Control Panel (FSCP). Locate the FSCP on the "FP" drawings, preferably within, or in close proximity to, the fire protection equipment room. To minimize cost and to simplify testing and maintenance, specify FSCP's with integral annunciators rather than providing remote annunciators. Include a sequence of operation in narrative form, controls matrix or both as necessary to describe system operation.

6.2.2 Foam System Riser Diagram. Identify and group the various i*nputs* and *outputs* associated with the control panel. This will include *alarm initiating* and *supervisory* ***input*** circuits as well as "*alarm notification* and *release device* ***output*** circuits.

a. *Alarm Initiating* Device Circuits--includes waterflow switch, nozzle system manual actuation station, heat detector, ultra-violet/infrared flame detector, etc.

b. *Supervisory* Device Circuits-- includes valve supervisory (tamper) switches, pump controllers, low liquid level, etc.

c. *Release* Device Circuits--includes circuits to solenoid valves for actuation of automatic water control valves controlling foam solution flow to nozzle systems and preaction sprinkler system.

d. *Alarm Notification* Device Circuits-- includes alarm bells, horns, sirens, strobe lights, rotating beacons, etc.

6.2.3 Schedule of Supervised Valves. For applications involving numerous valves requiring supervisory (tamper) switches, a valve schedule indicating designation, size, type, location, and area controlled is recommended. Include in the schedule the unique device identifier corresponding to what is shown in the riser diagram. Valves requiring supervision include those controlling water, foam concentrate and foam solution.

6.3 **Fire Protection Equipment Room**. Include an enlarged plan at a scale of 1:50 (1/4"=1'-0") of the fire protection equipment room. Show the AFFF concentrate tank, water service entrance, sprinkler riser/valve manifold, foam system control panel, and piping. Provide sections and details to clearly show the riser manifold and all associated components, piping, valves, fittings, etc.

Assure that the equipment is arranged to facilitate maintenance and regular testing. In particular, assure that AFFF bladder tanks are of the horizontal type and located with sufficient space at one end to permit removal and replacement of bladders. As much as practicable, arrange components to be serviceable from the floor. Otherwise, work platforms may be necessary.

6.4 **Fire Pump Building or Room**. Fire pumping systems for most hangar fire protection systems can provide water supply to the facility included in the current design project as well as future hangars. These pumping systems often involve multiple, high-capacity, diesel engine-driven fire pumps. It is therefore preferred to locate and arrange such pumping systems in a separate pump house or building adjacent to the water storage tanks from which the pumps take suction. This pump facility will house the pumps, drivers, controllers, fuel tanks, test headers and associated equipment. The configuration of the equipment space should consider the need to test, maintain and even replace major components of the system. If the fire pump installation must be co-located with the AFFF concentrate tank, proportioning equipment, valve header, and control panels, assure that adequate space is allocated to facilitate maintenance of all subsystems.

6.5 **Drawing Details.** Include details of critical system components including valve headers, nozzles, concentrate tanks, test headers, and etc. Clarify, to the greatest extent possible, the design intent. A number of standard details can be found in the CADD Details Library distributed by the Tri-Service CADD/GIS Technology Center. Keep in mind that these details must be customized for specific applications.

7. **ELECTRICAL DRAWINGS.**

7.1 **Building Fire Alarm System**. It is customary to include the building alarm system as part of the electrical design and to show the system on *electrical* rather than *fire protection* drawings. While this is considered appropriate, it is important that the design of the fire alarm system be coordinated with the design of the foam system, specifically the foam system control panel. In some cases, such as where there is a wet-pipe foam-water sprinkler system and no nozzles, there may be no need for a foam system control panel. In such cases, the building fire alarm panel can be used to perform all alarm and supervisory functions.

7.1.1 Riser Diagram. Identify and group the various *inputs* and *outputs* associated with the fire alarm control panel, similar to what is done for the foam system control panel. This will include *alarm initiating* and *supervisory* ***input*** circuits as well as *alarm notification* ***output*** circuits.

7.2 **Fire Protection Equipment Power**. On the electrical drawings, clearly indicate power to fire pumps, fire pump controllers, foam concentrate pumps and controllers, foam system and fire alarm system control panels. Assure that power supply arrangements to pumps are in compliance with NFPA 20, *Centrifugal Fire Pumps.* This applies to centrifugal fire pumps (water) as well as gear or vane type pumps used for AFFF concentrate. In particular, assure that disconnecting means, if provided, are in accordance with Chapter 6 of NFPA 20. Also assure that feeder routing and installation complies with all requirements of this chapter. Power supplies for foam system control panels and fire alarm system panels must be in accordance with NFPA 72, *National Fire Alarm Code.*

8. **SITE UTILITY DRAWINGS**.

Fire Protection Water System. Most aircraft hangar fire protection systems will require large volumes of water at high pressures. With few exceptions, water supplies are delivered to the hangar through separate fire protection water mains supplied by fire pumps taking suction from one or more ground level water storage tanks. In many cases, an existing fire protection water system can supply demands of the new hangar fire protection systems. In such cases, the drawings will indicate extensions of existing water distribution systems. Otherwise, a new water storage, pumping and distribution system will be required. The site utility drawings need to include provisions for the water storage tanks and underground piping system. The fire pump facility, and the pumps provided therein, will be included with the fire protection drawings. Site utility drawings will also indicate locations of fire hydrants as required by applicable criteria. If the existing domestic water system is capable of supplying hose stream demands, fire hydrants should be supplied by the domestic water system rather than the fire protection system supplying hangar foam systems. The means for automatic filling of fire protection water storage tanks should be detailed on the site utility drawings.

9. **SPECIFICATIONS.**

9.1 **Corps of Engineers Guide Specifications (CEGS)**. As applicable, CEGS will be used to delineate technical requirements of the hangar fire protection system. CEGS for various portions of the overall fire protection system are listed below. It is important to verify that the specification is consistent with what is shown on the drawings. To minimize the potential for conflicts, it is recommended that system requirements be delineated either in the specifications or on the drawings, with little or no redundancy.

a. CEGS-15320, *Fire Pumps.*

b. CEGS-15355, *AFFF Fire Protection System*.

c. CEGS-16721, *Fire Detection and Alarm System*.

9.2 **Editing and Submittal.** Edit or mark up CEGS as early as practicable during the project design. Use care when customizing guide specifications, particularly with regard to modifying or deleting specific provisions. The preliminary or 60% design submittal will include a mark-up, either by hand or with word processing techniques, of the *original* CEGS. It is essential that the mark-up identify which original CEGS provisions have been deleted and which have been modified. Assure that the final specification reflects the changes accepted during the design review process.

10. **TECHNICAL GUIDANCE.**

10.1 **Fire Protection Water System**.

10.1.1 General. In most instances, fire pumps taking suction from aboveground water storage reservoirs will be required for hangar foam fire suppression systems. Except for filling of water storage tanks, avoid connections to domestic water systems.

10.1.2 Locate water storage tanks and associated pumping facilities as close as practicable to the hangar facilities or hangar groups being protected. Size tanks for 120% of the supply needed to meet the calculated demand for the duration required by applicable design criteria. Where required by applicable design criteria, divide water storage tanks into two approximately equal sections, so at least one-half of the water supply will always be maintained in service. As a practical matter, two interconnected tanks provide the most suitable means for meeting this requirement. Arrange tanks for automatic filling in accordance with NFPA 22, *Water Tanks for Private Fire Protection.*

10.1.3 Maximize the reliability of the underground water distribution system piping by looping mains where feasible. This is particularly applicable to water systems supplying multiple hangars. Limit dead end configurations as much as feasible. Generally, dead end mains should be limited to no more than 457 m (1500 ft). Provide underground sectional control valves to allow isolation of impaired sections of piping to minimize the number of facilities to be adversely affected by an impairment.

10.1.4 Provide fire pumps with rated capacities of 3785 L/min (1,000 gpm), 5678 L/min (1500 gpm), 7570 L/min (2000 gpm) or 9463 L/min (2500 gpm). If required by applicable criteria, provide one additional pump so the maximum water demand can be met with the largest pump out-of-service. Minimize the pressure rating of the pump as much as possible, but in no case design for normal system pressures exceeding 1207 kPa (175 psi).

10.1.5 Drivers for fire pumps will be electric motor or diesel engine as specified by applicable design criteria. Where electric pumps are provided, assure that electric power is arranged in accordance with NFPA 20, *Centrifugal Fire Pumps.* Provide a pressure maintenance (jockey) pump in accordance with NFPA 20.

10.2 **AFFF Concentrate Supply.**

10.2.1 AFFF Concentrate. Use only 3% aqueous film-forming foam concentrate (AFFF) conforming to the current military specification (MIL-F-21385).

