AWT Fire fighting foams

AWT has developed a surfactant technology which can reduce the surface tension of water to below 21 mN/m, a level previously only attainable through the use of toxic organosilicone or fluorinated surfactants.

Among the universal number of applications for the non-toxic AWT technology, its use in firefighting foams is perhaps the most significant because so much of the widespread PFOA and PFAS pollution has originated from fluorinated fire fighting foams.

The following paper provides an overview and comparative analysis of the AWT multi-phase surfactant technology applied to fire fighting foams.

The advantages of AWT technology have been detailed elsewhere but in summary:

- Not limited by micelle formation
- Is dose dependant, i.e. the higher the dose the greater is the reduction in surface tension. This is unique
- Non-toxic
- Environmentally friendly and rapidly breaks down in soils.

AWT formulations have been tested against the latest surfactants developed by BASF and Dow Chemicals and has been found to be considerably superior both in terms of detailed laboratory testing and also testing within BASF Ludwigshafen.

Given the implications of firefighting foams not performing, such foams must satisfy stringent military and civilian standards, including those of civil aviation.

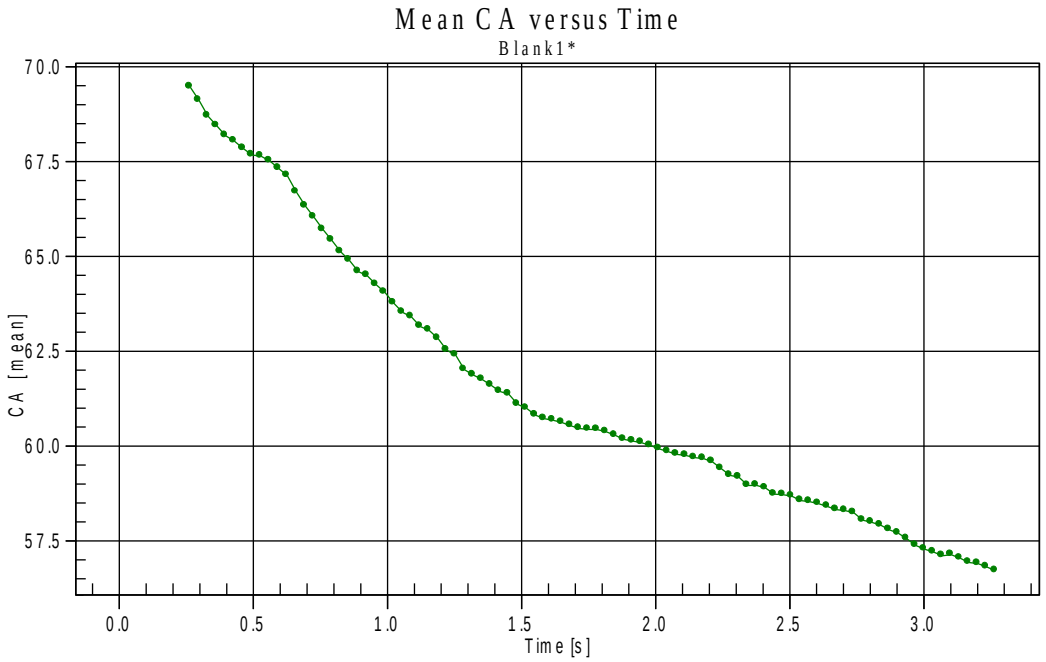
Firefighting foams are the most effective way of extinguishing fires that are hard to control and readily reignite such as liquid fuels and gases. They must readily spread over the fuel, expand rapidly and drain as slowly as possible to smother the fuel fire and prevent reignition.

With governments worldwide banning the production and use of fluoro surfactants, there is an environmental, economic and moral imperative not to the use of these highly toxic materials.

