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TESTING OF FLUORINE-FREE FOAM CONCENTRATE, IN ACCORDANCE WITH SECTIONS 10, 12, 14, AND 15 OF UL 162, FOAM EQUIPMENT AND LIQUID CONCENTRATES (JUNE 2022 EDITION)

FINAL REPORT
Consisting of 12 Pages

SwRI® Project No.: 01.27641.01.001
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Prepared for:

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1.0 INTRODUCTION

The objective was to conduct testing of a fluorine-free foam concentrate to evaluate its extinguishing and re-ignition performance. Fire testing was in accordance with Sections 10, 12, 14 and 15 of UL 162, *Foam Equipment and Liquid Concentrates (June 2022 Edition)*. Testing was performed on February 8 and 10, 2023, by Southwest Research Institute's (SwRI) Fire Technology Department (FTD), located in San Antonio, Texas. Mr. Evan Paden, representing Underwriter's Laboratories (UL), witnessed testing and maintains the official test record in support of their listing program.

The results presented in this report apply only to the materials tested, in the manner tested, and not to any similar materials or material combinations.

2.0 TEST SPECIMENS

SwRI received the foam concentrate and extinguishing system equipment on February 6, 2023. Figure 1 below shows a photograph of the foam concentrate (5-gal pails) received for this testing. The foam concentrate was identified by the Client as *Green Sheet Non-Fluorinated 3%* and was described as Synthetic Fluorine Free Foam Concentrate (SFFF). The batch number provided by the Client was HA148 (manufactured January 2023).

The client also provided foam equipment, including an inline proportioner, handline nozzle and special fire test discharge nozzle. Figure 2 and Figure 3 show a photograph of the handline discharge nozzle and the inline proportioner used for testing per Section 14 and 15 of UL 162. Additional details about this equipment is on file with UL.

Figure 1. Green Sheet Foam Concentrate.

Figure 2. Handline Discharge Nozzle.

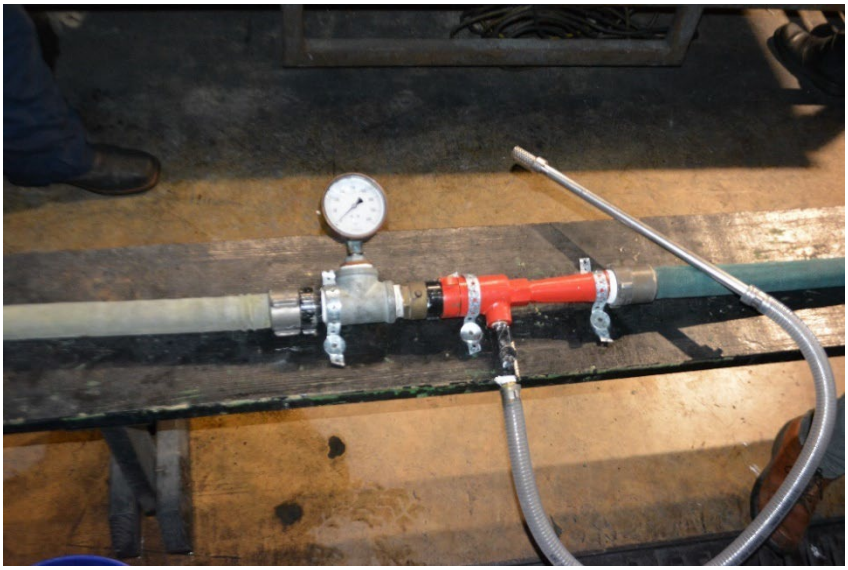

Figure 3. Inline Foam Proportioner.

3.0 FIRE TEST FACILITY

The large-scale fire engineering and research facility consists of a nominal 65 × 65 × 60-ft tall steel-lined building. An adjustable 55 × 55-ft false ceiling allows the simulation of different height structures.

Combustion air enters the building through 12 symmetrically placed louvers around the perimeter of the building. The twin exhaust fans (capable of moving 60,000 scfm of air) are operated during test runs to allow for quick and efficient smoke extraction.

A continuous 1-ft wide drain runs approximately 8 ft inside the perimeter of the building, leaving a 46-ft 9-in. inside inner concrete floor test area. The drain leads to a sump equipped with pumps to automatically transfer the waste liquid into a 40,000-gal tank.

Tests can be viewed from an exterior door and an elevated observation room adjacent to the building. The observation room also houses the data acquisition system, control systems for exhaust fans, and fire suppressant system. Figure 4 shows a basic schematic of the test facility site.

