AUXQUIMIA
Fire fighting products

THE FOAM SOLUTION

Fluorine Free Foams. Where is the limit?

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July 21st, 2016

Fire Fighting Foam Concentrate

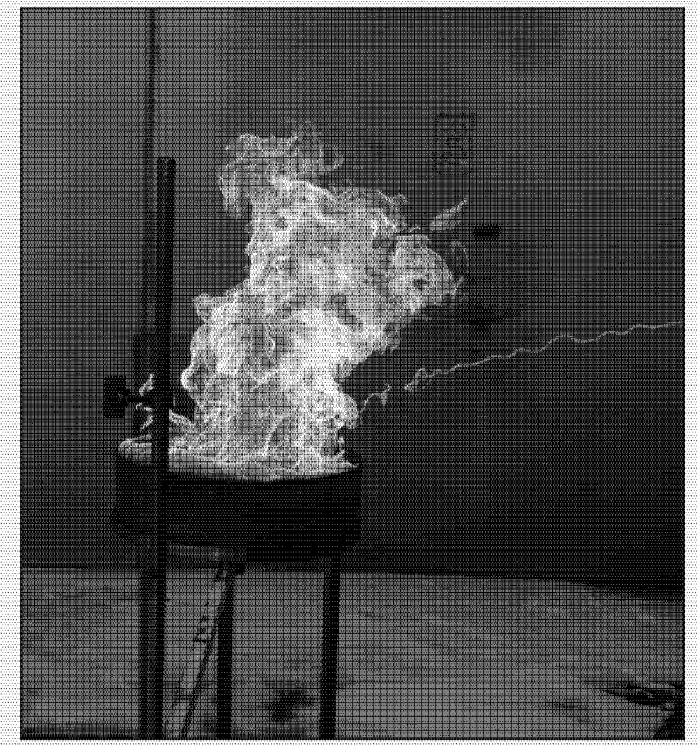
Liquid Concentrate – Mixed with water has the ability:

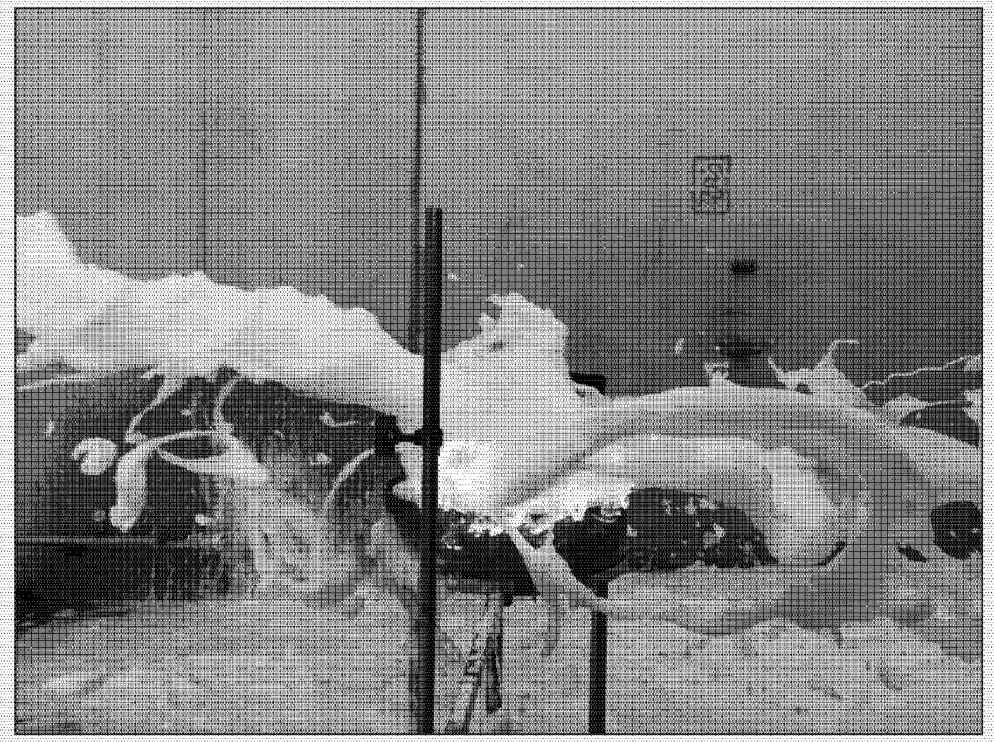
Create foam
Extinguish a fire

Performance?? Type of Fire?? It will depend on:

- **Concentrate**
- Equipment
- **Fuel**
- Application type
- **Application rate**

Introduction





Both Foams Extinguish …..but performance is different

Foam Concentrate Classification

- **Protein type**
  - Protein - P (*)
  - FluoroProtein - FP
  - Film Forming FluoroProtein – (FFFP)

- **Synthetic type**
  - Hiex (High Expansion) (*)
  - Class A (Solid Fires) (*)
  - Fluorine Free Foams - **FFF (*)**
  - Aqueous Film Forming Foam - **AFFF**

AR type (Polar Solvents)

(*) No Fluor

AFFF

Aqueous Film Forming Foam

Fluorocompounds (Persistant)

New C6 type – Improve Environmental footprint

Traditionally the most effective on class B fires (liquids)

Foam can be applied directly on hydrocarbons

FFF

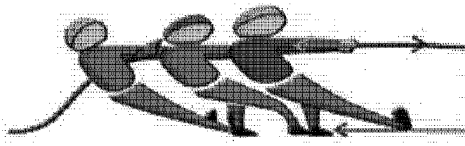
Fluorine Free Foam

No Fluorocompounds

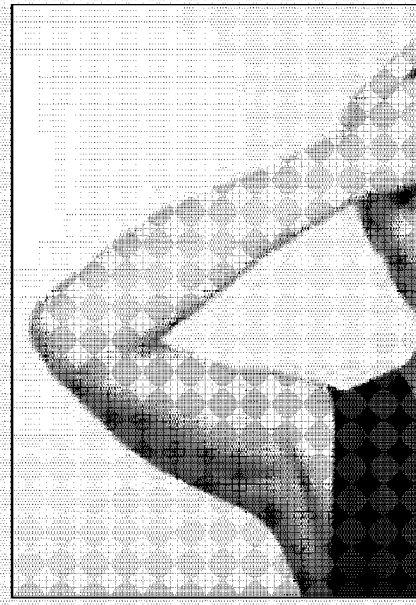
Environmental impact

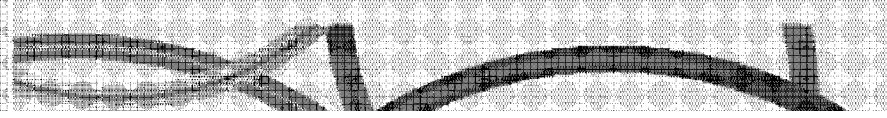
Novel technology for class B - New formulations

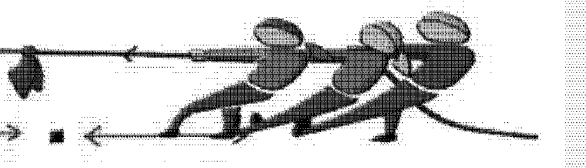
AFFF



Performance

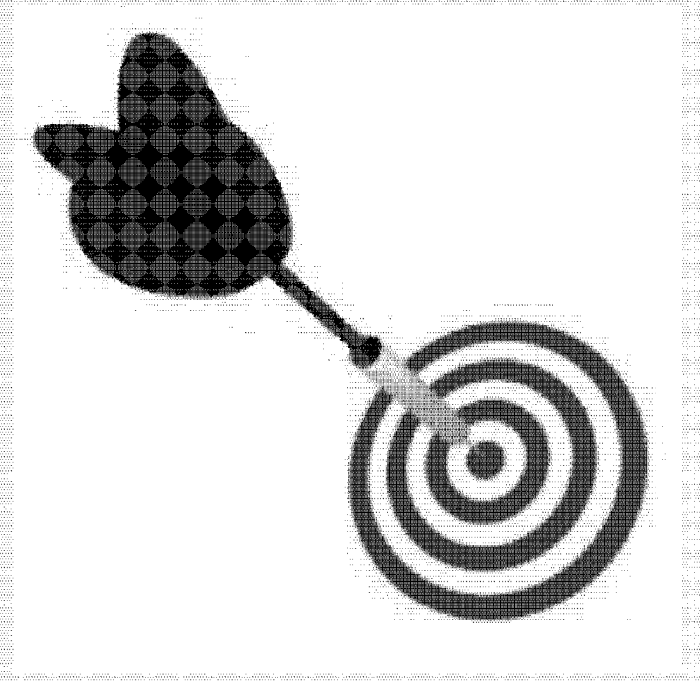






FFF

Environment



IDEAL SITUATION

FFF with same performance/properties than AFFF

Is it possible today?????

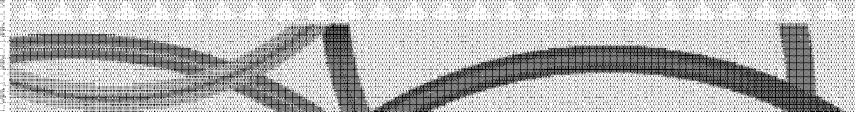
Goals of the Project

1. Investigate **fire performance** of AFFF's vs FFF's
   - On different **hydrocarbons**
   - Under same testing conditions
2. Identify if/when FFF's are an **alternative** to AFFF's
3. Focus on performance (No environmental data)
4. Not looking for conclusions on specific manufacturer
5. **Not marketing oriented**

Looking for a realistic approach!!!

Testing Program

- Research program on
  - 5 AFFF (AR-pseudoplastic)
  - 5 FFF (AR-pseudoplastic)
- 6 Manufacturers
- > 80 Fire tests
- > 50 Physico-chemical properties
- 4 Hydrocarbons
- 3 Application rates
- 2 Application type



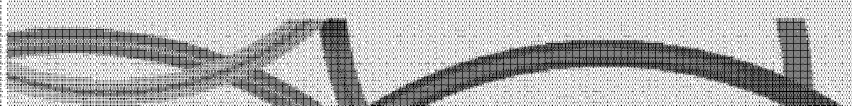
Products Tested (Data from Label and TDS)

Type	Nº	EN-1568-3	ICAO	LASTFIRE
FFF-AR 3x6	1	IB	NO	YES
FFF-AR 3x6	2	IIIB	B	YES
FFF-AR 3x3	3	IIIB	B	YES
FFF-AR 3x6	4	IA	B	NO
FFF 3%	5	IA	NO	YES
AFFF-AR 3x6*	1	IA	B	YES
FC-600	2	IA	B	YES
AFFF-AR 3x3*	3	IA	NO	YES
AFFF-AR 3x3*	4	IB	NO	NO
AFFF-AR 3x3	5	IIA	NO	NO

** Formulated with C6 Fluorocompounds*

Fuel - Properties

Fuel	Flash Point ºC	Surface Tension mN/m
Gasoline 95O	-40	20,1
Heptane	-4	19,4
Jet A1	40	24,6
Diesel	52-96	26,3