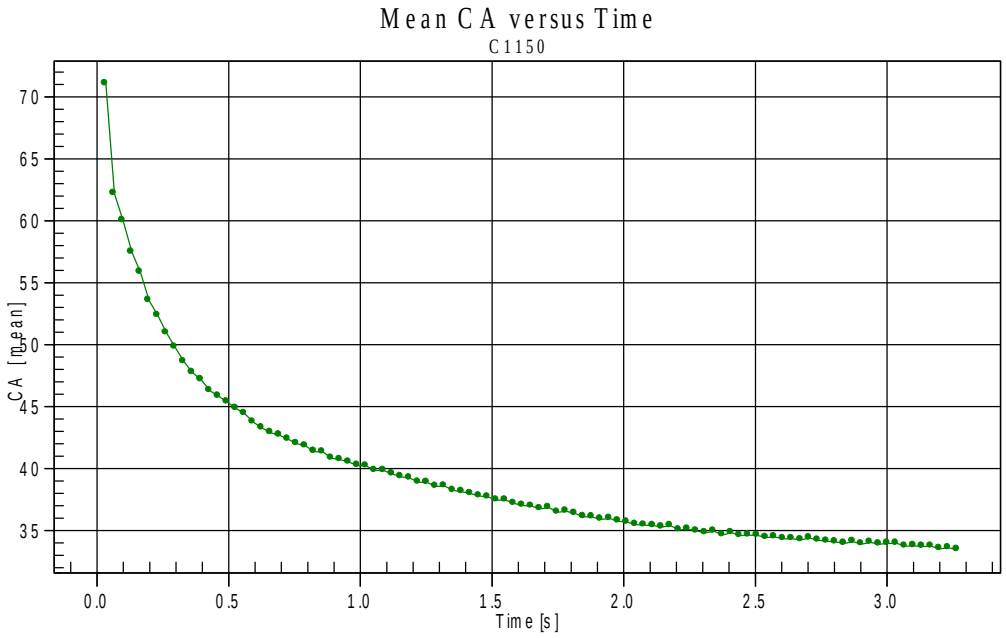
The focus has been to develop non-fluorinated materials that are effective. There are flouro free firefighting foams (FFFF) currently available however they use very crude surfactant technology based on non-ionic amphiphilic surfactants, alkoxylates or ethoxylates. Organo silicones have also been tried but without much success and here again they have long term environmental toxicity problems.

It has been imperative to develop systems that are significantly better than the currently used alternatives which are similar in performance to fluorinated materials. Such surfactants must be able to develop (expansion ratio) and maintain foam structure for as long as possible (drainage time) and enabling the foam to spread rapidly over the burning fuel.

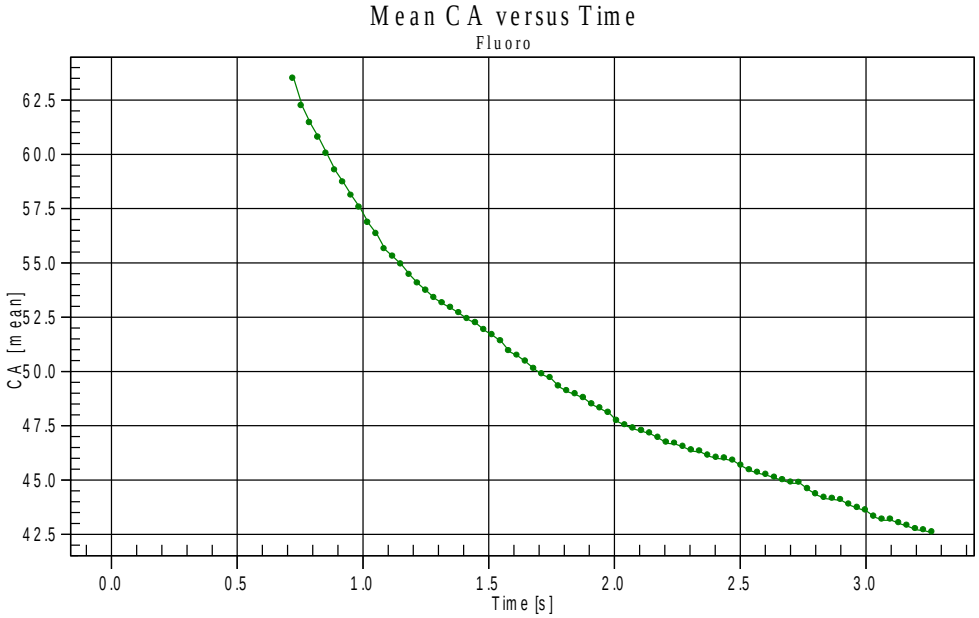
The first work on firefighting foams was with AWT formulation Evowet SS20 and tested against two fluorinated foams. The results are below. However even though it compared favourably against fluorinated foams the subsequent formulations tested are superior.



