Member of the FM Global Group

Assessment Standard

for

Proportioning Testing

Class Number 5138

April 2011

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1. INTRODUCTION

1.1 Purpose

Water equivalency proportioning and test liquid proportioning are methods of assessing the accuracy of an installed foam proportioning system without having to use the actual foam concentrate. This is intended to mitigate logistical difficulties resulting from the need to dispose of the foam solution produced in traditional proportioning tests. The use of water equivalency proportioning or test liquid proportioning should facilitate initial acceptance and annual testing of foam systems to verify their readiness. Such testing must be conducted with substantial discipline by properly trained personnel to be accurate and representative of the true performance of the proportioner. All such testing requires a baseline acceptance test in which the foam concentrate (or a proxy test liquid) is actually proportioned into water to establish performance of the proportioning system in its installed state. This baseline acceptance is then repeated using water or a test liquid in lieu of the concentrate. Since it can be reasonably assumed that any change in the true proportioning rate would be signaled by a change in the water equivalency proportioning rate or the test liquid proportioning rate, subsequent annual testing can be performed without flowing the concentrate, unless there is a substantial change in the water proportioning rate or test liquid proportioning rate.

1.2 Scope

1.2.1 This standard sets performance requirements for commercial entities providing evaluations of installed foam system proportioning accuracy.

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 water equivalency proportioning services. Services having characteristics not anticipated by this standard may be accepted if performance equal, or superior, to that required by this standard is demonstrated, or if the intent of the standard is met.

Alternatively, services that meet all of the requirements identified in this standard may not fall under the scope of this standard if other conditions which adversely affect performance exist or if the intent of this standard is not met.

1.4 Basis for continuance of validity of Certificate of Assessment

Validity of the Certificate of Assessment is based upon:

- The continued use of acceptable quality assurance procedures;
- Satisfactory field experience;
- Compliance with the terms stipulated in the Master Agreement
- Satisfactory Facilities and Procedure Audits (F&PAs) conducted as part of a follow-up program

1.5 Effective Date

The effective date of this standard is **30 April 2011** for full compliance with all requirements.

1.6 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. Appendix A lists the selected units and conversions to SI units for measures appearing in this standard. Conversion of U.S. customary units is in accordance with the Institute of Electrical and Electronics Engineers (IEEE)/ American Society for Testing and Materials (ASTM) SI 10 - 2002, American National Standard for Use of the International System of Units (SI): The Modern Metric System. One unit (liter), outside of but recognized by SI, is commonly used in international fire protection and is used in this standard.

1.7 Applicable Documents

This standard is used in conjunction with the following standards

ASTM E 729 – 96 (2007), Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians

FM Approvals, Approval Standard 5130, Approval Standard for Foam Extinguishing Systems, January 2011

FM Global Property Loss Prevention Data Sheet 2-81, Fire Protection System Inspection, Testing and Maintenance and Other Fire Loss Prevention Inspections, September 2008

FM Global Property Loss Prevention Data Sheet 4-3N, Medium- and High-Expansion Foam Systems, September 2010

FM Global Property Loss Prevention Data Sheet 7-93N, Aircraft Hangars, September 2004

FM Global Property Loss Prevention Data Sheet 4-7N, Low Expansion Foam Systems, September 2010

FM Global Property Loss Prevention Data Sheet 4-12, Foam-Water Sprinkler Systems, September 2010

IEEE/ASTM SI 10 - 2002, American National Standard for Use of the International System of Units (SI): The Modern Metric System

National Fire Protection Association (NFPA) 11, Standard for Low-, Medium-, and High Expansion Foam, 2010 Edition

NFPA 16, Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems, 2011 Edition

NFPA 409, Standard on Aircraft Hangars, 2011 Edition

United States Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances (EPA OPPTS) 850.175, Fish Acute Toxicity Test, Freshwater and Marine

US EPA OPPTS 870.1100, Acute Oral Toxicity

US EPA OPPTS 870.1200, Acute Dermal Toxicity

US EPA OPPTS 870.2500, Acute Dermal Irritation

1.8 Definitions

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

Around the Pump Proportioner

See Pump Proportioner.

