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THE EMERGENCE OF CAF FIXED-PIPE FIRE SUPPRESSION SYSTEMS

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He has worked in the fire protection industry for the past 16 years and possesses an extensive background in fire suppression systems and special hazard applications. He was also involved in the development, testing and approval of the CAF Systems technology.

HISTORY AND BACKGROUND

Compressed-air foam (CAF) is a fire suppression medium created by injecting air under pressure into a foam solution stream. CAF fire suppression systems are high energy foam generation systems which produce small-bubbled, uniform foam in a high momentum jet. CAF fixed-pipe fire suppression systems 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. CAF technology itself has also been used for decades in the petroleum industry to enhance crude oil production. In fixed-pipe fire suppression systems, CAF systems are now a reality as a mean to reliably generate and transport CAF through a fixed-piping network and to distribute it effectively using specially-designed nozzles.

Until the CAF system development became available, fixed pipe foam fire suppression systems utilized aspirating nozzles, blowers and sprinklers. Each had its advantages and disadvantages. By being able to deliver CAF through a fixed-piping network and to apply it to a fire, FireFlex Systems ICAF fixed-pipe technology has 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. 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 FireFlex Systems ICAF fixed-pipe fire suppression systems 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-vapor 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:

ICAF 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/ft² for CAF represents only 25% of the water requirement for standard foam-water sprinkler systems having a design density of 0.16 gpm/ft² 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:

ICAF systems use significantly less water and foam, requiring less drainage and water treatment after a fire.

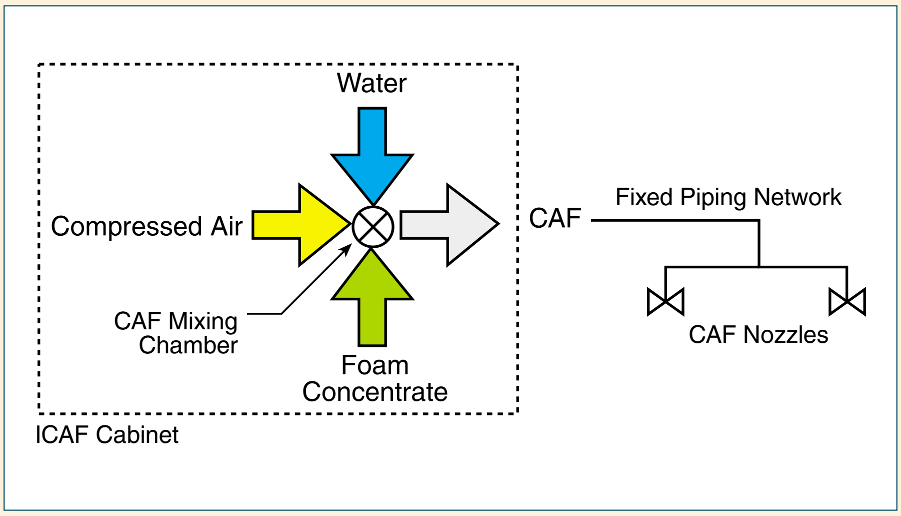

Figure 1. *Schematic of a CAF system*

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.

Figure 2. *Typical CAF consistency*

Under licence from NRCC, FireFlex Systems Inc, has developed Integrated CAF fixed-pipe systems (ICAF) 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 the consistency of CAF produced by these nozzles. Figure 3 shows the factory assembled ICAF generation system.

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. Full-scale fire test

Figure 3. Integrated Compressed Air Foam (ICAF) System Package

comparisons between CAF systems and foam-water sprinkler systems demonstrated the comparative performance of CAF with currently-accepted technology. An illustration of this test arrangement during operation is shown in Figure 4.

Researchers chose the UL 162 – Standard for Foam Equipment and Liquid Concentrates fire test as the basis for this comparison. 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 15 ft. above the floor. A second round of tests was conducted with the grid raised to 25 ft. above the floor, different from UL162 but necessary to compare the 2 systems for high bay applications.

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 25 ft. provided similar results.

This research demonstrated clearly that ICAF systems can provide equivalent and better fire extinguishment and burn-back performance when compared to foam-water sprinkler systems with significant economies in foam concentrations and solution flow rates.

CAF SYSTEM APPLICATIONS

The two main applications that were initially examined were flammable liquids hazards and electrical transformers. With the initial focus on Class B hazards, 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

Table 1 - Class B Foam (AFFF) Comparison – 15 ft. 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/ft² (L/min/m²)	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

foam-water sprinkler **CAF**

Figure 4. Comparison after 40 seconds

Table 2 - 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

shown that CAF is comparable to Class B foams for protecting those Class B hazards.

