Member of the FM Global Group

Examination Standard for Foam Extinguishing Systems

Class Number 5130

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Foreword

This standard is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

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1 INTRODUCTION

1.1 Purpose

1.1.1 This standard describes requirements for fixed fire extinguishing systems that use an aqueous foam as the extinguishant.

1.1.2 Testing and certification criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance program.

1.2 Scope

1.2.1 This standard applies to low expansion (including CAF) and high expansion foam fire extinguishing systems for use in Class B applications and which are designed for manual or automatic control. Medium expansion foam systems and the Class A applications with high expansion foam systems are excluded from the scope of this standard. Compatible Certified detectors and detection and release controls are required for automatic operation of these systems but are not included in the scope of this standard.

1.2.2 A basic foam fire extinguishing system comprises at least the following three aspects; a concentrate, a device to proportion the concentrate in the proper ratio into water, and a discharge device to deliver the foam to a burning liquid surface. A discharge device may assume the entire task of expanding the foam, or function primarily to distribute foam which has been partially or completely expanded by an upstream device, such as a foam maker. Compatible certified detectors and detection and release controls are required for automatic operation of these systems, but are not included in the scope of this standard

With the exception of variable viscosity proportioners outlined in 1.2.3, this standard requires the examination of complete foam fire extinguishing systems. Incomplete systems (i.e. foam concentrates without associated system hardware or. system hardware components without a specified foam concentrate) shall not be evaluated.

1.2.3 Variable viscosity proportioners shall be certified for use with certified foam concentrates having viscosities that are within the variable viscosity proportioners certified range, and as part of a complete certified foam fire extinguishing system including its associated discharge devices. Use of these products with foam concentrates or as part of foam fire extinguishing systems, including discharge devices, that are not certified shall not be considered a certified foam Extinguishing System.

1.2.4 It is the responsibility of the manufacturer to ensure that the submitted system is complete and suitable for the proposed application(s) in the field. To be considered complete, a system shall consist of at least the component parts and auxiliary equipment arrangements detailed in Appendix K, these being the minimum considered necessary for the system to be viable and operate satisfactorily, as well as at least one specified concentrate.

1.2.5 Any purchased devices which form part of the complete system such as pumps, tanks, control valves, and sprinklers, must be submitted by the system manufacturer for evaluation as a part of their system along with design, installation, operation, and maintenance instructions. Following initial certification, the manufacturer may submit additional separate component parts or auxiliary equipment for use on their system for assessment.

1.2.6 This standard sets performance requirements for foam extinguishing systems in product categories that are identified by the following class numbers.

Table 1.2.6 Product Categories and Class Numbers

Class	***Product Category***
5130	Extinguishing Systems, Fixed Foam
5135	Low Expansion Foam Systems
5136	Compressed Air Foam (CAF) Systems
5137	High Expansion Foam Systems
5139	Variable Viscosity Proportioners

1.3 Basis for Requirements

1.3.1 The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists has also been considered.

1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of foam fire extinguishing systems (hereinafter referred to as "systems") for the purpose of obtaining certification. Systems having characteristics not anticipated by this standard may be certified if performance equal, or superior, to that required by this standard is demonstrated.

1.4 Basis for Certification

Certification is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1 Examination and tests on production samples shall be performed to evaluate

- the suitability of the product;
- the performance of the product as specified by the manufacturer and required for certification; and as far as practical,
- the durability and reliability of the product.

1.4.2 An examination of the manufacturing facilities and audit of quality control procedures may be made to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. Subsequent surveillance may be required by the certification agency in accordance with the certification scheme to ensure ongoing compliance

1.5 Basis for Continued Certification

The basis for continual certification may include, but is not limited to, the following based upon the certification scheme and requirements of the certification agency:

- production or availability of the product as currently certified;
- the continued use of acceptable quality assurance procedures;
- satisfactory field experience;
- compliance with the terms stipulated by the certification;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory surveillance audits conducted as part of the certification agencies product surveillance program.

1.6 Effective Date

The effective date of this certification standard mandates that all products tested for certification after the effective date shall satisfy the requirements of this standard.

The effective date of this Standard is eighteen (18) months after the publication date of the standard for compliance with all requirements.

1.7 System of Units

Units of measurement used in this Standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10.

Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection and are used in this Standard.

1.8 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the cited edition applies.

ANSI/IEEE/ASTM SI 10, *American National Standard for Metric Practice*
ASTM B 117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*
ASTM D 412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension*
ASTM D 1141, *Standard Practice for the Preparation of Substitute Ocean Water*
ASTM D 1331, *Standard Test Methods for Surface and Interfacial Tension of Solutions of Surface-Active Agents*
ASTM D 5798, *Standard Specification for Ethanol Fuel Blends for Automotive Flexible-Fuel Automotive Spark-Ignition Engines*
FM Approvals, Examination Standard Class 2000, *Automatic Control Mode Sprinklers for Fire Protection*
FM Approvals, Examination Standard Class 3010, *Fire Alarm Systems*
FM Approvals, Examination Standard Class 3810, *Electrical and Electronic Test, Measuring, and Process Control Equipment*
FM Approvals, Examination Standard Class 1313, *Positive Displacement Fire Pumps (Rotary Gear Type)*
FM Approvals, Assessment Standard Class 5138, *Assessment Standard for Proportioning Testing*
National Electrical Manufacturers' Association (NEMA) 250, *Enclosures for Electrical Equipment (1000 Volts Maximum)*
National Fire Protection Association (NFPA) 11, *Standard for Low-, Medium-, and High Expansion Foam*.
National Fire Protection Association (NFPA) 72, *National Fire Alarm and Signaling Code*

1.9 Terms and Definitions

For purposes of this standard, the following terms shall apply:

Accepted

This term refers to installations acceptable to the authority enforcing the applicable installation rules. Acceptance is based upon an overall evaluation of the installation. Factors other than the use of certified equipment impact upon the decision to accept, or not to accept. Acceptance is not a characteristic of a product. It is installation specific. A product accepted for one installation may not be acceptable elsewhere.

Air-Aspirating Discharge Device

A discharge device which mixes air into a foam solution to create a controlled expansion of the foam at the point of discharge.

Alcohol-Resistant Foam (AR)

A foam produced from a synthetic or protein foam concentrate that resists being dissolved in liquids normally miscible with water, and that can also be used to protect liquids immiscible in water.

Aqueous Film-Forming Foam (AFFF)

A foam produced from a synthetic concentrate and that forms an aqueous vapor barrier film on the surface of liquids immiscible in water, and is measured to have a spreading coefficient greater than zero when tested as described in Section 4.6.

Area of Coverage

The maximum area which can be protected by a foam discharge device, based upon the minimum effective application rate for the hazard, the maximum application rate which will not cause substantial differences in the foam quality from that producing successful extinguishment in tests, and the maximum distance from the application device to the burning surface which will also not significantly effect foam quality.

Aspirating High Expansion Foam Generator

A high expansion foam generator in which airflow is induced by the spraying of the concentrate solution.

Automatic Control

A device or arrangement of devices for initiating foam discharge including a panel which monitors fire detectors and releases the agent when pre-established conditions have been met, without requiring human intervention.

Automatic Foam Concentrate Control Valve

A valve controlling the flow of foam concentrate to the proportioner. The valve is automatically actuated by either hydraulic, pneumatic, or electrical power and incorporates means to supervise its position.

Automatic Sprinkler

A discharge device that is actually a certified fire protection sprinkler designed for use with plain water, and that does not aspirate air into the water discharge.

Balanced Pressure Bladder Tank

A foam concentrate supply tank fitted with an internal bladder to separate water from the concentrate. Water pressure on the outside of the bladder pressurizes the concentrate inside and drives it through a modified venturi type Proportioner into the water stream at the Specified rate, based upon the pressure differential created by the venturi.

Balanced Pressure Pump-Type Proportioning

Foam proportioning using a foam concentrate pump and an automatic pressure balancing valve that is operated by water supply pressure and is located in the concentrate bypass line to the pump to balance concentrate and water pressures to a modified venturi-type proportioner.

Blower Type High Expansion Foam Generator

A high expansion foam generator in which airflow is produced by a blower driven by an electric motor, water jet, or turbine, or other device powering the blower’s fan blades

CAF Nozzle

The discharge device for a CAF system that is designed to distribute the pre-expanded CAF over a specified area with minimal destruction of bubbles.

Calm Air

Wind conditions of 0 – 8.0 miles/hour (0 – 3.6 m/s)

Class A Fires

Fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.

Class B Fires

Fires in ignitable liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.

Class C Fires

Fires in which the ignition source is energized electrical equipment.

Compressed Air Foam (CAF)

Foam produced by combining a low expansion foam solution with compressed air or an inert gas in a mixing device and typically having a very small and uniform bubble size.

Compressed Air Foam System (CAFS)

A foam generation and delivery system that consists of a pressurized air or inert gas source, a source of foam solution (water pump and proportioner), and a means to apply the foam. In a CAF system, the distribution piping carries already expanded foam and the discharge device only distributes the foam without further expansion. CAF systems have unique hydraulic considerations which must be addressed by the manufacturer to ensure delivery of an effective foam to the discharge device. These systems may be pre-engineered or engineered designs.

Concentration

The volume percent of a foam concentrate in water. May also be referred to as 'concentration ratio', 'mixture strength' or 'ratio'.

Design Application Rate

The application rate that may be considered when designing a system. The design application rate is derived from the test application rate and either includes an additional safety factor or is a multiplier to be applied to the test application rate as applicable to the equipment concerned .

Discharge Device

A nozzle or other device that is used to distribute the extinguishing foam uniformly over or into a specific area, within a specific volume, or both.

Discharge Outlet

A discharge device that is permanently affixed to an ignitable liquid containment vessel or other structure to protect a defined hazard.

Discharge Duration

The time interval between the first appearance of foam at the discharge device and the time at which the foam concentrate primary supply is depleted.

Direct Injection Variable Pump Output Proportioning

Proportioning using flowmeters for both concentrate and water supply and a control system to vary foam concentrate pump flow in proportion to water supply flow.

E85

A blend of nominal 85 percent ethanol and 15 percent hydrocarbons and other additives, as defined by ASTM D 5798 and that may contain as much as 30 percent non-ethanol constituents, depending on the volatility class specified for a particular geographical region and season.

E85 Test Fuel

A blend of 70 percent ethanol and 30 percent normal heptane used as a conservative representative test fuel to qualify the fire extinguishment capabilities of foam.

Eductor

A device that uses the Bernoulli pressure reduction caused by the flow of water through a venturi to allow atmospheric pressure to drive foam concentrate into the water stream to produce a mixture of the specified concentration. May also be referred to as an 'inductor'.

Engineered System

A fire extinguishing system design in which friction loss of piping, nozzles, and other components, and an analysis of the piping configuration, are used in hydraulic calculations to predict flows and pressures at individual nozzles.

Expansion Ratio

The ratio of the volume of expanded foam to that of the same weight of the foam solution.

Film-Forming Fluoroprotein Foam (FFFP)

A foam produced from a fluoroprotein concentrate that includes a fluorinated surfactant to form a vapor barrier film on the surface of liquids immiscible in water.

Fire Control

Fire Control is the state achieved following the beginning of foam application when the average radiative heat flux levels, 1 ½ pool widths from the pool center measured in the crosswind direction, have reached 10 percent of the initial steady-state uncontrolled values. For the purposes of fire testing, this may be considered to be achieved when 90% of the fuel surface is covered with delivered foam solution.

Fire Control Time

Fire Control time is the elapsed time from the beginning of foam application when fire control is reached.

Fluoroprotein Foam

A foam similar to protein foam, but which also includes a fluorinated surfactant.

Floor nozzle system

A system that provides low-expansion foam discharge nozzles installed flush with the structural floor, supplied with foam-water solution through piping installed in trenches in the floor.

Foam

A stable aggregation of bubbles produced from an aqueous solution of foam concentrate that has a sufficiently low density and sufficient fluidity to allow it to float on top of and form a blanket on the surface of a liquid being protected.

Foam Chamber

A Type I or II discharge outlet normally installed along the perimeter of an ignitable liquid storage vessel or containment structure to ensure delivery of foam to the contents, when required.

Foam Concentrate

A concentrated aqueous liquid formulated to produce firefighting foam when mixed in the proper concentration with water and in which air can be entrained to reach the specified Expansion Ratio.

Foam Generator

A device used with high expansion foam concentrates to produce foam by spraying the concentrate solution onto a screen and forcing air through the screen.

Foam Maker

A device that generates foam and that is intended to be installed between the supply piping of foam solution and piping leading to discharge outlets.

Foam-Water Sprinkler

A discharge device that is an air-aspirating, usually-open fire protection sprinkler designed to create foam, as well as providing effective water discharge upon depletion of the foam concentrate supply.

Foam-Water Sprinkler System

A modified sprinkler system that is pipe connected to a source of foam concentrate and to a water supply. The system is equipped with appropriate discharge devices for foam-water solution discharge and for distribution over the area to be protected. Upon opening of the water control valve, water flows through the piping system and foam concentrate is proportioned and injected into the water, and the resulting solution discharges through devices that generate and distribute the foam. Upon exhaustion of the foam concentrate supply, water continues to discharge until shut off manually. These systems can be of wet pipe, dry pipe, deluge, or preaction designs, paralleling the design and using most of the components of the equivalent water-only sprinkler systems. They differ primarily in the addition of foam concentrate proportioning equipment or pre-priming of the sprinkler piping with foam-water solution. The introduction of the foam concentrate may be controlled by a detection system and can precede or follow the water-only discharge.

Foam Solution

A solution of foam concentrate in water that is named by the concentrate's name and the specified concentration.

High Expansion Foam

A foam that is produced in foam generators and has an expansion ratio greater than 200:1.

Ignitable Liquid

For the purposes of this standard, an ignitable liquid is simply a liquid that will burn. While some other organizations use different terms to identify liquids that burn, we believe that our approach is consistent with the hazard that is created by these liquids. Liquids that burn create challenging fire hazards and those hazards are not defined by the closed cup flash point of the liquid. The hazard is driven by the simple fact that the liquid burns (i.e., has a fire point).

In-Line Balanced Pressure Proportioning

Balanced foam proportioning using a concentrate pressure which is greater than the water supply working pressure under all operating conditions. Automatic pressure balancing valves operated by the water supply pressure to the proportioner are used to regulate the concentrate pressure individually to each proportioner. Concentrate pressure may be created by either a bladder tank or a concentrate pump.

Inline Eductor

An eductor that is installed upstream of the discharge device and which uses a foam concentrate supply at atmospheric pressure.

Local Application System

A fire extinguishing system designed to protect a defined area by the direct discharge of foam onto burning materials.

Lock-Out Valve

A lockable manually operated valve which can be used to isolate the foam supply from the rest of the system during maintenance and service.

Low Expansion Foam

A foam having an expansion ratio less than 20:1 and that may be produced by various devices.

Manual Control

A device or arrangement of devices for initiating system discharge that requires action by a human to release the agent.

Maximum Working Pressure

The pressure in a foam extinguishing system at the maximum available pressure of the water and foam concentrate supplies.

Minimum Working Pressure

The pressure in a foam extinguishing system below which it will not produce foam of acceptable quality.

Monitor

A fixed or portable device that is mounted on a supporting structure and delivers a large foam stream from a nozzle that may be aimed over a variety of vertical and horizontal angles. May also be referred to as 'foam cannon'.

Non-Air-Aspirating Discharge Device

A discharge device, such as a fire protection sprinkler, which delivers unexpanded foam concentrate solution to the hazard and relies on subsequent turbulence to entrain the air required for expansion.

Nozzle

A discharge device that may be either hand held or mounted on a monitor, is designed to expand the foam solution, and is capable of directing a stream of foam into a narrow targeted area.

Operable Pressure Range

The pressure range corresponding to the pressures in the water supply at the specified minimum and maximum flow rates at which the system is intended to be operable.

Oscillating Monitor

A monitor that can be set to move the direction of its stream automatically and continuously over a range of horizontal angles by means of a water pressure driven or electrically powered device.

Polar Solvent

An ignitable liquid such as an alcohol or ketone that is miscible in water and that tends to dissolve foams and thereby reduce their fire extinguishing effectiveness.

Pre-Engineered System

A fire extinguishing system design in which a predetermined range of piping and nozzle characteristics and configurations are used to predict individual nozzle flow rates.

Premixed Foam Solution

A foam solution produced by introducing a measured amount of foam concentrate into a known amount of water in a storage vessel.

Pressure Proportioning Tank

A bladderless foam concentrate supply tank that uses water flow through a port located high in the tank to displace the concentrate in the tank through a low mounted port with an orifice. Since buoyancy is the only mechanism separating the concentrate from the water, this method is only suitable for concentrates with a minimum specific gravity of 1.15. The concentrate orifice controls its flow rate into the water stream to approximate the specified concentration in the combined stream.

Proportioner

A device used to meter foam concentrate into a water stream at the prescribed nominal concentration within the specified tolerances.

Proportioning

The continuous introduction of foam concentrate at the specified ratio into the water stream to form foam solution.

Pump Proportioner

A system using a venturi eductor installed in a bypass line between the discharge and suction lines of a water supply pump and suitable orifices or a metering valve to control the amount of concentrate supplied in proportion to pump discharge (system water supply) pressure.

Protein Foam

A foam produced from concentrate consisting primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise ensure readiness for use.

Proportioning Testing Service Provider

A commercial entity that has been successfully evaluated for competency to test installed foam systems using the test liquid or water equivalency proportioning methods.

Ratio Controller

A modified venturi proportioning device designed to meter foam concentrate into the water stream over a defined flow range as part of a balanced pressure proportioning system. Typically, an orifice plate is installed at the concentrate inlet with the quantity of foam metered controlled according to the size of the orifice. Different size orifices may be used for different concentrates and concentrations.

Salt Water

Manufactured artificial sea water, as defined by ASTM D 1141, *Standard Practice for the Preparation of Substitute Ocean Water*. May also be referred to as 'synthetic seawater'.

Self-Educting Nozzle

A nozzle that includes a venturi to draw foam concentrate into the water stream through a short length of flexible tubing connected to a supply container, effectively incorporating a nozzle and an eductor in one device.

Semisubsurface Foam Injection

Discharge of foam at the liquid surface within an ignitable liquid storage tank from a floating hose that rises from a piped connector near the tank bottom upon system actuation.

Specified

The value of a design parameter set by the manufacturer.

Spray Nozzle

A discharge device that may be an open automatic sprinkler or specially designed nozzle attached to fixed piping and discharges water or foam in a fixed spray pattern.

Subsurface Foam Injection

Discharge of foam from an outlet near the bottom of an ignitable liquid storage tank. The foam then rises to the liquid surface due to buoyancy.

Synthetic Foam

A foam produced from concentrate consisting of foaming agents other than hydrolyzed protein.

Synthetic Fluorine Free Foam (SFFF)

A foam produced from a synthetic concentrate which excludes any fluorinated surfactants other than trace elements.

System Water Supply

In most cases, the water flow and pressure available to the foam system after the point of foam concentrate introduction. For systems using a premixed foam solution it is the flow and pressure available at the connection to the discharge piping, downstream of any pump or other pressure source.

Test Application Rate

The ratio of quantity of foam discharged to the discharge time measured within ± 1 second divided by the area covered by the discharge during fire testing. When a minimum test application rate is indicated, reference is made to the minimum quantity of foam solution discharged and the time measured within ± 1 second per unit area of surface covered. The test application rate is expressed in units of gal/min/ft^2 (L/min/m^2, which equals mm/min). The volume used to calculate application rate is that of the foam solution prior to expansion into foam for consistency among foams of different expansion ratios.

Test Liquid

A non-foaming liquid that replicates the viscosity, specific gravity, and other relevant properties of the actual foam concentrate used in a system and that is used to test the accuracy of proportioners and similar devices in an installed system.

Test Liquid Proportioning Testing

A method of evaluating the proportioning accuracy of an installed foam fire extinguishing system using a test liquid in lieu of the concentrate to minimize the difficulties in disposing of the required discharge in the annual retesting of a foam system.

Topside Discharge Device

A discharge device such as a foam chamber that applies foam to the surface of a burning liquid from above.

Total Flooding System

A high expansion foam extinguishing system designed to protect an enclosed hazard area by discharging foam to reach and maintain a minimum level 1.1 times the maximum height of or 2 ft (0.61 m) above all protected contents, whichever is greater, throughout the enclosed area sufficiently quickly and of sufficient duration to extinguish a fire. For a given foam, parameters of required depth of submergence, discharge rate, and duration must be determined by test because they are dependent upon the construction of the building, the nature of the contents, and the storage configuration.

Type I Discharge Outlet

A discharge outlet designed to deliver the extinguishing foam gently onto a liquid surface with no submergence or agitation.

Type II Discharge Outlet

A discharge outlet designed to deliver the extinguishing foam onto a liquid surface with minimal submergence or agitation.

Type III Discharge Outlet

A discharge outlet designed to deliver the extinguishing foam onto a liquid surface with significant submergence or agitation.

Vapor Seal

Frangible component designed to prevent tank contents vapors from entering the atmosphere through the foam chamber while allowing foam to flow into the tank during system operation.

Variable Viscosity Proportioner

A proportioner with the capability to accurately proportion foam concentrates at the specified ratio into the water stream to form foam solution at a range of concentrate viscosities and system flow rates without adjustment or modification (such as changing an orifice plate). These are commonly of the water motor driven or electronically controlled types.

Water Equivalency Proportioning Testing

A method of evaluating the proportioning accuracy of an installed foam fire extinguishing system using water in lieu of the concentrate to minimize the difficulties in disposing of the required discharge in the annual retesting of a foam system.

Wide Range Proportioner

A proportioner which automatically adjusts the concentrate orifice size based on the water flow rate (automatically variable geometry) to proportion foam concentrate into the water stream allowing proportioning across wider flow ranges than a traditional ratio controller.

Wood Crib

A square stack of alternate layers of kiln-dried spruce or fir in nominal 2x4 inch trade size and equal lengths placed at right angles to the preceding layer and spaced to allow air flow between the members. Each layer consists of the same number of evenly spaced members placed on edge, except for the top layer, which has fewer evenly spaced members placed on their sides. The outer members of all layers are placed flush with the ends of the members of the adjacent layers. All members are carefully nailed in place to avoid splitting the wood. Wood cribs are a standard test fuel for Class A fire tests. For the purposes of this standard, the high expansion foam Class A fire extinguishment test wood crib shall consist of members 87.125 in. (2213 mm) long arranged in 10 layers of 21 on edge, with a top layer of 14 on side.

Working Pressure

The water supply pressure to a foam extinguishing system at a condition of zero flow. May also be referred to as 'operating pressure'.

2 GENERAL INFORMATION

2.1 Product Information

Foam fire extinguishing systems are special protection systems designed to limit fire damage in an ignitable liquid use occupancy, or as an alternate to providing an emergency drainage system. The expanded foam is used to cool the fire and to coat the fuel, preventing its contact with oxygen.

To meet the intent of this standard, foam fire extinguishing systems shall be examined on a model-by-model, type-by-type and manufacturer-by-manufacturer, and plant-by-plant basis. This is predicated on the basis that identical designs, fabricated in identical materials by different manufacturers or, even by different plants of the same manufacturer, have been seen to perform differently in testing. Sample foam fire extinguishing systems, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Certification Application Requirements

The manufacturer shall provide the following preliminary information with any request for certification consideration:

- A complete list of all models, types, sizes, and options for the products or services being submitted for certification consideration;
- Any marketing literature showing the general specifications and functions of the system.
- An instruction manual–listing all design, installation, operation, and maintenance instructions.
- Quality control procedures detailing routine testing and final inspection procedures. These may include receiving inspection, in-process inspection, final inspection, and calibration of measuring and testing equipment procedures.
- Procedures detailing the system acceptance testing once the foam fire extinguishing system is installed.
- The following drawings should be provided:
    - Electrical schematic(s) for automatic systems
    - Final assembly drawings and parts lists sufficient to detail primary components (all), operator controls, and their locations;
    - Complete set of mechanical drawings for all machined parts;
    - Complete part specifications (including manufacturer's model numbers, size, ratings, etc.) for all purchased parts;
    - Specification sheets for all parts/components;
    - Drawings showing all construction details, sheet metal gauge and paint finish;
    - Product label drawing(s) showing all required marking information. The label drawing shall show the proposed label location on the equipment and artwork showing the manufacturer's name, address, model and serial numbers, equipment ratings, warning markings, and the certification agencies mark.
- The number and location of manufacturing facilities.
- All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

2.3.1 Following authorization of a certification examination, the manufacturer shall submit samples for examination and testing determined by the certification agency.

2.3.2 Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.

