Foam Quality Effects on the Firefighting Capabilities of PFAS-Free Foams

WP19-5374

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Final Debrief

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● The ultimate objective is to predict the firefighting capabilities of PFFs when discharged through typical Department of Defense (DoD) nozzles and systems
  - o Demonstrate firefighting capabilities of PFFs as a function of foam quality (expansion ratio and drainage time)
  - o Characterize the foam quality produced by typical DoD discharge devices and legacy protein foam hardware

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NRL

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40 years of USN firefighting experience and research

Stan Karwoski, Senior Firefighting Technician
20 years of practical firefighting experience and research

Technical Objectives

The ultimate objective is to predict the firefighting capabilities of PFFs when discharged through typical Department of Defense (DoD) nozzles and systems

- Demonstrate firefighting capabilities of PFFs as a function of foam quality (expansion ratio and drainage time)
- Characterize the foam quality produced by typical DoD discharge devices and legacy protein foam hardware

Two separate demonstrations conducted in parallel

Technical Approach

Firefighting Capabilities

Demonstrate firefighting capabilities of PFFs as a function of foam quality (expansion ratio and drainage time)

Four leading PFFs tested (and baseline C6 AFFF)

Tests conducted in MILSPEC 28 ft^2 pan (two fuels)

Foam qualities tested over a range of expansions 1 to 9

Two flow rates:

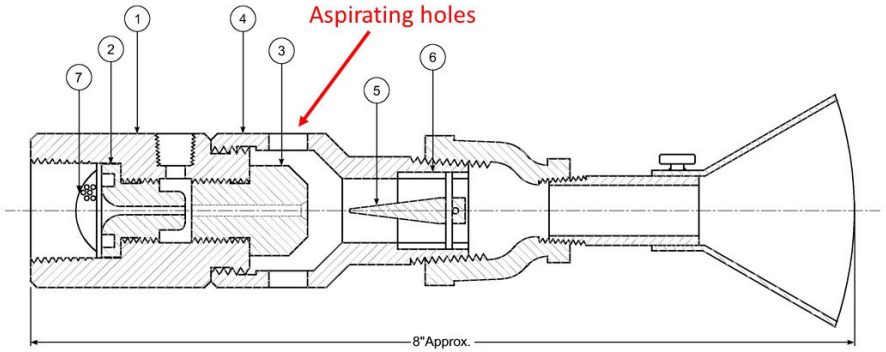
- 2 gpm (0.07 gpm/ft^2)
- 3 gpm (0.11 gpm/ft^2)

Test Design – Fire Performance

Foam Concentrates

Manufacturer	Foam Name	Type	Viscosity
Buckeye	Mil-Spec Type 3	AFFF	Newtonian
Bio-ex	ECOPOL A3+	PFF	Newtonian
Fomtec	Enviro USP	PFF	Non-Newtonian
National	Avio Green	PFF	Newtonian
Solberg	RE-HEALING RF3	PFF	Non-Newtonian