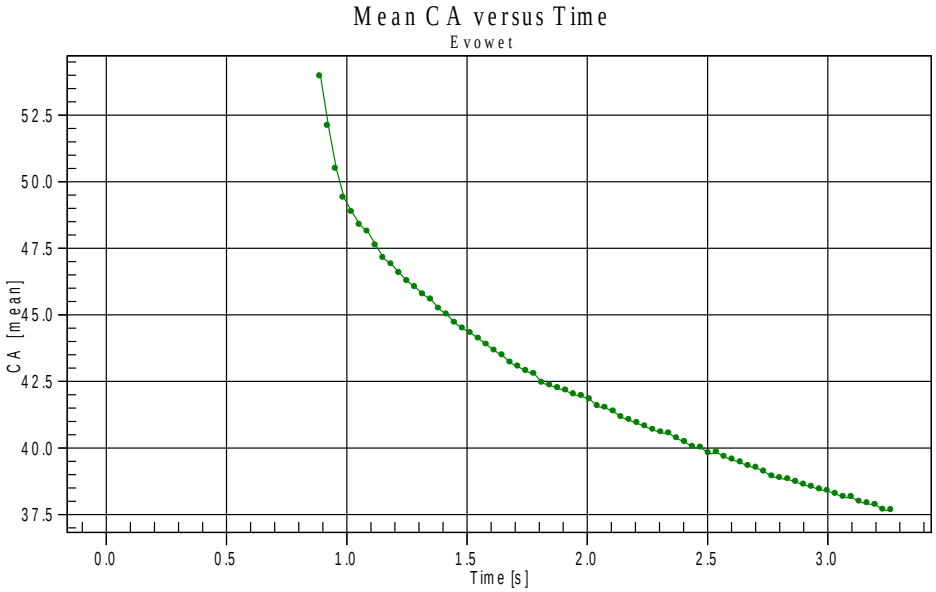
Blank i.e. no surfactant



Capstone 1150 fluoro surfactant note the exponential decay in contact angle i.e. wetting is slowing down and will never reach zero degrees



Fluorosurfactant again showing a somewhat exponential decay in wetting



This is Evowet SS20 an AWT formulation. Note the final contact angle is less than that of the fluoro and the decay becomes as linear (if not more so) than the fluoro. This combination had the best drainage rate and foam expansion ratio of any of the above. This is a very effective Class B Carbon repellent firefighting foam i.e. for fuel fires. The multi-phase surfactant formulation would also work for Class A (carbon attracting) firefighting foams as it already has been shown to be able to penetrate, wet or dry wood, plant foliage etc.

The competition is short fluorinated 1-4 carbon groups but these will be regulated out, and foams produced from non-film-forming surfactant formulations of which some of my formulations fall into. This is also what Solberg is working toward and I believe I have solved.

Solberg believe the most important gaps in knowledge comprise the lack of data on the dynamic surface tension of foams. This can be inferred from my data set.

Latest developments using AWT technology

AWT in conjunction with a joint venture company involving the University of NSW in Sydney have been asked to tender for supply of non-fluorinated surfactants for use in Class A and B firefighting foams by the Swedish and Australian defence as well as the Swedish airports corporation Swedavia AB. all of whom are very interested in "green" firefighting foams that currently perform better than existing non-fluorinated foams.

