A comparison of the fire suppression performance of compressed air foam with air aspirated and unexpanded foam-water solution

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Abstract

Compressed-air foam (CAF) has been proven to be an effective fire suppression material for both Class A and B fires. Comparison testing between CAF, air-aspirated and foam water solution had not been conducted previously to quantify the amount of foam required to extinguish a liquid fuel fire.

This paper describes a series of full-scale Class B fire tests designed to compare CAF (Compressed-air Foam), air-aspirated, and foam water solution in extinguishing a 4.64 m^2 pool fire in accordance with CAN/ULC-S560-98 Standard for Category 3 Aqueous Film-Forming Foam (AFFF) Liquid Concentrates.

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Comparison of the Fire Suppression Performance of Compressed-Air Foam with Air Aspirated and Unexpanded Foam Water Solution

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1.0 Introduction

1.1 Background

It should first be noted to avoid confusion that "foam" refers to a solution of water and foam concentrate that has been expanded by air to form a bubble structure. Expansion ratio refers to how much the volume of the solution has increased. Air can be injected under pressure (CAF) or through entrainment. Air aspirated foam is created close to or in the nozzle by entraining air with a water jet and impacting on one or more obstacles. Some of the energy of the stream is used to agitate the mixture and foam is produced. "Foam-water" refers to a foam solution of water and foam concentrate that has not been expanded by air.

Compressed-air foam (CAF) has been proven to be an effective fire suppression material for both Class A and B fires, however, the effectiveness of CAF compared to air-aspirated systems and foam water systems has not yet been quantified. While air-aspirated foam systems have been around for many years, the development of high quality Aqueous Film-Forming Foam (AFFF) concentrates have allowed foam systems with little or no air expansion to be used in controlling large flammable liquid fuel fires. To effectively compare these systems, a series of 22 full-scale fire tests were conducted with CAF, air-aspirated foam and foam water solution using the CAN/ULC-S560-98 Standard for Category 3 Aqueous Film-Forming Foam (AFFF) Liquid Concentrates [1] as a guide.

Extinguishment density is a calculation determined by the applied flow rate multiplied by the time to extinguishment and divided by the area of the pan fire. This yields a quantity of material per unit area that is required to extinguish the fire. This number is independent of time and provides a good measure of comparison between systems. It also establishes minimum application densities that can act as guidelines for more practical applications. Extinguishment densities would be calculated for each test in this series that proved successful in extinguishing the fire.

1.2 Project Description

This report describes a series of 22 full-scale Class B fire tests designed to compare CAF, air-aspirated, and foam water solution in extinguishing a 4.64 m^2 pool fire in accordance with CAN/ULC-S560-98 [1]. In addition to visual observations, radiant heat flux was also measured at a point 1.83 m from the edge of the fuel pan and 1.5 m off the ground.

The Standard deals with many aspects of the foam concentrate that were not addressed in this test series such as sedimentation, surface tension, precipitation, environmental impact and corrosion to name a few. The areas that were studied were those specifically pertaining to foam expansion and drainage and fire performance, specifically the 4.6 m^2 fire test and burn back. Deviations from the test procedure involved the use of heptane fuel and regular gasoline instead of grade 80 aviation gasoline. Also the pass / fail criteria was not used and the fuel load was increased from 55 L to 80 L to permit extinguishment times longer than 1 min. Heptane was used for most of the fire tests so that comparisons of these results with those conducted under UL162 Foam Equipment and Liquid Concentrates could be made.

2.0 Test Details

2.1 Test Facility

The tests were conducted indoors at the Fire Risk Management Program's National Fire Laboratory where the burn hall measures 55 m long by 30 m wide by 12 m high. At the time of the experiments, the ambient temperature was between 12 and 20°Celsius. The 4.64 m^2 test pan measured 2.43 m in diameter with a wall thickness of 6 mm and a wall height of 125 mm (see Figure 1). The fuel was floated on 5 mm of water to ensure complete coverage of the pan. Each test used 80 L of heptane with the exception of Tests 16 to 19, where regular winter formula gasoline was used for comparison. Heptane fuel was chosen due to its consistent nature and for comparison with the previous testing performed by NRC under the UL 162 Standard for Foam Equipment and Liquid Concentrates [2]. All of the tests were videotaped for record purposes.

Extinguishment data was taken using a 2 w/cm^2 heat flux meter and Solartron data acquisition system*.