Air-Aspirating Nozzle
Openings Varied
2 & 3 gpm



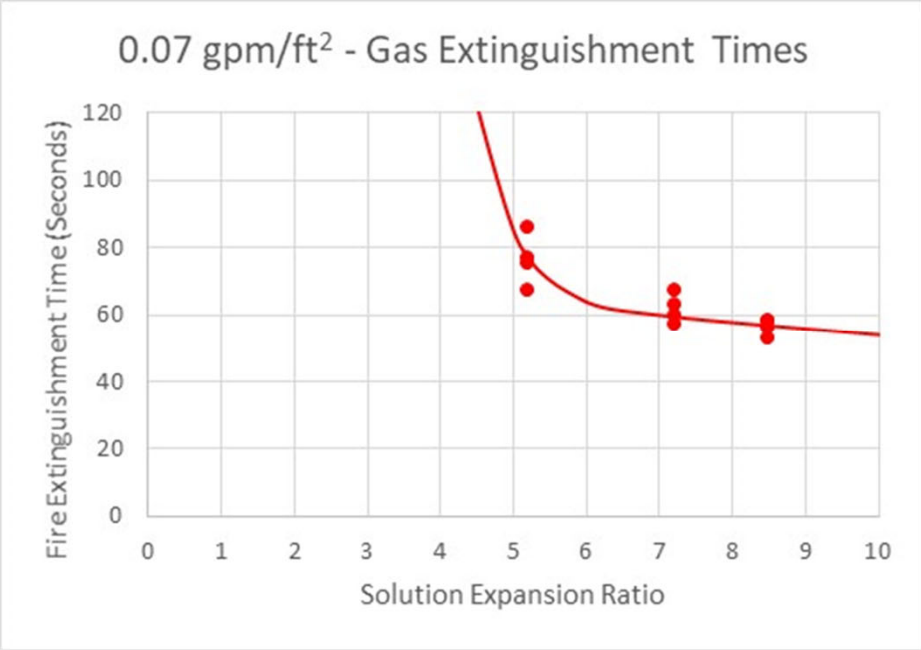
Assembly
2 GPM Test Nozzle

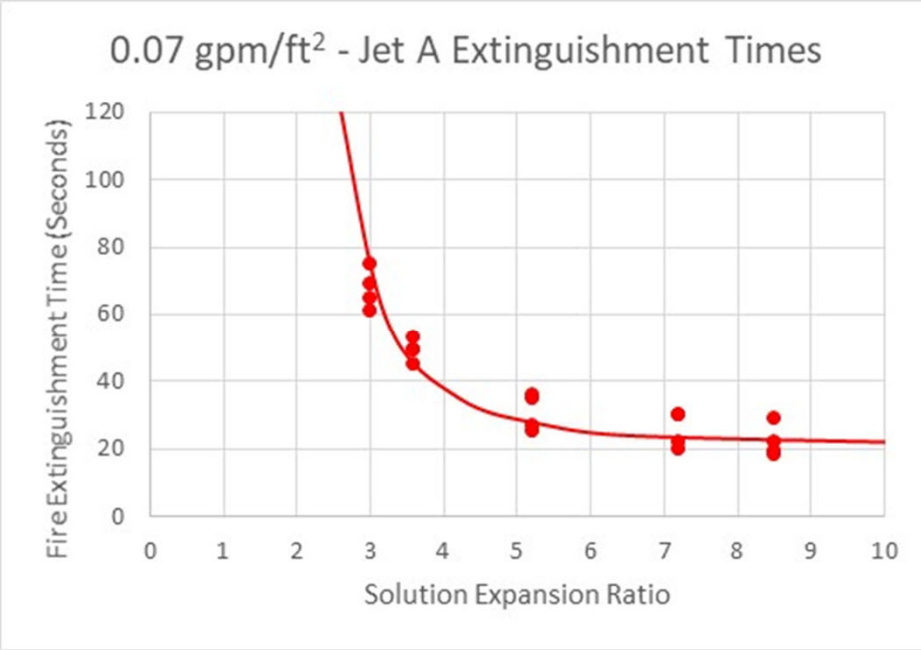
28 ft^2 Mil-Spec Fires and Procedures
Jet A and Gasoline

10 second preburns, 90 second discharges

Firefighting Data Review

Focus on 0.07gpm/ft^2 application rate
Foam quality/aspiration produces similar trends and application rate – “L curves”
Extinguishment similar between products
Critical expansion for gas 5-6 expansion
Critical expansion for Jet A 3-4 expansion

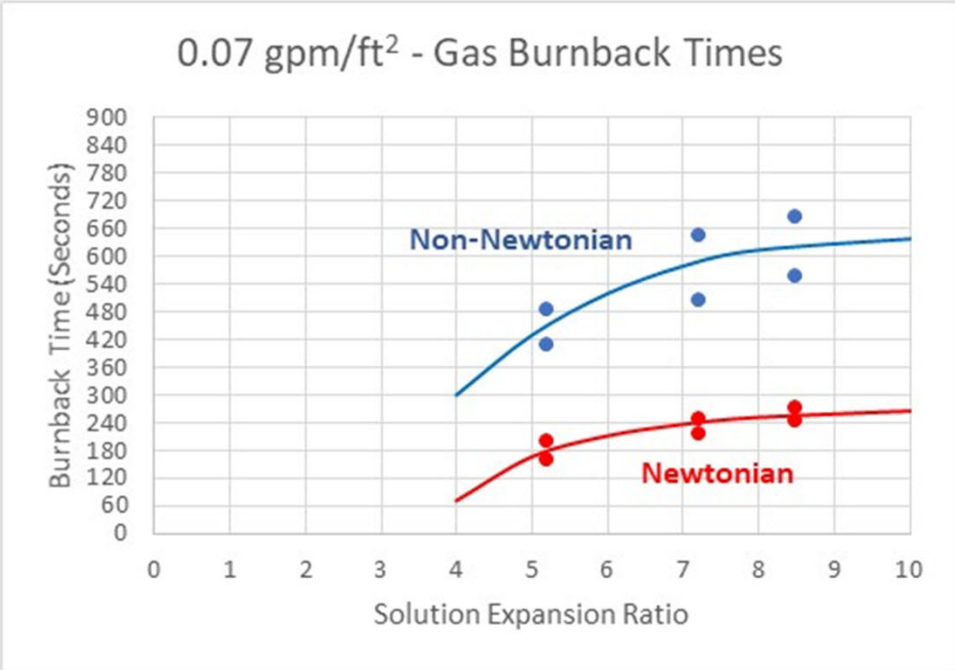


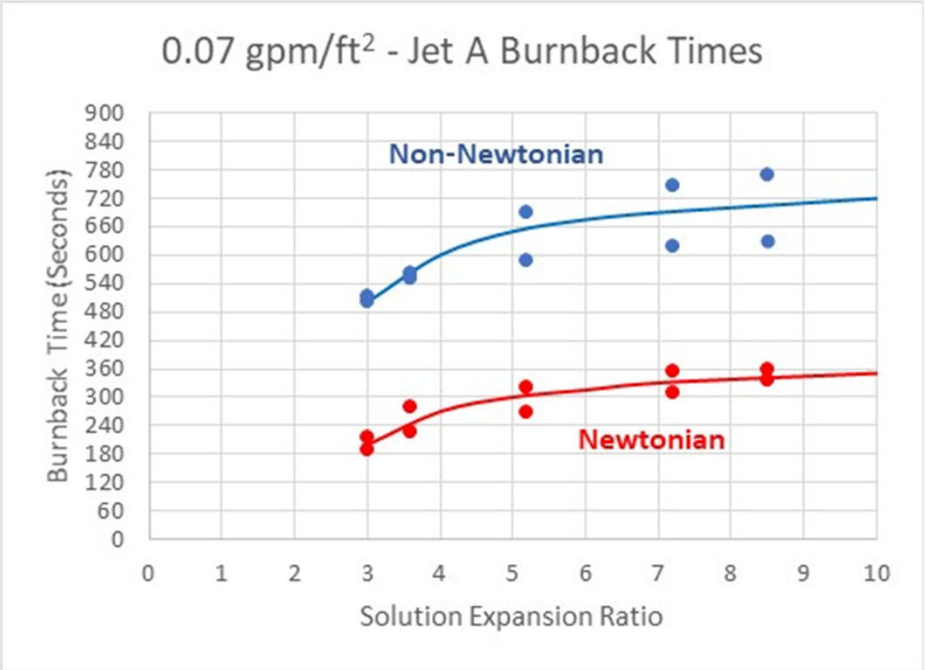


AFFF pushes lines to left 2 exp points

Burnback Data Review

90 second foam discharge
Burnback varied between product types (i.e., Newtonian and Non-Newtonian)
Non-Newtonian provides an additional 3-5 minutes of protection

