Willson Consulting

Submission to Rural and Regional Affairs and Transport References Committee Senate Inquiry:

The Provision of Rescue, Firefighting and Emergency Response at Australian Airports

Terms of Reference covered includes:

(a) the current standards applicable to the provision of aerodrome rescue and firefighting services relating to community safety and the emergency personnel safety;

(c) the comparison of safe systems of emergency response standards and systems of work for firefighting and rescue operations for structure fires, aircraft rescue, emergency medical response and other emergency incidents;

(d) the consideration of best practice, including relevant international standards;

(e) the mechanisms and criteria for the review of the provisions of safety standards for the provision of rescue and firefighting services, if any;

(f): a review of Airservices Australia policy and administration of aviation rescue and firefighting services;

(g) the effectiveness and independence of the regulator CASA to uphold Aircraft Rescue and FireFighting (ARFF) safety standards;

h) the impact on Australia's national and international reputation and aviation safety record as a result of any lowering of aviation rescue and firefighting services;

21st February 2019.

Contents: Page

1. Main Focus

Thank you for the opportunity to make this submission to the Senate Inquiry. I hope it will inform the Committees with beneficial information to improve their understanding of the complexity of firefighting foams and their impact on Aviation Rescue and Fire Fighting (ARFF) issues.

This submission contributes to the Terms of Reference sections a; c; d; e; f; g; and h, by bringing specific firefighting foam expertise from over 30 years involvement in firefighting foams and foam systems, to contribute valuable information to your Inquiry in the broader perspective of the adequate (or inadequate) provision of ARFF Services at Australian Airports where Fluorine Free Foam (F3) has been chosen, yet may not have been adequately tested at larger scale to address the major hazards of large Airbus A380 aircraft, increased passenger numbers and flight frequencies, larger fuel loads, and increasingly volatile climatic conditions being experienced at airports around Australia. I also draw your attention to relevant international legislation and research findings relating to PFAS firefighting foam agents, which are also important for the Committee to consider.

My focus is therefore on firefighting foam suitability, and research which may show that F3 is not the foam type best suited to providing adequate life safety protection of firefighters, aircrew and the travelling public around Australia.

This submission will address each of the nominated terms of reference separately in Section 3 below. Please not reference numbers are highlighted in red for clarity.

2. Background

Australia as a 3M™ firefighting foam manufacturing location prior to 2003[1], not surprisingly had many foam users standardized on 3M Lightwater™ AFFFs and AR-AFFFs which were based on the ElectroChemical Fluorination (ECF) Process which produced fluorinated chemicals with breakdown products which included PFOS, PFHxS and PFOA[2].

Airservices Australia were one of those major users who standardized on 3M Lightwater™ AFFF across all its Australian airports, used it extensively for intensive training over many years[3].
All other major firefighting foam manufacturers (eg. Angus Fire, Ansul, National Foam, Dr. Sthamer, Orion, Fomtec etc) used fluortelomer surfactants which did not contain or breakdown to PFOS or PFHxS, contained typically 50% less fluorochemical surfactants than 3M™ brands, which would also have had small amounts of PFOA as a breakdown product, prior to 2016, but no PFOS or PFHxS emissions at all[4.5].

2.1 Why are we using PFAS in firefighting foams anyway?

The main reason so many sites have been using PFAS based foams for over 50 years, goes back to 1967, and the USS Forrestal disaster[6-9]. This resulted in 134 lives lost, 161 injured, 21 aircraft destroyed and 40 damaged.

This disaster employed the use of earlier Fluorine Free Foams (F3), a protein based agent, which like modern synthetic F3 agents have no fuel shedding capability and poor vapour sealing, particularly on volatile fuels like Jet A1 and gasoline. As a result of this failure to adequately control the USS Forrestal fire, research was focused on the development of Aqueous Film Forming Foams (AFFF) using fuel shedding and film forming PFAS ingredients to quickly and effectively control and extinguish such fires in future. This was intended to prevent any similar such tragedy ever occurring. This subsequently led to the development of AFFFs with extensive small and large scale testing (3,000m^2), which verified effective AFFF performance under a wide range of fire incident conditions[10-14]. To my knowledge no similarly large scale fire tests have ever been conducted on F3s. One has to wonder why not? …Is it just cost?

The latest US Mil-PRF 24385F (SH)Amendment 2:2017 Specification[15] fire test was originally developed in late 1960's by the US Military as a rigorous acceptance test for these AFFF foams. It is widely regarded as the world's toughest foam specification. It requires 7 separate fire tests in fresh and seawater, half strength and multiple strength to be passed, before any foam agent can be accepted as a US Mil Spec qualified product. Modern US Mil Spec AFFFs are extensively used by civil aviation and all military sites throughout the USA. In contrast ICAO (International Civil Aviation Organisation)[16] requires only a single freshwater fire test to pass its Level B and Level C fire tests, without any of the strict environmental criteria or supplementary acceptance conditions which are essentially required by the US Mil Spec.

Recently the US Airforce has spent over US$6m transitioning to the more environmentally benign short-chain C6 AFFF agents[17] rather than F3 agents which are incapable of passing either the fire tests, environmental tests or supplementary acceptance conditions required by Mil Spec. This Mil Spec fire test standard and agents meeting its tough requirements, have also been adopted by several other Military organisations around the world. Similarly tough Military fire protection standards are used in Australia, with Def [Aust] 5706:2009 [18] to which C6 AFFF Mil Spec agents would undoubtedly comply. Misleading suggestions by some in IPEN and NFPA 403:2018 that ICAO Level C somehow has "equivalency" to US Mil Spec, is completely unfounded and comprehensively disproved in a recent comparative aviation article[19].

2.2 3M Lightwater™ manufactured by Solberg in NSW

The first AFFF agents meeting this tough MilF Spec standard were produced by 3M in USA[20]. Subsequently widely exported overseas, including Australia, where a manufacturing plant was set up in NSW. 3M Lightwater™ brands were manufactured there by Solberg, until 3M™ ceased manufacture of fluorochemicals and firefighting foams in late 2003, when it is understood ownership of production facilities and F3 intellectual property rights were transferred to Solberg[21].

These 3M™ agents were produced using the ElectroChemical Fluorination (ECF) process which led to Persistent, Bioaccumulative and Toxic (PBT) breakdown products including PFOS, PFOA and PFHxS[3]. Defence facilities were seemingly being widely told by 3M™ that they were quite safe to use and had no environmental hazards. Consequently, they were used widely and liberally, particularly for training over many years, usually intensively at specific training facilities, without being treated as industrial chemicals of potential harm. This has left a legacy of quite severe contamination at major usage sites like airports, Defence sites and Fire Brigade training grounds, where they were extensively used over decades[22-25]. 3M™ announced in May 2000[1] it was ceasing manufacture of these ECF chemicals in 2000, following US EPA pressure due to research anticipating adverse environmental and human health impacts from their continued use. Manufacturing ceased in USA and most other places by late 2002[2], but it was delayed in Australia until late 2003[26].

3M™ had been developing Fluorine Free Foams (F3) for both Class A (bushfire) and Class B (flammable liquids) applications, before they ceased production. The intellectual property rights and formulations to these fluorine free foams were acquired by Solberg in 2007, along with hiring 3M's former chief chemist in Australia Ted Schaefer, who subsequently developed the Re-healing foam (RF) brands™ as leading F3 alternatives to fluorinated foams[27].

It is understood from Airservices Australia's submission to the WIlliamtown Senate inquiry (Part B – Other sites)[154]. It states that "***from the early 1980s until the early 2000s, Airservices Australia was using a fire fighting foam called 3M Lightwater. This product contained perfluorooctane sulfonate (PFOS) as an active ingredient and other PFCs such as perfluorooctanoic acid (PFOA). Following increasing concerns about the possible environmental and health impacts of PFOS, in 2003 Airservices changed to another approved fire fighting foam called Ansulite a fluorotelomer foam that was understood to not contain PFOS or PFOA. It was later found to contain trace amounts of both of these chemicals."*** It is unclear why this was the case as Fluorotelomers cannot contain PFOS[2,4,5,105]. Perhaps some contamination occurred when foam tanks previously holding 3M Lightwater™ had not been adequately flushed, so residues of PFOS remained and became mixed into the new Ansulite™ foam at very low levels of contamination? Could this have been used perhaps as a reason to justify a major change out to F3? It seems detection of PFOS (and possibly PFOA) in Ansulite™ AFFFs was basically the trigger for their switch, with incumbent substantial change out costs (to remove all traces of PFOS/PFAS from all vehicles, equipment, fire stations etc prior to F3 replacement) to be incurred. This submission confirms "***In 2010, Airservices transitioned to a PFC free foam, Solberg RF6, at all airports where Airservices provides ARFF services with the exception of the joint civil military airports of Darwin and Townsville***"[154].

I wonder if they would have switched to F3 so quickly, if they did not find the levels of PFOS/PFOA their testing found, especially PFOS - the presence of which it is understood Ansul could not explain.

Presumably Airservices Australia investigated alternative AFFFs and F3 agents that could potentially meet ICAO Level B without PFOS or PFOA, but they seem not to have gone out to tender to foam manufacturers openly investigating the most suitable alternative (either AFFF or F3) replacement for their existing - now contaminated - AFFF? Seemingly it was preferable to place contracts with Solberg and begin using a relatively un-tried and un-tested RF6 F3 alternative, which already had known fire performance weaknesses and viscosity/proportioning issues? Why was that?

3. My responses to the Terms of Reference for consideration by the Committee, are as follows:

<u>Term of Reference (TOR) (a):</u> the current standards applicable to the provision of aerodrome rescue and firefighting (ARFF) services relating to community safety and the emergency personnel safety;

Ensuring effective and reliable outcomes from ARFF services is critical to providing passenger, crew and emergency responder safety, which is frequently determined or influenced by the speed and effectiveness of the firefighting foam performance. Current Standards rely on foam agents being witnessed to pass International Civil Aviation Organisation (ICAO) fire test Level B at most airports outside USA, China and Russia. This fire test standard has been diluted with significant changes in 2014.

Is fast, effective, reliable firefighting still available with current F3 agents under ICAO Level B - across Australia?

The importance of being able to reliably and quickly extinguish a fire during any emergency aircraft incident, especially when innocent aircraft passengers of indeterminate age and fragility need to be evacuated in the vicinity of a fire, should not be under-estimated – particularly when we are facing more extreme and severe ambient temperature variations across Australia. Australia's long-term reputation could be severely damaged by a major air accident where current foam usage may be inadequate to control and extinguish any resulting fire.

It is believed the choice of Fluorine Free Foam (F3) has largely been driven by environmental considerations as a result of significant legacy long-chain C8 PFAS contamination issues at many high profile Airport and Defence site around Australia[1-4]. Consequently, fire performance aspects may have been a secondary consideration, when incidents thankfully are rare, and leading F3s are certificated to the ICAO Level B Fire test Standard[16] as required by Australia's Civil Aviation Safety Authority (CASA) Manual of Standards (MOS) Part 139H[28] and CASA's ARFF Services Procedures Manual 2016[29] to which all Australian ARFF Services are required to comply.

The use of firefighting foams that contain Per- and polyfluoroalkyl substances (PFAS) like AFFF (Aqueous Film Forming Foam) and FFFP (Film Forming Fluoroprotein) remain unrivalled in their speed and effectiveness when forcefully applied onto volatile fuel fire incidents, including Jet A1 and gasoline[30-33]. In his recent article "What is the price of fire safety?"[30] Reisch confirmed
…Researchers at the US Naval Research Laboratory (NRL) who write the specifications for firefighting foams are actively looking at fluorine-free alternatives, but they say they haven't found any that meet performance standards that include extinguishing a 2.6 m2 test fire in as little as 30 secs.
John Farley, director of fire test operations at NRL, says ***"the lab has qualified 16 firefighting foams containing C6 chemistry. They are mostly updated recipes for PFOA-based materials. "We need to come up with fluorine-free foam. But what's available now can't meet specification,"*** he says.
Katherine M. Hinnant, a chemical engineer who leads NRL research on firefighting foams, says fluorinated foams ***"outperform fluorine-free foams by a factor of four to five," by containing a fire and suppressing vapors that can reignite. Fluorine-free foams are stable for 3 min, while the fluorosurfactant kind can last 30 min."*** she says,
In the search for more effective fluorine-free foams, Hinnant says she ***"is evaluating***

hydrocarbon surfactants, silicones, and sulfonated surfactants. "Fluorine is really amazing," she says, but ***"we are focusing on eliminating fluorine."***"[30]
Reisch quotes Perimeter Solutions CEO Edward Goldberg as saying" ***The move from C6 fluorochemical foams to fluorine-free versions 'is a natural evolution of the market', however the shift will involve a trade-off"***, he says. "***Fluorine-free foam can't match the performance of C6 foams. When life and property are at risk, you want to put the fire out as quickly as possible, and that currently requires fluorosurfactant chemistry in many cases***", he says[30].

Some, like IPEN, contend that Fluorine Free Foams (F3) can provide adequate levels of firefighting performance to AFFFs[34,122-125] which may be so on smaller less volatile fires, but even small scale comparative testing shows substantial differences between F3 fire performance and AFFF[31-33,35-42]. There also seems to be no evidence of any large scale F3 fire performance on Jet A1 or other volatile fuels. Why not?

Why have AFFFs been successfully used over the last 50+ years?

Hydrocarbon surfactant based foams containing fluorosurfactant additives do not suffer from fuel pick up and reduced burnback like F3s, because the fluorotelomer surfactants enable them to shed fuel and seal vapours[31-33,35,36]. In large volatile fuel fires, it is normal to help protect firefighter lives by discharging foam as an aspirated rope from as far away as possible, while applying the foam as gently as possible by bouncing off obstructions. Inevitably where fuel pools >25mm, there will be some mixing with the foam, it cannot be avoided. These volatile hydrocarbon fuels are attracted to the bubble structures of hydrocarbon surfactant foams[43], become entrained in the bubbles which can cause the F3 foam blanket to burn[31-33, 35-43,44].

The USS Forrestal disaster in 1967[6-9], resulted from fluorine free foam without fuel shedding capabilities (like modern F3s) being unable to control a major fire on this aircraft carrier. 134 people tragically died, 161 were seriously injured, 21 aircraft were destroyed and 40 damaged.

AFFFs were fast-tracked for development following this disaster, to try and avoid such carnage happening in future – and it hasn't since by using high performance fluorinated foams.

Following this disaster, major fire tests were conducted using AFFFs up to 3,000m² area[10-14] to verify their suitability on large and difficult to control fires, before they were widely accepted by Military and Civil airports in USA, as well as other military organisations around the world.

This does not seem to be the case with F3s on major hazard facility fires including Aircraft fires and those involving airport fuel terminals and potentially aircraft hangars (except non-fluorinated high expansion systems).

Foam users should therefore not be forced or encouraged to use F3s in high risk applications, such as aerodrome rescue, or where the foam used must be able to provide the highest levels of firefighting performance available. Such high risk applications should require the continued use of high purity short-chain C6 fluorotelomer foam agents, manufactured in compliance with the US EPA PFOA stewardship program[45-47] and meeting European REACH regulatory requirements from 2020 onwards[48] (***see comments in TOR e***). Why should we risk putting the clock back and unnecessarily jeopardise the safety of passengers, crew, firefighters, other responders and surrounding communities?

