The fluorine free issue

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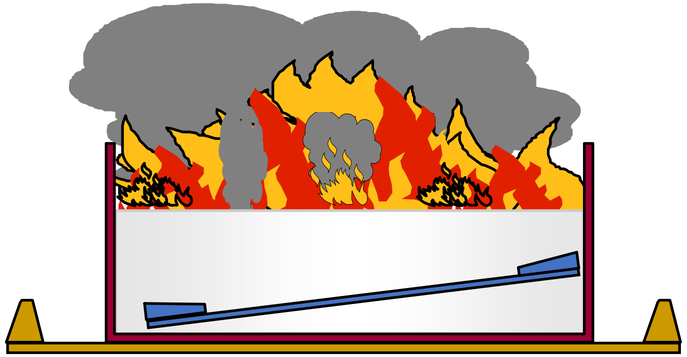
Niall Ramsden

30 + years experience as independent
>90 countries – foam systems, testing, training etc
Previously worked with foam companies
Member NFPA 11 committee (25+ years)
Member NFPA 30 committee (Past)
Member EN 13565 Part 2 (Systems) committee
Member of EI Process Safety Committee
Member UL 162 Foam Approvals STP
Adviser at Buncefield event
LASTFIRE Project Coordinator

LASTFIRE
Large Atmospheric Storage Tank Fires

A consortium of international oil companies developing best industry practice in storage tank **Fire Hazard Management** through operational feedback, networking, incident analysis and research



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Current Members

Full members

lyondellbasell
MARATHON
MOL
NESTE
TotalEnergies
Chevron
SINOPEC
PETRONAS
Reliance Industries Limited
Qatar Petroleum
PHILLIPS 66
Tüpras
bp
CALTEX
woodside
NYNAS
ExxonMobil
Coogee
PUMA ENERGY
VIVA Energy Australia

Associates

FireDos
Dr. STHAMER HAMBURG
SPBI Svenska Petroleum & Biodrivmedel Institutet
GB gezamenlijke brandweer
Knowsley SK
Perimeter SOLUTIONS
VIKING

Project Coordinator

ENRg Consultants

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Pragmatic Position

Yes – Fluorosurfactants gave special properties
They have been used successfully globally .. But!
Let's stop the histrionics and emotional comments!
Recognise we will not be able to use them in the long term
- In the short term in some cases!

Yes – we can make them work but:
- Minimise transition cost and disruption
- Optimise efficiency and application
- Develop solutions for sustainable policies

Whatever size test you do, there will always be – what if?
Should always take risk into account
- Risk = Probability x Consequences
- Not always recognised!
- e.g. Some legislation in some countries

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The Fluorine Free Issue

- Major international consequences
- A lot of vested interests
    - Sometimes from “independent” sources
- LASTFIRE
    - End user driven, definitely independent
    - Pragmatic approach
        - All PFAS will be banned in foam eventually
    - ECHA!

ECHA
EUROPEAN CHEMICALS AGENCY

ANNEX XV RESTRICTION REPORT

PROPOSAL FOR A RESTRICTION

SUBSTANCE NAME(S): Per- and polyfluoroalkyl substances (PFAS) in firefighting foams

Opinion?

Very comprehensive

A genuine attempt to be practical and understand and recognise the risk

Good summary

It is doable

Some may disagree but others have already started (and completed) the process

Some good background information and help

Risk
Probability x Consequences

Some realistic points to emphasise!

- No histrionics or scare mongering
- Check independence and expertise/experience
- Respect all true stakeholders. Work with all industry sectors
- End users know their hazards and risks
- Recognised, experienced, hands-on experts that have transitioned can't all be wrong!
- Major foam attacks have sometimes failed due to logistical issues – they will again
  - Don't blame the foam
  - ITC fire?
  - Most foam application is for asset/business protection
  - Requires cost benefit justification
  - Not for aviation hazards of course!
- Much of current standards is based on relatively little test work
- You cannot only base your policies on the least credible but worst case scenario
- New foams are being subjected to more testing and expectation than old generation
  - e.g. Polar solvent application, crude oil application

An example

More on this later

Another example LASTFIRE/GESIP PIT

Flickers at far end of pit

Some time to seal against hot metal and concrete

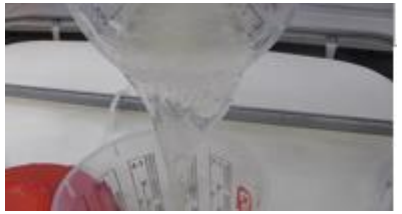
This was the C6 foam!

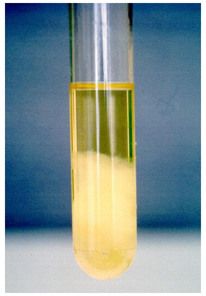
Risk
Probability x Consequences

This is an opportunity!

Some realistic points to emphasise!

No histrionics or scare mongering
Check independence and expertise/experience
Respect all true stakeholders
End users know their hazards and risks
Recognised, experienced hands-on experts that have transitioned can't all be wrong!
Major foam attacks have sometimes failed due to logistical uses – they will again
Don't blame the foam
Most foam application is for asset/business protection
Requires cost benefit justification
Much of current standards is based on relatively little test work
You cannot base your policies only on the least credible but worst case scenario
New foams are being subjected to more testing and expectation than old generation
e.g. Polar solvent application, crude oil application
We have seen it all before!
Viscosity issues, Separation etc!





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EUROPEAN CHEMICALS AGENCY

Defence not considered to require extended times

A lot of detail, and various clauses – but the basics……

- Whole PFAS Class
  - Notes that similar effects of short chain PFAS to longer chain PFAS are being reported as research efforts progress
- Preferred Option- ban (10 years):
  - Placing on market
  - Use
  - Export

Note limit <1ppm

- Use/Sector Specific Transition periods
  - 18 months after entry into force for training and testing (except tests of the firefighting systems for their function), municipal fire service (except if in charge of SEVESO III industrial establishments)
  - 3 years for civilian ships
  - 5 years for portable fire extinguishers and all other uses not defined specifically*
  - 10 years for SEVESO III establishments

Other issues……

- Six months after entry into force (Foams >1ppm)
  - Only use for Class B
  - Minimise emissions to the environment and direct/indirect exposure to humans
  - Establish a site-specific ***"PFAS-containing firefighting foams management plan"***
  - Ensure that collected waste is handled and treated correctly
    - Proof required
  - New supplies - Labelling "***WARNING: Contains per- and polyfluoroalkyl substances (PFASs)"***

"PFAS-containing firefighting foams management plan"

- Justification of use
- Details of the conditions for use and disposal (containment, treatment, disposal of liquid and solid wastes from use, cleaning, maintenance operations)

Essentially proper preplanning

info@lastfire.org

Overall

- Practical
- Pragmatic
- Helpful guidance
- Management plan?
  - Realistically just good practice!

Note: LASTFIRE Reports and Deliverables normally publicly available – but we do not shout about it!

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Large Atmospheric Storage Tank Fires

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The Old Rectory, Mill Lane, Monks Risborough, Bucks HP27 9LG
info@lastfire.org

Foam Assurance Guidance and Questionnaire

March 2017

Only real issue – REACH earlier deadlines. Some companies will ends up changing to a C6 because of it
A big regret spend!!

What is the most important role for foam?

Will it extinguish a fire?
Also! Will it prevent reignition?
Or prevent ignition of an unignited spill

The ideal fire test - Industrial!

Tends to be expensive!
Industry is good at preventing them!

The ideal fire test – Aviation!

Too late to find out it doesn’t work

The ideal fire test – Aviation!

Too late to find out it doesn't work
Fortunately relatively rare events!

Foam Testing - The challenge

Small scale testing

Truly representative?

Real World events

What makes a good fire test?

Relevant to application and critical specific aspects

- Rapid rescue?
- Industrial/Tank application?

Simulates “real life” scenario conditions

- Fuel/Foam Properties/Equipment/Application type/Preburn

Validated through larger scale testing

Validated against incident experience

Includes safety margin over design

- Test Application Rate < Design
- Allows for different fuels, ambient conditions etc.?

Reproducible

- Well defined
- Procedure/Equipment/Conditions
- Possible at different locations
- Not Operator dependent

Differentiates/Grades

Reasonable cost!

