

Firefighting Capabilities Assessment of Commercially Available PFAS-Free Foam and Agents

WP19-5324

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Final Debrief

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NRL



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Technical Objectives

Ultimate Goal: identify an environmentally acceptable PFAS-free AFFF alternative equivalent to MILSPEC AFFF (MIL-F-24385F)

- “Apples to Apples” comparison of the capabilities of MilSpec AFFF and the commercially available PFAS-free alternatives.
- Assess capabilities against on both approval-scale and real-scale test scenarios.
- Develop a database on product capabilities.
- Provide information for land-based MilSpec development.

Technical Approach

Two-year program started February 2019

		Task
1	1	Literature Search (to identify candidates)
2	2	Environmental Analysis (Preliminary)
3		Real-Scale Fire Tests
4		Capabilities Rankings
5		Approval-Scale Fire Tests
6	6	Program Documentation (database, final report, path forward)

Task 1: Literature Search

- Comprehensive literature review on foams and agents
- 60-70 products being marketed as PFAS-Free Alts.
- Potential candidates/agents (~ 40 identified)

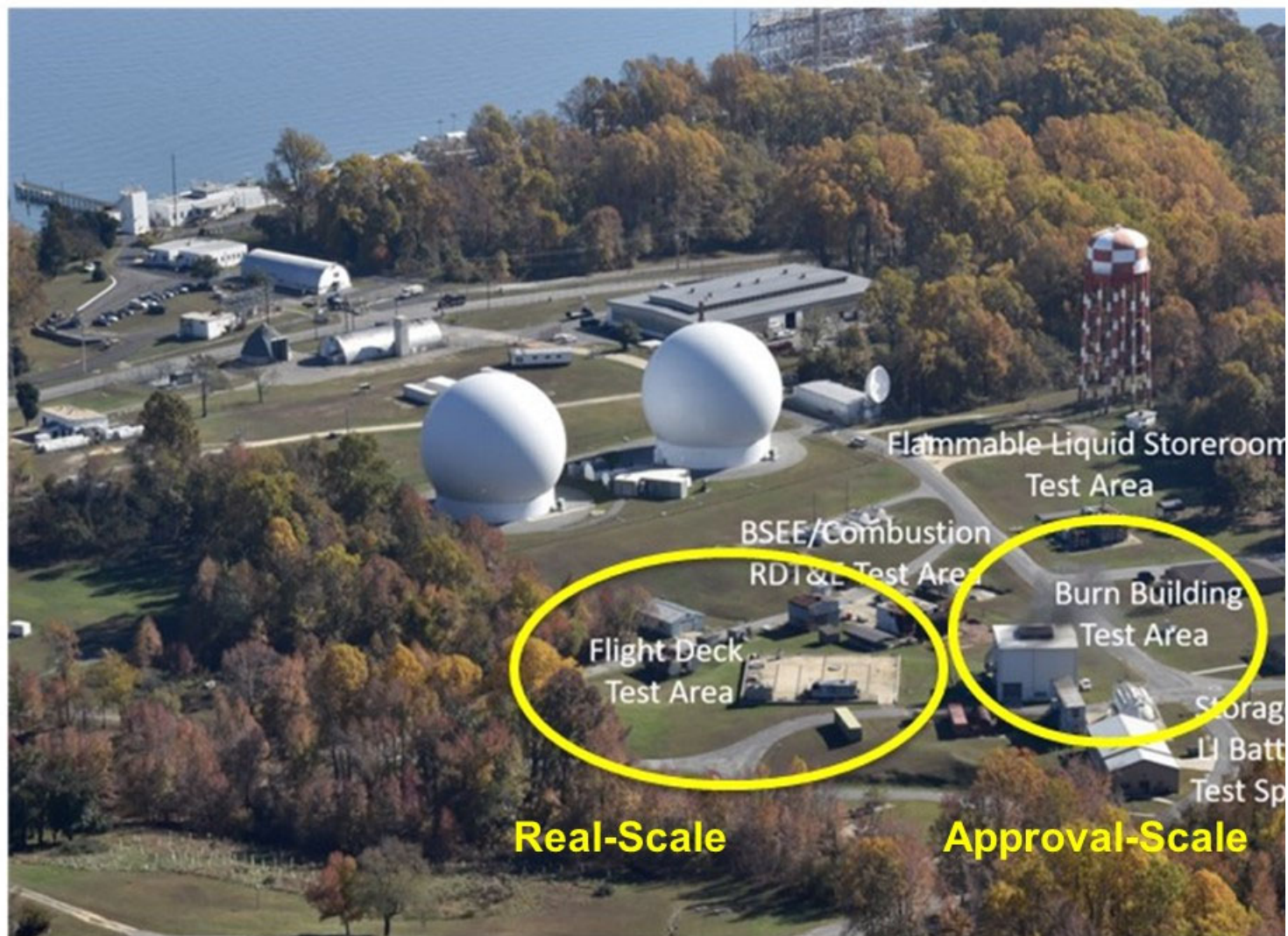
Task 2: Environmental Analysis

- General foam composition environmental assessment
- Life cycle environmental assessments
- No obvious “Show Stoppers”

Selected 10 for testing, grew to over 25

All “mechanical foams” so aspiration is key variable

Site Description – NRL/CBD



Test Design

Approval-Scale Testing

28 ft² pan fire (MilSpec)

2 & 3 gpm - Ext. & Burnback

Gasoline and Jet A

Aspirating nozzle

(MilSpec - gasoline - 2 gpm - 30 sec)



Real-Scale Testing

