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Ser 6180/0028

29 FEB 2016

From: Commanding Officer, Naval Research Laboratory
To: Commander, Naval Sea Systems Command (Code 05P5 S. Fletcher)

Subj: RESULTS OF MIL-F-24385F QUALIFICATION TESTING OF THE SOLBERG
COMPANY ARCTIC 3% MIL-SPEC AFFF AND ARCTIC 6% MIL-SPEC AFFF
CONCENTRATES

Encl: (1) One copy of subject report

1. Enclosure (1) is forwarded for your information and retention.
2. This report provides results of the qualification testing for the Solberg Company Arctic 3% Mil-Spec AFFF and the Arctic 6% Mil-Spec AFFF concentrates, which were evaluated against the MIL-F-24385F, "Fire Extinguishing Agent, Aqueous Film Forming Foam (AFFF) Liquid Concentrate for Fresh and Seawater" qualification standard. Both the Arctic 3% Mil-Spec AFFF and the Arctic 6% Mil-Spec AFFF products met all of the fire extinguishment and burn back protection requirements for the MIL-F-24385F test standard. Based on these test results, it is recommended that the Arctic 3% Mil-Spec AFFF and the Arctic 6% Mil-Spec AFFF products be listed on the AFFF Qualified Products List (QPL).
3. The Naval Research Laboratory's point of contact is John P. Farley Code 6186, (202) 404-8459, e-mail: john.farley@nrl.navy.mil.


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By direction

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Results of Mil-F-24385F Qualification Testing of the Solberg Company Arctic 3% Mil-Spec AFFF and Arctic 6% Mil-Spec AFFF Concentrates

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**Test results--Paragraphs denoted below refer to the applicable section
of MIL-F-24385F**

Paragraph 3.3 Chemical and Physical Requirements for Concentrates:

Property:	Type 6 Criteria	Type 6 Value	Pass/ Fail	Type 3 Criteria	Type 3 Value	Pass/ Fail
Viscosity @ 25 °C cSt	≥ 2	2.65	Pass	≥2	3.55	Pass
Viscosity @ 5 °C cSt	≤10	5.22	Pass	≤20	7.15	Pass
Hydrogen Ion (pH)	7-8.5	8.19	Pass	7-8.5	8.32	Pass
Spreading Coefficient on cyclohexane (dynes/cm)	≥3.0	6.92	Pass	≥3.0	7.66	Pass
Index of refraction	≥1.3580	1.3605	Pass	≥1.3630	1.3652	Pass
Foamability (average of two measurements for each condition):						
Fresh Water Expansion Ratio	≥5.0	7.8	Pass	≥5.0	7.3	Pass
Fresh Water Drain Time (minutes)	≥2:30	5:00	Pass	≥2:30	4:40	Pass
Salt Water Expansion Ratio	≥5.0	8.3	Pass	≥5.0	7.3	Pass
Salt Water Drain Time (minutes)	≥2:30	4:52	Pass	≥2:30	5:15	Pass
Film Formation:						
Full Strength Fresh	No Ignition	No Ignition	Pass	No Ignition	No Ignition	Pass
Full Strength Salt	No Ignition	No Ignition	Pass	No Ignition	No Ignition	Pass
Corrosion Rate:						
steel (10 ⁻³ inches/yr)	≤1.5	0.17	Pass	≤1.5	0.18	Pass
Cu-Ni (10 ⁻³ inches/yr)	≤1.0	0.016	Pass	≤1.0	0.014	Pass
Ni-Cu (10 ⁻³ inches/yr)	≤1.0	0.017	Pass	≤1.0	0.016	Pass
Bronze (mg)	≤100	No Loss	Pass	≤100	8.11	Pass
Localized pitting (Corrosion- resistant steel)	No Pits	No Pits	Pass	No Pits	No Pits	Pass
Total Halides (ppm)	≤250	<50	Pass	≤500	<50	Pass
Dry Chemical Compatibility:						
Burn Back time (s)	≥360	517	Pass	≥360	525	Pass
Environmental Impact:						
Toxicity (LC ₅₀) mg/L	≥1000	≤2000*	Pass	≥500	≤2000*	Pass
COD (g O ₂ /L)	≤500	359	Pass	≤1000	337	Pass
BOD ₂₀ /COD	≥0.65	0.78	Pass	≥0.65	0.89	Pass

NOTE* – No fish (killifish (*Fundulus Heteroclitus*)) mortality observed at a concentration ≤ 2000 mg/L for the Arctic 3% AFFF or the Arctic 6% AFFF concentrates.

