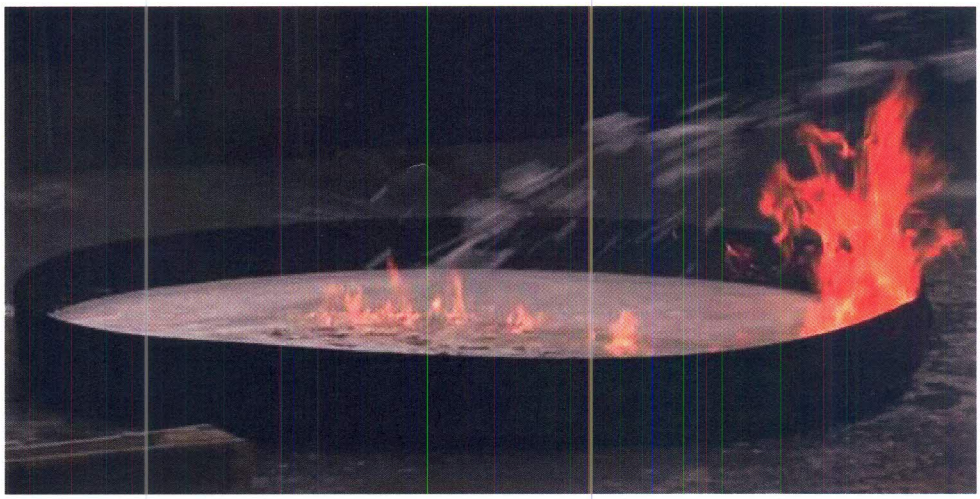
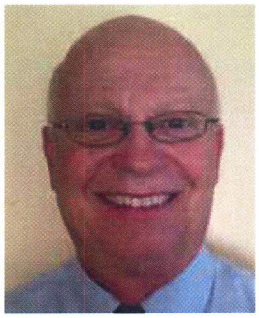


Typical ICAO Level B performance of tested F3s at one-minute

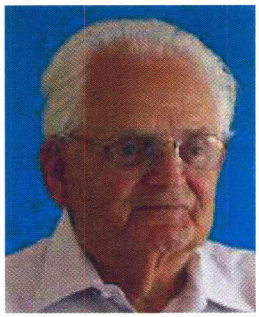
Independent Evaluation of Fluorine Free Foams (F3)

A Summary of ICAO Level B & EN 1568 Fire Test Results



Mitch Hubert

Chang Jho



Eduard K. Kleiner

Dynax Corporation

Dynax Corporation is a major producer of C6-telomer-based fluorosurfactants and fluorochemical foam stabilisers for use in AFFF, AR-AFFF, FP, FFFP and AR-FFFP agents, and a founding member of the Fire Fighting Foam Coalition (FFFC). In the past, Dynax has received from customers and other sources conflicting information regarding the fire performance levels of Fluorine Free Foam (F3) agents, particularly against the ICAO Level B foam standard. Despite individual attempts by some foam manufacturers in the past, F3 agents have rarely been subjected to an independent and comparative evaluation under the same test conditions.

As a member of the Fire Fighting Foam Coalition (FFFC) Dynax is involved in the evaluation of the proposed ICAO Level C standard that has recently raised some serious issues, such as extending the extinguishment time requirements by permitting flicker fires from 60 seconds to 120 seconds. If adopted, this change of extinguishment time requirements would also apply to the existing ICAO Level A and B standards.

In an effort to obtain independent and comparative fire performance data on F3 agents under the same test conditions, Dynax, as the sponsor of this project, commissioned Resource Protection International (RPI) to provide an independent third-party witnessing service for the fire tests according to ICAO Level B and EN 1568 (Part 3 and 4). RPI is uniquely qualified to witness such tests as it has sitting members on the NFPA and EN Foam Technical Committees, as well as being LASTFIRE testing coordinators and LASTFIRE steering committee members. Dafo Fomtec and Falk Nutec provided logistical support. The test data presented in this article is taken directly from the full report prepared by RPI.