10.2.2 AFFF Concentrate Tank. Provide a single foam concentrate storage tank. Do *not* provide a reserve tank unless specifically required by applicable Department of Defense (DoD) design criteria. Tank capacity should be based upon the maximum calculated foam solution demand for a duration of 10 minutes unless a longer duration is otherwise required by applicable design criteria. For design purposes, an additional amount of approximately 20% should be added to the calculated capacity requirement.

10.2.2.1 Atmospheric Tanks. Tanks constructed of fiberglass or polyethylene are generally used for pumped AFFF concentrate systems because they are impervious to the corrosive effects of the AFFF concentrate. Vertical tanks are recommended because they require less floor space than horizontal.

10.2.2.2 Diaphragm Tanks. Provide bladder tanks of the horizontal type in lieu of vertical type to facilitate filling, maintenance and bladder removal. Lessons learned indicate these tanks are often located in equipment rooms where insufficient space is allocated for proper maintenance and filling. To assure sufficient space for bladder removal, the bladder tank can be positioned in the room opposite double doors or a single overhead door.

10.2.3 Concentrate Piping System. Specify all piping systems, piping, valves and fittings, that comprise the AFFF concentrate system to be stainless steel. Specify welded fittings to avoid leaks associated with threaded joints. Do *not* use galvanized steel or plastic piping. Route foam concentrate piping aboveground inside buildings. Do *not* install concentrate piping underground or under concrete floors.

10.2.4 Concentrate Control Valves. Provide an automatically-actuated control valve in the foam concentrate line upstream of each proportioner. This valve is a critical component in the system, since foam cannot be produced if this valve fails to open. Automatically-actuated valves operated by system water pressure are specified because of their simplicity of operation and inherent reliability as compared to electrically powered motorized valves. Arrange to operate from the alarm line trim of its respective automatic water control or alarm check valve. Provide an electrically supervised manual ball valve upstream of the automated valve to facilitate maintenance without impairing other systems or the entire AFFF concentrate system.

10.2.5 Proportioning Systems.

10.2.5.1 Concentrate Pumping. Provide AFFF concentrate pumps of the positive displacement rotary gear or vane type. Provide one pump to meet the system demand and a back-up or reserve pump of the same capacity. Establish pressure rating at approximately 207 kPa (30 psi) greater than the maximum water pressure, at the point of foam concentrate injection (proportioner). Configure foam concentrate pumps in accordance with applicable provisions of NFPA 20, *Centrifugal Fire Pumps*. Assure that power is in accordance with NFPA 20, 6-3. Pumping of concentrate, as opposed to using a bladder tank, is mandatory when using in-line balanced-pressure proportioners (ILBP's). *Note: The use of a bladder tank and ILBP's as shown in the appendix of NFPA 16A is not permitted.*

10.2.5.1.1 Pump Control. Arrange foam concentrate pump for automatic starting of the primary pump upon detection of flow within the fire protection system. In the event the primary pump fails to start, the reserve pump should start. Provide necessary lockout to prevent both pumps from running simultaneously. Also, arrange pump to start upon pressure drop within the foam concentrate piping systems. Where the length of AFFF concentrate piping exceeds 50 feet from the pump discharge to the proportioners, provide a pressure maintenance or jockey pump. Arrange pumps to automatically stop upon actuation of a low-liquid level switch in the concentrate tank.

10.2.5.2 Diaphragm Supply. With this arrangement, water from the fire protection water system simultaneously supplies water to the proportioner and pressurizes the foam concentrate through an elastomeric bladder which separates the foam concentrate from the water in the tank. Locate bladder tank in close proximity to the proportioners it serves. Provide a single connection and water line from the fire protection valve header to the bladder tank for pressurization of the bladder. Include a check valve in the line to prevent backflow of AFFF concentrate into the water system in the event of a bladder rupture. Arrange connection of *bladder pressurization* line to avoid foam solution from entering or migrating into the piping and space between the bladder and the tank after the system has operated.

10.2.5.3 Proportioners (Ratio Controllers). The term *proportioner* is used by some manufacturers whereas *ratio controller* is used by others. The two terms are synonymous. *Proportioner* is used throughout this technical letter.

10.2.5.3.1 Location and Arrangement. Locate foam proportioners in the fire protection equipment room along with concentrate tanks and sprinkler and nozzles system risers and control valves. Provide one proportioner in each sprinkler riser unless extenuating circumstances justify using one proportioner for a single overhead sprinkler system and a nozzle system. This approach may have merit for relatively small facilities with only one sprinkler system and one nozzle system.

10.2.5.3.2 Flow Range. All proportioners have a range over which they can be expected to correctly proportion the foam concentrate with water in the correct ratio. Flow ranges for the same size proportioner can vary significantly between manufacturers. For example, published data of one major manufacturer's 150 mm (6-in) proportioner indicates a nominal flow range of 1136-9464 Lpm (300-2500 gpm) whereas another manufacturer's data indicates a range of 1136-

12870 Lpm (300-3400 gpm). In consideration of the limited number of manufacturers, prudent design requires basing the design on the one with the more limited nominal flow range.

10.2.5.3.3 Proportioner Size. Determine required proportioner size based upon detailed hydraulic calculations because flow rates above or below the manufacturers' specified nominal flow range are apt to result in the foam solution being too lean or too rich. The resulting foam solution can lack the necessary qualities to produce effective fire fighting foam. Therefore, assure that design utilizes proportioners of the size capable of proportioning for the calculated foam-water demand for the system or systems involved. With few exceptions, a 150 mm (6-in) proportioner will be appropriate for sprinkler system applications.

10.2.5.3.4 Test Header. Provide a test header for handling test flows of foam solution. The test header connection must be downstream of each proportioner and must permit flowing foam solution through the proportioner at various flow rates. Concurrent with flowing foam solution, samples of solution are taken and analyzed to verify that the minimum concentration level of 3% concentrate by volume is being produced by the proportioner. Size the test connection to accommodate the largest anticipated test flow, which will be the design flow in most cases. For most applications, particularly those with 150 mm (6-in) proportioners, a test header with four 65 mm (2-1/2-in) hose valves will be adequate. For sprinkler systems, provide an OS&Y gate valve for the test connection as well as one for system isolation. (Refer to NFPA 16A, Figure A-6.1). Do not provide a flow meter similar to those used for fire pump applications unless specifically required by applicable design criteria.

10.3 **Foam-Water Sprinkler Systems**.

10.3.1 System Type. With few exceptions, automatic sprinkler systems provided in DoD aircraft storage and servicing areas will be of the closed-head, foam-water type. Where the threat of freezing is minimal or non-existent, wet-pipe systems will be provided. As outlined in applicable design criteria, preaction systems will be provided where certain climatic conditions exist. Do not provide supervisory air for preaction sprinkler piping systems even though such is otherwise required by NFPA 13, *Automatic Sprinkler Systems.*

10.3.2 Sprinklers. Use standard sprinklers. Do *not* use air-aspirating foam water sprinklers. With few exceptions, sprinklers will be nominal 15 mm (1/2-in) orifice. Avoid use of either small orifice or large orifice sprinklers except such design requirements cannot be achieved otherwise. Specify sprinklers to be *quick response* type with 79^0C (175^0F) temperature rating unless otherwise required by applicable design criteria.

10.3.3 System Size. Configure foam-water sprinkler systems so each covers an area approximately the same as each other system. Limit the area covered by a single system to less than 1393 m^2 (15,000 ft^2).

10.3.4 Sprinkler Spacing. Space sprinklers in aircraft storage and servicing areas uniformly throughout the protected area so spacing does not exceed 12.1 m^2 (130 ft^2) per sprinkler. *Note: This spacing is consistent with NFPA 409, 3-2.2.3 and NFPA 13, 4-2.2.4.*

10.3.5 Design Density. Design foam-water sprinkler systems to provide a minimum discharge density of 6.5 L/min/m^2 (0.16 gpm/ft^2) for the entire design area. Design for sprinkler discharge to be uniform between sprinklers on individual sprinkler systems. Strive to limit densities to a maximum variation of 20% *above* the design or minimum design density. Variation *below* the minimum is *not* permitted. This means that where a sprinkler discharge provides a design density of 6.5 L/min/m^2 (0.16 gpm/ft^2), no other sprinkler, on the same system, should provide a density greater than 7.82 L/min/m^2 (0.192 gpm/ft^2). In other words, if sprinklers are spaced uniformly to 12.1 m^2 (130 ft^2) each, all sprinklers in the design area should discharge a minimum of 78.7 L/min (20.8 gpm) and a maximum of 94.6 L/min (25.0 gpm).

10.3.5.1 Maximum Variation in Discharge. A specified maximum variation in discharge is a means to quantify *uniform discharge*. Although this concept was originally applied to deluge sprinkler systems where all sprinklers flow, it can also be applied to closed-head systems. While this may seem like a questionable design requirement, particularly for closed-head systems, significant excess discharge can unnecessarily increase water supply and AFFF concentrate requirements. However, designers should use only reasonable conventional piping configurations in order to satisfy this somewhat subjective design parameter.