2.3.3 The manufacturer shall submit samples representative of production. Any decision to use data generated using prototypes is at the discretion of the certification agency.

2.3.4 It is the manufacturer's responsibility to provide any necessary test fixtures, such as those which may be required to evaluate the foam quality, fire performance and proportioning performance of the system.

3 GENERAL REQUIREMENTS

3.1 Review of Documentation

3.1.1 During the initial investigation and prior to physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use. The certification examination results may further define the limits of the final certification.

3.1.2 Within this standard, the system is the combination of foam concentrate and the mechanical components that contain, proportion, deliver, and discharge the resultant foam. Frequently there is more than one corporate entity involved with the manufacturing of the various components of the system however the responsibility for design control resides with the system manufacturer. Where foam concentrates and mechanical components are made elsewhere, and not covered by their own individual certification, the system manufacturer shall have an agreement with each manufacturer and a process to ensure that design changes are communicated to certification agency in advance of implementation. This information shall be made available during the examination so that the needs for auditing can be accounted for.

3.2 Physical or Structural Construction Features

3.2.1 Foam Concentrate

3.2.1.1 Foam concentrates shall be certified with a complete system; certification of a foam concentrate without an associated system shall not be permitted.

3.2.1.2 Certification of foam concentrates shall be limited for use as part of certified foam extinguishing systems that have been performance tested specifically with that concentrate and at the nominal concentration ratio(s) at which they are tested. The listing for a foam concentrate shall be shown individually if the manufacturer of the concentrate is different than the manufacturer of the system.

3.2.1.3 Foam concentrates shall not be considered for certification if they contain materials regulated by the U.S. Environmental Protection Agency (EPA) or equivalent local authorities, except within the permitted usages of those materials. The foam concentrate industry has committed itself to a voluntary stewardship program to eliminate the use of fluorosurfactants in orders of C8 or higher (greater than eight-carbon chain molecules). In support of this effort, the certification agency will not consider foam concentrates violating this constraint for certification.

3.2.1.4 Foam concentrate manufacturers seeking certification as part of a system certification shall supply a controlled formulation document to be retained by the certification agency as part of the examination. Foam concentrate manufacturers shall be enrolled in the certification agency foam concentrate sampling program where samples will be collected at the program's stipulated frequency.

3.2.1.5 Foam concentrates shall only be certified at the nominal concentration ratio(s) at which they have shown successful fire extinguishment.

3.2.1.6 Unless specified as suitable for fresh water only, extinguishment testing will be performed with salt and fresh water.

3.2.1.7 Foam concentrate manufacturers seeking certification as part of a system certification shall publish the nominal viscosity of the concentrate in accordance with the methods stated in Appendix J:

- (Brookfield) Viscometer, stating the spindle number used and the spindle RPM stated at the standard temperature of 68°F (20°C) and at the manufacturers stated minimum use temperature.

- (Brookfield) Rheometer, stating the dynamic viscosity as function of the shear rate; for pseudoplastic foam concentrates only stated at the standard temperatures of 35°F, 68°F, & 120°F (2°C, 20°C, & 49°C) as well as the minimum or maximum rated use temperatures if outside of this range.

Foam concentrate manufacturers shall also publish the acceptable range of viscosity when samples are sent for quality control testing. At the discretion of the certification agency, examinations may be specified in accordance with Section 4 for concentrates at the limits of this viscosity range.

3.2.1.8 Foam concentrate manufacturers seeking certification as part of a system approval shall publish documentation/graph/charts on the friction loss of the foam concentrate for various pipe diameters used in the system or absolute (dynamic) viscosity of the foam concentrate to calculate the friction loss.

3.2.2 Components

3.2.2.1 With the exception of Variable Viscosity Proportioners, components for foam systems shall only be certified as part of the system(s) with which they have been performance tested.

3.2.2.2 All component parts subject to full system operating pressure shall be designed for a minimum working pressure of 175 psi (1205 kPa). Components protected from exposure to full system operating pressure by a pressure relief device may be designed for the reduced pressure, subject to satisfactory evaluation of the protection device or system.

3.2.2.3 All components shall be made of corrosion resistant materials suitable for their intended use.

3.2.2.4 Elastomeric components used in the system shall be compatible with the concentrate. Compatibility shall be determined by successful performance at maximum and minimum installation temperatures while exposed to the agent. At minimum, tensile strength and ultimate elongation of samples of un-reinforced materials shall not be changed by more than 15 percent from new condition by a 60 day exposure to the agent at the maximum storage temperature.

3.2.2.5 Bladder tanks and other pressurized containers shall conform to the appropriate regulations for the installation location. In the U.S.A., DOT regulations are appropriate for cylinders which are shipped pressurized and ASME unfired pressure vessel code for cylinders filled after installation. The following documents shall be submitted for each diameter of cylinder design to demonstrate compliance with the relevant design standard.

- Calculation of wall thickness per the method specified in the standard, with appropriate supporting references, as necessary.
- Certificate of chemical analysis of materials.
- Certificate of physical properties of materials.

3.2.2.6 Automatic concentrate control valves, water supply valves, and water alarm check valves shall be equipped with electrical supervision of operating position to allow for remote monitoring and annunciation and a position indicator. All valves equipped with electrical supervision shall be provided with a minimum NEMA Type 1 or IP-10 housing or enclosure if electrically operated by a solenoid.

3.2.2.7 Automatic concentrate control valves must be equipped with an emergency manual operator, and a strainer in the actuation line and means to flush that line, if hydraulically operated. All automatic concentrate control valves shall be provided with a local manual reset.

3.2.2.8 Automatic valve actuators shall be provided with tamper resistant construction to restrict access to components and protection to vents or orifices to prevent tampering or clogging that would render the valve inoperable.

3.2.2.9 All valves and control devices with exterior movable parts that are vulnerable to obstruction or physical damage shall be protected by paneled enclosures or cages. This requirement shall not apply to levers, push buttons and other operators requiring manual access for their function to the extent necessary to provide such access. Conduit shall be used for cables, tubing, or wires outside the enclosures. Heat detection tubing, in the areas being monitored by the tubing, shall not be installed in conduits but shall be routed and supported to protect it from mechanical damage.

3.2.2.10 Manifolds of proprietary designs used in place of standard pipe and fittings shall have minimum internal cross-sectional areas no less than that of their corresponding pipe sizes. All manifolds and foam concentrate and foam solution pipe shall be designed and installed in accordance with the piping section of NFPA 11 and/or the certification agency or the authority having jurisdiction.

3.2.2.11 Discharge devices shall be manufactured from corrosion resistant materials that will not be deformed or otherwise damaged by the fire exposure. Fire exposure resistance shall not be required for hand-held devices or other components normally located outside of the fire area.

3.2.2.12 Pressure operated switches may be used to shut down fans, conveyors, or other electrical equipment in the protected area and activate alarm and indicator circuits. These switches shall operate at a maximum water supply pressure of 50 psi (345 kPa) and not release water from the system. They may have means for alternate, manual control and shall be designed for manual resetting only.

3.2.2.13 Alarms and/or indicators shall be provided to show that the system is operating, warn personnel of the forthcoming discharge of foam and signal the failure of any supervised equipment. Indicators which show that the system has been used and must be serviced shall operate upon actuation of the system and require manual resetting.

3.2.2.14 Manufacturers of proportioners as part of a system certification shall publish the following information (at minimum):

- Nominal pipe size corresponding to each proportioner model designation
- Concentrate(s) that have been specifically tested and certified for use with each proportioner
- In the case of foam concentrate variable viscosity proportioners, concentrate viscosity ranges that have been specifically tested and certified for use with the subject proportioner
- Minimum inlet pressure associated with certification and specific concentrate(s)
- Maximum inlet pressure associated with certification and specific concentrate(s)
- Inlet pressure vs. Foam solution flow representation throughout certified ranges
- Friction loss vs. Foam solution flow representation throughout certified ranges
- Description of test and installation criteria in accordance with the requirements of the certification agency or the authority having jurisdiction with a minimum as follows:
    - Provide a length of either (A) a minimum of five pipe diameters; or (B) the proportioner manufacturer's recommended amount of straight, unobstructed pipe on the inlet and discharge side of the proportioner.

3.2.2.15 For proportioners with moving parts specifically designed to operate over wide flow ranges, the proportioner manufacturer must state piping configuration limitations. For installations where there are one or more downstream pipes of smaller diameter than the proportioner nominal pipe diameter, the proportioner manufacturer must state the minimum straight pipe length between the proportioner and the reduction or tee. It shall also be stated in the product literature that using this style of proportioner in the described configuration could lead to a condition where the time necessary to achieve the nominal concentration ratio at low flow rates may be influenced by the large volume of water required to be evacuated in the proportioner nominal diameter piping on the inlet and discharge side of the proportioner.

3.2.2.16 Proportioners used in dry valve configurations shall include special procedures addressing flushing of foam concentrate after inspection and operations. In addition, examinations by the certification agency may be administered to proportioning system components used in dry systems.

3.2.2.17 Water motor driven variable viscosity proportioners may be configured to allow for remote concentrate injection or concentrate injection further downstream of the water motor. For these configurations it is important that the concentrate line from the outlet of the foam pump is designed properly for the system to function as intended. Accordingly, the remote injection line from the foam pump discharge to injection point should not produce a greater pressure loss than the pressure loss in the water line between the original injection point and the new remote injection point. A higher pressure loss in the remote injection line can be tolerated, as long as the sum of pressure loss of the remote injection line and the backpressure at the injection point is below the rated pressure of the variable viscosity proportioner foam pump. By ensuring these circumstances, the accuracy of the proportioning rate will not be affected.

3.2.2.18 Manufacturers of foam chambers and foam makers seeking component certification as part of a system certification that use an outlet leading to a tank penetration shall define acceptable methods for connecting to the deflector or pourer on the inside of the tank.

3.2.2.19 Manufacturers of foam chambers or foam makers leading to a dike shall define acceptable methods for mounting to the deflector or pourer on the side of the dike.

3.2.2.20 Foam makers may not be certified for use with "high back pressure" configurations unless explicitly tested and certified for the maximum rated back pressure.

3.2.3 Variable Viscosity Proportioners

3.2.3.1 The manufacturer shall state the minimum and maximum rated water flows, minimum and maximum rated backpressure, the nominal foam concentrations, and the minimum and maximum rated viscosities of concentrate which the product is intended to be able to proportion.

3.2.3.2 The product shall be capable of performing according to the requirements of this standard when tested according to the limits specified by the manufacturer per Section 3.2.3.1.

3.2.3.3 The manufacturer of the variable viscosity proportioner shall be able to supply all necessary fittings and accessories.

3.2.3.4 The variable viscosity proportioner housing shall be designed to permit examination and/or removal of rotors and interior parts without disturbing the suction or discharge piping of the (main) water connections. A drain opening(s) shall be provided so that all parts of the variable viscosity proportioner housing can be drained. The opening shall be threaded to receive a corrosion resistant pipe plug a minimum of ½ inch nominal size. Replaceable housing wearing liners may be provided.

3.2.3.5 All liquid passages of variable viscosity proportioners shall be designed to minimize the possibility of foreign materials becoming lodged in them (e.g. strainer). For potentially contaminated water sources a strainer may be necessary. Pump housing design strength calculations shall show the wall thicknesses to be adequate with maximum stresses that do not exceed those allowable for the material, and housing bolt strength calculations shall demonstrate design stresses no greater than those allowable for the material according to the appropriate FM Approvals certification standards for the pump type concerned.

3.2.3.6 Rotors shall be fixed to the variable viscosity proportioner shaft and so designed to prevent contact with the housing under normal operating conditions (e.g. keyed).

3.2.3.7 Variable viscosity proportioners shall be designed with shaft seals that adequately safeguard against excessive fluid leakage when suction pressure is above atmospheric and prevent air leakage when suction pressure is below atmospheric.

3.2.3.8 Variable viscosity proportioners fitted with bearings shall be designed to support radial and axial thrust loads encountered during maximum load conditions. Water slingers and dust caps or other suitable means of preventing fluid or other foreign matter from entering the bearings shall be provided. Bearings shall be sized to provide a minimum calculated L10 life rating not less than 5000 hours at maximum load, and be grease lubricated, with a grease fitting and relief hole if lubrication is necessary.

3.2.3.9 Variable viscosity proportioners shall be designed with a baseplate that can support the proportioner assembly, including the pump, water motor and all ancillary components without excessive vibration or visible distortion.

3.2.3.10 Variable viscosity proportioners that are fitted with closeable valves between the pump discharge and the fire service water shall be equipped with relief valves. Relief valves shall be examined per the requirements of FM Approval standard 1359, as applicable, and selected to provide relieving capacity and relief pressure for each pump model and rated capacity. Valve adjustments shall be preset at factory and tamper resistant.

3.2.3.11 Variable viscosity proportioners shall be designed for flow rates equal to or greater than 1 gal/min (3.75 L/min). Rated pump pressures shall be a minimum of 40 psi (275 kPa). Castings shall be free of defects which could make them unfit for the intended use. Flange dimensions, bolt layouts and threaded openings used in pipe connections shall conform to a recognized national or international standard.

3.2.3.12 If fabricated (welded) steel or cast fittings which are not certified are provided as part of the variable viscosity proportioner assembly (i.e. suction and discharge adapters), they shall be evaluated as part of the certification program. This shall normally include a review of detail drawings and hydrostatic tests per Section 4.11.

3.2.4 System

3.2.4.1 Systems shall only be certified for use with concentrates and at concentration ratio(s) with which they were fire tested.

3.2.4.2 Certification of a system is based upon its ability to proportion a concentrate accurately into water and produce and deliver a foam within the limits of expansion ratio and 25 percent drainage times of foams demonstrating successful fire extinguishing performance. The listing shall identify the foam concentrate and concentration ratio(s) used as well as main system components.

3.2.4.3 Fire testing shall be performed at the minimum specified test application rate on hydrocarbon fuels and polar solvent liquids specified by the manufacturer. Authorities having jurisdiction may mandate higher design application rates for specific hazards than the certified minimums.

3.2.4.4 System components shall operate within the temperature ranges of 35 F to 120 F (1.7 C to 49 C). If the system manufacturer specifies a lower minimum or higher maximum installation temperature, system and component evaluations will be based on the resulting greater range.

3.2.4.5 In all cases, certified foam extinguishing systems must be able to be configured to supply a minimum 20 minute duration of foam solution to the hazard area.

3.2.4.6 For normal operation, a system shall be either automatically controlled or operable from a manual control that is easily accessible to the hazard, or both. If the normal manual means of actuation utilizes electric power, the source of that power shall be completely independent of any electric power source used for automatic operation. Alternatively, a power source used for both normal and automatic operation shall be provided with an independent back-up, such as a battery. Whether normally operated automatically or manually all systems shall also be provided with an alternate means of fully mechanical manual emergency control. Fully mechanical manual emergency controls shall not require an electric power source but may make use of water supply pressure to operate the release. These emergency controls shall be located at or near the device being controlled.

3.2.4.7 Control panels shall comply with NFPA Standard 72, *National Fire Alarm Code,* and FM Approvals requirements for Classes 3010, *Fire Alarm Systems*, Classes 1321 and 1323, *Controllers for Electric and Diesel Engine Driven Fire Pumps* and 3810, *Electrical and Electronic Test, Measuring, and Process Control Equipment*. Control panels need not be submitted as part of the system. However, system design shall be such that the system is operable by at least one certified detection and release panel.

3.2.4.8 System manufacturers shall specify that the certification of their system is contingent upon piping designed and installed in accordance with NFPA 11 and/or the requirements of certification agency or the authority having jurisdiction.

3.2.4.9 The manufacturer of a system to be certified must have effective control over the configuration and manufacture of the components and the formulation of the concentrate to be included to ensure that all systems produced under the certification will offer essentially the same performance as that originally tested.

This can be accomplished in two ways:

1. The manufacturer can be the manufacturer of all components and the concentrate and demonstrate effective quality control, or the manufacturer can enter into written agreements with the component or concentrate manufacturers to control the designs and formulations per the Certification Agreement, and the certification agency shall be permitted to periodically audit this "outside" manufacturer (either on behalf of the manufacturer or as the result of component listing of the outsourced items), or

2. The manufacturer can demonstrate sufficient quality control of the critical characteristics of the outsourced components as to ensure system performance. Generally, this will include a minimum of some performance testing. System configuration and application shall be prescribed by appropriate design, installation, and operation information to be provided by the manufacturer. The certification agency will review such information to verify completeness and conformance to FM Global loss prevention recommendations and the limits of the certification to be granted.

3.2.5 High Expansion System Configuration Requirements

3.2.5.1 A pressure operated release shall be provided on all doors, windows, and other openings below the intended flooding level in the protected hazard area. The release shall operate at a maximum pressure of 50 psi (345 kPa) system water pressure. The release shall not permit the escape of water from the system. It shall automatically reset and may have a control for manual operation.

3.2.5.2 A delay device shall be installed on systems when safety dictates the evacuation of personnel from the hazard area. This device may either delay the operation of the system or delay the discharge of foam after the system has been actuated. In the first arrangement the actual discharge may be manually controlled. A manual override shall be provided in the second arrangement to allow for instant discharge.

3.2.5.3 High expansion foam systems shall use air from outside the protected space for foam generation. Air must be vented from the protected space at the same rate of flow to allow the foam generators to operate at their specified capacities. Air intake and venting devices for air movement into the foam generators and out of the protected volume shall be automatically operated at system actuation and protected from mechanical damage, corrosion, and freezing.

3.2.5.4 Electrical equipment below the design level of flooding shall be designed for submerged operation to eliminate the risks of short circuiting of controls and shocking to personnel.

3.2.6 High Expansion Foam Stability under Sprinkler Discharge

Foam breakdown testing per Section 4.11, *High Expansion Foam Breakdown Due to Sprinkler Discharge*. shall be conducted with the full range of foam concentrates, concentrations, and application rates submitted for certification to determine the breakdown coefficient.

3.3 Markings

3.3.1 Foam Fire Extinguishing System Markings

A conspicuously mounted nameplate shall be affixed to the proportioning device or the main concentrate supply container, or a combination of both, and shall display the following markings, at minimum:

- Manufacturer's name and address
- System type
- A list of the major components including proportioners
- Concentrate identification
- Concentrate viscosity
- Specified concentration ratio
- Application density
- Allowable ambient storage temperature range
- Year of manufacture
- Location of manufacture if different from manufacturer's address
- Reference to NFPA 11, *Standard for Low-, Medium-, and High Expansion Foam*, or other relevant local standard and the manufacturer's design, installation, operation, and maintenance instructions.
- Volume of main and back-up concentrate supplies
- The actual filled volume of concentrate
- Inspection requirements
- Any additional markings required by certification agency or the authority having jurisdiction

3.3.2 Component Markings

A component of a foam fire extinguishing system covered by this standard (including but not limited to tanks, proportioners, variable viscosity proportioners and discharge devices other than sprinklers) shall be permanently marked where it shall be easily visible with the following information, any additional markings required by certification agency or the authority having jurisdiction shall also be provided:

- Manufacturer's name and address
- Model or type designation
- Allowable ambient storage temperature range
- Year of manufacture
- Location of manufacture if different from manufacturer's address
- Reference to NFPA 11, *Standard for Low-, Medium-, and High Expansion Foam*, or other relevant local standard and the manufacturer's design, installation, operation, and maintenance instructions
- Minimum and maximum rated flow capacity
- Concentration(s) of proportioned fluid in water (e.g. 1%, 3% etc)
- The size of any orifice/restrictor fitted (where multiple options for the model exist)
- Range of viscosity of fluid to be proportioned
- Minimum and maximum rated system pressure
- Direction of flow
- Serial number
- Variable viscosity proportioners shall also be marked with any additional markings required by certification agency or the authority having jurisdiction

3.3.3 Products that are produced at more than one location shall be marked to allow identification of the specific location of manufacture.

3.3.4 The direction of flow shall be cast, permanently engraved, or stamped into the water motor driven variable viscosity proportioners housing, cover, or end plate. A corrosion resistant metal nameplate bearing the direction of flow shall be considered acceptable if permanently fastened to the pump.

3.3.5 Combination instruction and identification plates shall be mounted on or next to all control devices. All significant component parts or assemblies shall also bear an identification mark, such as a part, catalog, or pattern number.

3.3.6 Discharge devices shall be marked with a model or other identifying number to allow determination of capacity, throw, and other information required to verify appropriateness for the application.

3.3.7 Proportioning devices and foam generators shall be marked with a model or other identifying number to allow determination of capacity, and other information required to verify appropriateness for the application.

3.3.8 Valves, proportioners, and other devices requiring installation providing the correct direction of flow for proper operation shall be marked with the specified flow direction.

3.3.9 Proportioners shall be marked with the orifice size or other configuration details, as required by the design to set the specified proportioning ratio for the installation.

3.3.10 Where required by the authority having jurisdiction, provision shall be made to allow attachment of a tag or label stating the actual injection percentage of foam concentrate at the proportioner for the minimum and maximum rate of flow and the actual viscosity of the foam concentrate determined during an acceptance test or annual discharge test.

3.3.11 All marking plates shall be made of materials which will not corrode or otherwise become illegible from the action of system liquids or vapors, or normal, local conditions. All markings shall be legible and durable.

3.3.12 When hazard warnings are needed, the markings should be universally recognizable.

3.3.13 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the certification agency’s mark of conformity.

3.4 Design, Installation, Operation and Maintenance Manual

3.4.1 Design, installation, operation, and maintenance instruction manual(s) providing complete instructions to properly design, install, operate, and maintain the system including acceptance and reconfirmation testing of a foam system shall be submitted for review. An English version of this manual should be submitted to the certification agency.

3.4.2 The review by the certification agency shall verify compliance to the requirements outlined by the certification agency, National Fire Protection Association (NFPA) 11, *Standard for Low-, Medium-, and High Expansion Foam* and the relevant standard(s) recognized by the authority having jurisdiction for the manufacturer’s specified market(s).

3.4.3 The manual(s) should also reflect those requirements that are applicable to foam extinguishing systems, as outlined in the following sections.

- The manual(s) shall provide a description and operating details of all equipment associated with the fire protection system by part and/or model number.
- The mode of fire protection (control, suppression, or extinguishment) afforded by the system shall be indicated.
- The manual(s) shall specify the size, schedule, supporting method, and material for all piping, tubing, and fittings, as well as allowable shapes.
- The manual(s) shall specify all critical system valves and identify the proper positioning of the valves.
- The installation instructions shall be clear and concise and specify all limitations and restrictions. Diagrams of typical system installations shall be included for typical hazards.
- Any variations of the system shall be discussed in detail, including the limitations and restrictions of each system. The manual(s) shall clearly identify which configurations are certified by the certification agency.
- The manual(s) shall specify performance criteria for all discharge devices including, but not limited to, maximum ceiling heights, spacing and arrangement, flow rates, area of coverage, spray angle, and application density.
- The manual(s) shall include guidance on discharge device obstructions in accordance with NFPA

11, *Standard for Low-, Medium-, and High-Expansion Foam*.
- The manual(s) shall clearly identify all requirements for detection and actuation.
- The manual(s) shall state if the fire protection systems can be interconnected. If the systems can be interconnected, the manual(s) shall clearly indicate how the system interconnections are accomplished.
- The manual(s) shall state the ambient operating temperature range of the fire protection system. If the discharge devices and delivery system have different temperature ranges, these shall be specifically noted.
- The minimum and maximum operating pressures of the system and its sub-systems shall be clearly specified at ambient 70°F (21°C) conditions, and at the minimum and maximum operating temperatures.
- The manual(s) shall specify a test connection configuration for systems to protect any application that does not permit the discharge of the foam system.
- The manual(s) shall identify the Resistance to Snow Loading test weight applied to each model of vent tested in accordance with Section 4.25.4.1.
- The manual(s) shall specify the required acceptance and commissioning procedures, as described in Section 4.33, this includes a sample test form for Acceptance Testing.
- The manual(s) shall specify the required inspection and maintenance for the system. In addition, the manual(s) shall specify the frequency and method of the inspections and maintenance.
- The manual(s) shall contain detailed instructions for restoring the complete system to full operation after a complete or partial discharge. In addition, the manual(s) shall specify the estimated time to return the system to operation.
- The manual(s) shall identify either a date or revision to the manual, as well as a designation number, and shall be provided with a means by which the user can readily identify if the manual(s) are of the current revision. These items are to be identified on each page of the manual.
- The manual(s) shall identify the manufacturer or private labeler, address, contact and service information.
- If there are references to other manuals, these publications should be included or summarized so that information needed for proper design and installation is available.

3.5 System Acceptance, Commissioning and Reconfirmation Documentation

3.5.1 All foam extinguishing systems shall successfully meet all system acceptance, commissioning and reconfirmation procedures and should be documented with copies to the system owner and manufacturer (at a minimum).