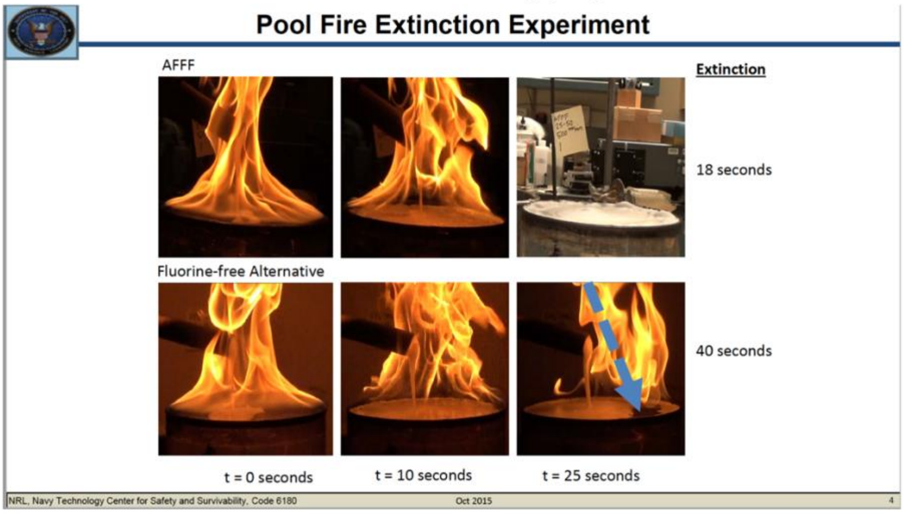
These environmentally more benign C6 foams provide the fastest, effective and reliable fire protection to control and extinguish the fire quickly, minimising damage, reducing volumes of foam and water resources used[31-33, 35-37, 41,42] reducing the risk of escalation and/or flashbacks, reducing the amount of firewater runoff and breakdown products of the fire (including smoke) generated, which minimises adverse environmental impacts from the whole incident. This was recognised by the UK Environment Agency in 2014, recommending ***"foam users primary concern should be which foam is the most effective at putting out the fire. All firewater runoff and all foams present a pollution hazard."***[49]

F3s lack critical fuel shedding and vapour sealing capabilities

F3s typically lack critical fuel shedding capabilities and enhanced vapour sealing because they do not contain fluorinated surfactants[31-33,35,36,44] which the C6 fluorotelomer firefighting foams provide. When fuel vapour is not suppressed effectively by a foam blanket on the fuel, or the foam blanket has mixed with and picked up fuel, it can sustain ignition and burn, or the fire can flash back unexpectedly, presenting significant issues to both escaping passengers, crew, firefighters and other emergency responders involved in the incident. This can delay evacuation and place lives at unnecessarily increased danger.

Research conducted by US Naval Research Laboratories (NRL) clearly established that F3 agents are substantially slower to control and extinguish volatile fuel (n-heptane) fires requiring 40 seconds to extinguish, compared to AFFF extinguishing in just 18 seconds[31].

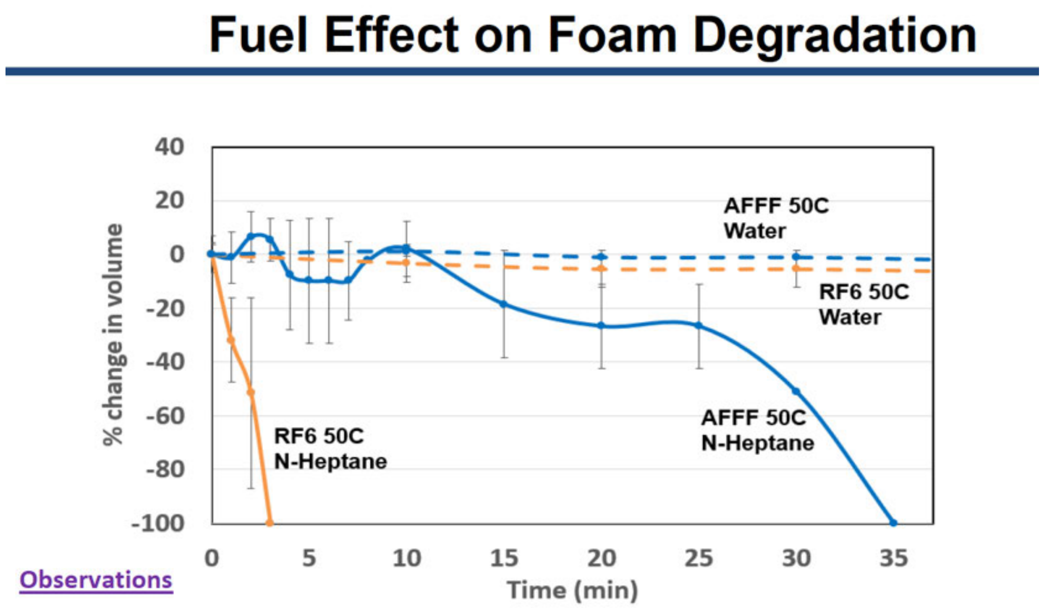
Comparison AFFF v Fluorine Free Foam Extinguishment on same n-Heptane pool fire - US Naval Research Laboratory (NRL), 2015



Source: Hinnant K, et al 2015 - "Evaluating the Difference in Foam Degradation between Fluorinated and Fluorine-free foams for Improved Pool Fire Suppression," US Naval Research Laboratory, ARL-TARDEC Fire Protection Information Exchange Meeting, Aberdeen Proving Ground, MD, October 14, 2015.

Seconds count to save a life, particularly in aviation where it is widely recognized that three minutes exists to extricate passengers and casualties from a burning fuselage before they are likely to be overcome by smoke[50]. ICAO extending its fire extinguishment requirement to 120 seconds[16] plus NFPA 403:2018[136] extending response times from previously 2 minutes to now 3 minutes[51], would seem to be expecting survivable atmospheres in aircraft to now exceed 5 minutes. If this is the case, where is the evidence base and fire testing results to verify what seems to be a convenient "assumption", which may be placing passenger, crew and firefighter's lives at unnecessarily increased risk?

NRL research[31-35] has shown unignited warm heptane at 50°C dramatically attacks a well formed F3 blanket in just 3 minutes, compared to AFFF which resists attack for 35 mins – 11 times longer.



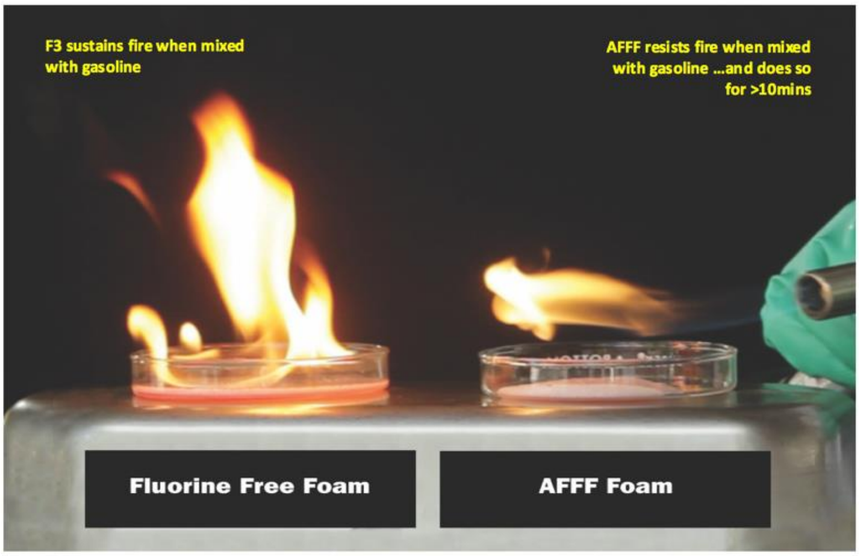
Observations

Source: Hinnant K et al, 2015 - Evaluating the difference in foam degradation between Fluorinated and fluorine-free foams for improved pool fire suppression, US NRL, Exchange meeting Aberdeen proving ground, MD[31].

This research confirms AFFF as being 90% more effective than F3s on volatile fuel. Both foams lasted over 1 hour on water.

Earlier research by Jho in 2012[35,36] showed that when F3 and AFFF foams are mixed with gasoline (simulating plunging into fuel in-depth fires - defined as >25mm fuel depth), and then exposed to an ignition source above (not touching) the foam blanket, the fluorine free foam (F3) sustains ignition immediately, while the AFFF resists ignition, even after 10 minutes (see below). Watch the youtube video – link: www.youtube.com/watch?v=IuKRU-HudSU

Comparison F3 v AFFF equally mixed with gasoline and placed in a petri dish. When a flame is introduced above the foam blanket, F3 immediately ignites and sustains ignition until it burns away, while AFFF resists ignition, ...and does so for more than 10 minutes.



Source: *Jho C, 2012 – You Tube Comparative video tests "Flammable firfighting foams - evidence superior burnback when AFFFs are used on volatile fuels like gasoline ,* www.youtube.com/watch?v=IuKRU-HudSU

How can F3s be considered suitable equivalents to AFFF for ARFF Services?

Evidence indicates F3s likely to be unreliable in Australia

Despite being very fortunate without suffering any major aircraft incidents in Australia over the last 10 years or more, we should not be complacent and ever vigilant to improve our safety standards wherever possible to the benefit of passengers, crew and emergency responders, including ARFF personnel. We seem to be relying solely on an F3 foam which passes the ICAO Level B fire test[16] on a good day when "all environmental factors are within our control" (see demo substitution[52,53] in TOR a). This seems to be a pre-requisite for F3s, as five different F3 agents (some of which were certificated to pass ICAO Level B) failed to pass these independently witnessed ICAO Level B tests in Denmark 2012[38,39] (see Table 1 below), yet those same results would have qualified four out of five F3s passing the same ICAO Level B fire test - after the 2014 changes[16] were implemented by ICAO. How does that improve fire safety?

Table 1: Independently witnessed ICAO Level B fire test results, Denmark 2012, compared to those results assessed against today's ICAO Level B test criteria (post 2014 ICAO update).

Table 17: Results From Fire Tests To ICAO Level B (2012)

Test Fuel: *Jet A1* ***Foam Premix:*** *with fresh water*

Test No.	Nozzle	95% CONROL	99% CONTROL	EXTINCTION	25% BURNBACK	PASS/ FAIL	Probable result under 2014 ICAO Level B (Jet A1) criteria
Product A - F3: 6%							
3	UNI86	0' 35"	0' 45"	None	N/A	FAIL	*FAIL*
4	MMS	0' 30"	0' 45"	1' 58"	(6' 45")	FAIL	*PASS*
Product B - F3: 3-6%							
9	UNI86	0' 40"	0' 45"	1' 24"	(7' 50")	FAIL	*PASS*
10	MMS	0' 35"	0' 55"	None	N/A	FAIL	*FAIL*
Product C - F3: 3%							
35	UNI86	0' 50"	1' 05"	2' 00"	(8'30")	FAIL	PASS
36	MMS	0' 50"	1' 45"	None	N/A	FAIL	FAIL
Product D - F3: 3-3%							
38	UNI86	0' 55"	1' 05"	1' 40"	(9' 50")	FAIL	PASS
Product E - F3: 3-6%							
37	UNI86	0' 40"	0' 55"	1' 50"	(8' 05")	FAIL	PASS

MMS (Modified Military Specification); FXR (Foam Expansion Ratio); QDT (Quarter Drainage Time); CT (Control Time); EXT (Extinguishment Time); BB (Burnback Time). *Source: RPI 2012 Report*

Source: *Resource Protection International, 2012 - Fluorine Free Foam (F3) fire tests, Falck Nuberg Training Centre, Esbjerg, Denmark - Report P-1177. With additions reflecting current ICAO Level B acceptance critria (since 2014 changes) most would now PASS.*

This is not an isolated instance. 2016 testing in Spain confirmed that five different F3 agents were on average 50% slower than C6 AFFF and all failed to extinguish Jet A1 fuel fires at 2.5L/min/m^2 application rate (see Table 2)[40]. F3s were also typically 60% slower than C6 AFFFs on gasoline at the same application rate, with three F3s failing to extinguish the gasoline fuel fire. Two also failed to extinguish Heptane at the same application

	FFF (F3)					AFFF				
Test/Fuel	1	2	3	4	5	1	2	3	4	5
Gas. 950	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

NB: 1-5 above represent five unique, commercially available AFFFs and F3 foams

Table 2: Comparison of five different F3s v five different AFFFs ***(1,3 & 4 are C6 AFFFs, 2&5 are C8 AFFFs)*** on heptane **at a 2.5L/min/m^2 application rate.**

rate[40]. How does that translate into acceptable reliability for ARFF services, when all ≤C6 AFFFs PASSED all these fuel fire tests?

How can this dilution of ICAO fire test criteria in 2014 be in the interests of improving public safety? It seems to be putting lives in danger by allowing poor quality AFFFs and F3s previously failing, to now pass this fire test- **Why?**

Further testing in Sweden 2016, highlighted that expansion ratio of the foam can also significantly affect fire performance (see Table 3 below)[41]. An F3 and C6 AFFF were tested against the UL162 fire test protocol. Both foams passed at expansion rations of around 7:1. When the expansion ratio was reduced to 4.4:1 the F3 foam failed the fire test, yet the C6 AFFF passed at a lower 3.6:1 expansion ratio. Notice that to achieve similar results the F3 agent required 50% higher application rates and a longer duration time. This effectively almost doubled the F3 quantity required to pass this test[41]. What implications could this have on ARFF services? At lower expansion the F3 still failed to pass this test, despite a significantly 50% higher application rate.