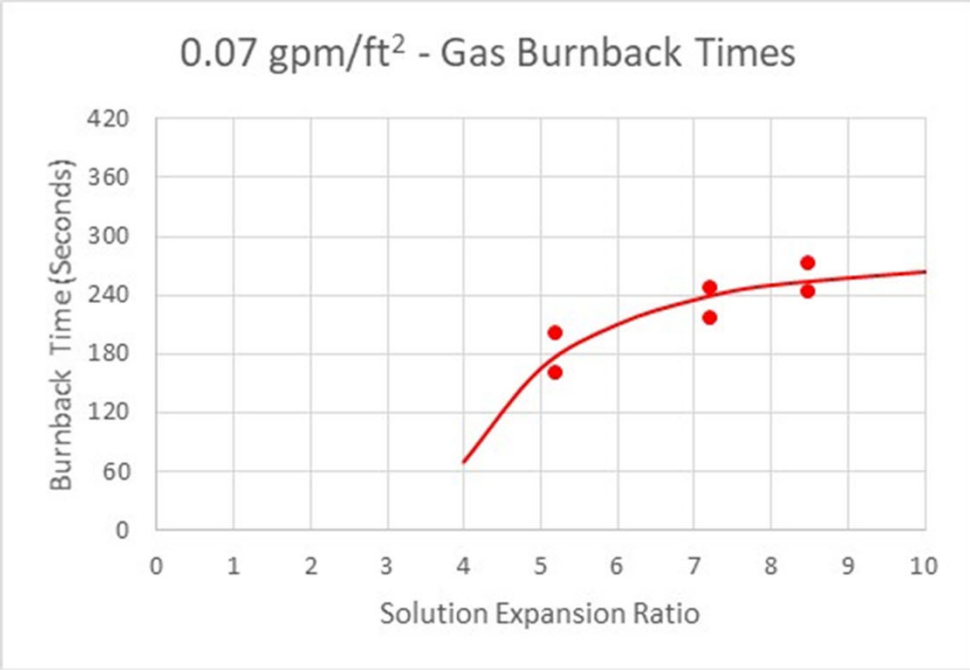


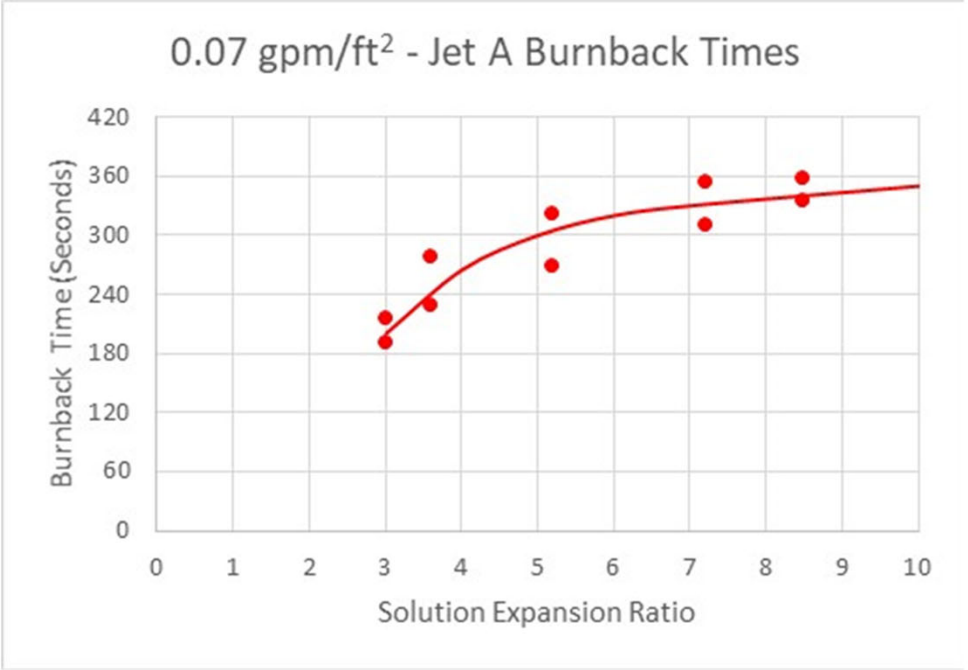


AFFF similar to Newtonian PFFs

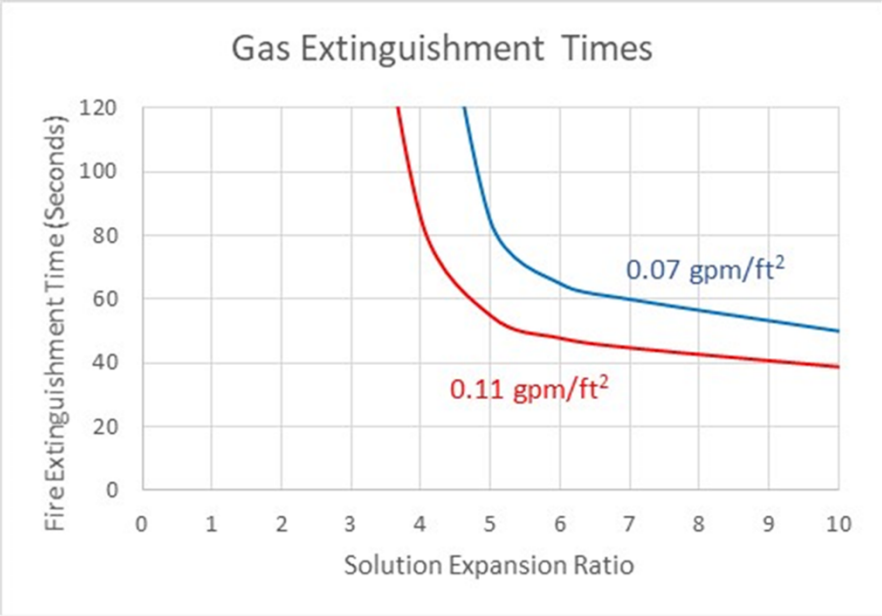
Burnback Data Review – Newtonian

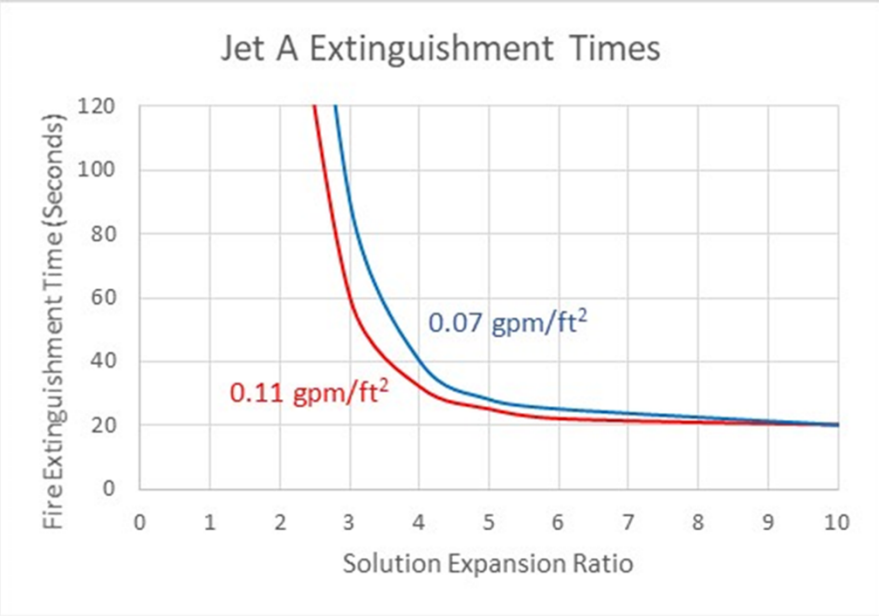
Land-based Mil-Spec (MIL-PRF-XX727) eliminates non-Newtonian products
Gradual increase with increased expansion/aspiration (2–3-minute increase)
Gas 3-4 minutes of protection over 5-9 expansion range (delta 1.5 minutes)
Jet A 3-6 minutes of protection over 3-9 expansion range (delta 3 minutes)