3.5.2 All acceptance, commissioning and reconfirmation procedures shall be reviewed by the certification agency. Changes requested by the certification agency may be mandatory prior to the granting of certification.

3.5.3 Acceptance, commissioning and reconfirmation testing procedures should include the following, at a minimum, and shall be documented as part of the manufacturer's design, installation, operation, and maintenance manual(s):

3.5.3.1 Acceptance procedures shall be in accordance with the requirements outlined by the certification agency, the authority having jurisdiction, and NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, or the equivalent national code of the country of use.

3.5.3.2 An appropriate Authority Having Jurisdiction representative should be given advance notice of acceptance, commissioning and reconfirmation testing and be present for commissioning of the system.

3.5.4 A trained manufacturer's representative should be present to properly test and reset the system following any acceptance, commissioning and reconfirmation testing.

3.5.5 Proportioning for periodic reconfirmation testing may be assessed in accordance with the FM Approvals Assessment Standard 5138, *Proportioning Testing Assessment*, April 2011 where the discharge of the system for test purposes is not permitted by the authority having jurisdiction.

3.5.6 Where required by certification agency or the authority having jurisdiction, a full discharge test to verify system performance may be conducted. During the discharge test, a pressure gauge or transducer should be attached at the discharge device and readings to verify proper discharge pressure, consistent with the design calculations recorded or observed.

3.6 Calibration

3.6.1 Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage. A copy of the calibration certificate for each piece of test equipment is required. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified and traceable to an acceptable reference standard and certified by an ISO/IEC 17025 accredited calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service provider's accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory should be available.

3.6.2 When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of thus equipment.

4 PERFORMANCE REQUIREMENTS

4.1 Examination

4.1.1 Requirements

The foam fire extinguishing system shall conform to the manufacturer's drawings and specifications and to certification requirements.

4.1.2 Test/Verification

A foam fire extinguishing system, and all individual system components, representative of the manufacturer's final production equipment to be certified shall be examined and compared to drawings and engineering specifications. It shall be verified that the sample system conforms to the physical and structural requirements described in Section 3, General Requirements.

4.2 Low Expansion Foam Concentrate Extinguishing Performance

4.2.1 Requirement

Low expansion foam concentrates shall demonstrate extinguishing performance in Class B fire tests. Fires shall be extinguished by the end of the allowable discharge time and shall not reignite during the post extinguishment observation period.

4.2.2 Test/Verification

4.2.2.1 The fire test pan, see Figure C-2, shall be square and fabricated of steel with a minimum thickness of 1/4 in. (4.8 mm). The inside dimensions shall be 85 in. (2.16 m) square by a minimum of 12 in. (305 mm) deep. All surfaces shall meet at 90º angles and shall be joined by continuous, liquid tight welds. The upper edge of the pan shall be reinforced by an externally attached 1-1/2 in. (38 mm) steel angle of 1/4 in. (4.8 mm) minimum thickness. The angle shall be attached to the pan by continuously welding its outside corner to the top edge of the pan, so that the upper surface of one leg of the angle is flush with the top of the pan and the other leg of the angle is tight against the outside wall of the pan. The lower leg of the angle shall be attached to the pan by approximately 1/2 in. (12 mm) long tack welds spaced approximately every 2 in. (50 mm). The pan may be fitted with a drain connection and lifting lugs below the reinforcing angle, if desired. Other, equivalent construction shall be allowed, provided that minimum section thicknesses are met or exceeded.

4.2.2.2 The fire test shall be conducted with the pan resting on a flat surface or elevated no more than a 12 in. (305 mm) above that surface.

4.2.2.3 The class B fuels for which the concentrate is to be certified shall be agreed with the certification agency in advance of testing.

The extinguishing capability of the concentrate shall be tested with all class B fuels to be certified but shall, as a minimum, include testing with commercial grade heptane. Heptane shall be considered representative of other hydrocarbon liquids as follows:

- When testing P, FP, S, FFFP and AFFF concentrates, Heptane is considered representative of all hydrocarbon liquids.

- When testing SFFF concentrates, Heptane is considered representative of hydrocarbon liquids with the following characteristics:

    - Flash point equal to, or greater than, Heptane.
    - Vapor pressure equal to, or less than, Heptane.
    - Pure liquids (i.e. not blended such as gasoline/alcohol combinations).

At the discretion of the certification agency, SFFF concentrates for use in applications that do not include automatic sprinklers or air aspirating foam water sprinklers as discharge devices, and which are designated by the manufacturer as being unsuitable for use with heptane, may exclude testing with heptane. Any such concentrates shall be clearly identified as being restricted in application and for use only with the fuels tested.

After the pan has been leveled, the fuel shall be added to a minimum depth of 2 in. (50 mm). Then water shall be added to raise the heptane level to provide a minimum freeboard of 8 in. (203 mm). Additional freeboard shall be allowed as necessary if high application rates and/or highly expanded foam would cause foam to flow over the top of the pan, alternately, water shall be allowed to drain from the bottom of the pan during the test so long as 2" of water is maintained.

For water-miscible fuels, water cannot be used to adjust the fuel level in the pan. Therefore, a shallower pan may be used if the manufacturer does not wish to test with a freeboard greater than 8 in. (203 mm).

4.2.2.4 The test laboratory shall be an indoor facility of adequate size with natural or minimal ventilation so as to not interfere with fire testing. Additionally, the size of the test laboratory should not impact extinguishment of any test fires (i.e., depletion of oxygen due to an inadequately sized test laboratory). Based on the size of the test laboratory relative to the size of the fire test enclosure the certification agency may require oxygen concentration to be monitored outside the fire test enclosure to validate this requirement.

4.2.2.5 Tests shall be conducted with premix and fuel temperatures between 50 F and 90 F (10 C and 32 C).

4.2.2.6 Foam solution shall be prepared by mixing the specified amount of concentrate with water, either in a premixed solution or continuously by use of suitable proportioning equipment. Volume measuring, weighing, or flow measuring equipment shall be of sufficient accuracy to assure that concentration is within ± 5 percent of the nominal value. If conductivity measurements are to be used as a proxy for direct measurements of volume, weight, or flow to determine concentration, the procedure of Appendix F shall be used to validate the correlation of conductivity to concentration.

4.2.2.7 The discharge device and test application rate to be used in test shall be selected by the manufacturer and configured as specified in Appendix D. Appendix D describes the required test configurations and locations for various types of discharge devices in relation to the pan's location.

4.2.2.7.1 For automatic sprinkler and air aspirating foam water sprinkler fire tests; the design application rate corresponding to the test application rate used in accordance with Appendix D shall define the minimum design application rate to be certified for the concentrate and sprinkler combination.

4.2.2.7.2 For all foam concentrates; Type I, II or III tests as described in Appendix D must be completed at the specified minimum test application rates. Test application rates specified by the manufacturer may vary, above the minimum, where specified in Appendix D. Foam Qualities shall be attained during this test and may be utilized for qualifying discharge devices per the criteria of FM 5130 Section 4.4 Qualification of Other Low Expansion Discharge Devices.

4.2.2.8 For each new or modified foam concentrate submitted to the certification agency as part of a certified Foam Extinguishing System; testing in accordance with 4.2.2.7.2 is required to prove extinguishment at a verified Foam Quality. Successful completion of the foam water sprinkler fire test protocol by itself shall not qualify a foam concentrate for certification.

4.2.2.9 Extinguishment

The test fuel shall be ignited and allowed to burn for the preburn time indicated in Appendix E prior to the application of foam. Foam application shall continue for the duration indicated in Appendix E. The fuel surface shall be completely covered by the foam blanket and the fire completely extinguished by the end of foam discharge. For all discharge devices, Appendices D and E shall be followed.

4.2.2.9.1 Extinguishment – Air Aspirating Foam Water Sprinklers and Automatic Sprinklers

If the discharge device is an air aspirating foam water sprinkler or automatic sprinkler, or a device which may be installed under a building fire protection system, then water-only discharge shall continue for an additional five minutes to verify that the foam blanket cannot be easily degraded by subsequent water discharge. The water application rate shall be as stated in Table D-1 at minimum, higher water application rates may be selected by the manufacturer up to the application rate at the associated maximum sprinkler pressure at even steps of 0.1 gal/min/ft2 (4.1 mm/min). The fuel surface shall be completely covered by the foam blanket by the end of water discharge.

If the test fuel is water miscible, the water-only discharge will not be used for that fuel because the mixing of water with the fuel will prejudice the reignition and sealing evaluations. All concentrates and concentrations submitted for use on water miscible fuels shall also be tested on heptane fuel with subsequent water-only discharge.

4.2.2.9.2 Extinguishment –Topside Discharge Devices

For Type II application, the nozzle is to be positioned in front of and above the test pan, fixed in position by mechanical means and centered on the near side of the pan. The nozzle is to be positioned so that foam is directed across the pan and strike a flat steel backboard on the opposite side of the pan throughout the duration of the foam application. In no case is the nozzle to extend over any part of the test pan.

For Type III application, the nozzle is to be positioned in front of and above the test pan. The nozzle position must remain unchanged until fire control is attained; all foam application is to be from behind one side of the test pan and discharged directly onto the fuel surface. After fire control is attained, foam application may be from the front and one adjacent side and may be directed onto the inside of the test pan and the fuel surface. The nozzle may be moved beyond the adjacent side extensions. In no case is the nozzle to extend over any part of the test pan.

If a discharge device is capable of being installed under a fire protection sprinkler system, such as a low level discharge device for under wing protection in an aircraft hangar; then the instructions of Appendix E, Note 1 shall be followed.

If the discharge device is intended never to be installed under a fire protection sprinkler system, the additional water-only discharge is not required. Appendices D and E shall be followed.

4.2.2.10 Reignition Resistance

After the completion of discharge, the foam blanket shall remain undisturbed for an observation period, as indicated in Appendix E. During this time, the fuel shall not reignite when a lighted torch is passed within 1 in. (25 mm) of the surface of the foam blanket. Reignition attempts shall be made within 1 minute after the end of discharge and within one minute before the end of the observation period. Reignition attempts shall be 1 minute in duration, during which time the torch shall be passed within approximately 1 in. (25 mm) over the surface of the blanket (e.g. all four edges, including the corners, perpendicular lines from the center of each side crossing in the middle of the pan and any noted weak points in the foam blanket). The torch shall consist of an approximately 4 in. (100 mm) diameter by 4 in. (100 mm) long tightly wrapped roll of heptane-soaked cotton cloth at the end of a steel rod approximately 4 ft (1.2 m) long. Alternatively, a propane torch can be used for this purpose if provided with a non air-aspirating tip at the end of a minimum length 4 ft (1.2 m) wand and adjusted to produce a yellow flame a minimum of 4 in. (100 mm) long. The propane container shall be at the operator end of the wand and shall not be extended over the pan surface. Other torch configurations may be utilized if found to be comparable to the above configurations.

Exception: Candling, flaming or flashover that self-extinguishes is acceptable provided that the phenomenon does not remain in one area for more than 30 seconds.

4.2.2.11 Burnback Resistance

At the end of the observation period, the foam blanket shall be deliberately broken and the fuel shall be reignited in the rift. The rift shall be created by placing a vertical pipe in the pan, removing the foam blanket from within the pipe, reigniting the fuel within the pipe, and slowly removing the pipe. The pipe shall be fabricated from steel sheet of 0.015 in. to 0.048 in. (0.38 mm to 1.23 mm) thickness and a minimum of 12 in. (305 mm) inside diameter and approximately 14 in. (355 mm) long. The pipe shall be placed with its outer surface approximately 2.5 ft (0.76 m) from both walls of the pan in the corner where the foam blanket appears to be weakest. If a determination cannot be made where the foam blanket appears to be the weakest, the rift shall be created by placing the pipe in the corner where the fire was observed last. The foam blanket captured within the pipe shall be removed as thoroughly as possible without agitating the surface of the fuel outside of the pipe. The fire within the pipe shall be allowed to burn for one minute prior to removing the pipe. Subsequently, the burning rift shall either re-close or not enlarge beyond 10 ft^2 (0.9 m^2) over a 5 minute observation period. During this observation period; fire originating from the rift and passing over the surface of the foam blanket shall be allowed as long as the approximate flame height is 2 ft (.6 m) or less and does not remain in one place other than the original rift area for more than thirty seconds. The total area involved in flames in any one area must remain less than 10 ft^2 (0.9 m^2) at all times during the observation period.

4.2.2.12 Appendix E provides a tabular chronology of the schedule of events for this test.

4.2.3 For topside fire tests, a foam sample shall be captured under the same discharge conditions as used for the extinguishment test. Quality measurements shall be taken from this sample, as described in Section 4.3. These values shall be used to verify that discharge devices submitted for certification with this concentrate can produce foam sufficiently similar to that used in the successful fire tests.

4.3 Low Expansion Foam Quality Measurements

4.3.1 Requirements

The expansion ratio and 25 percent drainage time for foam produced from a concentrate at a specified concentration ratio that has been successfully fire tested shall be measured to establish benchmark values for use in evaluation of the effectiveness of any discharge devices proposed for use with that foam.

4.3.2 Test/Verification

4.3.2.1 A foam slider shall be used to collect foam samples for determining foam quality. A typical “slider” is illustrated in Figure C-1 and consists of a sheet of smooth metal, plastic, or wood held on a frame at an angle of 45 degrees to the floor. Foam reaching the “slider” surface shall be guided into a foam sample container placed at the bottom of the sheet. Excessive overflowing of foam solution shall be avoided to prevent foam agitation in the container.

4.3.2.2 Two collection containers shall be used. The containers shall be graduate cylinders of 1600 to 2000 ml capacity. Each container shall be weighed prior to the test to the nearest gram and these tare weights shall be recorded. The specific size of the containers used is not critical, as long as the volume is accurately measured and the gradations are a maximum of 0.1 times the liquid volume for 25 percent drainage.

4.3.2.3 The foam discharge shall be stabilized at the desired concentration and flow rate. The foam shall be running freely down the slider, presenting a uniform, steady-state appearance at the time of sample collection.

4.3.2.4 Each container shall be filled with foam from the sample collector. Timers shall be started at the completion of filling.

4.3.2.5 Observations of the liquid level at the bottom of each container shall be recorded at 15 second intervals. Data recording shall continue for a minimum of 30 seconds after the liquid quantity exceeds 1/10 of the graduate cylinder’s volume, or all foam has been liquefied, whichever first occurs. Data recording intervals may be increased to 30 seconds if the 25 percent drainage times exceed 5 minutes.

4.3.2.6 The foam container external surfaces shall be thoroughly wiped off and each container reweighed. Net weights shall be calculated for each container by subtracting its tare weight from the final weight.

4.3.2.7 Each container shall be thoroughly rinsed out with water and refilled with foam solution, at the same concentration as used to generate the foam samples. The refilled containers shall be reweighed and the net weights of the solution shall then be calculated by subtracting the tare weights. Alternatively, the weight of foam solution may be calculated from the specific gravity of the solution and the container volume, if the solution specific gravity has been determined to a level of accuracy acceptable to the certification agency.

4.3.2.8 Expansion ratio shall be calculated by dividing the total of the net weights of the solution from both containers by the total of the net weights of the foam samples from each.

4.3.2.9 25 percent drainage time shall be determined by fitting the best line to the time versus collection data for each container and calculating the time for drainage of 25 percent of the container volume. This process shall be automated using an electronic spreadsheet program such as Microsoft Excel. The data for the time of collection (in seconds) shall be plotted as a function of the volume of solution collected (in grams) using the spreadsheet software. The spreadsheet shall also be used to fit the best line to the data and obtain the equation of that line, as well as its R^2 correlation coefficient. If the correlation coefficient is 0.95, or higher, then the equation for that line shall be used to calculate the time to collect liquid solution equivalent to 0.25 of the graduate cylinder’s foam weight. This shall be termed the “25 percent drainage time” for the sample. If the correlation coefficient is less than 0.95, the test shall be repeated until data is obtained which will generate a curve fit of acceptable accuracy. The value for the two containers shall be averaged and recorded. This shall determine the 25 percent drainage time to be used for future comparisons.

4.3.2.10 Tests shall be conducted under conditions of calm air, no precipitation, water, concentrate and premix temperatures between 50 F and 90 F (10 C and 32 C).

4.3.2.11 Other methods of measuring foam expansion ratio and 25 percent drainage time may be employed if judged by the certification agency to be sufficiently accurate. Such alternate methods may be desirable for particularly fast or slow draining foams. Appendix H describes one alternative method.

4.4 Qualification of Other Low Expansion Foam Discharge Devices

4.4.1 Requirement

A discharge device shall either be used to create foam used in a successful fire test, as described in Section 4.2, or shall produce foam of approximately equivalent quality to that undergoing a successful fire test, when tested using a solution of the same concentrate at the same concentration ratio.

4.4.2 Test/Verification

4.4.2.1 Testing of discharge devices shall be conducted as described in Section 4.2 to demonstrate -their ability to produce foam capable of extinguishing the Class B pan fire.

4.4.2.2 Fire extinguishment testing may be waived if the discharge device is of the same type as one used in a successful fire extinguishment test and demonstrates the ability to produce foam of essentially equivalent quality, when tested as described in Section 4.3. Table 4.4.2.2 lists the acceptable quality limits.

Table 4.4.2.2 - Quality Equivalency Limits

Parameter	***Minimum below Fire Extinguishment Foam***	***Maximum above Fire Extinguishment Foam***	***Remarks***
Expansion Ratio	-10 percent, or -1 expansion ratio unit, whichever is greater	+ 20 percent, or + 2 expansion ratio units, whichever is greater	A ratio of 3:1 denotes three expansion ratio units, 5:1 denotes five, et cetera
25 percent Drain Time	-10 percent, or -1 minute, whichever is greater	+ 20 percent, or +2 minutes, whichever is greater	25 percent drain time also shall never be less than 30 seconds

4.4.3 In the event that two successful fire extinguishment tests in accordance with 4.2.2.9.2 are completed with the same foam concentrate at the nominal percentage, discharge device foam qualities falling between the minimum and maximum fire extinguishment foam qualities, with tolerances as applied above, are acceptable.

4.4.4 The operation of non-air aspirating fire sprinklers makes the collection of valid foam samples for quality testing difficult. Therefore, such devices shall always require fire extinguishment testing for certification.

4.5 Proportioning Tests

4.5.1 Proportioning

4.5.1.1 Requirement

Proportioning devices shall meter foam concentrate into water with acceptable accuracy throughout their specified ranges of installation orientation, flow, pressure, and concentration ratios. Proportioners utilizing a pump as part of their assembly must also demonstrate acceptable accuracy throughout their specified viscosity range.

Proportioning ratio measured in test shall match the specified ratio within a tolerance of -0 to +30 percent.

Tests shall be conducted at water and concentrate temperatures within a range of 60 F to 80 F (15 C to 27 C).

The option to obtain proportioning results through the use of flowmeters may also be considered acceptable, only if the manufacturer first qualifies the accuracy of the flowmeter method by comparison with results obtained using a weight/time measurement method. The procedure/requirements for this qualification is detailed in Appendix I.

This test is not applicable to variable viscosity proportioners which shall be tested according to the proportioning requirements stated in Section 4.26.1 or 4.27.1 as appropriate.

4.5.1.2 Test/Verification

The device shall be installed and adjusted per the manufacturer's specifications and operated at maximum, midrange, and minimum flow rates. At each flow rate, it shall be operated at maximum and minimum specified inlet pressures. Proportioners that are not dependent on inlet pressure, such as balanced pressure proportioners, are not subjected to be evaluated at the minimum and maximum pressure at each flow rate. At each flow condition, it shall be tested at the specified minimum and maximum proportioning rate with each specified foam concentrate. Proportioners with automatically variable geometry shall be evaluated in each orientation (e.g. horizontal and vertical) to be included in the certification listing. Permanent changes in the proportioning ratio are not allowed in excess of the requirements outlined in Section 4.5.1.1.

4.5.2 Durability

4.5.2.1 Requirement

The proportioning accuracy of proportioners having moving components shall not be affected by normal operation.

Measured proportioning ratios shall remain within the allowed tolerance outlined in Section 4.5.1.1.

4.5.2.2 Test/Verification

4.5.2.2.1 Proportioners having moving parts shall be subjected to a 500 cycle durability test similar to that described in Section 4.13.5, except that the cycling shall be from 0 to maximum flow rate or by mechanical movement of all moving parts simulating 0 to maximum specified flow, prior to being tested for proportioning accuracy, as described above. This test may be conducted with water substituted for the concentrate to minimize unnecessary production of solution. At the conclusion of the test, proportioning accuracy can be determined with concentrate or test liquid.

Proportioners specified for use in dry sprinkler systems and having moving parts shall be subjected to 10 additional cycles of operation from an initially dry condition before being tested for accuracy.

4.5.2.2.2 Proportioners utilizing springs shall be subjected to a 5000 spring cycle durability test. The spring shall be removed from the assembly and shall be cycled from its zero position to the maximum compressed position as it would be compressed at the maximum flow rate associated with the proportioner assembly, at a rate of no more than 10 cycles per minute. The spring shall then be installed into the proportioner and tested for proportioning accuracy, as described above.

4.5.3 Endurance

4.5.3.1 Requirement

Measured proportioning ratios for proportioners with moving parts in the path of extinguishing water and/or foam solution shall not exceed 10 percent variation from the pre-tested condition and must remain within the tolerance as outlined in Section 4.5.1.1 following a flow endurance test. Deformation or degradation of any components or features that would significantly alter the function of the device shall not be allowed

4.5.3.2 Test/Verification

Proportioners shall be subjected to a flow endurance test of one hour at the maximum flow rate and associated maximum inlet pressure. At the conclusion of this test the proportioner shall be examined for deformation or degradation and tested for proportioning accuracy, as described above. Measured proportioning ratios shall not exceed 10 percent variation from the pre-tested condition, and must remain within the tolerance as outlined in Section 4.5.1.1.

Further post-testing may be specified at the discretion of the certification agency; including but not limited to Section 4.17 Equivalent Length Determination, Section 4.12.1 Hydrostatic Integrity and the cycle test described in Section 4.5.2.2.1 above.

4.5.4 With the exception of water motor driven variable viscosity proportioners which shall be assessed according to the requirements of Section 4.26, proportioners utilizing a pump as part of their assembly shall be evaluated in accordance with the requirements of this section and additionally be subjected to the requirements of Section 4.20. The requirements of Section 4.5.1 shall be met throughout the manufacturer stated flow range when tested at the minimum and maximum viscosity range of foam concentrates with which it will be considered for certification.

4.6 Concentrate Tests

4.6.1 Cold Proportioning

4.6.1.1 Requirement

Chilled foam concentrate shall be proportioned at a rate no less than 0.85 of the test at the standard temperature.

4.6.1.2 Test/Verification

Tests shall be conducted using an eductor capable of proportioning at the nominal concentration at both ambient temperature within the range specified in Section 4.5.1.1 and with the concentrate supply chilled to 35 F (1.1 C), or the manufacturer's minimum specified temperature, whichever is less. The test shall be conducted using the same common test conditions including water pressure and flow rates and the results of both tests shall be compared and the difference in proportioning ratio determined.

At the discretion of the certification agency this test may be conducted using the manufacturers actual proportioning hardware.

The actual foam concentrate shall be used for this test, rather than a test liquid.

4.6.2 Film Forming Test

4.6.2.1 Requirement

A film forming foam liquid concentrate shall have a spreading coefficient greater than zero when tested as described in Section 4.6.2.2.

4.6.2.2 Test/Verification

4.6.2.2.1 The surface tension of the foam solution and the interfacial tension of the foam solution and cyclohexane shall be determined using a tensiometer as described in ASTM D 1331, *Standard Test Methods for Surface and Interfacial Tension of Solutions of Surface-Active Agents*.

4.6.2.2.2 The surface tension of the foam solution shall be determined on samples of the foam liquid concentrate mixed with both distilled water and synthetic sea water in the concentration recommended by the manufacturer. The determinations shall be conducted with the samples conditioned at 70 F ± 5 F (21 C ± 3 C).

4.6.2.2.3 The interfacial tension of the foam solution and cyclohexane shall be determined as described for surface tension except that after immersion of the tensiometer ring in the foam solution, a layer of reagent grade (not less than 99 percent) cyclohexane shall be carefully added on top of the foam solution. Contact between the tensiometer ring and the cyclohexane should be avoided. After waiting 5 minutes, the interfacial tension shall be determined.