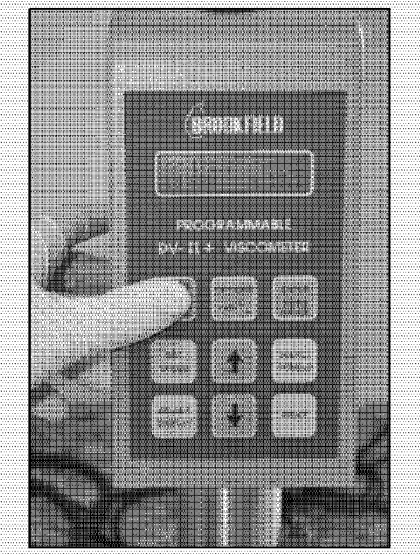
Physico-Chemical Properties

Viscosity

Physico-Chemical Properties

- ✓ pH
- ✓ Specific Gravity
- ✓ Refractive Index
- ✓ Freezing Point
- ✓ **Viscosity:** Resistance to flow
  - *Related to Temperature*

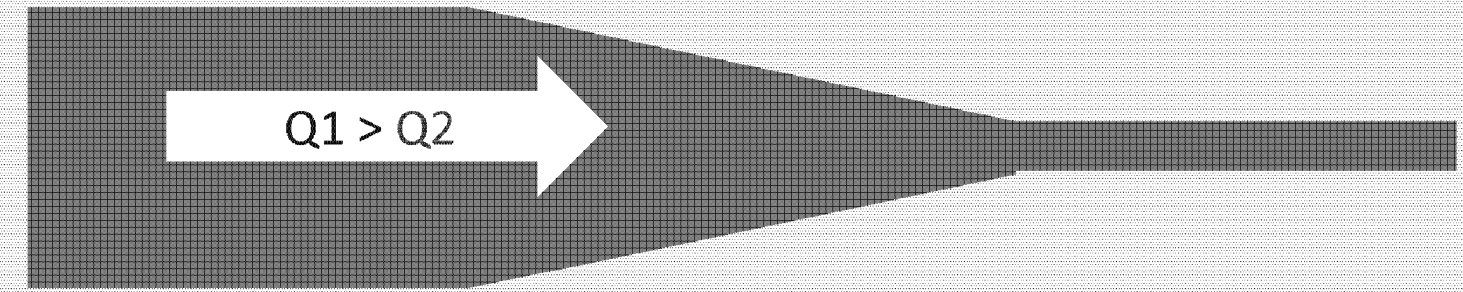
    (The Lower the Temp. – The Higher the Viscosity)

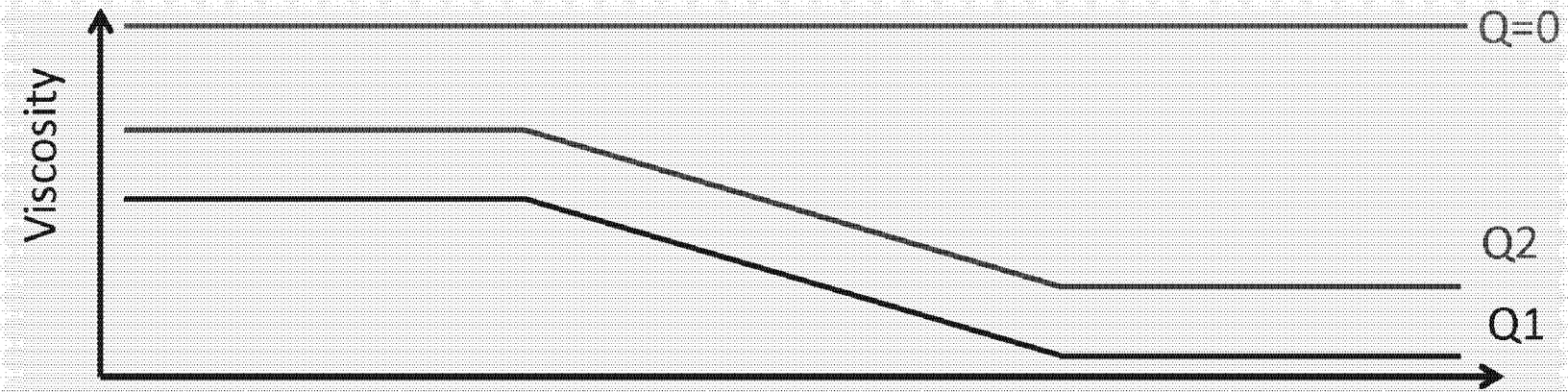


- ✓ ***Newtonian:*** *"Low Viscosity"*
- ✓ ***Pseudoplastic:*** *"High Viscosity" – "Gel"*

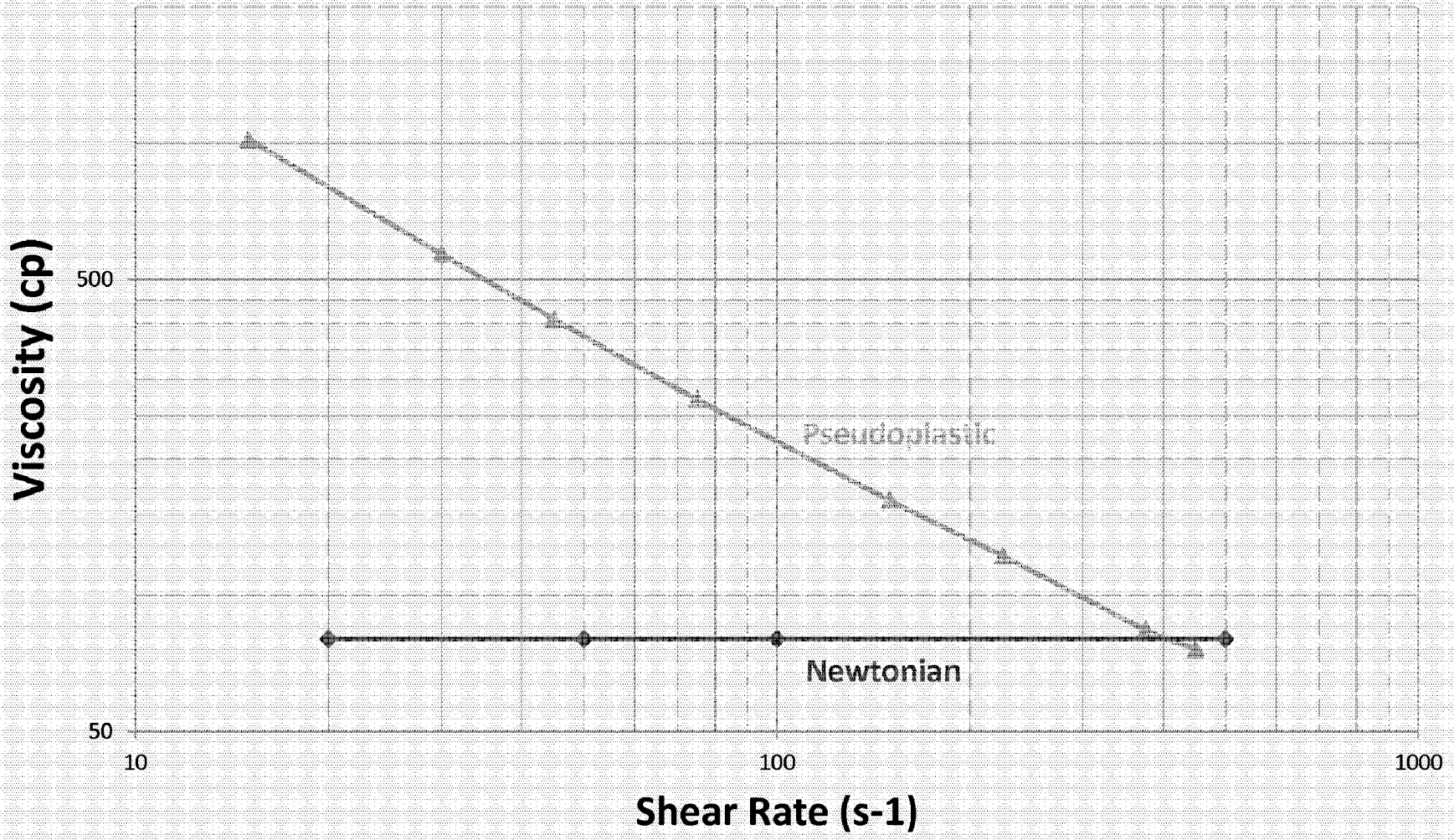
Pseudoplasticity

- ✓ Viscosity depends on shear rate / shear stress
- ✓ Viscosity depends on flow rate (for a specific pipe section)

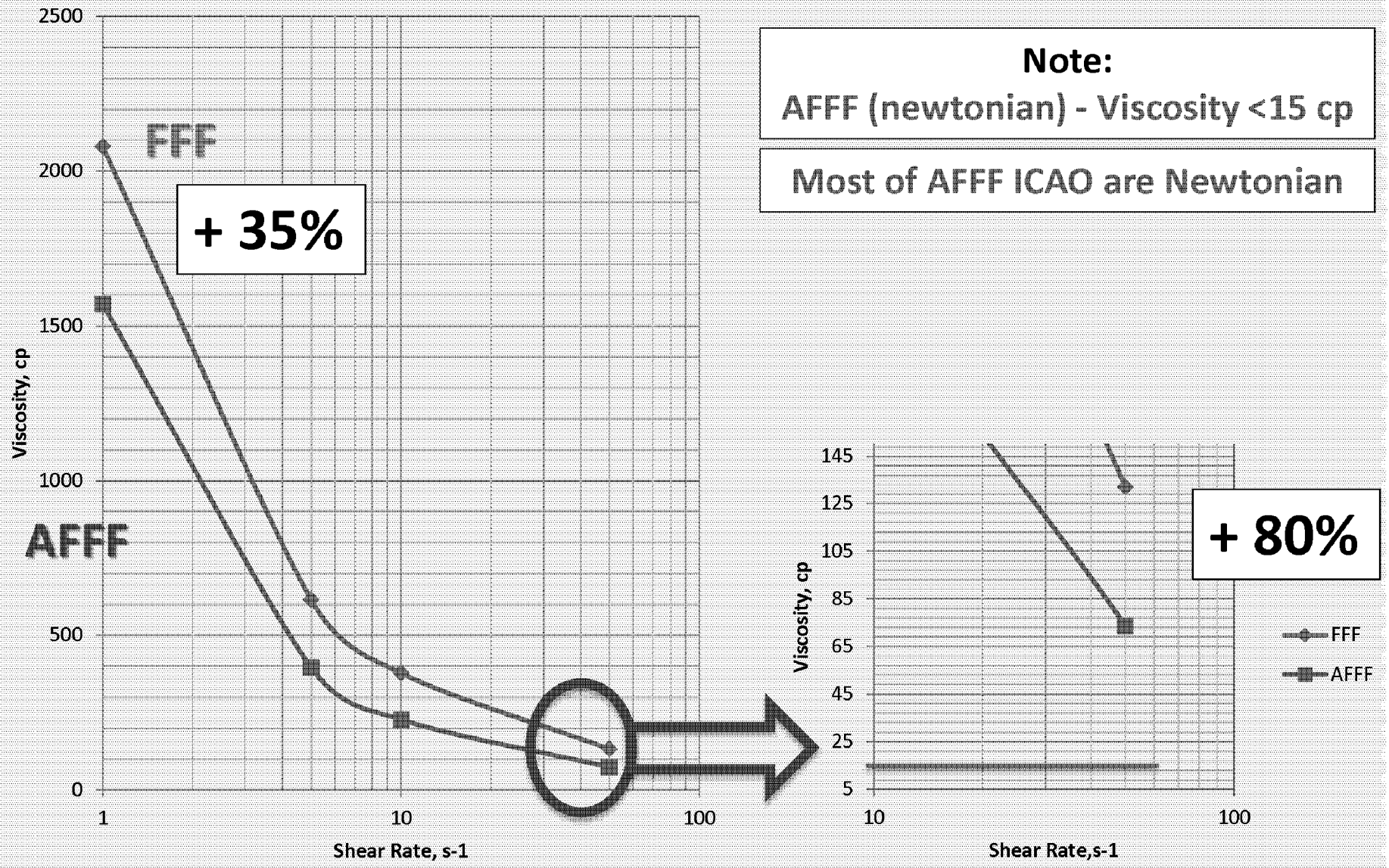




Viscosity


Viscosity (cp)
500
50
10
100
1000
Shear Rate (s-1)
Pseudoplastic
Newtonian

Viscosity FFF vs. AFFF (pseudoplastic)