Adaptable if required

- Fuel types, application devices, innovations

What makes a good fire test?

There is no "one size fits all"!

Different applications have different emphasis

Aircraft crash fires

Life Safety

Rapid Response

Short preburn

Rapid knockdown priority

Escape path

What makes a good fire test?

There is no “one size fits all”!

Different applications have different emphasis

Tank Fires

- Asset/Business/Public Image Risk
- Set up logistics time
  - Longer preburn

Secure extinguishment priority

Prevent reignition

- Stable foam blanket

What makes a good fire test?

There is no “one size fits all”!

Different applications have different emphasis

Different critical tests

Typical standards

EN1568

General Purpose

Performance grading

Underwriters Laboratories UL162

General Purpose

Specific application types (e.g. Sprinkler,Subsurface application)

CAP168

Aviation, Rapid Rescue

MIL-F-24385

Aviation, Rapid Rescue

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Tank Fires

Typical Test Sequence Principles

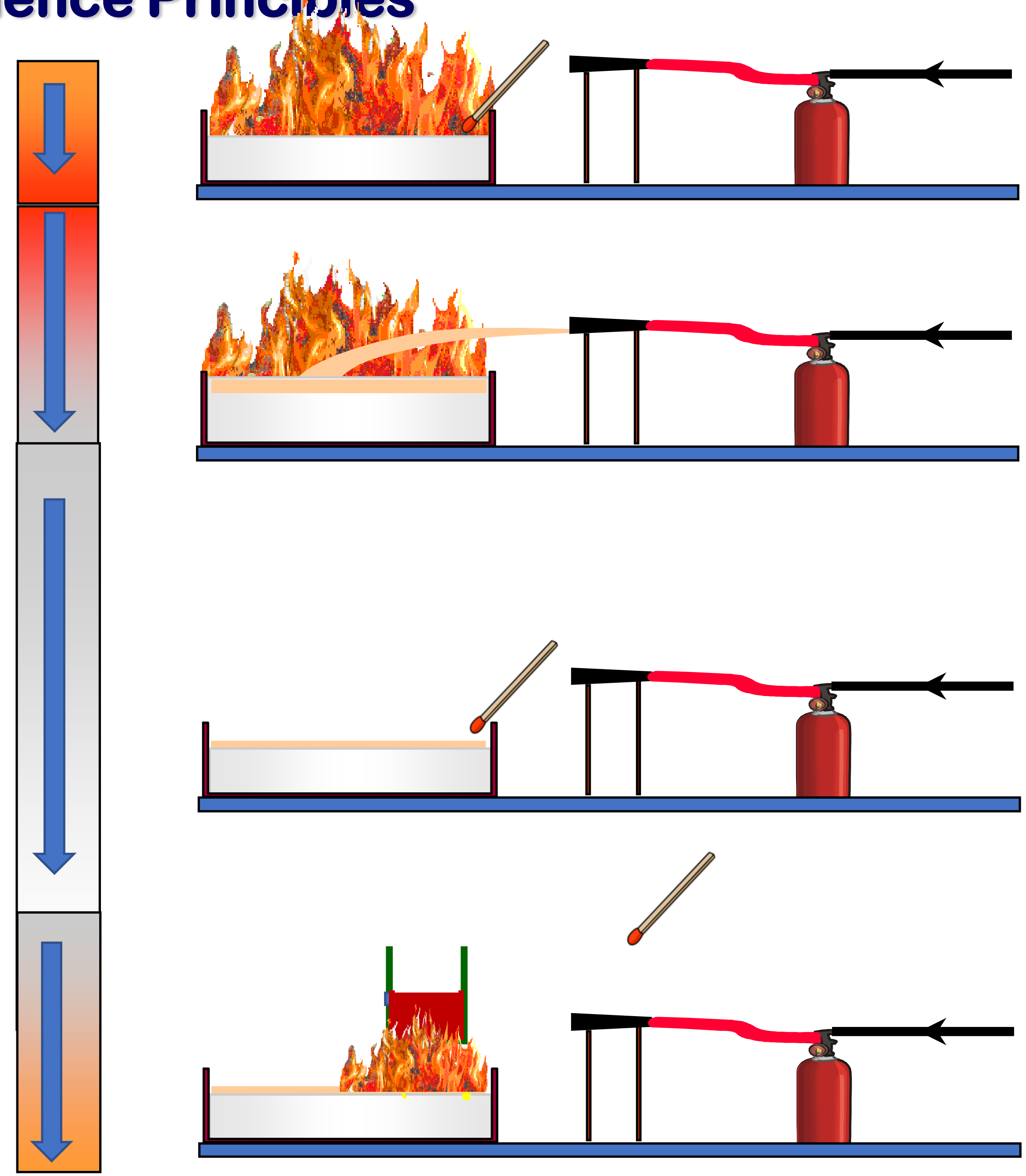
Preburn

Extinguishment

Vapour Seal

Burnback

End of Test



Same principles but…..

Different fire pans

Different preburns
Different fuels
Different criteria

Some example protocols

CAP 168 Level B – Aviation

MIL F 24385

LASTFIRE – Industrial- Tank Fires

Some example protocols

CAP 168 Level B – Aviation

MIL F 24385

LASTFIRE – Industrial- Tank Fires

CAP 168

Fuel ignition

Full surface involvement
Can take >20secs

Preparing for application

Starting application @ 60 secs

Foam blanket build up

Another example

MIL-F-24385F

Rapid rescue

    FAA, US DoD

Similar pan to CAP168 Level B

Short preburn in some parts (10 secs)

Gasoline

Operator movement

Full protocol includes other aspects

    Performance at 50% strength

    Performance at 5x strength

    Different pan sizes

    Freshwater/Salt water etc.

N.B
Updated to allow FFF

Another example

MIL-F-24385F

CAP168 vs MILF

Same application?

More or less but not entirely

Why so different?

Which is more relevant?

Which has more validation?

LASTFIRE Test

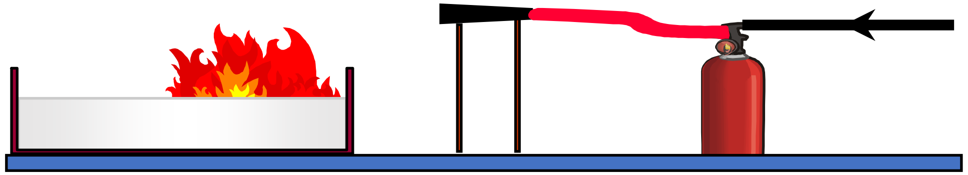

60mm
2ft

Test Sequence

Each nozzle

Preburn

0



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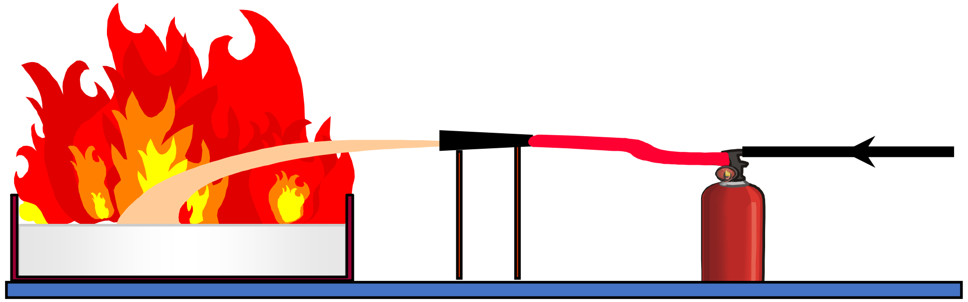
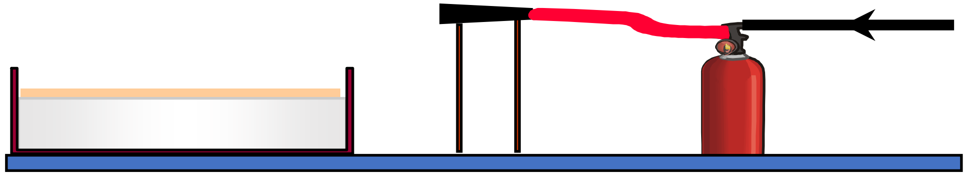
Extinguishment



