The Emergence of CAF Fixed-Pipe Fire Suppression Systems.

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History and background

Compressed-air foam (CAF) is a fire suppression medium created by injecting air under pressure into a foam solution stream [1]. CAF fire suppression systems are high energy foam generation systems which produce small-bubbled, uniform foam in a high momentum jet [2, 3]. CAF systems can produce an infinitely variable foam with a full range of consistencies and increased stability. In effect, CAF fixed-pipe fire suppression systems have emerged to the state that they now can deliver an excellent quality foam directly to a hazard.

While fire fighting foams have been around for over 100 years, the first mention of CAF as a fire suppression agent for hose streams appears in 1941 as a means to combat fires on floating bridges [2]. CAF technology itself has also been used for decades in the petroleum industry to enhance crude oil production, in the food industry to aerate chocolate and in car washes and shaving cream [2, 4]. In fixed-pipe fire suppression systems, CAF systems became a reality in the late 1990s with the development at the National Research Council of Canada of means to reliably generate and transport CAF through a fixed-piping network and to distribute it effectively using specially-designed nozzles [1]. Since that time, the technology for generating and distributing CAF has been improved and commercialized and the fire suppression characteristics of CAF have been evaluated for a number of applications. Until this CAF system development became available, fixed pipe foam fire suppression systems utilized aspirating nozzles, blowers and sprinklers. Each had its advantages and disadvantages [1]. By being able to deliver CAF through a fixed-piping network and to apply it to a fire, the developers of the CAF fixed-pipe technology have taken the next important step, and made a significant advance, in the evolution of foam fire suppression technology.

The first applications of CAF fixed-pipe technology were for the suppression of flammable liquids spill fires and shelf storage fires [1]. In these early evaluations, researchers were able to demonstrate the superior fire suppression performance of CAF systems compared to regular sprinkler and water mist technology – using both Class A and Class B foams. They also demonstrated the economics of lower water and agent concentration flow rates with CAF technology, and the significantly-improved visibility in the fire area with an operating CAF system. Since 1999, there have been even greater advances in evaluating and advancing CAF technology.

Benefits of CAF Systems

The benefits of CAF fixed-pipe fire suppression systems, which led the researchers and the manufacturer to advance system development, are readily apparent from the fire suppression, economic and clean-up perspectives.

CAF discharge reaches the fire:
The high momentum of CAF distribution, combined with the strength of the foam bubbles, allows the CAF to effectively penetrate the fire plume, making fire extinguishment quicker.

Produces a uniform foam of very small, strong bubbles:
CAF provides an improvement in foam drainage time and a better fuel-vapour barrier. Much better burn-back time with CAF provides extended fire protection after the foam has been discharged.

Produces a foam blanket that offers better thermal radiation protection:
A CAF blanket stays in place for extended periods of time on top of a fuel and sticks to vertical surfaces, in both cases offering good thermal protection for the fuel against fire exposure.

Improves visibility during fire conditions:
CAF systems significantly reduce steam production during fire extinguishment, ensuring very good visibility inside the hazard area.

Quantity of water and foam concentrate significantly reduced:
A design density of 0.04 gpm/sq ft for CAF represents only 25% of the water requirement for standard foam-water sprinkler systems having a design density of 0.16 gpm/sq ft. For Class B hazards, the foam (AFFF) concentration is only 2%, thus reducing the foam concentration by one third. In combination with the reduced water flow, the total foam concentrate used is only one-sixth of that of traditional foam systems. In locations where existing water supplies are limited or where a new water supply must be provided, the reduced quantity of foam solution required for CAF systems can provide an economic advantage over conventional foam-water sprinkler systems.

Easier clean-up after a fire:
CAF systems use significantly less water and foam, requiring less drainage and water treatment after a fire.

Recent advances

In attempting to capitalize on these potential benefits, research has resulted in significant advances in understanding the scientific basis for CAF fire suppression performance, in improving the CAF delivery technology itself and in demonstrating fire suppression applications.

Scientific studies have improved our understanding and have shown that the CAF mode of foam generation leads to the production of a uniform bubble size distribution, which has a positive bearing on the stability of the foam. This means that the CAF foam blanket establishes its fire suppression characteristics sooner and retains them longer than a foam with larger or non-uniform bubble distribution [3, 5].