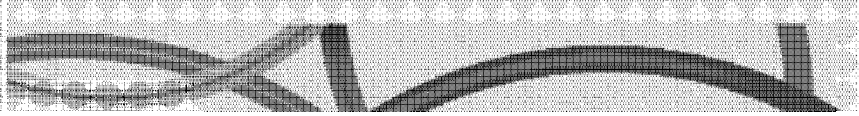


Note:

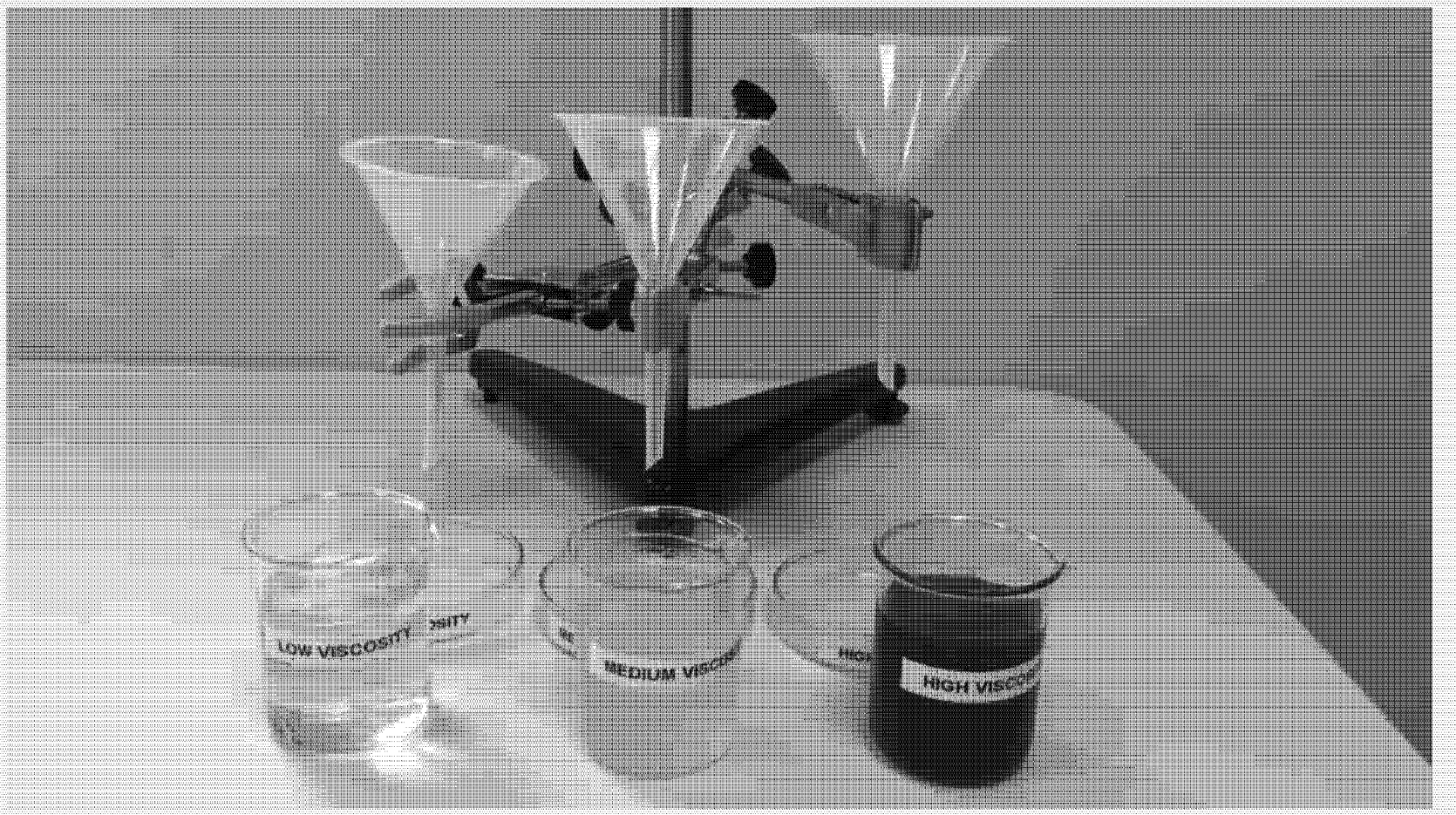
AFFF (newtonian) - Viscosity <15 cp

Most of AFFF ICAO are Newtonian

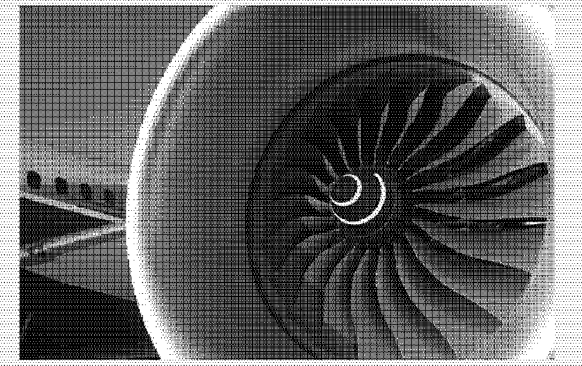
EN-1568 Methodology. Brookfield cone and plate



Viscosity Effect



From previous data …….

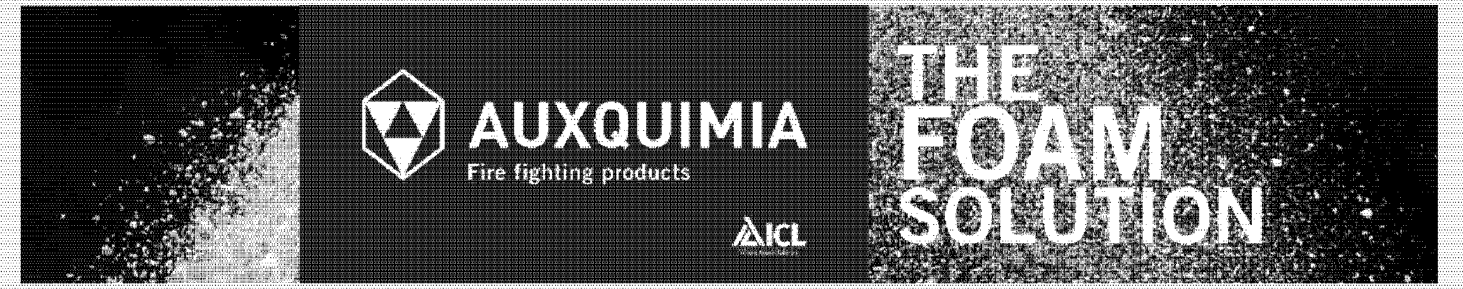


- ***Most of AFFF ICAO (Airports) are newtonian (Low visc.)***
- ***Most of Fluorine Free are pseudoplastic***

Fluorine Free (pseudoplastic) …..

…. have higher viscosity than …..

….. AFFF (pseudoplastic)



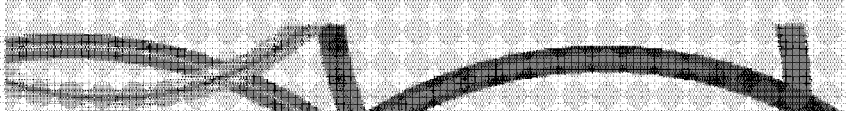
Physico-Chemical Properties

AFFF

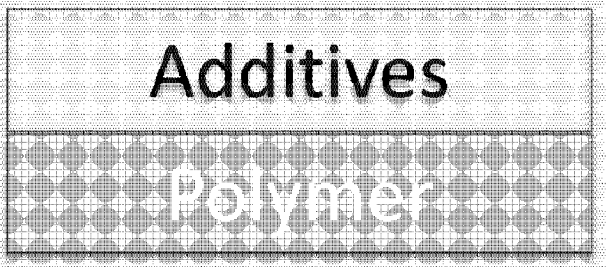
Components

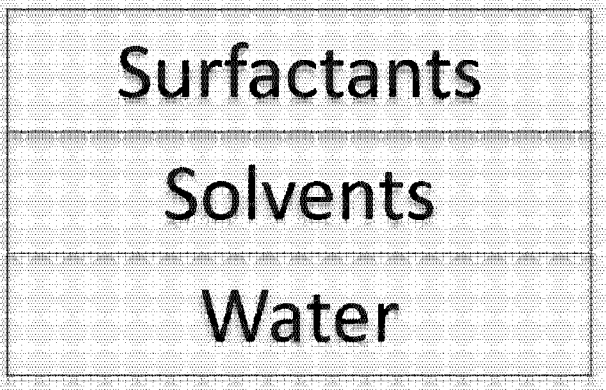
AFFF

- Additives
- Polymer (AR)
- **Fluorocompounds**
- Surfactants
- Solvents
- Water



FFF





Oil Repellence
Heat Resistance
Surface Tension Reduction (AFFF)

AFFF - Spreading Coefficient (Theoretical)

- ✓ Aqueous Film Forming Foam

Fuel Surface Tension

-

Foam Solution Surface Tension

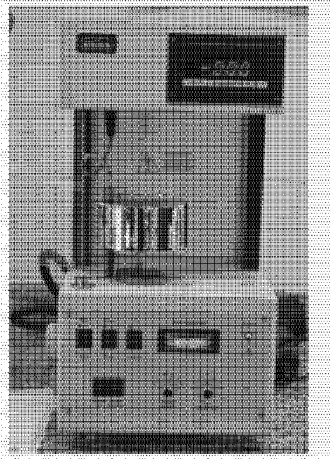
-

Interfacial Tension Solution/Fuel

Spreading Coefficient

>0 AFFF

<0 NO AFFF



Film Forming (Real)