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.

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.

Concentration

The volume percent of a foam concentrate in water.

Concentration Ratio

See Concentration.

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.

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.

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 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 Solution

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

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.

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.

Mixture Strength or Ratio

See Concentration.

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.

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 similar in function to an inline eductor, except that it uses a foam concentrate supply at a pressure higher than atmospheric.

Proportioning

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

Proportioning Testing Method Provider

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

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.

Specified

The value of a design parameter set by the manufacturer.

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 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 testing of a foam system.

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 testing of a foam system.

2. GENERAL INFORMATION

2.1 Requirements

The proportioning testing assessment shall be available to any commercial entity, irrespective of its affiliation or lack of same with any manufacturer of foam fire extinguishing systems.

The object of the assessment of these proportioning test methods is to assess alternate test methods from the discharge of foam concentrate and foam-water solutions in an accurate and consistent manner. The evaluation of these proportioning test methods is the assessment of the engineering requirements for successful testing, their ability to provide clear procedures for the testing, their training procedures and, their selection and maintenance of instruments and equipment appropriate for this testing, reporting the results in a clear and useful format, and procedures in dealing with the water and foam-water solution discharges so as to minimize the impact on the customer's facility.

Because of their complexity, foam proportioning systems require annual exercise and testing to maintain readiness. This testing has become increasingly burdensome for property owners, due to the difficulty and cost of control and disposal of waste foam solution generated in these tests. Water equivalency or test liquid proportioning testing is intended to eliminate this concern after the initial baseline acceptance testing has been performed. However, that baseline acceptance testing with concentrate is critical to accurate water equivalency results due to the variety of configurations possible for installed systems. FM Approvals will not consider procedures not including this baseline acceptance testing at each site without rigorous engineering analysis to validate an alternative procedure. Such procedures may include use of an accepted test liquid for the specific concentrate in use at the site.

3. GENERAL REQUIREMENTS

3.1 Documentation

The provider of the testing shall maintain a library of foam system manufacturer literature including equipment manuals, concentrate characteristics; material safety data sheets (MSDSs), codes and standards, and other references required for the provision of the service. The provider shall reference FM Approval listings for capacities and other relevant specifications for foam proportioning equipment.

3.2 Physical or Structural Construction Features

3.2.1 Test Liquids

Test liquids shall meet environmental requirements specified by the authority having jurisdiction.

Aquatic Toxicity

At minimum, test liquids specified maximum strength solutions to be used in the United States of America shall be tested using *Oncorhynchus mykiss* (rainbow trout) in accordance with ASTM E 729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians*, or OPPTS 850.175, *Fish Acute Toxicity Test, Freshwater and Marine*, or with an equivalent test procedure acceptable to the authority having jurisdiction.

Per ASTM E 729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians*, fish, 60 days (+/- 15 days) post hatch, shall be exposed under static conditions to test liquids maximum strength solutions in soft water for 96 hours at 54ºF, +/-2ºF (12ºC, +/- 1ºC). The LC_{50} concentrations shall be determined. These tests shall be conducted by an independent laboratory certified for toxicity testing and shall be submitted to FM Approvals. FM Approvals shall cite the toxicity levels in the Approval Report (Class 5130) for the test liquid.

Alternative Toxicity Evaluations

The toxicity of test liquids which are simple solutions or mixtures of non reacting components may be evaluated by examining the toxicity data for their components. A manufacturer choosing to submit such data shall be responsible for organizing the information for ready correlation to the test liquid composition for FM Approvals review.

3.3 Calibration

All equipment used shall be calibrated within an interval determined on the basis of stability, purpose, and usage of the equipment. A copy of the calibration certificate for each piece of test equipment is required for FM Approvals' records that indicate that the calibration was performed to standards traceable to the National Institute of Standards and Technology (NIST) or to other acceptable reference standards by an accredited ISO 17025 calibration laboratory. The test equipment must be clearly identified by label or sticker showing the last date of the calibration and the next due date. In addition, a copy of the ISO 17025 accreditation certificate for the calibration laboratory is required for FM Approvals records.

