FIRE PROTECTION LABS
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Foam Testing Explanation

Physical Properties

The physical properties described below are tested as part of fire-fighting foam concentrate and premix solutions analyzed by Dyne Fire Protection Labs. Physical properties tested on all foam and premix solution samples include Appearance, Refractive Index (if applicable), pH, Density, and Viscosity (if applicable). The physical property specifications are based on the most current published specifications provided by the manufacturer. If the brand or type is not known, a generic specification encompassing all of the brands is used. Physical properties of wetting agents, vapor suppressions, and other products may be affected differently. Please contact Dyne Fire Protection Labs if you have any questions about physical properties tested at Dyne.

The physical properties are not a measurement of performance and as such will not typically cause the sample to FAIL, with the exception of extremely low viscosities on AR-AFFF samples and out of spec pH results for foam tested to the International Maritime Organization (IMO) specification. If the value is outside of the specification, it is simply noted as OUT OF SPEC.

It is not uncommon for the physical properties to change as the foam ages and often times a change in a physical property does not adversely affect performance. However, the physical properties can provide valuable information as to how well the sample is aging, and also help indicate the reason why a sample is failing a performance. Please note that any of the physical properties can be OUT OF SPEC simply because the brand or type of foam is not accurately recorded. *It is the responsibility of the property owner or designated representative to ensure the sample information is correct (brand, type, etc.)* Note, if the customer designates the sample as freeze protected, and the physical properties are out of specification, it may be because the sample is not a freeze protected but is a standard foam concentrate. The testing completed by Dyne does not ensure the sample is freeze protected.

Physical Property Test Type	Definition	Possible Reasons Why Value is Out of Spec
Appearance	Appearance is the description of the color and consistency. The visible presence of sediment, particulates, rust, and mineral oil may also be reported.	If the appearance is different than the requirement, it can indicate several things such as: • Normal aging of the foam • A different type or brand of foam than indicated • Topping the tank off with a different brand or type of foam Other issues that may be found during the appearance test, but will appear as a comment on the foam report: • Sediment, particulates, or rust-coloring which are often the result of corrosion. • Presence of mineral oil, a material that manufacturers recommend to prevent evaporation of the foam.

Physical Property Test Type	Definition	Possible Reasons Why Value is Out of Spec
Refractive Index	The refractive index is a measurement of the angle in which light bends as it passes through the sample. The refractive index is proportional to the amount of solvent in the sample.	A refractive index less than the specification indicates: • A different type or brand of foam than indicated • The foam is diluted with water. If a foam is slightly diluted, it may still pass the performance specifications. However, if the foam is severely diluted, it will no longer pass the performance specifications and replacement is recommended. The refractive index of tap and sea water is approximately 1.3330 and 1.3393, respectively. • If the foam is indicated as a foam concentrate on the report, it may actually be a premixed solution A refractive index greater than the specification indicates: • A different type or brand of foam than indicated • A material with a higher refractive index has been added to the sample
Density (Specific Gravity)	The density is a measurement of the weight of a specified volume and is reported in grams per milliliter. Some labs report this as specific gravity, which is the relative density compared to water.	Typical class-B foams - such as AFFF, AR-AFFF and protein-based foam concentrates - have a density greater than water. Other types of foam concentrates - such as class-A, high expansion foams, or wetting agents - can have a density similar to or less than water. The density of tap and sea water is approximately 0.998 and 1.023 grams per milliliter at 20 °C, respectively. A density less than the specification indicates: • A different type or brand of foam than indicated • The foam is diluted with water. If a foam is slightly diluted, it may still pass the performance specifications. However, if the foam is severely diluted, it will no longer pass the performance specifications and replacement is recommended. A density greater than the specification indicates: • A different type or brand of foam than indicated • A material with a higher density has been added to the sample such as a different type or brand of foam concentrate.
pH	pH determines the acidity/basicity (ion activity) of the sample.	Unless otherwise specified by the manufacturer, the typical pH range of foam concentrates is 6.0-9.5: • A pH less than 6.0 means that the sample is acidic • A pH greater than 9.5 means the sample is basic • A pH outside of 6.0-9.5 often indicates corrosion within the tank or degradation of the foam concentrate Please note: The International Maritime Organization Specification MSC 1312 and NFPA 18 (Standard on Wetting Agents) requires foam concentrate to have a pH between 6.0 and 9.5 and 6.0 and 9.0, respectively. If a foam sample is being tested to one of these specifications, and has a pH outside of this range, the sample will FAIL regardless of the other test results.

