Fluorine-Free Foams
International Regulation and Performance Testing

CTIF Commission Fire and Rescue at Airports

04/11/2022

Eike Peltzer, E.P.FIRE

E.P.FIRE

Independent guidance
on fluorine-free foam
and AFFF

Disclaimer

- This presentation is for informational purposes only and does not constitute legal advice.
- This information is given in good faith and is based on data we believe to be reliable and on our current level of knowledge as of the date of this response.
- The author assumes no responsibility or liability for any errors or omissions in the content of this presentation. The information contained in this presentation is provided on an “as is” basis with not guarantees of completeness, accuracy, usefulness or timeliness.
- The material in this presentation is subject to copyright and shall not be reproduced without written permission from the author. Any further reproduction or communication of this material may be the subject of copyright protection.

E.P. FIRE

Eike Peltzer, B.Eng., M.Sc.

Independent consultant and project manager for
the transition from AFFF to fluorine-free foam

- 2008 – 2021: Manager Fire & Rescue Service at LyondellBasell, Germany
- B.Eng. in Rescue Engineering (TH Cologne, Germany),
- M.Sc. in Disaster Management (Coventry University, UK)
- Chair of the working group on firefighting foam of the WFVD (German Industrial Firefighters Association)
- 2-year German national training program for senior fire officers

E.P. FIRE

Independent guidance
on fluorine-free foam
and AFFF

National and international clients

- Köln/Bonn Airport
- Leipzig/Halle Airport
- BCRC Caribbean
- Audi Neckarsulm
- Airbus Hamburg/Bremen/Stade
- Premium Aerotec Augsburg
- Volkswagen Kassel
- Alunorf Neuss
- Vattenfall Rostock
- Evonik Marl/Essen
- Bayer Hürth
- Byk Chemie Wesel
- Axalta Wuppertal
- Nynas Hamburg

International regulation of PFAS

International regulation of PFAS

Stockholm Convention on persistent organic pollutants (POPs)

Regulation (EU) 2019/1021
(„EU-POP-Regulation“)

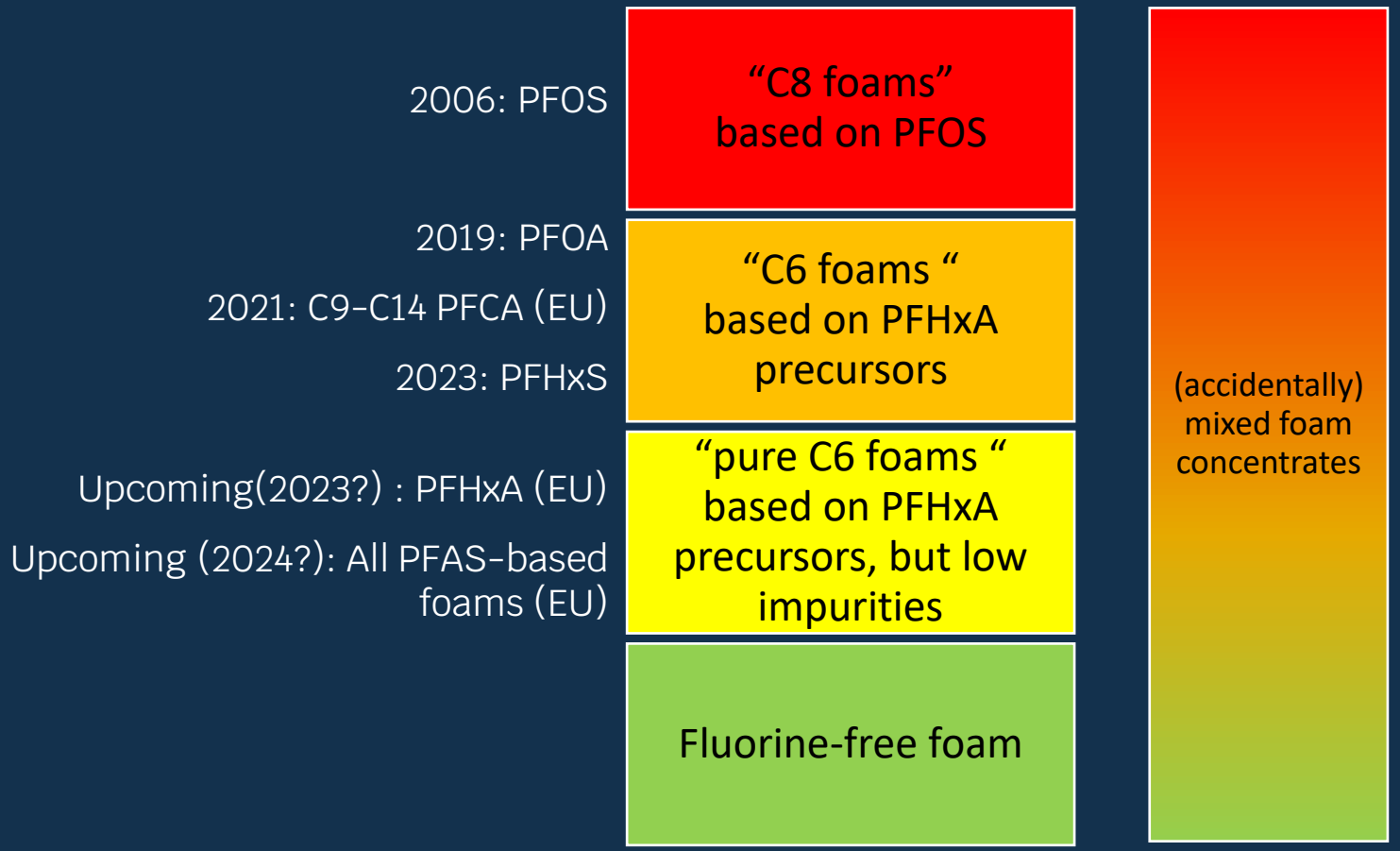
185 parties
(Notable non-ratifying states: United States, Israel, Malaysia)