10

12 - Torch Pass 1

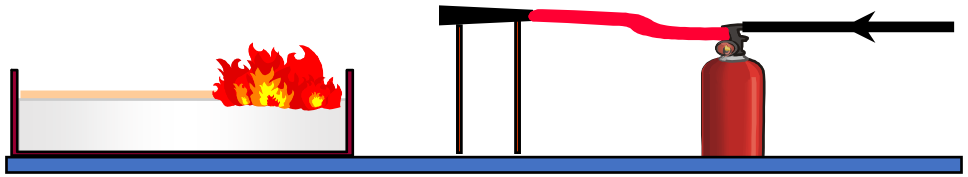


Vapour Seal

23 - Torch Pass 2

25 - Burnback Pot (removal @ 26)

Burnback



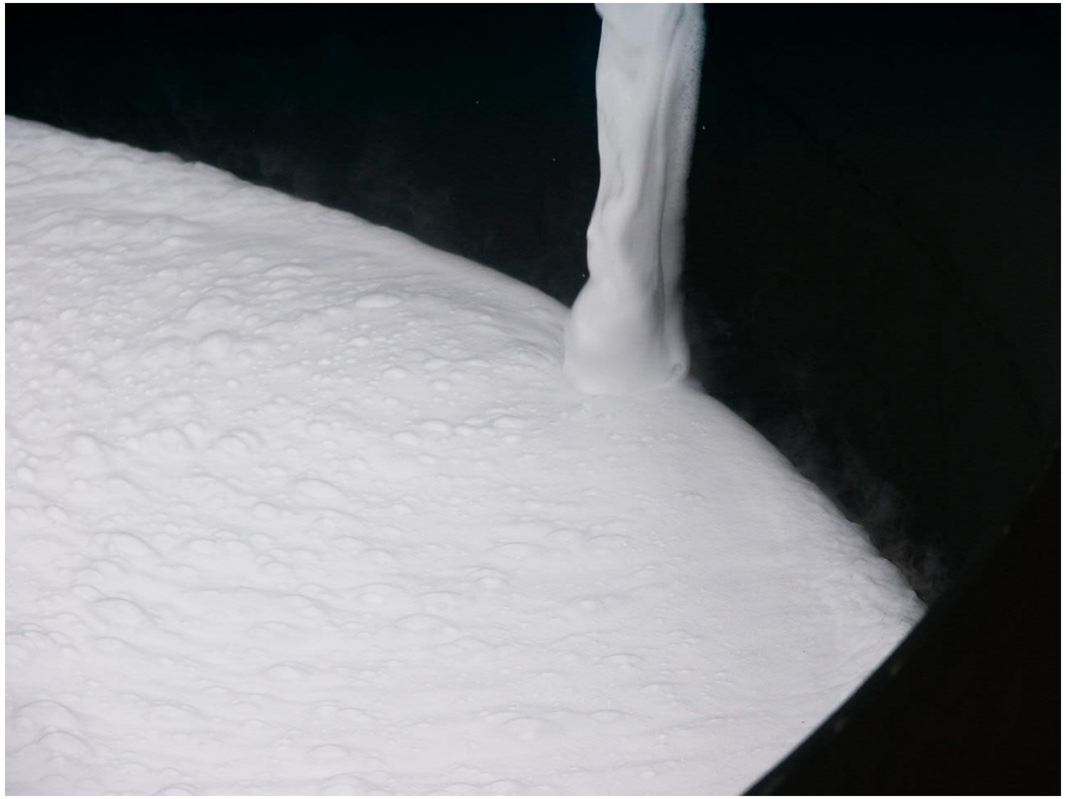
30 - END

Semi-aspirating and Aspirating Monitor Nozzles
Simulate ‘plunging application’

Semi-aspirating
Less dropout
More forceful

Aspirating
More dropout
Less forceful

Simulates 'gentle' application by fixed foam pourers
But actually quite forceful!



'System' Nozzle

Research Work – Rational Progression - more than 400 tests

Phases have included
- Different foams (C6 and FF)
- Different nozzles
- Different application methods
  - Monitor, Pourer, CAF, SEF, Hybrid etc
- Different rates
- Different fuels (including crude)
- Different preburns
- Fresh/Salt water

Small scale
Simulated tank fire
Critical application rates

Subsurface tests

Spill fire
Critical application rates

Larger scale
“Real life” Application
NFPA rates

Longer flow
“Real life” Application
NFPA rates

Self expanding foam

Vapour suppression

Hybrid Medium Expansion

Further obstructed spill fire testing

Research Work

Overall objective:

To provide a firm basis for future cost effective, long term, sustainable policies regarding the selection and use of fire fighting foam based on rational, relevant and independent, end user driven test programmes.

Research Work – Phase 1 Hungary

Initial work – FER Hungary

Research Work – Phase 2 France

Monitor application – Real World conditions

Research Work – Phase 2 France

CAF application
Compressor fed – continuous flow
Similar to standard monitor

Research Work – Phase 2 France

System application

Proportioning Systems Analysis Results

Foam	A		B		C		D		E		F		Ref 1		Ref 2		
	Venturi Z4	FireDos	Venturi Z4	FireDos	Venturi Z4	FireDos	Venturi Z4	FireDos	Venturi Z4	FireDos	Venturi Z4	FireDos	Venturi Z4	FireDos	Venturi Z4	FireDos	FireDos
Real Mixing Rate	2.20	2.39	2.51	3.00	2.26	2.39	2.30	2.46	1.89	1.05	2.52	2.90	2.65	2.94	0.84	2.53	1.17
Viscosity (mm2/s)	515.50	434.50	528.10	414.20	554.50	539.70	398.80	380.20	827.20	1223.20	441.90	404.60	18.20	18.20	947.10	448.40	753.3
Specific Gravity	1.039		1.057		1.026		1.042		1.04		1.024		1.153		1.036		

Notes

- All done at 3% nominal
- Generally lower viscosity gives better proportioning
- Can be accommodated by site changes, but cannot be ignored!
- Air entrainment! (volume vs weight) Not unexpected issues – seen before with AFFF-AR

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Research Work – Phase 3 DFW

1 FF

“Long flow tests”

Application rates as per NFPA 11:

3 tests conducted:

Test 1: Initial Fire Test with CAF Pourer

Area approximately 7.2m x 10 m

Test 2: Full Test with CAF Pourer

Area approximately 7.2 m x 40 m

Test 3: Full Test with Conventional Pourer (*new test pan)

Area approximately 2.25 m x 33 m

Had intended more!

Joint venture with GESIP
October 2020
Focus on monitor
- Conventional
- CAF
- Hybrid

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GESIP

Initial work carried out with a C6 for a reference point

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GESIP

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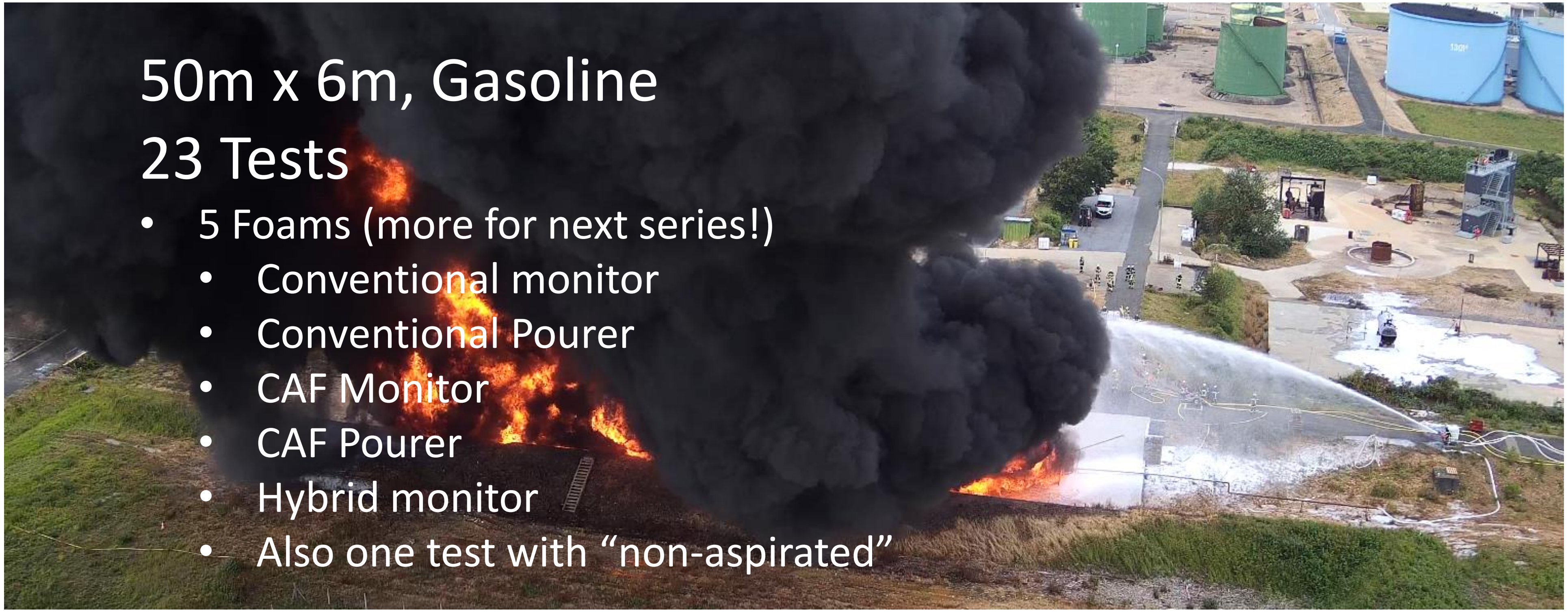
GESIP