4.6.2.2.4 The spreading coefficient of the foam liquid concentrate shall be calculated as follows:

$$SC = S_c - S_f - S_{cf}$$

Where:

SC = Spreading coefficient, dynes/cm
S_c = Surface tension of cyc1ohexane, dynes/cm
S_f = Surface tension of foam solution, dynes/cm
S_{cf} = Interfacial tension of the foam solution and cyclohexane, dynes/cm

4.6.3 Foam Concentrate Stability

4.6.3.1 Requirements

All foam concentrates shall remain homogeneous solutions when stored at the maximum and minimum specified temperatures.

4.6.3.2 Test/Verification

An approximately 0.16 gallon (600 ml) sample of concentrate shall be placed in a transparent closed container and stored at the manufacturer’s minimum specified temperature, but no higher than 35 F (1.1 C) and a second, similar sample at the manufacturer’s maximum specified temperature, but no less than 120 F (49 C). Both samples shall remain undisturbed for 90 days. At 30 days, 60 days, and 90 days the samples shall be examined for separation or stratification. No such separation or stratification shall be visible. Visible evidence of separation or stratification shall include the development of two or more distinct layers or the precipitation of any solids. Cloudiness or other changes in appearance without loss of homogeneity shall be acceptable.

4.6.4 Concentrate Viscosity

4.6.4.1 Requirements

The viscosity of all foam concentrates shall be determined and compared to the manufacturer’s specification.

4.6.4.2 Test/Verification

Viscosity measurements shall be determined using the “Viscosity Test Procedure” per Appendix J.

4.6.5 Concentrate Identification Benchmarking

4.6.5.1 Requirements

Concentrates shall be subjected to analysis using the High Pressure Liquid Chromatography/Diode Array Detection-Charged Aerosol Detection (HPLC/DAD-CAD) technique to obtain a benchmark profile for future reexamination reference.

4.6.5.2 Test/Verification

A 0.25 gal (1 L) minimum sample of each concentrate submitted for certification shall be provided for HPLC/DAD-CAD analysis.

The HPLC/DAD-CAD analysis shall be conducted in the FM Global Research Laboratory or at another competent laboratory with witnessing by a certification agency representative. The resulting spectrum shall be retained by the certification agency for use in identifying deviations from the as-certified composition, either through formulation changes, production process faults, or contamination of installed systems.

At the certification agencies discretion, concentrates identified as being ‘fluorine free’ may be assessed to confirm the validity of this status.

4.6.6 Foam Premix Stability

4.6.6.1 Requirements

Unless specifically excluded by the manufacturer from being stored as a premix, a solution of the manufacturer’s foam liquid concentrate and water, of each highest percentage concentration at which the system is to be assessed, shall remain homogeneous when stored at the maximum and minimum specified temperatures.

4.6.6.2 Test/Verification

An approximately 0.16 gallon (600 ml) sample of premix foam solution shall be placed in a transparent closed container and stored at the manufacturer’s minimum specified temperature, but no higher than 35 F (1.1 C) and a second, similar sample at the manufacturer’s maximum specified temperature, but no less than 120 F (49 C). Both samples shall remain undisturbed for 90 days. At 30 days, 60 days, and 90 days the samples shall be examined for separation or stratification. No such separation or stratification shall be visible. Visible evidence of separation or stratification shall include the development of two or more distinct layers or the precipitation of any solids. Cloudiness or other changes in appearance without loss of homogeneity shall be acceptable.

4.7 High Expansion Foam Fire Extinguishment

4.7.1 Requirement

Foam concentrates and generators shall demonstrate effective fire extinguishment, when tested per Section 4.7.2. A minimum of one successful Class A and one successful Class B fire test are required.

At present, FM Global does not have any allowable Class A applications for high expansion foam and will not list this product for that application, irrespective of fire test performance. However, to receive certification for Class B applications, successful Class A extinguishment is also required.

4.7.2 Test/Verification

4.7.2.1 Foam solution shall be prepared by mixing the specified amount of concentrate with water, either in a premixed solution or continuously by use of suitable proportioning equipment. Volume measuring, weighing, or flow measuring equipment shall be of sufficient accuracy to assure that concentration is within -0/+30 percent of the specified value. If conductivity measurements are to be used as a proxy for direct measurements of volume, weight, or flow to determine concentration, the procedure of Appendix F shall be used to validate the correlation of conductivity to concentration.

4.7.2.2 Tests shall be conducted under conditions of calm air, no precipitation, and at ambient temperatures between 50 F and 90 F (10 C and 32 C).

4.7.2.3 Class B Fire - A minimum of one generator of each type shall be tested with each concentrate and at each concentration submitted for Certification. At minimum, the concentrate shall be tested with commercial grade heptane for the test fuel. If extinguishing capability with other class B fuels is to be certified, tests using those fuels shall also be conducted. For water-miscible fuels, water cannot be used to adjust the fuel level in the pan. Therefore, sufficient fuel shall be used to achieve the required freeboard.

4.7.2.3.1 The size of the test enclosure shall be determined by the specified generation rate for the generator used. Test enclosures shall be a minimum of 20 ft (6.1 m) or 1/100 of the generator capacity, whichever is greater, wide and 10 ft (3.0 m) high. Enclosure length shall be a minimum of 10 ft (3.0 m) + 0.75 times the generator capacity divided by the enclosure width, see Figure C-3. The following equations describe the relationship among the enclosure dimensions in terms of generator capacity.

W = R/100, 20 ft (6.1 m), minimum.

L = (0.75 x R/W) + 10 ft (3.0 m)

Where,

W = the width of the enclosure,
L = the Length of the enclosure, and
R = the foam discharge rate in compatible unit (feet or meters) length and width cubed per minute.

These relationships are based upon the assumption that the advancing foam front will reach the full 10 ft (3.0 m) height of the test enclosure and the requirements that the fire test fuel array be located a minimum of 10 ft (3.0 m) away from the wall of the enclosure farthest from the generator and that the transit time for the foam front to reach the top leading edge of the fuel array shall be a minimum of 7.5 minutes. The 7.5 minute requirement is based upon 1.5 times the 5 minute maximum design submergence time for ignitable liquids specified in NFPA 11, *Standard for Low-, Medium-, and High Expansion Foam*. The certification agency may allow other test enclosure sizes as long as the minimum transit time requirement is met.

4.7.2.3.2 The foam generator shall be mounted at one end of the enclosure, at a height above intended depth of submersion to prevent discharge from being impeded by backpressure created by submergence. The fuel array shall be positioned 10 ft (3.0 m) away from the center of the opposite wall. There shall be sufficient free height above the anticipated maximum foam level to avoid interference with discharge from the generator. The foam shall not contact the ceiling of the enclosure during the test.

4.7.2.3.3 A test without a fire shall be conducted to verify the 7.5 minute minimum transit time and to determine the location of the unimpeded foam front 1 minute prior to its reaching the fuel array. This will determine the point at which the fuel can be ignited to ensure a minimum of a 1 minute preburn. If the height of the foam front is less than 10 ft (3.0 m), the movement of the foam front shall be evaluated to determine the suitability of the enclosure. If the required preburn time has been completed and the foam front has reached a stable configuration and rate of advance before reaching the test fuel, the enclosure may be accepted for the test, at the sole discretion of the certification agency. Otherwise, the length or width of the enclosure shall be increased to provide the minimum 7.5 minute transit time

4.7.2.3.4 The fuel array for the Class B test shall be the same as that described in Section 4.2.2. However, the fuel level or overall tank height shall be adjusted to provide a freeboard of approximately 6 in. (150 mm).

4.7.2.3.5 The generator shall be operated for a maximum of 15 minutes. The fire shall be extinguished within 12 minutes and so remain through the end of foam discharge.

4.7.2.4 Class A Fire – The test arrangement and criteria for success shall be the same as for the Class B fire, with the following exceptions:

A. The minimum transit time shall be 12 minutes, based upon 1.5 times the maximum design submergence time of 8 minutes for Class A combustibles specified in NFPA 11, *Standard for Low-, Medium-, and High Expansion Foam*. This requires the substitution of 1.2 for the factor of 0.75 in the above equation for length of enclosure. Transit time is the total time from the start of generation to the time when the top leading edge of the foam front reaches the fuel array.

B. The ignition time shall be adjusted to allow a minimum preburn time of 3 minutes.

C. The fuel array shall consist of a wood crib, with a moisture content between 9 and 13 percent. The crib shall be suspended a maximum of 2 ft (0.61 m) above the floor on noncombustible supports. A 76 in. square by 12 in. high (1930 mm square by 305 mm high) pan containing 10 gallons (38 L) of heptane floating on water shall be placed approximately 1 ft (0.3 m) below the bottom of the crib and used to ignite the array.

D. The foam generator shall be run for a maximum of 30 minutes. The fire shall be extinguished by the end of foam discharge and not reignite while submerged in the foam for an additional 15 minute observation period.

4.7.3 Foam quality measurements per Section 4.8 shall be made to establish benchmark values for evaluation of other sizes of foam generators of similar design.

4.8 High Expansion Foam Quality Measurement

4.8.1 Requirement

The expansion ratio for foam produced from a concentrate at a specified concentration ratio that has been successfully fire tested shall be measured to establish benchmark values for use in evaluation additional sizes of foam generators of similar design that are also proposed for use with that foam.

4.8.2 Test/Verification

4.8.2.1 The collection container shall be weighed prior to the test to the nearest 0.1 pound (0.045 kg) and the tare weight shall be recorded.

4.8.2.2 The foam discharge shall be stabilized at the desired concentration and flow rate. The foam shall be discharging freely, presenting a uniform, steady-state appearance at the time of sample collection. Foam samples shall be collected directly from the generator's discharge opening in a container placed approximately 2 ft (0.61) below and centered on the discharge outlet.

4.8.2.3 The collection container shall be a specially designed tank approximating the dimensions of a standard 55 gallon nominal capacity drum. The modification shall consist of a wheeled support stand to elevate the drum above the floor and a central drain connection centered on the bottom of the drum. The bottom of the tank shall be tapered toward the drain. The drain shall be approximately 1/2 in. (12.5 mm) in diameter and shall be connected to a full diameter ball quarter-turn shutoff valve. An alternate configuration collection container may be used, as long as it is configured to collect foam without the formation of voids. Sizing of the container shall be such that the duration of collection does not exceed one minute to avoid errors in expansion ratio calculation due to breakdown of the foam during collection.

4.8.2.4 The collection container shall be moved into the foam discharge stream. The drain valve shall remain open until collection is complete to remove any liquid that may form due to foam breakdown to improve accuracy of expansion ratio calculation. The container shall be withdrawn from the discharge stream, the drain valve closed after any liquid discharge ceases, and the foam doctored off flush with its top. The outside of the container shall be rinsed with water to remove any clinging foam and dried off before any weights are taken.

4.8.2.5 The foam collection container external surfaces shall be thoroughly wiped off and the container reweighed. Net weights shall be calculated for the container by subtracting its tare weight from the final weight.

4.8.2.6 The container shall be filled with water and reweighed. The net weight of the solution shall then be calculated by subtracting the tare weight and multiplying that weight by the specific gravity of the foam solution.

4.8.2.7 Expansion ratio shall be calculated by dividing the calculated net weight of the solution from the container by the net weight of the foam sample.

4.8.2.8 Expansion ratio may alternately be determined by discharging into a known area and measuring the average height of the foam and calculating the volume of expanded foam. The ratio of the total volume of expanded foam to the total solution flow over the duration of discharge is an acceptable expression of the expansion ratio.

4.9 Qualification of High Expansion Foam Generators

4.9.1 Requirement

A foam generator shall either be used to create foam used in a successful fire test, as described in Section 4.7, or shall produce foam of approximately equivalent expansion ratio to that undergoing a successful fire test, when tested using a solution of the same concentrate at the same concentration ratio.

4.9.2 Test/Verification

4.9.2.1 Testing of foam generators shall be conducted as described in Section 4.7 to demonstrate their ability to produce foam capable of extinguishing the required Class B pan fire.

4.9.2.2 Fire extinguishment testing may be waived if the foam generator is of the same type as one used in a successful fire extinguishment test and demonstrates the ability to produce foam of essentially equivalent quality, when tested as described in Section 4.8. Table 4.9.2.2 lists the acceptable quality limits. To qualify as being of the same type, a generator shall be of essentially the same configuration and differ only in size or materials from the generator which produced the foam that demonstrated successful extinguishment performance. If foam of more than one quality has been successfully fire tested, a generator need only produce foam which replicates the expansion ratio for it to be qualified.

This is intended to allow a manufacturer to produce generators for different quality foams to address specific hazard scenarios which have been shown to respond better to a drier or wetter foam.

Table 4.9.2.2 - Quality Equivalency Limits

Parameter	***Minimum below Fire Extinguishment Foam***	***Maximum above Fire Extinguishment Foam***	***Remarks***
Expansion Ratio	-10 percent, or -50 expansion ratio units, whichever is greater	+ 20 percent, or + 200 expansion ratio units, whichever is greater	A ratio of 300:1 denotes three hundred expansion ratio units, 500:1 denotes five hundred, et cetera

4.10 High Expansion Foam Generator Capacity

4.10.1 Requirement

Foam generators shall produce their specified capacities with each concentrate and at each concentration ratio for which they are certified.

4.10.2 Test/Verification

4.10.2.1 Tests shall be conducted with all combinations of concentrate, concentration ratio, and with fresh or salt water within the manufacturer's specification.

4.10.2.1.1 Expansion ratio testing for comparison of fresh water to salt water may be conducted on small scale test equipment.

4.10.2.2 The collection container shall be a minimum of 10 x 10 ft (3.05 x 3.05m) in area and of a height sufficient to contain a minimum of 30 seconds of foam discharge at the specified rate.

4.10.2.3 The generator shall be operated at a steady state. The discharge shall be directed into the collection container and timing shall begin. When the foam overflows the top of the container, the timer shall be stopped and the time recorded.

4.10.2.4 Measured discharge rate shall be calculated by dividing the collected volume by the time for collection.

4.10.2.5 Measured discharge rate shall be equivalent to the specified rate, within a tolerance of ± 15 percent.

4.11 High Expansion Foam Breakdown Due to Sprinkler Discharge

4.11.1 Requirement

High expansion foams shall not be degraded by sprinkler discharge beyond the manufacturer's specified breakdown rate.

4.11.2 Test/Verification

The high expansion foam generator capacity test of Section 4.10 shall be repeated while under sprinkler discharge.

A 10 x 10 ft (3.05 x 3.05 m) hydraulically balanced sprinkler grid shall be centered at a minimum height of 6 ft (1.83 m) over the collection container. Four certified K5.6 pendent design open fire sprinklers shall be installed.

A maximum water application rate for foam breakdown, as specified by the manufacturer shall be tested for certification. This maximum application rate may be selected by the manufacturer from 0.3 gal/min/ft^2 to 1.0 gal/min/ft^2 (12.2 mm/min to 40.8 mm/min) at even steps of 0.1 gal/min/ft^2 (4.1 mm/min).

Foam discharge shall commence after sprinkler discharge is established.

Time to fill the container during sprinkler discharge shall be measured at both the maximum and minimum generation rates for the generator used.

The foam breakdown rate in volume of foam lost per minute per rate of sprinkler discharge per minute per unit area shall be determined as follows:

$$S = (Q - G_s)/D$$

Where,

S is the breakdown rate in ft^5/gal (m^3/mm),
Q is the total sprinkler water flow in gal/min (L/min),
G_s is the generation rate of foam under sprinkler discharge, calculated the same way as G and is expressed in the same units, and
D is the sprinkler discharge rate per unit area and is expressed in gal/min/ft^2 (mm/min).

S shall be calculated for each foam generation rate. The highest value so calculated shall not exceed the manufacturer's specified rate.

Where generation rates are high enough to require an enclosure of larger area, the sprinkler grid shall be expanded in multiples of the 10 x 10 ft (3.05 x 3.05 m) spacing and the total water flow rate and calculations adjusted to provide the same specified discharge rates.

4.12 Hydrostatic Pressure Testing

4.12.1 Hydrostatic Integrity

4.12.1.1 Requirement

All components of the foam system shall be capable of withstanding the maximum specified system pressure. No cracking or excessive distortion shall result. Any distortion which would impair function shall be regarded as "excessive distortion".

Check valves shall be subjected to hydrostatic test both with the disc open to pressurize the entire body and in a separate test with the pressure applied through the outlet connection against the disc while the inlet connection is open to atmosphere.

At the discretion of the certification agency, devices which do not incorporate a means for trapping system pressure me be exempted from hydrostatic test.

4.12.1.2 Test/Verification

The device shall be closed by means of its normal connections to the system. Means shall be provided for the introduction of water and the venting of any trapped air. After filling and venting, the device shall be pressurized to 80 percent of the required pressure and the pressure raised the remaining 20 percent at a rate not to exceed 100 psi (6.9 bar) per minute.

Required test pressure shall be four times the specified rated operating pressure, or 700 psi (48.3 bar), whichever is greater.

The required test pressure shall be held for one minute.

4.12.2 Leakage

4.12.2.1 Requirement

Valves shall not leak more than 1 fluid ounce (0.008 ml) per second when held at twice the specified rated operating pressure. No cracking, fracture, or failure to retain the test pressure shall be allowed.

All valves shall be tested in new condition, as supplied by the manufacturer.

4.12.2.2 Test/Verification

The device shall be closed by means of its normal connections to the system, the inlet of the valve shall be pressurized and the outlet shall remain open. After filling and venting, the device shall be pressurized to 80 percent of the required pressure and the pressure raised the remaining 20 percent at a rate not to exceed 100 psi (6.9 bar) per minute.

Required test pressure shall be two times the specified rated operating pressure, or 350 psi (24.1 bar), whichever is greater.

The required test pressure shall be held for five minutes.

4.12.3 Durability

4.12.3.1 Requirement

Excessive wear shall not occur as a result of operation of a valve 500 times at pressure.

4.12.3.2 Test/Verification

A representative size of valve shall be tested. If differing designs are used, a minimum of one valve of each design shall be tested.

The valve shall be cycled from full open to closed 500 times with the outlet open to atmosphere and the inlet pressurized with water from a supply with a static pressure equal to the valve's rated pressure, 175 psi (12.1 bar), minimum.

Cycling rate shall be approximately 4 cycles per minute.

Subsequent to this cycling, the valve shall be meet the requirements of Section 4.12.2 with the test pressure reduced to the specified rated operating pressure or 175 psi (12.1 bar), whichever is greater.

4.12.4 If the authority having jurisdiction requires that the cylinder manufacture be under recognized third party surveillance, hydrostatic testing shall not require witnessing by the certification agency. Instead, certifications of tests witnessed by the recognized third party shall be reviewed by the certification agency for compliance with this requirement. Acceptable third parties shall include those granted reciprocity for boiler and pressure vessel inspection to the ASME (American Society of Mechanical Engineers) code.

4.13 Automatic Concentrate Control Valve Operation

4.13.1 Pressure Operated Valves

4.13.1.1 Requirement

Concentrate control valves shall operate under the most adverse normal pressure (maximum system pressure and minimum actuator pressure) when conditioned to the maximum and minimum specified installation temperatures. The range of installation temperatures specified shall include at minimum, 35

F to 120 F (1.7 C to 48.9 C).

4.13.1.2 Test/Verification

A minimum of one sample of each device shall be conditioned to the minimum specified installation temperature for 16 hours. While still at that temperature, the device shall be operated and shall display no detectable hesitation, partial operation, or other failure. Devices motivated by pressure shall be tested at maximum or minimum normal system pressures, whichever is more adverse for the design of the specific component. If which condition is the most adverse is not readily discernable, the device shall be operated at both extremes of pressure.

A minimum of one sample of each device shall be conditioned at the maximum specified installation temperature for 16 hours and the same evaluations shall be conducted.

4.13.2 Electrically Operated Valves

4.13.2.1 Requirement

Electrically operated valves shall also operate properly at 85 and 110 percent of rated voltage while at maximum and minimum specified installation temperatures.

4.13.2.2 Test/Verification

A minimum of one sample of each valve shall be tested. The tests of Section 4.13.1.2 shall be conducted on a device powered at 85 percent of rated voltage and again at 110 percent of rated voltage. No deterioration in operation shall be allowed.

4.13.3 Hydrostatic Integrity

4.13.3.1 Requirement

Valves shall be capable of withstanding the maximum specified system pressure. No cracking or excessive distortion shall result. Any distortion which would impair function shall be regarded as “excessive distortion”.

4.13.3.2 Test/Verification

The device shall be closed by means of its normal connections to the system. Means shall be provided for the introduction of water and the venting of any trapped air. After filling and venting, the device shall be pressurized to 80 percent of the required pressure and the pressure raised the remaining 20 percent at a rate not to exceed 100 psi (6.9 bar) per minute.

Required test pressure shall be four times the specified rated operating pressure, or 700 psi (48.3 bar), whichever is greater.

The required test pressure shall be held for one minute.

4.13.4 Leakage

4.13.4.1 Requirement

Valves shall not leak throughout the full range of specified inlet water pressures.

4.13.4.2 Test/Verification

The outlet of the valve shall be open to atmosphere and the inlet suitably closed. The inlet closure shall be provided with pressurization and venting connections.

After venting any trapped air, the valve shall be pressurized to 30 psi, 100 psi, and 175 psi (2.0 bar, 6.90 bar, and 12.0 bar) in successive trials. Additionally, a fourth trial shall be run at the rated pressure if that pressure is greater than 175 psi (12.0 bar).

Each trial shall be 5 minutes in duration.

No visible leakage shall be allowed on the outlet side in any trial.

4.13.5 Actuator Gland Leakage

4.13.5.1 Requirement

Valves having glands or seals to prevent internal pressure from leaking past moving or rotating connections to external operators shall demonstrate the effectiveness of those components.

4.13.5.2 Test/Verification

The tests of Section 4.13.4.2 shall be repeated with the valve outlet plugged. During the five-minute observation period, the valve shall be operated once per minute. The actuator sealing locations shall be observed. No visible leakage shall be allowed.

4.13.6 Durability

4.13.6.1 Requirement

Excessive wear shall not occur as a result of operation of a valve 500 times at pressure.

4.13.6.2 Test/Verification

A representative size of valve shall be tested. If differing designs are used, a minimum of one valve of each design shall be tested.

The valve shall be cycled from full open to closed 500 times with the outlet open to atmosphere and the inlet pressurized with water from a supply with a static pressure equal to the valve's rated pressure, 175 psi (12.1 bar), minimum.

Cycling rate shall be approximately 4 cycles per minute.

Subsequent to this cycling, the valve shall be subjected to the evaluations of Sections 4.13.4.2 and 4.13.5.2 with no failures.

4.13.7 Pressure Actuator Integrity

4.13.7.1 Requirement

Actuators of valves operated by pressure shall withstand hydrostatic pressure equal to twice the valve's rated pressure with no failure.

4.13.7.2 Test/Verification

With the valve inlet and outlet connections open to atmosphere, the connection to the actuator shall be pressurized with water to twice the valve's rated pressure, 350 psi (24.1 bar) minimum, for five minutes. If an actuator is rated at a lower pressure and equipped with a pressure relief, it shall be tested at twice its rated pressure or a minimum of 1.1 times the setting of the pressure relief, whichever is greater. Pressure relief devices shall be appropriately tested to verify reliability.

No failure or visible leakage shall be allowed.

Subsequently, the valve shall demonstrate unimpeded operation.

4.14 Dielectric Withstand

4.14.1 Requirement

Electrical components shall withstand application of twice their rated voltage plus 1000 V between all terminals provided for external connections and ground. Devices rated at 60 V, or less, shall be tested at 500V.

4.14.2 Test/Verification

Voltage shall be applied, in turn, between each terminal and ground. For devices rated at 60 V, or less, the test voltage shall be 500 V. Components subjected to the Dielectric Withstand test shall continue to function normally subsequent to this test.

4.15 Salt Fog Corrosion

4.15.1 Requirement

System components shall withstand a 240 hour exposure to a 20 percent salt in water (laboratory grade sodium chloride in demineralized water) fog without incurring damage which would impair function.

4.15.2 Test/Verification

Test samples shall be selected to represent all material combinations and configurations. The test shall be conducted in conformance to ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*.

4.15.3 Tested samples shall remain fully functional and exhibit no corrosion, galvanic action, loss of legibility of markings, or separation of protective coatings which would impair future functionality. Superficial discoloration with no substantial attack of the underlying material shall be acceptable.

4.16 Individual Component Functionality

4.16.1 General

4.16.1.1 Requirement

Existing certified devices need not be tested for inclusion within a foam extinguishing system if they are used in conformance to the certification agencies listed ratings and applications. Otherwise, components shall be evaluated by the certification agency to determine suitability for the intended use. Such evaluations shall address all relevant the certification agency requirements for the type of device.

4.16.1.2 Test/Verification

Pressure operated devices shall be tested to verify that they operate at the minimum required pressures.

