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CONFERENCE & TRADESHOW 2019

Learning from Past Foam Incidents and Considerations Necessary when Changing Foams - *How Might We Fare Today?*

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Willson
Consulting

- Investigate past & recent major fire incidents - flammable liquids
- Usage of AFFF/FFFP, AR-AFFF/AR-FFFP and Fluorine Free Foams F3/AR-F3
- Assessment of outcomes
- What are our “Realistic Expectations”?
- What necessary considerations? ...suitability, compatibility, effectiveness
- What agent options? ...change implications, likely outcomes
- Complex inter-relationships examined & **best practice** conclusions drawn

*Dual Aims: reducing environmental impacts
+ providing reliable life safety protection*

12 Major Flammable Liquid Fire Incidents

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29 July 1967: USS Forrestal Aircraft carrier disaster

- Major fire involving munitions, aircraft and crews
- **Fluorine Free Foam (F3) used - Protein - like modern F3s without fuel shedding capabilities & poor vapour sealing**
- **Major disaster:** 134 died, 161 injured, 21 planes destroyed, 40 planes damaged
- Accelerated further research & development into AFFFs *...to ensure such a tragedy never happens again*
- Extensive large scale testing (3,000m²) to verify effective small scale AFFF performance under wide range of “incident” conditions (*not seen with Modern F3s*)
- Mil F 24385F Spec resulted - toughest fire test there is!

Started the need for AFFFs...



MilF Spec: 7 different fire tests, fresh & salt water, ½ strength, over-rich, low application rate, corrosion, environmental, high temp (65°C) use, plus concentrate compatibility & storage tests!

1978: Los Angeles Aircrash

DC-10 severe fire on take-off



- Left landing gear collapsed on take-off
- Full left wing fuel tank ruptured at 295kms/hr
- **Intense fire added to severity of incident**
- Left side of aircraft destroyed
- Mil F spec AFFF used, preventing spread
- **198 lives saved out of 200 onboard**
- 28 passengers & 3 crew seriously injured
- 156 passengers & 11 crew suffered minor injuries
- **Initial foam attack protected evacuating passengers escaping on right side**
- **Fire extinguished in 2 mins once fire crews arrived on left side aircraft**

May 2016: Tokyo Aircrash

B777 engine fire

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- Engine failure when accelerating for take-off
- Debris ruptured fuel line - caught fire
- Onboard engine fire suppression system activated - did not extinguish
- **Fire crews extinguished using AFFF in few minutes**
- All 319 passengers & crew evacuated safely
- 19 minor injuries sustained
- **Plane undamaged**



B777 engine fire Tokyo - 27May16

Maximised Life Safety

Minimised Infrastructure damage

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Seeing a mix:

- Most transitioning away from C8 AFFF/AR-AFFF/FPs
- F3s use: Training, Brigades, Civil airports
- Environmentally more benign \leq C6 agents: where fuel shedding, vapour sealing, heat resisting, fast capabilities needed for MHFs ...incl. airports, military, offshore

- Fluorinated Foams provide best fire protection for 50yrs+
- Legitimate public concerns & health fears on legacy issues
- PFOS-PFOA-PFHxS found in people, animals, food, water
- Historic heavy C8 legacy foam usage - poorly managed
- Considered harmless & safe ...by manufacturer - Led to extensive usage & problems ...**NOW regulated chemicals**

- Unintended & unacceptable legacy of community contamination
- A legacy we have to clean up and continue managing ...*BUT* management controls dramatically tightened since 2006 - C8s no longer sold
- Less training now, most done with Fluorine Free Foams (F3)
- Less C6 PFAS foam usage ...emergencies only, more care, better collection, better containment ...and effective **remediation/safe disposal**

= Preventing such legacy contamination perpetuating

What are our “Realistic Expectations”?

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- No loss of life & minimised injuries
- Fast, reliable fire control and extinction
- **Minimised:** *infrastructure loss*
smoke, run-off, resulting damage
risk of closure & job losses
community grief and disruption
foam usage
environmental harm
clean-up & repair costs

...Anything **critical** missing?



Which foam agents can effectively deliver these expectations ...across all fire emergencies?