400 ft² pan fire

30 gpm nozzle – Ext only

w & w/o foam tube

mostly Jet A (some gasoline)



Both conducted at 0.07 gpm/ft²

Over 100 Approval-Scale Tests

#	Manufacturer	Agent Type	Gasoline				Jet A			
			2 gpm		3 gpm		2 gpm		3 gpm	
			Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)
B	Buckeye MILSPEC 3%	AFFF	30	501	24	584	16	712	12	817
1	National - Avio Green	Foam	57	262	45	244	30	365	20	507
1A	Angus -Jet Foam	Foam	49	244	42	285	19	357	15	537
1B1	National Universal Green AR-FFF	Foam	145	189	84	242	30	245	26	314
1B2	Angus -AR-FFF	Foam	156	196	77	246	33	257	29	322
2	Solberg - RE-HEALING RF3	Foam	53	726	45	1019	33	690	22	1008
3	Fomtec - Enviro USP	Foam	58	434	37	678	24	647	15	767
3A	Fomtec - AR-FFF	Foam	128	246	73	282	32	232	27	334
4	Bio-ex - ECOPOL N F3 HC	Foam	No	-	No	-	No	-	114	311
4A	Bio-ex - ECOPOL A	Foam	57	278	52	372	26	350	18	407
5	Dr. Sthamer - MOUSSOL FF 3x6	Foam	77	240	65	335	25	445	21	539
5A	Dr. Sthamer - VA Pure XLV ICAO	Foam	77	170	55	225	27	352	15	285
6	vs FOCUM - Silvara APC 3x3	Foam	126	189	71	252	22	424	16	445
10	Perimeter Sol. - Auxquimia ICAO	Foam	No	-	123	0	26	363	20	412
11	FireBull FFF	Foam	84	208	67	501	22	507	17	648
15A	GreenFire GFFF	Foam	107	70	62	94	32	156	25	212
16	XAERUS - 3LV	Foam	No	-	No	-	103	35	87	68
7	Amiran - Flame Out	Wetting	-	-	No	-	-	-	95	40
8	Pyrocool - Pyrocool FEF	Wetting	No	-	124	153	29	203	20	277
9	Novacool - Novacool UEF Foam	Wetting	No	-	104	39	32	232	27	334
12	F-500	Wetting	No	-	No	-	57	55	35	165
13	FIREREIN - Eco-Gel A/B	Wetting	No	-	No	-	No	-	No	
14	ATIRA Sys. - Strong Water	Wetting	No	-	No	-	No	-	No	
15	GreenFire WA	Wetting	No	-	No	-	36	177	29	198

Approval-Scale Test Observations

Fuel Type

Flammable Liquid (flashpoint) < 100°F < Combustible Liquids (flashpoint)