10.3.6 Design Area. Design area is related to the total discharge from sprinklers expected to operate in an anticipated fire scenario. Design area can be specified in terms of the number of complete sprinkler systems expected to be actuated by a fire, or it can be specified in terms of the floor area equating to the number of sprinklers over such an area. Design area for DoD hangar applications can involve as many as three complete sprinkler systems or floor areas of more than 2230 m^2 (24,000 ft^2). The required design area will be specified in the applicable DoD criteria.

10.3.7 Sprinkler System Configuration. To facilitate limiting the *maximum variation in discharge* noted above, configure piping systems to achieve a reasonably balanced discharge when all sprinklers on a system are flowing. Among other things, this requires an evaluation of the roof configuration and slope. For buildings with a sloped roof, for example, locating crossmains at or near the peak of the building, with branch lines running down the slope, will result in a more balanced system. Such an arrangement results in a pressure gain at lower level sprinklers due to flow from higher to lower elevations. This gain will offset at least a portion of the friction loss in the branch line, yielding similar discharge pressures between sprinklers.

10.3.7.1 Sprinkler Riser Nipples (Sprigs). Locate sprinkler branch lines close to the underside of the hangar roof deck so maximum allowable sprinkler deflector distances can be achieved without having to install sprinklers on individual riser nipples or *sprigs* as they are commonly referred to.

In order to achieve this, branch lines may have to be run through open-web steel joists. If necessary, branch line segments can be coupled between sprinklers in order to permit getting piping between closely-spaced joists. This is preferable to using sprigs, particularly where such would have to be several feet in length. If the use of sprigs is unavoidable, provide for individual bracing of sprigs longer than about 1 m (3 ft).

10.3.7.2 Auxiliary Drains. Connect branch lines running down roof slopes to a common manifold or ganged drain at the low points. This will permit simultaneous draining of several branch lines through one drain valve.

10.3.8 Relief Valves. Provide relief valves or auxiliary air reservoirs on gridded wet-pipe foam water sprinkler systems in accordance with NFPA 13. *Note: Wet-pipe systems with branch lines manifolded into gang drains are considered to be gridded.*

10.4 **Nozzle Systems**.

10.4.1 General. Nozzle systems are often provided for rapid application of foam to combat fuel spill fires that threaten irreparable damage to aircraft. For fixed-wing aircraft, the area where the wings connect to the fuselage are particularly vulnerable to damage from a fuel spill fire. Consequently, applicable design criteria will often require nozzle systems for certain fixed-wing aircraft but not helicopters. Nozzle systems can effectively minimize damage to the aircraft of fire origin and prevent fire spread to adjacent aircraft. Such fire control will indirectly protect the hangar facility from catastrophic damage. The decision of whether or not to provide nozzle systems will be based upon various factors as addressed in MIL-HDBK-1008C or supplemental design criteria of the pertinent DoD agency involved.

10.4.2 Nozzle Placement and Alignment. Experience has shown that nozzles are often susceptible to failure due to being blocked by moveable equipment used in a hangar. Consequently, nozzle placement is extremely critical. The designer must consider all factors that can adversely affect nozzle effectiveness. This includes hangar size and configuration, aircraft to be housed, proposed and possible aircraft parking positions, equipment proposed for use, and other factors known by the facility user. To maximize nozzle performance, provide multiple nozzle locations. The number of locations will vary with the size and configuration of the facility. Aim nozzles toward designated or assumed aircraft parking locations. Where possible, direct discharge toward hangar doors. Locate nozzle assemblies, including control valves, along walls as necessary to avoid obstruction from equipment that can or will be used in the hangar. If permitted by facility configuration and use, locate nozzle assemblies away from walls to afford protection against obstruction. In such cases, provide pipe trenches in concrete floors for routing of piping. Provide concrete-filled pipe bollards to protect nozzle assemblies from physical damage.

10.4.3 System Arrangement. Arrange nozzle assembly control valves to minimize the time-delay between system actuation and foam discharge from the nozzles. For most applications, proportioners will be located downstream of alarm check valves in nozzle system risers centrally located in fire protection equipment rooms. The foam-water solution will be supplied to individual automatic water control (deluge) valves in the hangar area. For alteration of existing systems where fire protection water is supplied to multiple riser manifolds within the hangar area, it may be feasible to omit alarm check valves and supply nozzles directly from automatic water control valves.

10.4.4 Discharge Requirement. Design nozzle systems to produce a minimum application rate of 4.1 L/min/m^2 (0.10 gpm/ft^2) over the under-aircraft area to be protected. This application rate is applicable to the area beneath the wings and fuselage of the aircraft. As a practical matter, nozzle systems cannot be designed to cover *just* the "shadow areas" of the aircraft. Nozzle discharges should impact the floor in front of or beside the protected aircraft. The objective is to achieve gentle application of foam onto burning fuel presumed to exist beneath the aircraft. Determine the area of coverage of each nozzle and provide a flow rate that achieves the required application rate. For example, if the discharge from one or more nozzles covers an area of 400 m^2 (4300 ft^2), the flow rate of a single oscillating nozzle, or the combined flow rate of multiple fixed nozzles, needs to be approximately 1640 L/min (430 gpm) in order to achieve the minimum application rate.

10.4.5 Nozzle Type. Nozzles can be either fixed or oscillating type. Use *fixed* type nozzle systems except in unusual situations where *only* oscillating type will provide the required performance. Fixed nozzle systems are more reliable than oscillating because they are not dependent upon water or electric-powered oscillating mechanisms to perform effectively. Also, fixed nozzles are less suspectable to incorrect alignment after installation. Historically, oscillating nozzles have experienced numerous problems with maladjustment. Often times, the angle of nozzle elevation has been found changed from original setting. In some cases, this has resulted in damage to aircraft where discharges were directed *onto* the protected aircraft, rather than *under* the aircraft.

10.4.5.1 Fixed Nozzle Systems. Available fixed nozzles used in hangar applications have a discharge characteristic generally less than that of oscillating nozzles. Consequently, multiple fixed nozzles, with varying discharge rates and patterns, are typically used in a tree or manifold arrangement. The combined flows of individual nozzles can approximate the flow of a single oscillating nozzle. For fixed nozzle systems, use nozzles 75 mm (3 in) or less in length. Generally, flow rates of individual fixed nozzles should be limited to 473 L/min (125 gpm) or less.

10.4.5.2 Oscillating Nozzles. Use oscillating nozzle systems ***only*** when fixed nozzle systems cannot provide effective performance. If fixed nozzles are not used, the reasons must be clearly addressed and substantiated in the design analysis. Where oscillating nozzles must be used, provide water-powered, non-aspirating *short barrel* type with individual nozzle flow rate of 1893 L/min (500 gpm) or less.

10.5 **Interior Hose Stations**.

10.5.1 General. Do not provide hose stations in aircraft servicing and storage areas unless specifically required by applicable Department of Defense (DoD) criteria. The NFPA 409 requirement is not valid for providing hose stations.

10.6 **System Valves and Components**.

10.6.1 Alarm Check Valves. Use alarm check valves in wet-pipe foam-water sprinkler systems and in systems supplying foam solution to nozzle system automatic water control (deluge) valves. Include retard chambers with the alarm line trim piping on alarm check valve installations. Arrange alarm line piping to individually actuate respective water-powered foam concentrate control valves.

10.6.1.1 Waterflow Switch with Time Delay. Unless otherwise required by applicable design criteria, provide waterflow switches with adjustable time delay for use in wet-pipe systems required to actuate nozzle systems upon detection of flow in the sprinkler system. Locate the switch in the alarm trim *upstream* of retard chamber and independent of other circuit closers (pressure switches). Assure that the switch is installed so that there is no shutoff valve in the piping to the switch. Specify switch to have adjustable time delay of 0 to 45 seconds (minimum).

10.6.2 Automatic Water Control (Deluge) Valves. Provide automatic water control valves in preaction sprinkler systems and for automatic control of nozzle system flow. Arrange alarm line piping to individually actuate respective water-powered foam concentrate control valve. To facilitate resetting valve after operation, specify such valves to have the feature of being resettable without having to use special tools or to remove the face-plate of the valve.

10.6.3 Shut-off Valves. Specify only UL-listed indicating-type control valves for controlling water or foam solution. Provide OS&Y type valves for controlling water or foam solution. Provide indicating type ball valves for controlling AFFF concentrate.

10.6.4 Basket Strainers. Provide basket strainers for installations with nozzle systems. Omit strainers on systems with overhead sprinklers only. Locate the strainer in the valve manifold or the nozzle system riser located in the fire protection equipment room.

10.6.5 Fire Department Connections. Do not provide fire department siamese connections on aircraft hangar foam-water sprinkler systems supplied by water systems with fire pumps.