The calibration of recently purchased new equipment is also required. Documentation indicating either the date of purchase or date of shipment, equipment description, model and serial number is required for identification. The period from the time the equipment was put into service to the date of testing must be within an interval that does not require the equipment to be calibrated as determined on the basis of the parameters mentioned above.

4. PERFORMANCE REQUIREMENTS

4.1 Engineering Requirements

4.1.1 Requirement

The provider of the testing shall maintain a library of foam system manufacturer literature including equipment manuals, concentrate characteristics; material safety data sheets (MSDSs), codes and standards, and other references required for the provision of the service. The provider shall reference FM Approval listings for capacities and other relevant specifications for foam proportioning equipment.

4.1.2 Test/Verification

Each proportioning test method provider location shall be audited by an FM Approvals representative. During the audit, reference material shall be reviewed for appropriateness and completeness for the range of proportioning equipment and methods to be assessed. The engineering requirement shall document a comprehensive understanding of the relationships between flow, pressure, and viscosity. Explanation of the differences among the various commonly used types of proportioning to the provider's proportioning test method(s) will be documented. Any limitation identified from review of the proportioning testing method for each type of proportioning to be assessed.

4.2 Procedures

4.2.1 Requirement

Specific procedures shall be developed for use by trained personnel for appropriate and consistent rendering of the proportioning test method.

4.2.2 Test/Verification

The provider's written procedures shall be reviewed for completeness, clarity, and correctness.

At minimum, these procedures shall address the test configurations and required instruments and other devices required for each proportioning configuration(s) for proportioning testing, the sequence of actions required to conduct successful tests, and the format for reporting results.

In general, such procedures shall include:

- Determining the flows at which testing will be conducted, based upon the foam system design flows.
- Verifying that the Approved range for the proportioner is appropriate for the foam system design flow range. If not, the property owner shall be notified that the system design requires review before testing will be useful.
- Conducting baseline acceptance testing incorporating actual proportioning of the concentrate into the water flow to measure the proportioning ratio over the range of flows required.
- Measuring proportioning ratio by an appropriate means such as measurement of the water and concentrate flows, conductivity, refractometry, or other techniques valid for the installed configuration and concentrate.
- Collecting and disposing of the solution created in testing in conformance to local regulations and the property owner's requirements.
- Instrumenting and otherwise reconfiguring the system to allow introduction of the test liquid or measurement of water flow in the concentrate line during the baseline acceptance testing without contamination of the concentrate supply.
- Measuring the test liquid proportioning ratios by appropriate means such as conductivity or refractometry related to appropriate calibration sample test measurements for the flows corresponding to the minimum and maximum flows used for the concentrate proportioning tests., if using the test liquid method, or
- Calculating the water equivalent proportioning ratios for the flows corresponding to the minimum and maximum flows used for the concentrate proportioning tests, if using the water equivalency method.
- Reporting the test liquid or water equivalency baseline acceptance concentration ratios, test flow rates, test pressures, and equivalent water flows to the property owner for subsequent annual retests of the foam system.
- Providing a durable placard on each proportioner listing the as-installed measured proportioning ratios at flows, as determined in the baseline acceptance testing.
- Restoring the system to the proper configuration for use.

4.3 Training of Personnel

4.3.1 Requirement

The proportioning testing provider shall establish and maintain a program for training and qualifying its representatives for proper provision of the service, maintain a listing of and training records for all qualified persons, and shall only assign fully qualified persons to responsible on-site supervision of the testing service.

4.3.2 Tests/Verification

FM Approvals shall review the training program and records for completeness, clarity, and correctness. A sampling of the individual qualified persons shall be interviewed and demonstrate acceptable familiarity with the test liquid or water equivalency proportioning testing process, as appropriate.

The competence of qualified personnel shall also be assessed during a minimum of one customer site visit by FM Approvals for witnessing of rendering of the service.