Devices for which there are no established certification requirements shall be evaluated to confirm function as required for system operation and integrity at the extremes of the anticipated service conditions. Such ad hoc evaluations shall be structured based upon the engineering judgment of the certification agency. Wherever possible, established standard evaluation methods shall be used. While manufacturer advice and counsel is welcomed, the evaluation protocols selected shall be at the discretion of the certification agency.

4.16.2 Stress Corrosion

4.16.2.1 Requirement

Devices manufactured of copper alloys containing greater than 15 percent zinc shall exhibit resistance to stress corrosion susceptibility, when tested as described in Section 4.16.2.2 for 10 days.

4.16.2.2 Test/Verification

The openings of each sample shall be filled with deionized water and sealed with a non-reactive material (e.g., plastic cap) so as to prevent the introduction of the ammonia atmosphere into the interior of the component. The samples to be tested shall be free from any non-permanent protective coating and, if necessary, shall be degreased. If a permanent coating is an inherent part of the design, such coating shall be subjected to tests as deemed necessary by the certification agency to evaluate its protective integrity. The samples shall be tested in their intended orientation.

There shall be provisions in the test chamber to prevent droplets of condensation from falling from the top of the enclosure directly onto the samples. Such shield or other means shall be constructed of glass or other non-reactive materials.

The samples shall be exposed to the moist ammonia-air mixture maintained in a glass chamber with a volume of 0.73 ± 0.34 ft^3 (0.02 ± 0.01 m^3).

Aqueous ammonia having a density of $5.86\text{x}10^{-5}$ lb/ft^3 (0.94 g/cm^3) shall be maintained in the bottom of the chamber, approximately 1.5 in. (40 mm) below the bottom of the samples. A volume of aqueous ammonia equal to 0.075 gal/ft^3 (10 L/m^3) of the test chamber volume results in approximately the following atmospheric concentrations: 35 percent ammonia, 5 percent water vapor, and 60 percent air. Prior to beginning the exposure, the chamber shall be conditioned to a temperature of 93 F ± 4 F (34 C ± 2 C) for a period of not less than one hour, and shall be maintained as such throughout the exposure period. The moist ammonia-air mixture shall be maintained at essentially atmospheric pressure. Provision shall be made for venting the chamber, such as by the use of a capillary tube, to avoid buildup of pressure.

The test duration shall be 10 days.

Upon removal, samples shall be rinsed in potable water and air dried. Following a two- to four-day drying period, visual examination of the samples shall be made. Following exposure, the samples shall not show evidence of cracking, delamination, or degradation.

4.16.3 Thermal Shock

4.16.3.1 Requirement

Components such as high expansion foam generators, monitors, nozzles, and other discharge devices, which are exposed to the protected space, shall remain functional if heated by a fire prior to the system discharge. Functionality shall be defined as appropriate for the specific component.

4.16.3.2 Test/Verification

The component shall be connected to a 175 psi (12.1 bar) water supply, or, in the case of a high expansion foam generator, to a foam solution supply.

The component shall be placed on the edge of the fire test pan described in Section 4.8, arranged as it would be to protect the pan. High expansion foam generators shall be located 10 ft (3.05 m) above the pan. Heptane fuel shall be provided in sufficient depth to last six minutes.

Components other than high expansion foam generators shall be dry for the first minute of fire exposure.

Then water shall be flowed for an additional 5 minutes. High expansion foam generators shall remain dry for 5 minutes and shall then be supplied with foam solution at the same rate as used for the fire extinguishment test of Section 4.7.

After this test, the component shall exhibit normal operation. Normal operation for a high expansion foam generator shall include the ability prior to cooling to immediately produce foam with an expansion ratio identical to that produced prior to exposure within ± 15 percent. The pan and generator shall be separated by distance or an appropriate barrier prior to conducting this test to avoid exposure of the test personnel to the hot pan.

After being allowed to return to room temperature, the sample shall be inspected for damage. No damage which would impair function shall be allowed.

Small assemblies such as CAFS Nozzles and aspirating foam water nozzles may be tested to FM 2000 Section 4.23 *High Temperature Exposure* in lieu of the Thermal Shock test, at the discretion of the certification agency.

4.17 Equivalent Length Determination

4.17.1 Requirement

The friction loss of all components in the system flow path shall be determined to allow system design calculation.

4.17.2 Test/Verification

A minimum of four tests at different flow rates over the specified range of operation for the device shall be performed. The test medium shall be water. Flow rate and pressure differential shall be measured and the data used to perform a regression analysis to justify the equivalent length figure used in system design. Equivalent length shall be calculated on the basis of the discharge outlet nominal pipe size, using a Hazen-Williams coefficient of 120. This test shall be conducted for each different component design.

All concentrate control valves, check valves, and other non-standard components in the flow path shall be tested to determine equivalent length.

4.18 Bladder Materials

4.18.1 Tensile Strength and Elongation

4.18.1.1 Requirement

Unreinforced materials shall have a tensile strength of not less than 500 psi (3.45 MPa) and at least 100 percent ultimate elongation to ensure adequate toughness for service in bladder tanks. Reinforced materials shall have a tensile strength not less than 2000 psi (13.80 MPa) and are not subject to an initial minimum elongation requirement.

4.18.1.2 Test/Verification

Tensile strength and ultimate elongation shall be determined in accordance with ASTM D 412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension, Method A*. If either the measured tensile strength or ultimate elongation of the specimen is less than the required value, an additional specimen shall be tested, and those results shall be considered final. Results of tests for specimens that break in the curved portion just outside the benchmarks shall be permitted to be accepted if the measured strength and elongation values are within the minimum requirements. A minimum of three samples shall be tested and the results shall be averaged.

4.18.2 Air Oven Aging

4.18.2.1 Requirement

Materials used for bladders and their bonded seams shall be resistant to aging in air.

4.18.2.2 Test/Verification

Three samples of each material shall be subjected to air-oven aging for 60 days at 158 F (70 C), and then allowed to cool at least 24 hours in air at 74 F (23 C), at 50 percent relative humidity. At the conclusion of this test the samples shall be inspected for cracking and crazing. There shall be no cracking or crazing as a result of this test. An additional three samples cut perpendicular to a centrally located bonded seam shall also be tested. No separation of the seam shall result from this exposure.

Tensile strength and elongation shall then be measured per Section 4.18.1.2. For unreinforced materials, neither shall average less than 0.85 of the average values obtained from new samples of the same material. Reinforced materials shall instead be limited to a 2000 psi (13.90 MPa) minimum tensile strength and a minimum of 0.5 of their original elongation after this exposure. Bonded seam samples shall not fail at the seam.

4.18.3 Compatibility with Foam Concentrate

4.18.3.1 Requirement

Bladder materials and their bonded seams shall be resistant to aging while immersed in concentrate.

Tensile strength and elongation shall then be measured per Section 4.18.1.2. For unreinforced materials, neither shall average less than 0.85 of the average values obtained from new samples of the same material. Reinforced materials shall instead be limited to a 2000 psi (13.90 MPa) minimum tensile strength and a minimum of 0.5 of their original elongation after this exposure. Bonded seam samples shall not fail at the seam.

4.18.3.2 Test/Verification

Three samples of each material shall be immersed in each foam concentrate and subjected to aging for 60 days at 158 F (70 C). Subsequently, the samples shall be rinsed off in water and allowed to dry at least 24 hours in air at 74 F (23 C), at 50 percent relative humidity. At the conclusion of this test, the samples shall be inspected for cracking and crazing. There shall be no cracking or crazing as a result of this test. An additional three samples cut perpendicular to a centrally located bonded seam shall also be tested. No separation of the seam shall result from this exposure.

4.19 Polymeric and Fiberglass Components

4.19.1 Air Oven Aging

4.19.1.1 Requirements

Components constructed from or incorporating polymeric and other non-metallic materials (other than elastomeric seals) shall be exposed high ambient temperature conditioning. Following the exposure period the components shall show no evidence of cracking or crazing and shall show no deterioration of function.

4.19.1.2 Test/Verification

A sample component shall be conditioned at 158 F (70 C) oven aging for 180 days, after conditioning the sample shall be allowed to cool at ambient temperature for 24 hours.

If necessary, the test may be conducted at a lower temperature for a longer duration or at a higher temperature for a shorter duration. In this event the duration shall be calculated using the following formula:

$$D = (184049)e^{-0.0693t}$$

where:

D is test duration in days, and
t is test temperature, °C.

In no case shall the test be conducted below the manufacturers stated maximum working temperature.

Following conditioning the sample component shall be visually examined for cracking or crazing or any damage that would impede proper functioning of the component. Components subject to pressure of shall function as normal when operated at their maximum inlet pressure and maximum flow rate for a period of 1 minute.

4.19.2 Foam Liquid Concentrate Immersion Test

4.19.2.1 Requirements

Components constructed from or incorporating polymeric and other non-metallic materials (other than elastomeric seals) that are in continuous contact with foam liquid concentrate shall be immersed in the foam liquid concentrate. Following the exposure period, the components shall show no evidence of cracking or crazing and shall show no deterioration of function.

4.19.2.2 Test/Verification

A sample component shall be immersed in the manufacturers foam liquid concentrate for 210 days at 122 ± 3.6 F (50 ± 2 C). After conditioning, the sample shall be rinsed with clean water and then allowed to cool at ambient temperature for 24 hours.

Following conditioning the sample component shall be visually examined for cracking or crazing or any damage that would impede proper functioning of the component. Components subject to pressure of shall function as normal when operated at their maximum inlet pressure and maximum flow rate for a period of 1 minute.

4.19.3 Foam Solution Immersion Test

4.19.3.1 Requirements

Components constructed from or incorporating polymeric and other non-metallic materials (other than elastomeric seals) that are in continuous contact with foam solution shall be immersed in the foam solution. Following the exposure period, the components shall show no evidence of cracking or crazing and shall show no deterioration of function.

4.19.3.2 Test/Verification

A sample component shall be immersed in a solution of the manufacturers foam liquid concentrate and water, of the highest percentage concentration at which the system is to be assessed, for 210 days at 122 ± 3.6 F (50 ± 2 C). After conditioning, the sample shall be rinsed with clean water and then allowed to cool at ambient temperature for 24 hours.

Following conditioning the sample component shall be visually examined for cracking or crazing or any damage that would impede proper functioning of the component. Components subject to pressure of shall function as normal when operated at their maximum inlet pressure and maximum flow rate for a period of 1 minute.

4.19.4 Ultraviolet Light and Water Test

4.19.4.1 Requirements

Components constructed from or incorporating polymeric and other non-metallic materials (other than elastomeric seals) shall be exposed ultraviolet light and water conditioning. Following the exposure period the components shall show no evidence of cracking or crazing and shall show no deterioration of function.

4.19.4.2 Test/Verification

A sample component shall be exposed to ultraviolet light and water for 720 hours in accordance with Table X3.1, Condition 1, of ASTM G 155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*. The nozzle shall be inspected for cracking and crazing after 360 hours. If no cracking or crazing is apparent, the exposure shall continue for the full 720 hours. During each operating cycle, each sample shall be exposed to light and water spray for 18 minutes and to only light for 102 minutes (total 120 minutes). The air temperature within the apparatus during operations shall be 109 ± 4.5 F (43 ± 2.5 C) and the relative humidity 30 ± 5 percent.

Following conditioning the sample component shall be visually examined for cracking or crazing or any damage that would impede proper functioning of the component. Components subject to pressure of shall function as normal when operated at their maximum inlet pressure and maximum flow rate for a period of 1 minute

4.20 Foam Concentrate and Water Pumps

Foam concentrate and water pumps shall be evaluated per FM Approvals Examination Standard 1313, Positive Displacement Rotary Fire Pumps. If designs other than positive displacement rotary gear pumps are to be used, additional or alternative evaluations and tests may be required, at the discretion of the certification agency.

4.21 Monitors for use with Foam and CAFS

Monitors and associated Nozzles for use with foam shall be evaluated per FM Approvals Examination Standard 1421, *Examination Standard for Fire Protection Monitor Assemblies*, and FM Approvals Examination Standard 5511, *Examination Standard for Firefighting Nozzles for Use with Hose, Monitor Assemblies and other Firefighting Equipment*.

Foam Monitors and CAFS Monitors and Nozzles for Low-Level Foam Protection systems shall be evaluated per the applicable sections of FM Approvals Examination Standard 1421, *Examination Standard for Fire Protection Monitor Assemblies* , and FM Approvals Examination Standard 5511, *Examination Standard for Firefighting Nozzles for Use with Hose, Monitor Assemblies and other Firefighting Equipment* , as determined by the certification agency.

Additionally, Electrically Operated Monitors shall be evaluated per FM Approvals Examination Standard 3611, *Nonincendive Electrical Equipment for Use In Class I and II, Div. 2 & Class III, Divisions 1 & 2 Hazardous (Classified) Locations* and FM Approvals Examination Standard 3810, *Electrical and Electronic Test, Measuring and Process Control Equipment*.

In addition, the following requirements are to be met:

4.21.1 Coverage

4.21.1.1 Requirements

Oscillating Foam Monitors and CAFS Monitors for Low-Level Foam Protection Systems shall deliver foam or CAF at the specified application rate over the specified area within the specified range. It is up to the manufacturer to define the area of coverage at specified nozzle vertical orientations (where applicable), for certification. All possible configurations of vertical nozzle adjustment are subject to the requirements of this Section for the purpose of certification.

4.21.1.2 Test/Verification

Each monitor, nozzle, concentrate, and concentration shall be tested.

Monitors for Low-Level Foam Protection Systems shall be operated at maximum flow rate and range while traversing the specified maximum horizontal angle. The test shall be repeated at the minimum flow rate and range with the same criteria for success. At all flow rates and areas of coverage; monitors must satisfy a minimum application rate of 0.1 gal/min/ft^2. Foam samples shall be collected during this test and their quality determined per Section 4.3.

For Monitors for Low-Level Foam Protection with a nozzle angle above a parallel plane with the floor surface; collection pans of known area shall be placed within the specified area of coverage in locations where coverage appears weakest. Collection and area of coverage over a three minute period shall be measured.

For Monitors for Low-Level Foam Protection with a nozzle angle at or below a parallel plane with the floor surface; the monitor shall be operated and the area of coverage over a three minute period shall be measured.

For Monitors and associated Nozzles for use with foam where no area of coverage claim is made by the manufacturer; each device shall be exercised throughout all of its possible configurations with each specific concentrate for which certification is sought. Spray Character, Reach and Discharge vs. Pressure measured in accordance with FM Approvals Examination Standard 5511 Section 4.6 shall be required for each Monitor and associated Nozzle configuration.

In all cases above, foam quality shall match that obtained during successful fire tests of the same concentrate at the same concentration. Monitors for use with Foam and CAFS are to meet the foam quality specifications of Table 4.4.2.2 - *Quality Equivalency Limits*.

4.21.2 Durability

4.21.2.1 Requirements

Monitors for use with Foam and CAFS shall withstand continuous operation without failure.

4.21.2.2 Test/Verification

A monitor shall be operated throughout the maximum specified range of horizontal angles while elevated to the elevation which creates the most adverse condition for the oscillating mechanism and while flowing water at the maximum specified rate for one hour or 500 cycles, whichever is longer.

The monitor shall then be lowered to the minimum specified vertical angle and the test repeated.

Subsequent to these tests, the monitor shall continue to exhibit normal operation and no visible leakage.

4.21.3 Thermal Shock

Monitors for use with Foam and CAFS shall be subject to the thermal shock requirements of Section 4.16.3.

4.22 Foam Water Sprinklers

Automatic fire sprinklers designed for use with water shall be certified per FM Approvals Examination Standard 2000, Automatic Control Mode Sprinklers for Fire Protection, as a prerequisite for consideration for use in foam water sprinkler extinguishing systems. In addition, such sprinklers shall exhibit effective fire extinguishing performance when evaluated as described in Section 4.2 and Appendix D of this standard.

Air aspirating foam water sprinklers and foam water spray nozzles shall be allowed to be tested and certified as foam discharge devices. Such devices shall be subjected to the applicable sections of FM Approvals Examination Standard 2000, Automatic Control Mode Sprinklers for Fire Protection, at the discretion of the certification agency. In addition, such devices shall exhibit effective fire extinguishing performance when evaluated as described in Section 4.2 and Appendix D of this standard.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, is also referenced with regard to general information about the acceptable configurations and applications of these systems. However, the improved effectiveness of foam-water sprinkler systems over conventional water-only systems is highly dependent upon the commodities and configurations being protected, as well as the specifics of the system design. As a result, it will be necessary to conduct full-scale fire tests to certify a foam water sprinkler system which deviates from the established design criteria for water-only fire sprinkler systems.

4.23 Subsurface and SemiSubsurface Distribution Devices

4.23.1 Requirements

Subsurface and semisubsurface distribution devices shall demonstrate fire extinguishment effectiveness with each specified concentrate and at each specified concentration.

4.23.2 Test/Verification

4.23.2.1 The test arrangement shall comprise a vertical, open-topped steel tank of 15 ft (4.6 m) minimum diameter and 13 ft (4 m) minimum height. The tank shall contain a minimum 10 ft (3 m) depth of fuel. If non-polar solvent fuel is used, the fuel may be supported on a maximum 1 ft (0.3 m) layer of water. Freeboard shall be no less than 3 ft (0.9 m) nor greater than 4 ft (1.2 m).

4.23.2.2 Fuel shall be commercial grade heptane, unless otherwise specified.

4.23.2.3 The device under test shall be installed no higher than 2ft (0.61 m) above the bottom of the tank.

4.23.2.4 Tests shall be conducted under conditions of calm air, no precipitation, and at ambient temperatures between 50 F and 90 F (10 C and 32 C).

4.23.2.5 A 10 minute preburn shall be followed by 10 minutes of foam discharge at the manufacturer’s specified test application rate.

4.23.2.6 Foam shall completely cover the surface and all fire shall be extinguished within 15 minutes of the start of discharge. In addition, semi-subsurface devices shall exhibit normal specified operation, including full deployment of the hose to the surface.

4.24 Compressed Air Foam Systems

CAF systems may include pressurized air or nitrogen cylinders and related control components, specialized nozzles, and other devices not normally included in low expansion foam systems. Accordingly, evaluations detailed in FM Approvals Examination Standard 5600, germane to the specific configuration, may be required. Depending upon hazard selection and system design, a CAF system may also require nonstandard fire extinguishment tests to evaluate the manufacturer's specified uses. In all cases, certified CAF Systems must be able to be configured to supply a 20 minute duration of CAF application to the hazard area.

4.24.1 CAF Fire Extinguishment

CAF fire extinguishment tests are similar to those described in Section 4.2 for low expansion foam concentrates. Appendix D provides the specifics of the required configurations and Appendix E provides the test chronology. Because CAF systems use specialized discharge devices and spacing, it is necessary to iterate to the required test configurations as follows.

Extinguishment tests shall be conducted using four nozzles installed on the manufacturer's maximum specified square spacing and at the manufacturer's minimum recommended design application rate. Nozzle height shall be the manufacturer's specified minimum. A second set of tests shall be conducted using the manufacturer's maximum area of coverage asymmetry; if other than square spacing is specified for the system. After review of the test results, the worst performing combinations of concentrates, hardware, and installation geometries shall also be tested at the manufacturer's maximum recommended installation height.

Tests shall be conducted with each concentrate submitted for certification and at the manufacturer's specified concentration(s).

Discharge duration shall be 5 minutes with 5 minutes of subsequent water discharge. Since CAF discharge devices are typically not sprinklers, this will require overlaying of the CAF piping grid with a second sprinkler grid. The sprinkler grid shall be as described for high expansion foam breakdown testing in Section 4.11.2 with a minimum water application rate of 0.3 gal/min/ft^2 (12.2 mm/min). A maximum water application rate for foam breakdown as specified by the manufacturer shall be tested for certification. The maximum water application rate may be selected by the manufacturer from 0.3 gal/min/ft^2 to 1.0 gal/min/ft^2 (12.2 mm/min to 40.8 mm/min) at even 0.1 gal/min/ft^2 (4.1 mm/min) steps. The timing for reignition attempts and the burnback resistance evaluation shall be as specified for foam water sprinklers and the type of concentrate, as shown in Appendix D.

For water miscible fuels, discharge duration shall be 5 minutes with no subsequent water discharge. The timing for re-ignition attempts and the burnback resistance evaluation shall be as specified for foam water sprinklers and the type of concentrate, as shown in Appendix D.

If a premixed solution is not used, concentration shall be verified by appropriate instrumentation to measure water and concentrate flow rates or weight or volume changes.

A second set of tests shall be conducted using the manufacturer's maximum area of coverage asymmetry, if other than square spacings are specified for the system.

Foam quality measurements shall be made, as described in Section 4.3, *Low Expansion Foam Quality Measurements*, for comparison with foam quality produced by other mixing devices.

4.24.2 CAF Generation and Proportioning

Generation rates shall be measured for all sizes of mixing devices, with each specified concentrate, and at minimum and maximum specified water pressures.

When the mixing devices also perform the proportioning function, all sizes shall be tested to verify accuracy of proportioning of all concentrates over the manufacturer's specified range of supply pressures. Tests shall be repeated using concentrate supplies at the manufacturer's minimum specified temperature, but no higher than 35 F (1.7 C).

The quality (expansion ratio and 25 percent drainage time) of the foam produced in each test shall be measured as described in Section 4.3, *Low Expansion Foam Quality Measurements*, and shall conform to the limits specified in Table 4.4.2.2, when compared to the relevant CAF used in successful extinguishment tests.

The foam generation rates measured in these tests shall meet or exceed the manufacturer's specified capacities for each size of mixing device.

4.24.3 CAF Area of Coverage

Areas of effective coverage for each nozzle design shall be measured by foam collection at the specified flow rate, in known size pans throughout the specified coverage area. These tests shall be conducted using both the most highly and least highly expanded foams identified in the CAF generation tests and at the minimum specified nozzle height, or worst case height as determined by the certification agency. The minimum specified design application rate shall be achieved over the entire specified areas of coverage.

4.24.4 CAF Hydraulics

Because CAF systems transport foam from the generator to the discharge device in a fully expanded state, the manufacturer shall demonstrate the ability to predict flow rates at the discharge device either by testing the most restrictive specified balanced piping arrangements, or by conducting tests at the specified limits of design methodology for unbalanced systems. In these tests, discharge rates and foam quality shall be measured for all discharge points and compared to the predicted rates and the quality of the foam applied in the successful extinguishment tests.

Foam quality matching shall be evaluated against the criteria of Table 4.24.4.

Table 4.24.4 – CAF Quality Equivalency Limits

Parameter	***Minimum below Fire Extinguishment Foam***	***Maximum above Fire Extinguishment Foam***	***Remarks***
Expansion Ratio	-10 percent, or -1 expansion ratio unit, whichever is greater	+ 20 percent, or + 2 expansion ratio units, whichever is greater	A ratio of 3:1 denotes three expansion ratio units, 5:1 denotes five, et cetera
25 percent Drain Time	-10 percent, or -5 minutes, whichever is greater	+ 20 percent, or +10 minutes, whichever is greater	25 percent drain time also shall never be less than 30 seconds

Foam discharge rates shall match within ± 10 percent among all discharge points.

4.24.5 Suitability and Durability

The system shall be exercised through all its operating modes and shall operate as specified by the manufacturer. All possible combinations of inputs shall be applied, and responses shall be as specified. A minimum of three trials shall be conducted for each combination with successful results. Components shall operate normally at the maximum and minimum installation temperatures, water pressures, air pressures and other extremes of specified operating ranges.

4.24.6 Gas Pressure Containing Components

All components subject to gas pressure that are intended to be shipped pressurized shall meet the relevant U.S. Department of Transportation or Transport Canada requirements or equivalent relative standard for the jurisdiction of installation. Cylinder construction shall be verified to be in compliance to the standards to which they are designed. This will require design calculations per the appropriate standards, chemical and physical data for the materials, and drawings illustrating the relevant construction details, such as wall thickness and materials. All components subject to gas pressure shall not leak at the proof test pressure and shall not be damaged when subjected to 5/3 that pressure, or twice the pressure relief setting, whichever is greater. For pressure vessels, that will be transported while pressurized, permanent volume expansion resulting from a 30 second application of the proof pressure shall not exceed 10 percent of the total expansion.

4.24.7 Durability

All operating devices shall not fail, leak, or significantly change their operating characteristics after being cycled 500 times at rated conditions.

4.24.8 Nozzle Materials

Nozzles shall not exhibit corrosion which would compromise their hydraulic or mechanical performance after being subjected to salt fog testing per Section 4.15, *Salt Fog Corrosion.*

Any nozzle incorporating moving parts showing increased resistance to motion after this test shall be retested at the lowest foam delivery pressure to ensure that it can still maintain its specified coverage area.