10.7 **Detection and Control Systems.**

10.7.1 Foam System Control Panel (FSCP). A foam system control panel, with integral annunciator, will be provided for most applications. This panel will be separate from, but interconnected with, the building fire alarm panel. Arrange the FSCP to perform all functions related to control of the foam fire protection system. Specify the FSCP provided for actuating nozzle system or preaction system automatic water control valves to be approved by Factory Mutual for *releasing device service* with the particular make and model of automatic water control valve provided.

10.7.1.1 Arrange the system so the actuation of any alarm initiating device, i.e., UV-IR fire detector, rate compensating heat detector, nozzle system manual actuation station, alarm pressure or flow switch, etc., will actuate local alarms associated with the foam system, actuate the building fire alarm system, and simultaneously transmit an alarm to a central receiving station.

10.7.1.2 Nozzle System Activation. For systems involving nozzle systems, provide manual actuation stations near exit doors for nozzle system activation. Arrange sprinkler system waterflow detection devices to activate nozzles upon detection of waterflow in the overhead sprinkler system. Where specifically required by applicable design criteria, arrange nozzle system activation by other specific means as specified.

10.7.1.3 Alarm Notification Devices. Provide audible and visual alarm notification appliances within the aircraft hangar area to warn of a detected fire condition and the impending discharge of foam fire suppression systems. Assure that audible devices are capable of producing sound pressure levels adequate to overcome ambient noise levels. In some cases, the use of electronic horns with field-selectable tones will provide satisfactory service. In some applications, rotating beacons are suitable for providing required visual alarms. Alarm notification in portions of the facility other than the hangar area may be provided by appliances associated with the building fire alarm system.

10.7.2 Alarm Initiating Devices.

10.7.2.1 Heat Detectors. Provide rate-compensated type heat detectors for preaction sprinkler systems. Do *not* provide heat detection systems in areas protected by wet-pipe sprinkler systems. Detectors of the fixed-temperature, rate-of-rise or combination fixed temperature/ rate-of-rise type are *not permitted.* Space detectors to a maximum of 7.6 m x 7.6 m (25 ft x 25 ft) per detector. Arrange so activation of any single detector will trip the preaction sprinkler system and any associated underwing nozzle system within the protected area served by the actuated detector. Fire test results reported in the National Institute of Standards and Technology (NIST) document, *Analysis of High Bay Hangar Facilities for Fire Detector Sensitivity and Placement*, indicate that activation temperatures of heat detectors used in conjunction with preaction sprinkler systems should be closely matched to automatic sprinkler temperature ratings. Thus, designers should specify detector temperature ratings of 71ºC to 76ºC (160ºF to 170ºF) unless other ratings are mandated by applicable design criteria or ambient conditions.

10.7.2.2 Optical Detectors. Where required by applicable design criteria, provide optical detectors of the dual spectrum ultraviolet-infrared type. Specify detectors to be certified by a nationally recognized testing laboratory to be capable of detecting a fully developed 3 m x 3 m. (10 ft x 10 ft) JP-4, JP-8 or JET-A fuel fire at minimum distance of 45 m (148 ft) within 5 seconds. Provide a sufficient number of detectors at approximately 3 m (10 ft) above the hangar floor so the a fire developing in the under-aircraft area will be in the cone of vision of at least one detector. Connect detectors to the foam system control panel (FSCP) and arrange for alarm-only unless design direction from the customer requires arranging detectors for nozzle system actuation. Do *not* arrange optical detectors to actuate overhead sprinkler systems.

10.7.2.3 Nozzle System Manual Actuation Stations. Provide manual stations for activation of foam-water nozzle systems. Specify stations to have distinctive labeling and coloring to differentiate these stations from manual fire alarm stations. Provide a clear plastic tamper-resistant enclose to protect the station from accidental operation.

APPENDIX B

AIRCRAFT HANGAR FIRE PROTECTION SYSTEMS

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AIRCRAFT HANGAR FIRE PROTECTION SYSTEMS

1. **GENERAL**. Fire protection systems are provided in aircraft hangars for protection against a potentially devastating fire and the loss of valuable military assets. Current state-of-the-art protection systems utilize aqueous film-forming foam (AFFF) to combat fuel spill fires that can occur in facilities housing fueled aircraft. Because of the critical nature and the inherent complexity associated with foam fire protection systems, it is essential that they be designed and installed by those with the required expertise and experience. Lessons learned have identified numerous installation and operational problems that can adversely affect system adequacy, reliability and maintainability. It is therefore imperative that attention be directed to the design and installation of these systems. The focus of this ETL is on *design.* Since there is a correlation between the adequacy of the design and the acceptability of the final installation, emphasis must be placed on producing designs that are technically correct and comply with applicable design criteria. To better assure system acceptability, it is essential to thoroughly and clearly define system requirements. This ETL establishes a number of procedures and technical direction to assist designers in achieving this objective.

2. **DESIGNER REQUIREMENTS**. Design of foam-water sprinkler systems for aircraft hangars requires specialized design knowledge and expertise. To assure adequacy of design, it is essential that such systems be designed and specified by engineers with extensive experience in this specialized area of fire protection system design. This is mandatory for Air Force projects covered by Air Force ETL 96-1, *Fire Protection Engineering Criteria-New Aircraft Facilities*.

3. **SUBMITTALS**. Each design submittal stage should address crucial considerations affecting the fire protection system design. This includes water supply systems, proposed types of sprinkler and nozzle systems, foam concentrate proportioning systems, fire detection and controls systems, etc. Of particular importance is the water supply system which must meet system demands. Lessons learned indicate the need for more comprehensive water demand and water supply analyses. After the initial design submittal, each succeeding submittal should be a further elaboration and refinement of what was previously submitted. For example, whereas the concept submittal may include only rough approximations of system water demand, the intermediate (preliminary) and final submittals need to include detailed hydraulic calculations to confirm that calculated system demands can in fact be met with the existing or proposed water system. This analysis should be correlated with the design to provide substantiation of pump selection, pipe sizes, nozzle selection, sprinkler discharges, etc. Specific requirements for design analysis, drawings and hydraulic calculations are described later in this document.

4. **TECHNICAL CENTER OF EXPERTISE (TCX)**. A TCX for Aircraft Hangar Fire Protection was established to provide technical assistance to those involved in the design, installation, and testing of aircraft hangar foam fire suppression systems. The TCX will provide,

on a cost reimbursable basis, technical guidance and assistance to those tasked to design hangar fire protection systems. The office requesting services will provide funding to cover TCX costs associated with each project. Costs are directly related to the size and complexity of the project and the quality of the design submittal. Arrangements should be made by contacting Mr. Ed Lockwood at (540) 665-3919 (voice) and (540) 665-3628 (facsimile). Correspondence and submittal packages should be sent as follows:

U.S. Postal Service:	***Federal Express or UPS***
U.S. Army Corps of Engineers	U.S. Army Corps of Engineers
Transatlantic Programs Center	Transatlantic Programs Center
ATTN: CETAC-EC-TM (Lockwood)	ATTN: CETAC-EC-TM (Lockwood)
P.O. Box 2250	201 Prince Frederick Drive
Winchester, Virginia 22604-1450	Winchester, Virginia 22602

4.1 **Required Design Reviews**. As mandated by U.S. Air Force ETL 96-1, aircraft facility fire protection designs will be submitted for technical review by the TCX. Comments will be incorporated to the satisfaction of the Air Force. For other than Air Force designs, Corps offices are encouraged to utilize the TCX for technical assistance and to submit designs for review. This will serve to assure technical adequacy of the design and conformance to the requirements of this ETL.

4.2 **Submittal Procedures.** Corps offices tasked to design projects with aircraft facility fire protection systems will contact the TCX as early as possible during the design process to discuss required services, design schedule, and funding requirements. To assure timely reviews by the TCX, the requesting office should transmit required funds as early as possible, but in no case less than 10 work days prior to submission of the first submittal. A submittal schedule should be provided to the TCX to facilitate workload management. All design submittals, i.e., concept, intermediate (preliminary) and final, will be submitted to the TCX for review. Documents will include all drawings, design analyses, calculations, specifications, confirmation notices, meeting minutes, and other related documentation associated with the project. As soon as possible following their submission, technical comments provided by the TCX will be annotated with the action taken and returned to the TCX reviewer. Comments to which exception is taken will be discussed and resolved prior to continuation of the design process and submission of the next submittal.

5. **DESIGN ANALYSIS.**

5.1 **Narrative**. Provide a Fire Protection narrative separately from other disciplines. Prepare a comprehensive design analysis in accordance with MIL-HDBK-1008C. Clearly indicate the basis of design and application of specific design criteria. Describe the overall fire protection system proposed for the facility including types and arrangement of all systems and subsystems. This includes sprinkler, nozzle, detection, control, AFFF concentrate, proportioning, and etc. Include detailed descriptions of sprinkler systems in terms of applicable sprinkler types, spacing limitations, and etc. As applicable, include reference to other disciplines where related systems are described. For example, refer to applicable civil site utility portions of the analysis for description of water storage, distribution, and etc.

