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UL 139

**Outline of Investigation for Medium- and High-Expansion Foam-
Extinguishing System Equipment and Concentrates**

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Summary of Topics

This Seventh Issue of the Outline of Investigation for Medium- and High-Expansion Foam-Extinguishing System Equipment and Concentrates, UL 139, is being published to include changes to 10.4.1.

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INTRODUCTION

1 Scope

1.1 These requirements cover foam liquid concentrates, proportioning equipment, and discharging equipment for producing foam intended for fire extinguishment or control. For medium-expansion foam, the expansion ratio is 20:1 to 200:1. For high-expansion foam, the expansion ratio is 200:1 to approximately 1000:1. These requirements are based on the premise that a specific foam liquid concentrate shall be investigated for use with the intended foam equipment.

1.2 Requirements for the design, installation, operation, testing, and maintenance of foam systems for fire protection are included in the Standard for Low-, Medium-, and High-Expansion Foam, NFPA 11.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this Outline of Investigation shall comply with the requirements for that component.

2.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this Outline of Investigation; or
- b) Is superseded by a requirement in this Outline of Investigation.

2.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this Outline of Investigation shall be interpreted as referring to the latest edition of that code or standard.

5 Glossary

5.1 For the purpose of these requirements, the following definitions apply.

5.2 DISCHARGE COEFFICIENT "K" – Coefficient of discharge in the formula:

$$K = \frac{Q}{\sqrt{P}}$$

in which:

Q is the flow in gallons per minute (L/s x 15.85),

P is the pressure in pounds per square inch gauge (psig) (MPa x 145).

5.3 FIXED FOAM GENERATOR – Foam producing and discharge equipment that is installed in a fixed position and is not mobile.

5.4 FOAM – A fire fighting agent made by mechanically mixing air with a solution consisting of fresh or salt water to which a foam liquid concentrate has been added.

5.5 FOAM BREAKDOWN – The diminishing effect produced on foam by water discharged from sprinklers.

5.6 FOAM BREAKDOWN CONSTANT – An empirically determined constant used to calculate the rate, in cubic feet per minute, at which foam is diminished by sprinkler water discharge. This constant is expressed as feet to the fifth power per gallon.

5.7 FOAM CAPACITY – The foam volume, in cubic feet per minute, produced with the intended foam generator operating at an inlet pressure while flowing a specific foam solution.

5.8 FOAM CONCENTRATION – The percent of foam liquid concentrate contained in a foam solution.

5.9 FOAM LIQUID CONCENTRATE – A concentrated liquid foaming agent that is intended to be diluted with water.

5.10 FOAM QUALITY EXPANSION RATIO – A measure of foam's physical characteristics, expressed as the ratio of the final foam volume to original foam solution volume prior to the addition of air.

5.11 FOAM SOLUTION – A proportioned or premixed homogeneous mixture of water and foam liquid concentrate.

5.12 FULL SCALE EQUIPMENT – Field installed devices for proportioning foam solution or producing and discharging foam.

5.13 HEPTANE – A commercial grade hydrocarbon used as a test fuel with the following characteristics:

Minimum Initial boiling point	190°F (88°C)
Maximum Dry point	212°F (100°C)
Specific gravity (60°F/60°F) (15.6°C/15.6°C)	0.69 – 0.73

5.14 INDUCTION – A method that uses the venturi principle to introduce a proportionate quantity of foam liquid concentrate into a water stream.

a) Pressure Induction – This method utilizes the water supply to pressurize the foam liquid concentrate storage tank. At the same time, water flowing through an adjacent venturi or orifice creates a pressure differential. The difference between the water supply pressure and this lower pressure area forces the foam liquid concentrate to flow through a fixed or metering orifice into the water stream.

b) Vacuum Induction – This method utilizes the reduced pressure created by water passing through a venturi to draw the foam liquid concentrate from a storage tank or container at atmospheric pressure, through a pick-up tube and mix it with the water stream.

c) Pump and Motor Induction – This method utilizes an auxiliary pump to inject foam liquid concentrate into the water stream passing through an inductor. The inductor may be inserted in the line at any point between the water source and the discharge equipment.

5.15 INDUCTOR – A device that uses the venturi principle to introduce a proportionate quantity of foam liquid concentrate into a water stream.

a) Line Proportioner Type – The pressure at the throat is below atmospheric pressure and will draw in foam liquid concentrate from atmospheric storage.

b) Ratio Controller Type – The pressure at the throat is below the pressure at the foam liquid concentrate inlet allowing it to flow in from the pressurized source.