AWT formulations have been tested at a National Association of Testing Authorities (NATA) laboratory to the United Kingdom DEF STAN 42-40/2 and four AWT formulations when combined with Class B firefighting foams satisfied the necessary requirements of that standard. As such it can be sold as an alternative to Class B foams containing fluoro surfactants. NATA accredited facilities are recognised worldwide. The four selected for testing were added to the foam by the only manufacturer of such foams in Australia and were selected on the basis of their structural differences and wetting characteristics.

The summarised results of the testing show that the two critical characteristics of firefighting forms are:

- Expansion ratio where after application on the burning fuel, the greater the expansion ratio the greater is the opportunity to remove O_2 from the fire irrespective of fuel type, i.e no oxygen no fire.
- Drainage time is the time taken for the foam to break down and allow oxygen to re-establish the fire, i.e. reignition. The greater this value the longer it would take for the fuel to reignite. Given that after a period of time the areas surrounding the fuel are usually red hot, then this is a fundamental consideration.

Other key characteristics of firefighting foams are:

- Ability to withstand chemical attack from fuels such as gasoline, NATA data demonstrate that AWT formulations are highly resistant to such limitations.
- Speed of extinction of fire which from the results in *Table 1* is clearly demonstrated.
- Time to reignition, the longer the better and again in the table below this is ably demonstrated in a particularly harsh test.

AWT formulations performed very well with these two characteristics and even bettering the performance of the base foams and significantly exceeded the UK defence requirements..

AWT formulations are now being used in combination with Class A foams especially in the application of wildfire suppression in advance of the flame front. This means that the foam can be spread ahead of the fire when risk to firefighters is lower while not killing the vegetation. AWT formulations have been tested in detail and proven not to be phytotoxic hence the suitability for the task. Existing Class A foams have a surface tension in the high twenties however the AWT formulation Evowet SS20 reduces surface tension of such materials to below 24mN/m.

In addition, seven AWT foam formulations were subjected to very severe extinguishing and reignition tests, the method being:

1. Add the seven AWT formulations at a rate of 3% to foams.

2. Add 6mls of 1. above to 94mls of water.
3. In a fireproof pan add 160 mls of water.
4. Add 200mls of heptane
5. Mix to a foam until all the liquid phase is onverted to a foam.
6. Ignite heptane and leave for 20 seconds.
7. Pour foam onto heptane to extinguish fire measure time to extinguishment and leave for 10 seconds.
8. Using a butane blowtorch, at a single point apply the tip of the "Blue" flame to surface of foam.
9. Continue to apply blowtorch flame until the heptane reignites and measure the length of time in seconds between the application of the flame and heptane reignition. If the foam closes over continue to apply flame.

AWT formulation	**Time to extinguish (s)**	**Time for reignition (s)**	**Contact angle after 1s**	**Contact angle after 2m**
Evowet SS20 @ 3%	16.2	85	43.09	7.51
PCLL6 @ 3%	8.8	60	42.49	6.25
PCLL5 @ 3%	8	95	51.32	16.26
PCLL2 @ 3%	7.8	80	40.09	10.63
PCLL7 @ 3%	8.9	69	38.52	6.29
PCLL7A @ 3%	10.2	90	45.11	9.17
PCLL8 @ 3%	11.6	71	47.88	15.19
Blank @ 3%	13.4	70	47.14	17.52
Evowet SS20 @ 6%	10	83	42.5	13.57
PCLL6 @ 6%	5.2	98	34.49	5.87
PCLL2 @ 6%	10.3	95	40.44	16.24
PCLL5 @ 6%	10.1	107	44.32	11.99
PCLL7 @ 6%	17.9	70	43.05	13.84
PCLL7A @ 6%	9.5	110	39.96	7.1
PCLL8 @ 6%	9.2	97	46.0	18.65
Blank @ 6%	10.3	107	44.03	18.48

Table 1; Extinguishing and reignition performance of various AWT formulations added to a Class B firefighting foam at UNSW.

Detail about foam efficacy can be determined from drainage time i.e. breakdown of the foam which of course varies the time to reignition. In some instances when tested to the UK DEF STAN 42-40/2 these characteristics were improved with the addition of AWT formulations.