June 2021 Large scale fire testing



50m x 6m, Gasoline

23 Tests

- 5 Foams (more for next series!)
  - Conventional monitor
  - Conventional Pourer
  - CAF Monitor
  - CAF Pourer
  - Hybrid monitor
  - Also one test with “non-aspirated”

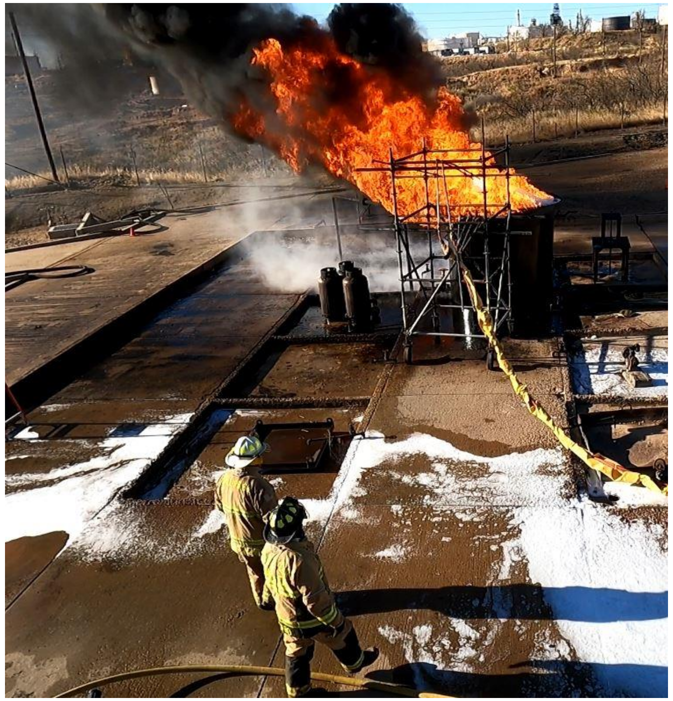
Note: Travel distance from conventional pourer – 50m! Standards suggest 30m maximum
Result confirms that from test carried out previously with FER

Hot off the press!

Crude oil testing

Long preburns

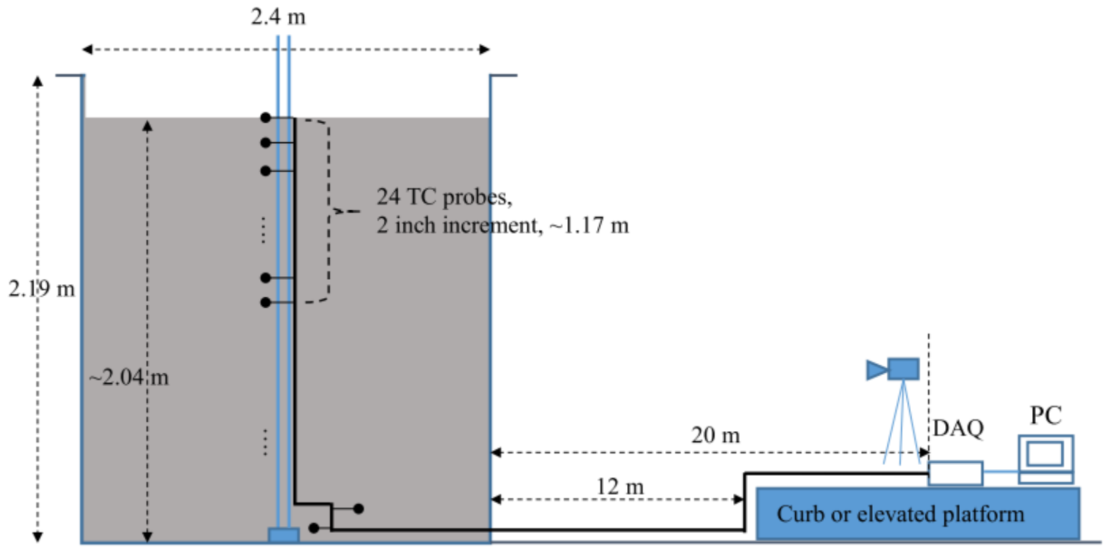
Hot zone build up



Borger Refinery Texas

Crude Testing

- Initial phase – 5m^2 (50 ft^2) tank
  - The LASTFIRE Pan
- Different application techniques
  - LASTFIRE Nozzles and CAF
- Different foams
- Also! Check proportioning rates
- Thermocouple measurements (Dr Park, OSU)
- Partners:
  - ILTA
  - API
  - OSU



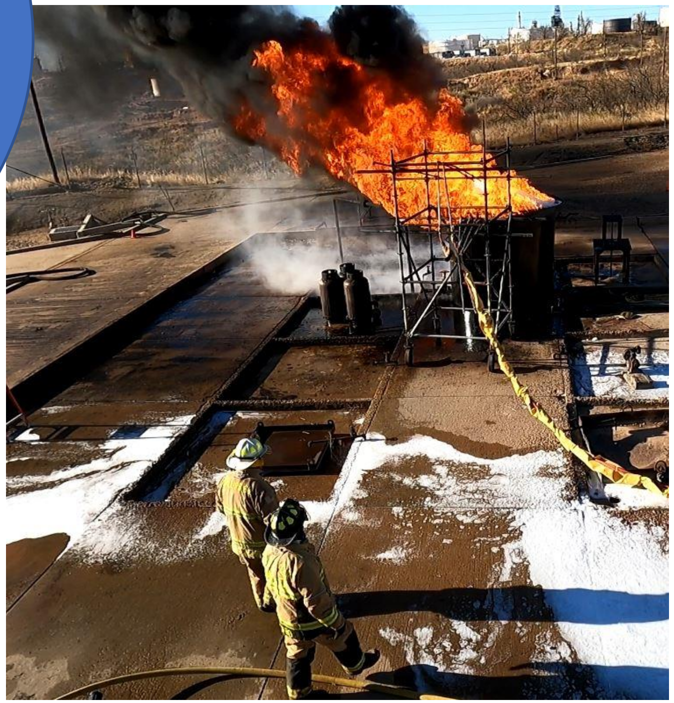
Hot off the press!