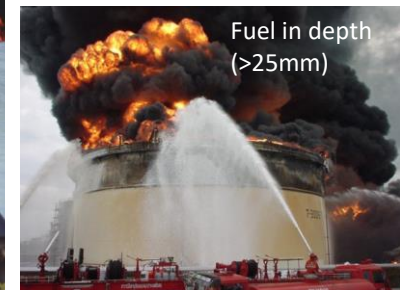
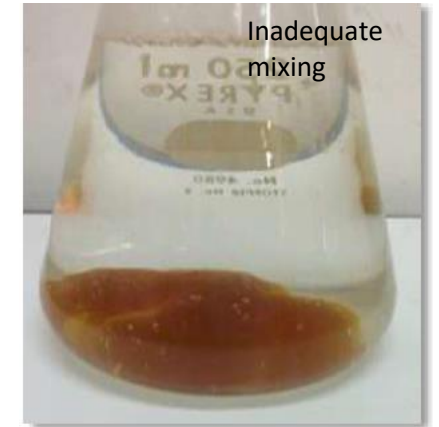
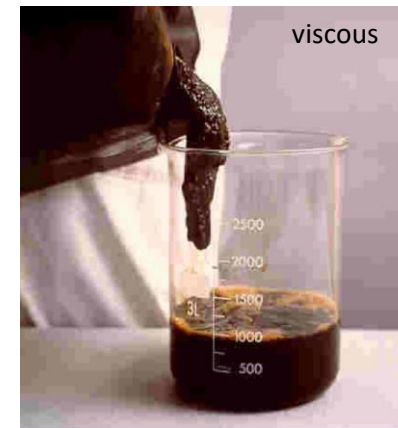
Change-out considerations

- from Legacy C8 foams

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- **Which alternative? - F3s or C6 agents?** (*water alone sinks through fuel spreading it rapidly into other areas*) ...depends on fuels, scale hazard, site conditions, existing systems, life safety, escalation potential etc. etc. - do fire tests with site fuels & equipment to verify...
- **Consider** corrosion/seals attack, storage stability, efficiency, compatibility - existing systems & fuels etc ...*Is duty of care fulfilled?*
- **Check** suitability/proportioning accuracy with viscosity of **new** foam
- **Either way** ... tanks, proportioners, pipework needs to be thoroughly cleaned (*or replaced*) to prevent **new** foam cross contamination risk -C8
- **Clean** proportioners/pumps/delivery devices/dead ends etc.
- **Record process & residual PFAS level** - use TOP assay lab sample results of final washwater to check - **before** filling with **new** foam
- **Verify** system design criteria is NOT compromised by changes
- **Ensure** new foam will act swiftly, effectively, reliably, not risk overflowing containment areas, nor place lives in unnecessary danger



Remember: all foams pollute & all firewater/runoff needs containing, collecting, testing for PFAS & potential treatment ...**before** release to WWTPs

May 2013: Heathrow, UK

A319 engine fire on landing

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A319 small engine fire, London Heathrow, 24th May 2013

- Both engine cowls detached (*left unlatched after maintenance*) damaging airframe on take off
- Fuel leak ignited right engine during landing approach
- Engine immediately shut-down, on-board extinguishing system activated, reduced fire intensity, landed safely
- **F3 used to rapidly extinguish fire**
- All 80 passengers and crew safely evacuated via left side
- No injuries reported

A further claimed “effective use” of F3 at Heathrow - 12 July 2013

- Ground fire in unpowered, unoccupied B787 aircraft
- Likely cause: crossed wires from lithium battery in rear fuselage created slow burning fire in internal composite materials above cabin
- **F3 used external to the aircraft, but fire extinguished internally with hose-reel water spray**

Not defined by ICAO Annex 13 as either Accident or Serious Incident



ELT Location
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Feb.2016: Danish Port Fire

Fertiliser & Palm Oil Tanks, Fredericia

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Fredericia port fire, Denmark Feb.2016



- Silo explosion caused major port fire
- 12,000 tonnes liquid fertiliser (*Ammonium Nitrate*) burst from overfull storage silo, mixed with 2,266 tonnes palm oil catching fire (stored at 70°C)
- **Firefighters worked all night and into next day to control fire - F3 used** (*palm oil not volatile - high <148°C flashpoint, cooling watersprays potentially effective to extinguish*)
- **Claimed as F3 “success”** by IPEN ...but F3 likely added to BOD problems in harbour
- **Caused an environmental disaster - one of worst in recent Danish history**
- >100 people deployed to “clean up thick layer of palm oil, water and foam”
- **Caused resignation of Danish Environment & Food Minister**