4.24.9 Nozzle Impact Resistance

Nozzles shall withstand a drop of 30 in. onto a concrete surface in various impact orientations with no adverse effect on hydraulic or mechanical performance.

Any nozzle incorporating moving parts showing increased resistance to motion after this test shall be retested at the lowest foam delivery pressure to ensure that it can still maintain its specified coverage area.

4.24.10 Nozzle Vibration Resistance

Nozzles shall withstand 25 hours of vibration with no failure to retain all parts or loss of ability of moving parts to move freely.

Testing shall be in accordance with FM Approvals Examination Standard 2000, Section 4.21. Any nozzle showing increased resistance to motion of moving parts or any other symptom of impaired operation after this test shall be retested at the lowest foam delivery pressure to ensure that it can still maintain its specified coverage area.

4.25 High Expansion Foam Air Inlet and Outlet Vents

4.25.1 Vent Sizing

4.25.1.1 Requirements

High expansion foam generators require adequate venting to ensure movement of air from outside the protected space into the generator and displacement of air from the space to the outside to prevent back-pressurizing the generator. The manufacturer shall specify the allowable back pressure on his generators and shall provide sizing calculations for the required venting.

4.25.1.2 Test/Verification

The certification agency shall review the vent sizing calculations and may, at its discretion, require a demonstration of foam capacity per Section 4.10, while the specified maximum backpressure is applied to the generator.

4.25.2 Vent Durability

4.25.2.1 Requirements

Vents shall operate reliably over 60 cycles of operation while supplied with the minimum driving force (voltage, pressure, as applicable).

4.25.2.2 Test/Verification

A sample vent of each design and size shall be operated 60 times as quickly as the mechanism allows while supplied with the minimum driving force. If electrically operated, this test shall be conducted at 0.85 of the rated voltage. If hydraulically operated, the minimum specified pressure shall be used. The vent shall not fail to fully open within 30 seconds of initiation of the actuation sequence.

4.25.3 Vent Resistance to Wind Loading

4.25.3.1 Requirements

A vent shall operate while subjected to wind loading.

4.25.3.2 Test/Verification

The durability test of Section 4.24.2 shall be repeated for 3 cycles while a uniform force of 2 lb/ft^2 (96 N/m^2) is applied to its exterior surface. For this test, the vent shall be mounted in a horizontal position with its exterior face upward. Force shall be applied by means of a 1/2 in. nominal thickness sheet of plywood with additional loose weights applied, as necessary. The vent shall fully open in each trial while so loaded.

4.25.4 Vent Resistance to Snow Loading

4.25.4.1 Requirements

A roof mounted vent shall operate while subjected to simulated snow loading. The applied test weight used shall be stated in the certification and the manufacturer's DIOM.

4.25.4.2 Test/Verification

The test of 4.25.3.2 shall be repeated with the uniform weight increased to a minimum of 10 lb/ft^2 (478 N/m^2). No failure to operate in three trials shall be allowed. Vents with shields to prevent snow loading on moving parts shall be tested to verify that the shields will support the snow load. At the manufacturer's discretion, the applied weight may be increased in increments of 10 lb/ft^2 (478 N/m^2).

4.25.5 Vent Operation under Icing Conditions

4.25.5.1 Requirements

A vent shall remain fully functional under icing conditions.

4.25.5.2 Test/Verification

A vent shall be mounted in its normal installation orientation. If designed for both vertical and horizontal mounting, one sample shall be tested in each orientation. The icing exposure shall be applied to the surfaces normally exposed to the weather after a normal installation on a building wall or roof. Those areas protected by the building shall not be subject to water spray. However the entire assembly shall be subjected to the lowered temperatures. The test shall be conducted per NEMA 250, *Enclosures for Electrical Equipment (1000 Volts Maximum)*, Section 5.6.1, *External Icing Test Method*. At the end of the exposure and formation of the full 3/4 in. (20 mm) ice layer, and while still between 20 F and 27 F (-7 C and -3 C), the vent shall be operated with the minimum operating force. It shall fully open within 60 seconds of initiation of operation.

4.26 Water Motor Driven Variable Viscosity Proportioners

In addition to any applicable tests stated elsewhere in this standard, water motor driven variable viscosity proportioners shall be tested as described in this section.

4.26.1 Proportioning

4.26.1.1 Requirements

When tested in accordance with Section 4.26.1.2, water motor driven variable viscosity proportioners shall meter foam concentrate into water with acceptable accuracy throughout their specified ranges of flow, pressure, and concentration ratios for fluids representing the maximum and minimum viscosities for which certification is intended. The variable viscosity proportioners nominal ratings shall be consistent with the maximum and minimum limitations achieved during testing.

Where the manufacturer allows the proportioner to operate with the concentrate supply below atmospheric pressure (suction lift), the test shall be conducted using the most demanding condition allowed by the manufacturer.

Proportioning ratio measured in test shall match the specified ratio within a tolerance of -0 to +30 percent.

Tests shall be conducted at water and concentrate temperatures within a range of 60 F to 80 F (15 C to 27 C).

4.26.1.2 Test/Verification

Water motor driven variable viscosity proportioners shall be tested over the full range of flows and pressures submitted for certification. Flow shall be considered the total water flow through the water motor, prior to injection of foam concentrate. Pressure shall be considered the pressure measured in the water line at the point of concentrate injection. This will be referred to as the system backpressure.

Pressure readings shall be taken at:

- The inlet and outlet of the water motor
- The water line and concentrate line at the point of concentrate injection.

At minimum, each water motor driven variable viscosity proportioner shall be tested for proper proportioning performance at the following test points:

- Minimum flow, minimum backpressure, minimum fluid viscosity
- Minimum flow, maximum backpressure, minimum fluid viscosity
- Minimum flow, maximum backpressure, maximum fluid viscosity
- Middle flow, minimum backpressure, minimum fluid viscosity

- Maximum flow, minimum backpressure, minimum fluid viscosity
- Maximum flow, maximum backpressure, minimum fluid viscosity
- Maximum flow, maximum backpressure and maximum fluid viscosity

Alternate test points may be required, at the discretion of the certification agency, to ensure that all worst case test conditions are represented.

Proportioning measurements and results shall be obtained using the “Conductivity Test Procedure”, as specified in Appendix F. When using water as a test fluid representing minimum viscosity, salt shall be added to the water to differentiate the conductivity from the main water supply. The baseline conductivity curve shall be developed using the salt solution prior to the proportioning testing.

The option to obtain proportioning results through the use of flowmeters may also be considered acceptable, only if the manufacturer first qualifies the accuracy of the flowmeter method by comparison with results obtained using a weight/time measurement method. The procedure/requirements for this qualification is detailed in Appendix I.

4.26.2 Dry Operation and Self-Priming

4.26.2.1 Requirements

The same water motor driven variable viscosity proportioner samples used for the performance tests shall demonstrate their ability for limited dry operation and to self-prime from a dry condition.

4.26.2.2 Test/Verification

Inlet and outlet piping shall be drained of all liquid. The sample water motor driven variable viscosity proportioner shall be operated at the unit’s maximum operating speed with a closed concentrate suction valve for a minimum of 10 minutes. The water motor driven variable viscosity proportioner shall then be shut down.

The inlet shall then be immersed into a container of test fluid representing maximum viscosity conditions, with the liquid surface approximately 2 ft. (0.6m) below the pump centerline, or at the maximum suction lift height specified by the manufacturer, whichever is greater. Inlet and outlet valves shall be fully open. The pump shall then be started at the units minimum operating speed and shall draw in the concentrate and fully evacuate all air.

4.26.3 Endurance Test

4.26.3.1 Requirements

The water motor driven variable viscosity proportioner shall be capable of continuous operation for 24 hours under the conditions stated in Section 4.26.3.2, without excessive vibration, loosening of parts (fasteners, et cetera), visible distortion, excessive generation of heat in the bearings, or rubbing of the rotor. This test shall be conducted with a fluid representing the lowest viscosity (water).

Following the endurance test, the water motor driven variable viscosity proportioner shall continue to meet the requirements stated in Section 4.26.1 *Proportioning*, within the operating ranges established on a pre-endurance tested unit. An increase to the minimum rated flow rate is allowed, however, the increase shall be no greater than 10%. In cases where the minimum startup flow, the flow at which the proportioner achieves the minimum acceptable proportioning rate, is less than the minimum rated flow, the 10% limit of increase shall apply to the minimum startup flow. If the 10% limit is exceeded, the minimum rated flow of the proportioner shall be adjusted so that the minimum startup flow achieved after the endurance test is no greater than a 10% increase.

4.26.3.2 Test/Verification

Sample water motor driven variable viscosity proportioners representative of the product line, selected at the discretion of the certification agency, shall be operated continuously for 24 hours at maximum speed, flow and pressure. No loosening, distortion, overheating, or degradation of performance shall be allowed. Following the test, the pump shall be disassembled and examined for signs of rubbing. A method of ensuring that the pump runs continuously for 24 hours must be provided. All tests must be maintained within ± 4 percent of the maximum rated flow throughout the test.

Prior to and at the conclusion of this test, the proportioner shall be tested for proportioning accuracy per Section 4.26.1 *Proportioning*. In cases where the minimum rated flow differs from the minimum startup flow (the flow at which the proportioner achieves the minimum acceptable proportioning rate), the minimum startup flow shall also be recorded at each minimum flow test condition. Further post-testing may be specified at the discretion of the certification agency.

4.26.4 Flange And Gasket Tightness

4.26.4.1 Requirements

No leakage shall be observed in a 5 minute observation period when the water motor driven variable viscosity proportioner, including the pump assembly and water motor, is hydrostatically tested at the required pressure according to Section 4.26.4.2 or 4.26.4.3 as appropriate.

4.26.4.2 Test/Verification – Water motor and components subject to fire service water pressure

The water motor driven variable viscosity proportioner shall be closed by means of its normal connections to the system. Means shall be provided for the introduction of water and the venting of any trapped air. After filling and venting, the device shall be pressurized to a pressure equal to two times the specified rated operating pressure, or 250 psi, whichever is greater, and held at that pressure for the required duration. Observations of any leakage shall be recorded.

4.26.4.3 Test/Verification – Pump and components subject to foam concentrate pressure

The water motor driven variable viscosity proportioner shall be hydrostatically tested to a pressure equal to, or greater than, the sum of the maximum rated differential pressure of the pump plus a maximum allowable suction pressure specified for the pump by the manufacturer (Pmax + Pmax. Suction). The maximum rated differential pressure, Pmax, is the highest relief valve setting specified for certification. The test pressure shall be held for five minutes. In no case shall the maximum allowable suction pressure, Pmax. Suction, be less than 75 psi (5.15 bar), or the leakage test be run at less than 250 psi (17.25 bar). Housing bolts normally provided shall be used for this test.

4.26.5 Hydrostatic Strength

4.26.5.1 Requirements – Water motor and components subject to fire service water pressure

Parts of the water motor driven variable viscosity proportioner subject to fire service water pressure shall meet the requirements of Section 4.12.1.

4.26.5.2 Requirements – Pump and components subject to foam concentrate pressure

No rupture, cracking or excessive distortion of any part of the water motor driven variable viscosity proportioner, including the pump assembly and water motor, shall be observed in a 5 minute test when hydrostatically tested at the required pressure according to Section 4.26.5.4.

4.26.5.3 Test/Verification **-** Components subject to fire service water pressure

The water motor driven variable viscosity proportioner shall be hydrostatically tested according to the Test/Verification methods stated in Section 4.12.2.

4.26.5.4 Test/Verification – Pump and components subject to foam concentrate pressure

The water motor driven variable viscosity proportioner shall be hydrostatically tested to a pressure equal to, or greater than, twice the sum of the maximum rated differential pressure of the pump plus a maximum allowable suction pressure specified by the pump manufacturer, 2 x (Pmax + Pmax. Suction). The maximum rated differential pressure, Pmax, is the highest relief valve setting submitted for certification. The test pressure shall be held for five minutes. In no case shall the maximum allowable suction pressure, Pmax. Suction, be less than 75 psi (5.15 bar), or the test be run at a pressure less than 400 psi (27.60 bar).

4.26.6 Salt Fog Corrosion

4.26.6.1 Requirements

The water motor driven variable viscosity proportioner shall meet the requirements stated in in Section 4.15.1 when tested in accordance Section 4.15.2.

4.26.6.2 Test/Verification

Sample water motor driven variable viscosity proportioners representative of the product line, selected at the discretion of the certification agency, shall be tested according to Section 4.15.2.

4.26.7 Friction Loss Determination

4.26.7.1 Requirements

The friction loss of all components in the fire service water flow path shall be determined and compared to the manufacturer’s published literature.

4.26.7.2 Test/Verification

While performing proportioning testing per Section 4.26.1, record measurements for inlet and outlet pressures across the water motor at each test point to determine the friction loss of the assembly.

4.26.8 Overflow Test

4.26.8.1 Requirements

A water motor driven variable viscosity proportioner shall show no signs of damage or abnormal wear when subjected to a momentary periods of overflow conditions.

4.26.8.2 Test/Verification

Samples representative of the product line, selected at the discretion of the certification agency, shall be subjected to a total water flow which exceeds the maximum limitation established under Section 4.26.1. The duration and magnitude of the overflow conditions shall be as follows:

- 1 hour @ 110% maximum flow
- 4 minutes @ 150% maximum flow

At the conclusion of this test the proportioner shall be tested for proportioning accuracy per Section 4.26.1 *Proportioning*. Measured proportioning ratios shall not exceed 10 percent variation from the pre-tested condition and must remain within the tolerance as outlined in Section 4.5.1.1 *Proportioning Tests*. Further post-testing may be specified at the discretion of the certification agency.

4.26.9 Viscosity Measurements

4.26.9.1 Requirements

Viscosity measurements of the fluids used to complete the testing shall be recorded, the measured viscosity figures shall determine the rated viscosity range of the water motor driven variable viscosity proportioner. If test fluids are recirculated during proportioning testing samples then samples shall be taken before and after testing and the worst performing measurement shall be used in the determination of the rated viscosity range of the water motor driven variable viscosity proportioner.

4.26.9.2 Test/Verification

Viscosity measurements shall be determined using the "Viscosity Test Procedure" per Appendix J. Measurements shall be taken of the test fluids representing minimum and maximum viscosity. Measurements shall only be required at room temperature (65°F ± 5°F or 18°C ± 3°C). If water is used to represent the minimum viscosity fluid, the minimum viscosity of the water motor driven variable viscosity proportioner may be considered 1 Cps.

4.26.10 Flowmeters

Where certified water motor driven variable viscosity proportioners are offered by the manufacturer with a function to allow field testing of the proportioning ratio of an installed unit, the flowmeters supplied shall meet the following requirements.

4.26.10.1 Flowmeters used in water motor driven variable viscosity proportioners shall meet the Operational and Accuracy requirements specified in FM Examination Standard Class Number 1046, *Fire Pump Flowmeter Systems* Section 5.1.

4.26.10.2 Flowmeters used in water motor driven variable viscosity proportioners shall meet subject the Hydrostatic Strength requirements in accordance with FM Examination Standard Class Number 1046, *Fire Pump Flowmeter Systems* Section 5.2.

4.26.10.3 Flowmeters used in water motor driven variable viscosity proportioners shall meet the Friction Loss requirements in accordance with Section 4.17.

4.27 Electronically Controlled Variable Viscosity Proportioners

In addition to any applicable tests stated elsewhere in this standard, electronically controlled variable viscosity proportioners shall be tested as described in this section.

4.27.1 Proportioning

4.27.1.1 Requirements

When tested in accordance with Section 4.27.1.2, electronically controlled variable viscosity proportioners shall meter foam concentrate into water with acceptable accuracy throughout their specified ranges of installation orientation, flow, pressure, and concentration ratios for fluids representing the maximum and minimum viscosities for which certification is intended.

The electronically controlled variable viscosity proportioners nominal ratings shall be consistent with the maximum and minimum limitations achieved during testing; additionally the times specified by the manufacturer for the device to adjust to the correct proportioning rate following a change in flow conditions, shall be verified at each test point.

Proportioning ratio measured in test shall match the specified ratio within a tolerance of -0 to +30 percent.

Tests shall be conducted at water and concentrate temperatures within a range of 60 F to 80 F (15 C to 27 C).

4.27.1.2 Test/Verification

Electronically controlled variable viscosity proportioners shall be tested over the full range of flows and pressures submitted for certification. Flow shall be considered the total water flow through the electronically controlled variable viscosity proportioner, prior to injection of foam concentrate. Pressure shall be considered the pressure measured in the water line at the point of concentrate injection. This will be referred to as the system backpressure.

Pressure readings shall be taken at:

- The inlet and outlet of the electronically controlled variable viscosity proportioners water line and concentrate line
- The water line and concentrate line at the point of concentrate injection.

At minimum, each electronically controlled variable viscosity proportioner shall be tested for proper proportioning performance at the following test points:

- Minimum flow, minimum backpressure, minimum fluid viscosity
- Middle flow, minimum backpressure, minimum fluid viscosity
- Maximum flow, minimum backpressure, minimum fluid viscosity
- Minimum flow, maximum backpressure, minimum fluid viscosity
- Middle flow, maximum backpressure, minimum fluid viscosity
- Maximum flow, maximum backpressure, minimum fluid viscosity
- Minimum flow, minimum backpressure, maximum fluid viscosity
- Middle flow, minimum backpressure, maximum fluid viscosity
- Maximum flow, minimum backpressure, maximum fluid viscosity
- Minimum flow, maximum backpressure, maximum fluid viscosity
- Middle flow, maximum backpressure, maximum fluid viscosity
- Maximum flow, maximum backpressure, maximum fluid viscosity

Alternate test points may be required, at the discretion of the certification agency, to ensure that all worst case test conditions are represented.

Proportioning measurements and results shall be obtained using the "Conductivity Test Procedure", as specified in Appendix F. When using water as a test fluid representing minimum viscosity, salt shall be added to the water to differentiate the conductivity from the main water supply. The baseline conductivity curve shall be developed using the salt solution prior to the proportioning testing.

The option to obtain proportioning results through the use of flowmeters may also be considered acceptable, only if the manufacturer first qualifies the accuracy of the flowmeter method by comparison with results obtained using a weight/time measurement method. The procedure/requirements for this qualification is detailed in Appendix I.

4.27.2 Concentrate Control Valves

When tested in accordance with section 4.13.5 *Durability*, automatic concentrate control valves used as part of an electronically controlled variable viscosity proportioner the number of cycles tested shall be increased to 5000 cycles.

4.27.3 Flowmeters

4.27.3.1 Flowmeters used in electronically controlled variable viscosity proportioners shall meet the Operational and Accuracy requirements specified in FM Examination Standard Class Number 1046, *Fire Pump Flowmeter Systems* Section 5.1.

4.27.3.2 Flowmeters used in electronically controlled variable viscosity proportioners shall meet subject the Hydrostatic Strength requirements in accordance with FM Examination Standard Class Number 1046, *Fire Pump Flowmeter Systems* Section 5.2.

4.27.3.3 Flowmeters used in electronically controlled variable viscosity proportioners shall meet the Friction Loss requirements in accordance with Section 4.17.

4.27.4 Pressure Transmitters

4.27.4.1 Pressure Transmitters used in electronically controlled variable viscosity proportioners shall meet the Pressure switch/pressure transmitters requirements specified in FM Examination Standard Class Number 1321/1323, *Controllers for Electric Motor Driven and Diesel Engine Driven Fire Pumps* Section 5.9.

4.27.5 Control Unit/Enclosure

4.27.5.1 Control units used in electronically controlled variable viscosity proportioners shall be individually assessed at the discretion of the certification agency, to ensure that all worst case test conditions are represented, but shall typically meet the following requirements specified in FM Examination Standard Class Number 3010, *Fire Alarm Signaling Systems*:

Sections 3.4 *Markings*, 3.5 *Manufacturer's Installation and Operation Instructions*, 4.1 *Normal Operations*, 4.2 Power Supply/Electrical Supervision, 4.3 Characteristics of Circuits and Pathways, 4.11 *Voltage Variations*, 4.12 *Environmental Conditioning*, 4.13 *Battery Charge/Discharge*, 4.15 *Vibration*, 4.16 *Jarring*, 4.17 *Endurance*, 4.18 Dielectric, 4.19 System Load Rating and Overload, 4.20 DC Circuit Reverse Polarization, 4.21 *Protective Grounding/Bonding*, 4.22 *Power Supply Failure*, 4.23 *Component Temperature*, 4.24 *Power Limited and Non Power Circuits*, 4.25 *Extraneous Transients (RFI Immunity)*, 4.29 *Static Discharge*, 4.31 *Software Requirements*, 4.32 *Releasing Circuits.*

4.27.5.2 Enclosures used in electronically controlled variable viscosity proportioners shall meet the Enclosure requirements specified in FM Examination Standard Class Number 3010, *Fire Alarm Signaling Systems* Section 4.14 Enclosure and the following requirements from IEC 60529:

Accessibility (IP1X/2X3X/4X), *Dust exclusion Test* (IP5X or IP6X, as appropriate), *Hosedown Test* (IPX3, IPX4, IPX5 or IPX6 as appropriate).

Enclosures shall meet the requirements commensurate with an IP rating of at least IP 54.

4.27.6 Viscosity Measurements

4.27.6.1 Requirements

Viscosity measurements of the fluids used to complete the testing shall be recorded, the measured viscosity figures shall determine the rated viscosity range of the electronically controlled variable viscosity proportioner. If test fluids are recirculated during proportioning testing then samples shall be taken before and after testing and the worst performing measurement shall be used in the determination of the rated viscosity range of the electronically controlled variable viscosity proportioner.

4.27.6.2 Test/Verification

Viscosity measurements shall be determined using the “Viscosity Test Procedure” per Appendix J. Measurements shall be taken of the test fluids representing minimum and maximum viscosity. Measurements shall only be required at room temperature (65°F ± 5°F or 18°C ± 3°C). If water is used to represent the minimum viscosity fluid, the minimum viscosity of the electronically controlled variable viscosity proportioner may be considered 1 Cps.

4.28 Foam Chamber Vapor Seal Requirements

4.28.1 Requirements

Burst Discs for use in Foam Chamber Assemblies shall demonstrate repeatable functionality at inlet pressures below the lowest rated operating pressure of the associated Foam Chamber Assembly.

The minimum allowable hydrostatic burst pressure for any vapor seal shall be 10 psi (0.7 bar).

The maximum allowable hydrostatic burst pressure for any vapor seal shall be 25 psi (1.7 bar).

4.28.2 Test/Verification

Each configuration of Foam Chamber body size and style, configured with the smallest and largest orifice plates shall be fitted with representative samples of the manufacturer’s specified vapor seal as it would be arranged in service.

Water shall be introduced to the Foam Chamber Assembly through the inlet at a minimal pressure as measured by a gauge installed near the flange inlet. Water pressure shall be increased at a continuous rate not exceeding 15 psi (1.0 bar) per minute until the vapor seal ruptures. The pressure at the time of rupture is to be recorded.

Three trials per each body size, orifice plate, and vapor seal combination shall be completed with acceptable results per Section 4.28.1.

4.29 United States Coast Guard Requirements

The USCG mandates additional requirements for Systems used in marine applications, as listed in Appendix G. Conformance to all the requirements of this standard are a prerequisite for the evaluations described in Appendix G.

4.30 Additional Tests

4.30.1 Additional tests may be required, at the discretion of the certification agency, depending on design features and results of any foregoing tests.

4.30.2 A re-test following a failure shall be acceptable only at the discretion of the certification agency and with a technical justification of the conditions or reasons for failure.

5 OPERATIONS REQUIREMENTS

5.1 Demonstrated Quality Control Program

5.1.1 A quality assurance program is required to assure that subsequent production of foam extinguishing systems and their components produced by the manufacturer, at an authorized location, shall present the same quality and reliability as the specific foam extinguishing system and components examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the certification examination and tests and is documented in the certification report.
- Continued conformance to this standard is verified by the certifier's surveillance program.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

5.1.2 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- Existence of corporate quality assurance guidelines;
- Incoming quality assurance, including testing;
- In-process quality assurance, including testing; (if applicable)
- Final inspection and tests;
- Equipment calibration;
- Drawings, operating manuals, and specific test procedures change control;
- Product labeling;
- Packaging and shipping;
- Handling and disposition of non-conformance materials.

5.1.3 Documentation/Manual

There should be an authoritative collection of quality procedures and policies. It should provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.4 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture.

5.1.5 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the certification report, may be required to be reported to, and authorized by the certification agency prior to implementation for production.
- Records of all revisions to all certified products shall be maintained.