Crude oil testing

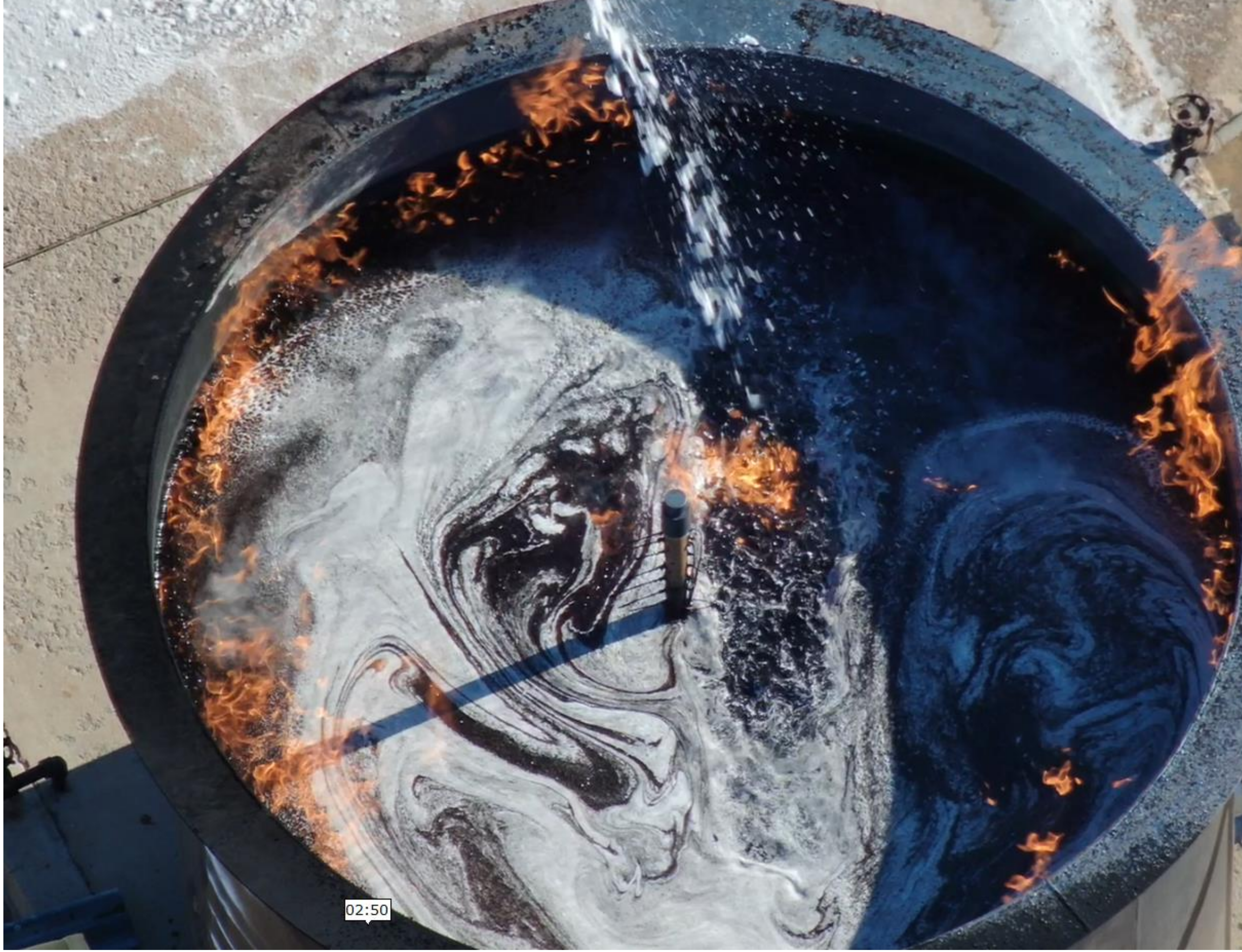
Lo

They can work!
Some interesting learning points re crude oil fires in general!

Texas



TEST 4
1’39” BEFORE EXTINGUISHMENT



TEST 4
EXTINGUISHMENT

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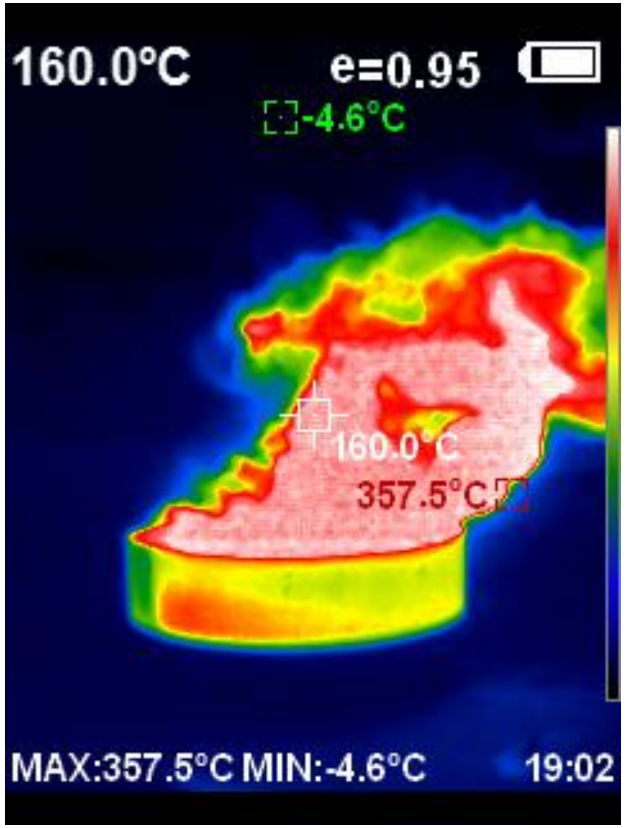
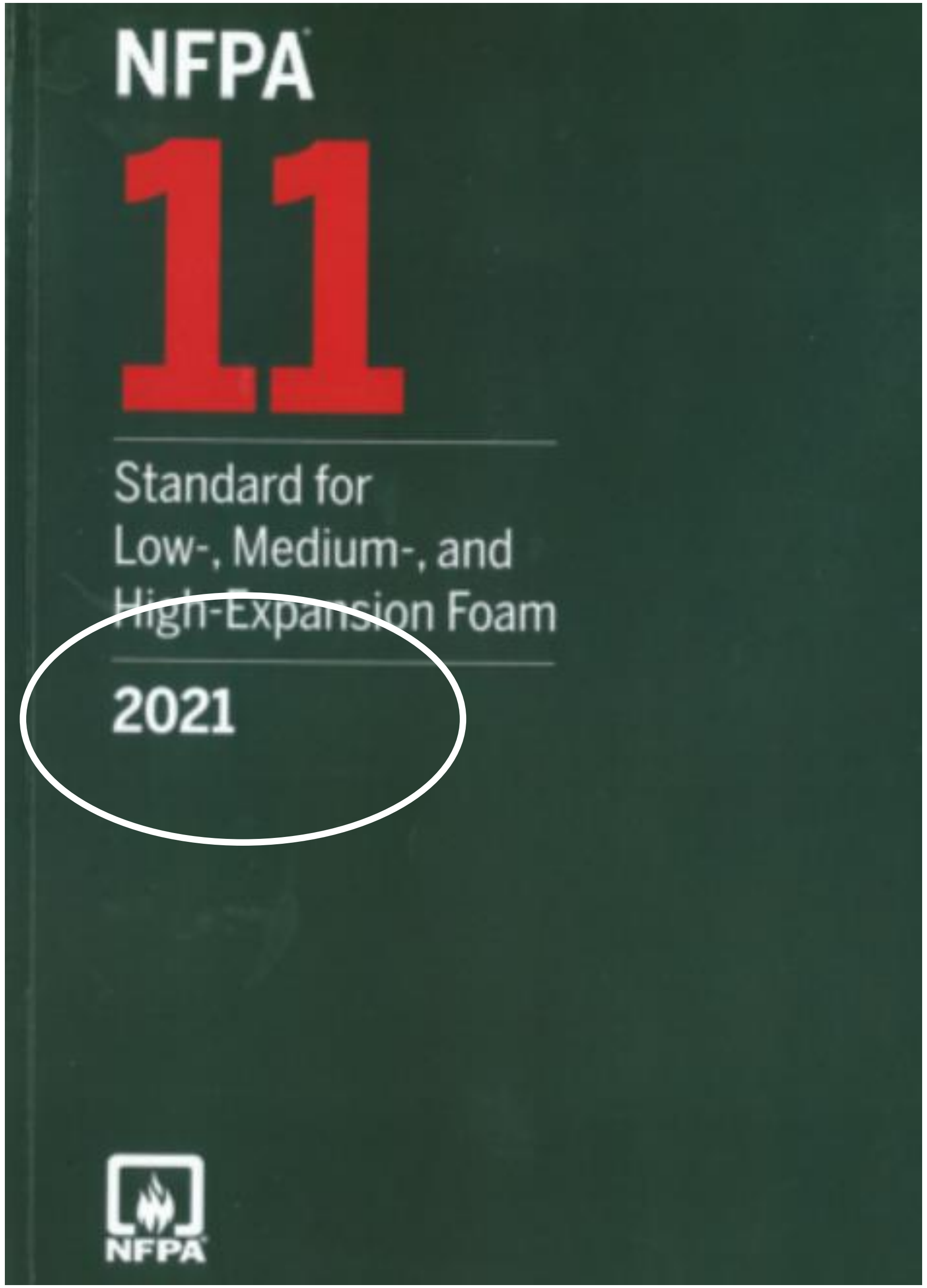
Current work
Large Scale Polar Solvent Test Fires
A specific client