Under licence from NRCC, a Canadian manufacturer has developed CAF fixed-pipe systems and nozzles that can be used for a number of fire suppression applications. A schematic of the current CAF generating system is shown in Figure 1. Effectively, water, compressed air and foam concentrate, in appropriate proportions, are brought together in a mixing chamber and the resulting high-momentum CAF pushed through a specially-designed piping network to the nozzles. Figure 2 shows a packaged version of the CAF generation system.

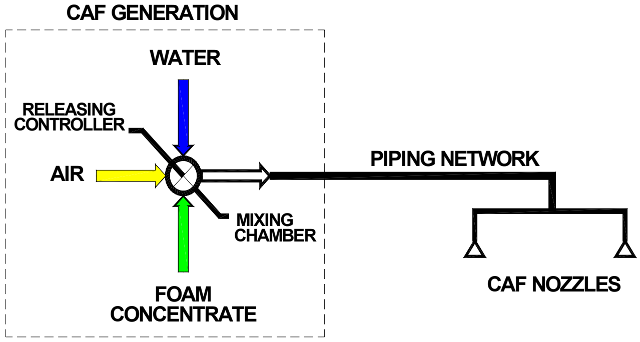


Figure 1 – Schematic of a CAF System

Figure 2 –Integrated Compressed Air Foam (ICAF®) System Package

Recent advances include the improvement of the mixing chamber and the development of a computer program to calculate CAF flow through pipes.

Full-scale fire tests comparing CAF systems to air-aspirating nozzles and foam-water sprinklers have demonstrated significant advantages in fire suppression and economies of agent and water supply in using CAF technology.

Full-scale fire testing has demonstrated the ability of CAF systems to provide superior fire suppression for flammable liquids and electrical transformer applications, and for Class A hazards.

Advances in understanding CAF fire suppression

While research and development of the technology was continuing in Canada over the past 5 years, research on understanding the scientific basis for CAF fire suppression was taking place in Australia. The Australian research relates both to fire suppression by foam agents, in general, and to CAF.

In studies on the deformation and flow of foam through pipes and nozzles, researchers found that the stability and flow of a foam are strongly influenced by the foam's bubble size distribution and gas-liquid fraction [6, 7]. As a result of its smaller bubbles (which result in a decrease in drainage) and its more uniform bubble size distribution and high initial gas-volume fraction (which result in greater stability), researchers showed how CAF was a superior foam compared to others studied. The researchers point out that one other advantage of CAF is the fact that the ratio of air and foam solution can be varied for almost any application – low expansion for wetting and direct application to a fire and higher expansion for adherence to materials and vertical surfaces to act as a barrier to thermal radiation.

Other Australian research shows how CAF demonstrates better coarsening characteristics (meaning the growth of the average bubble diameter which leads to bubbles breaking), and better disproportionation characteristics, which is the widening of bubble size distribution resulting in lesser performance [3]. This research on AFFF and FFFP compressed air foam further indicated how these properties affect drainage rates and foam stability. Researchers explain the better drainage and coarsening characteristics of CAF as being the result of uniform, small diameter bubbles.

As well, the Australian researchers have provided a better understanding of the complex flow properties of CAF through piping[4]. Their goal was to be able to predict conditions under which a stable foam (CAF) would flow and still maintain its desirable qualities at the nozzle. At the same time, the CAF system manufacturer developed a computer program for the hydropneumatic calculation of CAF flow through piping. The term "hydropneumatic" has been coined since CAF flow involves a mixture of both hydraulic and pneumatic elements which must be addressed together to preserve the CAF bubble structure until it is discharged on a hazard. As an example of the differences between CAF and water flow that must be accommodated by new calculation techniques, the pressure loss of CAF due to elevation difference is approximately one-tenth that of water.

Comparisons with air-aspirated foam and unexpanded foam-water solution

In 2003, scientists at NRCC wanted to assess the fire suppression characteristics of CAF as an agent compared to foam generated by traditional air-aspiration means. As well, they wished to address the differences between fire suppression using unexpanded foam-water solution and CAF. To accomplish these comparisons, the scientists undertook a series of full-scale fire tests using a standardized pool fire as the hazard.

