

PFF/CAF

PFAS-Free-Foam/Compressed Air Foam

Fire Suppression Alternative

WP20-5334

PI David Munroe
ACAF Systems, Inc.

Final Debrief

11/18/22



REPORT DOCUMENTATION PAGE

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14. ABSTRACT The technical objectives of this project are listed below: <ul style="list-style-type: none"> ● Determine if PFF/CAF can meet Mil-Spec. ● Identify what ROA is required for PFF/CAF to meet Mil-Spec ● Prove PFF/CAF effective for military applications both firefighting and fire suppression. ● Identify advantages PFF/CAF has for firefighting and fire suppression systems for the DoD. ● What impact is there for change in ambient temperature to PFF/CAF. 					
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Technical Objectives

- Determine if PFF/CAF can meet Mil-Spec.
- Identify what ROA is required for PFF/CAF to meet Mil-Spec
- Prove PFF/CAF effective for military applications both firefighting and fire suppression.
- Identify advantages PFF/CAF has for firefighting and fire suppression systems for the DoD.
- What impact is there for change in ambient temperature to PFF/CAF.

Performance Objective	Metric	Data Requirements	Success Criteria	Success Criteria Achieved?
Quantitative Performance Objectives				
Determine if PFF/CAF can meet Mil-Spec	Fire Test 28 ft ² & 50 Section 4.7.13.1 of MIL-PRF- 24385F (May 7, 2019)	Foam Concentrate Mix Ratio Ambient Temperature Rate of Application Foam Expansion Ratio ¼ Drain Time Flow Rate Time to Extinguish Fire Fuel Temp	Fire extinguished in 30 seconds (28 sq. ft.) 50 seconds (50 sq. ft.)	<p>No, not to the current MIL-F standard with NEG</p> <p>Yes, to the proposed MIL-F standard with Jet A1</p>
Identify what ROA is required for PFF/CAF to meet Mil-Spec	Fire Test 28 ft ² & 50 Section 4.7.13.1 of MIL-PRF- 24385F (May 7, 2019)	Foam Concentrate Mix Ratio Ambient Temperature Rate of Application Foam Expansion Ratio ¼ Drain Time Flow Rate Time to Extinguish Fire Fuel Temp	Fire extinguished in 30 seconds (28 sq. ft.) 50 seconds (50 sq. ft.)	<p>3 X greater then AFFF for firefighting NEG</p> <p>Lower than AFFF in most fire suppression systems</p>
What impact is there for change in ambient temperature to PFF/CAF	Fire Test 28 ft ² & 50 Section 4.7.13.1 of MIL-PRF- 24385F (May 7, 2019)	Foam Concentrate Mix Ratio Ambient Temperature Rate of Application Foam Expansion Ratio ¼ Drain Time Flow Rate Time to Extinguish Fire Fuel Temp	Fire extinguished in 30 seconds (28 sq. ft.) 50 seconds (50 sq. ft.)	<p>Low to no impact on fire extinguishment time</p> <p>Slight impact on Burnback/ Reflash as higher temperature reduced performance</p>

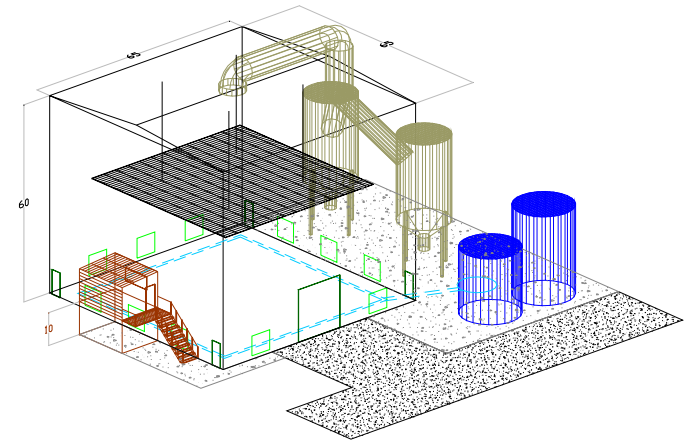
Performance Objective	Metric	Data Requirements	Success Criteria	Success Criteria Achieved?
Quantitative Performance Objectives				
<p>Prove PFF/CAF effective for military applications both firefighting and fire suppression.</p> <p>Identify what advantage PFF/CAF has for firefighting and fire suppression system for the DoD</p>	<p>Fire Test 50 ft²</p> <p>LASTFIRE</p>	<p>Foam Concentrate Mix Ratio</p> <p>Ambient Temperature</p> <p>Rate of Application</p> <p>Foam Expansion Ratio</p> <p>¼ Drain Time</p> <p>Flow Rate</p> <p>Time to Extinguish Fire</p> <p>Fuel Temp</p>	<p>Fire extinguished</p>	<p>Yes, performance by all PFF products as CAF was greater than PFF/AA</p> <p>Using the LASTFIRE test scoring system PFF/CAF achieved scores 95 – 100.</p>
<p>Determine if PFF/CAF can meet the current and proposed Mil-Spec</p>	<p>Fire Test 1,250 ft²</p> <p>MIL2438 (May 2, 1977)</p>	<p>Foam Concentrate Mix Ratio</p> <p>Ambient Temperature</p> <p>Rate of Application</p> <p>Foam Expansion Ratio</p> <p>¼ Drain Time</p> <p>Flow Rate</p> <p>Time to Extinguish Fire</p> <p>Fuel Temp</p>	<p>Maximum time of 40 s to extinguish 85% of the fire.</p>	<p>No, not with Non-ethanol gasoline the best performance is 50% at 40 seconds</p>
<p>Prove PFF/CAF effective for military applications both firefighting and fire suppression.</p> <p>Identify advantages PFF/CAF has for firefighting and fire suppression system for the DoD</p>	<p>Fire Test 3,280 ft²</p> <p>NEG Type II & III Applicators</p>	<p>Foam Concentrate Mix Ratio</p> <p>Ambient Temperature</p> <p>Rate of Application</p> <p>Foam Expansion Ratio</p> <p>¼ Drain Time</p> <p>Flow Rate</p>	<p>Fire extinguished</p>	<p>Yes, PFF/CAF outperformed PFF/AA with a 40% lower application rate.</p> <p>Fire extinguishment in half the time with nearly half the ROA.</p>