(Jet A is about 2 minutes longer than gas)

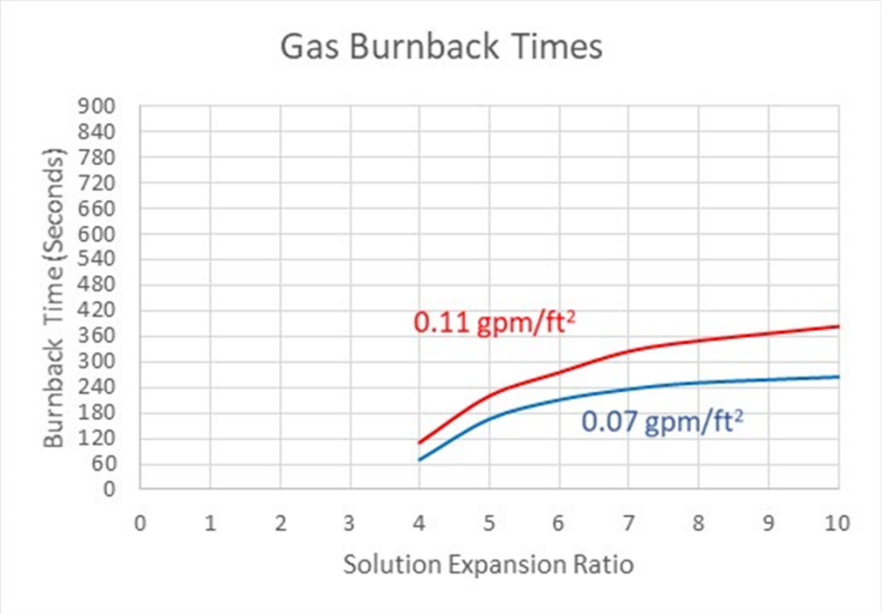


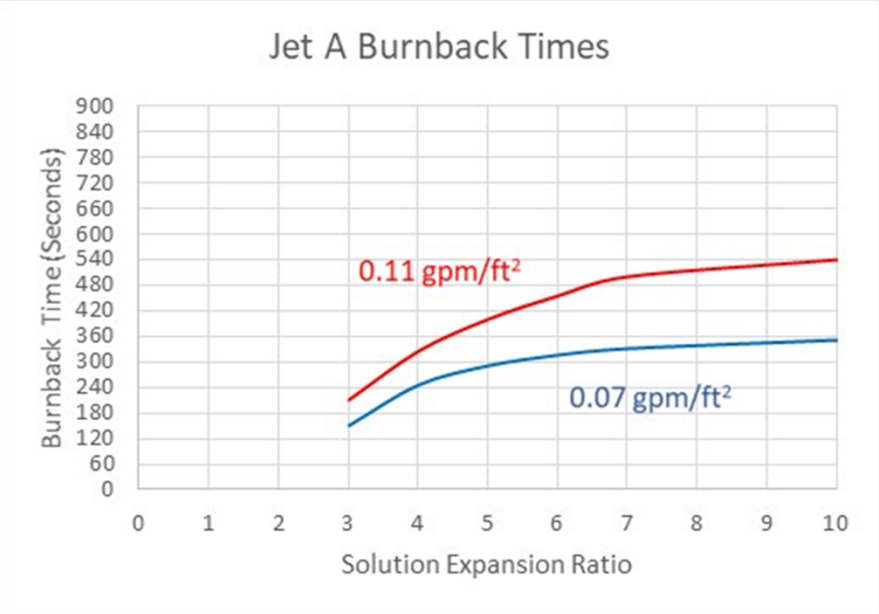


Increased Application Rate Data Review









Technical Approach

Foam Quality

Characterization of foam quality produced by typical DoD discharge devices (and legacy PF devices)

- Fixed system nozzles used throughout DoD (between 4-6);
- Manual firefighting nozzles used throughout DoD (between 2-4);
- Firefighting vehicle nozzles used throughout DoD (between 2-3);
- One PF nozzle of each type listed above.