The scientists chose CAN/ULC-S560 – Standard for Category 3 Aqueous Film-Forming Foam [8] as the basis for these comparative fire tests. This standard was chosen since it provides a robust fire exposure (4.64 m^2 pan) against which to test the foams and since it is the basis for purchasing foam by the Canadian Defence Department, the largest purchaser of foam in Canada. To provide a quantitative assessment of the process of fire suppression, the scientists installed sensitive heat flux meters viewing the entire pan at a distance of 1.8 m from the edge of the pan and 1.5 m above the floor. These instruments measured the heat being radiated from the fire in addition to the visual observations of the time of extinguishment by the researchers.

Using manual application with a special nozzle that generated better quality air-aspirated foam than would be expected from a fixed-pipe system nozzle, the scientists conducted a number of tests with CAF, air-aspirated foam and foam-water solution [9]. A comparison of the performance of CAF with this good quality air-aspirated foam, based on the heat flux meter readings, is shown in Figure 3. A similar comparison with unexpanded foam-water solution is shown in Figure 4.

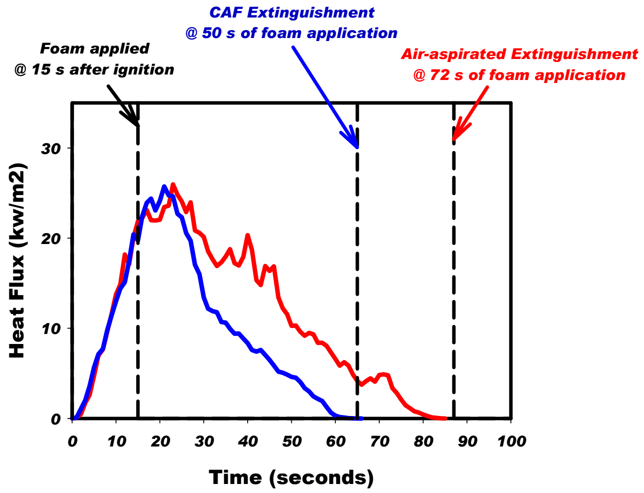


Figure 3 – Heat Flux with CAF and Air-Aspirated Foam Extinguishment

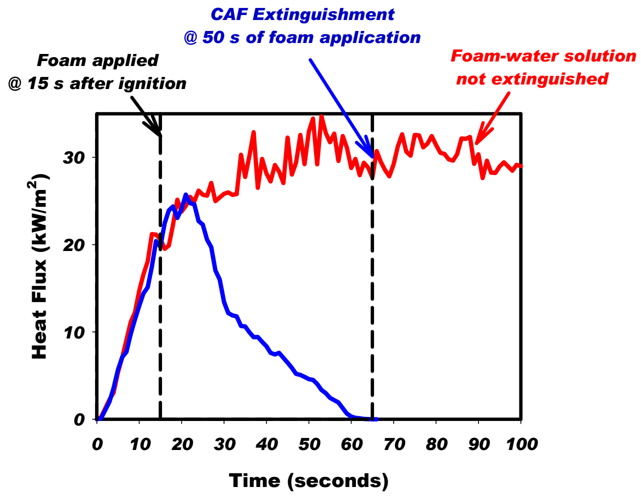


Figure 4 – Heat Flux with CAF and Foam-Water Solution Extinguishment

This research [9] showed that using 3% Class B foam on a heptane fuel and flowing CAF through a slot-type nozzle (not necessarily the most efficient means to distribute CAF) provided fire suppression in approximately 70% of the time required for air-aspirated foam and provided almost identical burn-back times. It accomplished this using 30% less foam solution. In 2 pairs of tests using 3% Class B foam on gasoline fires, CAF, on the average, extinguished the fire in 33% of the time and use only 35% of the solution for air-aspirated nozzles. In most experiments using 3% Class B unexpanded foam-water solution, the test fire was not extinguished, an example of which is shown graphically in Figure 4. CAF, using 0.6% Class A concentrate, was also shown to provide comparable fire suppression performance to 3% Class B air-aspirated foam.

What this research demonstrated was that foam fire suppression performance is directly related to the quality of the foam blanket. Since CAF generates superior quality foam, CAF provided excellent fire extinguishment performance – better than the air-aspirated foam currently in use, and even on gasoline fires.