Gasoline – Flam. Liq. – FP -40°F some 50 grades w/wo alcohol

Jet A – Comb. Liq. (kerosene based) – FP > 100°F min. variations no alcohol

Jet A is much easier to extinguish than gasoline (Ext. times less than ½)

Alcohol makes things even harder and is product specific

General Results

AFFF ext. times about ½ that of good PFAS-Free products

2 gpm (0.07 gpm/ft²) solution / Jet A AFFF ~15 sec most PFAS-Free ~ 30 sec

About 10% could not extinguish the fire

2 gpm (0.07 gpm/ft²) solution / gasoline AFFF 30 sec some PFAS-Free ~ 60 sec

Over 40% could not extinguish the fire

General Capabilities Rankings (Product Type)

1st AFFF, 2nd PFFs, 3rd WA, 4th New Formulations

~60 sec ext. gas @ 2 gpm - 0.07 gpm/ft²

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			2 gpm		3 gpm		2 gpm		3 gpm	
			Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)
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Approval-Scale Test Results



150 gal fuel (Gasoline or Jet A) ~80MW 40 ft Flame height 40 gpm burning rate

Approval-Scale Test Results



15° pattern
AFFF exp 5 - FFF exp 6



5° pattern
AFFF exp 18 - FFF
exp 22

30 gpm @ 100 psi --- .07 gpm/ft²

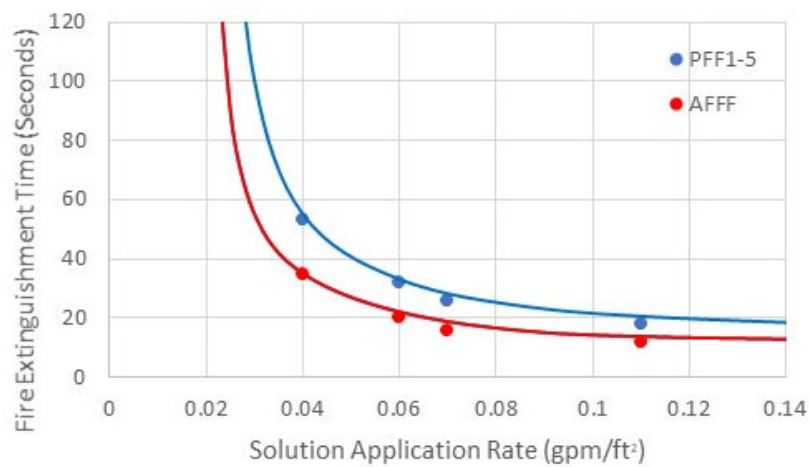
Real-Scale Testing Results

Foam/Agent	Fuel	STD Nozzle (.07 gpm/ft ²)		Foam Tube (.07 gpm/ft ²)	
		Cont (sec)	Ext (sec)	Cont (sec)	Ext (sec)
AFFF	Jet A	25	45	15	25
PFF1-5 (AVG)	Jet A	45	60	25	40
WA2	Jet A	60	No	60	102
AFFF	gasoline	30	50	30	45
PFF1-5 (AVG)	gasoline	100	135	60	105

- Standard nozzle spray patterns could be an issue (i.e., we needed 15°)
- Jet A tends similar as lab-scale test results (consistent and repeatable)
- Gasoline is very technique dependent (plunging is detrimental)
- Apples to Apples PFF1-5 about 1.5-2 times longer
- Foam tube reduces ext. time by 30-45%
- Foam tube reduces stream reach by 40%