Paragraph 3.3.2 Stability:

Property	Type 6 Criteria	Type 6 Value	Pass/ Fail	Type 3 Criteria	Type 3 Value	Pass/ Fail
Spreading Coefficient on cyclohexane (dynes/cm):						
using aged concentrate mixed with fresh water	≥3.0	7.06	Pass	≥3.0	7.48	Pass
using aged premix with fresh water	≥3.0	6.90	Pass	≥3.0	5.85	Pass
using aged premix with salt water	≥3.0	6.9	Pass	≥3.0	6.49	Pass
Foamability using aged concentrate(average of two measurements):						
Fresh Water Expansion Ratio	≥5.0	8.3	Pass	≥5.0	8.4	Pass
Fresh Water Drain Time (minutes)	≥2:30	5:27	Pass	≥2:30	4:13	Pass
Salt Water Expansion Ratio	≥5.0	8.0	Pass	≥5.0	7.5	Pass
Salt Water Drain Time (minutes)	≥2:30	5:45	Pass	≥2:30	4:54	Pass
Foamability using aged premix (average of two measurements):						
Fresh Water Expansion Ratio	≥5.0	8.0	Pass	≥5.0	7.7	Pass
Fresh Water Drain Time (minutes)	≥2:30	5:00	Pass	≥2:30	4:42	Pass
Salt Water Expansion Ratio	≥5.0	8.6	Pass	≥5.0	7.7	Pass
Salt Water Drain Time (minutes)	≥2:30	4:46	Pass	≥2:30	5:03	Pass
Film Formation:						
from aged concentrate, full strength, fresh water	no ignition	no ignition	Pass	no ignition	no ignition	Pass
from aged concentrate, full strength, salt water	no ignition	no ignition	Pass	no ignition	no ignition	Pass
from aged premix, full strength, fresh water	no ignition	no ignition	Pass	no ignition	no ignition	Pass
from aged premix, full strength, salt water	no ignition	no ignition	Pass	no ignition	no ignition	Pass
Fire Performance:						
Aged Concentrate, ½ strength, fresh						
Extinguishment time (s)	≤45	44	Pass	≤45	43	Pass
Burn back time (s)	≥300	401	Pass	≥300	392	Pass
Aged Concentrate, ½ strength, salt						
Extinguishment time (s)	≤45	33	Pass	≤45	28	Pass
Burn back time (s)	≥300	423	Pass	≥300	532	Pass
Aged Concentrate, full strength, Fresh						
Extinguishment time (s)	≤30	28	Pass	≤30	22	Pass
Burn Back time (s)	≥360	533	Pass	≥360	470	Pass
Aged Concentrate, full strength, Salt						
Extinguishment time (s)	≤30	29	Pass	≤30	30	Pass
Burn Back time (s)	≥360	466	Pass	≥360	615	Pass
Aged Premix, full strength, fresh						
Extinguishment time (s)	≤30	28	Pass	≤30	28	Pass
Burn back time (s)	≥360	533	Pass	≥360	532	Pass
Aged Premix, full strength, salt						
Extinguishment time (s)	≤30	29	Pass	≤30	28	Pass
Burn back time (s)	≥360	466	Pass	≥360	532	Pass
Aged Premix, ½ strength, fresh						
Extinguishment time (s)	≤45	30	Pass	≤45	43	Pass

Burn back time (s)	≥300	376	Pass	≥300	392	Pass
Aged Premix, ½ strength, salt						
Extinguishment time (s)	≤45	36	Pass	≤45	28	Pass
Burn back time (s)	≥300	471	Pass	≥300	532	Pass