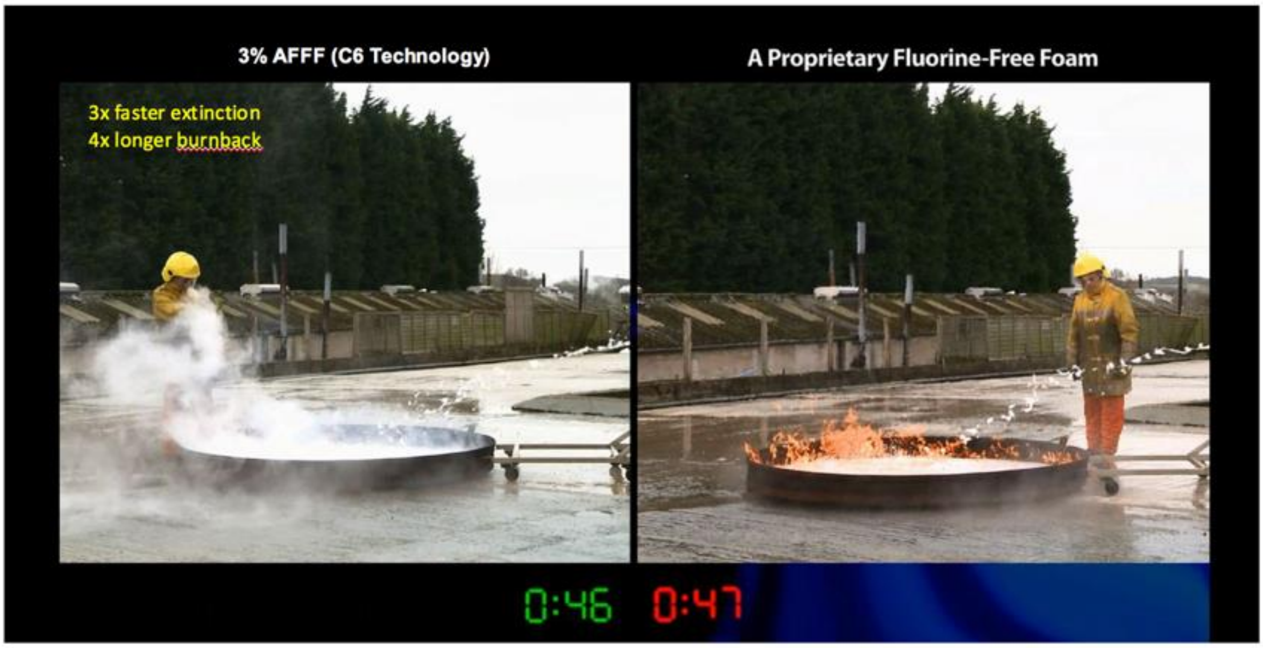
Table 3: Effects of Foam Expansion: F3 v C6 AFFF

Foam Type	C6 AFFF	F3	C6 AFFF	F3
	Higher Expansion		Lower Expansion	
Expansion Ratio	6.9	7.5	3.6	4.4
Application rate	7.6L/min	11.4L/min	7.6L/min	11.4L/min
Application time (mins)	3	5	3	5
90% control time (min:sec)	1:08	0:56	1:26	1:50
Extinction time (min:sec)	1:46	2:10	2:14	3:24
Burnback resistance	5%@5min	Self-extinct	10%@5min	Failed
Litres foam used: 90% control	8.6	10.6	10.9	20.9
LITRES foam used: Extinction	13.4	24.7	17	38.8

Courtesy: Swedish Research Institute/Dafo-Fomtec

Another ICAO Level B comparative fire test in 2013 also shows this combined problem[37], delivering slower fire control/extinction from a leading F3 (which maintains danger to life safety for longer) and poor resistance to re-ignition, when compared to much faster AFFF performance and much longer AFFF burnback resistance. Watch the youtube video: www.youtube.com/watch?v=3MG2fogNfdQ.

Comparison ICAO Level B Jet A1 Fire Test : 3% C6 AFFF v 3% F3 (without Fluorine)



***Source:** Angus Fire, 2013 – You Tube Comparative video tests "AFFF/AR-AFFF v Fluorine Free Foam (F3)", on ICAO Level B and EN1568-4 tests - evidence faster extinction, superior burnbacks and less agent usage with short-chain C6 fluorosurfactants,* www.youtube.com/watch?v=3MG2fogNfdQ

How can these 2014 ICAO changes[16] be providing any improvement to life safety standards? Why have Airservices Australia and/or CASA not identified these important adverse changes as diluting the safety standards of Australian ARFF operations? **This could be placing all passenger lives across Australia at increased risk of danger every day, of every year since 2014.**

Ted Schaefer (ex 3M and Solberg plus an author of the IPEN report), confirmed in his own 2008 F3 research[38] that ***"Under laboratory conditions, with a foam blanket 1-2 cm deep, best-performing FfreeF formulation (RF6) provides about 30% of the durability of an AFFF for protection against evaporation of low-flashpoint flammable liquids. We also note in the results the significant differences among FfreeF with almost no sealability of AVGAS vapours offered by the two other formulations."*** These findings have been supported by US Naval Research Laboratory in 2015[31], confirming that F3 cannot be relied upon to prevent sudden and unpredictable re-ignition and re-involvement of the fire, which could place life safety at unnecessarily increased danger.

2 similar aircraft fires: but different foams = different outcomes

How does a June 2016 Boeing 777 major engine fire in Singapore get extinguished in under 5 minutes using fluorinated AFFF/FFFP foams[55]. All passengers and crew were subsequently disembarked safely, *after* extinguishment, and the plane was returned to service several weeks later[55].

Yet an August 2016 Boeing 777 detached engine fire in Dubai during a go-around manoeuvre under wind shear conditions, burned for 16 hours under foam attack until the aircraft was destroyed[56-58]. It could not be returned to service- it was burnt out! Miraculously all passengers and crew escaped *before* the fire took hold. A brave firefighter tragically died in a fuel tank explosion 9 minutes after the crash. **Would these passengers and crew have survived had they remained on board after the fire started? Were their lives at increased risk?** IPEN's Appendix 1[34,125] confirms Dubai International Airport is a major F3 user, apparently since 2011, with recent fire truck F3 samples passing routine laboratory testing. Strong suggestions that F3 was perhaps used in this incident. **Why is the final investigation report still not issued from Gulf Civil Aviation Authority to explain this firefighting failure - over 2.5 years later?**


Dubai B777 fire burned for 16 hours.

This does not seem to translate into fast, effective and reliable fire control and extinguishment under emergency fire conditions, which is expected by ARFF Services, and occurred swiftly in a May 2016 Korean Air Boeing 777 engine fire in Japan[59] and the engine and wing fire already discussed above, on landing at Singapore[55]. Neither incident had passenger or crew casualties.

ICAO Level B Fire test demo in Singapore, 2016.
(a) pre-burn; (b) ≤C6 AFFF fire control; (c) ICAO Level B ≤C6 AFFF extinguishment

Why did a July 2016 planned F3 ICAO Level B fire demonstration[52] get substituted last minute by a C6 AFFF in 32°C humid Singaporean conditions? Because "***too many environmental factors were not under our control to do F3.***" This same fire was unable to be extinguished twice using F3 the day before in 32°C conditions, catching the fuel separator alight, indication virtually no fire control. C6 AFFF provided progressive control and extinction, without edge fiickers, despite the humid 32°C conditions[52].

Evidence seems to be mounting that F3 may not be well suited to major aircraft crash fires, so should F3 still be used for all ARFF services across all of Australia? Does it make you feel safe when next YOU fly?

Has CASA (Civil Aviation Safety Authority) investigated these failures, and if so has anything been done to identify the causes and establish whether the travelling public are at increased risk in Australia? If so, why has CASA seemingly done nothing in response to improve passenger safety?

Where is the evidence of F3 major firefighting capability or reliability on large volatile fuel fires, either large scale realistic test fires or actual aircraft fires? None has been found in the public domain.

The problem with remote yet potentially catastrophic risks – they do sometimes materialise, then otherwise very reasonable decisions start to look very UNreasonable, …even criminal.

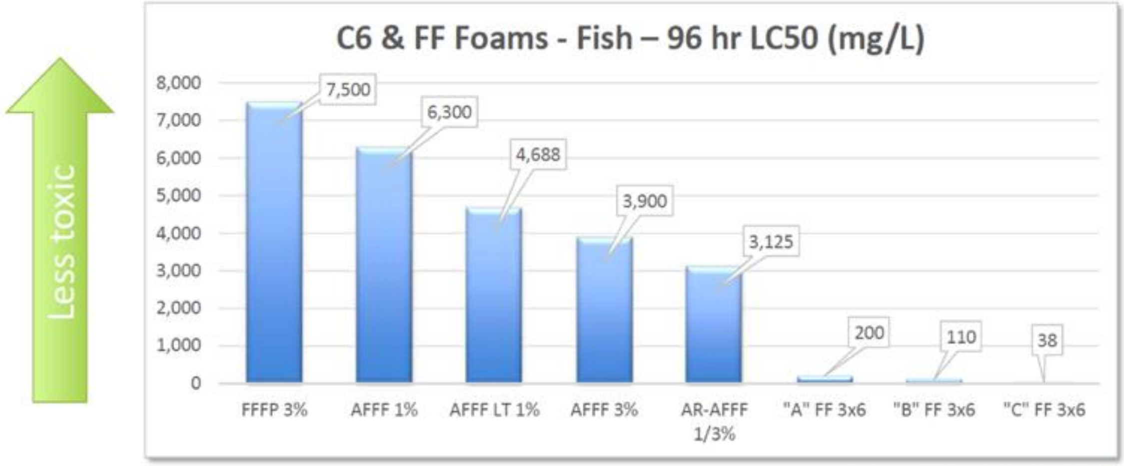
It is therefore respectfully requested that the Committee gives adequate consideration to the importance of good firefighting performance which also reduces adverse environmental impacts (**see comments under TOR e**), by allowing the continued responsible use of short-chain C6 fluorotelomer foams for high risk ARFF applications, as an essential use.

Smaller Aerodromes, Helidecks, Heliports, Aircraft Hangars and Maintenance Areas

These areas are similarly important for life safety as larger Airports, and therefore require inclusion as critical hazard areas within the ARFF category, where equally reliable, rapid and effective knockdown of fires is critical to minimising loss of life, prevention of escalation, while also effectively maintaining functionality and minimising site and traffic disruption from any fire incident. As evidenced above, fluorinated foams are so far proven to be essential in such situations, particularly when smaller aircraft are often using more volatile AVGAS fuel[60,61].

Environmental impacts of foam

Some misleadingly claim including IPEN[34,125] that *"**ALL foams fall into the very low acute toxicity categories…Effectively ten times almost nothing is still almost nothing. …The real issue is the chronic long-term toxicity associated with permanent PFAS pollution by AFFF**."*
Just because 2 foams may inhabit a broad "relatively harmless" category compared to other highly toxic contaminants, toxicity differences matter to fish, aquatic organisms and ecosystem health[61]. Aquatic toxicity data confirms Class B F3 agents are between 10 and 30 times more aquatically toxic than AFFFs, which means life or death, if you are a fish[62,63].



Source: Angus Fire testing (2014)

Independent aquatic toxicity data comparison of C6 fluorotelomer foam agents with Fluorine Free (FF) foams from French Eurofins Toxlab Report (presented 2016 Singapore conference)

Testing of Rainbow Trout, a sensitive species to pollutants in European rivers, shows that 50% of the test fish die over a 96 hr period when just 65µg/L of F3 agent is present in the water. Increase that level by a higher volume of F3 contaminant and more fish die. Testing using AFFF showed 50% of the test fish only died when 30 times more AFFF was added to the water (ie. 2,176µg/L)[63].

Table 1 – 96-hour LC50 Test in Fingerling Rainbow Trout

Agent	LC50 (mg/L)
Wetting Agent	1.06
Fluorine-free Foam A	65
Fluorine-free Foam B	71
Milspec AFFF	2176
AR-AFFF	3536
UL AFFF	5657

This becomes particularly significant in fire incidents, when typically 2-3 times higher usage of F3 agent is likely to be required in a real fire incident, compared to the more effective AFFF[38,41]. Containment areas for firewater runoff are more likely to overflow when higher volumes of foam and water resources are used.

Clearly aquatic organisms also require Oxygen to breathe and healthy rivers typically range from 6-9ppm dissolved oxygen levels[64]. Oxygen is also required for microbes in the water to

breakdown contaminants which is measured by its biological oxygen demand (BOD). ALL firefighting foams have high BODs, typically around 380,000mg/L (ppm) for concentrates with fluorinated and fluorine free agents quite similar on a litre for litre basis[64]. Surprisingly milk, beer and sewage are similarly harmful with high BODs, if spilt into waterways.
In a real fire incident, faster control and extinguishment ensures less C6 agent usage and less potential runoff, in terms of firefighting foam and breakdown products of the fire[61,65], reducing risks of entering waterways, which otherwise could potentially cause organisms to suffocate, during chemical break-down by micro-organisms, using up available oxygen doing so. Every effort is needed to contain and treat ALL firewater runoff, irrespective of foam type, to minimise such adverse environmental impacts from ANY fire incident.

When using F3 agents, we seem to risk a “double whammy” effect as potentially larger F3 volumes are likely to be used to gain control and extinction of the fire, so more could potentially overflow containment areas and leak into water courses. Faster and higher oxygen stress is likely to result, leading to potentially rapid suffocation, exacerbated by significantly increased F3 aquatic toxicity issues, which could be particularly significant for major fire scenarios.

Is this what we should be expecting from supposedly benign 100% biodegradable fluorine free “environment friendly” foam agents?
Surely using much less of a fast, effective, reliable, less toxic agent which is more easily contained, should reduce risk of overflows carrying other pollutants with it into rivers, so more fish and other critical ecosystem organisms should survive.

More foam usage means higher BODs

More F3 usage also means higher aquatic toxicity and higher BOD levels in the runoff which may overflow into rivers, potentially killing extensive aquatic life[62,63,66-68]. Result: Substantially more fish die than if less volume of a less toxic AFFF was used, with an inherrently lower risk of overflows occurring**.**

There is a disturbing trend for foam manufacturers to somehow expect ecological information on key ingredients to be an adequate substitution for testing on the specific mixture being provided ie. the specific foam concentrate[69]. *Why?* Fluorinated and fluorine free manufacturers seem equally lacking in this regard.
Disturbingly some manufacturers are not providing any product SDS on their website without a declaration of the Co. asking and lodging contact details, as availability is “upon request” only, which seems unacceptable. Latest Safety Data Sheets (SDS) with ecological information on all foam products (as a finished mixture) should be available 24/7 on all manufacturers websites, to facilitate any responders to a foam usage or spillage incident, help minimize the adverse impacts immediately - irrespective of whether they be fire, police, ambulance, regulators, water Cos, or members of the public, as it could help to save lives or minimise harm to rivers, lakes and

wildlife. To do so they need immediate and transparent access at all times globally. …What is there to hide? This should be a mandatory requirement.

Aircraft Hangar AFFF Spill Results in Minimal Environmental Impacts

April 2017 saw an accidental spillage of 22,000L C8 fluorotelomer AFFF concentrate at a Brisbane airport hangar, of which an estimated 5,500L escaped offsite into the environment. The Media labelled it a "toxic disaster"!

Queensland's (QLD) Department of Environment and Heritage Protection (DEHP) –(now Department of Environment and Science - DES) – reacted quickly, instigating extensive PFAS sampling data at multiple points in the area[70,71], to inform local communities.

Extensive sampling covered:

- **Water quality -** which was below Food Standards ANZ recreational water PFOA trigger levels throughout.
- **Fish -** showed zero PFOA detected, throughout.
- **Crustaceans/Seafood** - worst records were just 9 & 5ppb PFOA in just 2 crab samples.
- **Sediments -** sampled 0.3ppb PFOA - well below the 5ppb Food Standards ANZ screening value.

PFOS/PFHxS sampling data was recorded, but is likely to have derived from a different legacy source, potentially stirred up by this discharge, as neither PFOS nor PFHxS can derive from C8 fluorotelomer AFFFs.

Food Standards ANZ's 5.6 ppb PFOA trigger levels were not exceeded throughout the whole monitoring period in either water quality, fish or crustaceans.

An elevated level of combined PFOA AND its related substances was detected the day after the spill at 350ppb, but only nearest the spill site. Levels here returned to background within 7 days. Elsewhere combined PFOA & related substance levels did not exceed this 5.6ppb PFOA only trigger point, at any time …incredibly small, and arguably not significant.
(For context, 1part per billion equates to just 3 seconds in 100 years, …or since the 1st World War!) Some supposed experts reportedly said they "***feared the consequences of this spill could be felt by the city for decades***", which based on the evidence seems both misleading and alarmist.
The only conclusion was that NO significant environmental, wildlife, bioaccumulation or human health concerns emanated from this incident[71].