Test Design

Types of Discharge Devices

Fixed Non-Air-Aspirated Nozzles	Fixed Air-Aspirated Nozzles	NAVFAC Hangar Nozzle
		
Hose Line Nozzles	**Bumper/Roof Turret Nozzles**	**Foam Tubes**
		

Test Design – Foam Quality

Foam Concentrates

Manufacturer	Foam Name	Type	Viscosity
Buckeye	Mil-Spec Type 3	AFFF	Newtonian
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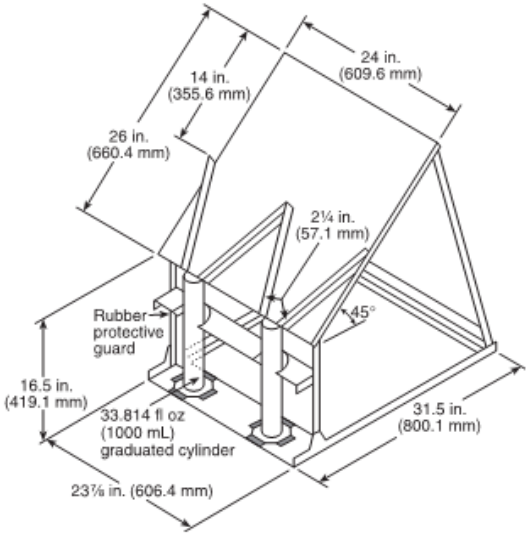
National	Avio Green	PFF	Newtonian
Solberg	RE-HEALING RF3	PFF	Non-Newtonian

NFPA 412 Backboard



China Lake Hose Line Nozzle Tests

CBD Nozzle Tests

Data Review

General Observations

PFFs “foamier” than AFFF about 1-2 expansion points higher across all devices

Non-Newtonian PFFs “foamier” than Newtonian PFFs (by about 1 expansion point)

Non-Newtonian foam is more robust and drains slower than Newtonian PFFs and AFFF (AFFF and Newtonian PFFs have similar drainage times) AFFF & Newtonian PFFs 3-5 minutes / Newtonian PFFs over 10 minutes

Foam quality (both expansion and drainage times) consistent for similar discharge devices (e.g., all non-air-aspirating hose line nozzles produced similar foam quality)

Data Review

DoD Discharge Devices Foam Quality Measurements

Man. / Model	Buckeye AFFF		National Avio		Solberg RF3	
	Exp. Ratio	Drainage (sec)	Exp. Ratio	Drainage (sec)	Exp. Ratio	Drainage (sec)
Tyco / B1	5.1	300	7.7	400	9.8	>2000
Bete / TF29-180-24	2.2	-	2.6	-	3.2	364
Globe / GL5601	3.5	-	4.7	-	5.4	630
Viking / GN 200/360	3.9	-	6.1	180	9.0	>2000
Elkhart / SFL-GN-95*	3.2	-	4.3	90	5.9	742
Akron Brass / 3023*	3.5	-	4.9	80	6.1	712
TFT / ME1VPGI-125*	3.1	-	4.6	-	6.7	723
Akron Brass / 3352*	3.3	-	4.9	-	6.6	765
Akron Brass / 3353*	3.2	-	4.6	-	6.5	732
Rosenbauer / RM25*	3.0	-	4.6	-	5.9	721

"-" below measurable range "*" Spray Pattern Specific (values shown are ~10 degree spray patterns)

Protein Foam Discharge Device Foam Quality Measurements

Man. / Model	Buckeye AFFF		National Avio		Solberg RF3	
	Exp. Ratio	Drainage (sec)	Exp. Ratio	Drainage (sec)	Exp. Ratio	Drainage (sec)
Angus K40	6.1	170	7.4	400	8.2	1430
National Foam JS-10	6.2	211	8.3	633	9.5	1635
National Foam PC-31	6.2	236	7.6	549	9.5	1569
Task Force Tips FJ-LX-HM	7.1	354	9.5	703	11.9	>2000
Task Force Tips FJ-MX-HM	8.9	401	16.9	765	20.7	>2000

Data Review

General Summary

Fixed system nozzles (non-air-aspirating) used by DoD (between 2-5 exp.)

- 2-3 expansion for standard orifice nozzles and 4-5 for deflector plate nozzles

Fixed system nozzles (air-aspirating) used by DoD (between 8-10 exp)

Fixed system NAVFAC Hangar Grate Nozzle (between 6-9 exp)

Manual firefighting nozzles used by DoD (between 2-6 exp., pattern dependent)