REACH

Regulation (EC) 1907/2006
(„REACH-Regulation“)

E.P. FIRE

PFAS in firefighting foams



E.P. FIRE

PFAS in firefighting foams (example)

Perfluorinated Compounds		"C8 foam"	"C6 foam"	"pure C6 foam"	"fluorine free"
Perfluorooctanesulfonic acid (PFOS)	ug/L	280000	<140	<140	<25
Perfluorooctanoic acid (PFOA)	ug/L	7200	6400	<190	<25
Perfluorohexanesulfonic acid(PFHxS)	ug/L	33000	<300	<300	<25
Perfluorohexanoic acid (PFHxA)	ug/L	11000	20000	320	<25
6:2 Fluorotelomer sulfonic acid	ug/L	<280	41000	49000	<25
8:2 Fluorotelomer sulfonic acid	ug/L	<250	11000	<250	<25
Perfluorobutanoic acid (PFBA)	ug/L	1900	1500	<210	<25
Perfluorobutanesulfonic acid (PFBS)	ug/L	8000	<210	<210	<25
Perfluoropentanesulfonic acid PFPes	ug/L	7400	<190	<190	<25
Perfluoropentanoic acid (PFPeA)	ug/L	2100	2300	<230	<25
Perfluoroheptanoic acid (PFHpA)	ug/L	2600	830	<250	<25

E.P. FIRE

Current restrictions:
Timeline for PFOS, PFOA and C9-C14 PFCAs

27/06/2011
PFOS

- Use of PFOS based foams prohibited

04/07/2020
PFOA

- Manufacturing and sales prohibited
- Training prohibited

01/01/2023
PFOA and C9-C14 PFCAs

- Using and testing of foam only if all releases are contained

25/02/2023
C9-C14 PFCAs

- Manufacturing and sales prohibited

04/07/2025
PFOA and C9-C14 PFCAs

- All uses prohibited

Limit values:
25 ppb for PFOA and its salts
1000 ppb for the sum of PFOA-related substances
25 ppb for the sum of C9-C14 PFCAs and their salts
260 ppb for the sum of C9-C14 PFCA-related substances

E.P. FIRE

You can still use AFFF if …

… you have pure C6 foam with PFOS, PFOA and C9–14 PFCAs below the limit values.