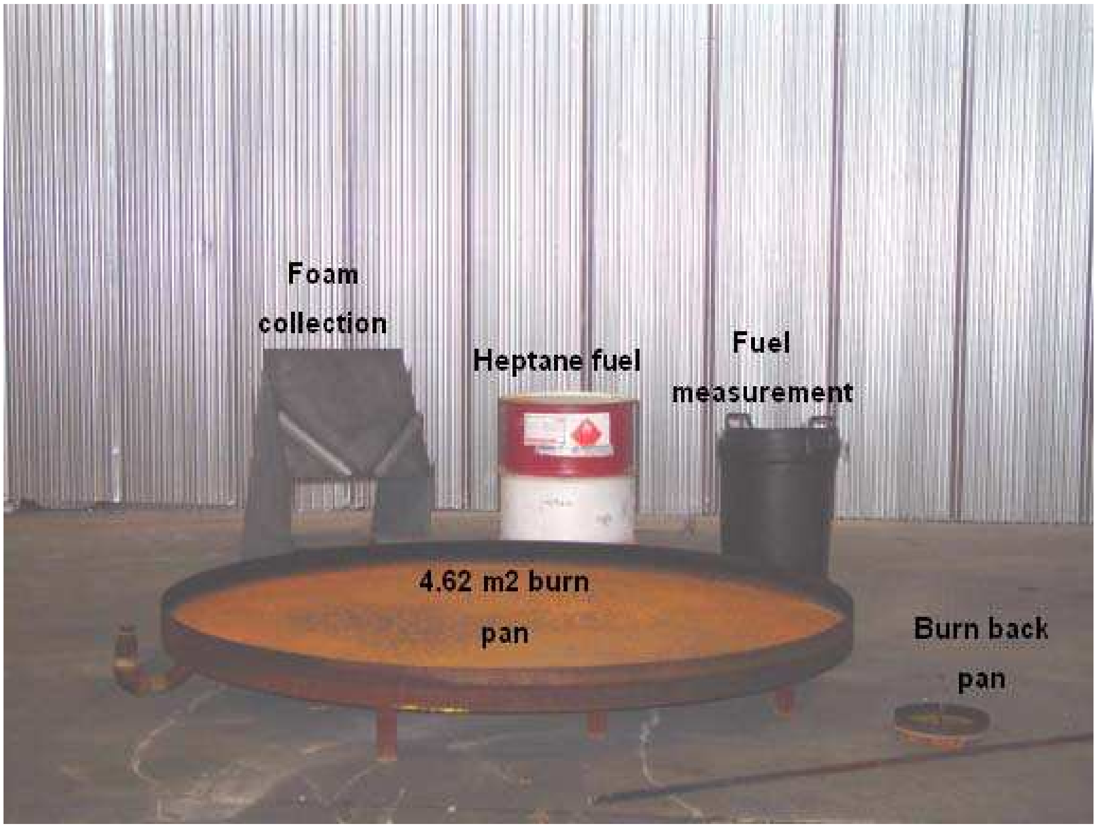

Figure 1. Fire test apparatus

2.2 Foam Delivery Systems

All of the foam systems delivered the same solution flow rate of 7.6 L per min. The solution was premixed in a cylinder that was pressurized to between 80 and 100 psi (Figures 2a & 2b). This was necessary to achieve the exact flow rate for each apparatus.

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*Certain commercial products are identified in this paper in order to adequately specify the experimental procedure. In no case does such identification imply recommendations or endorsement by the National Research Council, nor does it imply that the product or material identified is the best available for the purpose.

Figure 2a. Weigh scale and foam expansion and drain apparatus

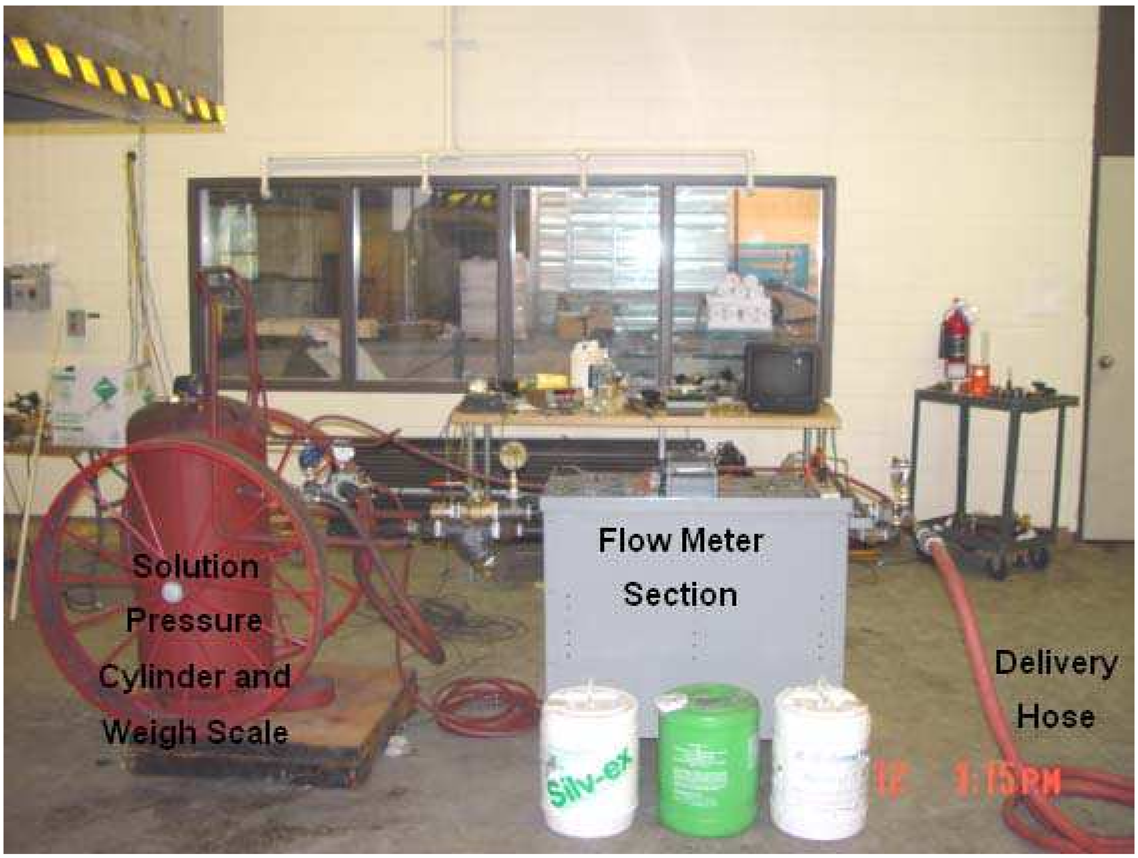


Figure 2b. Foam delivery apparatus.

The CAF produced in this series of tests was delivered through a slotted nozzle constructed to match the flow and distribution pattern of the standard air-aspirated nozzle (Figure 3). Test 15 was the only exception using a CAF Rotary Nozzle instead of the slotted nozzle. The CAF had measured expansion ratios ranging from 10.0:1 to 11.9: 1 (as described in CAN/ULC-S560-98 [1], UL 162 [2] and in NFPA Standard No. 412 [3]).

The air-aspirated foam was produced using the 7.6 L/ min nozzle described in the standard complete with the spreader attachment (Figure 3). The air-aspirated system produced measured expansion ratios of 4.7:1 to 10.1:1 (as described in CAN/ULC-S560-98 [1], UL 162 [2] and in NFPA Standard No. 412 [3]).

Figure 3. Delivery nozzles

A slotted nozzle was constructed to deliver foam-water solution to match the flow and distribution pattern of the CAF and air-aspirated nozzles (Figure 3). There was no expansion of the foam solution with this system. It was necessary for the flow rate in Test 13 to be increased from 7.6 L/min (Test 10) to 22.7 L/min in order to extinguish the fire. To accomplish this, a fire hose nozzle was selected and adjusted to deliver a solid cone spray that enabled all of the foam solution to be delivered inside the pan without greatly changing the dynamics of the delivered pattern.

Tests 20, 21 and 22 had reduced CAF flow rates to determine how low a density could be applied and still extinguish the fire.

2.3 Instrumentation

The solution flow was monitored using a calibrated Krohne model Ecoflux 1010 Magnetic flow-meter and the airflow was measured using a Brooks Model 1112A09G3B1A rotometer. Pressures were measured using calibrated pressure gauges, and solution concentrations were determined by weight using a Mettler PC4400 calibrated balance and an Aurora Scale. Radiant heat flux measurements were taken using a Medtherm Heat flux transducer Model 64-02-14 Serial # 57496 and recorded on a Solartron model 3595 IMP data acquisition system. The tests were recorded on a Sony Model DCR-TRV340, 8 mm digital videotape and still photos were taken using a Sony Model DSC-F707 digital camera.