160.0°C
e=0.95
-4.6°C
160.0°C
357.5°C
MAX:357.5°C MIN:-4.6°C
19:02



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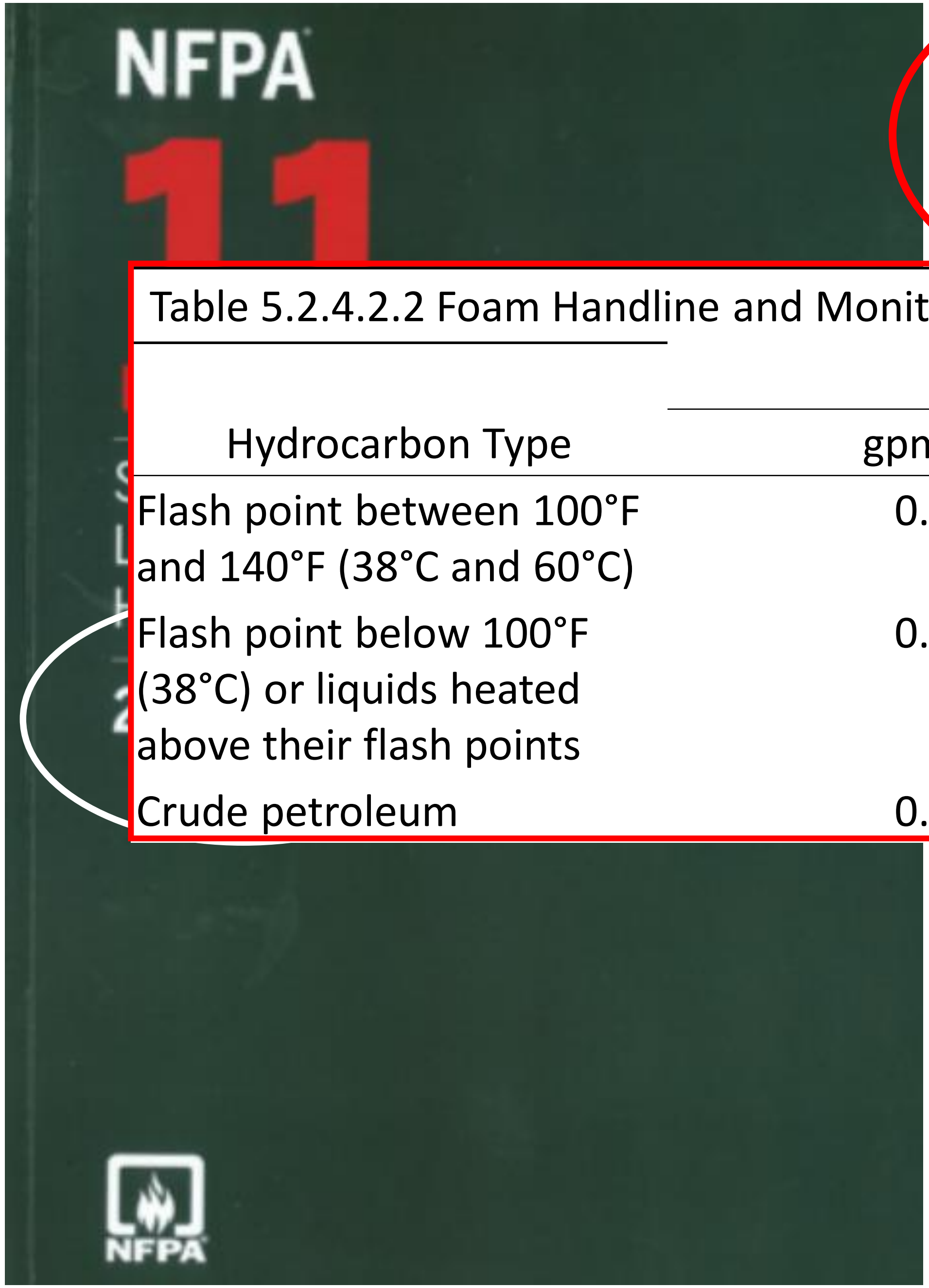
Some very significant changes
Specifically mentions LASTFIRE work



Similar comment on other tables related to pourers.

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Table 5.2.4.2.2 Foam Handline and Monitor Protection for Fixed-Roof Storage Tanks Containing Hydrocarbons			
	Minimum Application Rate		Minimum Discharge Time (minutes)
Hydrocarbon Type	gpm/ft^2	mm/min*	
Flash point between 100°F and 140°F (38°C and 60°C)	0.16	6.5	50
Flash point below 100°F (38°C) or liquids heated above their flash points	0.16	6.5	65
Crude petroleum	0.16	6.5	65

(5) When using SFFF, the user should refer to Annex H and the manufacturer's recommendations to determine application rates.