AFFF

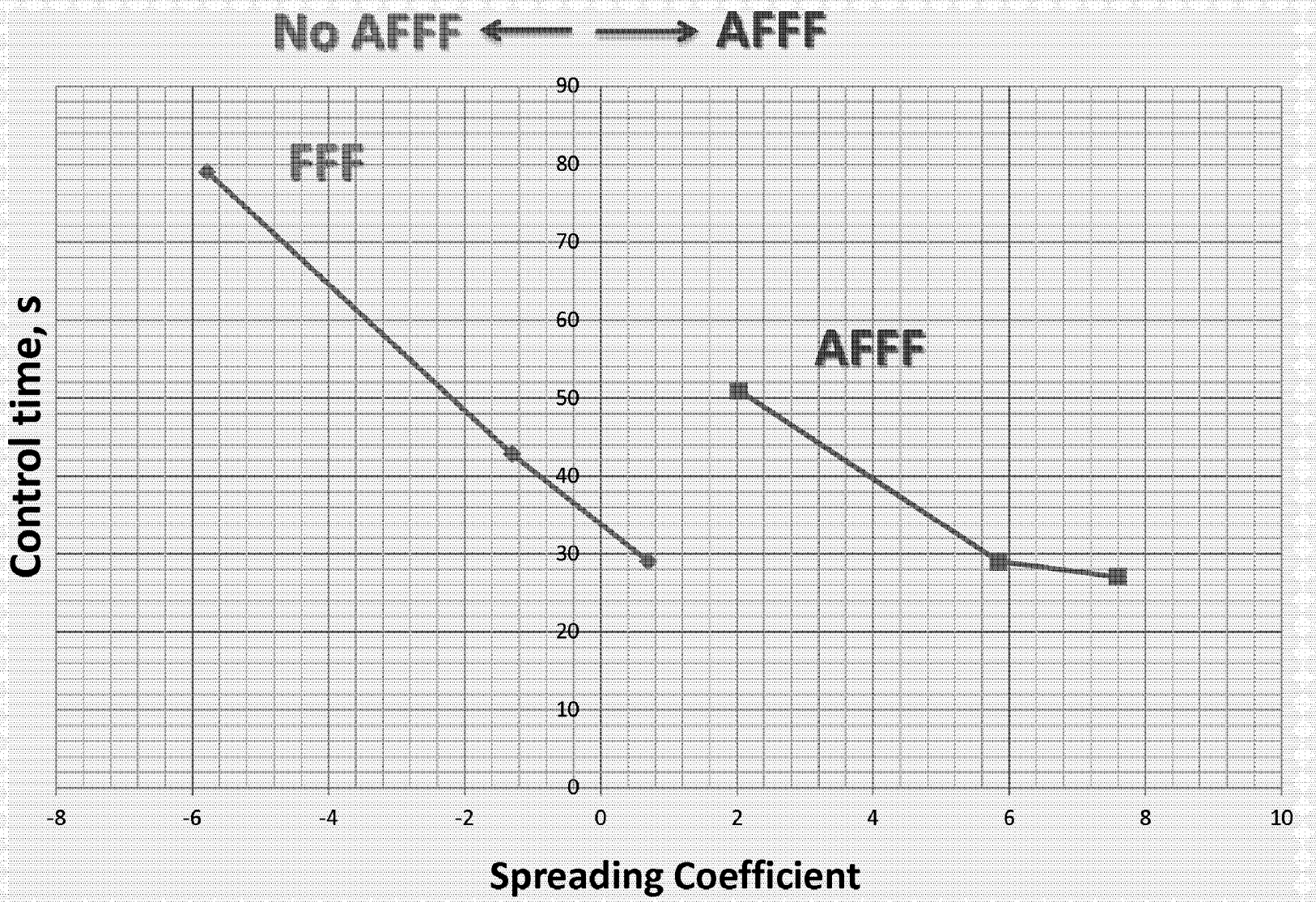
NO AFFF

Spray extinguishment

AFFF

NO AFFF

Control time vs. Spreading Coeficient

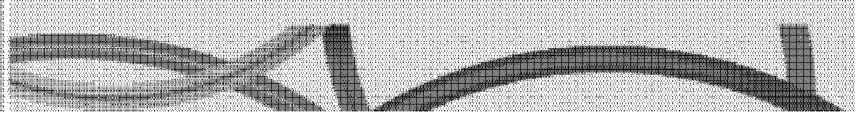


* *Average data - 5 FFF-AR and 5 AFFF-AR*

* *Tests on fresh water*

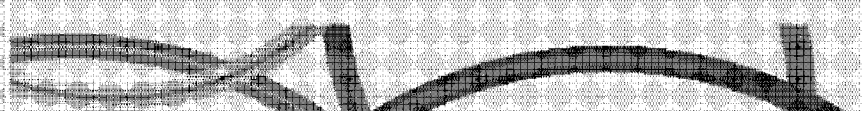
Film Forming Effect

has a positive impact on Fire Performance



Fire Performance

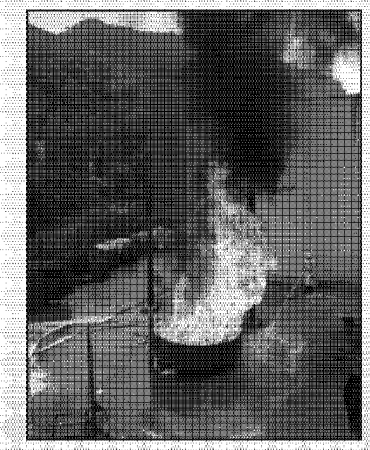
Low Expansion



Fire Performance - Standards

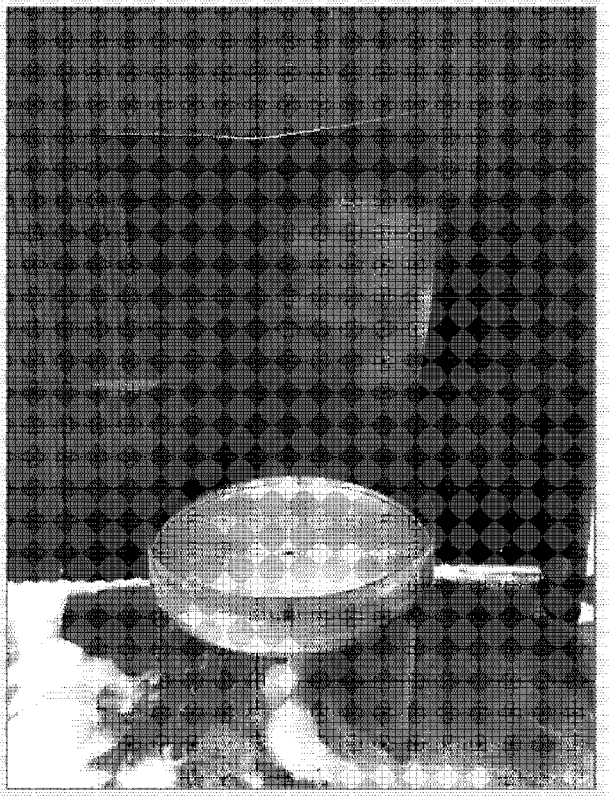
	Application type	Aplication Rate l/min·m2	Nozzle	Pan type	Fuel	Preburn
EN-1568-3	Forceful/Gentle	2,5	Fix	Circular	Heptane	1min
ICAO	Forceful	2,5	Fix	Circular	Jeat A1	1min
UL	Type III/ Type II	1,66 - 2,5	Mobile	Square	Heptane	1min
LASTFIRE	Semi/Asp/Syst	3,88-2,6	Fix	Circular	Heptane	3 min
IMO	Gentle	2,5	Fix	Square	Heptane	1 min
Mil.Spec.	Direct	1,66-2,5	Mobile	Circular	Gasoline	10 sec.

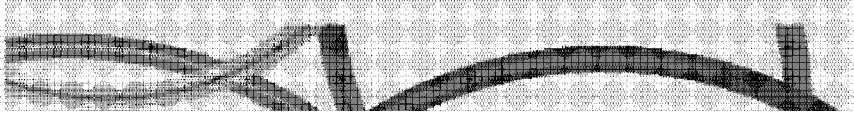
Impossible to compare performance !!!!!