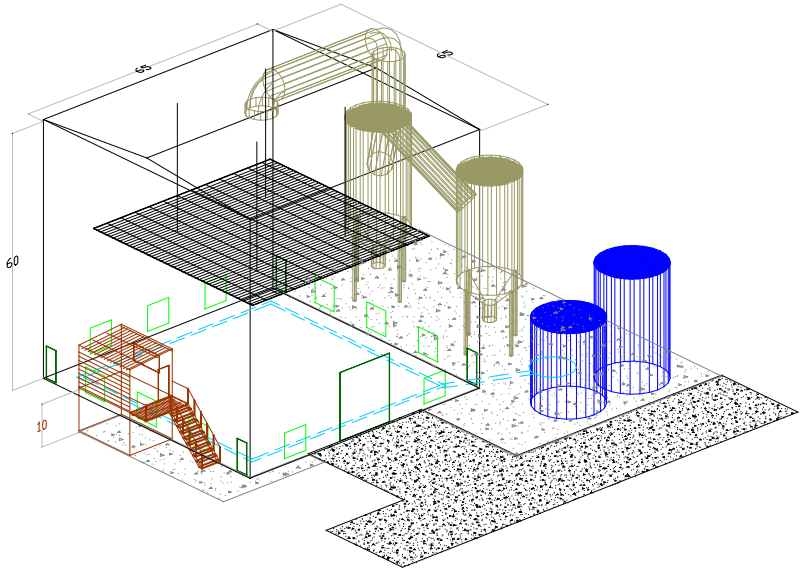

Figure 4. Large-Scale Fire Engineering and Research Facility Layout.

4.0 TEST PROGRAM AND PROCEDURES

The following subsections briefly review the specific UL 162 section procedures that were conducted for this project.

4.1 Foam Quality Tests (Section 10 of UL 162)

Section 10 of UL 162 describes the required foam quality tests to perform for a foam solution. This testing is applicable to the full-scale equipment as well as the special fire test equipment. The two primary quantities to determine are the expansion ratio and the 25% drainage time.

Foam is discharged against a foam slider board and allowed to slide down the board and into a sample collection container. The sample container is then weighed and the ratio of the weight of the container full of water and the weight of the container full of the foam sample, if defined as the expansion ratio. The foam sample weight is divided by 4 to determine the mass at which 25% of the foam sample will have drained out of the solution. The foam sample is allowed to drain into another collection cup and the time it takes to drain 25% of the foam sample mass is recorded. This is defined as the 25% drainage time.

Typically, initial foam quality tests are conducted with full-scale equipment and then matched within specified tolerances in UL 162 to the special fire test equipment.

4.2 Topside Fire Testing (Section 12 of UL 162)

The following subsections provide additional details about the fire testing setup and procedure.

Fire Test Pan

The fire test pan used was a UL-162 defined square, straight-sided steel pan 50 ft^2 in surface area. The top edge of the pan was reinforced with 2 × 2 × 3/8 in. angle. The test pan was 12 in. deep and supported on 6 in. channel.

Fire Test Nozzle Equipment

The Client provided the discharge device used for testing. This nozzle had an inner orifice with 0.101-in diameter and a 6-in long discharge tube with a 0.5-in diameter. This nozzle was connected to SwRI's pump configuration for testing. A calibration test was performed to adjust the pump pressure required to achieve the required test flow rate. This was verified by mass with a scale. The pump discharge pressure used during testing was 145 psig. Figure 5 shows a photograph of the discharge setup used for testing.

Figure 5. Special Fire Test Equipment (Left: Discharge Nozzle, Right: SwRI Pump and Tank).

Topside Fire Test Procedure Timing

Table 1 shows the typical timing sequence used for topside fire testing. The test conducted under this project was with a synthetic foam concentrate and a hydrocarbon fuel group (heptane). The discharge nozzle was positioned stationary for the beginning of the test and once control was observed by the UL inspector, the firefighter picked up the nozzle and began moving around two sides of the pan to achieve extinguishment. After the foam discharge period is complete, re-ignition tests are performed with a torch and burnback pot (artificial rift fire) to evaluate the robustness of the foam blanket.

Table 1. UL-162 Test Procedure Timing.

Application Type	Foam Concentrate Type	Fuel Group	Test Application Density (gpm/ft^2)	Time of Foam Application (min)	Duration Until Burnback Ignition (min)
Type III Discharge Devices	P, FP, SFFF, FFFP[a]	Hydrocarbon	0.06 (3 gpm)	5	15
	AFFF, FFFP[a]	Hydrocarbon	0.04 (2 gpm)	3	9

[a] P=Protein, FP=Fluoroprotein, SFFF=Synthetic, FFFP=Film-forming Fluorprotein, AFFF=Aqueous Film-Forming Foam.