2.4 Test Overview

Testing was performed using CAN/ULC-S560-98 [1] as a guide. This standard is designed to evaluate the performance of foam concentrates for military applications and demands quick control of the fire and extinguishment in less than 60 s. The foam is delivered via a hand line and manually applied to achieve the fastest knock down and extinguishment. These tests are very operator dependant so several tests were conducted to develop our operator's technique, which was used for all subsequent tests. Since our tests were for comparison purposes, the 60 s requirement was not used and the fuel load was increased from the required 55 L to 80 L per test to ensure sufficient fuel for the burn back portion. Foam expansion and drain times were determined for each test in accordance with the standard test procedure.

2.5 Test Procedure

The following test procedure is derived from CAN/ULC-S560-98 [1] and differs where noted.

A foam pressure cylinder was placed on a scale and its tare weight was zeroed. Foam concentrate was weighed (3.0 kg for 3% mixture) and added to the cylinder. Water was then added until the total weight reached 100 kg. This produced a 3% solution. The other concentrations used in the series (0.6%, 1.5%, and 2.0%) were created using the same procedure. The cylinder was then sealed and pressurized to between 80 and 100 psi so that a 7.6 L/min flow rate was produced. The foam was delivered through a 1 inch (needs to be metric – 2.54 cm?) diameter flexible rubber hose, approximately 18 m long, to the appropriate nozzle. In the case of the CAF system, air and solution were metered into a mixing chamber at the exit of the pressure cylinder and a hose was connected to the outlet of the chamber. For the solution and air-aspirated tests, the mixing chamber was by-passed and the solution was restricted to the correct flow at the nozzles. In all cases (with exception of Tests 13 and 20-22) the same solution flow rate of 7.6 L/min was used.

The foam was first delivered to a backboard assembly and collected for expansion and drain time tests as described in the standard.

The 4.65 m^2 pan was positioned in the burn hall with no less than 12 m to the nearest wall. Water was placed in the pan to cover the bottom to a depth of 5 mm. The fuel (80 L) was measured and poured into the pan. The data system was activated and the video camera was turned on. The fuel was then lit and allowed to burn freely for 15 s before the foam was applied. The operator attempted to apply the foam gently and evenly onto the fuel surface, cool down the walls and extinguish the fire as rapidly as possible making sure all the foam entered the pan. The time from first application to extinguishment was recorded. The 99% extinguishment time was derived from the heat flux data and confirmed with the video recording. Foam was to be continuously applied for a total of 90 s before the burn back portion of the test was initiated. If extinguishment occurred after 90 s, foam application was immediately terminated. Burn-back would be conducted but its results would not be directly comparable since excess foam was applied.

Burn-back testing was carried out for each test that was successful in extinguishing the fire. Immediately after the fire was extinguished, the 300 mm burn-back pan was ignited and placed gently into the middle of the large pan. The time for the small fire to break down the foam blanket and burn back 25% of the large pan area was recorded.

The pans were drained and rinsed clean before each test to ensure reproducible and fair results.

3.0 Results

3.1 Heptane Fire Tests

Tests 1 to 15 and 20 through 22 were conducted using 80 litres of Commercial Grade N-Heptane Lot 2/13/03. The results are listed in Table 1.

Table 1. CAF Comparison Test Results

Test Description					Foam Description				Extinguishment time; min:s		Burn Back Time; min:s
Test #	Foam Class A or B	Fuel 80 L - 15s preburn	Nozzle type	Flow L/min	Type	Concentration	Expansion	drain time 25%; min:s	99%	100%	
1	CAF A	* heptane	slot	7.54	Silvex	0.60%	10.5:1	9:30	na	2:45	9:50 extra foam added
2	CAF A	heptane	slot	7.54	Silvex	0.60%	10.0:1	9:06	1:17	1:38	6:10 extra foam added
3	CAF A	heptane	slot	7.56	Silvex	0.60%	10.5:1	10:05	1:02	1:30	6:02
4	Air Asp. A	heptane	standard test	7.2	Silvex	0.60%	3.07:1	1:32	none	none	na
5	CAF B	heptane	slot	7.55	National	3.00%	11.7 :1	5:02	0:46	0:50	12:05
6	Air Asp. B	heptane	standard test	7.2	National	3.00%	10:01	2:56	1:06	1:12	12:00
7	no expansion B	heptane	course spray	7.5	National	3.00%	none	none	none	none	na
8	Air Asp. B	heptane	standard test	7.2	National	1.50%	8.6:1	1:50	1:58	2:59	10:12 extra foam added
9	CAF B	heptane	slot	7.55	National	1.50%	12.2:1	3:30	na	1:22	8:10
10	no expansion B	heptane	slot	7.4	National	3.00%	none	none	none	none	na
11	CAF B	heptane	slot	7.5	National	1.50%	11.75:1	3:58	1:04	1:15	9:23
12	CAF B	heptane	slot	7.5	National	2.00%	12:1	4:15	0:46	0.55	10:15
13	no expansion B	heptane	fire hose	22.7	National	3.00%	1.7:1	none	1:57	2:06	6:30 extra foam added
14	Air Asp. B	heptane	standard test	7.2	National	2.00%	8.4:1	1:50	1:04	1:32	9:48
15	**CAF B**	**heptane**	**rotary**	**7.5**	**National**	**3.00%**	**11:01**	**4:30**	**0:40**	**0:44**	**15:10**
16	CAF B	gasoline	slot	7.5	National	3.00%	12:01	4:20	1:00	1:06	4:16
17	Air Asp. B	gasoline	standard test	7.2	National	3.00%	10:01	3:00	1:44	2:43	3:56 extra foam added
18	CAF B	gasoline	slot	7.5	Wormald mil spec	3.00%	10:01	5:00	0:50	1:00	5:48
19	Air Asp. B	gasoline	standard test	7.2	Wormald mil spec	3.00%	4.7:1	3:30	0:57	3:39	9:02 extra foam added
20	CAF B	heptane	slot	3.1	National	3.00%	11:01	4:10	none	none	---
21	CAF B	heptane	slot	3.6	National	3.00%	11:01	4:00	none	none	---
22	CAF B	heptane	slot	5.6	National	3.00%	11.9:1	3:50	0:53	1:30	15:40

* 30 second preburn

3.1.1 Class A Foam Tests

Tests 1, 2, 3 and 4 were conducted using 0.60% Class A (Silvex) foam solution. Test 1 had a 30 s pre-burn while all other tests had the required 15 s pre-burn. The extinguishment time for test 1 was 2 min and 45 s due primarily to the hotter pan wall from the longer pre-burn and the fact that Class A foam has trouble with closing off the fire since there is no film forming capability. Tests 2 and 3 showed that CAF using Class A foam can effectively extinguish the heptane fire in 90 s and provide over 6 min of burn-back protection. The air-aspirated system, in Test 4, made poor quality Class A foam and could not extinguish the fire with 5 min of application. No tests were conducted with unexpanded Class A foam-water solution since the air-aspirated foam did not extinguish the fire.