Property	Type 6 Criteria	Type 6 Value	Pass/ Fail	Type 3 Criteria	Type 3 Value	Pass/ Fail
Stratification:						
using aged concentrate mixed with fresh water	N.O.*	N.O.*	Pass	N.O.*	N.O.*	Pass
using aged premix with fresh water	N.O.*	N.O.*	Pass	N.O.*	N.O.*	Pass
using aged premix with salt water	N.O.*	N.O.*	Pass	N.O.*	N.O.*	Pass
Precipitation (vol%):						
using aged concentrate mixed with fresh water	≤0.05 mL	N.O.*	Pass	≤0.05	N.O.*	Pass
using aged premix with fresh water	≤0.05 mL	N.O.*	Pass	≤0.05	N.O.*	Pass
using aged premix with salt water	≤0.05 mL	N.O.*	Pass	≤0.05	N.O.*	Pass

N.O.* = None Observed.

Paragraph 3.3.3 Compatibility:

Mixture: Arctic 3% Mil-Spec AFFF/ Buckeye¹ (50/50) Type 3

Requirement	Criteria	Value	Pass/ Fail
Stratification:			
using aged concentrate	N.O.*	N.O.	Pass
Precipitation (vol%):			
using aged concentrate	≤0.05	N.O.	Pass
Foamability using aged concentrate(average of two measurements):			
Fresh Water Expansion Ratio	≥5.0	8.6	Pass
Fresh Water Drain Time (minutes)	≥2:30	4:38	Pass
Salt Water Expansion Ratio	≥5.0	8.4	Pass
Salt Water Drain Time (minutes)	≥2:30	4:41	Pass
Film Formation:			
from aged concentrate, ½ strength, fresh water	no ignition	no ignition	Pass
from aged concentrate, ½ strength, salt water	no ignition	no ignition	Pass
Fire Performance:			
Aged Concentrate, fresh water			
Extinguishment time (s)	≤30	30	Pass
Burn back time (s)	≥360	422	Pass
Aged Concentrate, salt water			
Extinguishment time (s)	≤30	28	Pass
Burn back time (s)	≥360	447	Pass

*N.O. = None Observed.

¹ Buckeye Lot Number 120066, Date 08/2014

Mixture: Arctic 3% Mil-Spec AFFF / Chemguard² (50/50) Type 3

Requirement	Criteria	Value	Pass/ Fail
Stratification:			
using aged concentrate	N.O.*	N.O.	Pass
Precipitation (vol%):			
using aged concentrate	≤0.05	N.O.	Pass
Foamability using aged concentrate(average of two measurements):			
Fresh Water Expansion Ratio	≥5.0	7.8	Pass
Fresh Water Drain Time (minutes)	≥2:30	3:58	Pass
Salt Water Expansion Ratio	≥5.0	7.5	Pass
Salt Water Drain Time (minutes)	≥2:30	4:22	Pass
Film Formation:			
from aged concentrate, ½ strength, fresh water	no ignition	no ignition	Pass
from aged concentrate, ½ strength, salt water	no ignition	no ignition	Pass
Fire Performance:			
Aged Concentrate, fresh water			
Extinguishment time (s)	≤30	28	Pass
Burn back time (s)	≥360	454	Pass
Aged Concentrate, salt water			
Extinguishment time (s)	≤30	23	Pass
Burn back time (s)	≥360	476	Pass

*N.O. = None Observed.

Mixture: Arctic 3% Mil-Spec AFFF / Tridol³ (50/50) Type 3

Requirement	Criteria	Value	Pass/ Fail
Stratification:			
using aged concentrate	N.O.	N.O.	Pass
Precipitation (vol%):			
using aged concentrate	≤0.05	N.O.	Pass
Foamability using aged concentrate(average of two measurements):			
Fresh Water Expansion Ratio	≥5.0	8.0	Pass
Fresh Water Drain Time (minutes)	≥2:30	4:45	Pass
Salt Water Expansion Ratio	≥5.0	7.6	Pass
Salt Water Drain Time (minutes)	≥2:30	4:57	Pass
Film Formation:			
from aged concentrate, ½ strength, fresh water	no ignition	no ignition	Pass
from aged concentrate, ½ strength, salt water	no ignition	no ignition	Pass
Fire Performance:			
Aged Concentrate, fresh water			
Extinguishment time (s)	≤30	26	Pass
Burn back time (s)	≥360	438	Pass
Aged Concentrate, salt water			
Extinguishment time (s)	≤30	27	Pass
Burn back time (s)	≥360	459	Pass