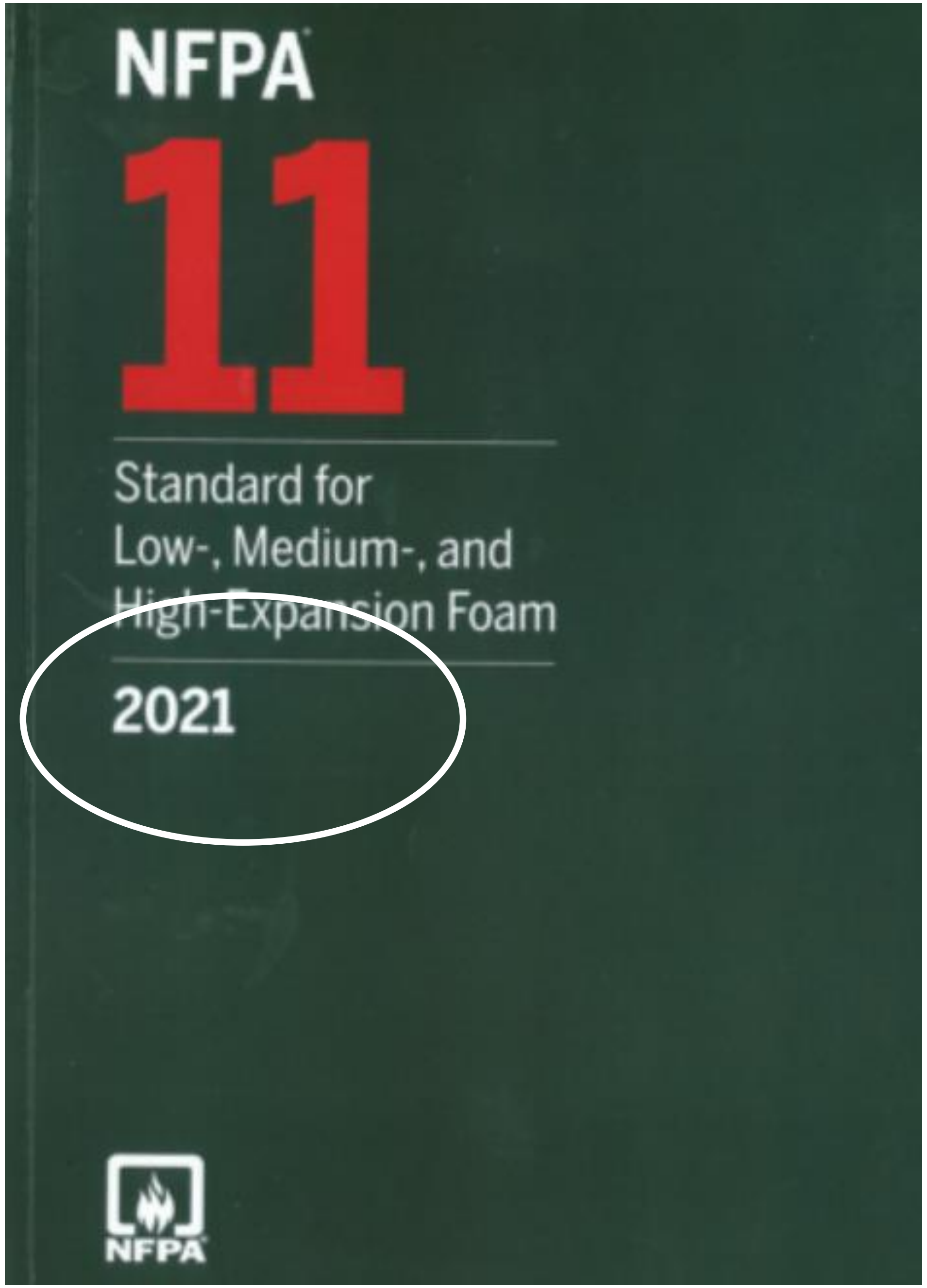

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Table 5.2.6.5.1 Minimum Discharge Times and Application Rates for Subsurface Application on Fixed-Roof Storage Tanks

And for subsurface!

(5) When using SFFF, the user should refer to Annex H and the manufacturer’s recommendations to determine application rates.

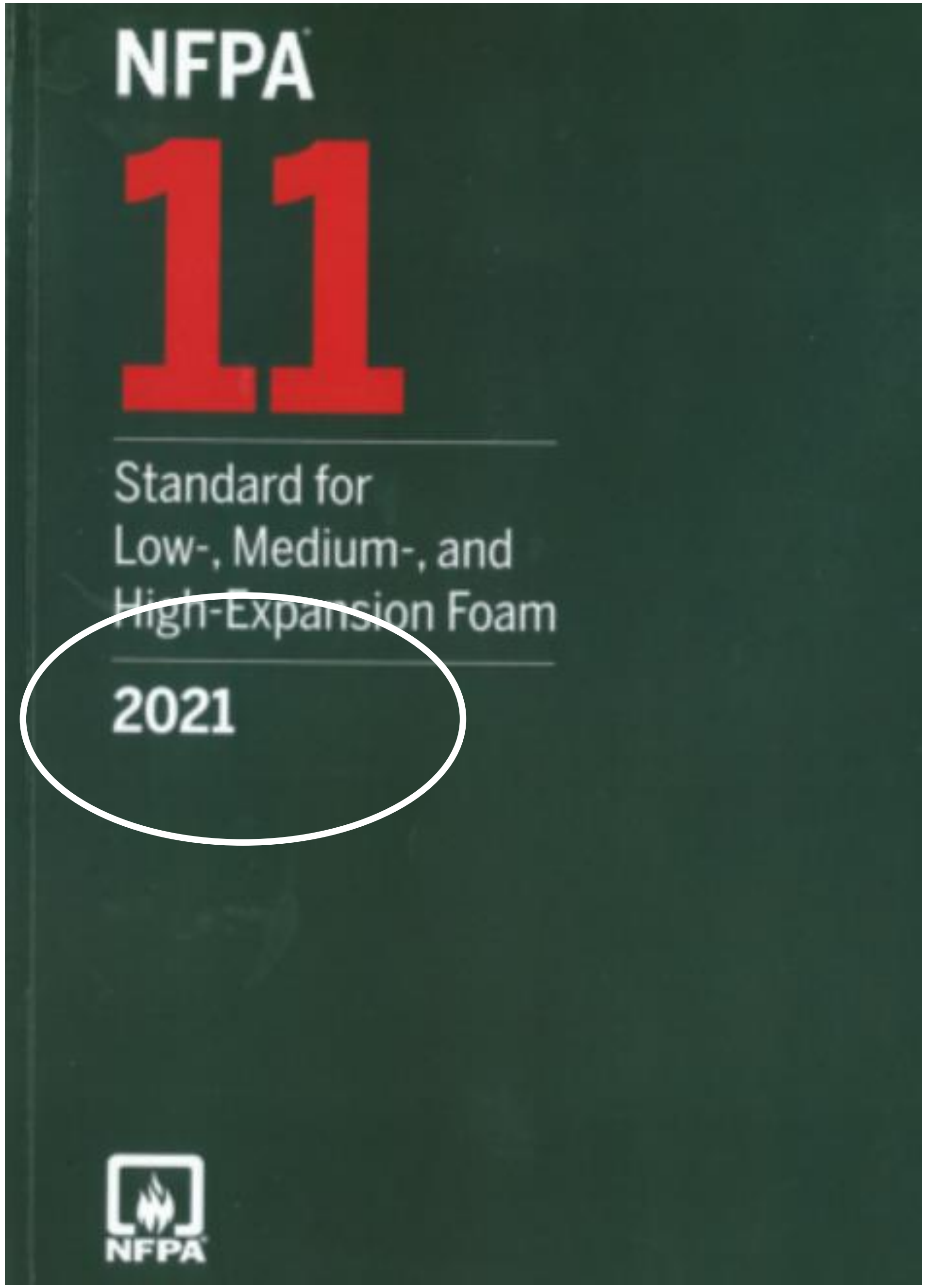

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Table 5.2.6.5.1 Minimum Discharge Times and Application Rates for Subsurface Application on Fixed-Roof Storage Tanks

And they said it wouldn't work!