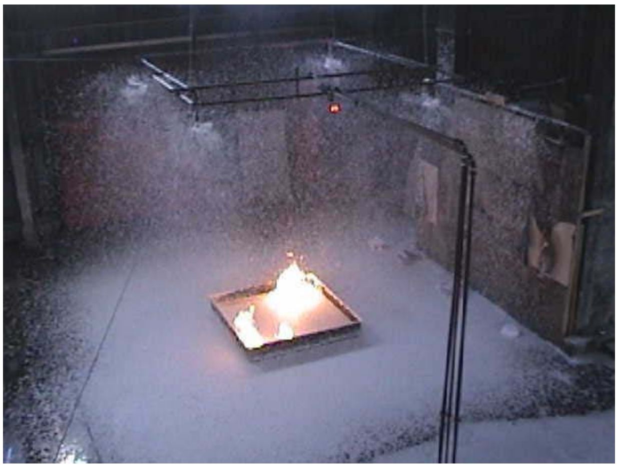
Impact of varying conditions

Research was also undertaken in 2002 to determine the effects on fire extinguishment performance of varying the CAF parameters, such as air pressure, water pressure and foam concentrate, above and below the design level. Forty-four full scale Class A and B fire tests, designed to challenge and evaluate the effectiveness of CAF, were conducted. The fire load for the Class A fires was wood cribs, designed to burn with a constant heat output of 450KW for over 25 minutes. The Class B tests utilized both shielded (50%) and unshielded heptane pan fires measuring 1m x 1m x 0.15m deep. Tests were also conducted to determine the possible degradation of CAF fire extinguishment performance with simultaneous sprinkler operation. For Class A fires, there were positive effects of simultaneous performance with more rapid wood crib fire extinguishment than for foam or water independently. For Class B fires, the extinguishment times were the same for simultaneous operation. This research program showed that CAF technology is very stable and can withstand normal variations in air and water pressure and foam concentrate levels while still offering very good fire suppression performance on Class A and Class B fires.

Comparisons with foam-water sprinklers

For the protection of flammable liquids hazards within buildings today, one of the most commonly used fire suppression methodologies is foam-water sprinklers. It was decided that full-scale fire test comparisons between CAF systems and foam-water sprinkler systems would help to demonstrate the comparative performance of CAF with currently-accepted technology. In 2003, NRCC with the manufacturer performed an extensive series of tests to comparatively evaluate the new CAF technology [11, 12]. An illustration of this test arrangement during operation is shown in Figure 5.

foam-water sprinkler



CAF

Figure 5 – Comparison after 40 seconds

Researchers chose the UL 162 – Standard for Foam Equipment and Liquid Concentrates [13] fire test as the basis for this comparison. This test method involves a piped network of 4 sprinklers or nozzles located above a 4.65 m^2 pan fire using heptane fuel. To pass this fire test, extinguishment must occur during the 5 min that foam is flowing and burn-back must not occur within specified limits. Since CAF systems are not designed to flow water alone following foam discharge, the provisions of UL 162 for polar foams (that permit no sprinkler discharge following foam discharge, but require extended foam sealing time in the pan), were employed.

Using Class B foam, a foam-water sprinkler system (3% AFFF concentration) and a CAF system (2% AFFF concentration) were evaluated, with the results of two identical tests shown in Table 1 for sprinklers and nozzles located 4.42 m above the floor. A second round of tests was conducted with the grid raised to 7.62 m above the floor. This height was different from UL162 but was necessary to compare the 2 systems for high bay applications.

Table 1 - Class B Foam (AFFF) Comparison – 4.42 m Height

Nozzle Type	**Foam-Water Sprinklers**	**CAF Nozzles**
Foam Type, Concentration	Class B, 3%	Class B, 2%
Solution Flow Rate GPM (L/min)	60 (227)	23.8 (90)
Test Application Density GPM/ft^2 (L/min/m^2)	0.1 (4.07)	0.04 (1.63)
Expansion Ratio	3.5:1	10.9:1
Drainage Time min:s	< 1 min	3:30
Extinguishment Time min:s	2:32	0:50
Burn-back Time min:s	9:00	23:35

As can be seen, the CAF system extinguished the pan fire in 33% of the time of the foam-water system and the burn-back time was 2.6 times longer with a solution flow rate 60% less and a 1/3 less foam concentration. Changing the height of the sprinklers and nozzles to 7.62 m provided a similar comparison as shown in Table 2.