The clear result from this experimental work is that all of the foams with AWT wetting formulations extinguished the fire in less time than the blank foams at the two concentrations. This is clear from the table above where by and large AWT formulations wet much better than the blank foam and given other data these formulations actually enhance the foam characteristics. Reignition times in the main were longer with AWT formulations than without and this is a significant result because in a lot of instances the addition of a surfactant to improve spreading over the liquid or gaseous fuel actually degrades the fundamental characteristics of a firefighting foam.

AWT formulation PCLL2

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Foam Concentrate Test Report No: 4355LM

Date: 27/10/2020

Customer: Seaguard Chemicals	
Address : Unit 6, 130-132 Bayfield Road East Bayswater, VIC 3153	
Customer P/O: PO-0560	**Ref:** Robert Bennett

Supplied Sample Identification:

Foam Brand/Type & %: Said to be 6% Fluorine Free Foam
Site/Location of Sample: Batch PCLL # 2
Type of Storage: Not Stated

Physical Characteristics (at 20 deg. Celsius)

TEST	REQUIREMENTS	In-House Method	RESULT	MU	COMPLIANCE
Specific Gravity	* 1.000 -1.100	STM003	1.012	±0.002	Complies
pH	6.0 – 8.5 UK DEF STAN 42-40/2	STM004	7.2	± 0.03	Complies
Sediment	%v/v Max 1.0 UK DEF STAN 42-40/2	STM002	< 0.03	± 0.03	Complies
Surface Tension	* > 20 mN/m	STM006	23.2	± 0.09	Complies

Test results are consistent with concentrate type: 6% Fluorine Free Foam

Gamil Ibrahim MRACI C Chem
Director/Laboratory Manager
Authorised Signatory
MasterChem Services Australia P/L

Gamil S. Ibrahim MRACI

NATA Accredited Laboratory Number 17315. Accredited for compliance with ISO/IEC 17025 Testing. The results of the tests, calibration and/or measurements included in this document are traceable to Australia/national standards. NATA is a signatory to the ILAC mutual recognition arrangement for the mutual recognition of equivalence of testing, calibration and inspection reports. This report shall not be reproduced except in full.

IMPORTANT NOTE: TEST RESULTS RELATE ONLY TO THE SAMPLE SUPPLIED. UNLESS OTHERWISE STATED, THE CLIENT IS RESPONSIBLE FOR OBTAINING SAMPLES IN SUCH MANNER THAT THEY REPRESENTATIVE OF THE FOAM STOCK FROM WHICH THEY ARE DRAWN.

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Foam Performance Characteristics (at 20 deg. Celsius) Tested at 6%

TEST	REQUIREMENTS	In-House Method	RESULT	MU	COMPLIANCE
Expansion	≥ 7:1 ≤ 20:1 UK DEF STAN 42-40/2	STM005	8.85	± 0.03	Complies
25%Drain Time	≥ 3 Minutes 30 Seconds UK DEF STAN 42-40/2	STM005	7' 05''	± 07''	Complies
Film Formation Coverage Time Seal 50% Burn back	* MasterChem In-House Specification ≤ 60 Seconds Must Seal ≥ 10 Seconds	STM009	N/A	± 01''	N/A
Petrol Tolerance	* < 60 Seconds	STM010	No Ignition	± 04''	Complies
Alcohol Resistance	* > 60 Seconds Using Isopropyl Alcohol	STM008	N/A	± 06''	N/A
Comments	The physical properties and foam performance characteristics are in a satisfactory condition and do comply with UK DEF STAN 42-40/2 requirements and In-House Quality Assurance specification.				

Notes:

1. The uncertainty of measurement reported with a confidence level of 95% and a Coverage Factor of 2.0
2. * MasterChem In-House Quality Assurance Specification.
3. Foam generated using the UK Defence Standard DEF 42-40 5Lpm branchpipe at 7 bar pressure. Foam collected in a 1630ml NFPA drainage pan.