Modified UL162 subsurface test

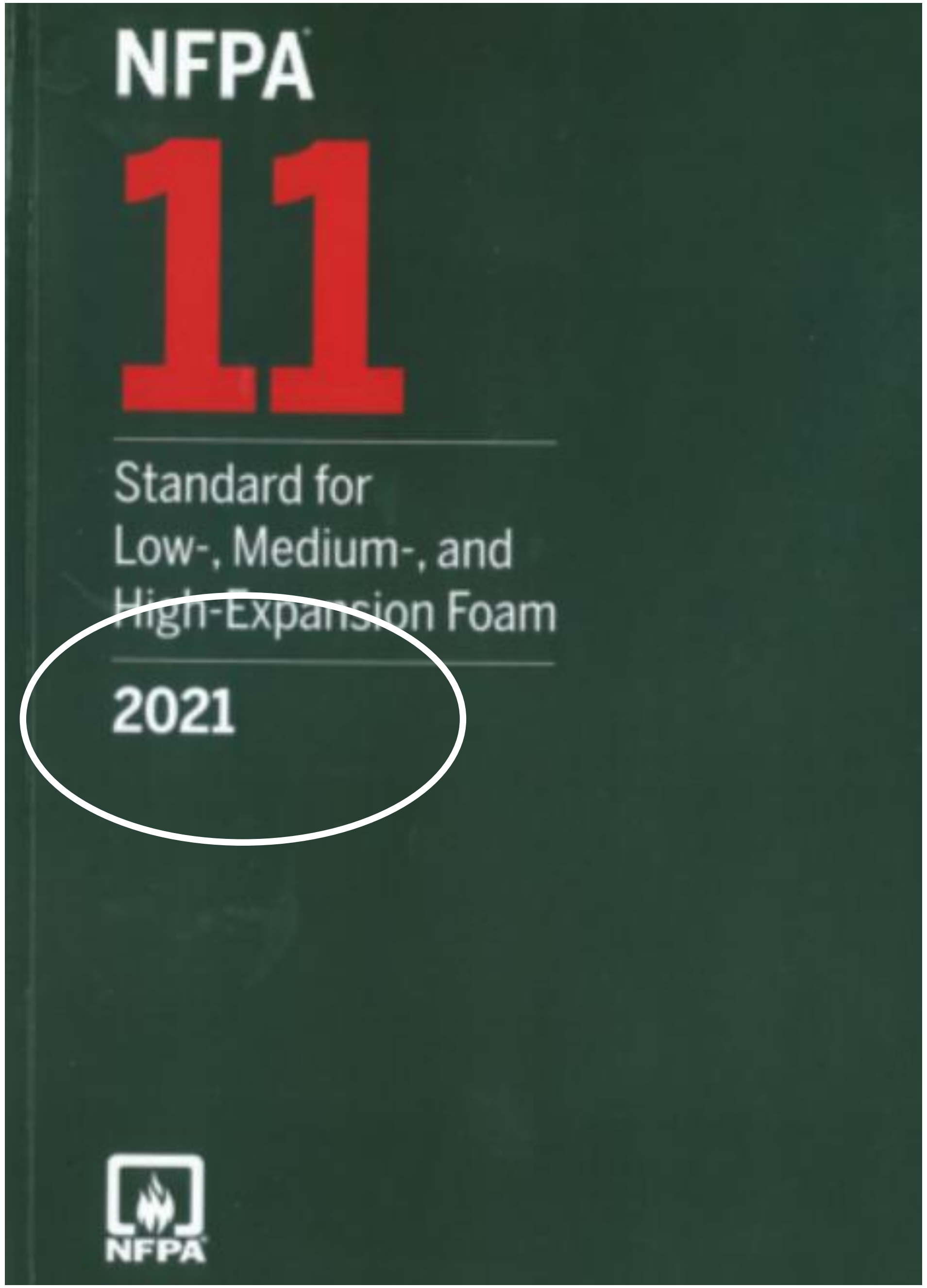
Jet A1

2 foams

Up to 10 min preburn

CAF and conventional

PS – Pourers too!



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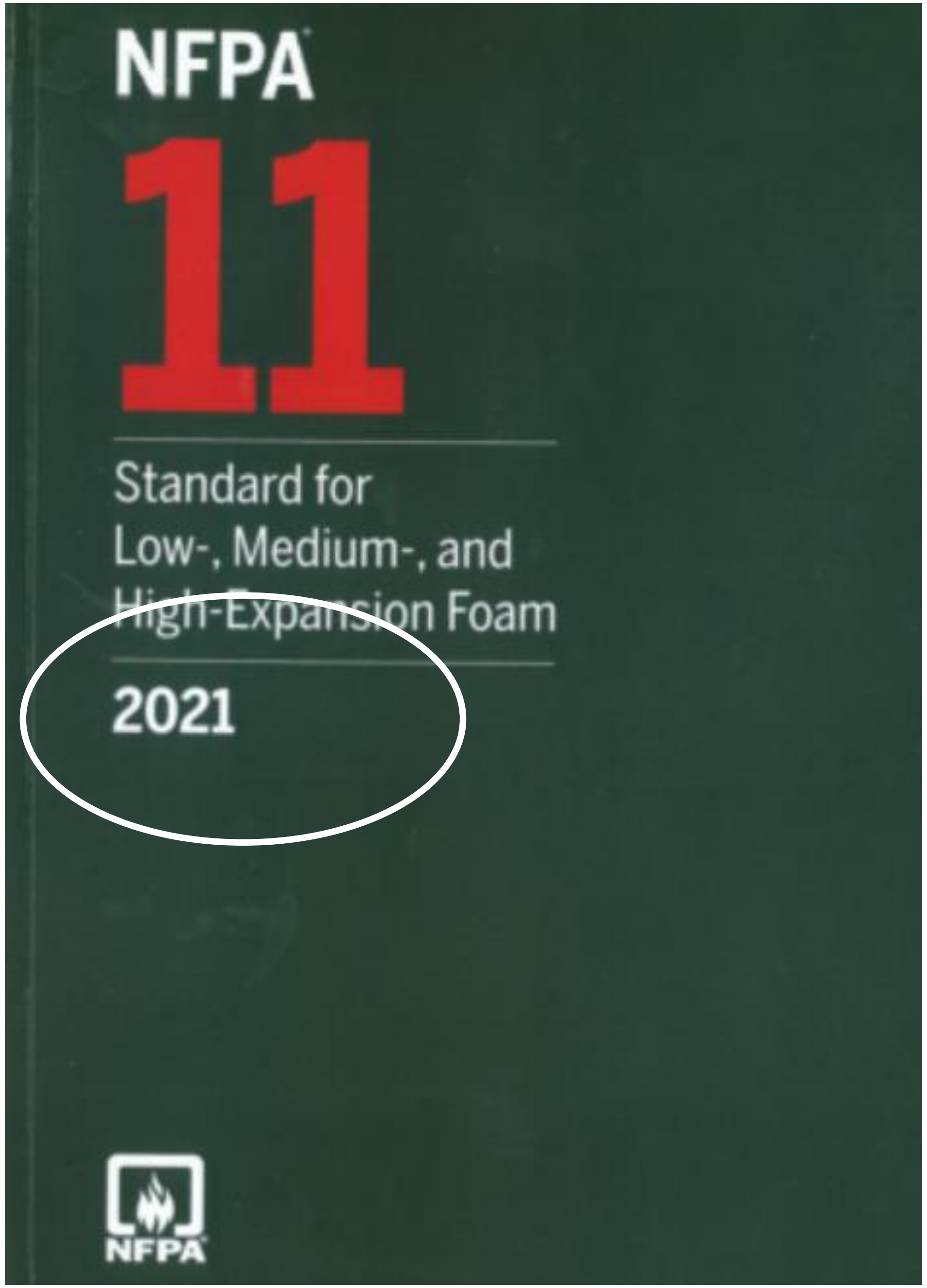
Appendix H Synthetic Fluorine-Free Foam (SFFF) Research Testing Summary

Test programmes

Examples of ongoing work

NFPA RF

NFPA Research Foundation
Essentially UL162
Issues with different test criteria for different foam types
UL162 under review



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Appendix H Synthetic Fluorine-Free Foam (SFFF) Research Testing Summary

Test programmes

Examples of ongoing work

NFPA RF

LASTFIRE

Much more comprehensive

EN13565 Part 2

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 13565-2

May 2009

ICS 13.220.20

English Version

Fixed firefighting systems - Foam systems - Part 2: Design, construction and maintenance

Strictly speaking – no changes

But does raise a question

Are test methods applicable to the application or to a foam type?

Some are not validated against large scale testing/scenarios

It’s not just about firefighting performance

Suitability for system

Proportioning system

Application equipment – will it provide the foam characteristics you want?

Materials compatibility

Arctic Council Project

Clean out of equipment/Systems

How clean is clean?

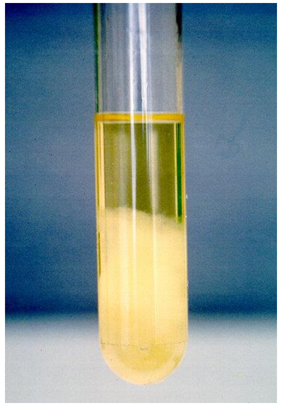
Use special cleaning agent?

A reminder!!

Environmental Impact

Environmental Data

Greenscreen?



Shelf Life Guarantees

Long term availability

A key issue!

Important to get procurement specification right!


E
G
D

Foam Transition Manual

- A sensible, pragmatic risk based approach to transition to fluorine free foam

- Produce one stand alone document to cover transition to fluorine free foam from all types of sectors and industry

Transition Manual Contents

- General overview
  - Overview of the project / Stakeholders / typical facilities / how to use the manual
- Background to the current situation and why the need to transition
- General protocols – common to all installations
  - Review of fire hazard assessment – do you need foam?
  - Foam procurement specification
  - Management of Change
  - Commissioning
  - Ongoing assurance
  - Scenario specific Emergency Response Plans
  - Training / System assurance
- Interim requirements prior to transition
  - Management plan / containment / Testing/training / preplanning for containment
- General notes and instructions applicable to all protocols
  - Key considerations
  - Worker Health and Safety Concerns associated with foams
  - Assessment of PFAS Content
- Specific Protocols

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The fluorine free foam issue – a summary!

OK – in some cases not as effective as a good AFFF AR

But they are good enough

We can do it!

Yes, a few issues to sort out

    Storage issues

Concentrate on optimising bubble structure/application

We should have been doing this better before!

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So – a lot of work related to industry

Is it relevant to aviation and other sectors?

Of course it is!

- **Spill fires**
- **Proportioning and storage issues etc**

The current focus

The PFAS in firefighting foam issue

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Large Atmospheric Storage Tank Fires

An opportunity – not a crisis!

Working together

info@lastfire.org