5.2 Surveillance Audit Program

5.2.1 An audit of the manufacturing facility may be part of the certification agencies surveillance requirements to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to ensure a uniform product consistent with that which was tested and certified.

5.2.2 Certified products or services shall be produced or provided at, or provided from, location(s) disclosed as part of the certification examination. Manufacture of products bearing a certification mark is not permitted at any other location prior to disclosure to the certification agency.

5.3 Installation Inspections

Field installation inspections may be conducted to review an installation. The inspections are conducted to assess ease of application, and conformance to written specifications. When more than one application technique is used, one or all may be inspected at the sole discretion of the certification agency.

5.4 Manufacturer's Responsibilities

5.4.1 The manufacturer shall notify the certification agency of changes in product construction, design, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation of such changes.

5.4.2 Where all or part of the quality control has been subcontracted, including components and the formulation of the concentrate, as detailed in section 3.2.4.8; the manufacturers chosen quality control method shall be verified. This shall, at a minimum, include conducting sufficient oversight audits to verify the continued application of the required controls and/or performance testing of the components concerned.

5.4.3 The manufacturer shall provide complete instructions for the recharge and usage of systems. The instructions shall provide specific quality assurance procedures on the use of calibrated equipment, such as scales, pressure gauges, and other necessary critical equipment, in the recharging a system.

5.4.4 The manufacturer shall only specify design criteria for systems which does not conflict with NFPA 11, Standard for Low-, Medium-, and High Expansion Foam, or any other standard specifically referenced in the certification report and listing.

5.4.5 The manufacturer shall fabricate and test pressure cylinders in accordance with the standard(s) referenced in the certification report.

5.4.6 The manufacturer, or assigned representative, shall perform a documented system acceptance check and operational test in accordance with:

- the requirements outlined by the certification agency,
- the requirements of the authority having jurisdiction,
  and
- the requirements as designated in NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*.

A copy of the results should be left on site and with the owner of the foam fire extinguishing system, at a minimum.

5.5 Manufacturing and Production Tests

5.5.1 Test Requirement No. 1 - System Operation

The manufacturer shall performance test all production foam extinguishing systems in accordance with their system acceptance and commissioning documentation per the requirements of section 4.30 *System Acceptance and Commissioning Documentation* and the appropriate national or international standard(s) or requirements of the authority having jurisdiction.

5.5.2 Test Requirement No. 3 - Equipment Seat Leakage

The manufacturer shall test all production system equipment, as applicable, for seat leakage at the maximum system operating pressure for a minimum of 15 seconds with no leakage allowed.

5.5.3 Test Requirement No. 4 - Equipment Hydrostatic Strength

The manufacturer shall test all production system components, as applicable, to 150 percent of the maximum system operating pressure. The pressure shall be held for a minimum of 30 seconds with no evidence of body leakage or distortion. Following the body leakage test, all applicable equipment shall be operated with no evidence of sticking or binding.

5.5.4 Test Requirement No. 6 – Variable Viscosity Proportioner Performance Test

The manufacturer shall performance test all production Variable Viscosity Proportioners to verify the proportioning ratio in accordance with the method and requirements of section 4.26.1 or 4.27.1 as appropriate.

5.5.5 Test Requirement No. 7 - Tank/Storage Container Leakage Test

The manufacturer shall leak test all agent storage containers prior to release for shipment.

APPENDIX A:

Appendix A is left intentionally blank

APPENDIX B: Component Examination Guide

Section	*Title*	*Equipment*	*Evaluation*	*Low Expansion Systems*	*High Expansion Systems*	*CAF Systems*	*Variable Viscosity Proportioners*	*Electronically Controlled Proportioners*	*Remarks*
4.1	Examination	All Foam Systems and Components	Examination						Conformance to manufacturer's drawings and specifications and to Section 3. General Requirements.
4.2	Low Expansion Foam Concentrate Extinguishing Performance	Low Expansion Foam Systems	Extinguishing Performance	Y	-	Y	-	-	At all concentrations and with both fresh and salt water
4.3	Low Expansion Foam Quality Measurements	Low Expansion Foam Systems	Foam Quality Measurements	Y	-	-	-	-	At all concentrations and with both fresh and salt water
4.4	Qualification of Other Low Expansion Foam Discharge Devices	Low Expansion Foam Systems	Foam Quality Measurements	Y	-	-	-	-	At all concentrations and with both fresh and salt water
4.5	Proportioning Tests	Proportioning	All Proportioning Devices	Y	Y	Y	Y	Y	See section 4.28 for additional requirements for water motor driven variable viscosity proportioners and Section 4.29 for additional requirements for electronically controlled variable viscosity proportioners
4.6.1	Cold Proportioning	Foam Concentrates	Concentrate Stability	Y	Y	Y	-	-	All foam concentrates
4.6.2	Film Forming Test	AFFF & FFFP Concentrates	Film-Forming Performance	Y	Y	Y	-	-	All film forming concentrates
4.6.3	Foam Concentrate Stability	Foam Concentrates	Concentrate Stability	Y	Y	Y	-	-	All foam concentrates and test liquids.
4.6.4	Concentrate Viscosity	Foam Concentrates	Concentrate Viscosity	Y	Y	Y	-	-	All foam concentrates and test liquids.
4.6.5	Concentrate Identification Benchmarking	Foam Concentrates	Concentrate Identification Benchmarking	Y	Y	Y	-	-	All foam concentrates and test liquids. Verification of 'Fluorine Free' status of any Foam concentrates and test liquids stated by the manufacturer.
4.6.5	Foam Premix Stability	All Foam Concentrates	Premix Stability	Y	Y	Y	-	-	Applicable to all foam concentrates other than those with a 'Shall not be stored as a Premix' statement included in DIOM.
4.7	High Expansion Foam Fire Extinguishment	High Expansion Foam Systems	Extinguishing Performance	-	Y	-	-	-	At all concentrations and with both fresh and salt water
4.8	High Expansion Foam Quality Measurement	High Expansion Foam Systems	Foam Quality Measurements	-	Y	-	-	-	All concentrates at all concentrations for extinguishment tests and for generators not requiring extinguishing tests
4.9	Qualification of High Expansion Foam Generators	High Expansion Foam Systems	Foam Quality Measurements	-	Y	-	-	-	All concentrates at all concentrations for extinguishment tests and for generators not requiring extinguishing tests
4.10	High Expansion	High Expansion	Foam Generator	-	Y	-	-	-	All generators with all

Section	*Title*	*Equipment*	*Evaluation*	*Low Expansion Systems*	*High Expansion Systems*	*CAF Systems*	*Variable Viscosity Proportioners*	*Electronically Controlled Proportioners*	*Remarks*
	Foam Generator Capacity	Foam Generators	Capacity						concentrates at all concentrations
4.11	High Expansion Foam Breakdown Due to Sprinkler Discharge	High Expansion Foam Generator Breakdown due to Sprinkler	Foam Generator Capacity	-	Y	-	-	-	All generators with all concentrates at all concentrations while under sprinkler discharge
4.12	Hydrostatic Pressure Testing	All Components Capable of Pressurization	Hydrostatic Integrity	Y	Y	Y	-	Y	Includes all devices subject to water or concentrate pressure. Special requirements for valves. Pressure vessel requirements are dependent upon the code to which they are designed. CAF systems use components subject to elevated air pressure, which shall determine test pressures for those devices. See section 4.13 for requirements for concentrate control valves, section 4.26 for requirements for water motor driven variable viscosity proportioners and Section 4.27 for additional requirements for electronically controlled variable viscosity proportioners
4.13.1	Automatic Concentrate Control Valve Operation	All Pressure Operated Concentrate Control Valve Assemblies	Functional	Y	Y	Y	Y	Y	All components that have moving parts which could experience increased resistance due to thermal contraction, viscosity increases, stiffening of polymers, et cetera
4.13.2		All Electrically Operated Concentrate Control Valve Assemblies	Functional	Y	Y	Y	Y	Y	Operation outside rated voltage and at minimum and maximum temperatures
4.13.3		All Concentrate Control Valve Assemblies	Hydrostatic Integrity	Y	Y	Y	Y	Y	Hydrostatic integrity
4.13.4			Leakage	Y	Y	Y	Y	Y	Leakage to be assessed both through seats and external.
4.13.5			Leakage	Y	Y	Y	Y	Y	Leakage to be assessed both through seats and external.
4.13.6			Durability	Y	Y	Y	Y	Y	Leakage to be assessed both through seats and external following cyclic testing
4.13.7			Hydrostatic Integrity	Y	Y	Y	Y	Y	Leakage to be assessed both through seats and external.
4.14	Dielectric Withstand	All Electrically Powered Devices	Dielectric Withstand	Y	Y	Y	Y	Y	Across all combinations of two externally accessible terminals and ground.
4.15	Salt Fog Corrosion	Discharge Devices, Valves and Other Representative Components.	Salt Fog Corrosion	Y	Y	Y	Y	Y	All materials and material combinations exposed to atmosphere with function vulnerable to corrosion.
4.16	Individual Component Functionality	All Mechanical, Electrical and Hydraulically	Functional	Y	Y	Y	Y	Y	See individual protocols to verify operation of all devices under most adverse conditions

Section	*Title*	*Equipment*	*Evaluation*	*Low Expansion Systems*	*High Expansion Systems*	*CAF Systems*	*Variable Viscosity Proportioners*	*Electronically Controlled Proportioners*	*Remarks*
		Operated Devices							
4.17	Equivalent Length Determination	All Components in the system Flow Path		Y	Y	Y	Y	Y	All concentrate control valves, check valves, and other non-standard components in the flow path.
4.18	Bladder Materials	Bladder Tank Materials	Bladder Material Suitability	Y	Y	-	-	-	Air-oven aging, concentrate compatibility
4.19	Polymeric and Fiberglass Component	All Polymeric and Fiberglass Materials	Compatibility	Y	Y	Y	Y	Y	Foam liquid concentrate immersion test only applicable to materials in contact with foam concentrate. Foam solution exposure test only applicable to materials in contact with foam solution.
4.20	Foam Concentrate and Water Pumps	All Pumps Other Than Mechanically Controlled Variable Viscosity Proportioners	Foam Concentrate Pumps	Y	Y	Y	-	-	Primary assessment to FM Examination Standard 1313 also required
4.21	Monitors for use with Foam and CAFS	Manual & Oscillating	Monitors	Y	Y	Y	-	-	Primary assessment to FM Examination Standard 1421 also required
4.22	Foam Water Sprinklers	Air Aspirating and Water Sprinklers	Foam Water Sprinklers	Y	-	-	-	-	Fire extinguishment per Section 4.1. Primary assessment to FM Examination Standard 2000 or 2008 also required
4.23	Subsurface and SemiSubsurface Distribution Devices	Subsurface and SemiSubsurface Discharge Devices	Subsurface and Semisubsurface Injection	Y	-	-	-	-	Fire extinguishment
4.24	Compressed Air Foam Systems	CAF Components Not Normally Included in Foam Systems	Compressed Air Foam Systems	-	-	Y	-	-	Most tests for low expansion foam concentrates and components are applicable. Special conditions and additional tests are specified in this section.
4.25	High Expansion Foam Air Inlet and Outlet Vents	High Expansion System Inlet and Outlet Vents	Sizing, Durability, Wind Loading, Snow Loading, Icing Resistance	-	Y	-	-	-	Vent performance is critical to proper operation of foam generators.
4.26	Water Motor Driven Variable Viscosity Proportioners	All Water Motor Driven Variable Viscosity Proportioners	Performance	-	-	-	Y	-	Applicable to all mechanically controlled proportioners for proportioning across a range of viscosities.
4.27	Electronically Controlled Proportioners	All Electronically Controlled Variable Viscosity Proportioners	Performance	-	-	-	-	Y	Applicable to all electronically controlled proportioners for proportioning across a range of viscosities Pump assessment per Section 4.19.
4.28	Foam Chamber Vapor Seal Requirements	Foam Chamber Assemblies	Functional	Y	Y	Y	-	-	-
4.29	Design, Installation,	Manuals, drawings, markings	Design Review	Y	Y	Y	Y	Y	Configurations shall be compatible with stated

Section	*Title*	*Equipment*	*Evaluation*	*Low Expansion Systems*	*High Expansion Systems*	*CAF Systems*	*Variable Viscosity Proportioners*	*Electronically Controlled Proportioners*	*Remarks*
	Operation and Maintenance Manual								recommendations.
4.30	System Acceptance and Commissioning Documentation	Manuals	Design Review	Y	Y	Y	Y	Y	-

APPENDIX C: Figures

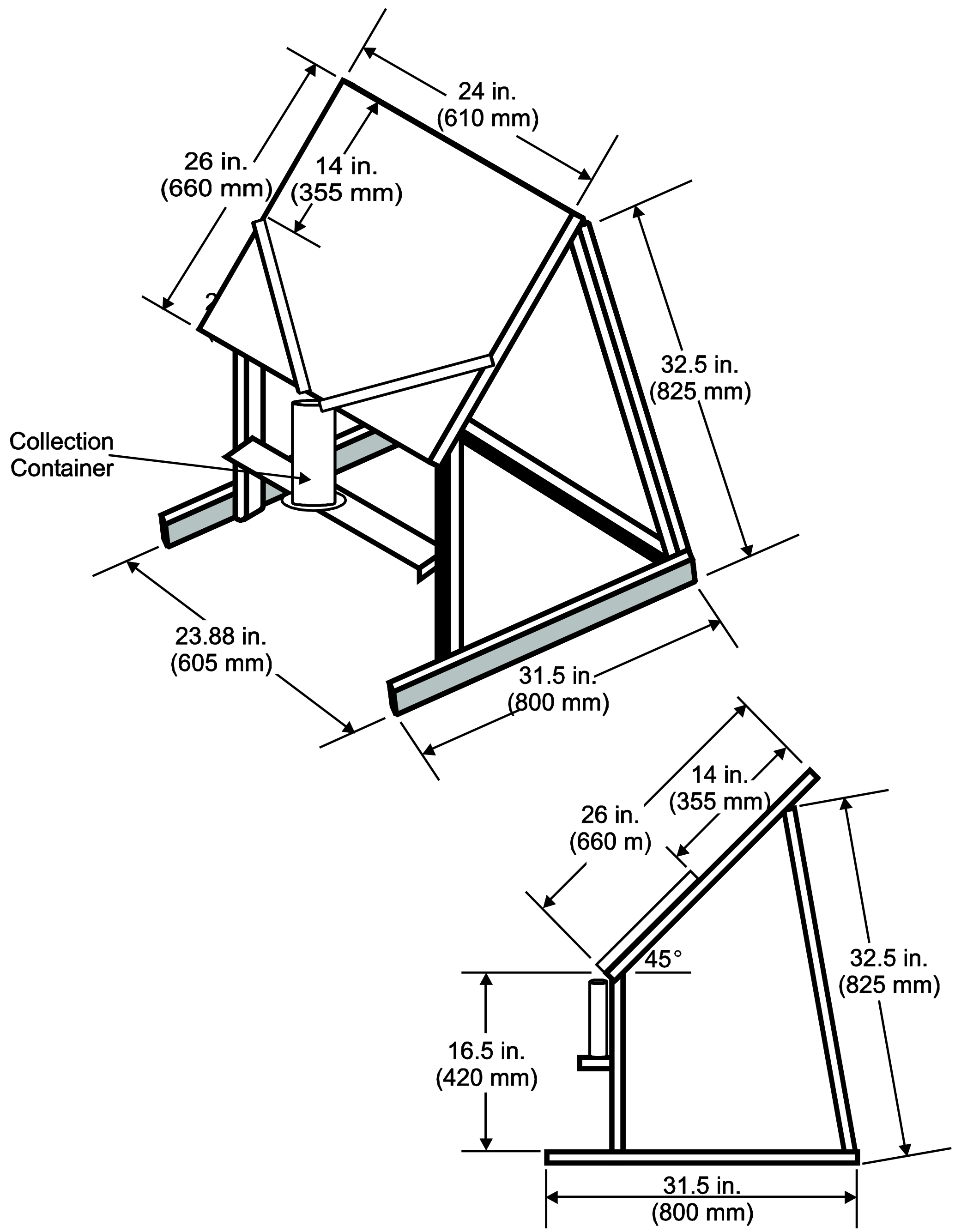

Figure C-1 *Typical Foam Slider*

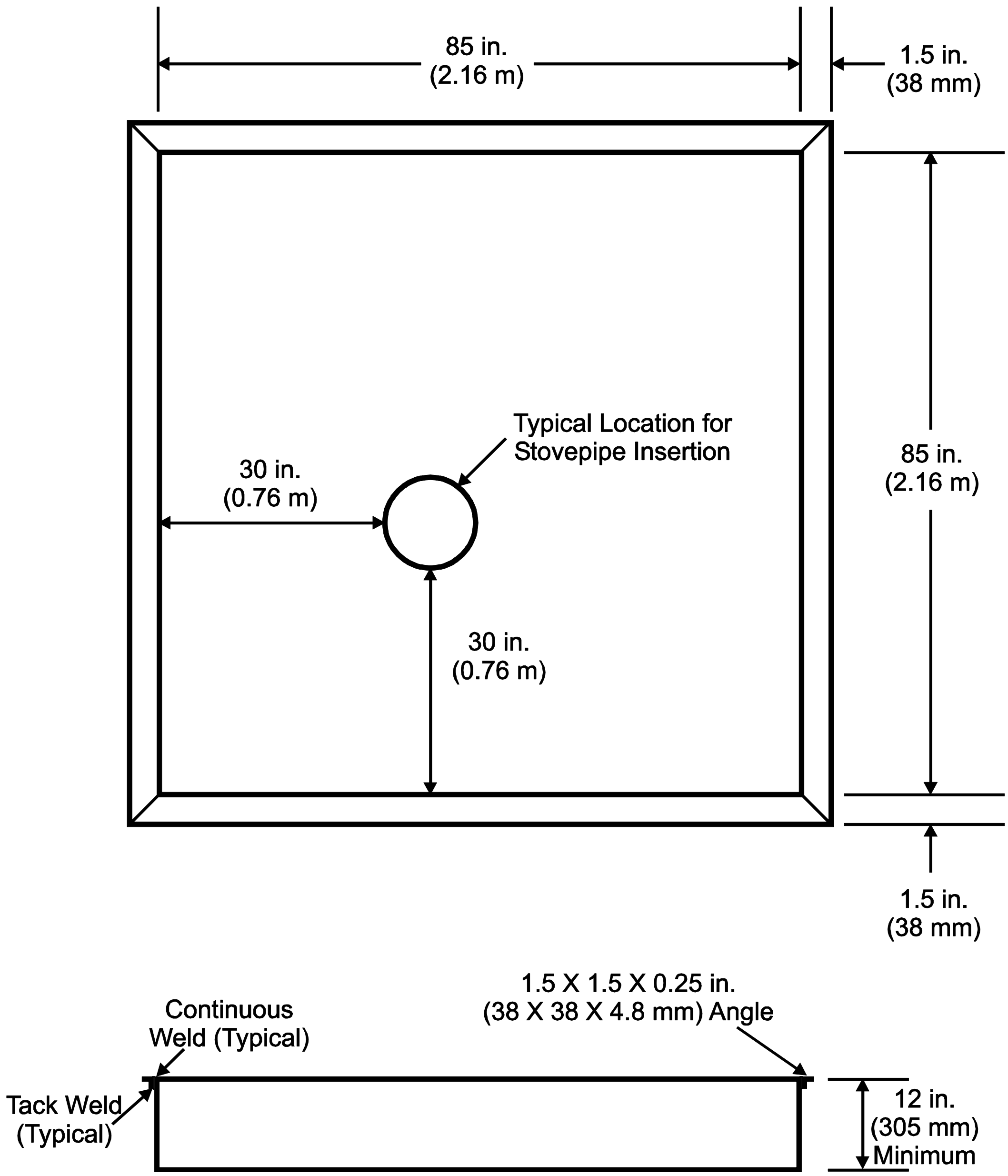

Figure C-2 *Low Expansion Fire Test Pan*

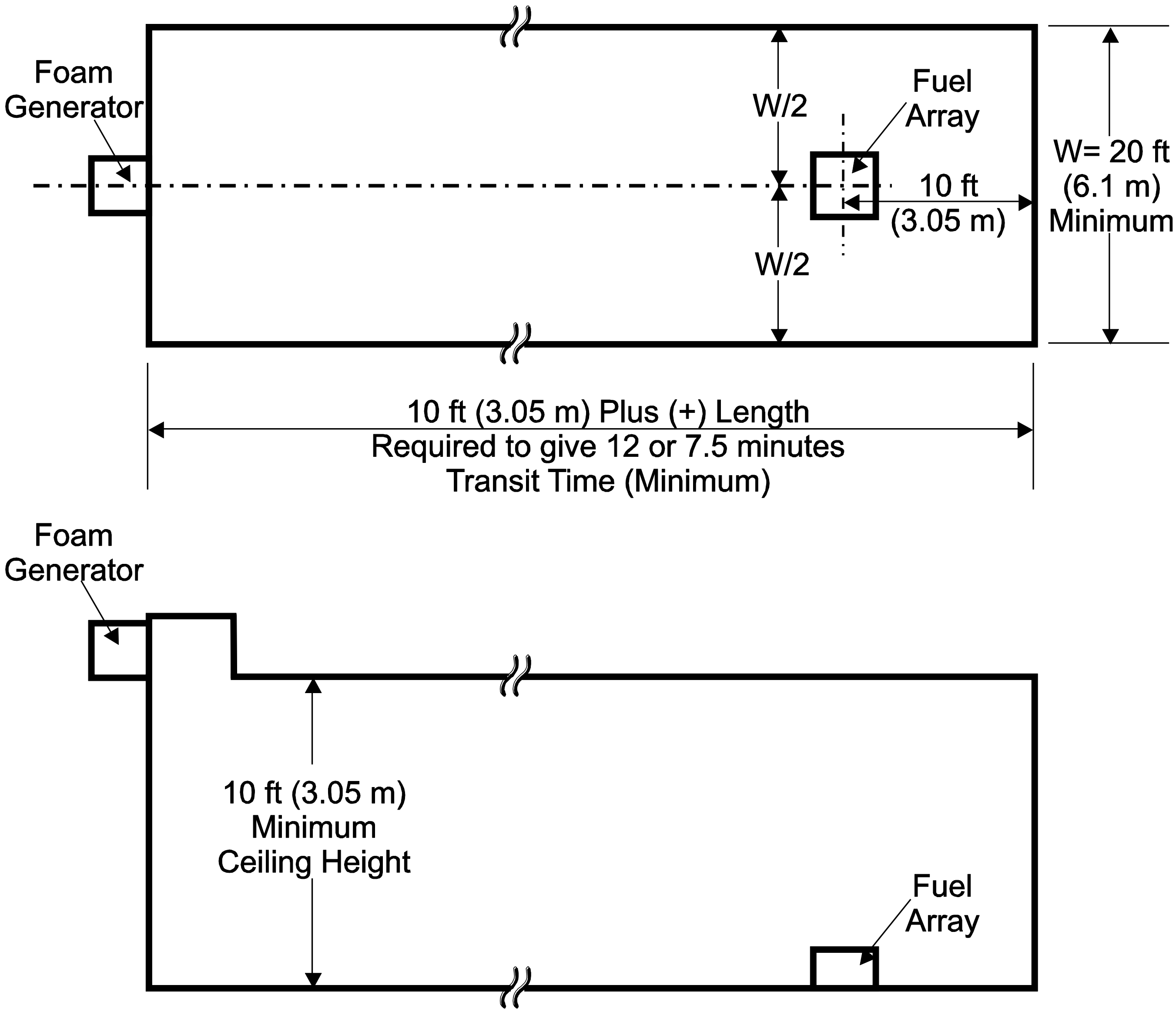

Figure C-3 *High Expansion Foam Fire Test Enclosure*

APPENDIX D: Low Expansion Foam Fire Test Configurations

Fire Test Configuration

Application Type	***Concentrate Type[1]***	***Fuel Group***	***Discharge Device Location Relative to Pan***	***Discharge Device Elevation Above Pan ft (m)***	***Minimum Test Application Rate gal/min/ft^2 (mm/min)***	***Minimum Design Application Rate gal/min/ft^2 (mm/min)***	***Remarks***
Type I	P, FP, S, FFFP (alt)	Hydrocarbon	Centered on near side	Bottom at elevation of top of pan	0.06 (2.45)	0.10 (4.1)	Device in fixed position
Type I	AFFF, FFFP	Hydrocarbon	Centered on near side	Bottom at elevation of top of pan	0.04 (1.63)	0.10 (4.1)	Device in fixed position
Type I	SFFF	Hydrocarbon	Centered on near side	Bottom at elevation of top of pan	0.04 (1.63) Higher minimum rates may be selected as specified by the manufacturer for hydrocarbon fuels	0.10 (4.1) or Test Application Rate x 1.67 whichever is greater.	Device in fixed position
Type II	P, FP, S, FFFP, (alt)	Hydrocarbon	Centered on near side with no overhang	2 ft (0.61 m) above top of pan	0.06 (2.45)	0.10 (4.1)	Nozzle in fixed position. Foam to strike backboard above far side.
Type II	AFFF, FFFP	Hydrocarbon	Centered on near side with no overhang	2 ft (0.61 m) above top of pan	0.04 (1.63)	0.10 (4.1)	Nozzle in fixed position. Foam to strike backboard above far side.
Type II	SFFF	Hydrocarbon	Centered on near side with no overhang	2 ft (0.61 m) above top of pan	0.04 (1.63) Higher minimum rates may be selected as specified by the manufacturer for hydrocarbon fuels	0.10 (4.1) or Test Application Rate x 1.67 whichever is greater.	Nozzle in fixed position. Foam to strike backboard above far side.