Table 2 - Class B Foam (AFFF) Comparison – 7.62 m Height

Nozzle Type	Foam-Water Sprinklers	CAF Nozzles
Foam Type, Concentration	Class B, 3%	Class B, 2%
Solution Flow Rate GPM (L/min)	60 (227)	23.8 (90)
Test Application Density GPM/ft^2 (L/min/m^2)	0.1 (4.07)	0.04 (1.63)
Expansion Ratio	3.5:1	10.9:1
Drainage Time min:s	< 1 min	3:30
Extinguishment Time min:s	2:16	0:50
Burn-back Time min:s	9:21	23:40

The researchers also wanted to determine how the performance of a CAF system using 1% concentration Class A foam compared to a foam-water sprinkler system with 3% concentration Class B foam. The results of two tests for this comparison are shown in Table 3 for sprinklers/nozzles at 4.42 m above the floor. In this comparison, the CAF system with Class A foam extinguished the fire in 39% of the time of the foam-water sprinkler system and provided a burn-back time that was 12% greater. When tested at the 7.62 m height, the Class A foam extinguished the fire in 51% of the time for the foam-water sprinklers but had a burn-back time of only 71% of the time for foam water sprinklers, which still met the test criteria of UL 162.

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Table 3 - Class A Foam Comparison – 4.42 m Height

Nozzle Type	Foam-Water Sprinklers	CAF Nozzles
Foam Type, Concentration	Class B (AFFF), 3%	Class A, 1%
Solution Flow Rate GPM (L/min)	60 (227)	23.8 (90)
Test Application Density GPM/ft^2 ($L/min/m^2$)	0.1 (4.07)	0.04 (1.63)
Expansion Ratio	3.5:1	9:1
Drainage Time min:s	< 1 min	10:00
Extinguishment Time min:s	2:32	0:59
Burn-back Time min:s	9:00	10:10

While UL-162 requires a 4 foam-water sprinkler array with overlapping spray patterns, this research was extended beyond the UL-162 requirement to assess the impact of a single sprinkler/nozzle on fire suppression and burn-back performance. To assess this impact, some of the tests at the 14.5 ft (4.42 m) height were conducted with only one sprinkler/nozzle operating. The fire suppression performance of a single foam-water sprinkler in a 4-sprinkler array, with the minimum water flow rate (0.10 GPM/ft^2) specified in UL-162 was not sufficient to extinguish the test fire. The solution flow rate was increased to 0.16 GPM/ft^2. This resulted in fire suppression and burn-back performance meeting the UL-162 benchmarks and provided a basis for comparison with the single CAF nozzle. The water flow rate for the CAF nozzle was, however, the same as the single nozzle rate in the four-nozzle test and the solution flow rate only one-quarter that of the foam-water sprinkler.

This comparison, using Class B foam, showed that the two systems performed comparably for extinguishment time (2 min 32 s for foam-water vs 2 min 49 s for CAF) and the burn-back time of the CAF system was almost twice that of the foam-water system. What must be noted, however, was that the solution flow rate for the foam-water sprinkler was four times that of the CAF nozzle. This research demonstrated clearly that CAF systems can provide equivalent and better fire extinguishment and burn-back performance when compared to foam-water sprinkler systems (in this test arrangement) with significant economies in foam concentrations and solution flow rates, including with Class A foam.

CAF system applications

With the development of CAF systems underway, the researchers and the manufacturer sought potential applications for this new technology. Two that were initially examined were flammable liquids hazards and electrical transformers. With the initial focus on Class B hazards [1], it has been shown that CAF can be used where flammable or combustible liquids are stored, handled or processed, either on exposed or shielded Class B hydrocarbon fires. Research has also shown that CAF produces excellent Class A foam that outperforms current foam technology for Class A hazards, and is comparable to Class B foams for protecting those Class B hazards evaluated thus far. Since the present NFPA standards for Class A foam do not yet envisage fixed pipe systems, this application has been scheduled for future development.

In evaluating early CAF system applications, NRCC undertook research with Canada's Department of National Defence to evaluate the impact of CAF systems on Class II aircraft hangars [14]. Prior to the development of the current nozzle technology, NRCC was able to demonstrate that CAF could protect aircraft hangars using nozzles at both the ceiling and the floor. The performance of later nozzle designs indicates that equivalent extinguishment performance could be obtained using nozzles at the ceiling only.