² Chemguard Lot Number 0923112, Date 9/23/2011

³ Tridol Lot Number L12136, Date 10/2014

Mixture: ¼ Arctic 3% Mil-Spec AFFF/Buckeye/Tridol/Chemguard Type 3

Requirement	Criteria	Value	Pass/ Fail
Stratification:			
using aged concentrate	N.O.*	N.O.	Pass
Precipitation (vol%):			
using aged concentrate	≤0.05	N.O.	Pass
Foamability using aged concentrate(average of two measurements):			
Fresh Water Expansion Ratio	≥5.0	7.8	Pass
Fresh Water Drain Time (minutes)	≥2:30	4:57	Pass
Salt Water Expansion Ratio	≥5.0	7.9	Pass
Salt Water Drain Time (minutes)	≥2:30	4:20	Pass
Film Formation:			
from aged concentrate, ½ strength, fresh water	no ignition	no ignition	Pass
from aged concentrate, ½ strength, salt water	no ignition	no ignition	Pass
Fire Performance:			
Aged Concentrate, fresh water			
Extinguishment time (s)	≤30	25	Pass
Burn back time (s)	≥360	383	Pass
Aged Concentrate, salt water			
Extinguishment time (s)	≤30	28	Pass
Burn back time (s)	≥360	458	Pass

*N.O. = None Observed.

Mixture: Arctic 6% Mil-Spec AFFF / National⁴ (50/50) Type 6

Requirement	Criteria	Value	Pass/ Fail
Stratification:			
using aged concentrate	N.O.	N.O.	Pass
Precipitation (vol%):			
using aged concentrate	≤0.05	N.O.	Pass
Foamability using aged concentrate(average of two measurements):			
Fresh Water Expansion Ratio	≥5.0	8.4	Pass
Fresh Water Drain Time (minutes)	≥2:30	4:06	Pass
Salt Water Expansion Ratio	≥5.0	8.3	Pass
Salt Water Drain Time (minutes)	≥2:30	4:37	Pass
Film Formation:			
from aged concentrate, ½ strength, fresh water	no ignition	no ignition	Pass
from aged concentrate, ½ strength, salt water	No ignition	no ignition	Pass
Fire Performance:			
Aged Concentrate, fresh water			
Extinguishment time (s)	≤30	29	Pass
Burn back time (s)	≥360	377	Pass
Aged Concentrate, salt water			
Extinguishment time (s)	≤30	25	Pass
Burn back time (s)	≥360	433	Pass

⁴ National Lot Number 15312, Date 11/2015

Mixture: Arctic 6% Mil-Spec AFFF / Fire Ade⁵ (50/50) Type 6

Requirement	Criteria	Value	Pass/ Fail
Stratification:			
using aged concentrate	N.O.*	N.O.	Pass
Precipitation (vol%):			
using aged concentrate	≤0.05	N.O.	Pass
Foamability using aged concentrate(average of two measurements):			
Fresh Water Expansion Ratio	≥5.0	8.3	Pass
Fresh Water Drain Time (minutes)	≥2:30	4:18	Pass
Salt Water Expansion Ratio	≥5.0	8.5	Pass
Salt Water Drain Time (minutes)	≥2:30	4:40	Pass
Film Formation:			
from aged concentrate, ½ strength, fresh water	no ignition	no ignition	Pass
from aged concentrate, ½ strength, salt water	no ignition	no ignition	Pass
Fire Performance:			
Aged Concentrate, fresh water			
Extinguishment time (s)	≤30	30	Pass
Burn back time (s)	≥360	498	Pass
Aged Concentrate, salt water			
Extinguishment time (s)	≤30	28	Pass
Burn back time (s)	≥360	431	Pass

*N.O. = None Observed.