Top PFAS-Free Firefighting Capabilities

Jet A Extinguishment Times

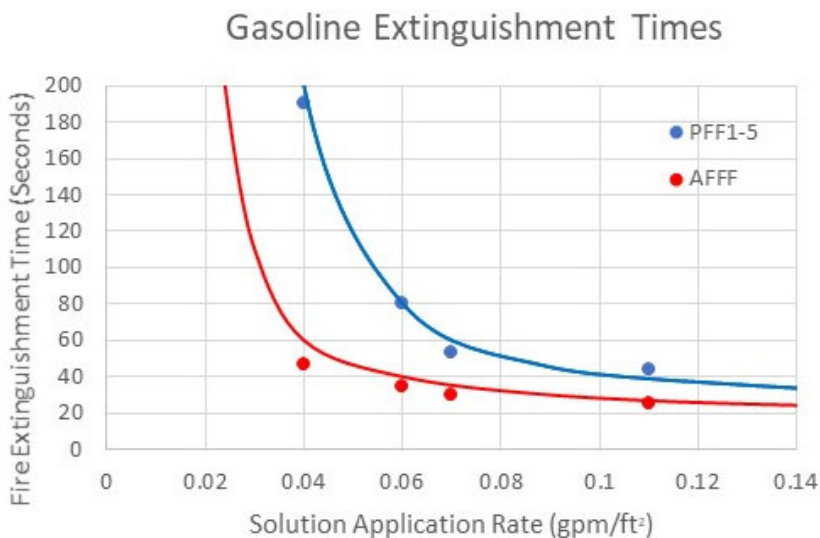


Jet A

Jet A “L” curves are parallel
(but don’t seem to converge?)

PFF1-5 under a minute even at .04 gpm/ft²

Gasoline



Gas “L” curves are parallel above .07 gpm/ft²
(but don’t seem to converge?)

Above .07 gpm/ft² PFF1-5 about 1.5 times
longer ext. times

Below .07 gpm/ft² PFF1-5 lose capabilities
against gasoline

Ran top five PFF against 50ft² @ 2/3 gpm for “L” curves

Project Summary

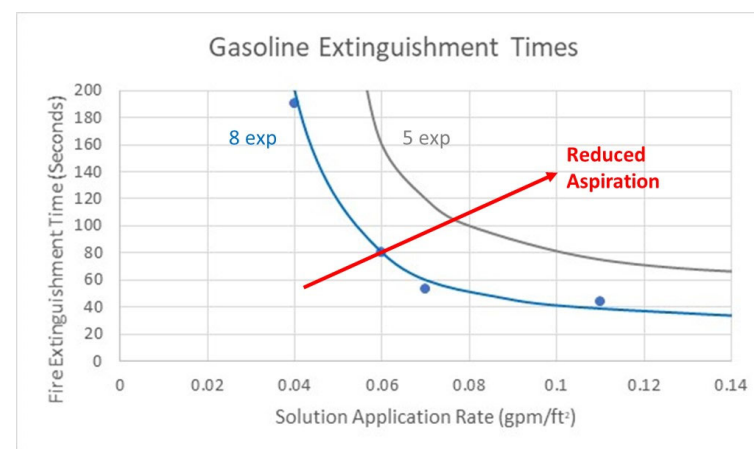
- 60+ Foams/Agents identified during literature search
- 40 had legitimate test/approval pedigrees
- 10 Selected for testing which grew to over 20 products tested
- 100 Approval-scale and 22 Representative-scale tests conducted
- Tests conducted with both gasoline and Jet A
- Top 5 foams demonstrated good capabilities
- Extinguishment times for Top 5 were ~ 1.5 to 2 times longer than AFFF (but were successful against all fires)
- We may be closer than originally thought