5.16 PORTABLE FOAM GENERATOR – Foam producing and discharge equipment that is intended to be stored so that the generator is not exposed to the fire hazard and is capable of being manually transported on an as-needed basis.

5.17 PREMIXED FOAM SOLUTION – A homogeneous mixture produced by introducing a measured amount of foam liquid concentrate into a given amount of water in a storage tank.

5.18 PROPORTIONER – A device intended to provide a continuous introduction of foam liquid concentrate at the recommended ratio into the water stream to form foam solution. The induction devices described in this document are considered proportioners.

5.19 PROPORTIONING – The continuous introduction of foam liquid concentrate at the recommended ratio into the water stream to form foam solution.

5.20 SALT WATER – Synthetic seawater complying with the Standard Practice for the Preparation of Substitute Ocean Water, ASTM D1141.

5.21 **SMALL SCALE EQUIPMENT** – Devices for proportioning foam solution or producing and discharging foam, used for the fire tests, that produce foam having a foam quality expansion ratio approximating that produced using full scale equipment.

5.22 **TRANSIT TIME** – The time required for the foam leading edge to travel from the point of foam generation to the top of the test combustibles.

CONSTRUCTION

6 Full Scale Equipment

6.1 Assembly

6.1.1 Threaded dimensions used for pipe connections shall comply with the requirements in the Standard for Pipe Threads, General Purpose, ASME B1.20.1 or other national or international pipe thread standards.

6.1.2 Flange dimensions and bolt layouts used for pipe connections shall comply with the requirements in the Standard for Pipe Flanges and Flanged Fittings, ASME B16.5 or other national or international pipe flange standards.

6.1.3 Bolts, nuts, and studs employed for the bolting of pressure-holding castings shall comply with the applicable requirements in the Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength, ASTM A307, or other equivalent national or international bolt and stud standards; and in the Standard Specification for Carbon and Alloy Steel Nuts, ASTM A563, or other equivalent national or international nut standards.

6.1.4 The load on any bolt shall not exceed the minimum tensile strength specified in the Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength, ASTM A307, or other equivalent national or international bolt and stud standards, when the equipment is pressurized to the hydrostatic test pressure as determined by the Hydrostatic Strength Test, Section 12.2. The area of the application of pressure shall be calculated as follows:

- a) If a full-face gasket is used, the area of force application is that extending out over the area circumscribed by the center line of the bolts.
- b) If an "O" ring seal or ring gasket is used, the area of force application is that extending out of the center line of the "O" ring or gasket.

6.1.5 An internal operating part whose removal is necessary during anticipated maintenance or repair shall be accessible, removable, and replaceable without damage to the equipment.

6.1.6 The construction of an operating part shall not permit it to be reassembled other than as intended if the part is disassembled during anticipated field servicing.

6.2 Materials

6.2.1 A casting shall be smooth and free from scale, lumps, cracks, blisters, sand holes, and defects of any nature that can affect the use for which it is intended. A casting shall not be plugged or filled, but is permitted to be impregnated to remove porosity.

6.2.2 Foam equipment and components constructed from brass containing more than 15 percent zinc shall resist stress corrosion cracking as determined by the 10-Day Moist Ammonia Air Stress Cracking Test, Section 12.4.

6.2.3 Foam equipment shall resist galvanic corrosion and corrosion caused by atmospheric conditions as determined by the Salt Spray Corrosion Test, Section 12.5.

6.2.4 An interior bolt, screw, or other similar fastener shall be made of bronze or of other material having the strength and resistance to corrosion at least equal to that of bronze.

6.2.5 A part that bears against, rotates within, or slides on stationary parts, and that must be free to move during intended operation, shall:

- a) Be made of corrosion resistant material, such as bronze, chrome-plated bronze, monel metal, and the like; or
- b) If made of materials lacking corrosion resistant properties, be fitted with bushings, inserts, or other parts made of corrosion resistant materials at those points where freedom of motion is required.

6.2.6 An elastomeric part other than hose shall comply with the requirements of the Elastomeric Parts Tests Other Than Hose, Section 13.1.

6.2.7 A rubber hose shall comply with the Rubber Hose Material Tests, Section 13.2.

6.2.8 Plastic or other nonmetallic components, other than an O-ring, gasket, hose, or bladder, shall comply with the requirements of the Exposure and Aging Tests for Polymeric and Fiberglass Components Used in Parts Other Than Containers, Section 13.3.