TABLE 1 – ICAO LEVEL B TEST RESULTS

Test Configuration: ICAO Level B
Test Fuel: Jet A1 / Premix: in Fresh water

Test Product	Nozzle	FXR	QDT	CT (90%)	CT (99%)	EXT	BB (25%)	Pass/Fail
Product A-F3-6%	UNI 86	9.6	18:26	0:35	0:45	None	N/A	Fail
	MMS	4.8	10:56	0:30	0:45	1:58	(6:45)	Fail
Product B-F3-3%/6%	UNI 86	10.2	15:07	0:40	0:45	1:24	(7:50)	Fail
	MMS	4.9	5:35	0:35	0:55	None	N/A	Fail
Product C-F3-3%	UNI 86	9.6	16:16	0:50	1:05	2:00	(8:30)	Fail
	MMS	4.5	18:38	0:50	1:45	None	N/A	Fail
Product D-F3-3%/3%	UNI 86	8.5	22:57	0:55	1:05	1:40	(9:50)	Fail
Product E-F3-3%/6%	UNI 86	7.4	17:00	0:40	0:55	1:50	(8:05)	Fail

MMS (Modified Militatry Specification); FXR (Foam Expansion Ratio); QDT (Quarter Drain Time); CT (Control Time); EXT (Extinguishment Time); BB (Burnback Time)

TABLE 2 – EN 1568-3 TEST RESULTS (FORCEFUL APPLICATION)

Test Configuration: EN 1568-3 / FORCEFUL Application
Test Fuel: Heptane / Premix: in Fresh water

Test Product	Nozzle	FXR	QDT	CT (90%)	CT (99%)	EXT	BB (25%)	Class
Product A-F3-6%	UNI 86	9.3	25:16	0:45	1:25	None	N/A	Fail
	UNI 86	8.8	18:25	0:25	1:00	None	N/A	Fail
	MMS	4.6	10:25	0:45	1:20	None	N/A	Fail
	MMS	5.0	9:33	0:40	2:50	None	N/A	Fail
Product B-F3-3%/6%	UNI 86	9.3	16:57	0:50	1:10	None	N/A	Fail
	MMS	4.5	6:04	0:55	DNA	None	N/A	Fail
Product C-F3-3%	UNI 86	8.5	21:32	0:45	1:20	1:49	6:00	→
	MMS	4.2	18:28	0:40	3:00	None	N/A	→
Product D-F3-3%/3%	UNI 86	8.7	19:11	0:40	1:15	2:09	5:55	→
	MMS	5.1	15:34	0:50	DNA	None	N/A	→

MMS (Modified Militatry Specification); FXR (Foam Expansion Ratio); QDT (Quarter Drain Time); CT (Control Time); EXT (Extinguishment Time); BB (Burnback Time); DNA (Did Not Achieve); → (Followed by Gentle application test)

TABLE 3 – EN 1568-3 TEST RESULTS (GENTLE APPLICATION)

Test Configuration: EN 1568-3 / GENTLE Application
Test Fuel: Heptane / Premix: in Fresh water

Test Product	Nozzle	FXR	QDT	CT (90%)	CT (99%)	EXT	BB (25%)	Class
Product A-F3-6%	UNI 86	9.3	25:16	0:35	1:00	None	N/A	Fail
	UNI 86	8.8	18:25	0:35	1:00	None	N/A	Fail
	MMS	4.6	10:25	1:00	1:40	None	N/A	Fail
	MMS	5.0	9:33	0:55	1:15	3:40	13:00	IIIC
Product B-F3-3%/6%	UNI 86	9.3	16:57	0:40	1:20	None	N/A	Fail
	MMS	4.5	6:04	1:00	1:45	None	N/A	Fail
Product C-F3-3%	UNI 86	8.5	21:32	0:35	1:20	2:17	24:30	IB
	MMS	4.2	18:28	0:45	1:55	4:05	23:30	IIIB
Product D-F3-3%/3%	UNI 86	8.7	19:11	0:35	1:05	1:40	21:50	IB
	MMS	5.1	15:34	0:45	1:30	2:50	12:45	IIIC
Product E-F3-3%/6%	UNI 86	8.7	18:04	0:45	1:25	2:08	17:00	IIIB
	MMS	4.4	5:58	1:25	2:10	None	(10:40)	Fail

MMS (Modified Militatry Specification); FXR (Foam Expansion Ratio); QDT (Quarter Drain Time); CT (Control Time); EXT (Extinguishment Time); BB (Burnback Time);

ICAO Level B & EN 1568 Fire Test Program

In May of 2012, a series of 38 fire tests were carried out with five different Fluorine Free Foam (F3) agents by the Danish Fire Laboratories (DFL) at the outdoor fire testing and training facilities of Falk Nutec in Esbjerg, Denmark. ICAO Level B and EN 1568 tests were conducted in fresh water. Although the ICAO Level B Standard allows nozzle movement in a horizontal plane during the test, all tests in this program were run with the nozzle in a fixed position to improve the reproducibility in comparing the performance of the F3 agents.