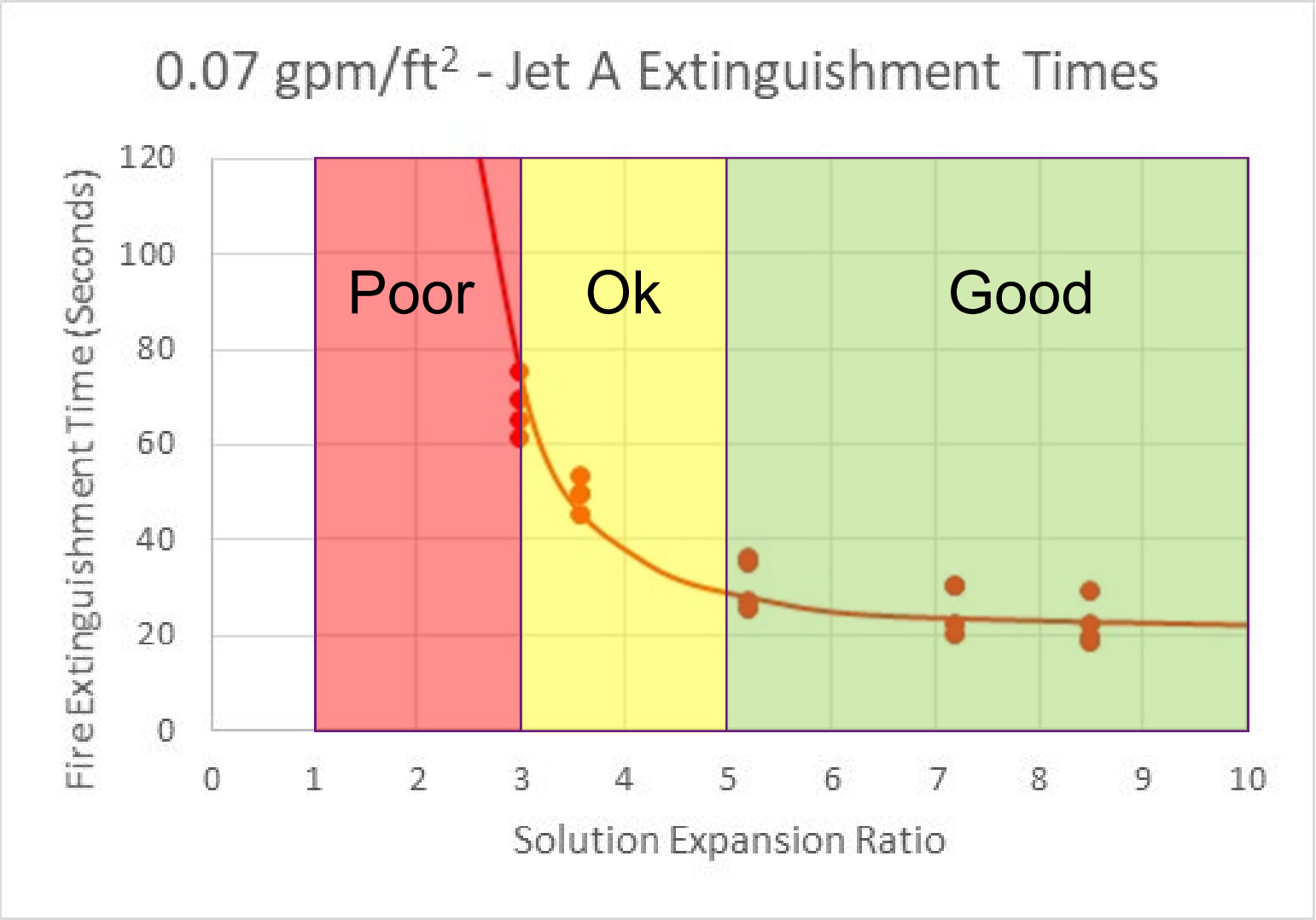
- 2-4 expansion for straight stream and 4-6 for narrow angle patterns (5-15 degrees)

Firefighting vehicle nozzles used by DoD (between 2-6 exp., pattern dependent)

- 2-4 expansion for straight stream and 4-6 for narrow angle patterns (5-15 degrees)

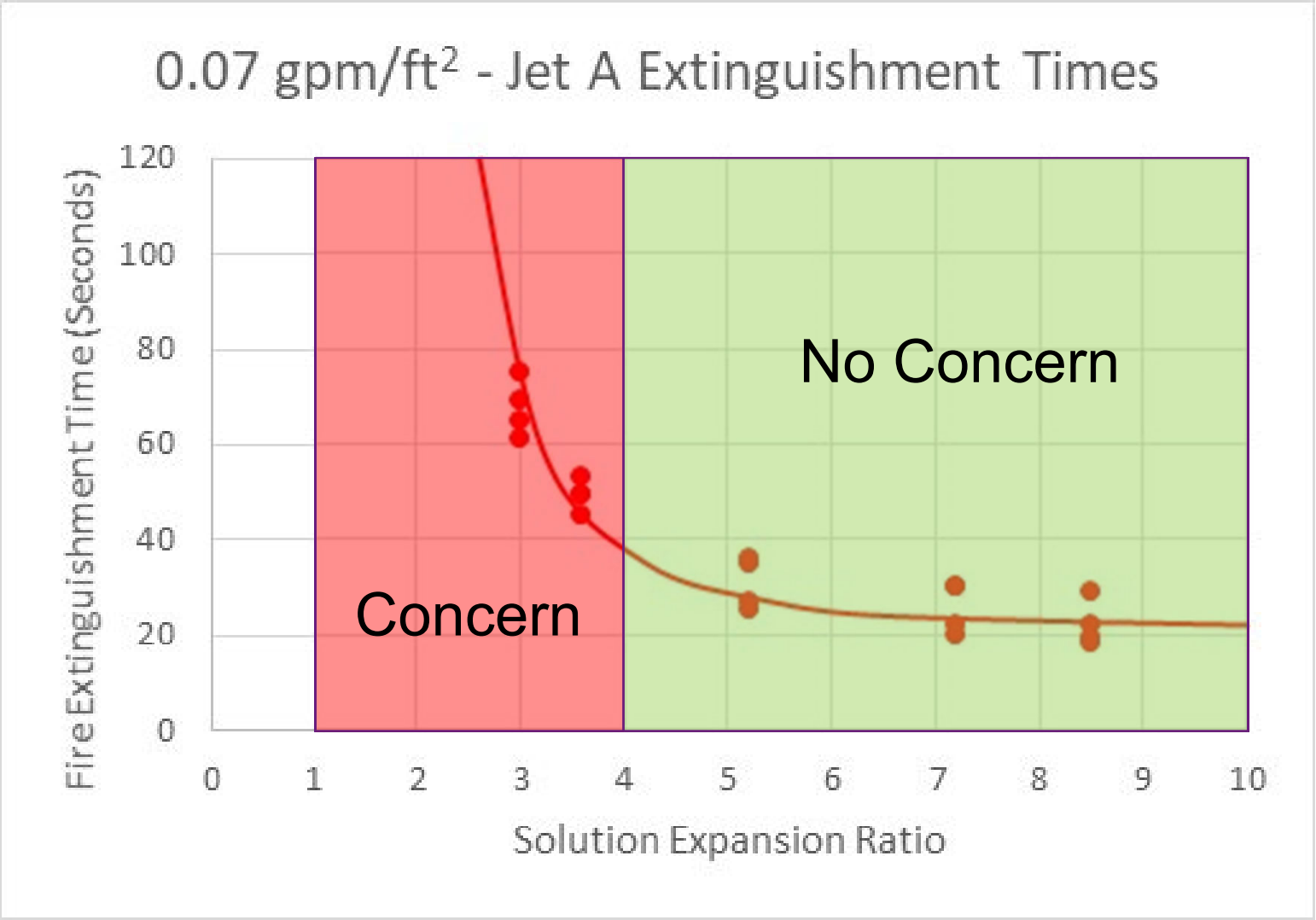
Foam tubes and legacy protein foam hardware (8-20 flow rate dependent)