4.4 Equipment and Instrumentation

4.4.1 Requirement

The proportioning testing provider shall select and maintain all equipment and instrumentation required for provision of the service. All equipment and instrumentation shall be selected and maintained as appropriate to the specific proportioning testing method for each type of proportioning included in the assessment. At minimum, this shall include:

- Flow measuring equipment adequate for the full water flow of the system.
- Pressure gauges for diagnostic evaluation of the proportioning system.
- Digital conductivity meters and refractometers.
- Beakers, graduate cylinders, droppers or pipettes, sample bottles, and scales for preparation and measurement of conductivity and refractometry samples.
- Flow measuring equipment for the waterflow measurement through the concentrate line, if using the water equivalency method.
- Hoses for connecting foam solution and water discharge to suitable disposal areas or facilities.
- Tools and materials for installation of test equipment.
- Batch or lot certifications for test liquids.

4.4.2 Tests/Verification

FM Approvals shall review equipment and instrumentation selection for appropriateness and adequacy for rendering of the proportioning testing method for each type of proportioning included in the assessment. Specifically,

- Water flow measuring equipment (both main water flow and concentrate line water flow) and pressure gauges shall be capable of +/- 5 percent accuracy.
- Conductivity and refractometry equipment shall be capable of +/-1 percent accuracy.
- Scales for weighing solution samples shall be capable of +/-0.01 g (+/-0.00035 ounce) resolution.

FM Approvals shall verify that a program of maintenance and calibration for all instrumentation is in place, documented, and practiced. All calibrations shall be performed by an agency certified per ISO 17025.

An FM Approvals representative shall examine equipment and review appropriate records to confirm their maintenance and calibration per the documented procedures for the proportioning test method.

4.5 Reporting Testing Results

4.5.1 Requirement

The proportioning testing provider shall maintain complete, accurate, and clear records of testing performed of the proportioning testing method for the sites having tests conducted.

4.5.2 Tests/Verification

FM Approvals shall review test records at each site using the proportioning test method. Records shall be coherently filed and readily retrievable for this review. A minimum of three records for each type of proportioning to be assessed different tested locations shall be randomly selected for this review. These records shall be cross-checked against training records to verify that trained personnel were on site, in responsible charge of all tests.

4.6 Customer Site Visit

4.6.1 Requirement

The proportioning testing method provider shall demonstrate the performance of the proportioning testing method each type of proportioning to be assessed at a customer site.

Or

The performance of the proportioning testing method shall be demonstrated at a customer site.

4.6.2 Tests/Verification

The proportioning testing method provider shall arrange for an FM Approvals witness to accompany trained personnel to an actual customer site to review the performance of the proportioning test method during an initial session to establish the baseline acceptance ratios, including the actual flowing of foam concentrate to make foam solution.

The proportioning testing method provider shall also arrange for an FM Approvals witness to accompany trained personnel to an actual customer site to review the performance of the proportioning test method during a follow-up visit to check the proportioning against the baseline acceptance test data by use of the test liquid or water equivalency method only.

4.7 Test Liquids

4.7.1 Requirement

A test liquid shall exhibit the proportioning performance as the concentrate for which it is intended to be a proxy.

Test liquids and correlating foam concentrates shall be subjected to a viscosity measurement and Fourier transform infrared spectroscopy (FTIR) analysis to obtain a benchmark profile for future re-examination reference.

4.7.2 Test/Verification

The proportioning tests of Approval Standard 5130 Section 4.4 shall be conducted with both the test liquid and the referenced concentrate using a minimum of one proportioner listed with the concentrate. Proportioning rates shall meet the requirements of Approval Standard 5130 Sections 4.4.2.2 and 4.4.2.4 with no change in proportioner settings between the two fluids.

A 0.25 gal (1 L) minimum sample of each test liquid and correlating foam concentrate submitted for Assessment shall be provided for viscosity measurement and FTIR analysis. The FTIR analysis shall be conducted in the FM Global Research Laboratory or at another laboratory acceptable to FM Approvals. The resulting spectrum shall be retained by FM Approvals for use in identifying deviations from the as-Assessed composition, either through formulation changes, production process faults, or contamination of installed systems. Viscosity measurement shall be performed as described in Appendix J of Approval Standard 5130.