5.2 **Water Supply/Demand Analysis**. Hangar fire protection systems typically have high water demands, in terms of water quantity and pressure. It is not unusual for such systems to have water demands for sprinklers and nozzles in excess of 18925 L/min (5000 gpm) at pressures of 862 kPa (125 psi). To assure adequacy of water supply to meet such demands, the designer must perform a detailed hydraulic analysis. This will compare the system demand with the supply and identify system adjustments necessary to assure that all applicable design parameters will be met. Include an exterior hose stream demand of 1893 L/min (500 gpm) where the water supply for the building sprinklers and nozzles also supplies hydrants available for use by the fire department.

5.3 **Hydraulic Calculations**. Calculations in the absence of a specific design will constitute, at best, rough approximations. While such approximations may suffice for the concept submittal, subsequent submittals need to include calculations based upon an actual layout of discharge devices and corresponding piping configuration.

5.3.1 Computer Software. Perform hangar fire protection system hydraulic calculations using recognized fire protection software. The “HASS” (*Hydraulic Analyzer of Sprinkler Systems*) is a recognized hydraulics program used by many contractors and fire protection design firms. This program is taught in PROSPECT Course, “*Fire Extinguishing System Design*”and should be used by Corps of Engineers offices performing or specifying fire protection systems for aircraft hangars.

5.3.2 System Sketch**.** Include in the design analysis (*not the contract drawings*) a sketch representative of the overall fire protection system. It should show all pipes and nodes in the sprinkler, nozzle and underground water distribution systems. Assure that the sketch corresponds to what is indicated on the project drawings as well as in the hydraulic calculations.

5.3.3 Hydraulic Reference Points. Identify all hydraulic reference points (nodes) in the piping system being calculated. Include elevation and pressure at each node in the system. For discharging nodes, indicate the k-factor and flow.

5.3.4 Pipe Segments. Identify all pipes in the system and indicate the two nodes to which each pipe is connected. Include the diameter, length, number and type fittings, equivalent length, friction loss per foot, flow, velocity, total friction loss in the pipe segment, Hazen-Williams coefficient, and etc. As permitted by computer software used, label pipe segments as “strainer,” "proportioner," "fire pump," "backflow preventer," and others as appropriate to identify the specific system components with special features and friction loss characteristics.

5.4 **Manufacturer's Catalog Data**. Include in the design analysis catalog information for all major items of equipment upon which the design is based. This includes, but is not limited to, fire pumps, jockey pumps, foam concentrate tanks, foam pumps, foam proportioners, automated foam concentrate valves, nozzles, automatic water control valves, sprinklers, and etc.

6. FIRE PROTECTION DRAWINGS

6.1 **Fire Protection Piping**. Prepare separate "FP" drawings to indicate all fire protection equipment and devices associated with the fire protection system. Provide complete fire protection system design including sizes and locations of all equipment and piping. Determine pipe sizes using computer software developed specifically for design of fire protection systems. Since the fire protection system design will be provided as part of the contract drawings, do *not* include design criteria on the drawings or in the specifications. This is apt to be misinterpreted by the contractor as an invitation to redesign the system.

6.1.1 Sprinkler and Piping Plan. Prepare a separate "FP" drawing showing the overall arrangement of the sprinkler system. Assure that the scale is adequate to clearly show sprinklers, branch lines, crossmains, riser nipples, feed mains, risers and other major components. A drawing scale of 1:100 (1/8"= 1'-0") is recommended. Indicate routing of all piping and identify pipe sizes, but do *not* indicate lengths of pipe segments. Leave this for the contractor to determine and provide for review and approval as part of shop drawing submittal.

6.1.2 Nozzle System Plan. Prepare a separate "FP" drawing showing nozzle system piping, automatic control valves as well as nozzles. Where possible, position nozzles so as to direct the foam discharge *toward the hangar door*. Nozzle system design should strive for gentle application of foam solution into the protected area. Keep in mind that the discharge velocity will carry the foam beyond the area of nozzle stream impact on the floor. Nozzle discharges should *not* overlap those from opposing or converging nozzles. Such arrangements will result in undesirable turbulence, particularly in the under-aircraft area and is apt to adversely affect fire control or extinguishment. Show the approximate area to be covered by each nozzle. Include a detail of each nozzle type required. Where possible, use nozzles with the same discharge characteristic as this will simplify installation and maintenance as well as design. Indicate, on the drawings, the k-factor for each nozzle. Where a number of different k-factors are involved, include a nozzle schedule to clearly convey design intent and requirements.

6.2 **Fire Detection and Control System**. Prepare separate "FP" drawings identifying each device connected to the foam system control panel (FSCP). Develop unique symbols for identifying the various components comprising the foam system. Clearly identify each symbol and omit any which is not used for a specific design. Assure that symbols are dissimilar to those used in the fire alarm or other building systems. Provide unique identification of each such device using a subscript indicating the applicable zone number and a sequentially allocated *device number* for each specific circuit. For example, if Zone 3 includes four manual actuation stations, identify them with subscripts of "3-1," "3-2," "3-3," and "3-4." If Zone 4, for example, has twenty (20) rate compensated heat detectors, identify them "4-1".......thru "4-20." Use this device numbering scheme for floor plans and riser diagrams.

6.2.1 Foam System Control Panel (FSCP). Locate the FSCP on the "FP" drawings, preferably within, or in close proximity to, the fire protection equipment room. To minimize cost and to simplify testing and maintenance, specify FSCP's with integral annunciators rather than providing remote annunciators. Include a sequence of operation in narrative form, controls matrix or both as necessary to describe system operation.

6.2.2 Foam System Riser Diagram. Identify and group the various i*nputs* and *outputs* associated with the control panel. This will include *alarm initiating* and *supervisory* ***input*** circuits as well as "*alarm notification* and *release device* ***output*** circuits.

a. *Alarm Initiating* Device Circuits--includes waterflow switch, nozzle system manual actuation station, heat detector, ultra-violet/infrared flame detector, etc.

b. *Supervisory* Device Circuits-- includes valve supervisory (tamper) switches, pump controllers, low liquid level, etc.

c. *Release* Device Circuits--includes circuits to solenoid valves for actuation of automatic water control valves controlling foam solution flow to nozzle systems and preaction sprinkler system.

d. *Alarm Notification* Device Circuits-- includes alarm bells, horns, sirens, strobe lights, rotating beacons, etc.

6.2.3 Schedule of Supervised Valves. For applications involving numerous valves requiring supervisory (tamper) switches, a valve schedule indicating designation, size, type, location, and area controlled is recommended. Include in the schedule the unique device identifier corresponding to what is shown in the riser diagram. Valves requiring supervision include those controlling water, foam concentrate and foam solution.

6.3 **Fire Protection Equipment Room**. Include an enlarged plan at a scale of 1:50 (1/4"=1'-0") of the fire protection equipment room. Show the AFFF concentrate tank, water service entrance, sprinkler riser/valve manifold, foam system control panel, and piping. Provide sections and details to clearly show the riser manifold and all associated components, piping, valves, fittings, etc.

Assure that the equipment is arranged to facilitate maintenance and regular testing. In particular, assure that AFFF bladder tanks are of the horizontal type and located with sufficient space at one end to permit removal and replacement of bladders. As much as practicable, arrange components to be serviceable from the floor. Otherwise, work platforms may be necessary.

6.4 **Fire Pump Building or Room**. Fire pumping systems for most hangar fire protection systems can provide water supply to the facility included in the current design project as well as future hangars. These pumping systems often involve multiple, high-capacity, diesel engine-driven fire pumps. It is therefore preferred to locate and arrange such pumping systems in a separate pump house or building adjacent to the water storage tanks from which the pumps take suction. This pump facility will house the pumps, drivers, controllers, fuel tanks, test headers and associated equipment. The configuration of the equipment space should consider the need to test, maintain and even replace major components of the system. If the fire pump installation must be co-located with the AFFF concentrate tank, proportioning equipment, valve header, and control panels, assure that adequate space is allocated to facilitate maintenance of all subsystems.

6.5 **Drawing Details.** Include details of critical system components including valve headers, nozzles, concentrate tanks, test headers, and etc. Clarify, to the greatest extent possible, the design intent. A number of standard details can be found in the CADD Details Library distributed by the Tri-Service CADD/GIS Technology Center. Keep in mind that these details must be customized for specific applications.

7. **ELECTRICAL DRAWINGS.**

7.1 **Building Fire Alarm System**. It is customary to include the building alarm system as part of the electrical design and to show the system on *electrical* rather than *fire protection* drawings. While this is considered appropriate, it is important that the design of the fire alarm system be coordinated with the design of the foam system, specifically the foam system control panel. In some cases, such as where there is a wet-pipe foam-water sprinkler system and no nozzles, there may be no need for a foam system control panel. In such cases, the building fire alarm panel can be used to perform all alarm and supervisory functions.