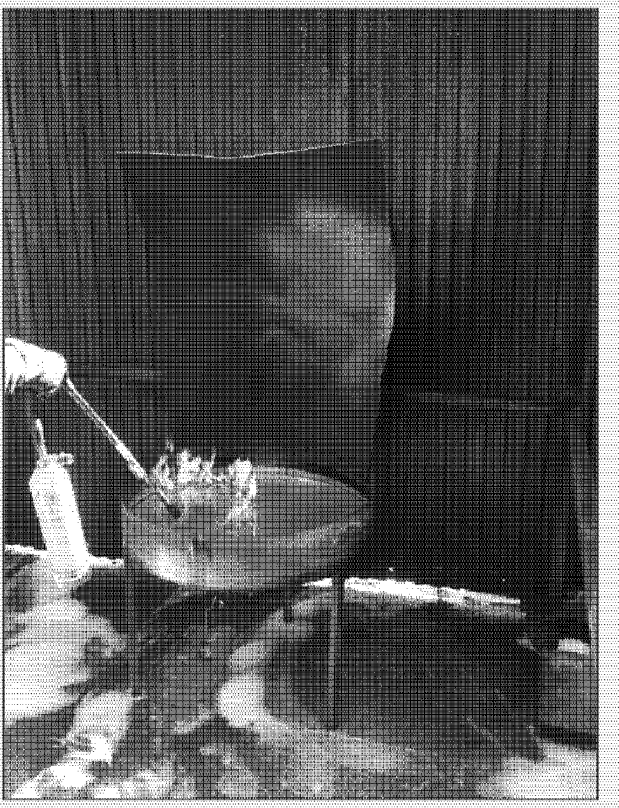
Small Scale Test - Low Expansion

- Circular Pan
- 0,74 m Diameter
- 10 l Fuel





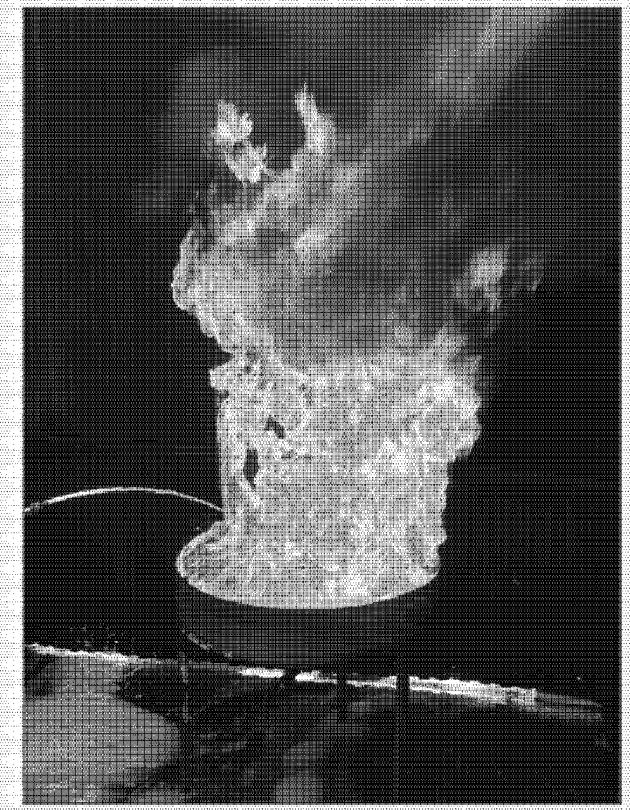
- **1 min Preburn**

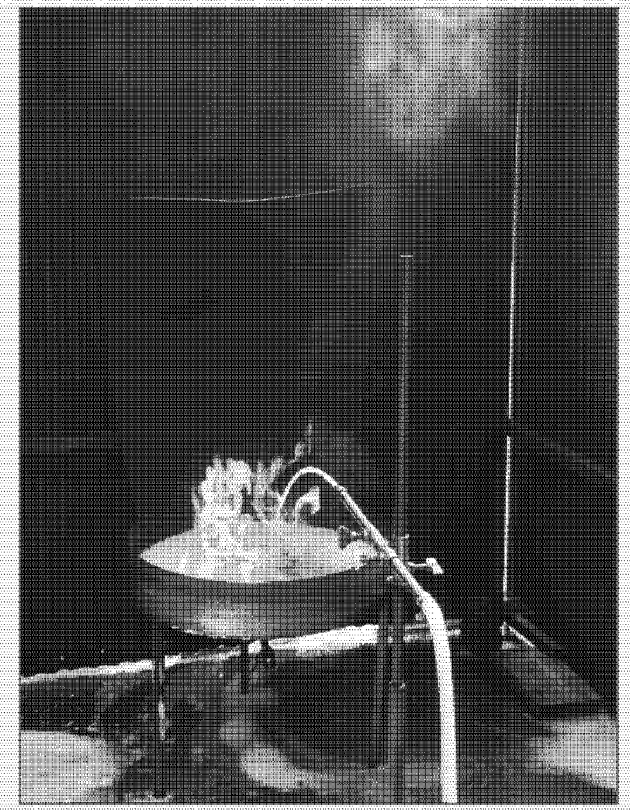


Small Scale Test - Low expansion

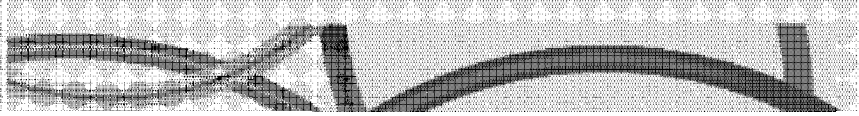
- 3 min application
- 1 l/min
- 2,5 l/min·m^2

- 90% Control time
- Extinguishment time
- Burnback

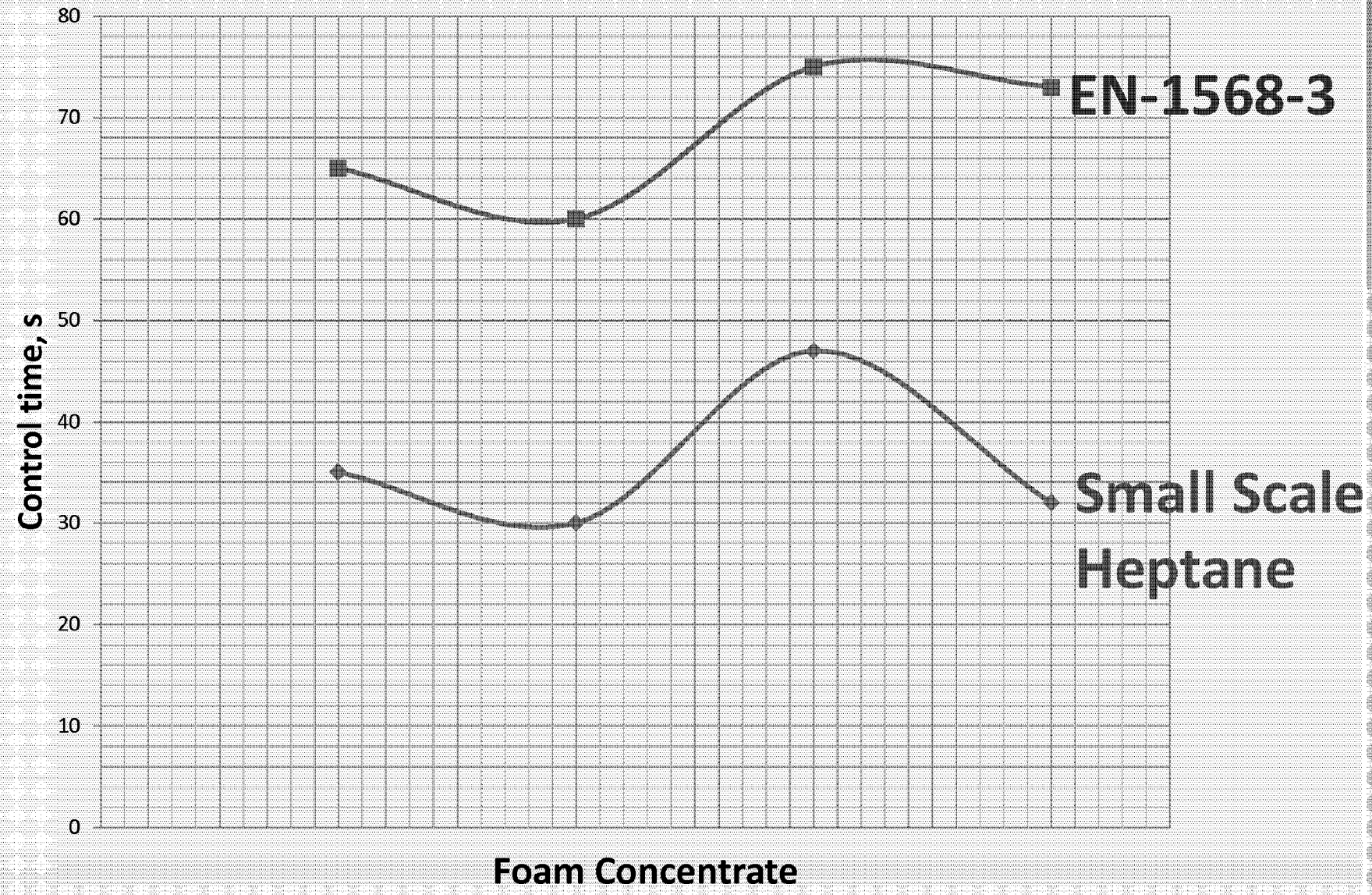




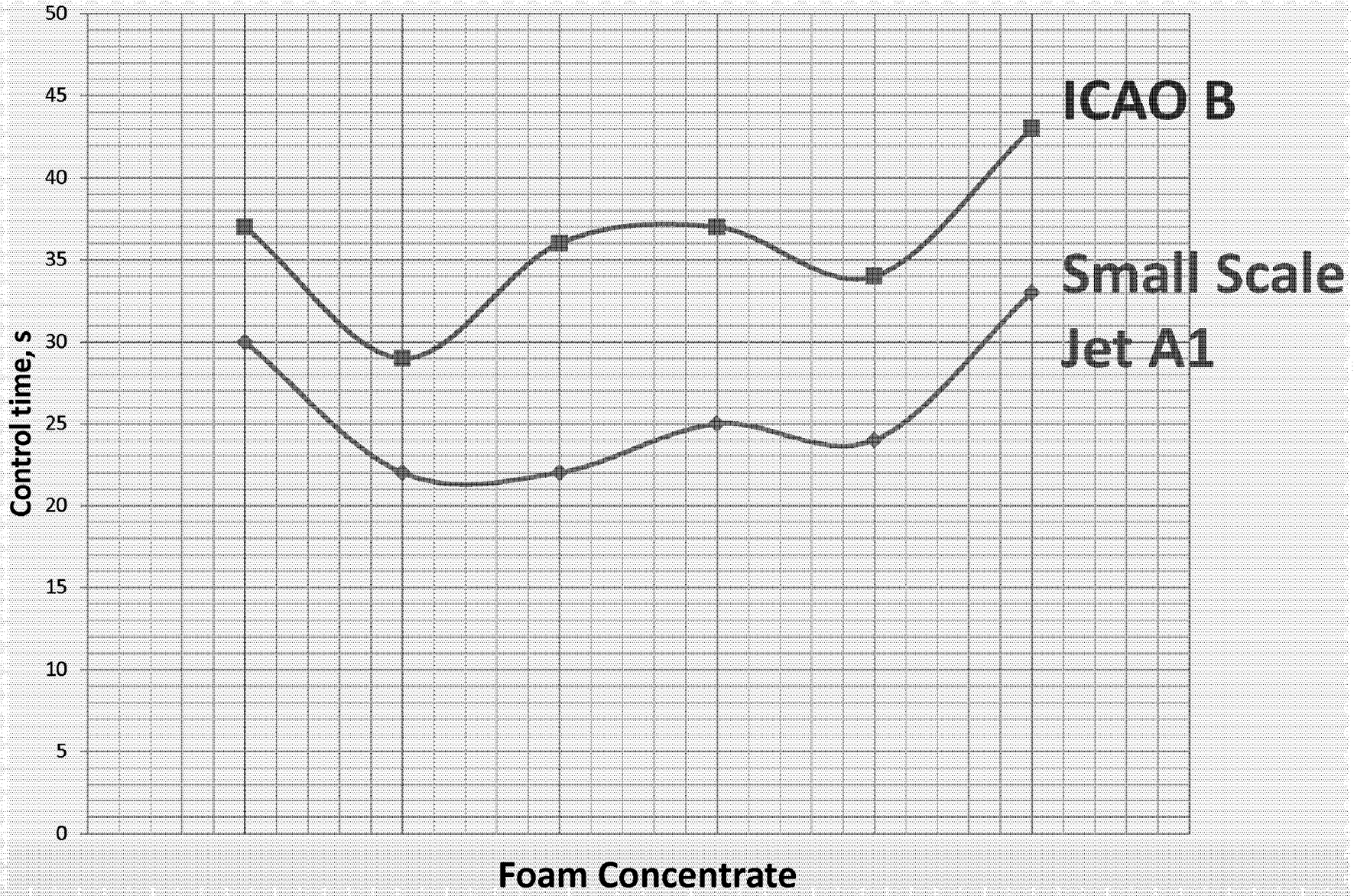
Foam Quality – Simulate "UNI 86"