5. OPERATIONS REQUIREMENTS

A quality assurance program is required to assure that services rendered by the provider shall present the same quality and reliability as the specific system(s) examined. Process methodology, conformance to the methodology, and record keeping are the areas of primary concern.

5.1 Facilities and Procedures Audit (F&PA)

5.1.1 The proportioning test method developer shall demonstrate continued conformance to the requirements of Assessment Standard 5138 as a condition of continuance of offering the service for the water equivalency proportioning test method.

5.1.2 An FM Approvals representative shall perform an unannounced follow-up F&PA at a minimum annual frequency at each site providing the proportioning test method. Every individual site operated by the proportioning test method developer shall demonstrate ongoing conformance to the requirements set forth in this standard as a condition of continuance of offering the service for the water equivalency proportioning test method.

5.2 Installation Inspections

Field 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 discretion of FM Approvals.

5.3 New or Alternate Testing Procedures

Submittals to FM Approvals for new or alternate testing procedures should include documentation of the performance objective and applicable scenario, together with any calculations, modeling, or other technical substantiation used to establish the performance of the methodology and installation criteria. A written expert engineering opinion, as deemed necessary, shall be engaged to evaluate the documentation of the new methodology and/or technology to confirm adequacy for proportioner test assessments. Additional information and data from review of the expert engineering opinion to assist in the determination of adequacy of the methodology to be equivalent shall be submitted, as deemed necessary.

5.4 Document Control

The proportioning testing provider shall establish a system of document control that shall allow no unauthorized changes to the proportioning testing method. Changes to critical documents, identified in the Assessment Report, must be reported to, and authorized by, FM Approvals prior to implementation.

APPENDIX A: Units of Measurement

AREA: in^2 - "square inches"; (mm^2 - "square millimeters")
$mm^2 = in^2 \times 6.4516 \times 10^2$

ft^2 - "square feet"; (m^2 - "square meters")
$m^2 = ft^2 \times 0.0929$

FLOW RATE: gal/min - "gallon per minute"; (L/min - "liters per minute")
L/min = gal/min x 3.785

FORCE: lb - "pounds", (N - "newtons")
N = lb x 4.448

HEAT: Btu - "British thermal units"; (J - "joules")
$J = Btu \times 1.0551 \times 10^3$

HEAT RELEASE RATE: Btu/min - "British thermal units per minute"; (kW - "kilowatts")
kW = Btu/min x 0.0176

LENGTH: in. - "inches"; (mm - "millimeters")
mm = in. x 25.4

ft - "feet"; (m - "meters")
m = ft x 0.3048

LIQUID: gal - "gallons"; (L - "liter")
l = gal x 3.785

MASS: lb - "pounds"; (kg - "kilograms")
kg = lb x 0.454

PRESSURE: psi - "pounds per square inch"; (bar - "bar")
kPa = psi x 6.895
bar = psi x 0.06895

TEMPERATURE: °F - "degrees Fahrenheit"; (°C - "degrees Celsius")
°C = (°F - 32) x 0.556

APPENDIX B: Assessment Information

Proportioning Testing Provider's name and address

Proportioning Testing Method: (*Water Equivalency or Test Liquid*)

Type of Proportioning Assessed	*Procedure/Document Number*	*Percent Concentration*	*Minimum Flow Capacity*		*Maximum Flow Capacity*	
			gal/min	*(L/min)*	*gal/min*	*(L/min)*

Orientations, piping configurations, or other considerations that may limit the effectiveness of the proportioning testing method and which reflect the proportioning testing provider's specified conditions under which it was tested.

Test Liquids:

List by trade name, type (AFFF, Alcohol Resistant, Protein, High Expansion, et cetera), concentration percent.

Test Liquid Designation	*Type*	*Foam Concentrate*	*Foam Concentrate Manufacturer*