June 2016: Singapore Aircrash

B777 engine fire on landing

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- Cracked fuel pipe in engine heat exchanger leaked fuel into right engine
- Engine and wing caught fire on landing
- Thrust reverser spread fire through core of engine
- **Fire extinguished using AFFF/FFFP in 3 mins**
- Re-involvement in hot engine 3 mins later **extinguished immediately**
- All 241 passengers & crew disembarked via mobile stairs - 15mins *after* fire extinguished
- **No injuries were sustained**
- **Minimal disruption resulted**
- **Plane repaired and returned to service**

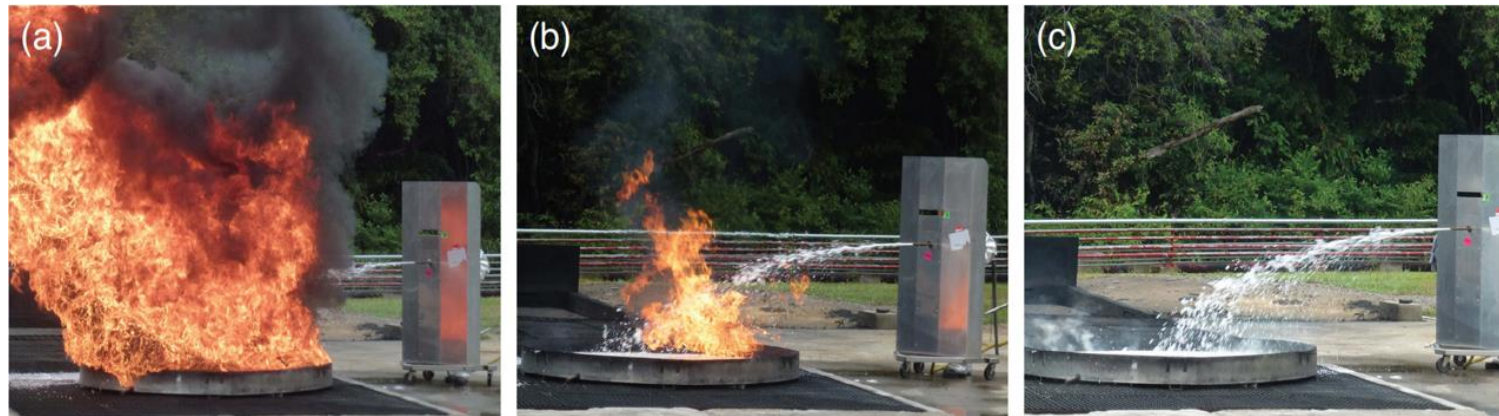


A safe and well executed “text-book” response

July 2016: Singapore demo

F3 replaced ...by more robust C6 AFFF

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Effective ICAO Level B Fire test demo using C6 AFFF at Singapore Fire Conference, July 2016.

An F3 agent intended as Conference highlight ...“showcasing its effectiveness”, had to be replaced by ≤C6 AFFF last minute - because ...“*too many environmental factors were not under our control to do F3*”! ie it was too hot at 32°C for F3 to be effective (Such ICAO Level B fire tests are usually conducted at around 15 °C).

Twice the day before at 32°C, the same fire demo was unable to be extinguished using F3 agents, ...and reportedly caught the training facility’s fuel separator alight.

A demo can be cancelled...REAL EMERGENCIES cannot!

Aug. 2016: Dubai Aircrash

B777 fire - plane burned out

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- Boeing 777 crashed during “attempted go-around” , 48 °C heat with wind-shear conditions
- Right engine detaching & structural damage on landing caused fuel fire
- All 282 passengers & crew safely evacuated as fuel fire developed
- 4 serious and 26 minor injuries

- **Foam - likely F3** (as Dubai major user) **applied to suppress the fire**
- **9 mins after crash a brave firefighter tragically lost his life when fuel tank exploded**
- Extensive foam application to fuselage continued...
- ***Full control not achieved until 16 hours after impact! ...Plane destroyed - apparently first ever in Emirates fleet.***
- Final investigation - still not yet concluded - *Why?*
- Cause of firefighting failure, ...whether foam or very high ambient temperatures contributed, not yet known - ***remains a possibility...***

Need to know - Why this fire attack failed?

Aug.2018: Footscray Chemical Factory Fire (Melbourne)

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- 1.4 ha, est. 100,000 chemical drums - 17 hours fire control & 5 days to extinguish all hot spots (*although some areas potentially shielded from foam attack*)
- **Only F3 used** by MFB during incident (*confirmed by EPA Vic*)
- PFAS chemicals detected at 16x recreational water quality criteria in runoff (*emanating from PFAS materials on site -not firefighting foam*)
- EPA Vic sampling **confirmed elevated PFAS levels remained for 2 weeks**
- 55million litres contaminated runoff pumped out of creek by 3rd day
- 170million m³ contaminated sediment removed from creek by 24th Sept.
- EPA Vic Chief Env. Scientist confirmed this incident was "**...probably as bad as it could be, ...the chemicals from the fire have had a 'massive impact' on the system - We've had more than 2,000 fish killed.**"
- Creek remediation is still on-going...