Perfluorinated Compounds		"C8 foam"	"C6 foam"	"pure C6 foam"	"fluorine free"
Perfluorooctanesulfonic acid (PFOS)	ug/L	280000	<140	<140	<25
Perfluorooctanoic acid (PFOA)	ug/L	7200	6400	<190	<25
Perfluorohexanesulfonic acid(PFHxS)	ug/L	33000	<300	<300	<25
Perfluorohexanoic acid (PFHxA)	ug/L	11000	20000	320	<25
6:2 Fluorotelomer sulfonic acid	ug/L	<280	41000	49000	<25
8:2 Fluorotelomer sulfonic acid	ug/L	<250	11000	<250	<25
Perfluorobutanoic acid (PFBA)	ug/L	1900	1500	<210	<25
Perfluorobutanesulfonic acid (PFBS)	ug/L	8000	<210	<210	<25
Perfluoropentanesulfonic acid PFPes	ug/L	7400	<190	<190	<25
Perfluoropentanoic acid (PFPeA)	ug/L	2100	2300	<230	<25
Perfluoroheptanoic acid (PFHpA)	ug/L	2600	830	<250	<25

But not for long …

E.P. FIRE

Proposal to restrict PFAS in firefighting foam in the EU

- Expected for 2023
- Proposed limit value: 1000ppb (sum of PFAS)
- Transitional periods per sector

Sector/type of use or placing on the market	Transitional period from entry into force
Seveso establishments	10 years
Other industries	5 years
Civilian aviation	5 years
Defence	5 years
Municipal fire services	1.5 years
Ready-to-use applications (fire extinguishers)	5 years
Marine applications	3 years
Training and testing	1.5 years
Export	10 years

E.P. FIRE

Summary on restrictions

Current restrictions

- PFOS and precursors
  Active ingredient in (very) old AFFFs
- PFOA and precursors
  Can be present as impurities in older AFFFs
- C9-C14 PFCAs
  Can be present as impurities in older AFFFs

Upcoming restrictions

- EU: PFHxA and precursors
  Will affect all AFFFs
- EU: PFAS in firefighting foam
  Will affect all AFFFs
- Stockholm Convention: PFHxS and precursors
  Can be present as impurities in AFFFs

Pure C6 foams based on PFHxA precursors can still be used. But further restrictions are coming.

AFFF is used here to describe all PFAS-based foams

E.P. FIRE

FAA Fluorine-Free Foam Testing

DOT/FAA/TC-22/23

Fluorine-Free Foam Testing

Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

July 2022

Final Report

U.S. Department of Transportation
Federal Aviation Administration

FAA Fluorine-Free Foam Testing

Abstract: “None of the FFFs evaluated had an equivalent extinguishing performance to AFFF. While other performance metrics or physical characteristics can be met or surpassed, the primary metric of concern is the extinguishment performance of the foam. In all the nominal concentration gasoline fires, none of the FFFs evaluated were able to extinguish the fire in an equal or lesser amount of time.”

E.P. FIRE

Summary of the tests

- Tests of 2 PFAS based AFFFs and 7 fluorine-free foams
- Test according to MIL-PRF-24385F and ICAO Level C
- Testing variables:
  - Fixed vs. active nozzle handling
  - Gasoline vs. Jet-A Fuel
  - UNI 86 vs. Mil-Spec nozzle
  - Longer preburn 90s instead of 10s for MIL-PRF-24385F test
- Other tests
  - Dry chemical compatibility
  - Aged foam concentrate

E.P. FIRE

Test parameters for MIL-PRF-24385F and ICAO Level C test (nominal)

MIL-PRF-24385F

Test pan: 2.6m²

Application 7.6l/min

Application rate: **2.92l/min/m²**

Preburn time: 10s

Foam discharge for 90s

Active foam application

Pass criteria for extinguishment: 30s

ICAO Level C test

Test pan: 7.3m²

Application rate: 11.4l/min

Application rate: **1.56l/min/m²**

Preburn time: 60s

Foam discharge for 120s

Fixed nozzle

Pass criteria for extinguishment: 60s for 99% 120s for 100%

E.P. FIRE

Notable findings (or confirmations in some cases)