3.1.2 Class B Foam Tests

Tests 5-15 and 20-22 were conducted using National Aerolite Class B AFFF foam solution. National Aerolite foam is a non-military specification foam that is generally used at 3% concentration. It is approved for use with standard sprinklers under the UL162 Standard [2].

Test 5 used CAF at 3% concentration and extinguished the fire in 50 s with a burn back time of 12 min and 5 s. The heat flux data for Test 5 is shown in Figure 4 and the photo sequence in Figure 5. Test 6 used air-aspirated foam (good quality 10:1 expansion with 3 min drain time) and extinguished the fire in 1 min 12 s with a burn-back time of 12 min. The heat flux data for Test 6 is shown in Figure 6 and the photo sequence in Figure 7. Tests 7 and 10 used foam-water solution only, with no expansion, and could not extinguish the fire with over 4 min of application. The heat flux data for Test 10 is shown in Figure 8 and the photo sequence in Figure 9.

To study how the system would perform under poor quality foam solution, tests were conducted at 1/2 strength foam concentration. CAF Tests 9 and 11 used a 1.5% Class B solution and extinguished the fire in 1 min 22 s and 1 min 15 s, respectively. Burn-back times were 8:10 and 9:23. Test 8 used the air-aspirated system with 1.5% solution (good quality 8.6:1 expansion with 1 min 50 s drain time) and the fire was extinguished in 3 min. The burn back time was 10 min 12 s but twice as much foam had been delivered to the pan (3 min instead of 90 s).

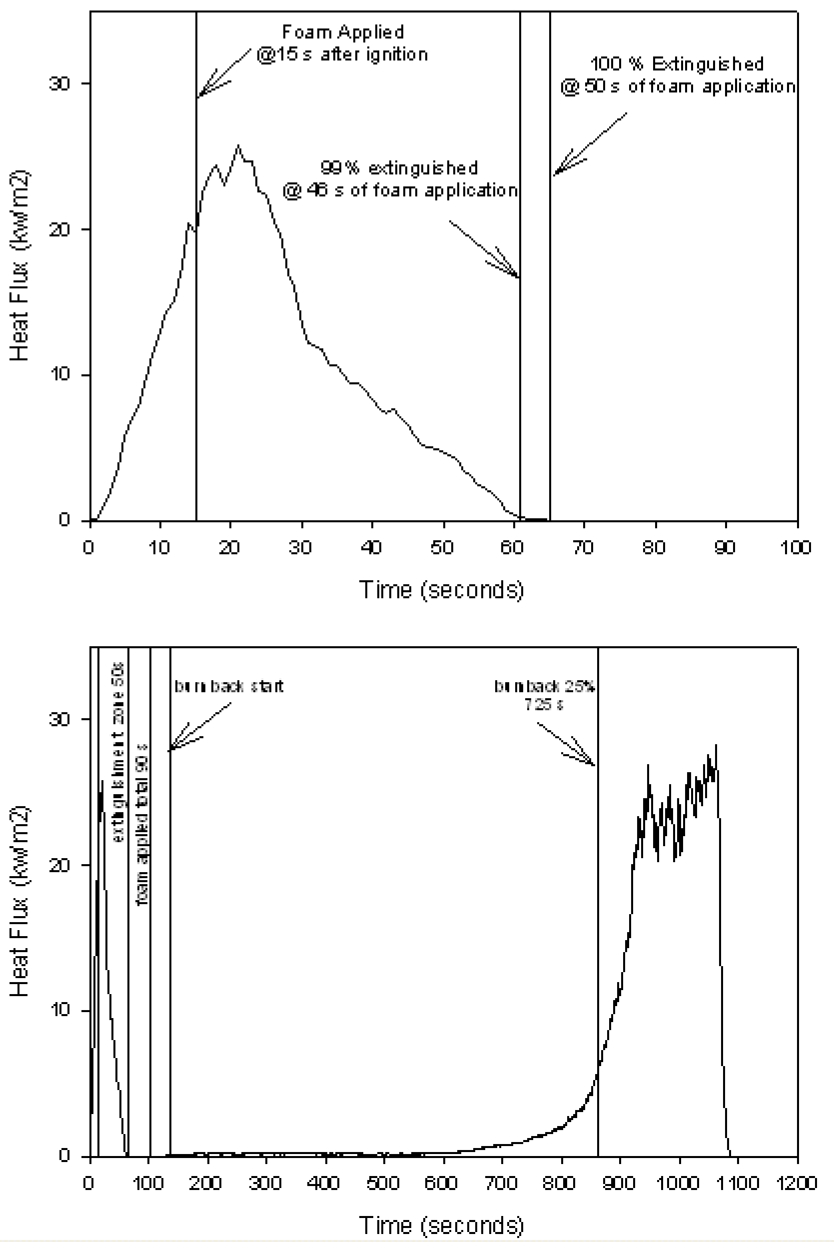


Figure 4. Test 5; CAF heat flux data using National Aerolite Foam @ 3%. Flow rate 7.6 L/min (2 USgal/min).

Foam applied 0.0 seconds

15.0 seconds

30.0 seconds

45.0 seconds

Extinguished 50.0 seconds

Figure 5. Test 5; CAF extinguishment photo sequence.
Flow rate 7.6 L/min (2 USgal/min).