The hangar operators also seem to have been made an example to others, seemingly being heavily penalised for this accidental spill, with excessive remediation requirements, longer term biota, sediment and food chain monitoring, as well as predicted $180,000 fines[72].

<u>TOR (c):</u> the comparison of safe systems of emergency response standards and systems of work for firefighting and rescue operations for structure fires, aircraft rescue, emergency medical response and other emergency incidents;

The focus in this submission is on the aircraft rescue and firefighting and operations of this TOR and contrast incidents where F3 and fluorinated foams have been used**.**

The Committee is encouraged to also **consider the response to TOR a) above** with respect to systems of work for firefighting and rescue operations for aircraft rescue, and life safety.

As a Technical Specialist with 30 years' experience, I am not aware of any major aircraft fire successfully and quickly extinguished using Fluorine Free Foams, nor any extensive large scale testing where it had been shown to be highly effective – despite assertions to the contrary by Graeme Day at London's Heathrow Airport in the IPEN report[34,125]. In Appendix 3 p55 he claimed ***"Since purchasing our fluorine free foam, we have used it on 2 separate aircraft fires (an A321 and a 787) and it worked perfectly. Furthermore, the clean-up costs from these incidents was zero."*** This is misleading as they were only small incidents and very little foam was used.

The Air Accident Investigation reports on these incidents show the Boeing 787 in July 2013 was a small electrical fire inside the aircraft while standing unoccupied[73]. A small amount of foam was used externally (probably unnecessarily and without effect) but no fire penetrated the fuselage. The fire was small, internal and extinguished with halon extinguishers. This could not be considered a major incident, nor an example of operational effectiveness of F3's capability. No surprise that clean-up costs were zero.

An Airbus A321 fire could not be found at London Heathrow, using UK Government Air Accident Investigation data, but a May 2013 Airbus A319 small engine fire was found on landing at Heathrow[74], where foam was used by Airport Fire and Rescue Service with London Fire Brigade also responding (it is unclear what foam LFB were using).

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

Source: UK Government Air Accident investigation Report 1/2015 on Airbus A319-131, G-EUOE, London Heathrow https://www.gov.uk/aaib-reports/aircraft-accident-report-1-2015-airbus-a319-131-g-euoe-24-may-2013

The fire was quickly extinguished prior to safe passenger evacuation. Whilst this was a significant incident, May temperatures are quite cool in UK, and it could hardly be claimed as a major fire or major performance success, since only a small fire in the right engine was involved[74], seemingly requiring little foam agent.

A large aircraft fire seems still not to have been efficiently controlled and extinguished by any F3 agent.

All Australian airports are using this questionable F3 technology to protect everyone flying in and out of Australia – daily, with no proven track record of success in large or difficult situations. In fact the Dubai Boeing 777 aircraft crash in August 2016[56-58] and the earlier F3 demonstration in Singapore[52] (**detailed in TOR a**) above) tend to confirm this. Why and how can that happen? Why has no-one questioned the potential safety implications under severe conditions?

Legacy C8 long-chain PFAS dominate contamination issues

Claims of reduced environmental impacts from ceasing to use fluorinated foams in ARFF services are certainly correct for legacy long-chain C8 AFFF agents[75-79]. Their widespread historic use has caused significant contamination at airports and Defence Sites[22-25], following unrestrained and intensive use of these chemicals over many decades in the same place.

We all understand the legitimate public concerns, rightly focusing on outrage that contamination is spreading from such high-profile sites into surrounding communities. Fears that PFAS exposure could be harming human health, with worrying talk about potentially increased cancer risks. This causes anxieties from toxicity issues, to contaminated food and water, plus falling land values[80].

The length of the PFAS fluorinated carbon chain can result in different physicochemical properties that influence the substance behaviour in the environment and in organisms (including humans), and its bioaccumulation and (eco)toxicity.

The United Nations OECD (Organisation of Economic Co-operation and Development) makes a clear distinction between long-chain perfluorinated compounds (LC PFASs) and short-chain perfluorinated compounds (SC PFASs), based on the toxicity and bioaccumulation differences between LC PFASs and SC PFASs[153].

- "Long-chain perfluorinated compounds" refers to:
  Perfluorocarboxylic acids with carbon chain lengths C8 and higher, including perfluorooctanoic acid (PFOA);
- Perfluoroalkyl sulfonates with carbon chain lengths C6 and higher, including perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonate (PFOS).

LC PFASs are commonly called "Legacy C8s" – particularly PFOS, PFOA and PFHxS. Although PFHxS is actually a C6, but categorised as a"C8" because unlike other C6's it is categorised Bioaccumulative and Toxic and has a very long average human half-life of 8.5 years[111] and behaves like a C8. Short-chain C6s are persistent but are not categorised as Bioaccumulative nor Toxic and have a very short human half-life averaging 32 days[110]. Legacy C8s regularly occur in people, animals, food and water from poor management practices and over-use many years ago, when it was considered harmless and quite safe to use anywhere[80,81]. There was no malice, it was unregulated and effective, so it was used extensively and continuously for training in the same places for decades. It's a legacy we have to clean up, …and continue managing. The PFAS chemicals of high concern are generally the so called "long-chain" PFAS of ≥8 carbon atoms in the molecule's chain, often referred to as C8s[75-81]. Some of these are derived only from the 3M ElectroChemical Fluorination (ECF) process like PFOS and PFHxS[4.5].

Australia is not unique in having legacy C8 PFAS contamination issues around Airport and Defence sites, as similar problems are also occurring in USA[82] and Europe[83,84]. There are legitimate public concerns about community impacts[75], but we should not ignore the significant PFAS contamination that is also occurring daily from Waste Water Treatment plants (WWTP)[85], landfall leachate[86] and dust in our own homes from the 95% of PFAS chemical usage outside firefighting foams[87], in stain repellent treatments for upholstery, carpets, clothing, paper sizing like glossy magazines, cleaning agents, mobile phones, computers, cosmetics, food packaging etc. etc. to which we are all exposed daily. This is being released in substantial quantities every day of every year via WWTP effluents[5] and landfill leachate[86] into our environment.

Most building structures in and around airports therefore also comprise PFAS components in the fit out of the buildings (eg. carpets, upholstery, communications, plumbing etc, etc) which are likely to contribute to PFAS in the firewater runoff, even if water alone has been used for firefighting through sprinkler systems, hose reels, firefighter handlines and nozzles[88-90].

Current changes to PFAS based foam management practices are designed to prevent our PFAS legacy perpetuating[91-92,133], and Australian Government human health guidance[81] confirms "***There is no current evidence that supports a large impact on an individual's health."*** from PFAS chemicals ***…***and ***"In particular, there is no current evidence that suggests an increase in overall cancer risk*** (see details below).

Short-chain C6s behave very differently – with negligible human health risk

It is important to separate legacy PBT long-chain C8 PFAS from the more environmentally benign short-chain C6 PFAS chemicals, which are widely accepted for continued use as P not B, not T. This includes USA EPA, European Chemicals Agency (ECHA) European REACH legislation[48], and the Industrial Chemicals Regulator in Australia, National Industrial Chemicals Notification and Assessment Scheme (NICNAS)[94-97].

i) NICNAS

In stark contrast to these legacy C8s, environmental Tier II IMAP (Inventory Multi-tiered Assessment and Prioritisation) assessments for short-chain C6 PFAS chemicals including PFHxA (which is the main breakdown product of C6), by Australia's NICNAS[96] conclude that whilst it is still persistent, it is neither considered Bioaccumulative nor Toxic (P not B, not T).

The IMAP Tier II human Health risk assessment[97] also concluded that ***"Therefore, the chemicals are not considered to pose an unreasonable risk to workers' health."*** and … "***the public risk from direct use of these chemicals is not considered to be unreasonable."***

ii) Dept. Health Expert Panel on PFAS

Australia's May 2018 Department of Health Expert Health Panel for PFAS Report's advice to the Minister confirmed[81] that ""***There is no current evidence that supports a large impact on an individual's health." …***and ***"In particular, there is no current evidence that suggests an increase in overall cancer risk. The main concerning signal for life-threatening human disease is an association with an increased risk of two uncommon cancers (testicular and kidney). These associations in one cohort were possibly due to chance and have yet to be confirmed in other studies." "Differences between those with the highest and lowest*** **[PFAS]** ***exposures are generally small, with the highest groups generally still being within the normal ranges for the whole population. There is mostly limited or no evidence for an association with human disease accompanying these observed differences."*** …***"The published evidence is mostly based on studies in just seven cohorts. These cohorts have generated hundreds of publications but there is a high risk that bias or confounding is affecting most of the results reported. Many of the biochemical & disease associations may be explainable by confounding or reverse causation." "Our advice to the Minister in regards to public health is that the evidence does not support any***

***specific biochemical or disease screening, or health interventions, for highly exposed groups** (except for research purposes).*"

iii) 2 recent PFHxA research papers

Two further detailed January 2019 peer reviewed research studies into the human health and toxicity effects of PFHxA confirm these findings.

The first paper by Lux et al[98], confirms that all PFAS are not equal, and separation is necessary between legacy C8 long-chains which need restrictions, and C6 short-chains which do not as they are proven far more benign. It concluded PFHxA (C6 short-chain breakdown product) is neither carcinogenic, nor developmental toxin nor reproductive toxicant. It is also not an endocrine disruptor. All things that long-chains like PFOS. PFHxS & PFOA are suspected of…if not proven already!

It developed a PFHxA Bench Mark Dose with rigorous uncertainty factors included for a human Reference Dose of 0.25mg/kg-day. This is 4 orders of magnitude larger than PFOA's ref dose (12,500 times larger), so basically far higher exposures show no adverse human effects. 4 orders of magnitude is the difference between a single 12oz bottle of beer (assume PFOA) vs 520 cases of 24x12oz bottles of beer (12,480 bottles for PFHxA)!

The second Anderson et al paper[99] has used this Chronic (long-term) human health toxicity value of the Reference Dose, to develop a human-health based screening level for drinking water over a lifetime of use at 1,400 microgram/L or 1,400,000ppt, when the US EPA's current recommended PFOA lifetime limit is just 70 ppt! (20,000 times lower for PFOA).

A residential groundwater screening level for children was also developed at 4,000microgram/L or 4,000,000ppt. This gives very high margins of safety for potential human PFHxA intake.
These results clearly show that exposure to PFHxA from short-chain C6 firefighting foams or other consumer items, **presents negligible human health risk to the general population**.
It also confirms PFHxA is substantially less hazardous than PFOA, and is not likely to substantially contribute to risk at sites contaminated with PFAS mixtures. Concluding that PFHxA may represent a suitable marker for the safety of C6 fluorotelomer replacement chemistry being used today[99].

iv) Breakdown products of fire cause increased cancer risk

Substantial scientific evidence from the Monash University 2015 Australian firefighter Study[100], Kirk & Logan's Queensland firefighter study[101,102] and Stec et al's 2018[103] occupational exposure study of UK firefighters, all confirm it is the volatile breakdown products of the fire responsible for increased cancer risk in firefighters. This includes known carcinogenic chemicals like Benzene, PAH's (Polycyclic Aromatic Hydrocarbons) like Benzo (a) pyrene, 3-MCA, and 7,12-dimethylbenz[a]anthracene, and Volatile Organic Compounds (VOCs) to which firefighters are being exposed, which is causing increased cancer risk in firefighters as an occupationally exposed group, and at higher levels than the average population.

The Monash study[100] showed 79% of the fires attended by career, paid part-time, and volunteer firefighters were in buildings, vehicles or bushfires, where water alone is normally used and Class B fluorinated foams would not be required. On the rare occasions foam may be used for specific large bushfires, it would only be a Class A fluorine free type, without PFAS chemicals.

v) C6 agents verified to deliver equivalent performance to C8 firefighting foam agents.

Leading firefighting agents are currently available that contain high purity ≥99% C6 and ≤1% C4 fluorotelomer based chemicals[104,105]. Most of these C6 agents when they breakdown produce no more than 15ppt of PFOA or 0.0000000015%, from use strength foam solution yet provide equivalent firefighting performance to legacy C8 based fluorotelomer surfactants with the same amount of fluorochemical in the firefighting agent. This has been evidenced by equivalency in the highest performing US Mil Spec (Mil PRF 24835F[SH] Amdt.2) firefighting foam fire test[15]. Use of C6-based fluorotelomer surfactants in these Mil Spec approved foams is not new: Some leading MilF approved foams have been using predominantly C6 based surfactants (>95-97%) for more than three decades, very effectively[105-107].

vi) Assessment confirms C6 cannot be POP listed

An Environ International report[108] assessed C6 short chain fluorotelomers for potential POP listing and concluded that only one of the four essential criteria -Persistence, Bioaccumulation, Long Range Transport [Mobility], and adverse harmful human or environmental effects – which includes Toxicity -was being met. That was Persistence, also with concerns about Mobility. These short-chain C6 agents were proven not to be Bioaccumulative nor Toxic, nor harmful to humans[96]. Short-chain fluorochemicals have subsequently been shown to be mobile, but without Bioaccumulation and Toxicity issues, this would not seem to be adequate justification for prohibition, rather restriction to use in Major Hazard Facilities where life safety could otherwise be placed at unnecessary and increased risk, along with severe incident escalation potential. Germany has recently withdrawn (Dec 2018) its application to ECHA for PFHxA to be assessed and considered as a SVHC substance[109].

Important scientific research work confirms the main C6 degradation product is PFHxA (PerFluoroHexanoic Acid) which is fully excreted through the human urinary system with a half-life average in humans of just 32days[110]. This contrasts dramatically with long-chain average human half-lives of 3.8 years for PFOA, 5.4 years for PFOS and 8.5 years for PFHxS[111,112]. The half-life of PFHxA in other representative mammalian animals (rats and monkeys) also shows similarly short half-lives, compared to these long-chain fluorochemicals (see Table 4 below).

Table 4: Comparison between human half-life of legacy C8 PFAS being several years, while short-chain C6 PFAS averages only 1 month, so does not accumulate and build up in humans to levels of potential concern.

Measurement	PFOS (ECF)	PFHxS (ECF)	PFOA (ECF), [reaction trace in FT]	PFHxA [FT]
Half life in rats	3mths	7 days	1-6 days	1-2 hrs
Half life in monkeys	3-6mths	4mths	3 Wks	1-2 days
Half life in humans	**5.4yrs**	**8.5 yrs**	**3.8yrs**	**Av. 32 days**

NB: (ECF) = ElectroChemical Fluorination process
[FT] = FluoroTelomer process

Sources:
Russell 2013, Elimination Kinetics Perfluorohexanoic Acid in Humans & comparison rats & monkeys;
Rotander 2015,Novel fluorinated surfactants tentatively identified in firefighters by controlled approach;
Environ Int'l 2014,Assessment of POP criteria for specific short-chain perfluorinated Alkyl substances;
Olsen 2007, Half-life serum elimination of PFOS, PFHxS, PFOA in retired fluorochemical production workers;
OECD 2013 - Synthesis of PFCs

The importance of this can be seen in Ski Wax Technician studies[113], where they start the season with residual levels of short-chain PFHxA which rises through the ski season (see Fig 12.), falling to background levels during the off season. It appears the short average 32day half-life ensures PFHxA is excreted during the off-season back to residual levels, so they begin the next season at the background population level, without experiencing upward trending levels over time, which has historically occurred with PFOS and PFOA giving justifiable cause for concern.