4.3 Induction Rate Test (Section 14 of UL 162)

This testing is conducted to evaluate the full-scale proportioning equipment with the foam concentrate under test. Successful results are reflected in the ability of the proportioner to induct concentrate to minus zero (0) percent to plus thirty (30) percent of the manufacturer's specified induction rate. For this project, the allowable induction rate range was from 3.0 – 3.9% concentrate in the foam solution. This is calculated by measuring the mass loss of the concentrate supply (5-gal pail), the solution flow rate and discharge time. This testing is for a liquid concentrate temperature of 60 ºF or higher.

4.4 Minimum Storage Temperature Tests (Section 15 of UL 162)

This testing is very similar to the induction rate testing, however, for this procedure the liquid concentrate is conditioned to its minimum storage temperature and the test is repeated. The quantity of liquid concentrate that is inducted at this lower temperature shall not be less than 85% of that inducted at a temperature of 60 ºF or higher. For this project, the minimum storage temperature stated by the Client was 35 ºF.

5.0 TEST RESULTS

Testing was performed on February 8 and 10, 2023, by Southwest Research Institute's (SwRI) Fire Technology Department (FTD), located in San Antonio, Texas. On February 8, full-scale equipment testing was conducted, which included induction rate tests, foam quality tests and minimum storage rate tests. On February 10, 2023, topside fire testing was conducted.

Table 2 provides a summary of the full-scale equipment test results. Table 3 provides a summary of the topside fire testing with freshwater premix solution. Figures 6-13 provide selected photographs from the topside fire testing.

Table 2. Test Results for Full-Scale Equipment Testing with *Green Sheet Non-Fluorinated 3%.*

Liquid Concentrate Temperature (ºF)	Foam Quality Measurements*		Inductor Inlet Pressure (psig)	Solution Flow Rate (gpm)	Handline Nozzle Pressure (psig)	Induction Percent (%)	PASS/ FAIL
	Expansion Ratio (-)	25% Drain (min:s)					
61	6.32 *	23:12 *	175	88.25	75	3.12	PASS
35	N/A	N/A	175	88.45	74	2.79	PASS

* Values in table are average of two trials, N/A: foam quality not performed during minimum storage temperature test.

Table 3. Test Results for Topside Fire Testing of *Green Sheet Non-Fluorinated 3%.*

Test Fuel	Foam Quality Measurements*		Time to Control (min:s)	Time to Extinguish (min:s)	Re-ignition with Torch (Y/N)?	Burnback Test Max Rift Area (ft^2)	PASS/ FAIL
	Expansion Ratio (-)	25% Drain (min:s)					
Heptane	5.57 *	21:36 *	1:00	2:05	No	8	PASS

* Values in table are average of two trials.

Figure 6. Pre-Test Conditions (Left) and Pre-Burn (Right) of Heptane Test Fire.

Figure 7. Foam Discharge Prior to (Left) and After (Right) Control Time.

Figure 8. Foam Discharge After Control with Firefighter (Left: Small Fire, Right: Extinguished).

Figure 9. First Torch Pass (Left) and Second Torch Pass (Right).

Figure 10. Start of Burnback Test (Left) and Removal of Stovepipe (Right).

Figure 11. Initial Large Flashover Observed after Removal of Stovepipe.

Figure 12. Additional Flame Spread During Burnback Test.

Figure 13. Largest Fire Size Observed at End of Test (Left) and Post-Test Conditions (Right).

APPENDIX A

CALIBRATED EQUIPMENT

(CONSISTING OF 1 PAGE)

Table A-1. Summary of Calibrated Equipment Usage.

Equipment Description	Make/Model Number	Serial Number	Calibration Due Date
Balance	SCOUT PRO SP6000	B151552468	09/23/2023
Scale	OHAUS T31P	B219926295	04/11/2023
Stopwatch	Control Company 5CVT8	210518337	06/18/2023
Flow Meter	Kobald S20N	4210487	10/14/2023
Pressure Gauge	Wika 213.53	24238	01/12/2024
Pressure Gauge	Noshok 4” Dial	40-300-400 PSI CC	01/13/2024
Pressure Gauge	Wika 213.53.4	81000J8D	09/08/2023
Temp/RH Meter	Omega HH414	210927	09/23/2023