Site Description



SOUTHWEST RESEARCH INSTITUTE

SwRI is headquartered in San Antonio, TX, and one of the oldest and largest independent, nonprofit, applied research and development organizations in the United States. Founded in 1947, SwRI provides contract research and development services to industrial and government Clients. SwRI is governed by a board of directors, which is advised by approximately 100 trustees.



Large-Scale Fire Engineering and Research Facility Layout.



Site Description

GESIP

Vernon, France

Gesip carries out performance or acceptance tests on its two sites for equipment and materials likely to improve safety.

Gesip is particularly very active in the field of foam concentrates, for the evaluation of product performance.

Finally, Gesip publishes professional guides, technical summaries and research documents resulting from the work of its discussion and study groups.



Test Design

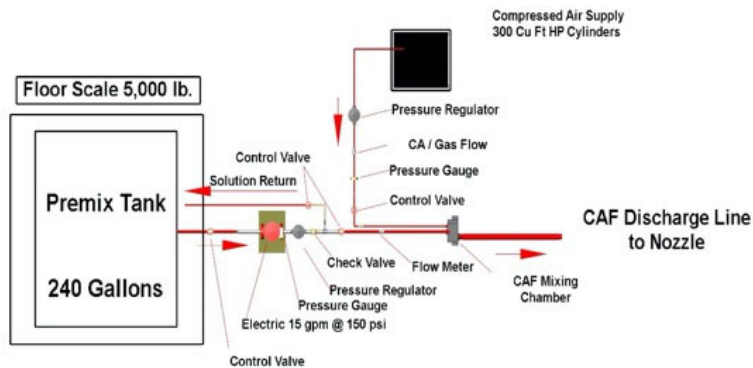
- PFF - CAF Test (28 sq. ft.) made to MIL-PRF-24385F, AMENDMENT 3, 4.7.13.1
- PFF – CAF Test (50 sq. ft.) made to MIL-PRF-24385F, AMENDMENT 3, 4.7.13.1
- CAF Optimization / Comparison LASTFIRE 50 ft² Fire Test Protocol
- PFF – CAF Test (1,250 sq. ft.) made to MIL- PRF-24385B, May 1977,
- Large Scale (164 ft. x 20 ft.) PFF/CAF Fire Testing to LASTFIRE Test Protocol

Foam Products Tested

Foam Concentrate ID	Manufacturer	Foam Trade Name	Foam Type
Product A	National Foam	Universal®F3 Green	PFF
Product B	Solberg	*R&D Product	PFF
Product C	National Foam	Aer-O-Water® 3EM	AFFF
Product D	National Foam	Avio®F3 Green KHC	PFF

Solberg R&D product is now to market as VERSGAR

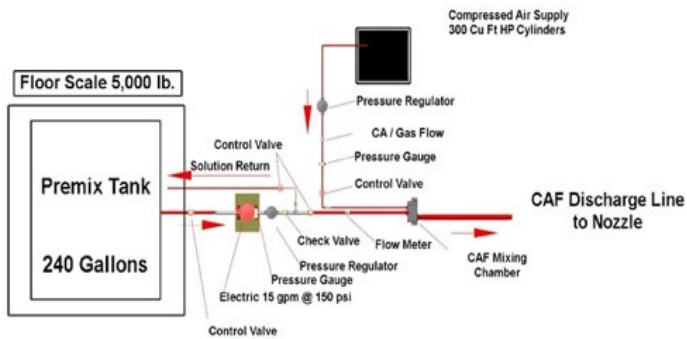
System Test Depiction: Small Scale Pan Fire Mil-Spec Test 28 & 50 sq. ft.