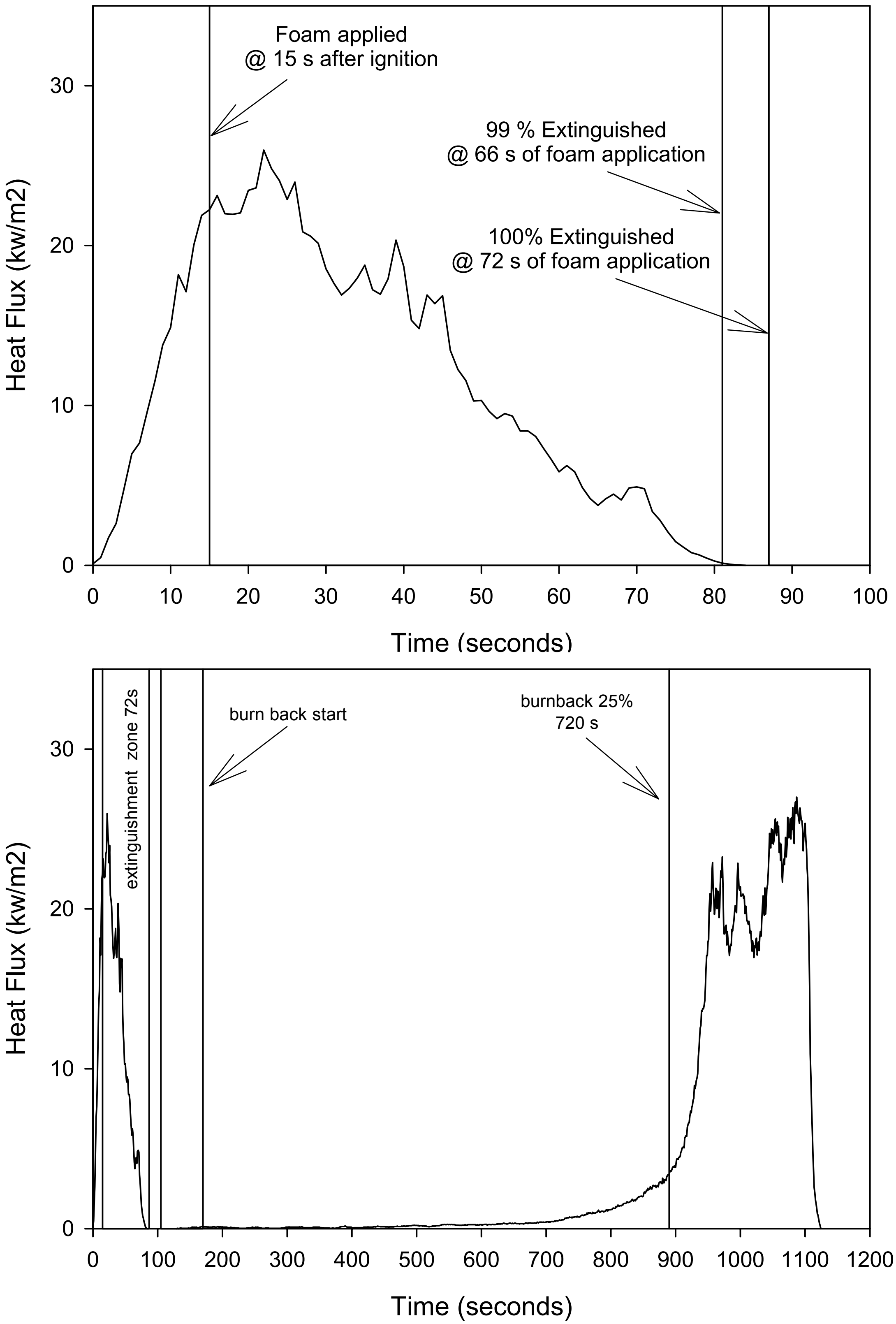


Figure 6. Test 6; Air-aspirated heat flux data using National Aerolite Foam @ 3%. Flow rate 7.6 L/min (2 USgal/min).

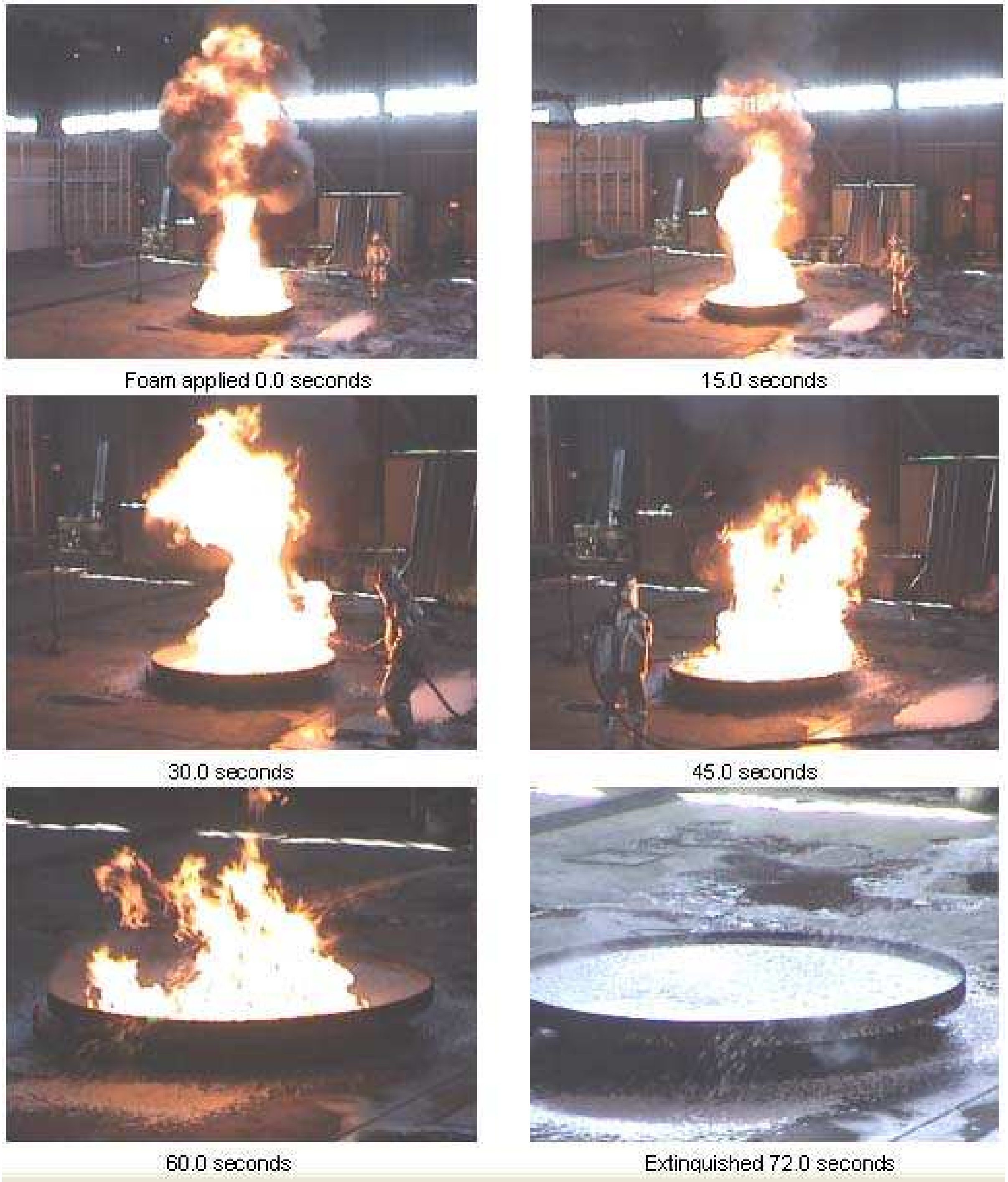


Figure 7. Test 6; Air-aspirated extinguishment photo sequence.
Flow rate 7.6 L/min (2 USgal/min)