- The use of an active foam application compared to a stationary application resulted in significantly lower extinguishment times
- Each foam was able to extinguish the Jet-A fires significantly faster than the gasoline fires
- More foams were able to extinguish the MIL-PRF-24385F than the ICAO Level C test, though most did fail to extinguish it within the defined time frame
- All the FFFs required additional tests to identify effective application methods. The FFFs' extinguishment times had a much greater degree of inconsistency than the AFFFs

E.P. FIRE

Strength

- Dedicated and new testing facility
- Good test setup
- Interesting modifications leading to notable findings

E.P.FIRE

Weakness

ICAO Level C test was chosen despite the fact that most of the selected fluorine-free foams do not have Level C rating

Table 5. Foam Certifications

Brand	Product	Type	Percentage	MIL-PRF-24385F	ICAO Level A	ICAO Level B	ICAO Level C	UL 162	EN 1568 – 1	EN 1568 – 2	EN 1568 – 3	EN 1568 – 4
Chemguard	C306	AFFF	3	x				x				
Solberg	Re-Healing RF3	FFF	3			x	x	x			x	
National Foam	Avio F3 Green KHC	FFF	3				x					
BioEx	Ecopol A	FFF	3			x						
BioEx	Ecopol F3HC	FFF	3								x	
Fomtec	Enviro USP	FFF	1–3			x			x	x	x	
BioEx	Ecopol A+	FFF	3			x					x	
Chemguard	C3IC1	AFFF	3				x	x				
Solberg	Avigard 3B	FFF	3			x						

Foam specifications and applications rates according to ICAO Doc 9137

Table 8-1. Foam specifications

Fire tests	*Performance level A*	*Performance level B*	*Performance level C*
Nozzle (air aspirated)			
a) Branch pipe	*"Uni 86" Foam nozzle (See Appendix 3)*	*"Uni 86" Foam nozzle (See Appendix 3)*	*"Uni 86" Foam nozzle (See Appendix 3)*
b) Nozzle pressure	700 kPa	700 kPa	700 kPa
c) Application rate	4.1 L/min/m^2	2.5 L/min/m^2	1.56 L/min/m^2
d) Nozzle discharge rate	11.4 L/min	11.4 L/min	11.4 L/min
Fire size	≈ 2.8 m^2 (circular)	≈ 4.5 m^2 (circular)	≈ 7.32 m^2 (circular)

2.3.5 The amounts of water specified for foam production are predicated on an application rate of 8.2 L/min/m^2 for a foam meeting performance level A, 5.5 L/min/m^2 for a foam meeting performance level B and 3.75L/min/m^2 for a foam meeting performance level C. These application rates are considered to be the minimum rates at which control can be achieved within one minute.

E.P. FIRE

Test results

ICAO Level C Test

Foam	Edge Flicker Time	Extinguishment Time
Chemguard C306	01:21	02:20
Chemguard C306	01:20	02:34
Chemguard C306	01:15	02:20
BioEx Ecopol F3HC	DNE	DNE
BioEx Ecopol F3HC	DNE	DNE
BioEx Ecopol F3HC	DNE	DNE
Solberg Re-Healing RF3	01:18	02:12
Solberg Re-Healing RF3	01:25	02:30
Solberg Re-Healing RF3	01:28	02:22
National Foam Avio F3 Green KHC	01:46	DNE
National Foam Avio F3 Green KHC	01:26	DNE
National Foam Avio F3 Green KHC	01:39	02:28
BioEx Ecopol A	01:43	DNE
BioEx Ecopol A	01:36	DNE
BioEx Ecopol A	01:51	DNE
Fomtec Enviro USP	DNE	DNE
Fomtec Enviro USP	02:13	03:13
Fomtec Enviro USP	DNE	DNE
BioEx Ecopol A+	01:57	DNE
BioEx Ecopol A+	01:44	DNE
BioEx Ecopol A+	01:54	DNE
Chemguard C3IC1	01:04	01:35
Chemguard C3IC1	00:52	00:56
Chemguard C3IC1	00:59	01:13
Solberg Avigard 3B	01:44	DNE
Solberg Avigard 3B	01:57	DNE
Solberg Avigard 3B	02:14	DNE