System Test Depiction:

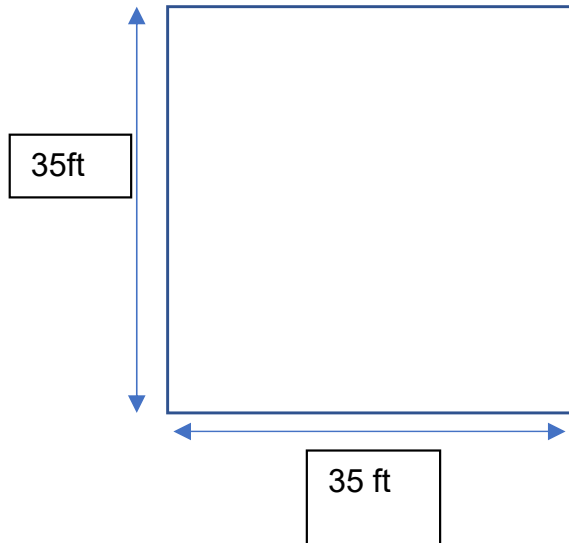
CAF Optimization / Comparison

LASTFIRE 50 ft² Fire Test Protocol



System Test Depiction: PFF – CAF Fire Test (1,250 sq. ft.) MIL- PRF-24385B

Test Pit



Equipment



ACAF Systems CAF Generator



FireDos FD 500 Foam Proportioner

Test Nozzles

CAF 1-1/2" open Pistol Valve

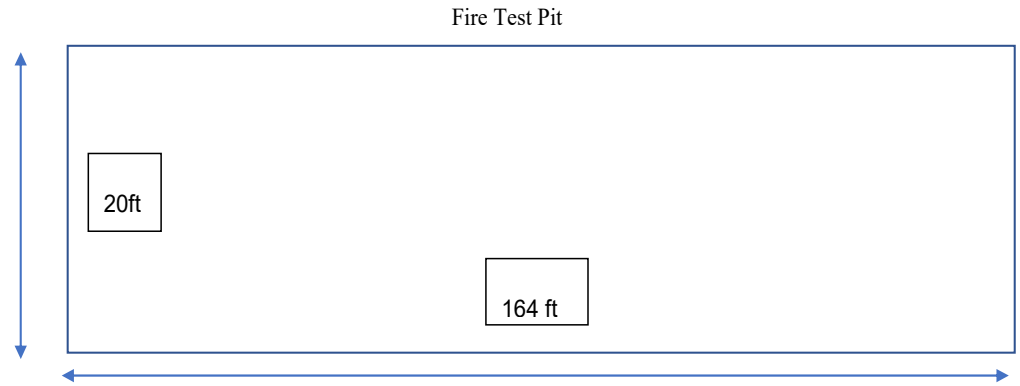


AA 1-1/2" Semi Aspirating with adjustable spray nozzle



System Test Depiction:

Large Scale 164 ft. x 20 ft. PFF/CAF Fire Testing to LASTFIRE

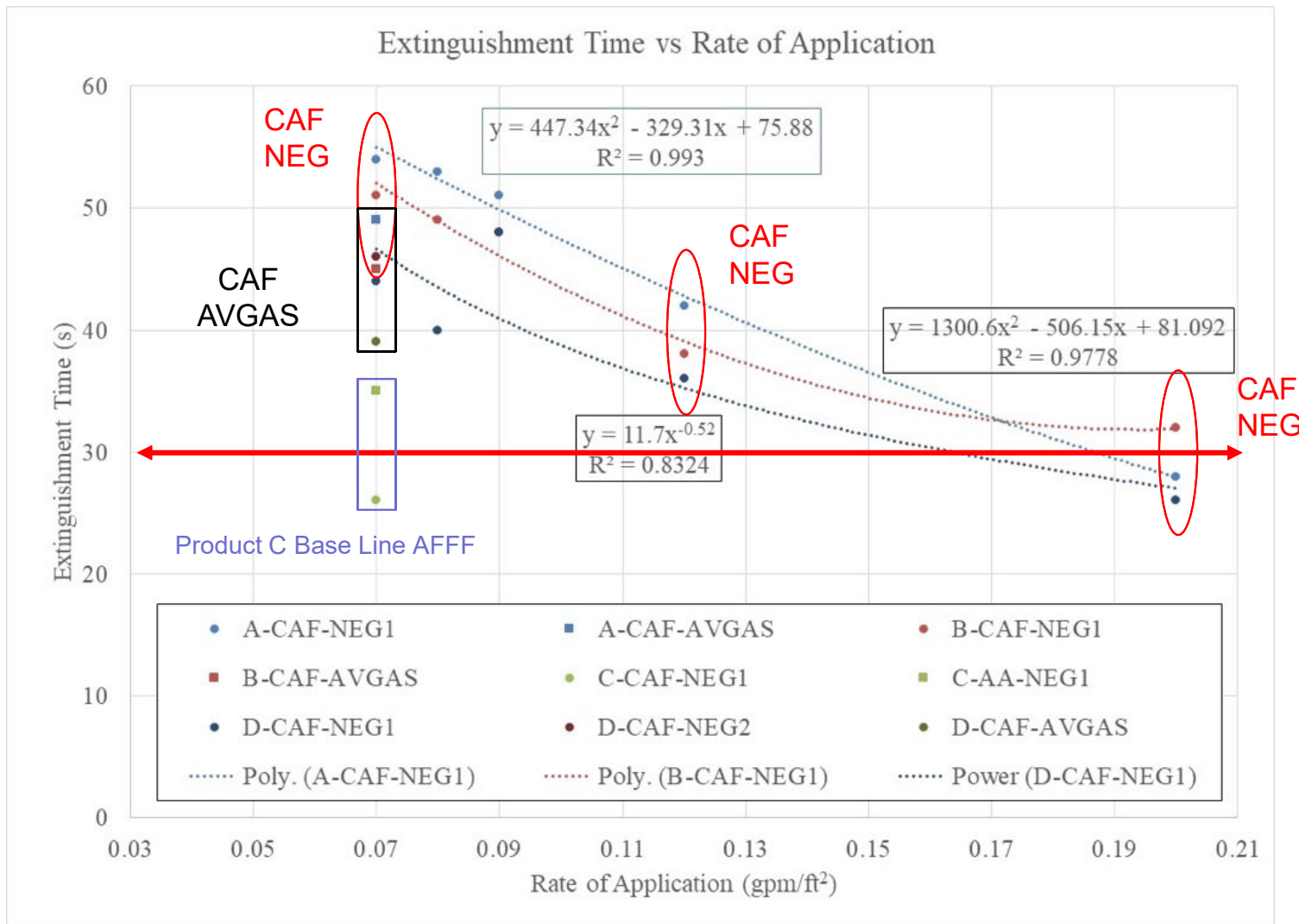


Performance Assessment

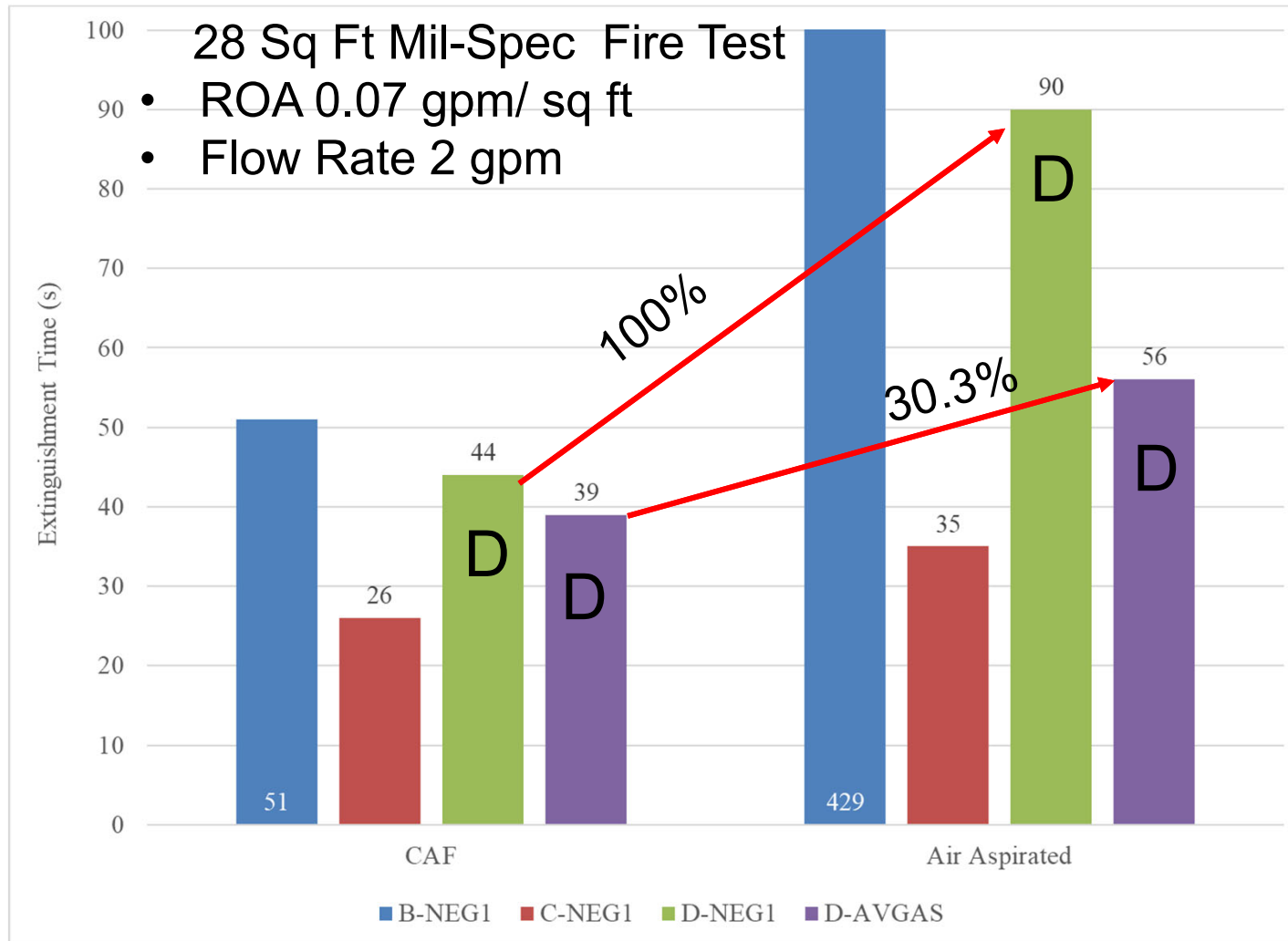


Small Scale Pan Fire
Mil-Spec Test 28 & 50 sq. ft.

ROA Summary Graph.