Data Interpretation – Jet A



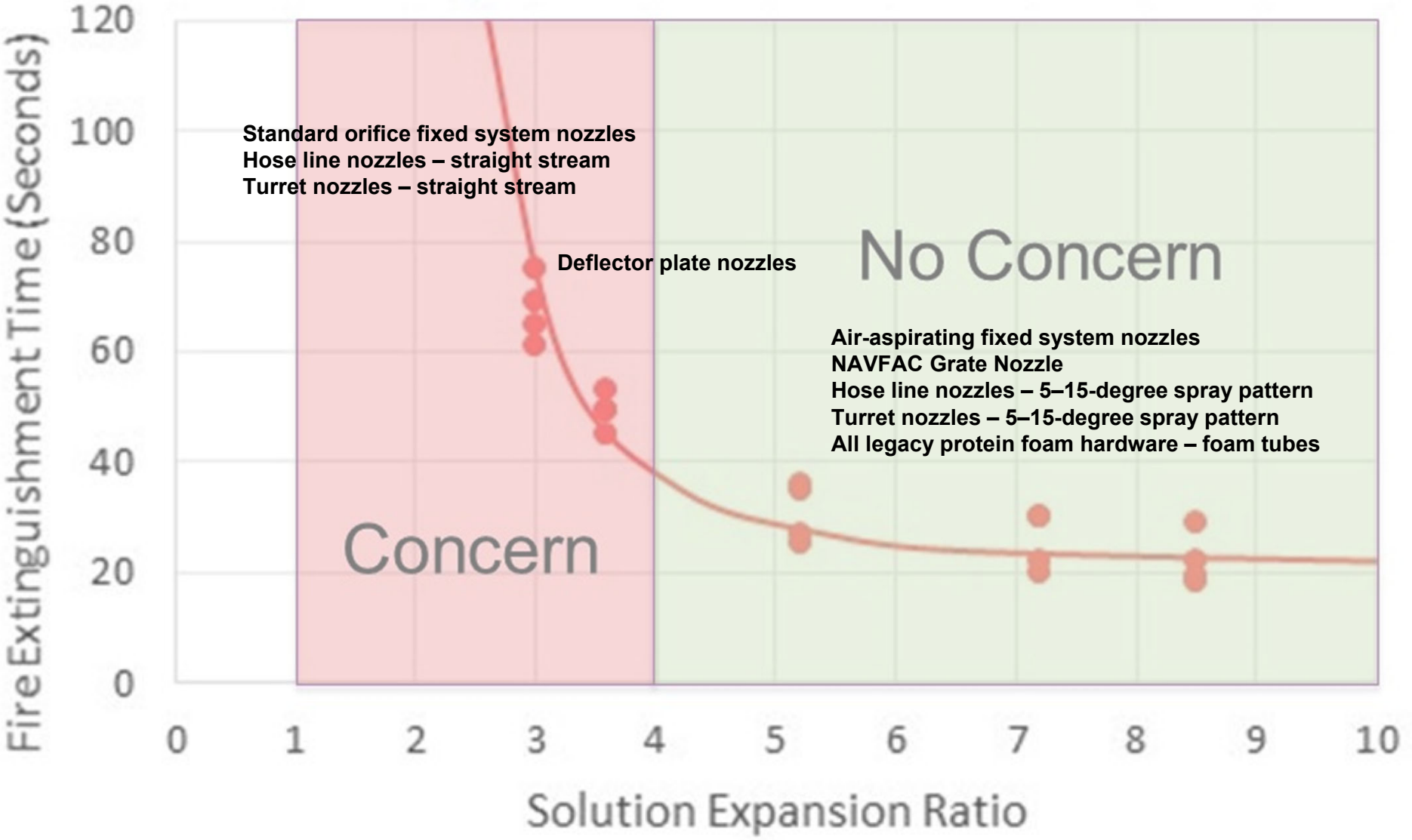
Data Interpretation – Jet A

Critical Expansion Ratio ~ 4



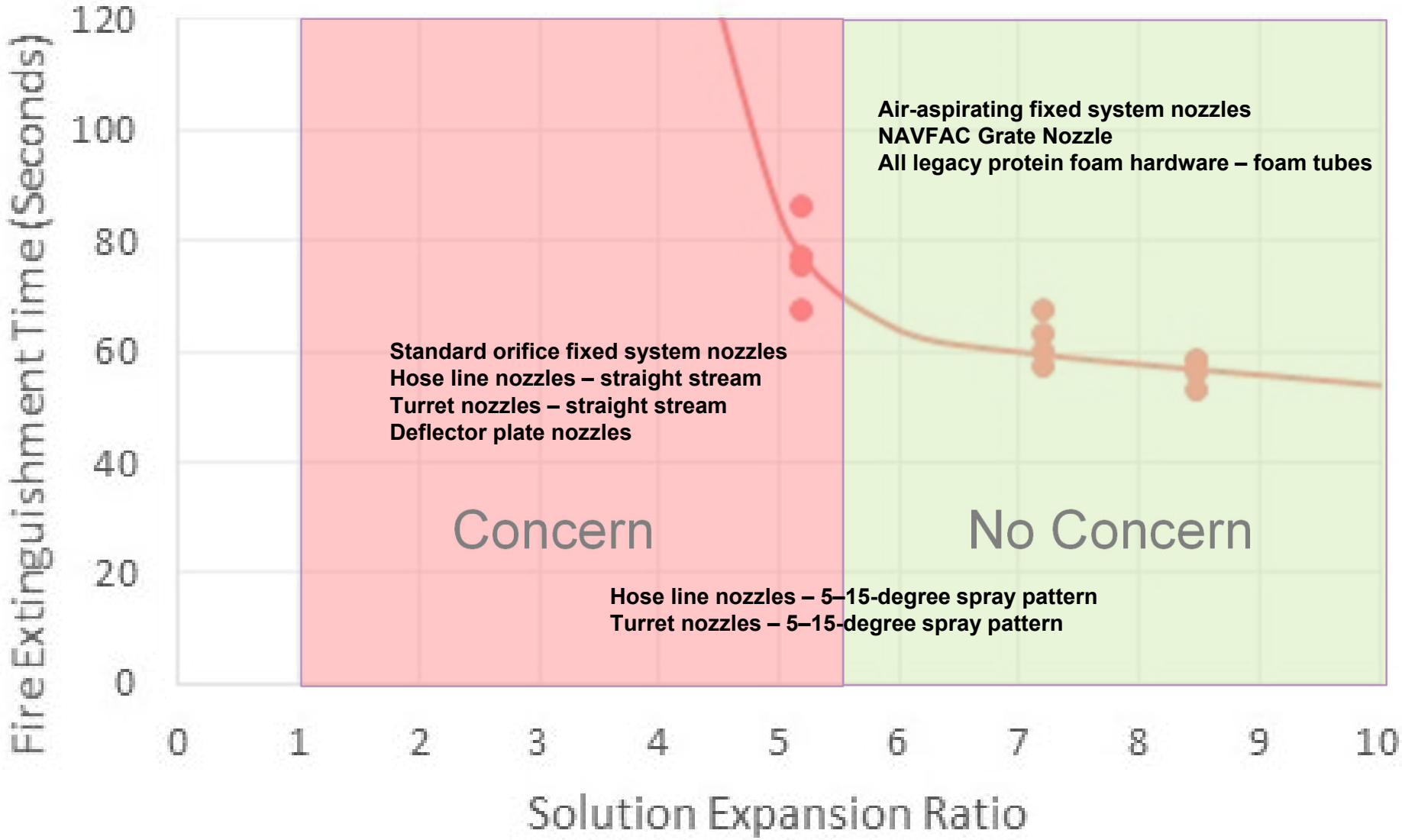
Data Application – Jet A

Critical Expansion Ratio ~ 4



Data Interpretation – Gas

Critical Expansion Ratio ~ 5.5



Key Points

Firefighting Capabilities

Firefighting capabilities increase with increased aspiration (5 or above should be fine)

Extinguishment ("L" type curve for ext. time vs expansion)
- Critical aspiration for PFFs ~4 exp. for Jet A and 5.5 exp. for gasoline (at 0.07 gpm/ft^2)

Burnback (Gradual increase with increased expansion/aspiration)
- Burnback varied between product types (Newtonian vs Non-Newtonian)
- Non-Newtonian provides an additional 3-5 minutes of protection
- PFFs provided protection Jet A 3-6 minutes for Jet A and 3-4 minutes for gasoline (at 0.11 gal/ft^2)

Foam Quality

- Typical DoD discharge devices produce foam in the 2-8 exp. range
- Protein foam discharge devices produce foam in the 6-20 exp. Range
- Manual firefighting nozzles (hose line and turret nozzles) are below critical at straight stream