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This certificate is valid until
2021-10-27

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Test Report No. 4355LM Page 2 of 2

This formulation had better foam characteristics i.e. expansion ratio and drainage time than the blank foam itself. This Class B foam is to be offered to the Swedish military forces and Swedavia AB who which owns and operates ten of Sweden's busiest airports who have shown interest in the technology. In addition the Australian Defence Forces are also interested in the Class B foam with AWT's PCLL2 multi-phase super wetter.

AWT formulation PCLL6

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Foam Concentrate Test Report No: 4357LO

Date: 27/10/2020

Customer: Seaguard Chemicals	
Address : Unit 6, 130-132 Bayfield Road East Bayswater, VIC 3153	
Customer P/O: PO-0560	**Ref:** Robert Bennett

Supplied Sample Identification:

Foam Brand/Type & %: Said to be 6% Fluorine Free Foam
Site/Location of Sample: Batch PCLL # 6
Type of Storage: Not Stated

Physical Characteristics (at 20 deg. Celsius)

TEST	REQUIREMENTS	In-House Method	RESULT	MU	COMPLIANCE
Specific Gravity	* 1.000 -1.100	STM003	1.013	±0.002	Complies
pH	6.0 – 8.5 UK DEF STAN 42-40/2	STM004	7.2	± 0.03	Complies
Sediment	%v/v Max 1.0 UK DEF STAN 42-40/2	STM002	< 0.03	± 0.03	Complies
Surface Tension	* > 20 mN/m	STM006	23.2	± 0.09	Complies

Test results are consistent with concentrate type: 6% Fluorine Free Foam

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Foam Performance Characteristics (at 20 deg. Celsius) Tested at 6%

TEST	REQUIREMENTS	In-House Method	RESULT	MU	COMPLIANCE
Expansion	≥ 7:1 ≤ 20:1 UK DEF STAN 42-40/2	STM005	8.42	± 0.03	Complies
25%Drain Time	≥ 3 Minutes 30 Seconds UK DEF STAN 42-40/2	STM005	5` 30``	± 07``	Complies
Film Formation Coverage Time Seal 50% Burn back	* MasterChem In-House Specification ≤ 60 Seconds Must Seal ≥ 10 Seconds	STM009	N/A	± 01``	N/A
Petrol Tolerance	* < 60 Seconds	STM010	No Ignition	± 04``	Complies
Alcohol Resistance	* > 60 Seconds Using Isopropyl Alcohol	STM008	N/A	± 06``	N/A
Comments	The physical properties and foam performance characteristics are in a satisfactory condition and do comply with UK DEF STAN 42-40/2 requirements and In-House Quality Assurance specification.				

Notes:

1. The uncertainty of measurement reported with a confidence level of 95% and a Coverage Factor of 2.0
2. * MasterChem In-House Quality Assurance Specification.
3. Foam generated using the UK Defence Standard DEF 42-40 5Lpm branchpipe at 7 bar pressure. Foam collected in a 1630ml NFPA drainage pan.

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2021-10-27

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AWT formulation PCLL5

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Foam Concentrate Test Report No: 4356LN

Date: 27/10/2020

Customer: Seaguard Chemicals	
Address : Unit 6, 130-132 Bayfield Road East Bayswater, VIC 3153	
Customer P/O: PO-0560	**Ref:** Robert Bennett

Supplied Sample Identification:

Foam Brand/Type & %: Said to be 6% Fluorine Free Foam
Site/Location of Sample: Batch PCLL # 5
Type of Storage: Not Stated

Physical Characteristics (at 20 deg. Celsius)

TEST	REQUIREMENTS	In-House Method	RESULT	MU	COMPLIANCE
Specific Gravity	* 1.000 -1.100	STM003	1.013	±0.002	Complies
pH	6.0 – 8.5 UK DEF STAN 42-40/2	STM004	7.4	± 0.03	Complies
Sediment	%v/v Max 1.0 UK DEF STAN 42-40/2	STM002	< 0.03	± 0.03	Complies
Surface Tension	* > 20 mN/m	STM006	24.2	± 0.09	Complies