The main objectives of this extensive fire test program were to:

- Confirm if the selected group of F3 agents meet, under the same test conditions, the requirements of ICAO Level B and EN 1568 (Part 3 and 4).
- Compare the above test results obtained with the UNI 86 nozzle (the nozzle specified in ICAO and EN 1568 Parts 3&4) with results obtained with a modified air-aspirating US Mil-Spec (MMS) nozzle providing the same nominal flow rate as the UNI 86 nozzle but approximately half the foam expansion and drain time values. The results of these comparative fire tests are considered important, because many commercial air-aspirating foam discharge devices, such as hand-line nozzles, branch-pipes and high flow turrets, generate foams with considerably lower expansion and drain time characteristics than those obtained with the UNI 86 nozzle.
- Determine if all the F3 agents included in this study are free of fluorine.

Test Samples

With one exception, the test samples were all commercial products purchased on the open market just prior to the test program. These products represent sampling of the major F3 agents currently available on the market. The F3 agents tested are coded as follows:

- Product A-F3-6%.
- Product B-F3-3%/6%.
- Product C-F3-3%.
- Product D-F3-3%/3% (a developmental product).
- Product E-F3-3%/6%

Results

As expected, test results showed variability between manufacturers. In general, the foams tested showed reasonable fire control but suffered persistent edge flicker fires so they failed to extinguish at all, or only extinguished with considerable difficulty.

Of particular interest were the results obtained from the ICAO Level B testing (Table 1), because a few airports and aerodromes have recently started using F3 agents in lieu of AFFF or FFFP agents.

When the nozzle was maintained in a fixed position, these tests showed that none of the F3 agents extinguished the fire within the maximum 60-second time limit specified in the ICAO Standard. Contrary to the expectation that the sloppier foam obtained from the MMS nozzle might provide a faster knockdown and extinguishment on aviation kerosene (Jet A1), control times actually got longer with the MMS nozzle in two out of the three tests, and in both of these cases extinguishment was not achieved.

EN 1568-3 test results summarised in Table 2

and 3 also show variability in performance between agents.

These sets of data have shown that only three of the five agents tested were able to gain an EN 1568-3 class rating. In all cases, the control and extinguishment times extended considerably as the UNI 86 nozzle was switched to the MMS nozzle. It is noted that none of the agents in this test program achieved an IA forceful application rating (Table 2). Even under the gentle application conditions (Table 3), some F3 foams failed to extinguish the fire when the MMS nozzle was used.

For EN 1568-4 testing (Table 4), only the three agents claiming polar solvent performance were tested. Only the developmental F3 agent passed these fire tests using both acetone and isopropyl alcohol (IPA). In general, all F3 agents did quite well on the acetone fire but poorly on the IPA fire.

All of the test results are summarised in Table 5.

TABLE 4 – EN 1568-4 TEST RESULTS

Test Configuration: EN 1568-4 / GENTLE Application
Test Fuel: IPA / Premix: in Fresh water

Test Product	Nozzle	FXR	QDT	CT (90%)	CT (99%)	EXT	BB (25%)	Class
Product B-F3-3%/6%	UNI 86	9.1	45:30	DNA	DNA	40% at 5 min	N/A	Fail
Product D-F3-3%/3%	UNI 86	8.2	19:22	1:25	1:55	2:06	15:15	IA
	MMS	5.0	16:15	1:45	2:10	2:57	15:30	IA
Product E-F3-3%/6%	UNI 86	8.1	44:27	1:50	2:25	3:00	8:45	IC
	MMS	4.9	21:57	DNA	DNA	50% at 5 min	N/A	Fail