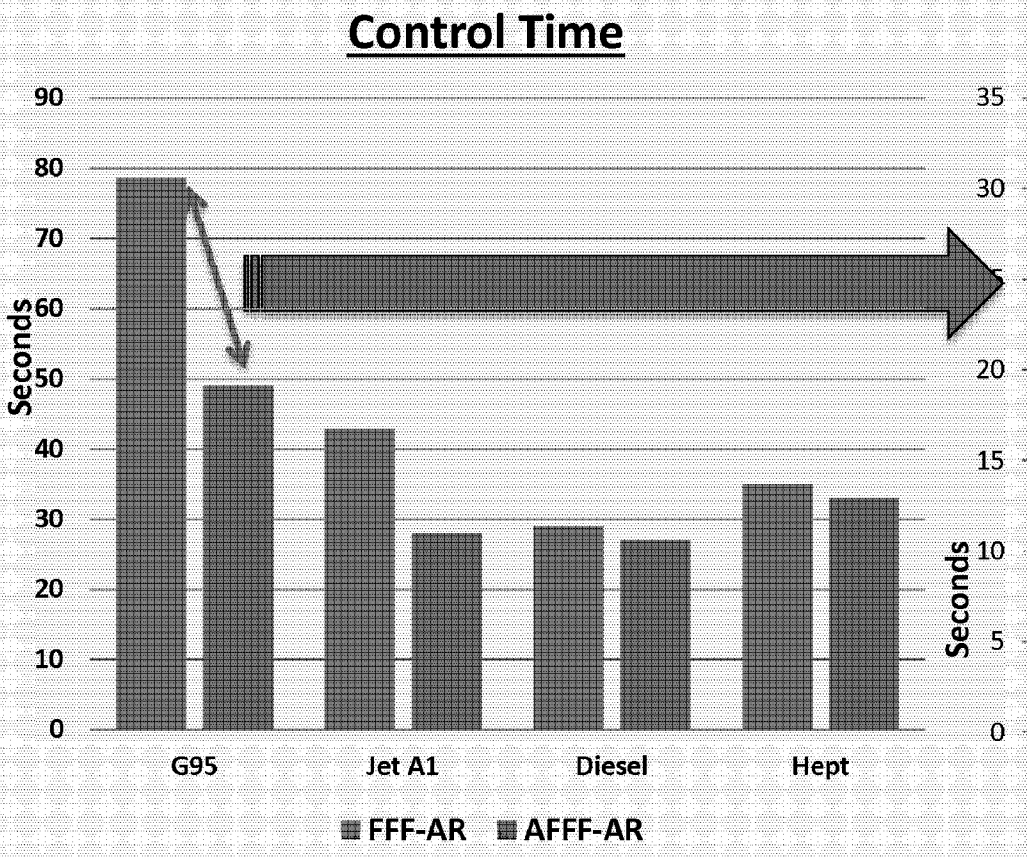
Method Validation - Heptane



Method Validation - Jet A-1

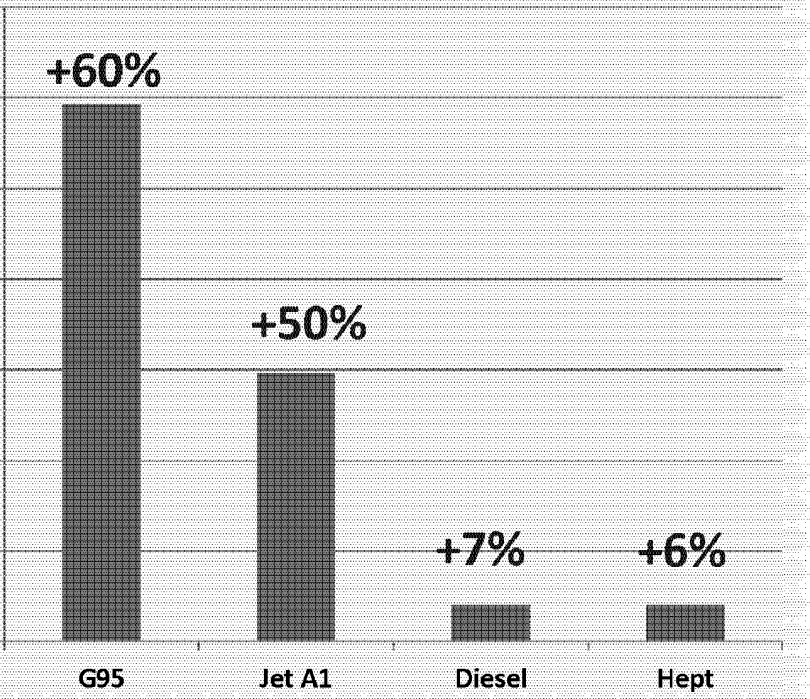


Control Time vs Fuel

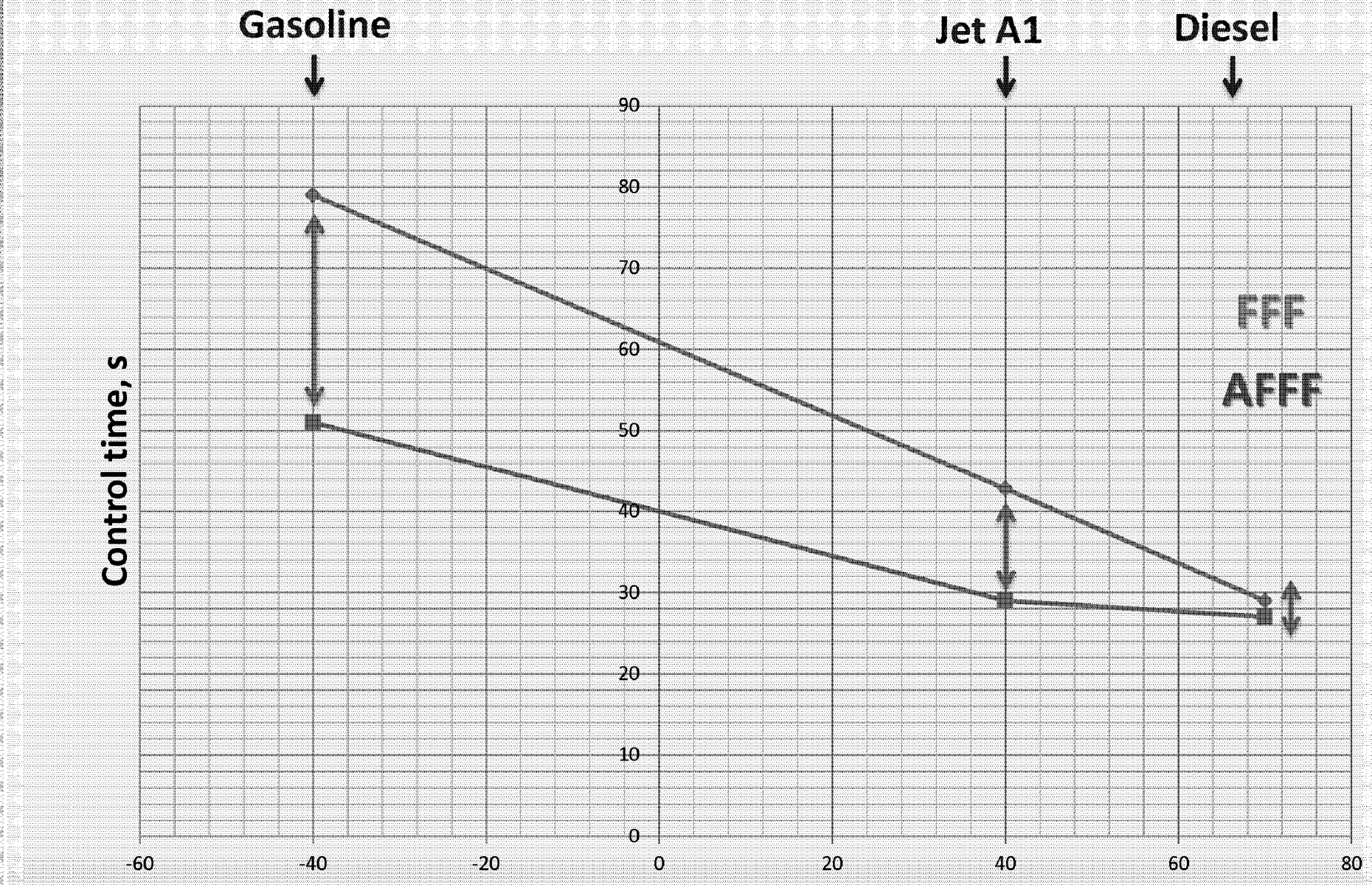


** Average data - 5 FFF-AR and 5 AFFF-AR*

Difference



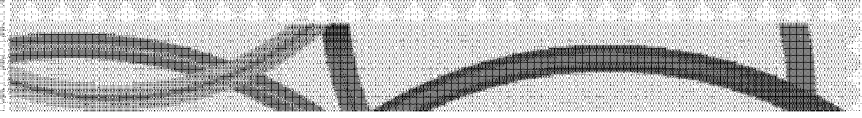
Control Time vs. Flash Point



Average data 5 FFF-AR and 5 AFFF-AR

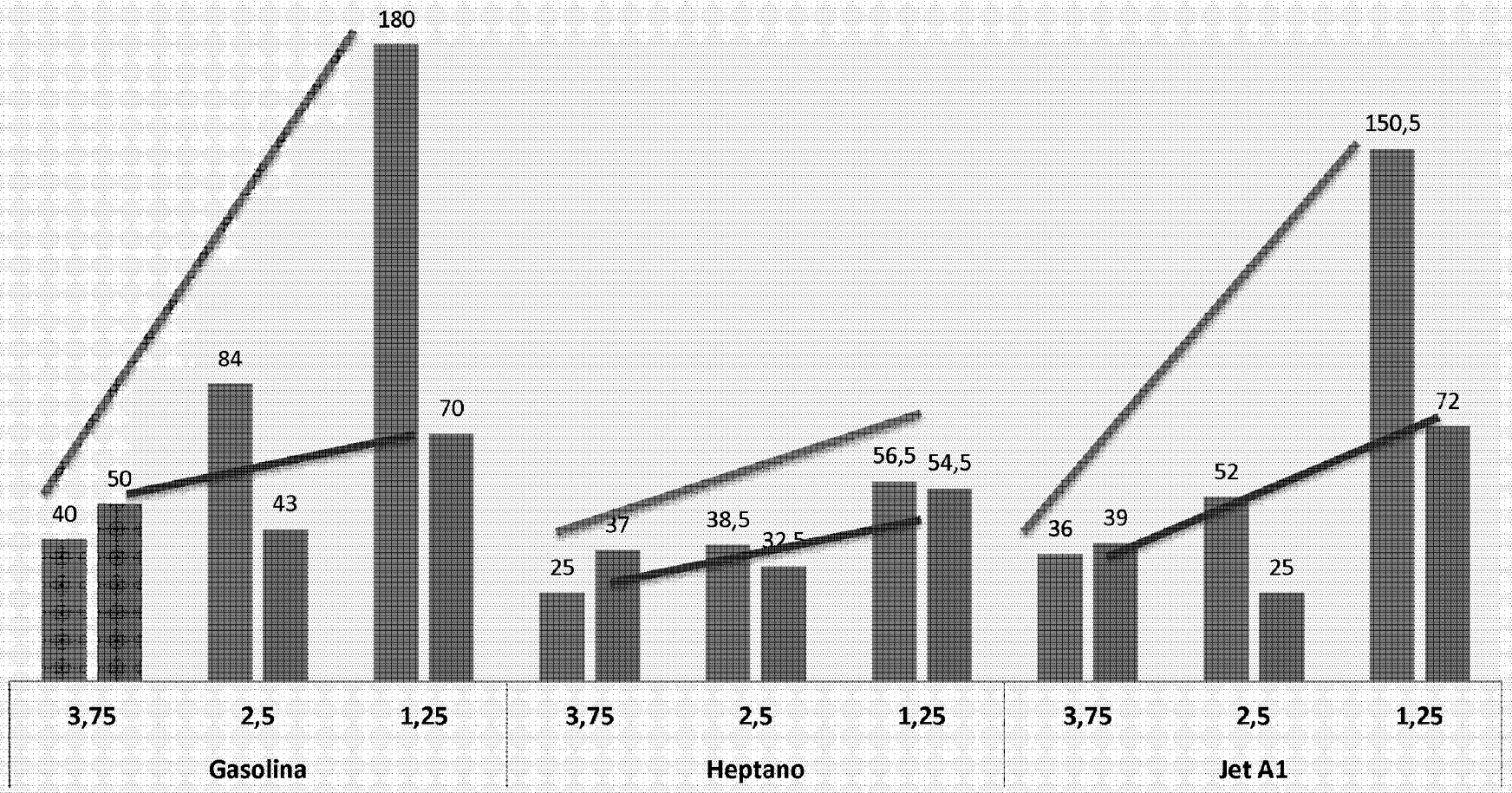
Extinguishment - Summary

Test	FFF 1	FFF 2	FFF 3	FFF 4	FFF 5	AFFF 1	AFFF 2	AFFF 3	AFFF 4	AFFF 5
Gas. 95O	YES	NO	NO	NO	Late	YES	YES	YES	YES	Late
Heptane	YES	NO	NO	YES	Late	YES	YES	YES	YES	YES
Jet A1	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
Diesel	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES



Can we improve performance increasing Application Rate?