MIL-PRF-24385F test

Foam	Extinguishment Time
Chemguard C306	00:27
Chemguard C306	00:28
BioEx Ecopol F3HC	DNE
BioEx Ecopol F3HC	02:05
Solberg Re-Healing RF3	00:46
Solberg Re-Healing RF3	00:54
National Foam Avio F3 Green KHC	01:00
National Foam Avio F3 Green KHC	00:52
BioEx Ecopol A	00:56
BioEx Ecopol A	00:38
Fomtec Enviro USP	01:21
Fomtec Enviro USP	01:14
BioEx Ecopol A+	00:43
BioEx Ecopol A+	00:46
Chemguard C3IC1	00:20
Chemguard C3IC1	00:29
Solberg Avigard 3B	00:50
Solberg Avigard 3B	00:46

Red = Failed test criteria

Green = Pass test criteria

ICAO Level C test

Application rate:

1.56l/min/m²

MIL-PRF-24385F test

Application rate:

2.92l/min/m²

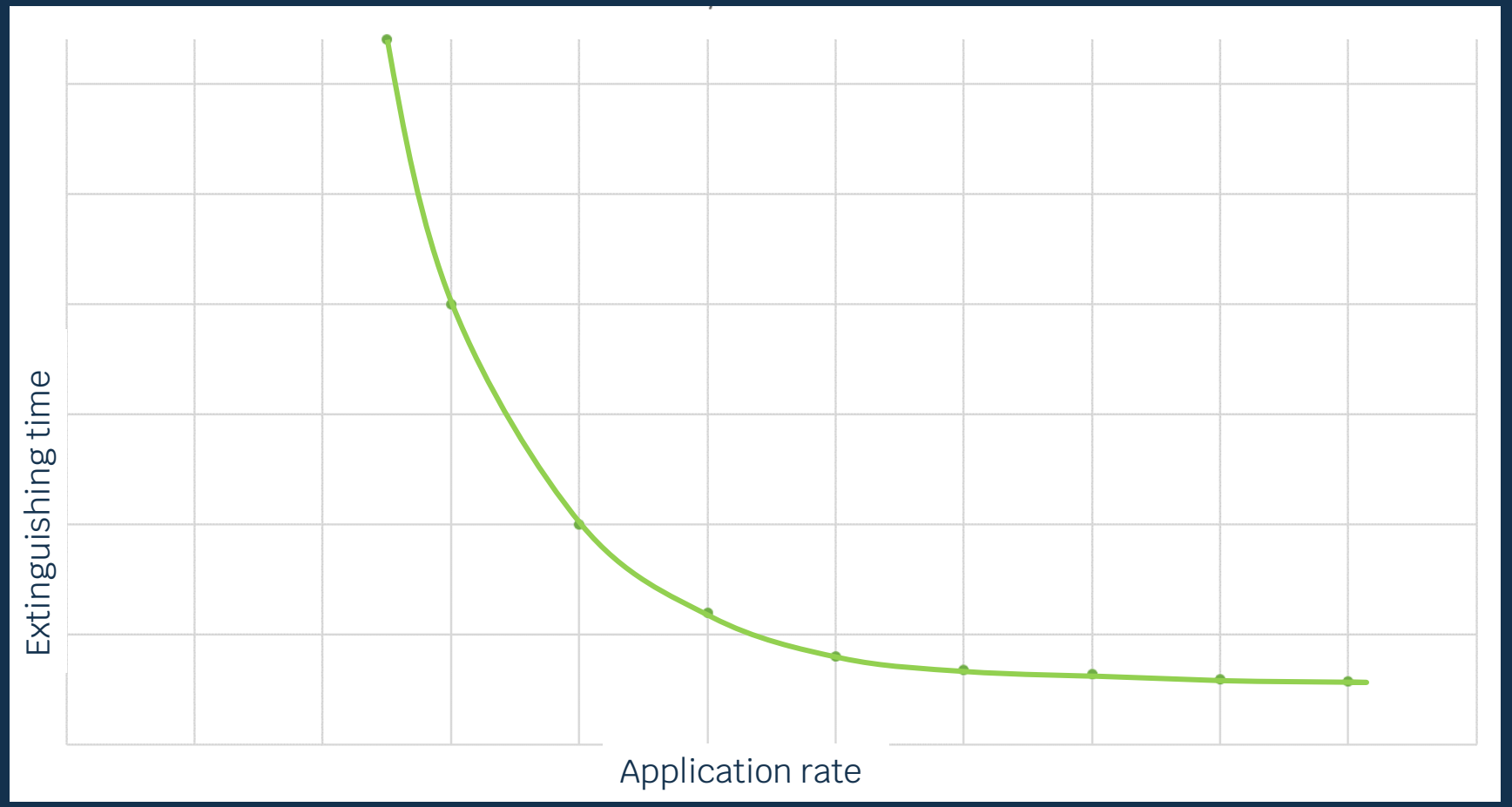
E.P. FIRE

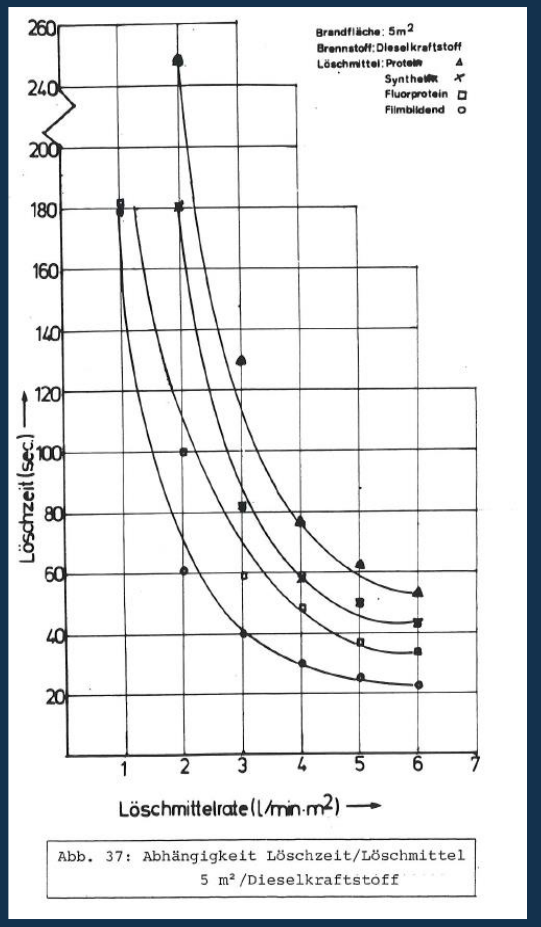
Weakness

- In general no attention to the effect of application rate on extinguishing performance