Graph: Foam Performance Comparison



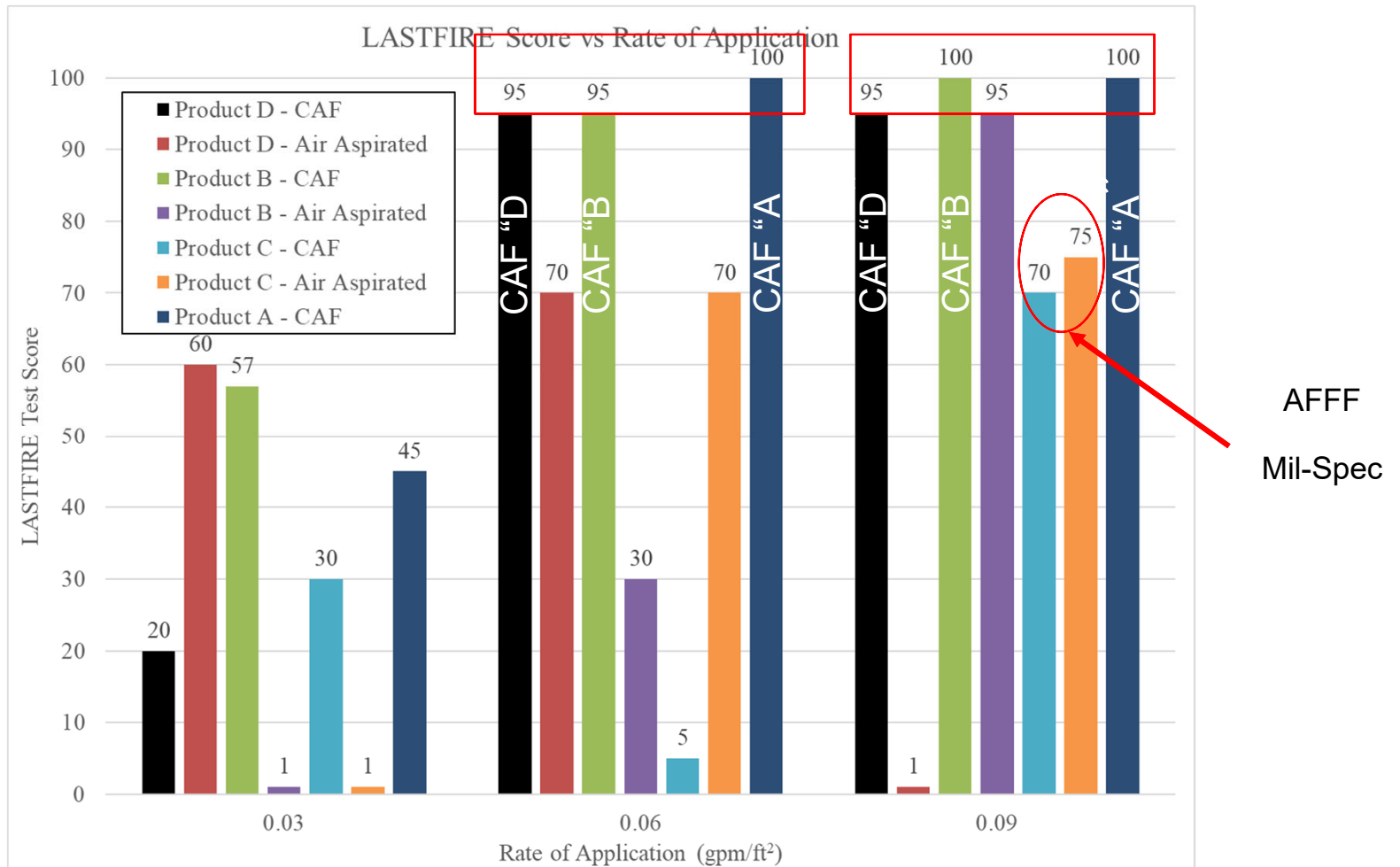
CAF yields faster extinguishment times for each of the four comparison tests. The greater difference in extinguishment time is with NEGI at 100% and higher.