Physical Property Test Type	Definition	Possible Reasons Why Value is Out of Spec
Viscosity	Viscosity is the measure of the apparent thickness of a sample. Only tested on viscous samples, such as alcohol resistant foam concentrates.	A viscosity less than the specification indicates: • The sample is diluted with water or another type or brand of foam such as a standard AFFF • Foam may be stored in an inappropriate environment or container causing the polymer to drop out of solution or degrade A viscosity greater than the specification indicates: • Normal aging of the foam – the polymer can hydrate after manufacture • A different type or brand of foam than indicated • Foam may be stored in an inappropriate environment or container • Contamination If the viscosity is greater than the specification, the system may proportion below its nominal concentration. If the viscosity is less than the specification, the system may proportion above its nominal concentration. If the viscosity is out of specification but the foam is passing the performance specifications, the system concentration (proportioning) should be tested. Please note: If a viscous foam sample has a viscosity less than ½ of the minimum requirement, the sample will FAIL as there is concern over the alcohol resistant properties of the foam concentrate. Customers may request a polar burnback test to determine if their concentrate is expected to hold up against polar solvents.

Performance Properties

The performance properties are designed to test the foam's ability to perform effectively in a fire situation. If a sample FAILS a performance property, it will typically FAIL the overall result. There are a couple tests in the performance section of the report that will be indicated as INFO ONLY. This is because these results are not directly correlated with the performance of a foam in a fire situation but can give a customer important insight about the condition of their foam and system.

The performance requirements are set by the manufacturer if specifications are provided. If the manufacturer does not provide specifications, the requirements are determined by the National Fire Protection Association (NFPA) or the International Maritime Organization (IMO) MSC 1312/USCG Title 46 Requirements.

Performance Test Type	Definition
Low Expansion	The expansion of low expansion foam is measured by generating foam through an air aspirated nozzle. The expansion ratio refers to the ratio of the volume of foam generated to the volume of the original foam solution. If the expansion is below the minimum requirement, the foam performance can be compromised, particularly if used in non-air aspirated application devices.
Drain Time	The drain time is a measurement of the time for 25% (low expansion foams) or 50% (high expansion foams) by weight of the expanded foam, generated in the expansion test, to drain back into foam solution. The minimum drain time will vary depending on the type of foam tested. For example, a standard aqueous film forming foam (AFFF) will have a faster drain time than an alcohol resistant aqueous film forming foam (AR-AFFF). If the drain time is below the minimum, the performance can be compromised, particularly the foam's ability to secure a spill and to maintain coverage until the fire is fully extinguished.
High Expansion	The expansion of high expansion foam is measured by dispensing the solution through a high expansion foam generator. The expansion ratio refers to the ratio of the volume of foam generated to the volume of the original foam solution. If the expansion ratio of a high expanded foam is below the minimum, the foam will not fully fill the intended enclosure and the fire may not extinguish.
Film Formation and Sealability	The film formation and sealability tests are conducted on film forming foams only - such as aqueous film forming foam (AFFF), alcohol resistant aqueous film forming foam (AR-AFFF), and film forming fluoroprotein foams (FFFPs). These two tests demonstrate the ability to form a film and seal on cyclohexane. NFPA 11 defines a film forming foam as having a positive spreading coefficient. Dyne's film formation test requires a foam to have a positive spreading coefficient to pass. Therefore, a sample that passes Dyne's film formation test has a positive spreading coefficient and meets the film formation requirement. However, a sample that fails Dyne's film formation test could still have a positive spreading coefficient. In the case of a failure on Dyne's film formation test, the spreading coefficient will be calculated and reported to determine a foam's ability to form a film.
Spreading Coefficient	The spreading coefficient is a measurement of the ability of one liquid to spontaneously spread across another. NFPA 11 defines a film forming foam as having a positive spreading coefficient. The spreading coefficient is calculated as follows: *Spreading Coefficient = Surface Tension of Cyclohexane (dynes/cm) – surface tension of the foam solution (dynes/cm) – interfacial tension between the cyclohexane and foam solution interface (dynes/cm)*
Surface Tension	The surface tension is a measurement of the cohesiveness of the solution surface. It is measured in fire-fighting foam to predict the ability of the foam to wet a surface. NFPA 18 specifies a maximum surface tension for wetting agents.