Mixture: Arctic 6% Mil-Spec AFFF / Chemguard⁶ (50/50) Type 6

Requirement	Criteria	Value	Pass/ Fail
Stratification:			
using aged concentrate	N.O.	N.O.	Pass
Precipitation (vol%):			
using aged concentrate	≤0.05	N.O.	Pass
Foamability using aged concentrate(average of two measurements):			
Fresh Water Expansion Ratio	≥5.0	8.0	Pass
Fresh Water Drain Time (minutes)	≥2:30	4:36	Pass
Salt Water Expansion Ratio	≥5.0	7.6	Pass
Salt Water Drain Time (minutes)	≥2:30	5:14	Pass
Film Formation:			
from aged concentrate, ½ strength, fresh water	no ignition	no ignition	Pass
from aged concentrate, ½ strength, salt water	no ignition	no ignition	Pass
Fire Performance:			
Aged Concentrate, fresh water			
Extinguishment time (s)	≤30	30	Pass
Burn back time (s)	≥360	517	Pass
Aged Concentrate, salt water			
Extinguishment time (s)	≤30	28	Pass
Burn back time (s)	≥360	507	Pass

⁵ Fire Ade Lot Number 122701, 01/2012

⁶ Chemguard Lot Number 0429131, Date 4/29/2013

Mixture: ¼ Arctic 6% Mil-Spec AFFF/National/FireAde/Chemguard Type 6

Requirement	Criteria	Value	Pass/Fail
Stratification:			
using aged concentrate	N.O.	N.O.	Pass
Precipitation (vol%):			
using aged concentrate	≤0.05	N.O.	Pass
Foamability using aged concentrate(average of two measurements):			
Fresh Water Expansion Ratio	≥5.0	8.3	Pass
Fresh Water Drain Time (minutes)	≥2:30	4:25	Pass
Salt Water Expansion Ratio	≥5.0	8.2	Pass
Salt Water Drain Time (minutes)	≥2:30	4:53	Pass
Film Formation:			
from aged concentrate, ½ strength, fresh water	no ignition	no ignition	Pass
from aged concentrate, ½ strength, salt water	no ignition	no ignition	Pass
Fire Performance:			
Aged Concentrate, fresh water			
Extinguishment time (s)	≤30	23	Pass
Burn back time (s)	≥360	469	Pass
Aged Concentrate, salt water			
Extinguishment time (s)	≤30	27	Pass
Burn back time (s)	≥360	489	Pass

Paragraph 3.4 Fire Performance:

	Type 6 requirement	Type 6 Value	Pass/Fail	Type 3 requirement	Type 3 Value	Pass/Fail
28 ft² Extinguishment Time (s)						
Fresh Water ½ strength	≤45	39	Pass	≤45	30	Pass
Fresh Water full strength	≤30	22	Pass	≤30	27	Pass
Salt Water ½ strength	≤45	31	Pass	≤45	29	Pass
Salt Water full strength	≤30	26	Pass	≤30	21	Pass
Salt Water Quintuple Strength	≤55	34	Pass	≤55	31	Pass
Burn Back Time (s)						
Fresh Water ½ strength	≥300	413	Pass	≥300	425	Pass
Fresh Water full strength	≥360	537	Pass	≥360	599	Pass
Salt Water ½ strength	≥300	435	Pass	≥300	451	Pass
Salt Water full strength	≥360	517	Pass	≥360	593	Pass
Salt Water Quintuple Strength	≥200	372	Pass	≥200	386	Pass
50 ft² Fire Test (Salt Water)						
Extinguishment time (s)	≤50	31	Pass	≤50	32	Pass
Burn back time (s)	≥360	386	Pass	≥360	430	Pass
40 second summation	≥320	344	Pass	≥320	349	Pass

Additional Measurements

- (1) Container cap torque test results: Arctic Type 3 – 30 in/lbs. & Arctic Type 6 – 45 in/lbs.
- (2) Total Fluorine: Type 6 – 0.539 %, Type 3 – 1.078 %.