Performance Assessment



CAF Optimization /
Comparison
LASTFIRE 50 ft² Fire Test
Protocol

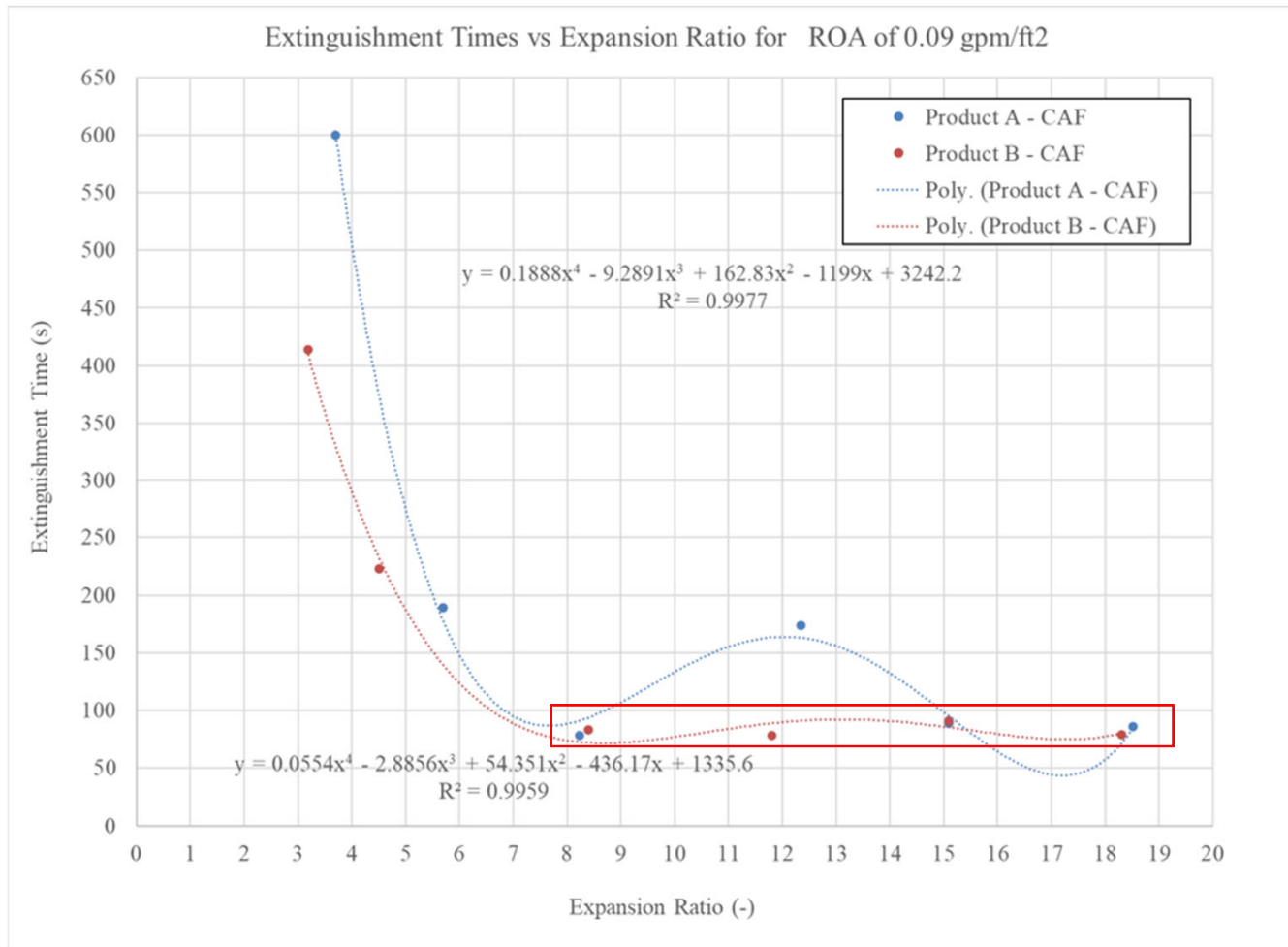
Graph: LASTFIRE 50 sq.ft. Test Scores



Test scores from (3) ROAs indicate CAF to be the higher performing process at lower ROAs.