All-in-All, there are only a few areas of concern when fielding the top performing PFFs in DoD applications

Next Steps / Path Forward

WP21-3461 & WP21-3465 Phase III

Manual firefighting nozzles (hose line and turret nozzles) require additional research

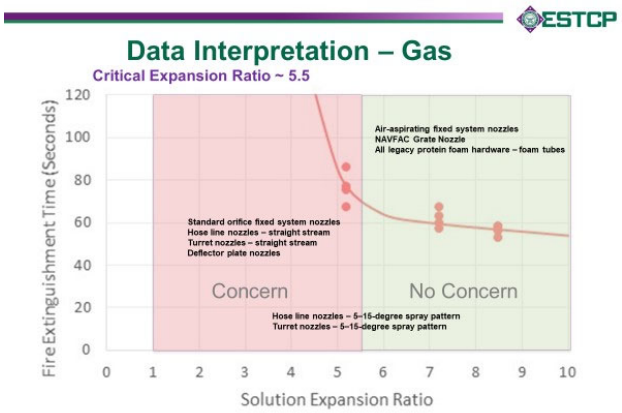
1. Development of novel nozzle designs specifically suited to discharge of PFFs (i.e., variable aspiration while maintaining pattern control).
2. Improvements to application techniques and firefighting tactics/doctrine to reduce the performance gap between AFFF and these PFFs

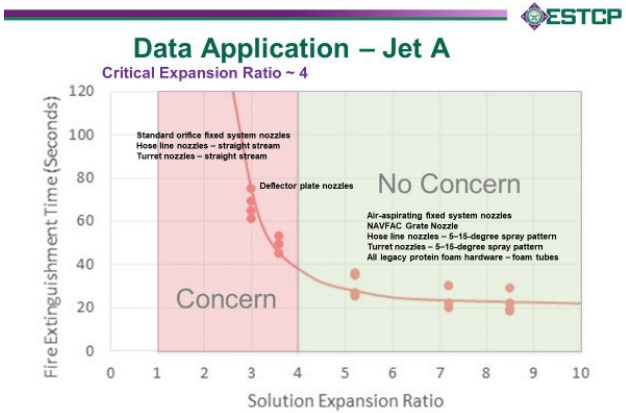
Technology Transfer

The final product is of this effort is the knowledge associated with the capabilities of PFFs as a function of foam quality.

This provides a tool to predict the firefighting capabilities of PFFs when discharged through typical Department of Defense (DoD) nozzles and systems (as well as others).

The information is available on the SERDP/ESTCP website and will presented at a least two technical conferences held by the fire protection industry over the next year or so.





Questions?

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