Footscray Chemical Factory Fire -Aug.2018

**Did slower control situation perhaps deliver worse outcomes?
...might faster attack have reduced runoff volumes?**

Oct.1996: Albright & Wilson Major Chemical Fire, Avonmouth UK

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- 6.8ha site - surrounded by another chemical complex, fuel storage depots, major port/docks, industrial units, 2 villages & congested residential area all within 2.5km radius
- Total inventory 220,000L volatile chemicals (incl. Propylene Oxide, phosphorous specialties, petroleum additives etc.)
- 20 tonne tanker delivering Epichlorhydrin at time - explosion caused major fire - explosion heard 8 miles away
- Est. fire area 2,400m², 100m high black smoke plume (incl. Hydrogen Chloride - acid rain!)
- **Major Fire extinguished after 4 hrs using est. 40,000L AR-FFFP foam concentrate**
- 6 firefighters, hospitalised for smoke inhalation - fully recovered
- 3 appliances monitored site for 10.5 hrs, before handover to UK Health & Safety Executive (HSE) ...*think Workplace Health & Safety in Australia*

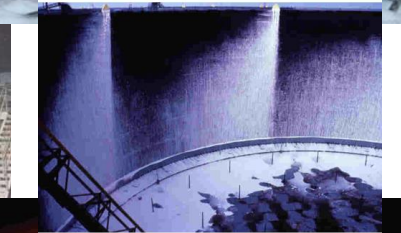
Fast reliable efficient control & extinction, protected critical infrastructure & prevented escalation

Foam Suitability Considerations

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- **Variety of fuels on site** - volatile hydrocarbons? Polar solvents?
- **Compatibility with existing foam systems equipment:**
 - proportioning* - accuracy? viscosity? flow? mixing?
 - delivery devices* - non-aspirated? aspirated? forceful? gentle? Pouring? monitors? sub-surface?
- **Suitability for spills *and* fuel in depth fires (>25mm):**
 - requires* - fuel shedding, vapour sealing, heat resisting
 - ie. no attack by fuel, no edge flickers, no burnback or re-ignition, no unpredictable flashbacks*
 - = infrequent top-ups, less foam use & reliable fire protection**
- **Minimised environmental harm** - less foam usage reduces aquatic toxicity & biological oxygen demands (reducing fish suffocation)



Reliable Remediation Options

Despite some misleading claims to the contrary...

Existing technologies **CAN** commercially concentrate and destroy $\geq C8$ long-chain & $\leq C6$ short-chain fluorochemicals ...including PFHxA, 6:2 FTS, PFBA, PFOS, PFOA, PFNA, PFHxS etc etc.



Fig 2. OCRA process with airport fire training area in background.

- **Modified clays and bioabsorbent granules** shown to adsorb and collect short-chain C4-C12 fluorochemicals effectively (*ground and firewater runoff*).
- **Some Ion Exchange Resins**
- **Reverse Osmosis/Nano-Filtration**
- **Heated Persulphate Oxidation**
- **Ozone Fractionation (OCRA)**
- **Electrical discharge plasma**
- **Sono-chemical breakdown**
- **Cement kiln or plasma Arc Incineration**

All can address a wide range of long & short-chain PFAS ...including PFOS, PFOA, PFHxS, PFBA, PFHxA, 6:2 FTS etc.

(Sources: Merino 2016, Bruton & Sedlak 2017, Hori 2008, Rodriguez-Friere 2016, Naidu 2015, Dickenson & Higgins 2016, etc.)

17-20Mar 2019 ITC Tank Fire, Deer Park Texas USA

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- Huge 107ha site, 242 storage tanks, **15 affected tanks in single bund!**
- Very challenging multi tank fire, congested bund area, strong winds
- Fire started am 17th in 1 tank, spread to 2nd tank (evening) increasing severity, then 5 more tanks alight by early 18th, and 8th tank by daybreak 18th, 2 more tanks alight 10 am 19th + 2 empty tanks collapsed
- Dwight Williams & new C6 1x3 AR-AFFF brought in 7am 19th, chopper tour site & over 4 hrs to set-up equipment - difficulty fighting fires from downwind and crosswind - (not usual upwind)!
- 12 tanks burned over 4 days
- All fires out by 3am 20th - 64 hours to extinguish
- Fuel in 3 tanks salvaged, adjacent tank spread prevented
- Rest 210 tanks on site incl. LPGs unaffected
- No reported injuries

How would F3 have fared?