Fuel type NEG

Expansion Ratio vs Extinguishment Times



Performance Assessment



PFF – CAF Fire Test
(1,250 sq. ft.)
MIL- PRF-24385B

Fire Extinguishment Observation

Test Number	Date	Ambient Temp (°C)	Water Temp (°C)	Fuel Temp (°C)	Relative Humidity	Wind Speed	Foam Type	Mix Rate	Application type	Application Rate (gpm)	Expansion	Extinguish-ment Time
2	3/30/2022	11	15.5	13.5	86	1	A	3%	CAF	60	8.98 to 1	2'40"
3	3/30/2022	11	15	11	86	1	A	3%	Aspirating	60	10.96 to 1	6'59"
4	3/30/2022	13	18	13	77	1.2	B	3%	Aspirating	60	8.21 to 1	10'30"
5	3/30/2022	14.5	21.5	14	75	1.4	B	3%	CAF	60	7.95 to 1	5'26"
6	3/30/2022	15.5	22.5	15.5	73	1.4	C	3%	CAF	60	13.67 to 1	3'52"
7	3/31/2022	12	13	15	80	2.5	C	3%	Aspirating	60	13.45 to 1	2'28"

Test Number	Foam	Application type	10 seconds	20 seconds	30 seconds	40 seconds	50 seconds	60 seconds	70 seconds	80 seconds	90 seconds
	Type										
2	A	CAF	0%	0%	0%	0%	0%	30%	60%	80%	90%
3	A	AA	0%	0%	0%	0%	0%	0%	0%	0%	15%
4	B	AA	0%	0%	5%	10%	0%	0%	0%	0%	0%
5	B	CAF	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	C	CAF	0%	0%	5%	5%	25%	40%	60%	75%	80%
7	C	AA	5%	10%	20%	50%	70%	60%	50%	50%	50%

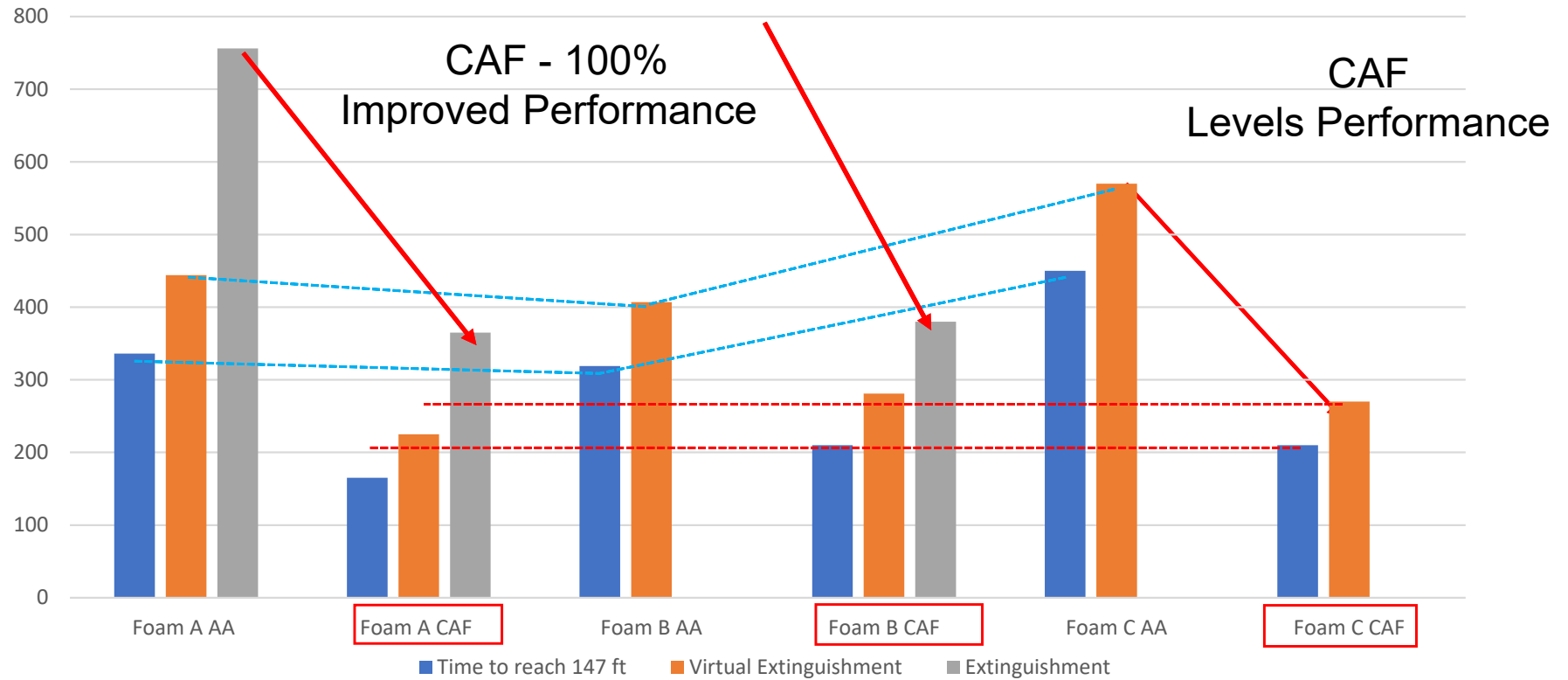
85%

Performance Assessment

Large Scale 164 ft. x 20 ft.
PFF/CAF Fire Testing to
LASTFIRE Protocol



Type II Foam A,B & C 164 ft Fire Test Results



Foam	Application Type	Time to 45 m	Virtual Extinguishment	Full Extinguishment
A	Aspirating Pourer	336	444	756
A	CAF Pourer	165	225	365
B	Aspirating Pourer	319	407	DNE
B	CAF Pourer	210	281	380
C	Aspirating Pourer	319	570	DNE
C	CAF Pourer	210	270	DNE