Application Type	*Concentrate Type[1]*	*Fuel Group*	*Discharge Device Location Relative to Pan*	*Discharge Device Elevation Above Pan ft (m)*	*Minimum Test Application Rate gal/min/ft² (mm/min)*	*Minimum Design Application Rate gal/min/ft² (mm/min)*	*Remarks*
Type II	Alcohol Resistant	Polar	Centered on near side with no overhang	2 ft (0.61 m) above top of pan	0.06 (2.45) Higher minimum rates may be selected as specified by the manufacturer	0.10 (4.1) or Test Application Rate x 1.67 whichever is greater.	Nozzle in fixed position. Foam to strike backboard above far side.
Type III	P, FP, S, FFFP (alt)	Hydrocarbon	Same as for Type II or may be moved to any non-overhanging position. Cannot move from near side until Fire Control Time has been established.	Any elevation above top of pan.	0.06 (2.45)	0.16 (6.55)	Foam discharge to strike fuel surface until Fire Control Time has been established. Subsequently, discharge may also be directed at wall.
Type III	AFFF, FFFP	Hydrocarbon	Same as for Type II or may be moved to any non-overhanging position. Cannot move from near side until Fire Control Time has been established.	Any elevation above top of pan.	0.04 (1.63)	0.10 (4.1)	Foam discharge to strike fuel surface until Fire Control Time has been established. Subsequently, discharge may also be directed at wall.

Application Type	*Concentrate Type*[1]	*Fuel Group*	*Discharge Device Location Relative to Pan*	*Discharge Device Elevation Above Pan ft (m)*	*Minimum Test Application Rate gal/min/ft^2 (mm/min)*	*Minimum Design Application Rate gal/min/ft^2 (mm/min)*	*Remarks*
Type III	SFFF	Hydrocarbon	Same as for Type II or may be moved to any non-overhanging position. Cannot move from near side until Fire Control Time has been established.	Any elevation above top of pan.	0.04 (1.63) Higher minimum rates may be selected as specified by the manufacturer for hydrocarbon fuels	0.16 (6.55) or Test Application Rate x 2.67 whichever is greater.	Foam discharge to strike fuel surface until Fire Control Time has been established. Subsequently, discharge may also be directed at wall.
Type III	Alcohol Resistant	Hydrocarbon	Same as for Type II or may be moved to any non-overhanging position. Cannot move from near side until Fire Control Time has been established.	Any elevation above top of pan.	0.04 (1.63)	0.10 (4.1)	Foam discharge to strike fuel surface until Fire Control Time has been established. Subsequently, discharge may also be directed at wall.
Air Aspirating Foam Water Sprinklers, Automatic Sprinklers[2,4]	All Low Expansion	Hydrocarbon and Polar	10 x 10 ft (3.04 x 3.04 m) spacing 4 sprinkler array centered on pan.	Manufacturer's specified minimum and maximum heights above floor[4]	See Table D-1[2]	As Minimum Test Application Rate	Five minutes of foam discharge are to be followed by five minutes of water only discharge at a minimum rate per Table D-1, for tests using fuels other than polar solvents
Automatic Sprinklers K= or >5.6[2,4]	All Low Expansion	Hydrocarbon and Polar	10 x 10 ft (3.04 x 3.04 m) spacing 4 sprinkler array centered on pan	Manufacturer's specified minimum and maximum heights above floor[4]	See Table D-1[2]	As Minimum Test Application Rate	

Application Type	*Concentrate Type[1]*	*Fuel Group*	*Discharge Device Location Relative to Pan*	*Discharge Device Elevation Above Pan ft (m)*	*Minimum Test Application Rate gal/min/ft^2 (mm/min)*	*Minimum Design Application Rate gal/min/ft^2 (mm/min)*	*Remarks*
Overhead CAF Nozzles	All Low Expansion	Hydrocarbon and Polar	Widest and most eccentric spacing specified[5]	Manufacturer's specified minimum and maximum height above floor.[4]	To be Specified by Manufacturer	As Minimum Test Application Rate	See Note 5

Notes:

1 P=Protein; FP=Fluoroprotein; S=Synthetic; FFFP=Film-Forming Fluoroprotein; AFFF=Aqueous Film-Forming Foam; SFFF=Synthetic Fluorine Free Foam; (alt) = reserved for new or innovative concentrate technologies

2 Minimum application rate(s) is based upon the assumption that the Air Aspirating Foam Water Sprinklers or Automatic Sprinklers will be tested, certified and installed on a 10 ft x 10 ft (3.04 m x 3.04 m) spacing. Typical K factors and the corresponding application rates are shown in Table D-1. Sprinklers may be tested at lower application rates but can only be certified at the application rates of Table D-1; sprinklers may not be tested at nozzle pressures below the manufacturer's specified minimum.

3 If worst case scenarios for extinguishment (combinations of concentrate, concentration, application rate, subsequent sprinkler water application rate, and fuels giving longest extinguishment times and least burnback resistance) can be identified for the lowest specified installation heights, then the certification agency may limit the number of tests required at the maximum specified installation heights.

4 The minimum allowable test and installation height for Air Aspirating Foam Water Sprinklers is 36 in (0.91 m). The minimum allowable test and installation height for Automatic Sprinklers is 72 in (1.82 m).

5 Uniformity of coverage to be separately evaluated, in non-fire distribution tests. Spacing and application rate shall be limited by minimum application rate successfully tested. Five minutes of foam discharge are to be followed by five minutes of water only discharge at a minimum rate of 0.3 gal/min/ft2 (12.2 mm/min), for tests using fuels other than polar solvents. Water discharge shall be from an overlaid sprinkler system utilizing either 5.6 K Factor or 8.0 K Factor, pendent certified sprinklers

Unless otherwise stated, all hydrocarbon fuel fires shall be extinguished at the minimum application rates tabulated. Polar solvent fuel fires, and hydrocarbon fuels where stated, may be extinguished at higher rates if so specified by the manufacturer.

Where alternate (alt) application rate minimums are offered, a concentrate will only be listed based upon the lowest rate at which it was successfully tested

Table D-1 Minimum Test/Design Application Rates for Sprinklers

Discharge Coefficient or K Factor	***Minimum Test/Design Application Rate gal/min/ft2 (mm/min)***	***Minimum Water Only Discharge Rate gal/min/ft2 (mm/min)***
5.6	0.2 (8.2)	0.3 (12.2)
8.0	0.3 (12.2)	0.3 (12.2)
11.2	0.3 (12.2)	0.3 (12.2)
14.0	0.4 (16.4)	0.4 (16.4)
16.8	0.5 (20.4)	0.5 (20.4)
22.4	0.6 (24.6)	0.6 (24.6)
25.2	0.7 (28.7)	0.7 (28.7)

APPENDIX E: Low Expansion Foam Fire Test Chronology

Event	*Target Time from Ignition, min:s*			
	Sprinklers & CAF Nozzles Reference Sections 4.2.2.7.1 and 4.2.2.9.1		**Topside Discharge *Devices*[1] *Reference Sections 4.2.2.7.2 and 4.2.2.9.2***	
	Hydrocarbon Fuels	***Polar Solvent Fuels***	***AFFF & FFFP*[2] *with Hydrocarbon Fuels***	***P, FP, S, SFFF, FFFP and (alt) foams with Hydrocarbon Fuels and Alcohol Resistant Foams with Polar Solvent Fuels***
Ignition Preburn Starts	00:00	00:00	00:00	00:00
Foam Application Starts Preburn Ends	00:15	00:15	01:00	01:00
Fire Control Time	Not Applicable	Not Applicable	Record actual time	Record actual time
Fire Out	Record actual time[3]	Record actual time[3]	Record actual time[3]	Record actual time[3]
Foam Application Ends	05:15	05:15	04:00	06:00
Water Application Starts	05:15	Not applicable	Not applicable	Not applicable
Water Application Ends	10:15	Not applicable	Not applicable	Not applicable
First Torch Pass	11:15	06:15	05:00 (or 10:00[2])	07:00
Second Torch Pass	17:15	17:15	11:00 (or 16:00[2])	18:00
Stovepipe Insertion	18:15	18:15	12:00 (or 17:00[2])	19:00
Stovepipe Ignition	19:15	19:15	13:00 (or 18:00[2])	20:00
Stovepipe Removal	20:15	20:15	14:00 (or 19:00[2])	21:00
Rift Fire Extinguished	Record actual time[4]	Record actual time[4]	Record actual time[4]	Record actual time[4]
Rift Fire > 10 ft^2	Record actual time[4]	Record actual time[4]	Record actual time[4]	Record actual time[4]
Final Observation	25:15	25:15	19:00 (or 24:00[2])	26:00

AFFF = Aqueous Film Forming Foam; FFFP = Film Forming Fluoroprotein; SFFF = Synthetic Fluorine Free Foam; P=Protein; FP=Fluoroprotein; S=Synthetic; (alt) = reserved for new or innovative concentrate technologies

At the discretion of the certification agency, chronology may vary slightly from target times, as long as the foam blanket remains undisturbed for a minimum of 10 minutes (15 minutes for polar solvent fuels) after the completion of all discharge (foam or water) and the rift fire is observed for a minimum of 5 minutes after removal of the stovepipe.

Notes:

1. Other application devices which may be used under fire protection sprinkler systems shall also be tested with 5 minutes of water application subsequent to the end of foam discharge at a minimum rate of 0.3 gal/min/ft^2 (12.2 mm/min). In such cases, the remaining target times will be increased to compensate for the added 5 minutes for the water application.
2. FFFP at 0.04 gal/min/ft^2 (1.63 mm/min) test application rate, only.
3. Fire shall be extinguished by the end of foam application.
4. If the fire in the stovepipe rift is extinguished, the time of extinguishment shall be recorded. Conversely, if the rift fire spreads to an area greater than 10 ft^2 (0.93 m^2), the time for that event shall also be recorded.

APPENDIX F: Conductivity Test Procedure

General

This method is based on changes in electrical conductivity as foam concentrate is added to water. A handheld conductivity meter is used to measure the conductivity of foam solutions in microsiemen units. Conductivity is a very accurate method, provided there are substantial changes in conductivity as foam concentrate is added to the water in relatively low percentages (i.e., 1 percent, 3 percent, or 6 percent). Since salt or brackish water is very conductive, this method might not be suitable due to small conductivity changes as foam concentrate is added. It will be necessary to make foam and water solutions in advance to determine if adequate changes in conductivity can be detected if the water source is salty or brackish. If conductivity is not an appropriate proxy for concentration due to one of these circumstances, then direct flow rate or timed volume or weight change measurements of the water and concentrate supplies shall be used to determine concentration.

Equipment Required

A base calibration curve shall be prepared using the following apparatus:

1. Four 1000-ml containers (e.g. glass beakers, plastic bottles with caps)
2. One 60-ml measuring pipette or 10-cc syringe
3. One 1000-ml graduated cylinder
4. A means of thoroughly stirring samples (A laboratory stirring device and plastic-coated magnetic stirring bars are highly recommended)
5. One portable temperature-compensated conductivity meter
6. A temperature measuring device
7. A personal computer
8. A spreadsheet program with graphing and straight line regression capability.

Procedure

Using the water and foam concentrate from the system to be tested, a minimum of three standard solutions each of minimum 500 ml volume shall be made up using the 1000-ml graduate.

At minimum, these standards shall include the nominal specified percentage of injection, the nominal percentage plus 1 or 2 percentage points, and the nominal percentage minus 1 or 2 percentage points.

The water shall be placed in the 1000-ml graduate (leaving adequate space for the foam concentrate) and then the foam concentrate samples shall be carefully added into the water using the syringe to measure the specified amount. Care shall be taken not to pick up air in the foam concentrate samples.

Each standard foam solution shall be poured from the 1000-ml graduate into a 1000-ml container. Each container shall be marked to identify the percent solution it contains. The sample shall be stirred thoroughly to mix the foam solution and care shall be taken to prevent the contents from spillage or contamination.

The samples shall be brought to the same temperature as the tested solution, 70 F ± 5 F (21 C, ± 2 C).

The conductivity of each solution shall be measured. Reference shall be made to the instructions for the specific conductivity meter to determine proper procedures for taking readings. It will be necessary to switch the meter to the correct conductivity range setting to obtain a proper reading. Most synthetic-based foams used with freshwater will result in foam solution conductivity readings of less than 2000 microsiemens. Protein-based foams will generally produce conductivity readings in excess of 2000 in freshwater solutions. Due to the temperature compensation feature of the conductivity meter, it can take a short time to obtain a consistent reading.

Once the solution samples have been measured and recorded, the bottles shall be set aside for control sample references. The standard concentrations and conductivity readings shall then be entered into a spreadsheet program and plotted with the foam solution percentage on the horizontal axis and conductivity readings on the vertical axis.

Using the spreadsheet utility, the best line shall then be fitted to the data and the equation of that line, as well as its R^2 correlation coefficient shall be obtained. If the correlation coefficient is 0.95, or higher, then the equation for that line shall be used to calculate the concentrations from conductivity readings, for that concentrate and water supply. If the correlation coefficient is less than 0.95, the test shall be repeated until data is obtained which will generate a curve fit of acceptable accuracy. This plot will serve as the known base (calibration) curve to be used for the test series.

Obtaining and Evaluating Test Samples

Foam solution samples shall be collected from the proportioning system, using care to ensure the sample is taken at an adequate distance downstream from the proportioner being tested and that the flow has been well established to flush any stagnant water from the system.

Once one or more samples have been collected and stabilized at 70 F, ± 5 F (21 C, ± 2 C), their conductivity shall be read and the corresponding percentage found using the line equation of the base curve prepared from the control sample solutions.

At the conclusion of all readings a water sample shall be obtained and a new calibration sample produced at the specified concentration to revalidate the base curve. If the measured and specified values do not match within 5 percent of the specified value, then additional calibration samples shall be made, and the software used to produce a new baseline equation. The test sample conductivities shall then be used to obtain new calculated concentrations and these averaged with those obtained from the pretest baseline to produce the final figures to be used for evaluation of the proportioning device.

APPENDIX G: United States Coast Guard Requirements

The USCG generally requires testing of foam extinguishing systems performed by the certification agency per this standard, but has some further restrictions on configurations and acceptable performance. These include:

- Only complete systems shall be certified. Component Approval shall not be allowed.
- Fire extinguishment tests shall be conducted per NFPA 11, *Standard for Low-, Medium-, and High Expansion Foam*, (2005 Edition), Annex G, Test Method for Marine Fire-Fighting Foam Concentrates Protecting Hydrocarbon Hazards.
- A safety factor of 8/3 of the successfully tested fire tested test application rate shall be used for the design application rate.
- Metallic components shall be resistant to corrosion in foam concentrate.
- Hard rubber hoses shall be certified for use with the foam solution. Tests shall include hydrostatic integrity, flexure at low temperature, and resistance to concentrate at maximum temperature.
- Discharge devices shall be constructed of corrosion-resistant materials but cannot be aluminum, brass having more than 15 percent zinc, or non-metallic materials.
- Monitors shall be tested for range. Design range of monitors shall be limited to 75 percent of the successfully tested range.
- ASME pressure tanks shall meet the criteria of Subchapter F of the CFR (Code of Federal Regulations).
- Piping for AFFF concentrates shall be stainless steel.
- Proportioners cannot be field-adjustable. They shall be factory-preset for a specific proportioning ratio.
- Foam vests (foam concentrate containers designed to be worn by personnel) shall not be certified. Eductors shall be configured to allow proportioning from 5 gal (18.9 L) concentrate containers.

APPENDIX H: Alternate Foam Quality Test Procedure

General

This method is an alternative to that described in Section 4.3 and is most useful for relatively slow draining foams, such as those with 5 minute or longer 25 percent drainage times.

Equipment Required

1. The foam slider, as described in Section 4.3.
2. A transparent or translucent collection container of 0.25 to 0.50 gal (1 to 2 L) size having a conical bottom. An inexpensive container can be made from an inverted 2 liter soft drink bottle with its bottom cut off.
3. A cock or valve to allow slow draining of liquid from the conical bottom of the container. A 1/4 in. nominal size plastic or brass valve can be fastened to the container by a length of transparent or translucent plastic tubing, a hose barb x threaded fitting, and hose clamps. A short length of tubing on the discharge side of the valve is useful to improve control of the drained fluid.
4. A receiving container for the drained fluid.
5. A stand to support the conical-bottomed collection container above the receiving container and scale.
6. A scale with accuracy of ± 0.1 g.
7. A squeegee or other straight edge for removing excess foam from the collection container.
8. A timer for measuring the drainage time.

Procedure

1. Zero the scale with the assembled empty collection container and its stand.
2. Fill the collection container with the foam solution and record the net weight. Discard the solution.
3. Collect the foam sample as described in Section 4.3, starting the timer when the container is full.
4. Clean any excess foam off the outside of the container and stand and doctor the foam surface flush with the top of the container using the straight edge.
5. Weigh the foam-filled container to obtain the net foam weight and remove from scale, recording that weight.
6. Place the receiving container on the scale and rezero the scale.
7. Divide the net foam weight by 4 to obtain the 25 percent drainage weight.
8. Place the collection container straddling, but not touching, the scale and receiving container.
9. Observe the tubing connecting the bottom of the collection container to the drain valve for presence of liquid.
10. Slightly open the valve to drain off any accumulated liquid until foam begins to emerge.
11. Repeat steps 9 & 10 until the 25 percent weight is reached and record the elapsed time as the 25 percent drainage time.
12. Divide the net weight of the solution by that of the foam and record the result as the expansion ratio.

APPENDIX I: Qualification of Proportioning Results Through the use of Flowmeters

Flowmeters may be used to obtain proportioning results – one flowmeter measuring flow through the concentrate line and one measuring flow through the water line. Proportioning percentage is determined by calculating the ratio of these flow measurements. Any manufacturer wishing to use this method to obtain proportioning results shall qualify the accuracy of the foam concentrate line flow meter. The accuracy shall be validated by comparison with results obtained using weight/time measurement.

The foam concentrate flowing through the concentrate line flowmeter shall be discharged and collected into a container. The amount of weight of foam concentrate collected shall be measured over a minimum of 30 seconds of runtime (may be increased for lower flows). Subsequently, a volumetric flow rate shall be calculated by using the concentrate's density to convert from weight to volume. The calculated volumetric flow rate shall then be compared to the flow rate measured by the flow meter. Percent error shall be determined for each test run.

Flow meter Vs weight/time measurements shall be collected for comparison as follows:

For systems using proportioners other than Variable Viscosity Proportioners, the concentrate flowmeter shall be verified at the following two (2) test points, using each foam concentrate with which it is to be certified, at a minimum:

- Concentrate flow associated with the minimum water flow of the proportioner being tested
- Concentrate flow associated with the maximum water flow of the proportioner being tested

Variable Viscosity Proportioners shall be operated at the following two (2) test points using the maximum viscosity fluid with which it is to be certified, at a minimum:

- Minimum flow, maximum backpressure, maximum fluid viscosity
- Maximum flow, maximum backpressure, maximum fluid viscosity

A minimum of two test runs shall be conducted at each test point. The percent difference resulting from the two test runs shall be averaged.

In addition, the following criteria shall apply:

- A data acquisition system (DAQ) is required when using the flowmeter measurement method.
- The flowmeters used must be appropriately sized for the expected flow range.
- All flowmeters shall be calibrated in accordance with the requirements of Section 3.6 of this standard.
- Each flowmeter model & size used to measure flow on the concentrate line shall be tested for accuracy by comparison with the weight/time method.
- Flow measurement readouts from the meter shall be collected at the same time as weight measurement during the same test run. Each flowmeter shall be tested using the smallest size of electronically controlled variable viscosity proportioner that the flowmeter will be used to conduct proportioning testing on, at a minimum. For Variable Viscosity Proportioners, the tests shall be conducted in accordance with Sections 4.26.1 or 4.27.1 of this standard as appropriate.
- For each test point, the percentage difference between the result obtained using the weight/time method and the result obtained using the flowmeter shall be determined using the equation below. The percentage difference for all measured points shall be within ± 5% of the result obtained using weight/time.

$$\text{Percentage difference} = (FM-WTM)/WTM*100,$$

where: "*FM*" = Flow reading from flow meter
"*WTM*" = Flow rate obtained using weight/time method

- After the qualification test, the manufacturer may continue to test using only the flowmeter method but with the general proportioning ratio tolerance (-0/+30%) adjusted (contracted) based on the worst case percentage difference determined during the qualification test. The adjustment shall be made as follows:
  - If the percentage difference is positive, then:

    $$\text{Minimum proportioning \% requirement} = N+(\Delta\%\, max)*N$$

    where: "N" = Nominal proportioning %
    "$\Delta\%\, max$" = Maximum positive % difference

  - If the percentage difference is negative, then no adjustments are necessary.

  In all cases, the established proportioning ratio tolerance of -0/+30% remains the maximum allowable limit and any required adjustment of the range may only result in a contraction of the allowable range.

- At the discretion of the certification agency, the qualification test as described above may be required to be rerun on additional models of Variable Viscosity Proportioner from the range of models to be certified, at any point during the test program.

APPENDIX J: Viscosity Test Procedure

Viscosity measurements shall be recorded using the following test methods:

Viscometer

The viscosity of the concentrate or test liquid shall be measured using a Brookfield viscometer, model LVT or LVF, or equivalent, while at a temperature of 68°F (20°C) and at the manufacturers stated minimum use temperature.

An appropriate straight-sided container (i.e. beaker) shall be positioned under the viscometer and the spindle shall be immersed in the liquid to the indicated depth. Spindle #2 shall be used for expected viscosity between 1 and 500 cP. Spindle #4 shall be used for expected viscosity greater than 500 cP. Measurements shall be recorded at spindle speeds of both 30 and 60 rpm. The spindle shall be allowed to rotate for a minimum of 1 minute prior to recording each measurement.

Rheometer

For non-Newtonian shear thinning concentrates or test liquids, in addition to viscometer testing, the viscosity shall be measured using a Brookfield Rheometer, model RST-CC, or equivalent, while at the temperatures of 35°F, 68°F, & 120°F (2°C, 20°C, & 49°C). If minimum or maximum rated use temperatures are outside of this range, viscosity measurements shall also be taken at those temperatures.

An appropriate straight-sided container (i.e. beaker) shall be positioned under the rheometer and the cylinder shall be immersed in the liquid to the indicated depth. Viscosity measurements shall be recorded at shear rates between 1 and 100 s^{-1}, at increments of 1 s^{-1} shear rate (100 data points). The dwell time at each point shall be a minimum of 10 seconds.

APPENDIX K: Minimum Viable System Guide

Determination of the minimum hardware required for a system to be considered complete is subject to the discretion of the certification agency. However, the each of the following components are nominally considered as the representing the minimum arrangements considered necessary for a complete system in accordance with Section 1.2.4.

- Minimum of three size fixed-system type proportioners or compatible variable viscosity proportioners assessed as suitable for the concentrate viscosity(s) intended.

  - Example: 3 size ratio controllers with bladder tanks or 3 size variable viscosity proportioner used with a certified foam concentrate pump.

- For topside discharge devices, a minimum combination of three size or types. This may consist of different foam chamber types/sizes or fire hose nozzle types/sizes or combinations of both.

- For foam-water sprinklers, a minimum of 4 sprinklers SIN's selected from the following types:

  - K5.6 upright and pendent
  - K8.0 upright and pendent
  - K11.2 upright and pendent
  - K14.0 upright and pendent
  - K16.8 upright and pendent
  - K22.4 upright and pendent
  - K25.2 upright and pendent

- For deluge nozzles a minimum of 4 different k-factors and size combinations.

  - Example 1: 2 k-factors in ½ inch and 2 k-factors in ¾ inch, or 4 k-factors in ½ inch.