In 2003, research was conducted to determine the potential to use CAF systems, instead of water spray systems, to protect large electric transformers. This full-scale testing [15] demonstrated that properly-designed CAF systems can provide protection against 3-dimensional fires in transformers, up to the 12 MW fire size tested, with superior fire suppression performance and significant savings in solution flows. Table 4 shows two comparable transformer tests on CAF and water spray systems; in other tests in this series, CAF performance was even better, however, only this result is presented here. To illustrate the two systems, Figure 6 shows the fires at different times during comparable water spray and CAF tests.

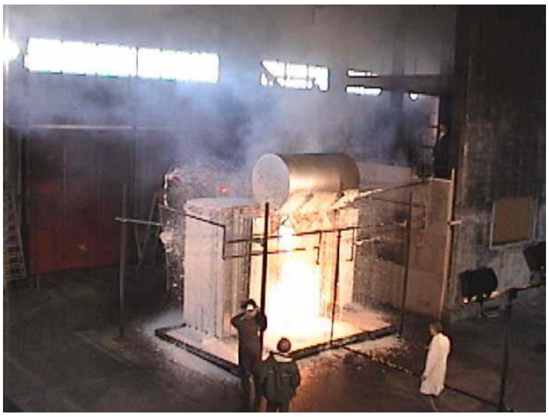
Table 4 - Comparable Transformer Protection Tests

	Water Spray System	CAF System
Water Flow Rate, l/min	890	165
Total Water Used, l	3486	248
Foam Concentration	NA	2%
Foam Concentrate Used, l	NA	5
Extinguishment Time, min:s	3:55	1:30

Fully developed fire:

Water Spray System **CAF System**

Comparison after 60 sec.:



Comparison after 90 sec.:

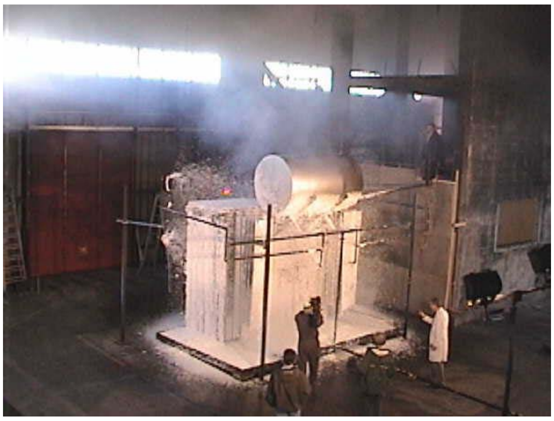


Figure 6 – Water Spray system vs CAF system for power transformer protection

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Conclusions

While CAF technology has been around for some time, its use in a fixed pipe fire suppression system has only emerged in the past 5 years. This introduction of CAF fixed pipe systems is part of the normal evolution in foam fire suppression systems development. From scientific and engineering studies, significant advances have occurred in understanding the dynamics and fire suppression mechanisms of CAF, as well as in the technology to generate, flow through pipe and distribute CAF for successful fire suppression. CAF itself has been shown to perform better than air-aspirated foam and unexpanded foam water solution.

Through testing, CAF systems have been shown to respond well to reasonable changes in water and air pressure and foam concentration. Using new technology, the manufacturer has ensured that potential system-limiting conditions cannot be reached with presently-designed equipment. CAF systems have been demonstrated to successfully extinguish challenging fires with less water and less foam than current fire suppression systems using foam and water.

With Class B foam, comparative full-scale tests have shown that CAF systems provide equivalent or better performance than foam-water sprinklers for heptane pan fires, the most common means of assessing such systems. CAF systems have been shown to provide appropriate protection for flammable liquids hazards and equivalent or superior protection to water spray systems for electrical transformer protection. Future applications for evaluating CAF systems include polar solvents and Class C fires.

In remote areas or areas with substandard water supplies, CAF systems provide a proven means to suppress flammable liquids fires. In these situations, fire suppression systems would seldom be installed due to the significant cost or local conditions, and hence the hazard would not be protected. CAF systems provide a means to lessen the hazard.