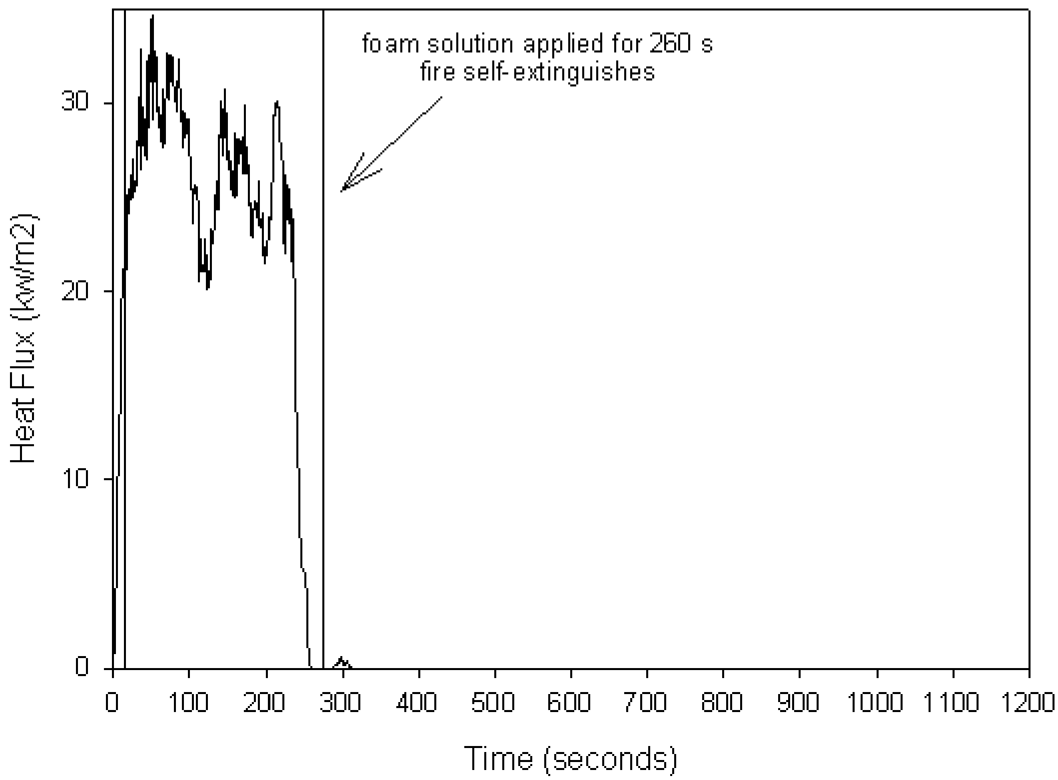


Figure 8. Test 10; Unexpanded foam solution heat flux data using National Aerolite Foam @ 3%. Flow rate 7.6 L/min (2 USgal/min).

Tests 12 and 14 were conducted at 2% concentration. Test 12 used CAF at 2% and extinguished the fire in 55 s with a burn-back time of 10 min 15 s. Test 14 used air-aspirated foam at 2% concentration and extinguished the fire in 1 min 32 s with a burn-back time of 9 min 48 s.

Since unexpanded foam-water solution could not extinguish the fire, it was decided to increase the flow rate by a factor of 3, from 7.6 L/min to 22.7 L/min. To accomplish this, a fire hose nozzle was selected and adjusted to deliver a solid cone spray that enabled all of the foam solution to be delivered inside the pan without greatly changing the dynamics of the delivered pattern. Test 13 was conducted at 3% concentration and extinguished the fire in 2 min 6 s with a burn-back time of 6 min 30 s. The burn-back time was poor, considering 4.2 times the allowed foam solution was used. The heat flux data for Test 13 is shown in Figure 10 and the photo sequence in Figure 11.

Foam applied 0.0 s

15.0 s

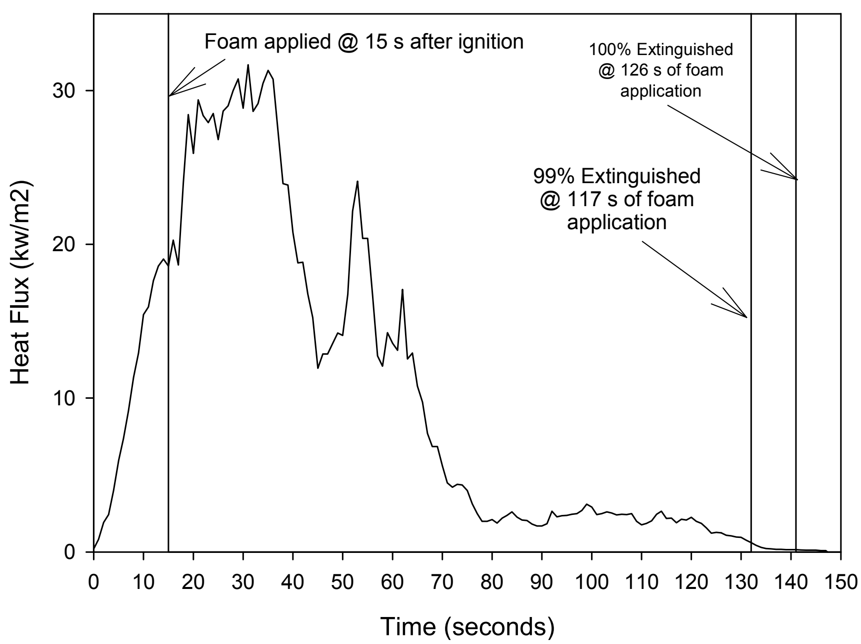
30.0 s

45.0 s

60.0 s

75.0 s

Test 15 was conducted using 3% CAF at the 7.6 L/min flow rate. The difference in this test was that the slot nozzle was replaced with NRC's patented CAF rotary nozzle. This test had the fastest knock down and extinguishment time of all the tests. It had a 99%