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. 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 also conducted to determine the potential to use CAF systems, instead of water spray systems, to protect large electric transformers. Full-scale testing demonstrated that 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 2 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 5 shows the fires at different times during comparable water spray and CAF tests.

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.

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.

Figure 4. *Fully developed transformer fire*

WATER SPRAY SYSTEM | **CAF SYSTEM**

Comparison after 60 sec.:

Comparison after 90 sec.

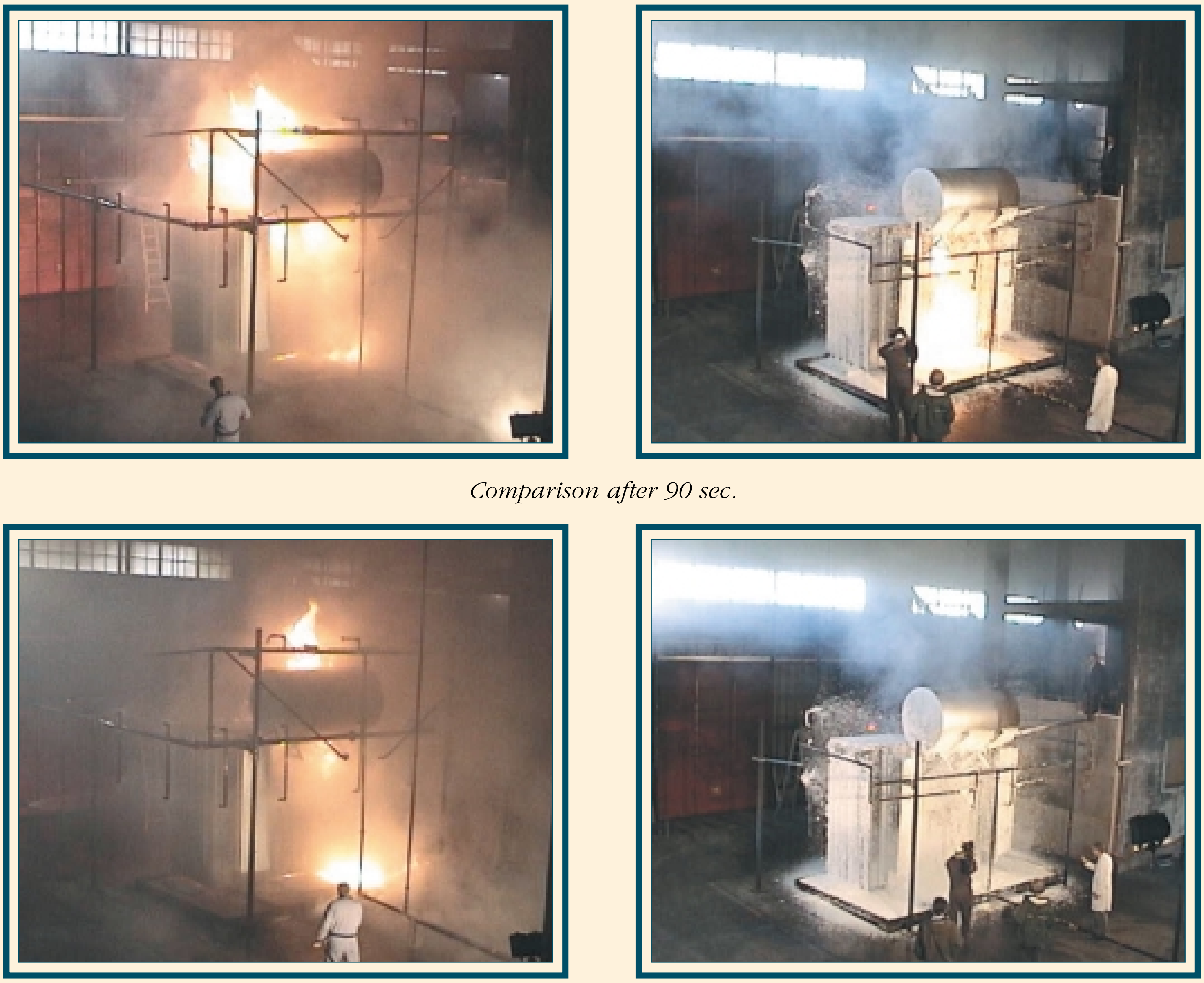

Figure 5. *Water Spray system vs. CAF system for power transformer protection*

In remote areas or areas with substandard water supplies, CAF systems provide a proven means to suppress flammable liquids fires. In these situations, fire suppressions 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. FireFlex Systems ICAF Systems are now FM Approved for use on Flammable Liquid Fires 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 is currently 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 flammable liquid fire hazards. Indeed, fixed-pipe CAF systems have arrived!

ACKNOWLEDGEMENT:

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