As a result of the significantly reduced water and foam usage, CAF systems can be installed in situations where environmental damage from fire suppressants and the fire itself must be minimized.

The ICAF systems, manufactured by FireFlex Systems Inc., are now FM Approved and a proposed Tentative Interim Amendment (TIA) requesting the addition of a new chapter on Compressed Air Foam Systems to NFPA 11, Standard for Low-, Medium-, and High-Expansion Foam [16] is presently under review.

The past few years have resulted in considerable advances in the evolution of CAF fixed-pipe system fire suppression technology. These systems are emerging as a significant new technology for the fire protection industry, with many applications for protecting fire hazards. Indeed, fixed-pipe CAF systems have arrived!

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References:

1. Crampton, G.P., Kim, A.K. and Richardson, J.K., A New Fire Suppression Technology, *NFPA Journal*, July/August, 1999 (pp 47-51).
2. Rochna, R., Compressed Air Foam: What is it!, *American Fire Journal*, August Edition, Fire Publications Inc., Bellflower, CA, 1991 (pp 28-34).
3. Magrabi, S.A., Dlugogorski, B.Z. and Jameson, G.J., A Comparative Study of Drainage Characteristics in AFFF and FFFP Compressed-Air Fire-Fighting Foams, *Fire Safety Journal*, Vol. 37, 2002 (pp 21-52).
4. Gardiner, B.S., Dlugogorski, B.Z. and Jameson, G.J., Prediction of Pressure Losses in Pipe Flow of Aqueous Foams, *Industrial & Engineering Chemistry Research*, Vol. 38, No. 3, 1999 (pp 1099-1106).
5. Kim, A.K. and Dlugogorski, B.Z., Multipurpose Overhead Compressed-Air Foam System and Its Fire Suppression Performance, *Journal of Fire Protection Engineering*, Vol. 8, No. 3, 1997.
6. Gardiner, B.S., Dlugogorski, B.Z. and Jameson, G.J., Rheology of Fire-Fighting Foams, *Fire Safety Journal*, Vol. 31, 1998 (pp 61-75).
7. Magrabi, S.A., Dlugogorski, B.Z., and Jameson, G.J., Bubble Size Distribution and Coarsening of Aqueous Foams, *Chemical Engineering Science*, Vol. 54, 1999 (pp 4007-4022).
8. CAN/ULC-S560 – Standard for Category 3 Aqueous Film-Forming Foam (AFFF) Liquid Concentrates, Underwriters' Laboratories of Canada, Scarborough, ON, 1998.
9. Crampton, G.P. and Kim, A.K., A Comparison of the Fire Suppression Performance of Compressed-Air Foam with Air-Aspirated and Unexpanded Foam-Water Solution, Proceedings of the NFPRF Conference on Fire Suppression, Orlando, FL, 2004.
10. Crampton, G.P. and Kim, A.K., The Effects of Varying Conditions and Cycling on the Performance of Compressed-Air Foam Systems, Report B-4135.1, Institute for Research in Construction, National Research Council of Canada, Ottawa, ON., 2002.
11. Kim, A.K., Crampton, G.P and Asselin, J.P., A Comparison of the Fire Suppression Performance of Compressed Air Foam and Foam-Water Sprinkler Systems for Class B Hazards, IRC Research Report No. 146, Institute for Research in Construction, National Research Council of Canada, Ottawa, 2004.
12. Kim, A.K., Crampton, G.P., Fire Suppression Performance of Compressed Air Foam (CAF) and Foam/Water Sprinkler Systems, Proceedings of the NFPRF Conference on Fire Suppression, Orlando, FL, 2004.
13. UL162 – Standard for Foam Equipment and Liquid Concentrates, Underwriters Laboratories Inc., Northbrooke, IL, 1994.
14. Kim, A.K. and Crampton, G.P., Application of a Newly-Developed Compressed-Air-Foam Fire Suppression System, Proceedings of INTERFLAM 2001, Edinburgh, UK, 2001.
15. Kim, A.K., and Crampton, G.P., Use of Compressed-Air Foam Technology to Provide Fire Protection for Power Transformers, Report B-4142.1, Institute for Research in Construction, National Research Council of Canada, Ottawa, 2004 (In Press).
16. NFPA 11 – Standard for Low, Medium, and High Expansion Foam, National Fire Protection Association, Quincy, MA, 2005.

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