This C6 situation is contrary to the upward trending levels of PFOA, and PFNA in the technician's blood which is significantly correlated to the number of years in the occupation[113]. Exposure was occurring faster than these long-chain C8 chemicals seem to be excreted from the body, presumably due to their long half-lives in humans. PFOA results reached a plateau and then began declining around 2008, as new well ventilated waxing trucks were introduced. Technicians sometimes suffered from flu-like symptoms caused by exposure to legacy C8 fluorinated wax, experiencing a higher physical tolerance to the exposure at the end of the season compared to the beginning.

Major incident findings

3 major incidents where Fluorine Free Foams (F3) were used, each ending in reported disaster:

- **<u>Fredericia Port, Denmark, 2016:</u>** In this particular Fredericia incident in Denmark, it seems no significant volume of volatile fuel was involved, the fuel was only Palm Oil, not classified as a flammable liquid, just a combustible liquid with a very high 162°C flashpoint. Fine water sprays normally extinguish this product, so it is questionable whether F3 was even necessary[114]. Ironically Palm Oil has even been used as a base for a firefighting foam agents. Interestingly press coverage focused on the environmental disaster[115] when reportedly ***"12,000 tonnes fertiliser and 2,266 tonnes palm oil were released into the harbour - possibly the biggest environmental catastrophe in Denmark.***"

DNF senior adviser Lisbet Ogstrup told Metroxpress. "*In general, monitoring and emergency responses must be dramatically improved.*"

"spilled as much fertiliser into the waters in an entire year. There is a risk of severe ... ard hit by pollutants," she said[115]. A ... nd an explanation from the environmental ... y said more than 100 people had been ... ***k layer of pam oil, water and foam[116]."*** A ... ***iliser had to be cleared from buildings,***

Somehow IPEN seems to regard this environmental disaster as an "F3 success"[34], when F3 wasn't strictly required, so seemingly added to the BOD loading problem in the harbour, unnecessarily.

- **Dubai Airport, Aug 2016:** Boeing 777 aircraft fire burned for 16 hours under foam attack. All passengers and crew evacuated before the fire took hold. One brave firefighter tragically died during a fuel tank explosion 9 minutes after the crash. 16 hours later and the aircraft was destroyed[56-58], despite a concerted foam attack (**see details under TOR a**). 2.5 years later the final investigation report has still not been issued.

- **Footscray chemical factory fire, Melbourne Australia 2018[88-90,116-121]:** It reportedly took 17 hours to get this fire under control and 5 days to finally extinguish all hot spots. EPA Victoria's Chief Environmental Scientist confirmed only F3 was used, and "***the incident was "probably as bad as it could be" and the chemicals from the fire have had a "massive" impact on the system. We've had more than 2,000 fish killed***." EPA Victoria confirmed only PFAS-free (F3) foams were used in this incident[89].

PFAS chemicals were detected at significantly high levels[118] (16x recreational water quality acceptance criteria of <0.7µg/L sum PFOS/PFHxS) in the runoff from the fire, evidently emanating from PFAS containing materials (not firefighting foam) on site. Elevated levels remained in the nearby creek for 2 weeks.

This incident disproves the IPEN report's misleading claim[34,122-125,132] *(section 4 p34)* that ***"The risk of release of persistent organic pollutants does not exist with the use of fluorine-free foams"***.

55 million litres of contaminated runoff water had been pumped out of the creek by 3rd day[120], into chemical waste facilities and WWTPs. This rose to approximately 70 million litres of water and 170 cubic metres of contaminated sediment removed from the creek by 24th Sept 2018[126].

Victoria's chief environmental scientist Dr Andrea Hinwood said the incident was "***probably as bad as it could be*" and the chemicals from the fire have had a "*massive*" impact on the system. "*We've had more than 2,000 fish killed,*"** she said[127]. Let's Remember the foam used was F3 - that IPEN are trying to convince you has no drawbacks, and no remediation costs associated with its use?

This situation appears worse than the likely outcome, had a significantly more effective C6 AR-AFFF been used[38-41,49,52,53,84]. This would have provided additional minimisation of smoke, less breakdown products from the fire, substantially less runoff from site and less risk of overflowing any containment, by providing significantly faster fire control and extinction, without the ensuing environmental disaster which reportedly killed all life in Footscray's Stony Creek.[117-121,126,127].

In contrast, **4 major incidents where Fluorinated foams were used effectively, swiftly and reliably - ended in successful incident resolution, minimal damage and disruption,** without causing any reported environmental disasters.

- **<u>Orion 82m dia. bulk gasoline storage tank fire, USA 2001</u>[128]:** This 5,281m² full surface fire burned for 12 hours while the foam attack was being co-ordinated. Using AR-AFFF fluorinated foam this massive fire was swiftly controlled and fully extinguished in just 65 minutes from starting the foam attack. This minimized firewater runoff issues into the environment and salvaged over 25million litres of valuable gasoline from destruction.

82m dia Full surface gasoline fire extinguished in 65 minutes with AR-AFFF foam in USA, 2001. 25million litres of valuable gasoline was salvaged from destruction[128].

- **Avonmouth Chemical factory fire, UK 1996[129]**: This major chemical fire and explosion **was controlled in 2 hours and extinguished in just 4 hours using fluorinated AR-FFFP foam**, despite 134 appliances responding & crews monitoring for 34hrs on site. Another chemical complex, fuel depots, major port, industrial units and congested residential areas surrounded this site, but neither escalation nor severe runoff were reported issues. The site was safely handed over to the Health and Safety Executive, within 10 hours of the fire starting.

Avonmouth major chemical factory fire, UK 1996, controlled in 2 hours and extinguished in 4 hours using AR-FFFP foam[129].

- **Boeing 777 engine fire, Singapore Jun 2016[55]:** This Boeing 777 major engine and wing fire in Singapore get extinguished in under 5 minutes using fluorinated AFFF/FFFP foams. All passengers and crew were subsequently disembarked safely, *after* extinquishment. The plane was returned to service several weeks later (**see also TOR a) above**).

- **Korean Air Boeing 777 engine fire in Tokyo Japan, May 2016**[59]: This Boeing 777 major engine fire was quickly and successfully extinguished with AFFF and all passengers and crew were evacuated unharmed[24 -26].

Korean Air Boeing 777 engine fire in Tokyo, May 2016. The fire was quickly extinguished with minimal aircraft damage[59].

The UK Environment Agency[49] recommends "***foam users primary concern should be which foam is the most effective at putting out the fire. All firewater runoff and all foams present a pollution hazard.***" It recognises that keeping fire incidents small, with quick effective interventions and minimal foam agent usage, is the first priority in reducing environmental impacts of the whole incident. It also reduces the clean-up required afterwards.

Shouldn't we be adopting such a practical, effective, life safety orientated, minimized environmental impact approach, for ARFF services in Australia?

TOR (d): the consideration of best practice, including relevant international standards;

Surely best practice means using a foam which regularly exceeds the requirements of the ICAO Level B fire test as defined in CASA's Manual of Standards (MOS) Part 139H[28], and ARFF Services Procedures Manual[29] to which all Australian ARFF Services are required to comply.

DNV

DET NORSKE VERITAS

Customer: Solberg Scandinavia AS
Ref.: VIK
Ord.No.: 53530165

Fire tests of foam concentrate in accordance with ICAO standard Document 9137-AN/898 Airport Services Manual,Part 1 Rescue and Fire Fighting (Third Edition) Chapter8, Table 8-1 Performance Level B; and United Kingdom CAA standard CAP 168 Chapter 8 Appendix 8E to Level B standard.

One fire test was performed at Solberg Scandinavian AS' outdoor test facilities on Feb. 19th 2003 in compliance with the above standards. The test was conducted by personnel from Solberg Scandinavian AS, and witnessed by the undersigned surveyor from Det Norske Veritas.

A synthetic and non-fluorinated fire fighting foam brand, developed by 3M Australia, manufactured in Europe by Solberg Scandinavian AS, was tested:

"Arctic RF3 - 3%" / "3M Foam RF3 3%", batch no. 030114 .

Results:

Total extinguishment, sec.	38
90 % control, sec.	30
Burnback time *)	12 min.
Expansion ratio	7,8
25% drainage time, sec.	20' 40"
Premixed foam solution	tap water
Solution strength	3%
Solution temperature, °C	5
Fuel temperature, °C	5
Air temperature, °C	0
Wind speed, meter/sec.	< 1
Nozzle calibration prior to test (ltr/min)	11,8

It is hereby confirmed that this brand passed the fire performance and re-ignition resistance properties specified in the ICAO level B test standard.

Date: February 19. 2003
Place: Sæbøvågen/Bergen

Einar Vik
Senior Surveyor

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Form No.: 40.91a Issue: January 98

Such a foam should surely be capable of meeting those requirements under a wide range of climatic conditions being experienced around Australia, not just the minimum requirement of 15°C suggested in ICAO Level B fire test protocol[16]? (Please note everyone aims to use as close to 15°C as possible because fuel volatility increases and foam stability decreases with rising temperature – making the test harder to pass!).

Best practice means going beyond the minimal

To ensure best practice is achieved and maintained, should we not at least be requiring the operational foam to reliably pass the ICAO Level B fire test using only operational Jet A1 fuel at a number of airport training areas around the country, under a diverse range of climatic conditions including realistically hot and cold, dry and muggy which adequately reflect the hazards around Australian airports? Rather than just accepting a piece of paper from a supplier showing it passed at 15°C, …or in the case of one 2003 ICAO acceptance certificate (see above), issued by a well-respected agency for an F3 product, tested and passed under unacceptably low ambient temperature conditions of 0°C and fuel/foam solution temperatures of 5°C[130],- well below ICAO acceptance criteria[16]. **Lower ambient temperatures reduce the volatility of the fuel, while enhancing the stability of the foam blanket making the test easier to pass.**

ICAO's fire test protocol clearly states ≥15°C, so this foam test failed to meet the test conditions for approval[16]. Despite this FAILURE, how does it have a PASS certificate? This certificate should NEVER have been issued, so where is the rigorous oversight and regulation by Aviation Authorities and Airport Services?

Tougher Standards usually provide wider safety margins

Best practice should also consider testing the approved foam against other tough test standards like Def (Aust) 5706[18] or US MilF Spec[15,106] fire tests. US Mil Spec has recently been amended as US Mil PRF 24385 F(SH) Amendment 2, in Sept. 2017 requiring a maximum 800ppb of PFOS or PFOA content verified by accredited laboratory analysis[15]. In October 2018 US Congress passed the Federal Aviation Administration (FAA) Re-Authorization Bill[142] which confirmed from 2021 NFPA 403 and US Mil Spec "…***shall not require the use of fluorinated chemicals to meet the performance standards referenced***…" which assumes they still pass the rigorous tests defined within. A foam passing Def Aust or US Mil Spec standards should also easily pass the ICAO Level B test, as defined in the regulations[16], but would go beyond the minimal, providing a level of confidence to the regulator that the foam in use was capable of dealing safely with realistic ambient conditions across Australia when any ARFF emergency strikes. Why does this not currently appear to be the case?

Yes there would be some minor cost implications on front-line foam purchase, but incidental compared to the emotional, reputational and potential damage costs of a destroyed plane load of corpses – because the foam failed …as so nearly seems to have happened in Dubai 's Boeing 777 go-around incident in August 2016[56-58] (**see section TOR a) above for details**). Think of the consequences and adverse impacts - tourism alone would suffer hugely, as well as our reputation as a safe travel destination – and what about Australian residents flying on business, seeing relatives, or holidaying?

Demonstrating best practice uses the best safety standards available, usually going beyond the minimal to build extra safety margin into acceptance criteria to make our emergency responses more robust, and capable of safely dealing with any emerging emergency situation – anywhere in Australia. Thus providing a level of confidence that our ARFF services would have the capability to deal with any aircraft emergency, anywhere in Australia, which is seriously questioned from these facts. How can this currently be the case? How can this currently be demonstrated to any external auditor? How is it still acceptable to CASA?

Adequate levels of life safety may not be possible until -or unless - a tougher benchmark fire test is used in Australia (eg. US MilF spec[15]) as a qualification benchmark (alongside ICAO Level B[16]) to demonstrate proven capability across the wide range of varying conditions prevailing across Australia. I would urge the Committee to consider this important requirement as a potential outcome.

Best Practice Guidance

There are three leading industry best practice guides I would strongly urge the Committee to review during its deliberations:

- **Fire Protection Association Australia's Jan 2017 Information Bulletin IB-06 "Selection**

and Use of Firefighting Foams"[133] available at: http://www.fpaa.com.au/technical/technical-documents/information-bulletins/ib-06-v11-selection-and-use-of-firefighting-foams.aspx

- **The US FireFighting Foam Coalition (FFFC) May 2016 "Best Practice Guidance for Use of Class B foams"**[134] available at: https://docs.wixstatic.com/ugd/331cad_188bf72c523c46adac082278ac019a7b.pdf
- **JOIFF** (The International Organization for Industrial Emergency Response and Fire Hazard Management - formerly Joint Oil Industry Fire Forum) Oct 2018– "**JOIFF Guideline on Foam Concentrate**"[135] available at: http://joiff.com/wp-content/uploads/2018/10/JOIFF-Guideline-on-Foam-Concentrate.pdf

All three recognize the superior benefits and essential qualities of high purity short-chain C6 fluorinated foams over F3s (or legacy C8s) for high risk large volatile flammable liquid fires at Major Hazard Facilities (MHF) including airports. They also recognize that all foams pollute and any runoff of any foam type – fluorinated or not fluorinated, whether during training, system testing or emergency use, should be collected, and contained wherever possible - prior to remediation and safe disposal in accordance with local regulations, ensuring maximum life safety, minimal foam usage and reduced adverse environmental impacts.

No evidence for equivalency between ICAO Level C and US MilF Spec

A recent International Airport Review article[137] highlighted these major differences between ICAO[16] and US Mil Spec[15]., despite misleading claims of "equivalency" by IPEN[34,122-125,132] the latest 2018 version of NFPA 403[136] and others, which seem not to be verified.

ICAO requires a single freshwater fire test to gain a pass at 15°C on kerosene (Flashpoint 37°C to 65°C) rather than the previous requirement for Jet A1 only with Flashpoint 38°C) and an extinguishment time of 120secs (to allow for edge flickers).Previously total extinguishment was required within 60 seconds to pass. Many airports even in Australia jut into the sea (eg. Sydney, Brisbane – and probably others), so potentially requiring emergency seawater for an air crash is possible, yet ICAO does not recognize this potential. Fire testing with seawater is usually harder to achieve a pass than freshwater, particularly for synthetic detergent based foams like F3s and AFFFs.
MilF Spec demands fast extinction (55 seconds for the lowest application rate, compared to 120secs for ICAO Level C), plus environmental performance, dry chemical compatibility and corrosion testing (not required by ICAO Level C) and which most F3s would probably not pass.

