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REFRACTOMETRY AND EXTINGUISHMENT/ BURNBACK TESTING OF PACIFIC AIR FORCES AFFF

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14. ABSTRACT At the request of Pacific Air Forces (PACAF), the Air Force Research Laboratory (AFRL) performed refractometry and extinguishment/burnback tests on samples of Ansulite and 3M aqueous film forming foam (AFFF) from an overseas air base. The Fire Chief at the air base was concerned about the effectiveness of the agent because of refractometry tests conducted on the foam concentrate and foam dilutions. AFRL used an Atago, Palette Series PR-32a Digital Refractometer to perform refractometry testing on fives samples. Each agent was mixed twice and three test were conducted with each agent/water mixture. Testing showed that even high end, calibrated digital refractometers produce varied results. After the refractometry testing was completed, two agents were chosen to conduct the Military Specification extinguishment and burnback. Results showed that both AFFF samples exceeded MIL-SPEC minimum requirements for extinguishment and burnback indicating that they maintain their fire fighting effectiveness.					
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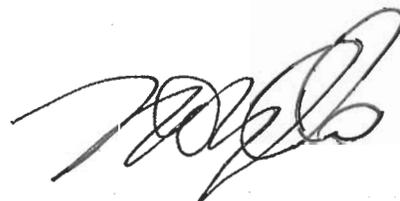
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INTRODUCTION

At the request of Pacific Air Forces (PACAF), the Air Force Research Laboratory (AFRL) performed refractometry and extinguishment/burnback tests on samples of Ansulite and 3M aqueous film forming foam (AFFF) from an overseas air base. The Fire Chief at the air base was concerned about the effectiveness of the agent because of refractometry tests conducted on the foam concentrate and foam dilutions. During July and August, 2005 AFRL performed refractometry testing on fives samples and extinguishment/burnback tests on two samples.

METHODS AND RESULTS

Refractometer

AFRL used an Atago, Palette Series PR-32a Digital Refractometer (Figure 1) to conduct testing. AFRL switched to this model last year when problems were experienced with the optical style refractometer (Figure 2). Testing was accomplished by mixing 30 ml of agent with 970 ml of water. Each agent was mixed twice and three tests were conducted with each agent/water mixture. Table 1 shows data from measuring refractometry at a carefully measured 3% concentration. Testing showed that even high end, calibrated digital refractometers produce varied results. The Ansulite sample read as low as 2.3%, while the 3M 560 and 131 read as high as 3.7%. Most measurements were $3\% \pm 0.3\%$.



Figure 1. Atago Digital Refractometer with Digital Readout.



Figure 2. Typical Optical Refractometer with Analog Readout.

Table 1. Refractometry Testing at 3% Concentration.					
Manufacturer	Batch Number	Manf. Date	Refractometer Test Results		
			#1	#2	#3
Ansulite	X27062	Dec-87	2.7%	2.7%	2.7%
			2.3%	2.3%	2.3%
3M	560	Sep-89	3.7%	3.7%	3.7%
			3.3%	3.3%	3.0%
3M	131	Dec-90	3.3%	3.3%	3.3%
			3.3%	3.3%	3.7%
3M	141	Mar-91	3.3%	3.0%	3.0%
			3.3%	3.3%	3.3%
3M	30042	Dec-98	2.3%	2.3%	2.3%
			2.3%	2.3%	2.3%

The second set of refractometer tests was accomplished by mixing dilutions of agent with water. The agents were baselined against Ansulite AFFF purchased by AFRL within the past six months. Table 2 showed variation across a range of concentrations, indicating that using a refractometer only provided an estimate of the actual foam concentration and that several samples should be evaluated to determine concentration.

Table 2. Refractometry Testing at 3, 6, 50 and 100% Concentrations.					
Manufacturer	Refractometer test results				
	Foam Concentration	100%	50%	6%	3%
AFRL Ansulite Baseline					
w/calibration constant		97.85	53.74	5.80	2.44
Ansulite					
w/calibration constant		102.64	53.74	6.28	2.92
3M					
w/calibration constant		133.33	75.31	8.19	4.36
3M					
w/calibration constant		139.08	72.44	7.71	3.88
3M					
w/calibration constant		132.85	60.93	5.32	3.88
3M					
w/calibration constant		103.12	51.82	5.80	2.92

MIL-SPEC Extinguishment And Burnback

After the refractometry testing was completed, two agents were chosen to conduct the Military Specification extinguishment and burnback. Procedures from MIL-F-24385F Fire Extinguishing Agent, Aqueous Film Forming Foam (AFFF) Liquid Concentrate, For Fresh and Sea Water, Section 4.7.13 for the 28 ft² fire test were followed.

Extinguishment Procedures

The fire tests were conducted in level, circular pans that were six foot in diameter, fabricated from ¼ inch thick steel with a four inch high side. A shallow water layer less than one inch in depth was used to protect the bottom of the pan and ensure complete coverage of the area with fuel. The nozzle used for foam application delivered 2 gal/min at 100 psi. Foam was generated at 23 °C ± 5.0 °C from agent solutions made with fresh water. The fuel used for testing was 10 gallons of unleaded gasoline (~0.6 inch fuel depth). All agent solutions were thoroughly mixed prior to testing.

The fuel was added then ignited within a 30 second period and allowed to burn freely for 10 seconds. After the preburn period, the burning fuel was extinguished as expeditiously as possible and the fire extinguishment time was recorded at the cessation of all flame and the foam application continued for a total of 90 seconds.

Burnback Procedure

Within 60 seconds of the completion of foam application, a burning pan (1 foot in diameter with 2 inch side) containing 1 gallon of unleaded gasoline was placed in the center of the 28 ft² pan and a timer started. When the fire had spread outside the pan so that burning continued, the pan was removed. The burnback time was that time at which 7 ft² (25 percent) of the total area was in flames. Intermittent flashovers were not considered part of the burnback area unless sustained burning occurred. All isolated, sustained burning areas were included in arriving at the seven ft² (or 25%) total area. Table 3 shows that both foams passed MIL-SPEC extinguishment and burnback.

Results showed that both the Ansulite and 3M PACAF AFFF samples exceeded MIL-SPEC minimum requirements for extinguishment and burnback, indicating that they should maintain their fire fighting effectiveness.

Table 3. MIL-SPEC Extinguishment and Burnback Testing.

Experiment Number	Agent	Pre-Burn Time (s)	Extinguishment Time (s)	25% Burnback Time (s)
NFPA Min Req't	3% Freshwater	10	30	360
1	Ansulite (# 1)	12	28	402
2	Ansulite (# 1)	10	32	347
3	3M (# 2)	10	25	397

CONCLUSIONS

Refractometry testing only provides a gross approximation of foam percentage. Switching from an optical to digital refractometer will improve results but variation may still exist. Confirmation of the foams in an actual fire scenario (extinguishment/burnback) confirmed that the foams are still effective and can be used for their intended purpose.

RECOMMENDATIONS

AFRL recommends replacing optical refractometers with digital refractometers. Digital refractometers are easy to read and give an exact number versus an analog scale, which can be difficult to interpret and can vary from person to person (Figures 1 and 2). At least three samples should be evaluated and compared to a baseline using foam and water from the site. If the results are not within $\pm 0.5\%$, recalibrate the instrument and rerun new samples. If results are still out of range, send a sample to AFRL for analysis. AFRL can also provide information on selecting a digital refractometer and help establish procedures for conducting foam concentration measurements.