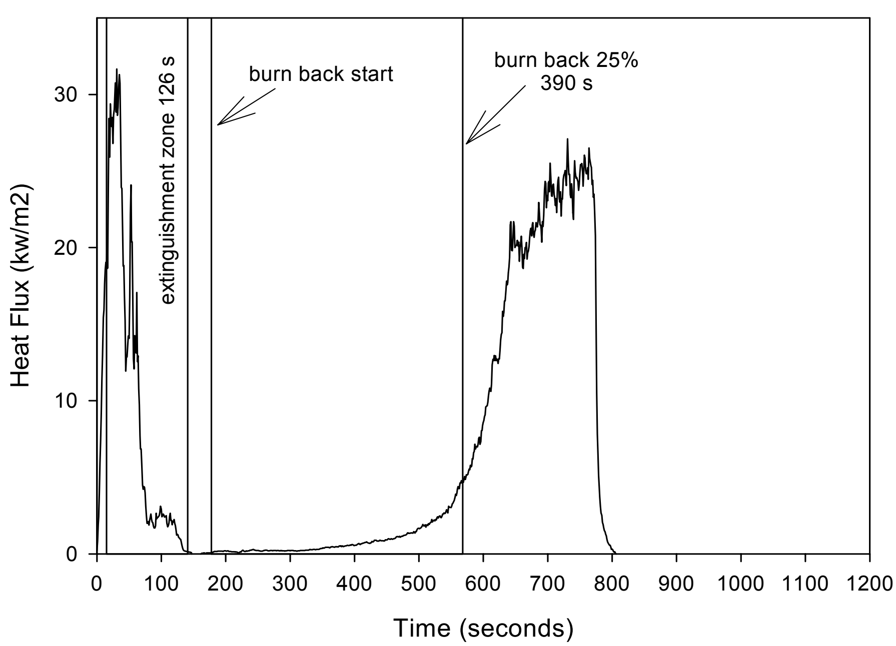


Figure 10. Test 13; Unexpanded foam solution heat flux data using National Aerolite Foam @ 3%. Flow rate 22.7L /min (6 USgal/min).

extinguishment time of 40 s and 100% in 44 s. The burn-back was 15 min and 10 s. The rotary nozzle had the ability to cover a large area of fire with a gentle application so the fuel surface was not agitated by the delivered foam.

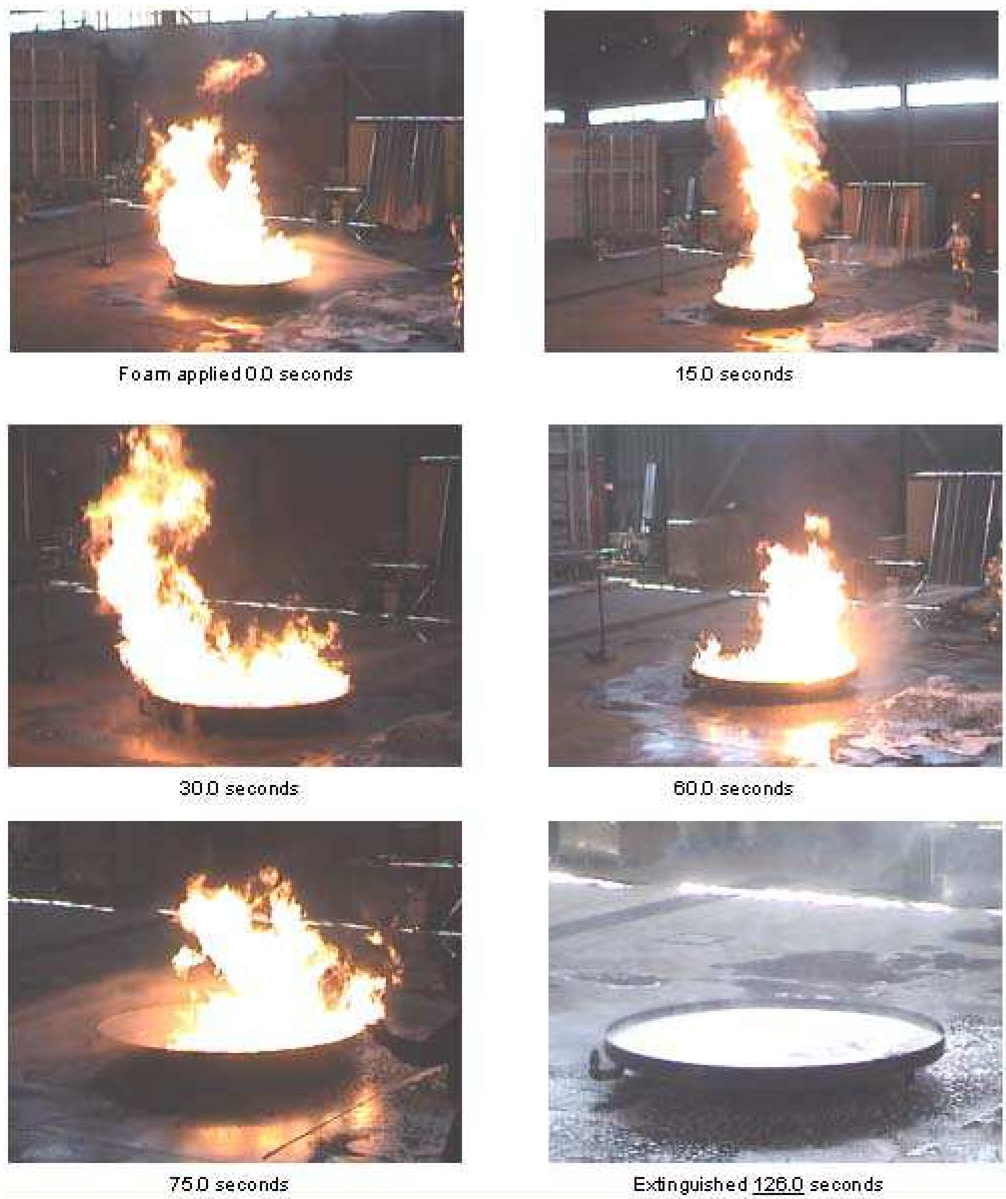


Figure 11. Test 13; Unexpanded foam solution photo sequence.
Flow rate 22.7 L/min (6 USgal/min).

Tests 20, 21, and 22 were CAF tests (slotted nozzle) conducted at reduced flow rates to determine the minimum application rate required to extinguish the fire. Tests 20 and 21 used 3% solution at a flow rate of 3.1 L/min and 3.6 L/min, respectively. Neither of these tests could extinguish the fire. Test 22 used 3% solution at a flow rate of 5.6L/min (¾ of the standard flow) and did extinguish the fire in 1 min 30 s with a burn-back time of 15 min 40 s.

3.2 Gasoline Fire Tests

Tests 16-19 were conducted using regular winter grade gasoline instead of heptane. The CAN/ULC-S560 standard [1] calls for aviation gasoline grade 80 and UL162 [2] calls for heptane. It was decided to use regular gasoline since aviation gas was not readily available and winter grade gas has a high vapour pressure for performance at low temperatures.