It also seems strange that NFPA 403;2018[136] has extended its ARFF response time by 50% from 2mins to 3 mins… again without clear justification or evident passenger benefit …This does not seem to relate to the survivable atmosphere inside the aircraft which historically has been considered to be around 3 mins –allowing up to 2 mins to respond and get there, up to 1 minute to apply foam, extinguish the fire and start safely evacuating passengers. Have fuselage survivable atmospheres shot up from typically 3 mins to over 5 mins recently? If so, …where is the evidence confirming this? It seems rather misleading and confusing to suggest the most important factor - speed with which ARFF equipment (including foam) can be put to use, is being compromised WITHOUT adversely impacting passenger safety.

US Mil F Spec[15] requires 7 separate fire tests in fresh and salt water, at half strength and over-rich at significantly lower application rates than ICAO level B (similar to ICAO Level C) but also with more onerous environmental and supplementary pass criteria and in less than half the time now allowed for all ICAO fire tests.
Why does NFPA 403:2018[136] delay response times by 60 secs, and endorse further 60 sec delays in ICAO Level B and C fire tests[16] since its 2014 changes?

NFPA 403:2018[136] now lists F3 as acceptable. It also accepts "equivalency" between ICAO Level C[16] and MilF Spec[15], …but without any justification. A recent comparison of these 2 test protocols[19] makes it abundantly clear they are far from equivalent in anything but a similar application rate and nozzle pressure. The ICAO UNI86 nozzle is a hand-made high performance nozzle, whereas MilF's nozzle requirement more closely resembles standard Military nozzles in field use.

Surely this represents a "double whammy" delay, allowing poor quality AFFFs and F3 to pass (when they previously failed) potentially jeopardizing passengers, crew and firefighter's life safety?

The latest 2017 US Mil PRF 24385F(SH) Amendmt.2 upgrade[15] to this standard removes the earlier requirement for the foam to be fluorinated, which some suggest is the only impediment to F3 gaining a pass. IPEN[34,125] misleadingly claimed this, in their position paper to the UN Stockholm Convention Persistent Organic Pollutant Review Committee (POPRC) last September in Rome. In fact F3s not only seem to fail the fire tests, but also seem to fail the tough environmental requirements , seem to fail the supplementary criteria, including effectiveness when mixed with other approved agents (which also has to be fire tested). Newtonian viscosity (ie flows like water, doesn't require shear-thinning, doesn't thicken with colder temperatures). 65°C temperature conditioning of concentrate before fire testing is also required, but missing from ICAO specifications, and also likely to fail most F3s submitted for US Mil F Spec testing.

The Committee is encouraged to read the detail in this recent Dec. 2018 article "Focusing on the best Fire Protection" published in International Airport Review[19].
https://www.internationalairportreview.com/topic/arff-recovery/

Best practice in Remediation

Increasingly we are seeing a need to remediate sites where legacy PFAS foams have been used. Particularly when PFOS saturated concrete pads at Fire Training Areas are leaching PFOS, after training with F3s … even when it rains. So Remediation is still required, despite no fluorinated foam being used for the last 8 years. We therefore have to consider what is best practice to protect our environment?

Effective adsoption and separation technologies are now available at scale for C8 and C6 PFAS contaminated waters, although most require pre-treatments for dissolved solids and organic matter particularly, to reduce the risk of breakthrough and extend life expectancy.

Despite some suggestions that C6 PFAS remediation is "very difficult" 9compared to C8) several commercial scale technologies are available[141, 147-152]. These include:

- Some Ion Exchange Resins
- Modified Clays
- Bioabsorbent granules
- OCRA (described above)
- Nano-filtration
- Reverse osmosis

Apart from Plasm Arc incineration, effective PFAS breakdown technologies for short-chain C6s as well as legacy C8 PFAS also include:

- Electrochemical oxidation
- Sonolytic destruction
- Cement kiln incineration

These technologies can permit the inherent advantages of short-chain C6 firefighting foams to return to use potentially at airports all around Australia to better protect life safety, as they are elsewhere at leading International airports like Los Angeles, Singapore, Tokyo, Kuala Lumpur, Hong Kong etc.

Two recent case studies showed remediation of sites affected by PFOS and a range of other PFAS including C6s has been proven highly effective using EVOCRA's Ozofractionatively Catalysed Reagent Addition (OCRA) process. Details were presented at Ecoforum in Sydney (Oct. 2018)[141,147-152]. PFAS decontamination of over 18million litres of firefighting foam impacted water, up to a maximum 5,810µg/L PFAS contaminated effluent treatment at a major Australian Airport, has recently been completed. Water is cleaned using Ozone, creating a high oxidation environment enhancing free radical creation, driving stabilising chemical reactions which are intensifying electrostatic attractions. Customisable to remove varied target compounds including long-chain C8 and short-chain C6 PFAS, plus co-contaminants like PAHs, heavy metals, pesticides, organics (sewage) and pathogens in a cost-effective on site facility built into 20ft containers. High volumes of clean water for re-use or environmental release achieved >99.7% (by mass) PFAS removal, separately concentrated to ≤0.3% mass for cost effective thermal destruction. OCRA removes sum of PFAS (using TOP Assay) down to 0.25µg/L. It was then further polished by

Reverse Osmosis (RO) down to sum PFAS at no detect (0.002µg/L)[141]. No Granulated Activated Carbon or Ion Exchange Resins were used for this project.

A smaller airport project treating firewater runoff from an active fire training ground, where F3 has been used for many years, but legacy C8 PFAS continues leaching from concrete fire training pads every time training with F3 is conducted, or even when it rains[141].

Source: Willson M, 2018 – "Cost-effective ≤C6 Remediation is Achievable", Presented at Ecoforum Australia, 2-4th Oct.2018[141].

Up to 25,000L/day is being treated effectively and efficiently from influent total PFAS levels of typically 60µg/L down to Food Standards ANZ drinking water guidance values (0.07µg/L PFOS & PFHXS combined, and 0.56µg/L PFOA). To meet client requirements a RO polishing plant further reduces sum PFAS levels down to no detect (0.002µg/L) before returning to the Waste Water Treatment Plant (WWTP) stream. With fewer co-contaminants, separated PFAS is concentrated to typically 0.03% by mass, for cost-effective disposal by incineration[141].

Relevant International Legislation and Standards relating to PFAS based foams:

i) US EPA's 2006-15 PFOA Stewardship Program[45-47]

But since 2006 management practices have changed dramatically. Manufacturers voluntarily encouraged collection and containment with less foam use, less training wherever possible. They also voluntarily signed up to the 2006-2015 US Environmental Protection Agency (EPA) PFOA Stewardship program to move away from long-chain C8 chemistry, which had 2 key objectives:

- ***by year-end 2010:*** *removal 95% PFOA, higher homologues and precursors from products, facilities & waste streams* **– which was achieved**.
- *by year-end 2015: work towards elimination of PFOA, its higher homologues and*

precursors from those facilities, products & waste streams – **which was also achieved**.

This program encouraged increasing development of high purity short-chain ≤ C6 Fluorotelomer (FT) surfactants, which allowed transition away from PFOA containing products. High purity C6 Fluorotelomers cannot degrade to PFOS or PFHxS but will contain minute traces of PFOA (at a low ppb level) as an unavoidable by-product of the manufacturing process, which is acceptable to US EPA and EU Reach legislation.

ii) UN Stockholm Convention[137, 75-78]

This major International treaty was first signed in 2001 under the United Nations Environment Program, and is now ratified by 187 countries. It prevents the use and harm from a list of 12 dangerous chemicals (including highly toxic pesticides) categorised as Persistent Organic Pollutants (POPs)[137]. 2009 saw PFOS added to this POP list[75].

173 of those 187 Countries have also ratified the 2009 amendment[76] adding 9 other chemicals including **PFOS** to the UN's Persistent Organic Pollutants (POP) list . NZ ratified in 2016, but those not yet ratified include: USA, Russia, **Australia**, Italy, Malaysia, India, and Israel.

The Australian Dept. of Environment and Energy has issued a PFOS RIS (Regulatory Impact Statement) for consultation[138], recommending a PFOS ban across Australia as the cheapest and most environmentally advantageous of the 4 options presented. This PFOS ban gained widespread support across the fire industry as there are alternative and equally effective short-chain C6 agents available, which are necessary to protect life safety and MHFs. PFOS has also been banned from use in EU[139] and Canada[140] for several years.

2017 saw the UN Review Committee adopted a recommendation to list **PFOA** as a POP under UN Stockholm Convention, based upon its PBT substance designation[77]. It is likely PFOA will be fully accepted/listed as a POP by 2019. BUT ...there are some important specific exemptions under EU REACH Legislation for ≤C6 PFAS[48] (see 6 below).

PFHxS has also been accepted as meeting the POP criteria at the UN Convention's Oct. 2017 review meeting[78]. It is therefore likely to be assessed during 2018/19 with potential addition to the POP list in future – possibly by 2020.
PFOS, PFOA and PFHxS are all breakdown products from the ECF process and contained in 3M Lightwater™ branded AFFF and AR-AFFF products (*PFOS & PFHxS are only derived from these products*)[4,5,105]. PFOA is also a breakdown product from Fluorotelomer production processes and products[105].

iii) Misleading and incorrect IPEN F3 Position Paper submitted to Stockholm Convention

September 2018 saw the well-respected IPEN (International persistent organic Pollutant Eradication Network) deliver a detailed position paper promoting Fluorine Free foam(F3)[34,125] to the Persistent Organic Pollutant Review Committee (POPRC) at their meeting in Rome - but it was full of over 60 misleading and incorrect statements. It seems to reject proven scientific facts, claiming somehow "Fluorine Free Foams can do all that Fluorinated Foams can do ", without critical analysis or substantiating verification. The US FireFighting Foam Coalition (FFFC) quickly sent a strong rebuttal to the UN POPRC[122] confirming ***"The IPEN paper contains numerous inaccuracies, omissions and misleading statements."*** …***"The foam manufacturers listed below, all of whom sell both fluorinated and fluorine-free foams (FFF), do not agree with many of the conclusions contained in the IPEN paper on the efficacy and environmental impact of firefighting foams. They specifically reject the conclusion that current-day FFF can provide an equivalent level of performance to AFFF agents for all class B applications and hazards, and thus the use of AFFF agents is no longer necessary and can be phased out."***
Eurofeu the European Committee of Manufacturers of Fire Protection Equipment and Fire Fifghting Vehicles, also sent a strong letter rejecting its suitability as noy objective, and concerned at several incorrect, partially incorrect and misleading statements in IPEN"s F3 Position paper. Both letters are available for reference from willsonconsulting26@yahoo.com.au

A detailed full review correcting these errors has also been sent to UN's POPRC, highlighting factual evidence contradicting its misleading, unsubstantiated, confusing and too frequently incorrect F3 statements[123,124] – also available directly from the author at willsonconsulting26@yahoo.com.au. These corrections were designed to bring more clarity and understanding to this complex topic. These documents are fast becoming essential reading for anyone trying to understand the complex implications, inter-relationships and consequences of modern firefighting foam usage, whether fluorinated or fluorine free. These corrections aim to help others understand often ignored facts, curtailing substantial over-reach of F3's claimed "abilities" to bring much needed common-sense into this complex arena.

I would strongly urge the Committee to read the summary article published in the latest January 2019 on-line issue of JOIFF Catalyst which summarises some of those findings. "Disturbing IPEN F3 Position Paper Seems to Reject Scientific Evidence"[125], p19-22 http://joiff.com/catalystdir/

iv) EU Legislation allows continued C6 PFAS usage[48]

Despite recommendations to the contrary and UN's current assessment of PFOA for POP listing under the Stockholm Convention[77], ECHA (European Chemicals Agency) and its Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) regulations increased the proposed PFOA impurities level for short-chain C6 fluorochemicals, in recognition of it's acceptance of their acceptability for continued use.

The low 2ppb PFOA impurity level initially proposed by Germany, was increased in this EU legislation 2017/1000[48], issued in June 2017, to:

- *25ppb of PFOA, its salts and*
- *1,000ppb for one or a combination of PFOA related substances, including precursors.*

ECHA also confirmed firefighting foams already in use were exempted from this impurity restriction, so effectively C8 fluorotelomer surfactant based foams purchased before July 2020, could still be used across Europe until their expiry date. This legislation becomes effective from July 2020, with a 3 year transition period[48].

This is important legislation because it fully accepts the presence of small unavoidable PFOA impurities and unintended contaminants in high purity ≤C6 fluorosurfactants currently being manufactured - and the products in which they are incorporated – now, and into the future, as does the US EPA PFOA Stewardship program[45-47].

It therefore includes ≤C6 fluorosurfactants being used in C6 firefighting foams across the European Union including UK, Norway, Iceland and Liechtenstein[48].

High purity (95-97%) C6 fluorochemical surfactants have been used in US Mil Spec AFFF formulations since 1982[4,5,105], with typically 40% less fluorochemical than 3M alternatives, so have been well tried and tested on a wide range of military fire incidents.

In addition the Industry has encouraged increasing use of Fluorine Free Foams (F3) for smaller fires and for firefighter training[133,134]. More care with re-filling, avoiding spillages, less system testing, less usage has also helped prevent such contamination recurring. Technology offering remediation and separation of PFAS (Per and Polyfluorinated Alkyl Substances) for incineration, particularly long chain C8 PFOS/PFHxS/PFOA based foams (3M Lightwater™), using Ozofractionatively Catalysed Reagent Addition(OCRA), Reverse Osmosis (RO), bioabsorbent granules, modified clays or Nano-Filtration(NF) can effectively adsorb and separate both C6 and legacy C8 PFAS from firewater runoff, drinking water and groundwater some like OCRA & RO down to no detect levels (≤0.002µg/L)[141]. Legacy C8s have widely been taken out of service, because of their undesirable Persistent, Bioaccumulative and Toxic (PBT) profiling.

v) 2018 US Washington State legislation[143-145]

PFAS-containing foams including aqueous film-forming foams (AFFF) and alcohol-resistant aqueous film-forming foams (AR-AFFF) are widely recognised and proven to be the most effective firefighting foam agents currently available to protect life safety and valuable assets against major flammable liquid fires[31-34, 35-41,45-49,84, 125]. Recognition of this is now included in US Washington State legislation[143] restricting the use of PFAS based Firefighting Foams, except for

Major Hazard Facilities (MHFs), following testimony to the House Environment Committee[144,145] where these issues were discussed at length during compelling testimonies from research and testing staff at two leading F3 manufacturers.

Sworn testimony by two F3 manufacturers to the US Washington State House Environment Committee confirmed that "***I have a very grave concern that this total ban would take away the ability to extinguish large catastrophic fires such as process area fires in refineries or fuel storage tanks, large atmospheric fuel storage tanks and the reason is that quite honestly, the fluorine free foams lose a lot of their effectiveness when you get into Fuel-In-Depth type fires***" and ***"…the fluorine free foams are very effective on spill fires but once you get to a situation where the foam actually has to plunge below the surface because of the application techniques, the fluorine free foams actually pick up some of that fuel and by the time the foam comes to the surface after plunging below it, it actually burns"***[145].