5-9Apr.2019: Campbellfield Chemical Factory Fire (Melbourne)

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- Major Chemical Factory Fire (similar size to Footscray-Aug18) - also took 4 days to extinguish (5-9Apr19)
- MFB confirmed *“175 firefighters & 40 firetrucks battled blaze ...likely to burn for several days”*
- **MFB only uses F3**
- Est. 300,000L chemicals on site ...double EPA’s licence allowance
- EPA Victoria working to minimise waterway impacts
- EPA Vic reported *“very low dissolved oxygen levels on 6 Apr. ...low enough to cause fish deaths”*
- Scale of environmental impacts from chemicals and foam used not yet known ...*although Footscray fire was widely declared an environmental disaster.*

5 May 2019: Moscow Aircrash

Sukhoi Engine Fire on Landing

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- Russian made Sukhoi Superjet 100 -1st flight 2011
- Technical problems after take-off (possible lightning strike) - returned as emergency
- **Engine ignited during hard emergency landing**
- Trail of burning fuel on runway
- Rear of plane caught & quickly sustained fire
- **Crew evacuated 37 passengers safely in 55secs**
- Firefighters battling blaze took over 1hr to reach tail section passengers - **Foam type unknown**
- **40 passengers & 1 cabin crew tragically died**
- 11 people injured, 6 hospitalised with burns
- Eyewitness said *“It’s a miracle anyone escaped”*
- Aeroflot have 50 such aircraft in current fleet



Sukhoi crash, Moscow May 2019



Pools fuel alight on runway behind aircraft

How would you respond to a major fire tomorrow?

Foam Comparisons: Fire & Environmental Performances

Characteristics	C8 legacy foam	Fluorine Free Foam (F3)	High purity ≤C6 foam
Speed control/extinguishment	faster	slower	faster
Fuel shedding ability	high	none	high
Re-ignition risk (<i>volatile fuels</i>)	lower	higher	lower
Application flexibility	forceful, gentle, non-asp, asp, in-depth, sub-surface	semi-forceful, gentle, aspirated, shallow (limited applications)	forceful, gentle, non-asp, asp, in-depth, sub-surface
Volume foam required (<i>for given size volatile fuel incident</i>)	smaller	larger	smaller
Fire Performance ability	reliable & robust	limited (ability & apps)	reliable & robust
Persistence	concerns	no known concerns	concerns
Bioaccumulation	major concerns	no known concerns	low concerns
Aquatic toxicity	concerns	10x higher than C8/C6	low concerns
Human health	major concerns	no known concerns	low concerns

Key:

		Good
		Acceptable
		Bad

How Do We Fare Today?



IF a major fire started in *your* facility today...

- **How would *you* Fare? ...How would *you* respond?**
- **What is critical to *you*?**
 - *Saving lives, reducing infrastructure damage, responding effectively?*
 - *Meeting your Duty of Care?*

Recent fires discussed, seem to show...

Fast, reliable, effective, efficient fire control and extinction are critical in:

- saving lives,
- reducing injuries,
- minimising escalation,
- reducing infrastructure damage,
- reducing smoke & toxins
- reducing runoff
- preventing escalation/moving off-site
- protecting nearby communities
- collecting & containing ALL runoff
- less contamination problem to deal with
- testing & treatment

= *avoiding environmental disaster*

What Is “Best Practice” Today?

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Using best available techniques for fast incident control.

This requires: effective well trained teams

- best suited equipment/systems for site hazards/conditions
- well maintained & appropriate systems/equipment/foams
- reliable catchment & bunding of ALL runoff
- reliable, proven, effective procedures - acting fast
- protecting lives, infrastructure, communities
- minimising aftermath ...“problems to deal with”
- collect & contain ALL runoff - including firewater runoff
- test and treat ALL runoff ...**before** entering WWTPs & environment
- remove & remediate potentially harmful fuel/chemicals

Any Q's or concerns... contact: willsonconsulting26@yahoo.com.au



Fast, effective control minimises escalation

“The key to preventing worst pollution is have a response plan to clear potential fire hazards ...All fire water runoff will be detrimental to the environment if allowed to enter water courses. ... best technique is to prevent pollution from entering in the first place.”

Source: UK Environment Agency, 2017