6.2.9 External plastic materials used in the construction of foam equipment shall have a flammability classification of Type HB, V-2, V-1, V-0, or 5V, when tested in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

6.3 Rated pressure

6.3.1 Foam equipment that is subjected to pressure shall be constructed of pressure retaining components and have a minimum rated working pressure of 175 psi (1.2 MPa).

6.3.2 A tank that is subjected to air, gas, or water pressure, or to a combination thereof, shall be designed, constructed, tested, inspected, and marked in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code or other national or international pressure vessel code.

6.4 Foam generators

6.4.1 Fixed and portable foam generators that include moving parts for proper operation shall be powered hydraulically by foam solution or water; or electrically by an electric motor complying with the Standard for Fire Pump Motors, UL 1004-5.

6.4.2 Portable foam generators shall include a handle or other similar device for manual transport.

7 Foam Liquid Concentrates

7.1 Storage temperature

7.1.1 The minimum storage temperature for a foam liquid concentrate shall be either minus 20°F (minus 28.9°C), 0°F (minus 17.8°C), 20°F (minus 6.7°C), or 35°F (1.7°C).

7.1.2 The maximum storage temperature for a foam liquid concentrate shall be 120°F (49°C).

7.2 Proportioning methods

7.2.1 A foam liquid concentrate shall be formulated so that it can be introduced into water flowing under pressure in pipe lines, by pressure induction, vacuum induction, or the pump-and-motor (combined with balancing valves) induction method.

7.3 Storage containers

7.3.1 A storage container for foam liquid concentrate shall have a capacity of not less than 1 gallon (3.8 L) and shall have durability, strength, and corrosion resistance at least equivalent to a container constructed of steel not less than 0.0209 inch (0.56 mm) thick. A container shall be fitted with a tamper seal or use indicator and shall be provided with a pour opening having an inside diameter not less than 1-1/2 inches (38.1 mm).

7.3.2 Storage containers shall comply with the requirements of the Drop Test, Section 14.1.

7.3.3 Nonmetallic storage containers and container materials shall comply with the requirements of the Nonmetallic Storage Container Tests, Section 14.2.

PERFORMANCE

8 General

8.1 Verification of foam concentration

8.1.1 A premixed foam solution or a water supply with a proportioning system shall be used to provide foam solution.

8.1.2 For a premixed foam solution, the foam concentration shall be verified during preparation of the foam solution.

8.1.3 For a foam solution prepared by use of a proportioning system, the foam concentration is to be verified by monitoring the foam liquid concentrate flowrate and water flowrate; or by comparing a specific property of a foam solution sample taken from the system or a discharge device to the same property of premixed foam solutions with known foam concentrations. The foam concentration of the proportioned foam solution shall comply with the Proportioning Rate Test, Section 10.1.

8.1.3.1 For verification, the specific property of a foam solution sample taken from the system or a discharge device is to be compared to the same property of premixed foam solutions with known foam concentrations. A minimum of three premixed foam solutions shall be prepared for comparison. A refractometer, conductivity meter, or other equivalent instrument (corrected for temperature, as necessary) shall be used to determine the corresponding property of each premixed foam solution and the foam solution sample. The property of each premixed foam solution shall be plotted with foam concentration as a function of the property and the equation for the linear fit to the data determined. The equation for the line shall be verified for accuracy by calculating the foam concentration of each premixed foam solution with the corresponding known property. If the calculated foam concentration of each premixed foam solution correlates to the known foam concentration of each premixed foam solution, the equation is valid and can also be used to calculate the foam concentration of the foam solution sample as a function of the specific property.

9 Foam Liquid Concentrates

9.1 Laboratory scale foam quality expansion ratio

9.1.1 When tested at least twice each, with both fresh and salt water using the same parameters and equipment settings, as described in 9.1.2 – 9.1.6, premixed foam solution prepared with as-received foam liquid concentrate shall produce foam with:

- a) For medium-expansion foam, an average expansion ratio of not less than 20:1 and not more than 200:1; and for high-expansion foam, an average expansion ratio of not less than 200:1 and not more than 1000:1;
- b) An expansion ratio for each test with the same parameters, equipment settings, and water type within ± 10 percent of the average expansion ratio with the same parameters, equipment settings, and water type; and
- c) An average expansion ratio with the same parameters, equipment settings, and salt water within ± 10 percent of the average expansion ratio with the same parameters, equipment settings, and fresh water.

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