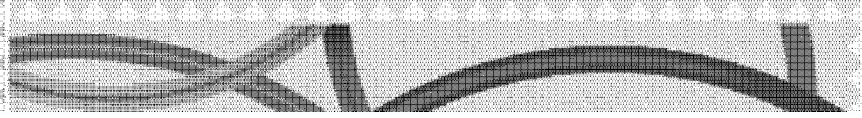
Control Time vs. Fuel – Application Rate



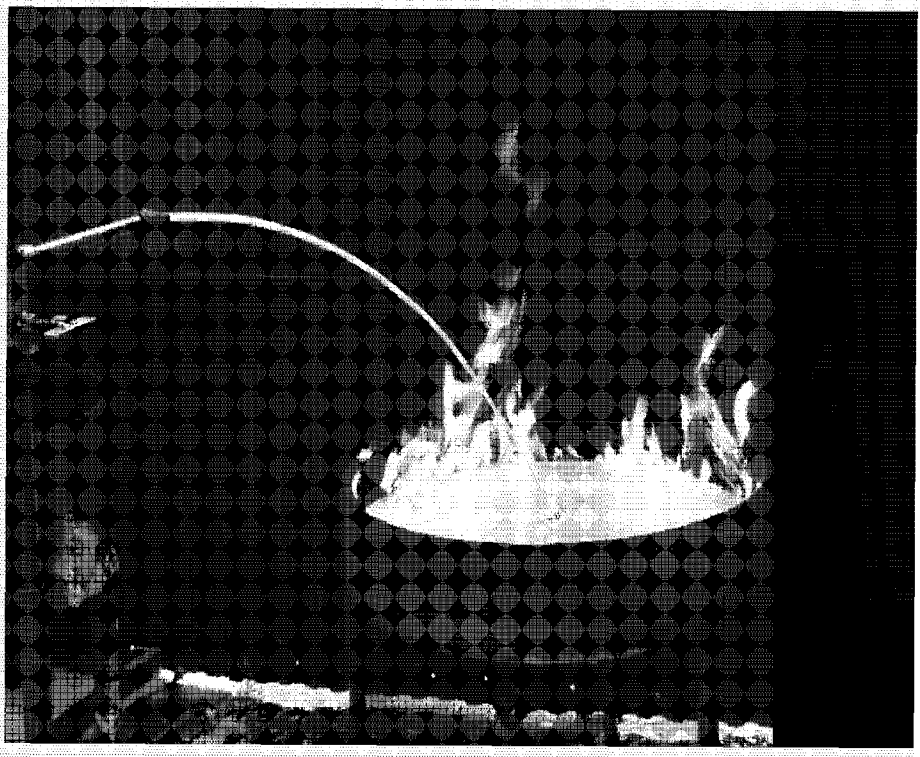
Average data 2 FFF-AR
2 AFFF-AR

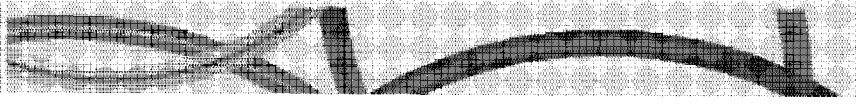
Extinguishment Time vs Application Rate

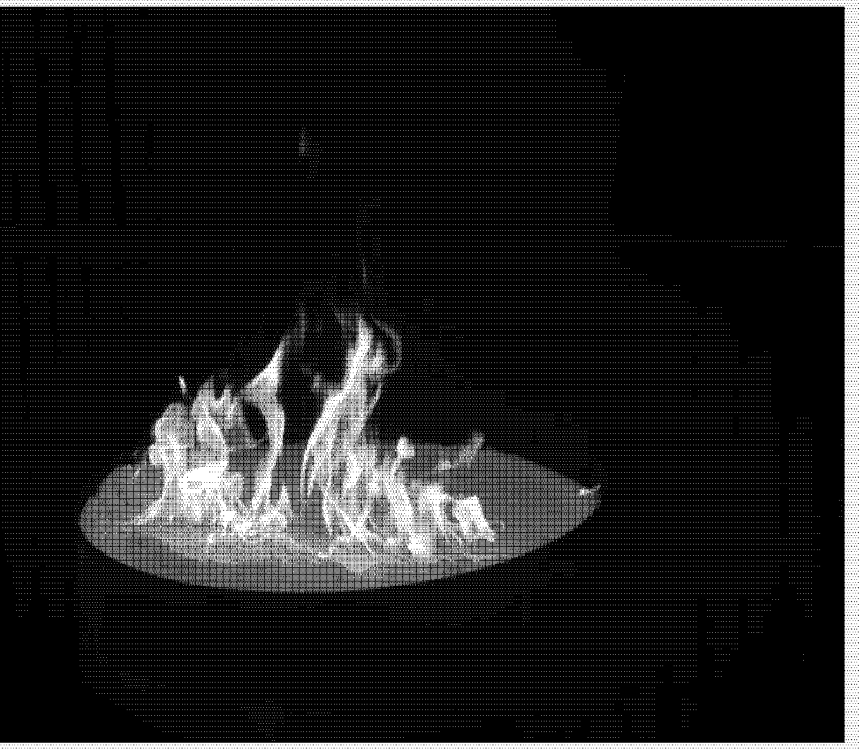
	l/min·m²	1,25	2,50	3,75
FFF	Gasoline	NO	YES/NO	YES/NO
	Heptane	YES	YES	YES
	Jet A-1	NO	NO	NO
AFFF	Gasoline	YES	YES	-
	Heptane	YES	YES	-
	Jet A-1	YES	YES	-



Foam Contamination

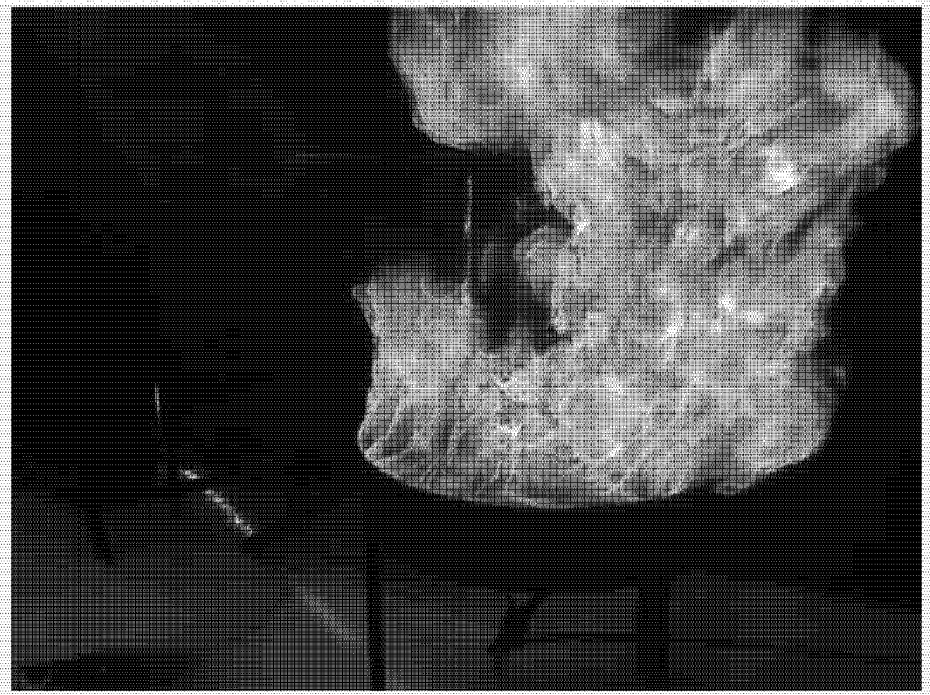






Fire Performance

AFFF



FFF

Jet A1 / 2,5 l/min·sq.m

From previous data……

- AFFFs control fire faster than FFFs
- AFFFs are "more versatile" (fuel range and conditions)
- AFFFs have better oil repellence