7.1.1 Riser Diagram. Identify and group the various *inputs* and *outputs* associated with the fire alarm control panel, similar to what is done for the foam system control panel. This will include *alarm initiating* and *supervisory* ***input*** circuits as well as *alarm notification* ***output*** circuits.

7.2 **Fire Protection Equipment Power**. On the electrical drawings, clearly indicate power to fire pumps, fire pump controllers, foam concentrate pumps and controllers, foam system and fire alarm system control panels. Assure that power supply arrangements to pumps are in compliance with NFPA 20, *Centrifugal Fire Pumps.* This applies to centrifugal fire pumps (water) as well as gear or vane type pumps used for AFFF concentrate. In particular, assure that disconnecting means, if provided, are in accordance with Chapter 6 of NFPA 20. Also assure that feeder routing and installation complies with all requirements of this chapter. Power supplies for foam system control panels and fire alarm system panels must be in accordance with NFPA 72, *National Fire Alarm Code.*

8. **SITE UTILITY DRAWINGS**.

Fire Protection Water System. Most aircraft hangar fire protection systems will require large volumes of water at high pressures. With few exceptions, water supplies are delivered to the hangar through separate fire protection water mains supplied by fire pumps taking suction from one or more ground level water storage tanks. In many cases, an existing fire protection water system can supply demands of the new hangar fire protection systems. In such cases, the drawings will indicate extensions of existing water distribution systems. Otherwise, a new water storage, pumping and distribution system will be required. The site utility drawings need to include provisions for the water storage tanks and underground piping system. The fire pump facility, and the pumps provided therein, will be included with the fire protection drawings. Site utility drawings will also indicate locations of fire hydrants as required by applicable criteria. If the existing domestic water system is capable of supplying hose stream demands, fire hydrants should be supplied by the domestic water system rather than the fire protection system supplying hangar foam systems. The means for automatic filling of fire protection water storage tanks should be detailed on the site utility drawings.

9. **SPECIFICATIONS.**

9.1 **Corps of Engineers Guide Specifications (CEGS)**. As applicable, CEGS will be used to delineate technical requirements of the hangar fire protection system. CEGS for various portions of the overall fire protection system are listed below. It is important to verify that the specification is consistent with what is shown on the drawings. To minimize the potential for conflicts, it is recommended that system requirements be delineated either in the specifications or on the drawings, with little or no redundancy.

a. CEGS-15320, *Fire Pumps.*

b. CEGS-15355, *AFFF Fire Protection System*.

c. CEGS-16721, *Fire Detection and Alarm System*.

9.2 **Editing and Submittal.** Edit or mark up CEGS as early as practicable during the project design. Use care when customizing guide specifications, particularly with regard to modifying or deleting specific provisions. The preliminary or 60% design submittal will include a mark-up, either by hand or with word processing techniques, of the *original* CEGS. It is essential that the mark-up identify which original CEGS provisions have been deleted and which have been modified. Assure that the final specification reflects the changes accepted during the design review process.

10. **TECHNICAL GUIDANCE.**

10.1 **Fire Protection Water System**.

10.1.1 General. In most instances, fire pumps taking suction from aboveground water storage reservoirs will be required for hangar foam fire suppression systems. Except for filling of water storage tanks, avoid connections to domestic water systems.

10.1.2 Locate water storage tanks and associated pumping facilities as close as practicable to the hangar facilities or hangar groups being protected. Size tanks for 120% of the supply needed to meet the calculated demand for the duration required by applicable design criteria. Where required by applicable design criteria, divide water storage tanks into two approximately equal sections, so at least one-half of the water supply will always be maintained in service. As a practical matter, two interconnected tanks provide the most suitable means for meeting this requirement. Arrange tanks for automatic filling in accordance with NFPA 22, *Water Tanks for Private Fire Protection.*

10.1.3 Maximize the reliability of the underground water distribution system piping by looping mains where feasible. This is particularly applicable to water systems supplying multiple hangars. Limit dead end configurations as much as feasible. Generally, dead end mains should be limited to no more than 457 m (1500 ft). Provide underground sectional control valves to allow isolation of impaired sections of piping to minimize the number of facilities to be adversely affected by an impairment.

10.1.4 Provide fire pumps with rated capacities of 3785 L/min (1,000 gpm), 5678 L/min (1500 gpm), 7570 L/min (2000 gpm) or 9463 L/min (2500 gpm). If required by applicable criteria, provide one additional pump so the maximum water demand can be met with the largest pump out-of-service. Minimize the pressure rating of the pump as much as possible, but in no case design for normal system pressures exceeding 1207 kPa (175 psi).

10.1.5 Drivers for fire pumps will be electric motor or diesel engine as specified by applicable design criteria. Where electric pumps are provided, assure that electric power is arranged in accordance with NFPA 20, *Centrifugal Fire Pumps.* Provide a pressure maintenance (jockey) pump in accordance with NFPA 20.

10.2 **AFFF Concentrate Supply.**

10.2.1 AFFF Concentrate. Use only 3% aqueous film-forming foam concentrate (AFFF) conforming to the current military specification (MIL-F-21385).

10.2.2 AFFF Concentrate Tank. Provide a single foam concentrate storage tank. Do *not* provide a reserve tank unless specifically required by applicable Department of Defense (DoD) design criteria. Tank capacity should be based upon the maximum calculated foam solution demand for a duration of 10 minutes unless a longer duration is otherwise required by applicable design criteria. For design purposes, an additional amount of approximately 20% should be added to the calculated capacity requirement.

10.2.2.1 Atmospheric Tanks. Tanks constructed of fiberglass or polyethylene are generally used for pumped AFFF concentrate systems because they are impervious to the corrosive effects of the AFFF concentrate. Vertical tanks are recommended because they require less floor space than horizontal.

10.2.2.2 Diaphragm Tanks. Provide bladder tanks of the horizontal type in lieu of vertical type to facilitate filling, maintenance and bladder removal. Lessons learned indicate these tanks are often located in equipment rooms where insufficient space is allocated for proper maintenance and filling. To assure sufficient space for bladder removal, the bladder tank can be positioned in the room opposite double doors or a single overhead door.

10.2.3 Concentrate Piping System. Specify all piping systems, piping, valves and fittings, that comprise the AFFF concentrate system to be stainless steel. Specify welded fittings to avoid leaks associated with threaded joints. Do *not* use galvanized steel or plastic piping. Route foam concentrate piping aboveground inside buildings. Do *not* install concentrate piping underground or under concrete floors.

10.2.4 Concentrate Control Valves. Provide an automatically-actuated control valve in the foam concentrate line upstream of each proportioner. This valve is a critical component in the system, since foam cannot be produced if this valve fails to open. Automatically-actuated valves operated by system water pressure are specified because of their simplicity of operation and inherent reliability as compared to electrically powered motorized valves. Arrange to operate from the alarm line trim of its respective automatic water control or alarm check valve. Provide an electrically supervised manual ball valve upstream of the automated valve to facilitate maintenance without impairing other systems or the entire AFFF concentrate system.

10.2.5 Proportioning Systems.

10.2.5.1 Concentrate Pumping. Provide AFFF concentrate pumps of the positive displacement rotary gear or vane type. Provide one pump to meet the system demand and a back-up or reserve pump of the same capacity. Establish pressure rating at approximately 207 kPa (30 psi) greater than the maximum water pressure, at the point of foam concentrate injection (proportioner). Configure foam concentrate pumps in accordance with applicable provisions of NFPA 20, *Centrifugal Fire Pumps*. Assure that power is in accordance with NFPA 20, 6-3. Pumping of concentrate, as opposed to using a bladder tank, is mandatory when using in-line balanced-pressure proportioners (ILBP's). *Note: The use of a bladder tank and ILBP's as shown in the appendix of NFPA 16A is not permitted.*

10.2.5.1.1 Pump Control. Arrange foam concentrate pump for automatic starting of the primary pump upon detection of flow within the fire protection system. In the event the primary pump fails to start, the reserve pump should start. Provide necessary lockout to prevent both pumps from running simultaneously. Also, arrange pump to start upon pressure drop within the foam concentrate piping systems. Where the length of AFFF concentrate piping exceeds 50 feet from the pump discharge to the proportioners, provide a pressure maintenance or jockey pump. Arrange pumps to automatically stop upon actuation of a low-liquid level switch in the concentrate tank.

10.2.5.2 Diaphragm Supply. With this arrangement, water from the fire protection water system simultaneously supplies water to the proportioner and pressurizes the foam concentrate through an elastomeric bladder which separates the foam concentrate from the water in the tank. Locate bladder tank in close proximity to the proportioners it serves. Provide a single connection and water line from the fire protection valve header to the bladder tank for pressurization of the bladder. Include a check valve in the line to prevent backflow of AFFF concentrate into the water system in the event of a bladder rupture. Arrange connection of *bladder pressurization* line to avoid foam solution from entering or migrating into the piping and space between the bladder and the tank after the system has operated.