These testimonies clearly re-inforce that poor fire-fighting performance increases adverse environmental impacts and places life safety at unnecessarily increased risk from slow knockdown, poor flashback resistance, unreliable post fire securement, increased risk of escalation etc. Longer extinguishment times also increase risk of escalation, creates more toxic combustion products, while also increasing risk to life, property and business continuity.
Use of larger quantities of foam and water generally creates more toxic/contaminated effluent, increases risk that loss of containment will occur. Fire-fighting performance therefore CANNOT be ignored or isolated when making selection decisions aimed at minimizing environmental Impacts, as they are an integral part of achieving the best outcomes for minimizing adverse impacts from fires, particularly in MHFs.

Washington State Senate Bill 6413 legislation[143,144] ***confirms:***
Training: PFAS-containing foams (AFFF and AR-AFFF) may not be discharged or otherwise used in Washington State for training purposes from 1st July 2018.

Emergency Use for Specified Sectors: The legislation does not restrict the use of PFAS-containing foams (AFFF and AR-AFFF) on fires involving specific Major Hazard Facility uses.
Manufacturers may only sell or distribute PFAS-containing foams (AFFF and AR-AFFF) for use in Washington State for the following specific uses, from 1st July 2020:

- **Airport and Military Applications** where the use of a PFAS-containing firefighting foam is required by Federal law, including but not limited to the requirements of 14 C.F.R. 139.317 (such as military and FAA-regulated civil airports).
- **Petroleum Terminals** (as defined in RCW 82.23A.010 *"**Terminal**" means a fuel storage and distribution facility that has been assigned a terminal control number by the internal revenue service. "**Petroleum product**" means plant condensate, lubricating oil, gasoline, aviation fuel, kerosene, diesel, motor oil, benzol, fuel oil, residual oil, and every other*

*product derived from the refining of crude oil, but the term does not include crude oil or liquefied gases. "**Rack**" means a mechanism for delivering petroleum products from a refinery or terminal into a truck, trailer, railcar, or other means of non-bulk transfer. "**Non-bulk transfer**" means a transfer that does not meet the definition: bulk transfer of fuel by pipeline or vessel.)*

- **Oil refineries**
- **Chemical plants** (as defined in WAC 296-24-33001 - *A large integrated plant or that portion of such a plant other than a refinery or distillery where flammable liquids are produced by chemical reactions or used in chemical reactions*.)

Municipal Fire Departments and all other non-specified applications in Washington State are required to use firefighting foam agents that do not contain PFAS chemicals.

Manufacturers of PFAS-containing foams must notify sellers of their products in Washington State of these restrictions in writing before July 1, 2019. The final Bill as passed[143] can be viewed at: http://lawfilesext.leg.wa.gov/biennium/2017-18/Pdf/Bills/Senate%20Passed%20Legislature/6413-S.PL.pdf

vi) Summary PFAS Foam Justifications (*extracted from testimony video*)[145]

A summary of the justifications accepted by Washington State Legislature in revising their proposed restrictions are identified below (paraphrased from video).

- Grave concerns expressed about continued ability to extinguish major fires in process areas, oil storage tanks and aircraft crashes if a complete ban went ahead, while dikes, bunding and modern management practices prioritise collection and containment of firewater runoff, treatment and safe disposal, preventing its discharge into the environment.
- While effective in most smaller spill fires, F3 loses its effectiveness for fuel in depth type fires. Where F3 is plunged below the fuel surface, it picks up fuel, rises to the surface and burns.
- Such problems are exacerbated in crude oil tanks where fatal boil-overs could result from slow or ineffective actions.
- Gulf refinery, Pennsylvania fire – no self-healing, no film formation and 8 firefighters died when disrupting the foam blanket which did not heal as they had expected, and usually happens with fluorinated alternatives to protect firefighters.
- Spraying Jet fuel was pooling into a dike fire, which led to tanks 4 then 5 then 10 also igniting. Once set up, it took specialty AFFFs 20 mins to put the fire out. This allowed firefighters safely into pooling fuel areas, disrupting it to use dry chemical to extinguish spraying fire and halt incident, without injury. Implication: without it, escalation and potential fatalities were probably inevitable.

- Double or triple application rates of F3 in such situations, was confirmed as usually unable to effectively control such major incidents.
- Removing such a vital tool is not safe, particularly when protecting people potentially trapped and facing death, without the critical benefits PFAS based foams can provide.
- Look at best practices, use non-fluorinated foams where we can, but retain short-chain chemistry critical for serious aircraft crash and major industrial fires to save lives and minimize damage.

Video to House Environment Committee of Testimony[145] regarding proposed PFAS firefighting foam ban across State Jurisdiction, Submissions 15th March 2018, can be viewed (starting after 16mins 30 secs) at.https://www.tvw.org/watch/?eventID=2018021146
These detailed testimonies convinced legislators to take sensible, realistic and precautionary action to exempt MHFs from unnecessary PFAS firefighting foam restrictions into the future.

vii) NICNAS accepts short-chain C6 PFAS[94-97]

NICNAS, the chemicals regulator in Australia, has confirmed through its 2015 IMAP (Inventory Multi-tiered Assessment and Prioritisation) Environmental Tier II assessments that legacy long-chain ≥C8s like PFOS[94] & PFOA[95] are categorised PBT. The assessment confirms "***It is not currently possible to derive a safe environmental exposure level for such chemicals and it is therefore not appropriate to characterise the environmental risks for these chemicals in terms of a risk quotient***."

Its 2015 IMAP Environmental Tier II assessment of short-chain PerFluoroCarboxylic Acids (PFCAs) and direct precursors (including PFHxA)[96] confirms in its Hazard characterisation summary that ***"Hexanoic acid, undecafluoro-; hexanoic acid, undecafluoro-, ammonium salt; pentanoic acid, nonafluoro-; pentanoic acid, nonafluoro-, ammonium salt; butanoic acid, heptafluoro-; and butanoic acid, heptafluoro-, anhydride are categorised as:***

- ***P***
- ***Not B***
- ***Not T***"

Further findings confirmed that ***"The chemicals in this group are not PBT substances according to domestic environmental hazard criteria."*** and ***"The chemicals in this group are not prioritised for further assessment under the IMAP Framework."***

In addition, its 2016 Tier II C6 Human Health Assessment's Occupational and Public Risk Characterisations[97] concluded: ***"Therefore, the chemicals are not considered to pose an unreasonable risk to workers' health."*** and … "***the public risk from direct use of these chemicals is not considered to be unreasonable***."

This stark contrast seems to misleadingly become blurred in their recent Draft Industrial Chemicals - Rules and Guidelines. It is hoped and expected that this will become rectified following their recent public consultation, where a separation between PBT Legacy Long-chain ≥C8 PFAS chemicals and the more environmentally benign P, NOT B, NOT T short-chain ≤C6 agents is necessary to acknowledge these substantial differences, and prevent them being categorised as equally hazardous to either human health or the environment.

viii) Australia's Department of Health confirms PFAS not harmful to human health[81].

It appears some regulators may have been over-cautious and over-reacting to a perceived threat from PFAS chemicals? …but now there is less need for so much concern.

Australia's Medical experts have reviewed all the human health data available regarding PFAS studies. Australia's extensive and detailed Department of Health Expert PFAS Panel Report[81] to the Minister concluded very recently (early May 2018) that "***There is no current evidence that supports a large impact on an individual's health." …***and ***"In particular, there is no current evidence that suggests an increase in overall cancer risk."*** This seemingly includes legacy long-chain PFAS (PFOS, PFHxS and PFOA), as well as significantly more environmentally benign short-chain ≤C6 PFAS chemicals degrading to PFHxA and PFBA.

The fire industry supports Australian Department of Environment and Energy's PFOS RIS recommendation 4: to ban PFOS use across Australia as soon as possible[138].
It also recommends a transition away from other telomer based long-chain ≥ C8 foam concentrates to environmentally more benign high purity ≤C6 short-chain telomer foam agents which are proven highly effective, efficient, reliable, while also retaining the critical high levels of life safety expected for casualties, firefighters, other responders, plus affected communities[138].
Such C6 agents are proven to be fast, minimising toxic smoke production, minimising fire spread and resulting damage, minimising agent usage, minimising noxious firewater run-off and inherent risk of containment overflows, while also minimising harmful environmental effects of the whole fire incident.

There were two particularly important finding areas in the Export Panel Report's Exec Summary[81]:
a) "***Differences between those with the highest and lowest exposures are generally small, with the highest groups generally still being within the normal ranges for the whole population***. *There is mostly limited or no evidence for an association with human disease accompanying these observed differences." "**There is no current evidence that supports a large impact on an individual's health. In particular, there is no current evidence that suggests an increase in overall cancer risk.** The main concerning signal for life-threatening human disease is an association with an increased risk of two uncommon cancers (testicular and kidney). These associations in one cohort were possibly due to chance and have yet to be confirmed in other*

studies."

b) "*The published evidence is mostly based on studies in just seven cohorts (see Kirk et al. 2018, page 15-16[101]). **These cohorts have generated hundreds of publications but there is a high risk that bias or confounding is affecting most of the results reported**. There are very large numbers of comparisons being done in many studies, such that the risk of random variation in exposures and outcomes being interpreted as real associations is greatly increased. This is compounded by the fact that there are multiple PFAS, and other environmental or occupational hazards, so that there may be interacting toxic effects, and it is hard to isolate the association with one or two analysed compounds. **Many of the biochemical and disease associations may be explainable by confounding or reverse causation (see Section 6.15). Many studies had limited power to detect important associations."***

***"Our advice to the Minister in regards to public health is that the evidence does not support any specific biochemical or disease screening, or health interventions, for highly exposed groups** (except for research purposes).*"
This seems to be a radical departure from previous rather cautious advice from health professionals globally, and seems fairly categoric that PFAS are NOT a human health problem!

This Expert Panel report[81] includes the health effects of PFAS exposure on cancers; liver and kidney function; thyroid effects; neonatal, infant and maternal outcomes from exposure during pregnancy; reproductive outcomes; immunological effects; Neurodevelopmental ad neurophysiological effects; diabetes, glycaemic control and metabolic syndromes; obesity, BMI and overweight issues; cardiovascular effects; respiratory & skeletal effects. Reverse causality and confounding may be able to explain previous findings, particularly in regard to suspected disease links. Limitations and issues about the human evidence base highlighted in key international reports and systemic reviews were also assessed, finding it still concluded that ***"The panel advised the evidence does not support any specific screening or health interventions for highly-exposed groups — except for research purposes. It also concluded there was insufficient evidence of causation between PFAS exposure and any adverse health outcomes."***

The Australian Government is still committed to supporting communities and responding effectively to PFAS contamination. This commitment has included reducing exposure from contaminated drinking water, providing mental health and counselling services, funding an epidemiological study into potential health effects and providing access to free blood tests for PFAS on a voluntary basis to help those communities fearful of exaggerated claims, media hype and speculation. "*After considering all the evidence, the Panel's advice to the Minister on this public health issue is that the evidence* **does not** support *any specific health or disease screening or other health interventions for highly exposed groups in Australia, except for research purposes. **Decisions and advice by public health officials about regulating or avoiding specific PFAS chemicals should be mainly based on scientific evidence about the persistence and build-up of***

these chemicals. *"* These important findings must be adequately taken into account when considering any restriction of these chemicals which must be proportionate to the risk, which on this evidence is significantly less than previously envisaged[81].

ix) 2015 Australian Firefighter Study suggests increased cancer risk from fire breakdown products[100]

The Australian 2015 Firefighter study[100] confirmed increases in Testicular cancer were likely caused by inhalation and skin absorption of volatile breakdown products of the fire (in smoke particularly), some of which are proven carcinogens like Benzene, and Benzo(a)pyrene. 79% of all firefighter responses were to structural, vehicle and bush fires where fluorinated foams are not used.

Important 2015 Queensland Fire & Emergency Services research[102] confirmed that fire breakdown products can enter skin under and through PPE (personal protective equipment), and from off-gassing during incidents, BA changes, clean ups, and transfers back to station. These routine exposures are also evidently contributing to increased cancer risks – not exposure to firefighting foams. This was confirmed by similar UK research[103].

TOR (e): the mechanisms and criteria for the review of the provisions of safety standards for the provision of rescue and firefighting services, if any;

Any future mechanisms and criteria should be realistic and represent actual conditions being experienced in Australia. Current ICAO fire test criteria[16] only require testing at ≥15°C, when most Australian airports regularly experiences ≥32°C. The 2014 changes under ICAO has diluted the fire test standard which helps no-one…. Safety standards ***should*** be getting tougher over time, not weaker, to better protect Airport life safety. The misleading and factually incorrect IPEN report[34,125] aims to convince foam users that F3 is somehow equivalent to AFFF. ICAO's diluted 2014 changes[16] have permitted F3s to gain approval, but not routinely or reliably as the extensive testwork described **under TOR a)** above, major incident outcomes described **under TOR c),** and best practice and IPEN's misleading and incorrect F3 position paper to UN Stockholm Convention confirms[34,125] **under TOR d)** above, confirm.

Some misleadingly suggest that achieving good environmental outcomes is solely associated with the use and selection of the firefighting foam. This is incorrect, as it is more strongly linked to firefighting performance and the speed with which the fire is controlled and reliably extinguished. The faster the fire is controlled and extinguished the smaller the incident, the less harm and damage is usually created, less risk of escalation or flare up, less danger to life safety and less adverse environmental damage usually results. Any realistic consideration of environmental impacts can only focus on the whole of incident from fire and environmental performances, not just firefighting foam properties in isolation. This is recognised by UK's Environment Agency when it recommends *"**foam user's primary concern should be which foam is the most effective at putting out the fire. All firewater runoff and all foams present a pollution hazard.**"*[49,84]

It is therefore respectfully requested that the Committee consider the importance of good firefighting performance as **fundamental** to ensuring the protection of the environment, critical infrastructure and community life safety. Allowing the continued responsible use of C6 fluorotelomer foams in high risk firefighting applications including ARFF is essential, particularly for Major Hazard Facilities. However, the use of these C6 fluorotelomer foams in routine training or system testing should be avoided and eliminated wherever possible, by applying alternative training and testing regimes which ultilise Fluorine free firefighting foams or alternative non-fluorinated surrogate liquids.

TOR (f): a review of Airservices Australia policy and administration of aviation rescue and firefighting services;

Testing and training with firefighting foam has been a key source of environmental contamination in the past that can be eliminated in most instances with alternative techniques. Consequently, most historical contamination is not as a result of actual firefighting incidents[1-3]. Most historical contamination is the result of poor practice during testing and training. Therefore, environmental contamination of soil and water with firefighting foam can be dramatically reduced, by using least possible volume of the most effective foam, and the use of firefighting foam systems and equipment testing and training techniques that eliminate the use of foam altogether or capture the discharge of any foam discharged for disposal in accordance with local regulatory requirements. This is advocated by UK Environment Agency[49,84] (see **TOR e)** above). Such techniques will prevent recurrence of the large scale historical contamination which we have seen in the past from legacy long-chain C8 foams.

Research by Baduel et al in 2015[146] of PFOS saturation of a fire training ground's concrete pad to 12cm depth showed it leaching PFOS even when it rained. Remediation was (and still is) required despite F3 being used for the last 8 years. Replacing fluorinated firefighting foam with a fluorine free alternative, even were it to meet the required high level of firefighting performance for use in actual fire incidents, will therefore not significantly reduce legacy PFAS contamination. The committee is urged to consider this research conducted on Airservices fire training facilities. These important findings are accessible at:
https://www.sciencedirect.com/science/article/pii/S0304389415001958

These factors and other information provided in this submission should be used as part of a major review of Airservices Australia's policy regarding ARFF Services.