E.P. FIRE

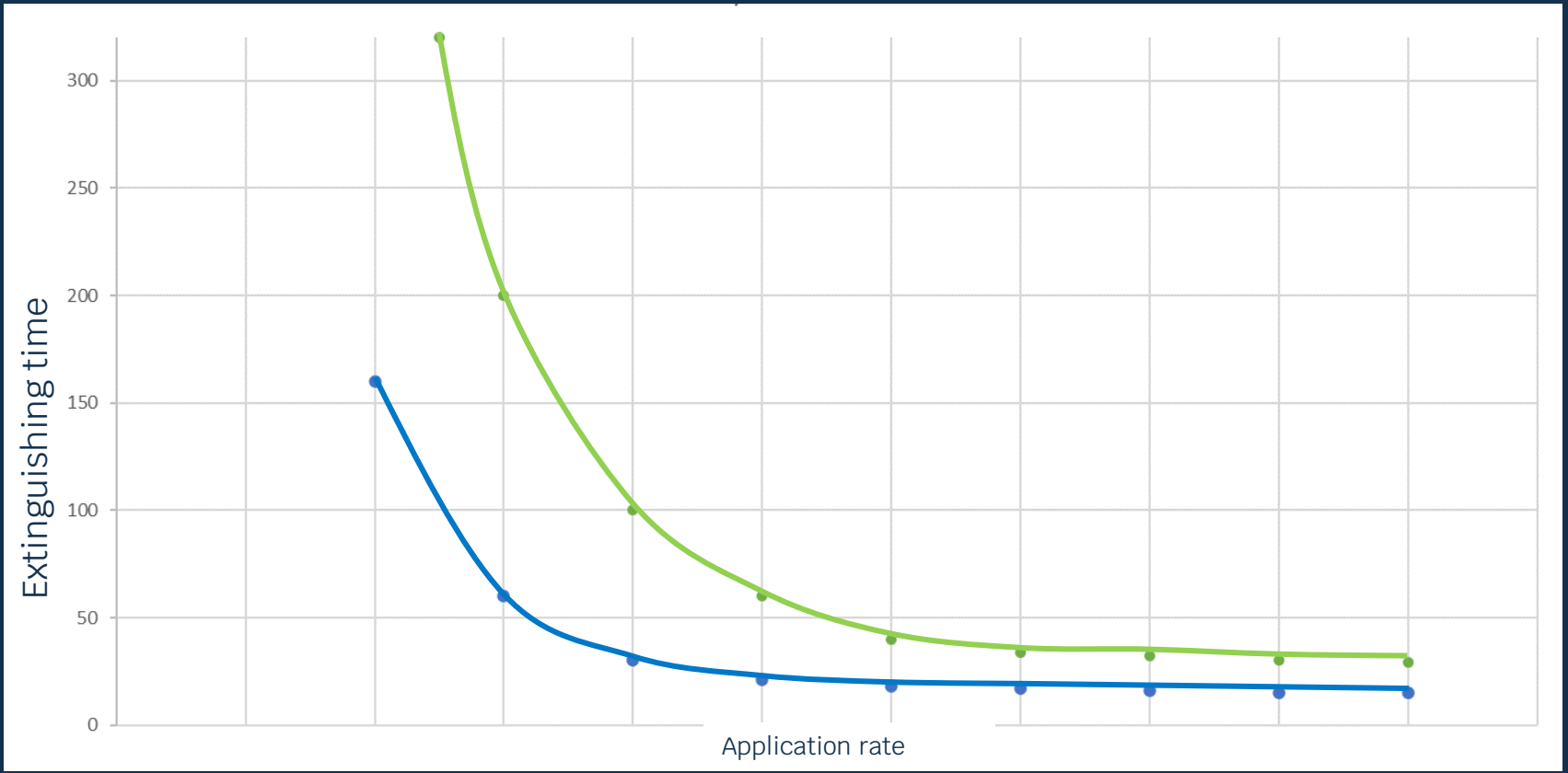
Application rate
The “L-Curve”





E.P. FIRE

Application rate
The “L-Curve”



Observations

- There is a critical application rate. Below this rate, foam does not extinguish
- At a low application rate, increasing the rate results in a significantly faster extinguishing time
- This effect is smaller with higher (more realistic) application rates
- A further increase in the application rate hardly has any effect (unless you want to compensate for losses and add a safety factor)
- With a higher application rate of a poor foam concentrate, you can achieve the same extinguishing time as that of a better one

E.P. FIRE

Other notable findings

- Two ICAO C rated foams do not pass ICAO C test
- Fluorine was found in three FF Foams using TOF analysis (but this does not necessarily come from PFAS)

Table 11. Physical and Chemical Properties Results

Mil-Spec Criteria	Requirement	BioEx Ecopol F3HC	BioEx Ecopol A	Fomtec Enviro USP	National Foam Avio F3 Green KHC	Solberg Re-Healing RF3	BioEx Ecopol A+	Solberg Avigard 3B
BOD_{20} (mg/L)		505,500	570,300	695,700	801,700	913,500	731,500	790,200
COD (mg/L)	Maximum: 1,000,000	382,000	351,000	585,000	893,000	554,000	454,700	574,300
BOD_{20}/COD	Minimum: 0.65	1.32	1.62	1.19	0.90	1.65	1.61	1.38
Fluorine (ppm)		87	30	<10	29	37	***	***

E.P. FIRE

E.P. FIRE

Independent guidance
on fluorine-free foam
and AFFF

Eike Peltzer

eike.peltzer@epfire.de

epfire.de/en

+49 (0) 172 21 07 406

youtube.com/AFFFvsfluorinefreefoam

linkedin.com/in/eike-peltzer

YouTube-Channel
AFFF vs. FF

AFFF vs. FF