10.2.5.3 Proportioners (Ratio Controllers). The term *proportioner* is used by some manufacturers whereas *ratio controller* is used by others. The two terms are synonymous. *Proportioner* is used throughout this technical letter.

10.2.5.3.1 Location and Arrangement. Locate foam proportioners in the fire protection equipment room along with concentrate tanks and sprinkler and nozzles system risers and control valves. Provide one proportioner in each sprinkler riser unless extenuating circumstances justify using one proportioner for a single overhead sprinkler system and a nozzle system. This approach may have merit for relatively small facilities with only one sprinkler system and one nozzle system.

10.2.5.3.2 Flow Range. All proportioners have a range over which they can be expected to correctly proportion the foam concentrate with water in the correct ratio. Flow ranges for the same size proportioner can vary significantly between manufacturers. For example, published data of one major manufacturer's 150 mm (6-in) proportioner indicates a nominal flow range of 1136-9464 Lpm (300-2500 gpm) whereas another manufacturer's data indicates a range of 1136-

12870 Lpm (300-3400 gpm). In consideration of the limited number of manufacturers, prudent design requires basing the design on the one with the more limited nominal flow range.

10.2.5.3.3 Proportioner Size. Determine required proportioner size based upon detailed hydraulic calculations because flow rates above or below the manufacturers' specified nominal flow range are apt to result in the foam solution being too lean or too rich. The resulting foam solution can lack the necessary qualities to produce effective fire fighting foam. Therefore, assure that design utilizes proportioners of the size capable of proportioning for the calculated foam-water demand for the system or systems involved. With few exceptions, a 150 mm (6-in) proportioner will be appropriate for sprinkler system applications.

10.2.5.3.4 Test Header. Provide a test header for handling test flows of foam solution. The test header connection must be downstream of each proportioner and must permit flowing foam solution through the proportioner at various flow rates. Concurrent with flowing foam solution, samples of solution are taken and analyzed to verify that the minimum concentration level of 3% concentrate by volume is being produced by the proportioner. Size the test connection to accommodate the largest anticipated test flow, which will be the design flow in most cases. For most applications, particularly those with 150 mm (6-in) proportioners, a test header with four 65 mm (2-1/2-in) hose valves will be adequate. For sprinkler systems, provide an OS&Y gate valve for the test connection as well as one for system isolation. (Refer to NFPA 16A, Figure A-6.1). Do not provide a flow meter similar to those used for fire pump applications unless specifically required by applicable design criteria.

10.3 **Foam-Water Sprinkler Systems**.

10.3.1 System Type. With few exceptions, automatic sprinkler systems provided in DoD aircraft storage and servicing areas will be of the closed-head, foam-water type. Where the threat of freezing is minimal or non-existent, wet-pipe systems will be provided. As outlined in applicable design criteria, preaction systems will be provided where certain climatic conditions exist. Do not provide supervisory air for preaction sprinkler piping systems even though such is otherwise required by NFPA 13, *Automatic Sprinkler Systems.*

10.3.2 Sprinklers. Use standard sprinklers. Do *not* use air-aspirating foam water sprinklers. With few exceptions, sprinklers will be nominal 15 mm (1/2-in) orifice. Avoid use of either small orifice or large orifice sprinklers except such design requirements cannot be achieved otherwise. Specify sprinklers to be *quick response* type with 79^0C (175^0F) temperature rating unless otherwise required by applicable design criteria.

10.3.3 System Size. Configure foam-water sprinkler systems so each covers an area approximately the same as each other system. Limit the area covered by a single system to less than 1393 m^2 (15,000 ft^2).

10.3.4 Sprinkler Spacing. Space sprinklers in aircraft storage and servicing areas uniformly throughout the protected area so spacing does not exceed 12.1 m^2 (130 ft^2) per sprinkler. *Note: This spacing is consistent with NFPA 409, 3-2.2.3 and NFPA 13, 4-2.2.4.*

10.3.5 Design Density. Design foam-water sprinkler systems to provide a minimum discharge density of 6.5 L/min/m^2 (0.16 gpm/ft^2) for the entire design area. Design for sprinkler discharge to be uniform between sprinklers on individual sprinkler systems. Strive to limit densities to a maximum variation of 20% *above* the design or minimum design density. Variation *below* the minimum is *not* permitted. This means that where a sprinkler discharge provides a design density of 6.5 L/min/m^2 (0.16 gpm/ft^2), no other sprinkler, on the same system, should provide a density greater than 7.82 L/min/m^2 (0.192 gpm/ft^2). In other words, if sprinklers are spaced uniformly to 12.1 m^2 (130 ft^2) each, all sprinklers in the design area should discharge a minimum of 78.7 L/min (20.8 gpm) and a maximum of 94.6 L/min (25.0 gpm).

10.3.5.1 Maximum Variation in Discharge. A specified maximum variation in discharge is a means to quantify *uniform discharge*. Although this concept was originally applied to deluge sprinkler systems where all sprinklers flow, it can also be applied to closed-head systems. While this may seem like a questionable design requirement, particularly for closed-head systems, significant excess discharge can unnecessarily increase water supply and AFFF concentrate requirements. However, designers should use only reasonable conventional piping configurations in order to satisfy this somewhat subjective design parameter.

10.3.6 Design Area. Design area is related to the total discharge from sprinklers expected to operate in an anticipated fire scenario. Design area can be specified in terms of the number of complete sprinkler systems expected to be actuated by a fire, or it can be specified in terms of the floor area equating to the number of sprinklers over such an area. Design area for DoD hangar applications can involve as many as three complete sprinkler systems or floor areas of more than 2230 m^2 (24,000 ft^2). The required design area will be specified in the applicable DoD criteria.

10.3.7 Sprinkler System Configuration. To facilitate limiting the *maximum variation in discharge* noted above, configure piping systems to achieve a reasonably balanced discharge when all sprinklers on a system are flowing. Among other things, this requires an evaluation of the roof configuration and slope. For buildings with a sloped roof, for example, locating crossmains at or near the peak of the building, with branch lines running down the slope, will result in a more balanced system. Such an arrangement results in a pressure gain at lower level sprinklers due to flow from higher to lower elevations. This gain will offset at least a portion of the friction loss in the branch line, yielding similar discharge pressures between sprinklers.

10.3.7.1 Sprinkler Riser Nipples (Sprigs). Locate sprinkler branch lines close to the underside of the hangar roof deck so maximum allowable sprinkler deflector distances can be achieved without having to install sprinklers on individual riser nipples or *sprigs* as they are commonly referred to.

In order to achieve this, branch lines may have to be run through open-web steel joists. If necessary, branch line segments can be coupled between sprinklers in order to permit getting piping between closely-spaced joists. This is preferable to using sprigs, particularly where such would have to be several feet in length. If the use of sprigs is unavoidable, provide for individual bracing of sprigs longer than about 1 m (3 ft).

10.3.7.2 Auxiliary Drains. Connect branch lines running down roof slopes to a common manifold or ganged drain at the low points. This will permit simultaneous draining of several branch lines through one drain valve.

10.3.8 Relief Valves. Provide relief valves or auxiliary air reservoirs on gridded wet-pipe foam water sprinkler systems in accordance with NFPA 13. *Note: Wet-pipe systems with branch lines manifolded into gang drains are considered to be gridded.*

10.4 **Nozzle Systems**.

10.4.1 General. Nozzle systems are often provided for rapid application of foam to combat fuel spill fires that threaten irreparable damage to aircraft. For fixed-wing aircraft, the area where the wings connect to the fuselage are particularly vulnerable to damage from a fuel spill fire. Consequently, applicable design criteria will often require nozzle systems for certain fixed-wing aircraft but not helicopters. Nozzle systems can effectively minimize damage to the aircraft of fire origin and prevent fire spread to adjacent aircraft. Such fire control will indirectly protect the hangar facility from catastrophic damage. The decision of whether or not to provide nozzle systems will be based upon various factors as addressed in MIL-HDBK-1008C or supplemental design criteria of the pertinent DoD agency involved.

10.4.2 Nozzle Placement and Alignment. Experience has shown that nozzles are often susceptible to failure due to being blocked by moveable equipment used in a hangar. Consequently, nozzle placement is extremely critical. The designer must consider all factors that can adversely affect nozzle effectiveness. This includes hangar size and configuration, aircraft to be housed, proposed and possible aircraft parking positions, equipment proposed for use, and other factors known by the facility user. To maximize nozzle performance, provide multiple nozzle locations. The number of locations will vary with the size and configuration of the facility. Aim nozzles toward designated or assumed aircraft parking locations. Where possible, direct discharge toward hangar doors. Locate nozzle assemblies, including control valves, along walls as necessary to avoid obstruction from equipment that can or will be used in the hangar. If permitted by facility configuration and use, locate nozzle assemblies away from walls to afford protection against obstruction. In such cases, provide pipe trenches in concrete floors for routing of piping. Provide concrete-filled pipe bollards to protect nozzle assemblies from physical damage.