CAF System Design Demands

Space Name	Area(ft^2)	CAF Generator	Nozzles	ROA GPM / Sq. Ft	Flow Rate (GPM)	Duration Minutes	Foam/ Water Demand (Gallons)	Compressed Air Demand (CFM)	Foam Concentrate Demand
Bay #1	2400	MxC 816-1	16	0.05	144	15	2160	187	65
Bay #2	2400	MxC 816-1	16	0.05	144	15	2160	187	65
Bay #3	2400	MxC 816-1	16	0.05	144	15	2160	187	65
			48				6480	561	194
								8,415	SCF

(AA) System Design Demands

Space Name	Area(ft^2)	Control Valve	Nozzles	ROA GPM/ Sq. Ft.	Flow Rate GPM	Duration Minutes	Foam/ Water Demand	Foam Concentrate Demand 3%	
Bay #1	2400	Deluge Control Valve	24	0.16	384	15	5,760	173	
Bay #2	2400	Deluge Control Valve	24	0.16	384	15	5,760	173	
Bay #3	2400	Deluge Control Valve	24	0.16	384	15	5,760	173	
			72				17,280	518	Gal.

Scale-up

- ◆ Moving from demonstration-scale to full-scale implementation, what to expect.
- ◆ To bring CAF to full scale implementation will require only the action of the DoD to accept the technology. Existing today are several FM Approved CAF systems that can be implemented in design according to NFPA 11, 2021.
- ◆ What are the constraints in terms of engineering limitations or equipment availability?
- ◆ For design of PFF/CAF systems there are no constraints that would prevent the DoD from allowing these type systems to be used. The existing FM Approved CAF systems have design guidance that the DoD may accept or modify to meet specific needs.

Next Steps

- Continue research in PFF/CAF for Military applications.
- Promote further development of PFF/CAF based solution.
- Develop a Mil-Spec standard for PFF/CAF solutions.
- Approve the use PFF/CAF for fire suppression and firefighting systems throughout the DoD.
- Include an element of fuel in depth fire testing in the new Mil-Spec fire test protocol.

Technology Transfer

- Adopt NFPA 11, 2021 for system design of Military Applications
- Require FM Approval or 3rd party certification such as LASTFIRE for all CAF based solutions
- Training workshops, live or via webinar
- Presentations at key conferences
- Guidance documents
- Technology fact sheets
- “How to” Videos

Key Findings

- PHAS Free Foam / CAF can be an alternative to AFFF for all Military applications.
- CAF is a performance enhancing foam making process for fluorine free foams.
- PFF/CAF may be used at lower than conventional application rates with high performance.
- PFF/CAF does produce a high-quality finished foam that yields faster fire control and extinguishment with stronger vapor protection.
- As tested, there is little impact in the performance PFF/CAF when ambient temperature is between 32F and 110F.
- As tested CAF, with PFF does meet the proposed new Mil-Spec. PFF/CAF will provide no less than 30% greater performance with low grade fuels like AVGAS and Jet A1, with up to 100% greater performance on higher grade fuels such as non-ethanol gasoline over conventional foam making process.

Publications



WP-20 5334: PFF/CAF Fire Suppression Alternative

Performers :

- Mr. David B. Munroe, Dr. Niall Ramsden, Mr. Jason Huczek

Technology Focus :

- *PFF/ CAF for Military Applications*

Demonstration Sites:

- *SwRI (San Antonio, TX) and GESIP (Vernon, France)*

Demonstration Objective:

The objective of this program is to provide test data to support Compressed Air Foam (CAF), a foam making process when used with a PFAS-Free Foams (PFF) to be effective in firefighting for aviation, naval, military applications that can meet all fire performance requirements of the MIL F 24385 test protocol.

Project Progress and Results:

- PFF/ CAF can be an alternative to AFFF for all Military applications.
- CAF is a performance enhancing foam making process for PFAS Free Foams.
- PFF/CAF may be used at lower than conventional application rates with high performance.
- PFF/CAF does produce a high-quality finished foam that yields faster fire control and extinguishment with stronger vapor protection

Implementation:

- Adopt NFPA 11, 2021 for system design of Military Applications
- Require FM Approval or 3rd party certification such as LASTFIRE for all CAF based solutions