Performance Test Type	Definition
Concentration (%)	The concentration of a foam solution is measured by comparing the refractive index value of the unknown solution to the refractive index values of known solutions mixed in the laboratory. NFPA 11 requires a foam system to mix foam concentrate no lower than its nominal concentrate and no more that 30% above its nominal concentrate or no more that 1% point above its nominal concentration – whichever is less. If a premix solution is mixed too lean—not enough foam concentrate and/or too much water—it may not be able to extinguish a fire. Many times, this is due to not flowing the solution for long enough during the flow test. If a premix solution is mixed too rich—too much foam concentrate and/or not enough water— there is a risk of running out of foam before the fire is fully extinguished and/or the foam may not be able to completely extinguish a fire. Both proportioning samples mixed too lean and too rich can be caused by many factors, such as: non-uniform tank of concentrate (the reference concentrate does not reflect the concentrate mixed into the solution), unbalanced pressures around the proportioner, and system water not representative with the water mixed into the solution. If the proportioning is found to be outside the range recommended by NFPA 11, the proportioning system should be adjusted and the foam solution should be re-tested.
Sediment	Sediment testing is required by the International Maritime Organization Specification MSC 1312. The maximum amount of sediment allowed is 0.25%. If a foam concentrate sample is found to have more than 0.25% sediment, the foam concentrate may not perform as intended and replacement is recommended. The sediment dispersion is tested through a 180 micron sieve. The test result is indicated as dispersed (all sediment dispersed through sieve) and non-dispersed (not all sediment dispersed through sieve). Non-dispersed sediment is a concern as it could potentially plug an orifice and cause the proportioning system to not operate properly. Sediment and particulates in foam concentrate can be removed by straining the foam tank contents through a screen.
Acetone Resistance Test	The acetone stability test is required on alcohol resistant protein based foams tested to IMO 1312. This test is to determine how well the concentrate holds up on polar solvents. It is recorded as a time in seconds before the foam blanket is degraded and the acetone fuel can be visually seen. The minimum time required is 120 seconds.
Polar Burnback Test	The polar burnback test is required on alcohol resistant protein based foams tested to IMO 1312. This test is to determine how well the concentrate holds up on polar solvents. It is recorded as a time in seconds before 50% of the surface of the fuel is in flames. The minimum time required is 54 seconds.
Expansion Shake Test	The Expansion Shake Test is a small scale version of low and high expansion tests that is performed on premix solutions. The Expansion Shake Test is conducted by agitating a portion of a premix solution and measuring the volume of foam generated. The Expansion ratio refers to the ratio of the volume of foam generated to the volume of the original foam solution.
Est % Concentration	The Estimated % Concentration is reported on all bladder/shell water samples. This calculation is based on the refractive index of a bladder water compared to the associated foam concentrate as well as performance tests when needed. A high estimated % concentration in a bladder/shell water could indicate a bladder integrity issue.
Est % Dilution	The estimated % dilution is a calculation based on the refractive index or density of the concentrate and the low tolerance based on the specifications on the manufacturer's datasheet (when available). The estimated % dilution is reported on all USCG samples for both sea water and fresh water.