Test Fuel: Acetone / Premix: in Fresh water

Test Product	Nozzle	FXR	QDT	CT (90%)	CT (99%)	EXT	BB (25%)	Class
Product B-F3-3%/6%	UNI 86	9.1	45:30	1:15	1:35	2:15	12:15	IB
Product D-F3-3%/3%	UNI 86	8.2	19:22	0:25	0:45	1:04	16:55	IA
Product E-F3-3%/6%	UNI 86	0:30	44:27	0:30	0:45	1:12	19:00	IA

MMS (Modified Militatry Specification); FXR (Foam Expansion Ratio); QDT (Quarter Drain Time); CT (Control Time); EXT (Extinguishment Time); BB (Burnback Time); DNA (Did Not Achieve)

Discussion

The F3 agents tested showed differences in fire performance between manufacturers and fuel types. Most agents during this test program suffered from persistent edge flicker fires causing problems meeting the extinguishment requirements. The results of these tests with a higher foam expansion UNI 86 nozzle and a lower foam expansion MMS nozzle show that firefighting effectiveness decreases with the foam quality.

The foam expansion and drain time values from the MMS nozzle are more realistic of the foam quality typically obtainable from real-world air-aspirated discharge devices. This drop-off in performance should be of major concern to any users of F3 agents. Many municipal and industrial fire brigades have switched away from air-aspirated discharge devices in favour of variable pattern non-aspirating nozzles. While these non-aspirating devices work effectively with fluorine-containing foams, the use of such devices with F3 agents seems to be questionable. Likewise, some ARFF vehicles have gone away from air-aspirating turrets and hand-lines in favour of non-aspirating devices in order to achieve greater reach of the foam from the turret and hand-lines and faster knockdown of the fire.

Surprisingly, all of the F3 agents tested failed to pass ICAO Level B performance requirements. A few airports and aerodromes have recently converted away from the conventional fluorine-containing foam agents such as AFFF and FFFP to F3 agents.

The failure of F3 foams to perform under forceful application conditions in both ICAO Level B and EN 1568-3 appears to be related to fuel contamination effects that are expected to be more pronounced under direct, forceful application conditions. Foams generated from the MMS nozzle are heavier and therefore expected to pick up more fuel than the lighter but unrealistic foams produced by the UNI 86 nozzle.

TABLE 5 – SUMMARY OF TEST RESULTS

Test Fuel / Mode of Application	Nozzle	ICAO Level B Jet A1	EN 1568-3 Heptane Forceful	EN 1568-3 Heptane Gentle	EN 1568-4 IPA Gentle	EN 1568-4 Acetone Gentle
Product A-F3-6%	UNI 86	Fail	Fail	Fail	–	–
	MMS	Fail	Fail	Fail / IIIC	–	–
Product B-F3-3%/6%	UNI 86	Fail	Fail	Fail	Fail	IB
	MMS	Fail	Fail	Fail	–	–
Product C-F3-3%	UNI 86	Fail	→	IB	–	–
	MMS	Fail	→	IIIB	–	–
Product D-F3-3%/3%	UNI 86	Fail	→	IB	IA	IA
	MMS	–	→	IIIC	IA	–
Product E-F3-3%/6%	UNI 86	Fail	–	IIIB	IC	IA
	MMS	–	–	Fail	–	–

ICAO: Fail – No extnguishment within 1 minute
EN 1568-3 (Forceful): Fail – No extinguishment within 3 minutes
EN 1568-3 (Gentle): Fail – No extinguishment within 5 minutes
EN 1568-4: Fail – No extinguishment within 5 minutes
→ : Indicates the test was repeated with Gentle Application

Conclusions

Five F3 agents were independently evaluated and compared under the same test conditions against the fire performance standards of ICAO Level B and EN 1568. In this test program, all failed to meet the ICAO Level B test requirements. Against EN 1568-3, none of the products met the IA class ratings under direct, forceful application conditions; some achieved the ratings only with indirect, gentle applications. Significant deterioration of firefighting performance was observed when the MMS test nozzle was used delivering foams with quality more realistic of widely used foam turrets and hand-lines.

Laboratory analysis of all F3 foams tested confirmed that they are fluorine free. APF

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For further information, go to www.dynaxcorp.com