Next Steps - Scale-up

Approval-scale data used in WP19-5373 foam selection

Continue to test new products

Assess aspiration/expansion ratio
and DoD hardware foam quality
WP19-5374

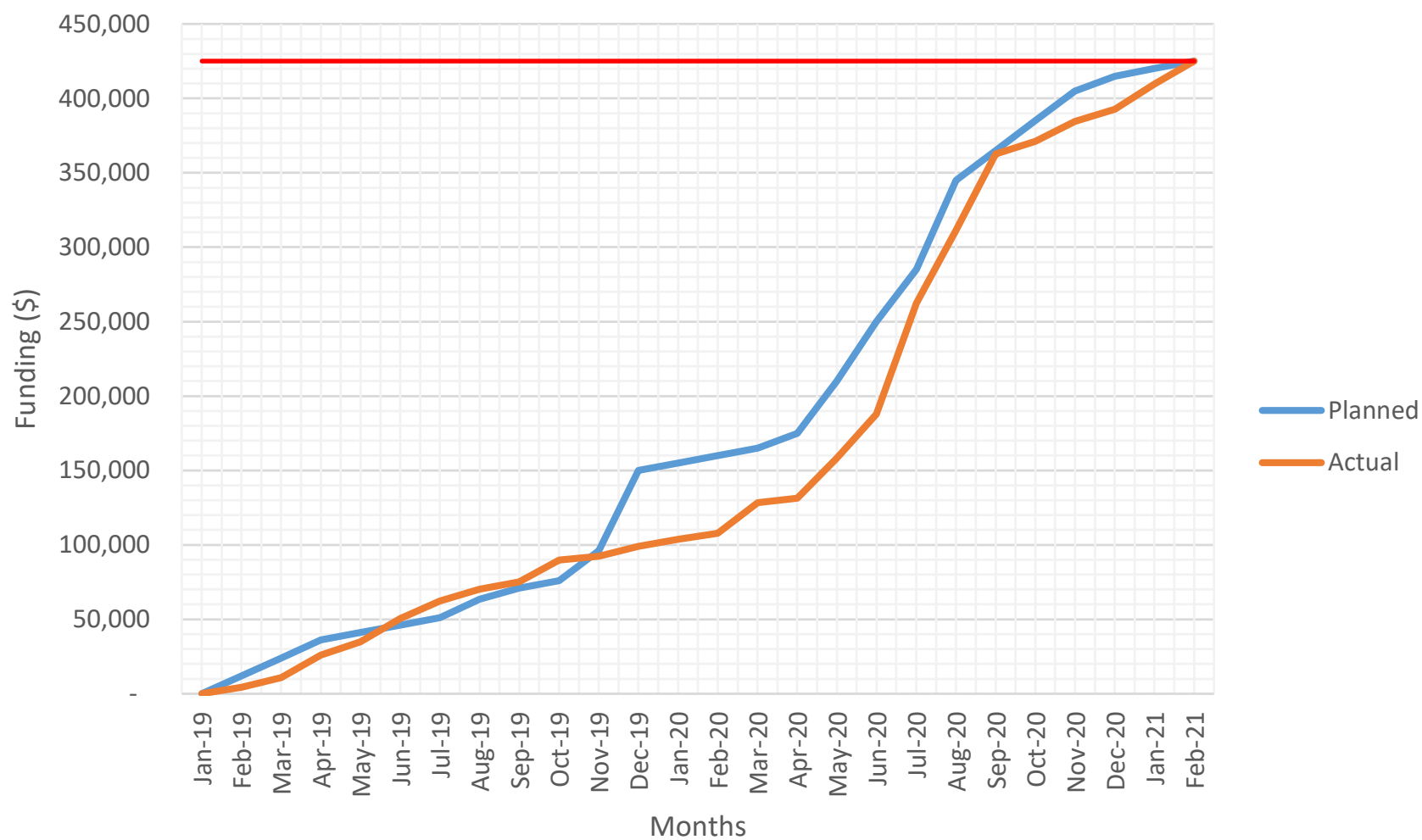


Also: fuel type, alcohol content

China Lake Debris Pile
Legacy / MCE – Final Validation

New Land-based MilSpec

Program Expenditures



Technology Transfer

1. Understanding current regulations and knowing when to make the transition

- a. Pre-emptive transition /Required transition

2. Selection of an acceptable AFFF alternative

- a. Hardware compatibility
- b. Firefighting capabilities and limitations

Designer Foams
Fuel type(s) - alcohol

3. Disposal of current AFFF products

4. Cleaning of equipment and definition of acceptable levels

- a. Disposal of cleaning effluents

5. Implementation of the selected alternative

- a. Proportioning issues and concerns (viscosity adjustments)
- b. Discharge devices (potential replacement and/or modifications)
- c. Techniques and tactics (training?)

Aspiration
Viscosity

6. Firefighter exposures

- a. Eyes and skin (rinsing and cleaning)
- b. Clothing and equipment (cleaning)

7. Post fire / post discharge cleanup and documentation

NFPA RF Roadmap --- DoD may need one as well



Aviation MCE ? Mil-Std-882E

Test Results/Video

PFF – Foam tube
0.07 gpm/ft²

20 sec Control
40 sec Exting.

NFPA 403 / 460

AFFF design criteria
0.13 gpm/ft²

60 sec Control

~30 sec ext. @ 0.07 gpm/ft²

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How good is good enough?