10.4.3 System Arrangement. Arrange nozzle assembly control valves to minimize the time-delay between system actuation and foam discharge from the nozzles. For most applications, proportioners will be located downstream of alarm check valves in nozzle system risers centrally located in fire protection equipment rooms. The foam-water solution will be supplied to individual automatic water control (deluge) valves in the hangar area. For alteration of existing systems where fire protection water is supplied to multiple riser manifolds within the hangar area, it may be feasible to omit alarm check valves and supply nozzles directly from automatic water control valves.

10.4.4 Discharge Requirement. Design nozzle systems to produce a minimum application rate of 4.1 L/min/m^2 (0.10 gpm/ft^2) over the under-aircraft area to be protected. This application rate is applicable to the area beneath the wings and fuselage of the aircraft. As a practical matter, nozzle systems cannot be designed to cover *just* the "shadow areas" of the aircraft. Nozzle discharges should impact the floor in front of or beside the protected aircraft. The objective is to achieve gentle application of foam onto burning fuel presumed to exist beneath the aircraft. Determine the area of coverage of each nozzle and provide a flow rate that achieves the required application rate. For example, if the discharge from one or more nozzles covers an area of 400 m^2 (4300 ft^2), the flow rate of a single oscillating nozzle, or the combined flow rate of multiple fixed nozzles, needs to be approximately 1640 L/min (430 gpm) in order to achieve the minimum application rate.

10.4.5 Nozzle Type. Nozzles can be either fixed or oscillating type. Use *fixed* type nozzle systems except in unusual situations where *only* oscillating type will provide the required performance. Fixed nozzle systems are more reliable than oscillating because they are not dependent upon water or electric-powered oscillating mechanisms to perform effectively. Also, fixed nozzles are less suspectable to incorrect alignment after installation. Historically, oscillating nozzles have experienced numerous problems with maladjustment. Often times, the angle of nozzle elevation has been found changed from original setting. In some cases, this has resulted in damage to aircraft where discharges were directed *onto* the protected aircraft, rather than *under* the aircraft.

10.4.5.1 Fixed Nozzle Systems. Available fixed nozzles used in hangar applications have a discharge characteristic generally less than that of oscillating nozzles. Consequently, multiple fixed nozzles, with varying discharge rates and patterns, are typically used in a tree or manifold arrangement. The combined flows of individual nozzles can approximate the flow of a single oscillating nozzle. For fixed nozzle systems, use nozzles 75 mm (3 in) or less in length. Generally, flow rates of individual fixed nozzles should be limited to 473 L/min (125 gpm) or less.

10.4.5.2 Oscillating Nozzles. Use oscillating nozzle systems ***only*** when fixed nozzle systems cannot provide effective performance. If fixed nozzles are not used, the reasons must be clearly addressed and substantiated in the design analysis. Where oscillating nozzles must be used, provide water-powered, non-aspirating *short barrel* type with individual nozzle flow rate of 1893 L/min (500 gpm) or less.

10.5 **Interior Hose Stations**.

10.5.1 General. Do not provide hose stations in aircraft servicing and storage areas unless specifically required by applicable Department of Defense (DoD) criteria. The NFPA 409 requirement is not valid for providing hose stations.

10.6 **System Valves and Components**.

10.6.1 Alarm Check Valves. Use alarm check valves in wet-pipe foam-water sprinkler systems and in systems supplying foam solution to nozzle system automatic water control (deluge) valves. Include retard chambers with the alarm line trim piping on alarm check valve installations. Arrange alarm line piping to individually actuate respective water-powered foam concentrate control valves.

10.6.1.1 Waterflow Switch with Time Delay. Unless otherwise required by applicable design criteria, provide waterflow switches with adjustable time delay for use in wet-pipe systems required to actuate nozzle systems upon detection of flow in the sprinkler system. Locate the switch in the alarm trim *upstream* of retard chamber and independent of other circuit closers (pressure switches). Assure that the switch is installed so that there is no shutoff valve in the piping to the switch. Specify switch to have adjustable time delay of 0 to 45 seconds (minimum).

10.6.2 Automatic Water Control (Deluge) Valves. Provide automatic water control valves in preaction sprinkler systems and for automatic control of nozzle system flow. Arrange alarm line piping to individually actuate respective water-powered foam concentrate control valve. To facilitate resetting valve after operation, specify such valves to have the feature of being resettable without having to use special tools or to remove the face-plate of the valve.

10.6.3 Shut-off Valves. Specify only UL-listed indicating-type control valves for controlling water or foam solution. Provide OS&Y type valves for controlling water or foam solution. Provide indicating type ball valves for controlling AFFF concentrate.

10.6.4 Basket Strainers. Provide basket strainers for installations with nozzle systems. Omit strainers on systems with overhead sprinklers only. Locate the strainer in the valve manifold or the nozzle system riser located in the fire protection equipment room.

10.6.5 Fire Department Connections. Do not provide fire department siamese connections on aircraft hangar foam-water sprinkler systems supplied by water systems with fire pumps.

10.7 **Detection and Control Systems.**

10.7.1 Foam System Control Panel (FSCP). A foam system control panel, with integral annunciator, will be provided for most applications. This panel will be separate from, but interconnected with, the building fire alarm panel. Arrange the FSCP to perform all functions related to control of the foam fire protection system. Specify the FSCP provided for actuating nozzle system or preaction system automatic water control valves to be approved by Factory Mutual for *releasing device service* with the particular make and model of automatic water control valve provided.

10.7.1.1 Arrange the system so the actuation of any alarm initiating device, i.e., UV-IR fire detector, rate compensating heat detector, nozzle system manual actuation station, alarm pressure or flow switch, etc., will actuate local alarms associated with the foam system, actuate the building fire alarm system, and simultaneously transmit an alarm to a central receiving station.

10.7.1.2 Nozzle System Activation. For systems involving nozzle systems, provide manual actuation stations near exit doors for nozzle system activation. Arrange sprinkler system waterflow detection devices to activate nozzles upon detection of waterflow in the overhead sprinkler system. Where specifically required by applicable design criteria, arrange nozzle system activation by other specific means as specified.

10.7.1.3 Alarm Notification Devices. Provide audible and visual alarm notification appliances within the aircraft hangar area to warn of a detected fire condition and the impending discharge of foam fire suppression systems. Assure that audible devices are capable of producing sound pressure levels adequate to overcome ambient noise levels. In some cases, the use of electronic horns with field-selectable tones will provide satisfactory service. In some applications, rotating beacons are suitable for providing required visual alarms. Alarm notification in portions of the facility other than the hangar area may be provided by appliances associated with the building fire alarm system.

10.7.2 Alarm Initiating Devices.

10.7.2.1 Heat Detectors. Provide rate-compensated type heat detectors for preaction sprinkler systems. Do *not* provide heat detection systems in areas protected by wet-pipe sprinkler systems. Detectors of the fixed-temperature, rate-of-rise or combination fixed temperature/ rate-of-rise type are *not permitted.* Space detectors to a maximum of 7.6 m x 7.6 m (25 ft x 25 ft) per detector. Arrange so activation of any single detector will trip the preaction sprinkler system and any associated underwing nozzle system within the protected area served by the actuated detector. Fire test results reported in the National Institute of Standards and Technology (NIST) document, *Analysis of High Bay Hangar Facilities for Fire Detector Sensitivity and Placement*, indicate that activation temperatures of heat detectors used in conjunction with preaction sprinkler systems should be closely matched to automatic sprinkler temperature ratings. Thus, designers should specify detector temperature ratings of 71ºC to 76ºC (160ºF to 170ºF) unless other ratings are mandated by applicable design criteria or ambient conditions.

10.7.2.2 Optical Detectors. Where required by applicable design criteria, provide optical detectors of the dual spectrum ultraviolet-infrared type. Specify detectors to be certified by a nationally recognized testing laboratory to be capable of detecting a fully developed 3 m x 3 m. (10 ft x 10 ft) JP-4, JP-8 or JET-A fuel fire at minimum distance of 45 m (148 ft) within 5 seconds. Provide a sufficient number of detectors at approximately 3 m (10 ft) above the hangar floor so the a fire developing in the under-aircraft area will be in the cone of vision of at least one detector. Connect detectors to the foam system control panel (FSCP) and arrange for alarm-only unless design direction from the customer requires arranging detectors for nozzle system actuation. Do *not* arrange optical detectors to actuate overhead sprinkler systems.

10.7.2.3 Nozzle System Manual Actuation Stations. Provide manual stations for activation of foam-water nozzle systems. Specify stations to have distinctive labeling and coloring to differentiate these stations from manual fire alarm stations. Provide a clear plastic tamper-resistant enclose to protect the station from accidental operation.