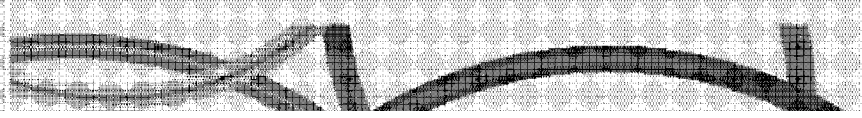
AUXQUIMIA
Fire fighting products
ICL

THE FOAM SOLUTION

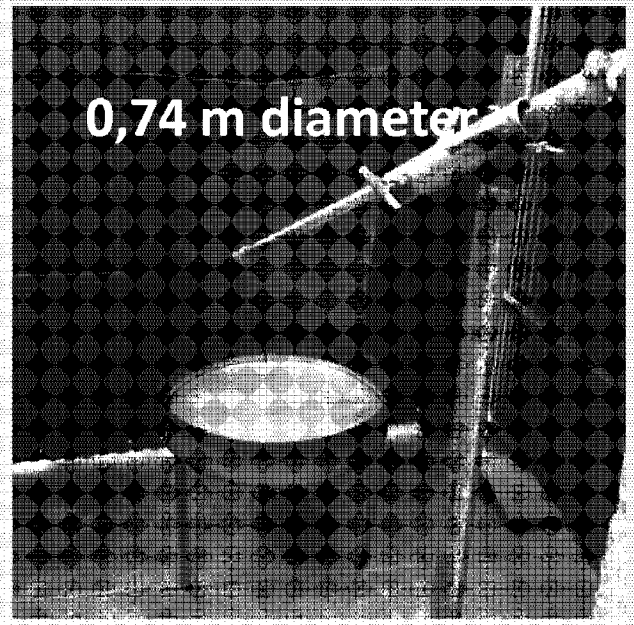
Fire Performance

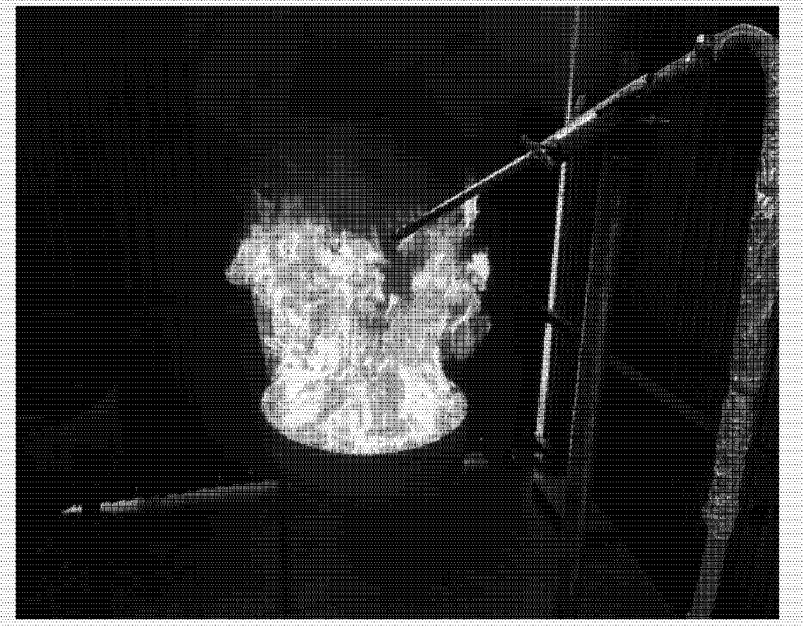
Spray Tests

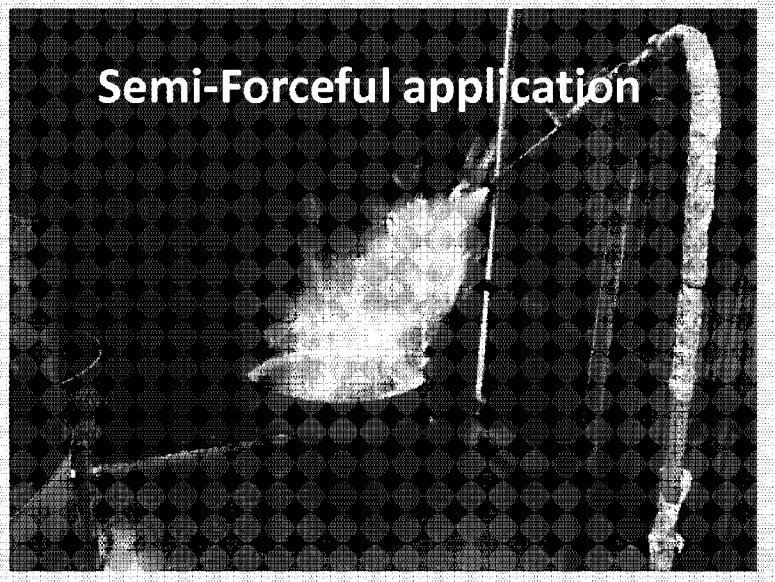
Non Aspirating

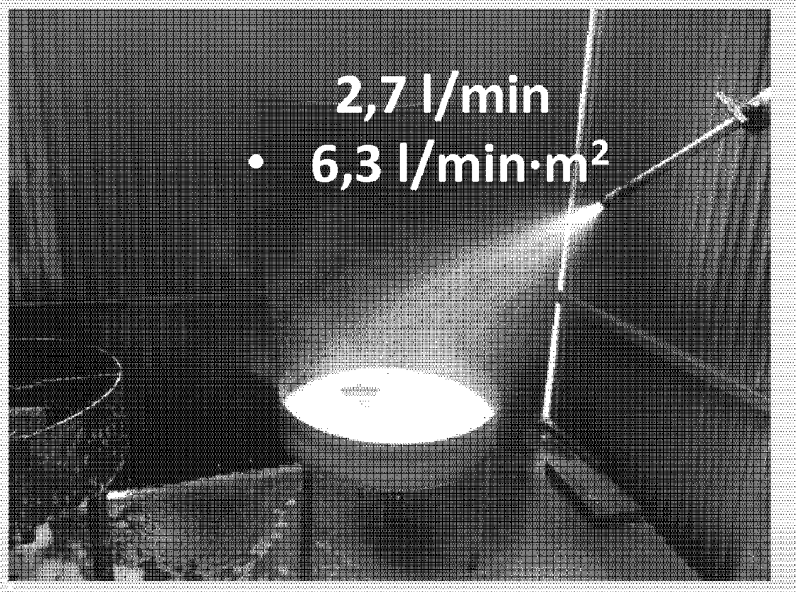


SprayTest Semi-Forceful (EN-1568-5 Project)







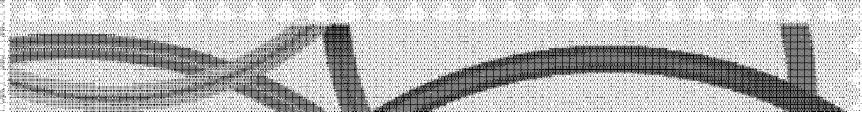


Data - Spray

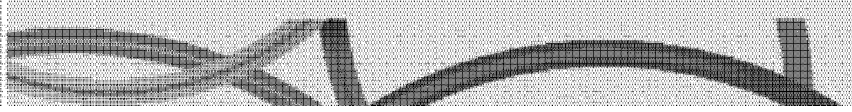
		Gasoline	Heptane	Jet A-1
FFF	Control 90%	NO	67	52
AFFF	Control 90%	16	46	19
Difference		-	+45%	+173%
Low Expansion C90% Difference		60%	+6%	+50%

Time in seconds

Average data 2 FFF-AR and 2 AFFF-AR



Using Non Aspirating systems
the difference in performance is higher
than using Low Expansion devices



In difficult scenarios:

- High flammable liquids
- Non Aspirating Devices
- Low application rates

The difference in performance between both technologies increase drastically.

??????

- Have FFF same performance than AFFF?
  - It's not … Could we accept this difference in performance?
- **Is "Film Forming" related to Fire Performance?**
- Is Heptane a good reference fuel for FFF as it is for AFFF?
- **Is the viscosity a problem?**

Is there a LIMIT for FFF use?

Each specific scenario has a limit……

Analyze your risk

Analyze your equipment

Analyze environmental impact

And only then….

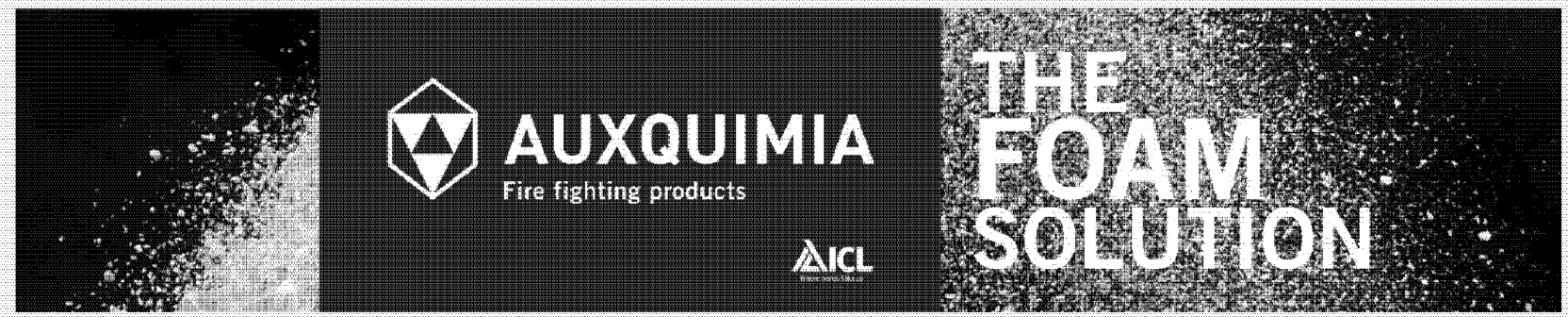
choose the best option <u>for you</u>

Where is the limit of FFF in July 2016?

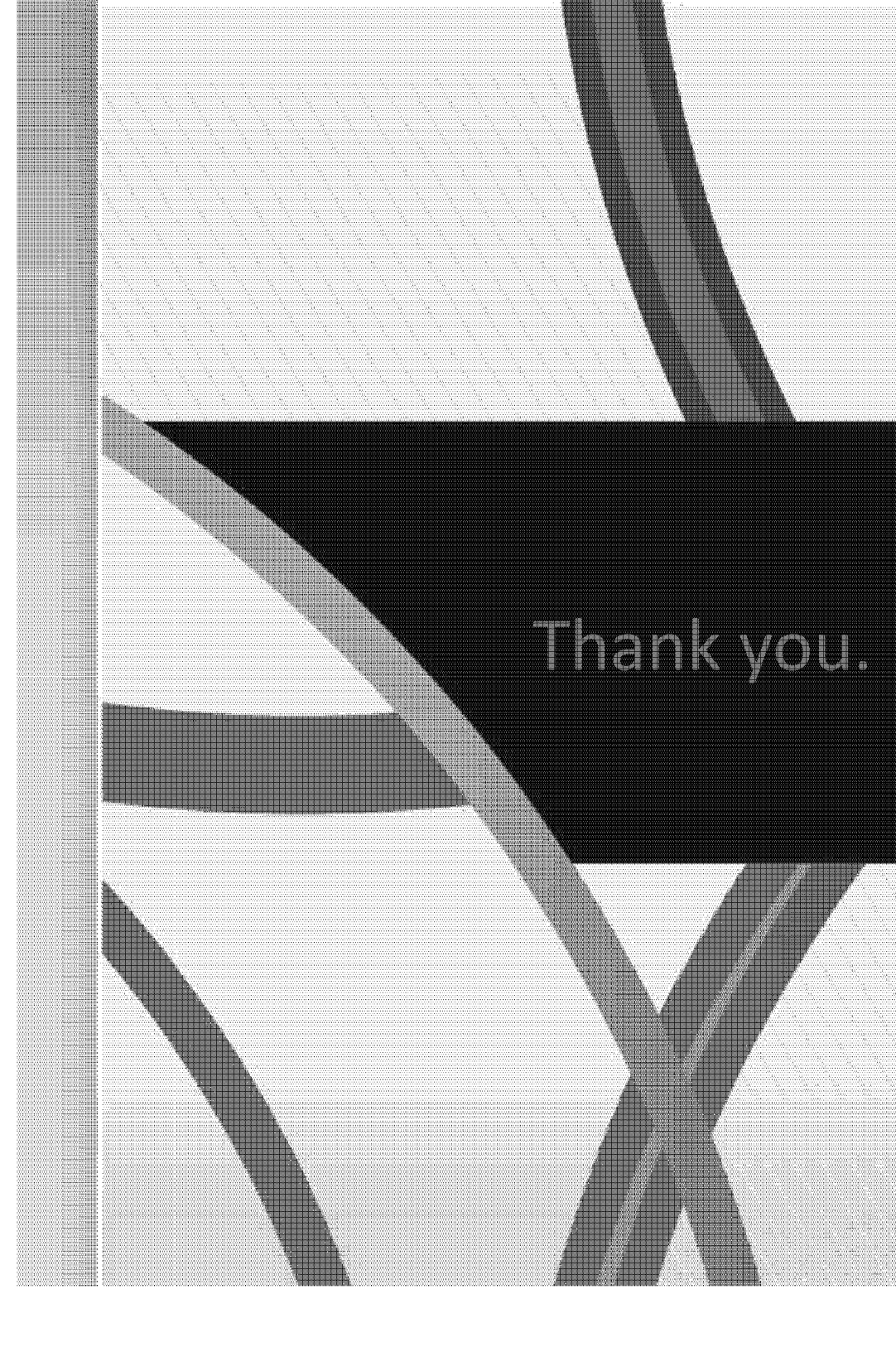
These **are** the **data**……..

…… and **the conclusions** are yours

You can decide your own limit!



Thanks to AUXQUIMIA Technical Team!!!


Thank you.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