Test 16 used CAF at 3% concentration and 7.6 L/min flow rate. The fire was extinguished in 1 min 6 s with a burn-back time of 4 min 16 s. The gasoline fire was a little more difficult to extinguish than the heptane fire but the largest difference was the burn-back time. The increase in vapour pressure from the gasoline greatly reduced the burn-back time. This was found to be true for all the gasoline tests.

Test 17 used air-aspirated foam at 3% concentration and 7.6 L/min flow rate. The fire was extinguished in 2 min 43 s with a 3 min 56 s burn-back. The burn-back was exceptionally poor, considering 1.8 times the allowed amount of foam was used in the test.

Test 18 used a mil-spec foam by Wormald at 3% concentration. This CAF test extinguished the gasoline fire in 60 s and had a burn-back of 5 min 40 s.

Test 19 used air-aspirated 3%, mil-spec foam by Wormald. The foam quality was not very good having an expansion of 4.7:1 and a 25% drain time of 3 min 30 s. The air-aspirated foam extinguished 99% of the fire in 57 s but the operator had trouble getting the last flames extinguished since the foam kept opening holes in the surface. At 3 min 39 s, the fire was fully extinguished.

4.0 Conclusions and Discussions

This test series has shown the superior fire extinguishing properties of compressed-air foam over air-aspirated foam and foam-water spray. This was true for both Class A and B foams on heptane and gasoline fires. Extinguishment density (Table 2) is a calculation determined by the applied flow rate multiplied by the time to extinguishment and divided by the area of the pan. These values reveal that CAF extinguishes the heptane fire with at least 30% less material than good quality air-aspirated foam and 87% less material than foam-water solution using Class B foam. These numbers are further improved when CAF is delivered through the CAF rotary nozzle. CAF also had the ability to extinguish the fire using Class A foam while air-aspirated foam could not. This is due to the fact that the delivered foam is uniform in consistency, has smaller more rugged bubbles, and longer drain times. As the quality of the air-aspirated foam improves, its performance improves, but it only approaches the quality of CAF and, as more energy is used to generate the foam, less power is available to the stream for transporting it. Unexpanded AFFF solution alone cannot match the performance of CAF or air-aspirated foam when delivered into the base of the fire. The flow rate had to be increased threefold before it could extinguish the fire, showing that the film-forming layer must remain on top of the fuel to be effective. This is difficult when the density of the solution is greater than the fuel.

The extinguishment densities for the gasoline tests demonstrated that CAF could extinguish the fire with at least 60% less material than the air-aspirated foam using Class B solution.

The reduced solution concentration tests showed that CAF extinguishment density increased 67% when the concentration was cut in half. The air-aspirated foam extinguishment density increased 150% when its concentration was halved. Reductions in solution concentrations affect foam quality and performance to a much greater extent in air-aspirated systems than CAF systems. This is a result of the foam being generated in the pipe rather than in the short expansion zone of an air-aspirated nozzle. Even when the concentration was reduced by a third to 2%, the CAF system only suffered a 13% performance reduction while the air-aspirated performance dropped 27%.

Table 2. Extinguishment Density.

Test Description					Total Concentrate to Extinguish; L	Total Solution to Extinguish; L	Extinguishment time; min:s		Extinguishment density; L/m2 (USgal/ft2)
Test #	Foam Class A or B	Fuel, 80 L - 15s preburn	Nozzle type	Flow; L/min			99%	100%	
1	CAF A, 0.6%	* heptane	slot	7.54	0.124	20.6	na	2:45	4.48 (0.11)
2	CAF A, 0.6%	heptane	slot	7.54	0.074	12.3	1:17	1:38	2.65 (0.065)
3	CAF A, 0.6%	heptane	slot	7.56	0.068	11.34	1:02	1:30	2.44 (0.06)
4	Air Asp. A, 0.6%	heptane	standard test	7.2	---	---	none	none	not ext.
5	CAF B, 3%	heptane	slot	7.55	0.189	6.3	0:46	0:50	1.34 (0.033)
6	Air Asp. B, 3%	heptane	standard test	7.2	0.26	8.64	1:06	1:12	1.96 (0.048)
7	no expansion B, 3%	heptane	course spray	7.5	---	---	none	none	not ext.
8	Air Asp. B, 1.5%	heptane	standard test	7.2	0.323	21.5	1:58	2:59	4.89 (0.12)
9	CAF B, 1.5%	heptane	slot	7.55	0.155	10.3	na	1:22	2.24 (0.055)
10	no expansion B, 3%	heptane	slot	7.4	---	---	none	none	not ext.
11	CAF B, 1.5%	heptane	slot	7.5	0.14	9.375	1:04	1:15	2.04 (0.05)
12	CAF B, 2%	heptane	slot	7.5	0.137	6.9	0:46	0.55	1.51 (0.037)
13	no expansion B, 3%	heptane	fire hose	22.7	1.4	47.6	1:57	2:06	10.27 (0.252)
14	Air Asp. B, 2%	heptane	standard test	7.2	0.221	11	1:04	1:32	2.49 (0.061)
15	**CAF B, 3%**	**heptane**	**rotary**	**7.5**	**0.165**	**5.5**	0:40	**0:44**	**1.18 (0.029)**
16	CAF B, 3%	gasoline	slot	7.5	0.25	8.25	1:00	1:06	1.79 (0.044)
17	Air Asp. B, 3%	gasoline	standard test	7.2	0.59	19.6	1:44	2:43	4.48 (0.11)
18	CAF B, 3%	gasoline	slot	7.5	0.23	7.5	0:50	1:00	1.63 (0.04)
19	Air Asp. B, 3%	gasoline	standard test	7.2	0.79	26.3	0:57	3:39	5.95 (0.146)
20	CAF B, 3%	heptane	slot	3.1	---	---	none	none	not ext.
21	CAF B, 3%	heptane	slot	3.6	---	---	none	none	not ext.
22	CAF B, 3%	heptane	slot	5.6	0.25	9:36	0:53	1:30	1.83 (0.045)

The reduced flow tests showed that, with a 26% reduction in solution flow (5.6 L/min instead of 7.6 L/min), the extinguishment density increased by 37%. This performance is still 7% better than air-aspirated foam at the normal flow rate of 7.6 L/min.

This test series demonstrated that CAF out-performs air-aspirated foam and foam water solution when delivered into the base of the fire. Comparison testing using overhead systems must be performed to study the effects of fire plume dynamics on CAF and conventional foam water sprinkler systems. This will be undertaken in future UL162 [2] fire tests comparing the fire extinguishing performance of foam-water sprinklers to a fixed pipe overhead CAF system.

5.0 Acknowledgements

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6.0 References

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