TOR (g): the effectiveness and independence of the regulator CASA to uphold Aircraft Rescue and FireFighting (ARFF) safety standards;

Consideration should be given to CASA perhaps being a more proactive agency, looking at new and better ways to provide improved ARFF services, not just a reactive one monitoring compliance alone.

Standing by and pointing to existing regulations which maintain the status quo, without seemingly investigating possible problems being highlighted which could cause life safety issues to ARFF personnel, other emergency responders, air crew and the travelling public potentially on all flights around Australia does not seem to be maximizing its potential as a regulatory Authority.

TOR h): the impact on Australia's national and international reputation and aviation safety record as a result of any lowering of aviation rescue and firefighting services;

The committee is encouraged not to put Australia's national and international reputation and aviation safety record at risk by focusing solely on foam environmental issues rather than travelling public safety, passenger and crew safety and emergency personnel safety.

It is imperative that the effectiveness and safety of ARFF services within Airservices Australia is fully scrutinized by this Senate Inquiry and subsequently by CASA, to ensure the future safety of all travelling passengers, crew and firefighters at all Australian airports is not being unnecessarily compromised at any location, or at any time, during the year.
Environmental safety is also important, but this should be assessed on the basis of environmental impacts of the whole incident (not just foam in isolation). This would give a far more realistic and accurate assessment of any environmental damage, while also protecting life safety by focusing on firefighting performance and life safety issues, as the undisputed priority which brings with it associated environmental benefits from less firewater runoff generated.

Reputational damage to Australia, nationally and internationally could be very substantial – potentially even catastrophic, as a result of the current lowering of ARFF Services due to dilution of ICAO Level B fire test requirements in 2014[16].

Imagine if an A380 crash-landed, the current F3 in use failed to work effectively …and the plane, passengers and all its contents were destroyed? Would there be a public outcry? Would there be massive reputational damage?

Other planes could probably not be diverted to any other Australian airports because all airports in Australia use the same F3 foam – which may have just failed? F3s are still without a proven track record of safety in major incidents, both aviation and industrial.

The evidence forming from the few major incidents so far attributable to F3 usage, and the clearly misleading and incorrect statements in the IPEN F3 position paper[34,125] seems to be suggesting the reverse is true. We still await the final investigation report into the Boeing 777 aircraft crash in Dubai (Aug 2016)[56-58] where the plane was destroyed after 16 hours and a concerted foam attack. All the indications so far seem to point to F3 being used in this incident.

One failed major incident at any Australian airport, could potentially shut down all Australian airports, - unless a proven alternative high performance foam concentrate were able to be made available immediately, or ARFF services were perhaps handed over to the Australian Military [using well proven high performance specification Def (Aust) 5706 or US Mil F Spec foam concentrates] for an emergency period?

Since we are a remote continent and a long way from anywhere, shouldn't we expect to have tighter safety measures in place than some other places? …to adequately protect our travelling public and visitors (whose continued attraction to Australia forms a huge part of our economy).

The Government seems to go to extreme lengths to penalise genuine refugees on border security issues, so why does Aviation safety not seem to gain the same level of scrutiny, when it arguably has an even greater impact on the life safety of average Australians, visitors, genuine refugees arriving by plane, and our economy's well-being?

5. Conclusions

Forcing the use of fluorine free (F3) firefighting foams in ARFF applications where its firefighting performance is inferior to a short-chain C6 fluorotelomer-based foam alternative (as evidenced in this submission) will likely result in slower acting, less effective, less reliable fire protection. Increased risks to life safety and potentially detrimental environmental outcomes and substantial reputational damage are likely to result.

Taking the whole incident into consideration, the use of C6 foams is likely to quickly and effectively control and extinguish the fire, providing for safe and rapid evacuation of passengers and crew, plus extrication of any trapped victims, reduce resulting aircraft damage, while keeping firefighters and other emergency responders as safe as possible. This in turn reduces volumes of foam and water resources used, reduces firewater run-off generated, reduces breakdown products and fire residues emanating from the incident, thereby minimising the adverse environmental impacts in most volatile flammable fuel scenarios being dealt with by ARFF services, including fuel terminals and maintenance hangars.

Evidence from the August 2018 chemical Factory Fire in Footscray, Melbourne[34,117-121, 126,127] where only F3 was used, confirms this major fire was not controlled until 17 hours after ignition, and took 5 days before all hot spots were extinguished. EPA Victoria's Chief Environmental Scientist confirmed "***the incident was "probably as bad as it could be" and the chemicals from the fire have had a "massive" impact on the system. We've had more than 2,000 fish killed***."

Accordingly this Committee is strongly urged to consider:

- Banning the use of all firefighting foams containing or breaking down to PerFluoroOctane Sulfonate (PFOS) and PerFluoroHexane Sulfonate (PFHxS).

- Encouraging the use of Fluorine free firefighting foams for training and for smaller fires, in applications where they provide adequate levels of firefighting performance.

- Substantial fires with potential for volatile fuels in-depth (≥25mm), where forceful application of foam agent occurs, should require agents with proven and effective fuel shedding and vapour sealing capabilities at a wide range of expansion ratios, to protect the life safety of passengers, crew and emergency responders at aircraft incidents in future. This should also take into account anticipated high ambient temperatures and fuel types likely to be encountered.

- Fire test standards even if based on ICAO Level B for regulatory purposes, should also be tested to a higher standard which adequately reflects higher ambient conditions experienced around most of Australia. This could be done by requiring the ICAO Level B test to be independently witness tested on Jet A1 fuel at ambient and fuel temperatures of 35°C.

- It is recommended that only firefighting foams capable of passing both the rigorous US MilF Spec test and the ICAO Level C fire tests should be accepted for future use at all Australian airports (for use in existing fire trucks to ICAO Level B and MOS Part 139(H) requirements, to provide reliable rapid extinguishment and post-fire security, better protect passengers, crew, emergency responders (including firefighters), and our receiving environment.

- Permitting the use of high-purity C6 Fluorotelomer based foams meeting the requirements of 2017 European Commission regulation 2017/1000 in all ARFF applications. This provides adequate life safety protection to passengers, crew, emergency responders (including firefighters), the airport, and surrounding communities, critical infrastructure (including aircraft, fuel storage, hangars etc.), reputations, and our environment, under the wide range of increasingly severe climatic conditions being experienced for all Australian airports in future.

- Encouraging best practice in any firefighting foam system testing and training techniques regarding collection, containment, remediation and disposal, with the use of Fluorine free firefighting foams for training, regardless of the foam type most appropriate for front-line use on the emergency hazard (in accordance with FPA Australia Information Bulletin IB-06 guidance).

- Accepting cost-effective remediation techniques like OCRA to concentrate PFAS to minimal volumes prior to destruction would enable the more effective fuel shedding and vapour sealing high purity C6 foams to be used, while also capturing any legacy seepage from historic uses at airport sites.

This submission has dealt with these important matters regarding firefighting foam use by ARFF Services in considerable detail, with extensive justifying references, to help inform the Committee of the complex and often inter-related issues in this area. They directly relate to the criticality of quick, effective, efficient and reliable fire protection for all Australian airports, to better protect the life safety of all passengers, crew and emergency responders. These safety concerns should encourage the continued use of F3 for emergency front-line duties by Airservices Australia, to be extensively questioned by this Inquiry. Consideration of its use for extensive training and system testing only should be undertaken.

F3 agents have been in use by Airservices Australia since 2010 at all their main State and Territory airports around Australia, miraculously without any major incident to expose its evident weaknesses for this critical front-line role. Although this seems largely based on approval documentation meeting post 2014 ICAO Leve B fire test protocols[16], without any major aircraft accident success using F3s anywhere in the world (to our knowledge). This is likely to be placing the general public at unnecessarily increased risk of harm, which should not be permitted to perpetuate.

Caution is therefore recommended before embarking upon the continued use of any F3s for these often life critical applications in aviation ARFF Services. The Committee is urged to consider the requirement for tougher testing of firefighting foam agents, whether F3 or fluorinated, to ensure adequacy in the worst potentially realistic emergency fire incidents that may happen at any Australian airport - before the foam's acceptance for front-line life-saving duty.

Perhaps a transition to an environmentally more benign high purity short-chain C6 fluorinated fuel shedding and vapour sealing firefighting foam alternative, should be considered and recommended as part of this Inquiry outcomes? Such a foam should adequately meet higher fire performance test requirements than ICAO Level B (ie US Mil Spec[15] with its ongoing policing and strict product listing of the only acceptable products[106]) to provide adequate confidence and safety margin to ensure life safety is not being unnecessarily threatened.

Comparative 2013 video of side by side fire extinguisher testing [37] re-confirms 2008[38] and 2012 research[55-56], further endorsed by 2015 and 2017 US Naval Research laboratory data[31-33] that C6 fluorochemical based foams can be 3 times faster at extinguishing volatile hydrocarbon fuel fires than F3, and provide 4 times longer protection against re-ignition after the fire when C6 foam agents are used[37]. …It makes for compelling viewing www.youtube.com/watch?v=3MG2fogNfdQ

Fire Performance Criteria

Foam Property	Advantage	C6 AFFF	F3
Fuel Repellency *	Yes	Yes	No
Fuel Shedding*	High	High	Low
Fuel Pickup*	Low	Low	High
Film Formation*	Yes	Yes	No
Foam spreading on fuel*	Yes	Yes	No
Fuel spreading on foam*	No	No	Yes
Fuel emulsification	Low	Low	High
Flammability of contaminated foam	Low	Low	High
Degradation of contaminated foam	Low	Low	High
Heat resistance of foam	High	High	Low

*Fundamental differences between C6 AFFF and F3 foams

This foam fire performance criteria chart (left) helps to highlight key differences between these 2 foam types.

Similarly, this environmental impact criteria chart (right) helps to highlight key environmental differences between these 2 foam types. Slower fire control and more F3 usage with higher aquatic toxicity and increased BOD (from larger F3 volumes required for given sized fires) suggest F3 does not have the significant advantage some misleadingly continue suggesting. Particularly when fire water runoff contains noxious and sometimes proven carcinogenic breakdown products of the fire.

Environmental Impact Criteria

Environmental Property	Advantage	C6 AFFF	F3
Aquatic Toxicity*	Low	Low	10x Higher
Persistence*	No	Yes	No
Bioaccumulation	No	No	No
BOD (Biological Oxygen Demand)	Low	High	High
Reduced foam and water resources use*	Yes	Yes	No
Reduced smoke and breakdown products generated*	Yes	Yes	No
Risk to life safety *	Low	Low	High
Escalation potential *	Low	Low	High
Reduced volumes of firewater runoff*	Low	Low	High
Disposal through Waste Water Treatment Plant (WWTP or POTW)	Yes	Yes (except QLD)	Yes

*Fundamental differences between C6 AFFF and F3 foams

Fire water effluent (including that from system testing/training) could potentially be contaminated with a wide range of potentially polluting materials irrespective of the foam type used. This could include:

- Hydrocarbon fuels & burning residues
- VOC's Volatile Organic Compounds (VOC's)
- PAH's (Polycyclic Aromatic Hydrocarbons)
- Water soluble polymers
- PFAS residues from burned commercial products (*eg. carpets, upholstery, glossy magazines, food packaging, clothing, footwear, cosmetics, mobile phones etc etc.*)
- Carbon, organic matter, suspended and dissolved solids
- Biocides/pesticides
- Detergents
- Solvents
- Others

All fire water effluent is therefore potentially hazardous, regardless of the type of foam agent used. All fire water effluent from foam system testing or training should therefore be:

- Contained
- Tested for contamination
- Treated/Remediated

- Disposed of in accordance with local regulations

Key Factors Required for ARFF services

These key factors can be summarized as being widely considered essential for ARFF Services to provide effectively controlled and rapidly extinguished incidents, allowing adequate provision of life safety protection and minimised risk of incident escalation:

- Minimising life safety risks
- Minimising escalation potential
- Reducing damage, delay and business interruption
- Reducing risk of extensive reputational damage
- Reducing community disruption
- Reducing volumes of firewater runoff
- Reducing smoke and breakdown products generated
- Reducing foam and water resources needed and used
- Avoidance of Bioacumulative, and Toxic chemical usage
- Less risk of containment overflow into the environment
- Less Aquatic toxicity and potentially less damaging BOD impacts
- Less runoff to collect, treat and dispose of safely, according to local regulations.

The Fire Protection Association Australia's Information Bulletin IB-06[133] and the USA's FireFighting Foam Coalition –Best Practice Guidance for use of Class B Firefighting Foams[134] provide Industry best practice guidance.

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Appendix A – About Willson Consulting

Thank you for inviting an open and consultative submission process to engage with interested stakeholders as part of this Senate Inquiry. I am confident this approach will produce better, more broadly accepted, robust, meaningful, useful and implementable outcomes, which also have an increased chance of being understood, respected and valued by the wider Aviation community after its deliberations and recommendations are concluded, because of this process and the broader understanding achieved - which I hope will contribute to its final outcome.

Willson Consulting is nationally and internationally recognised for providing Environmental and Fire Protection Consultancy Services, specialising in the area of firefighting foams, foam systems, their suitability, applications, system designs, environmental impacts and remediation.

It is run by Director Mike Willson, B.Sc Hons, MCIM. Mike has over 30 year's fire industry experience as an international specialist in Class B firefighting foams, fluorinated and fluorine free, their application and impacts, and design of foam systems, with expertise across product development, systems design, performance testing and evaluation, end-user sector requirements, environmental impacts, remediation and major incident emergency response. He has a wide range of clients including foam users, manufacturers, fire service Cos, Industry Associations and provides guidance through the minefield of complexity surrounding firefighting foams, to help achieve the best outcomes in decision making.

He was nominated as UK foam expert to the UK Government's 2004 PFOS (PerFluoroOctanyl Sulphonate) Strategy Review. He contributed major improvements to bunded areas, storage tank protection and LNG application additions as a member of the European CEN Standard Committee's development of Fixed Foam Firefighting Systems standard EN13565-2:2009.

Mike is a Technical Advisory Committee member at Fire Protection Association Australia for Special Hazards (incl.Firefighting Foams), and has contributed major improvements to standards and Regulatory positions on PFAS chemicals and foams, while helping to ensure good fire protection is maintained.

He is therefore particularly well qualified to make representation in response to this Senate Inquiry, by explaining the relevant existing legislation framework, nationally and internationally and uncovering the full complexity of these firefighting foam performance and environmental issues.

These comments are intended to improve the understanding of strengths and weaknesses of both F3 and C6 short-chain foam agents. Realising the importance of fast, effective and reliable action to protect critical life safety, minimise incident escalation which also minimises the overall environmental and societal impacts of the whole incident's assessment. Hopefully it clarifies and justifies separation of dangerous legacy C8 PBT chemicals of the past, from environmentally more benign and acceptable C6 short-chain (not B, not T) alternatives of today, with an important supporting role for F3s, to provide better informed decision making. These C6 agents are widely considered essential to ensure reduced life safety dangers for passengers, crew, emergency responders, airport site personnel and nearby communities adjacent to all our Airports around Australia, into the future.

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