Test results are consistent with concentrate type: 6% Fluorine Free Foam

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Foam Performance Characteristics (at 20 deg. Celsius) Tested at 6%

TEST	REQUIREMENTS	In-House Method	RESULT	MU	COMPLIANCE
Expansion	≥ 7:1 ≤ 20:1 UK DEF STAN 42-40/2	STM005	8.60	± 0.03	Complies
25%Drain Time	≥ 3 Minutes 30 Seconds UK DEF STAN 42-40/2	STM005	4' 24''	± 07''	Complies
Film Formation Coverage Time Seal 50% Burn back	* MasterChem In-House Specification ≤ 60 Seconds Must Seal ≥ 10 Seconds	STM009	N/A	± 01''	N/A
Petrol Tolerance	* < 60 Seconds	STM010	No Ignition	± 04''	Complies
Alcohol Resistance	* > 60 Seconds Using Isopropyl Alcohol	STM008	N/A	± 06''	N/A
Comments	The physical properties and foam performance characteristics are in a satisfactory condition and do comply with UK DEF STAN 42-40/2 requirements and In-House Quality Assurance specification.				

Notes:

1. The uncertainty of measurement reported with a confidence level of 95% and a Coverage Factor of 2.0
2. * MasterChem In-House Quality Assurance Specification.
3. Foam generated using the UK Defence Standard DEF 42-40 5Lpm branchpipe at 7 bar pressure. Foam collected in a 1630ml NFPA drainage pan.

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2021-10-27

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AWT formulation PCLL7

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Foam Concentrate Test Report No: 4358LP

Date: 27/10/2020

Customer: Seaguard Chemicals	
Address : Unit 6, 130-132 Bayfield Road East Bayswater, VIC 3153	
Customer P/O: PO-0560	**Ref:** Robert Bennett

Supplied Sample Identification:

Foam Brand/Type & %: Said to be 6% Fluorine Free Foam
Site/Location of Sample: Batch PCLL # 7
Type of Storage: Not Stated

Physical Characteristics (at 20 deg. Celsius)

TEST	REQUIREMENTS	In-House Method	RESULT	MU	COMPLIANCE
Specific Gravity	* 1.000 -1.100	STM003	1.015	±0.002	Complies
pH	6.0 – 8.5 UK DEF STAN 42-40/2	STM004	7.4	± 0.03	Complies
Sediment	%v/v Max 1.0 UK DEF STAN 42-40/2	STM002	< 0.03	± 0.03	Complies
Surface Tension	* > 20 mN/m	STM006	24.3	± 0.09	Complies

Test results are consistent with concentrate type: 6% Fluorine Free Foam

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Foam Performance Characteristics (at 20 deg. Celsius) Tested at 6%

TEST	REQUIREMENTS	In-House Method	RESULT	MU	COMPLIANCE
Expansion	≥ 7:1 ≤ 20:1 UK DEF STAN 42-40/2	STM005	9.15	± 0.03	Complies
25%Drain Time	≥ 3 Minutes 30 Seconds UK DEF STAN 42-40/2	STM005	4` 05``	± 07``	Complies
Film Formation Coverage Time Seal 50% Burn back	* MasterChem In-House Specification ≤ 60 Seconds Must Seal ≥ 10 Seconds	STM009	N/A	± 01``	N/A
Petrol Tolerance	* < 60 Seconds	STM010	No Ignition	± 04``	Complies
Alcohol Resistance	* > 60 Seconds Using Isopropyl Alcohol	STM008	N/A	± 06``	N/A
Comments	The physical properties and foam performance characteristics are in a satisfactory condition and do comply with UK DEF STAN 42-40/2 requirements and In-House Quality Assurance specification.				

Notes:

1. The uncertainty of measurement reported with a confidence level of 95% and a Coverage Factor of 2.0
2. * MasterChem In-House Quality Assurance Specification.
3. Foam generated using the UK Defence Standard DEF 42-40 5Lpm branchpipe at 7 bar pressure. Foam collected in a 1630ml NFPA drainage pan.

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