CAFS goes to Germany

Class A foam, especially in the form of compressed-air foam systems, faces a great deal of skepticism from the European fire services. A series of recent tests in Germany, however, will probably help win converts.

By Holger de Vries, Fire Protection Engineer
University of Wuppertal, Wuppertal, Germany

Photos courtesy the author

One of Ingolstadt's two new compressed-air foam pumpers, hooked up to a typical European below-grade hydrant.

The first two pumpers in Germany with compressed-air foam systems will have been in service with the Ingolstadt Fire Department in Bavaria (southeastern Germany) for about a year when this article is published.

As I outlined in the paper I co-wrote with Harald Herweg on the Berlin fire service [*Ed.: See "The Berlin fire service," August 1997, available at* <*www.firechief.com*>], the purchase of fire equipment in Germany is, for good reason, very much regulated by standards. Since CAFS is a new player here, and no standards match this technology, the Fire Authority of the Bavarian Ministry of the Interior mandated that it will support these vehicles with government grants only if:

1) the use of the CAFS pumpers and the benefits and drawbacks of the units could be properly documented, and

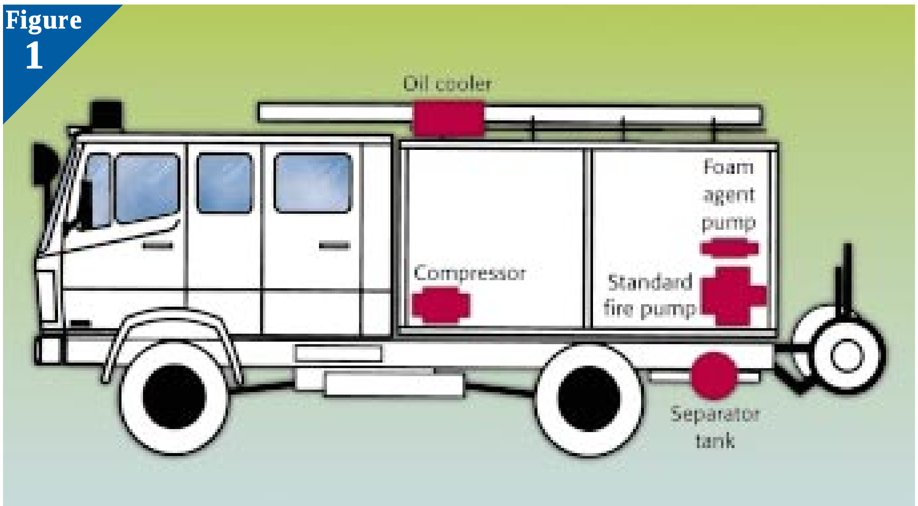
2) independent scientific research was carried out on the efficacy of the units.

I must admit that I was more than satisfied with these government agency findings, which basically match the conclusions of my "crib fire" article [*Ed.: See "When did you fight your last crib fire?" March 1997, available at* <*www.firechief.com*>]. We have been asked by the manufacturer (Hale's German subsidiary) to propose a realistic testing set-up.

Before describing the trials and their results in depth, let's take a look at the design of the two Ingolstadt CAFS pumpers. As is common in continental Europe, they're built on commercial chassis, in this case, a 12-metric-ton (26,500-pound) Mercedes chassis with a 177kw (240hp) diesel engine. The crew cab has seating for six personnel.

The body and pump were built by Ziegler, of Giengen/Brenz, one of the major German fire equipment manufacturers. The pump's minimum rating is 1,600lpm (430gpm) at 8 bars (116psi) discharge pressure. The pumper carries 1,200 liters (320 gallons) of water, 100 liters (26 gallons) of AFFF (1% concentrate) and 50 liters (13 gallons) of Class A concentrate. Ingolstadt decided to use a Hale CAFSMaster system.

Since in Germany pumps are never midships, but installed at the rear of the chassis, the CAFS components had to be mounted in various places of the body, as can be seen in



A schematic of how the cafs components are laid out in the Ingolstadt cafs pumpers.

Figure 1 (above). This requires longer lengths of piping and therefore very careful fine-tuning of the system. Except for the CAFS unit, the pumper very much represents a standard German vehicle.

"Cold" CAFS trials

In Germany, the 2- or 1¾-inch attack line is usually not run directly from the pump. Instead, a 3-inch line is run from the pump and feeds a 3-way ball valve siamese (or "water thief") with two 2-inch outlets and one 3-inch outlet. Attack lines are run from the outlets of the siamese.

The American literature on the subject recommends against using CAFS with siamese valves or water thieves. Since using these is common in Germany, however, we wanted to see what happens if you run CAFS through this set-up:

Fire pump → two lengths of 3-inch hose → water thief → one length of 42mm (between 1½- and 1¾-inch) attack line → nozzle

We used 200-liter (53-gallon) hazmat overpack drums and a clear acrylic tube 112cm (44 inches) high and 29cm (11.4 inches) in diameter to collect foam to determine expansion ratios and drain times of foam produced by the CAF unit, depending on the unit's foam quality setting. The foam was discharged through a 33mm (1.3-inch) smoothbore nozzle. Sample taking was quite a thrill, because we wanted not laboratory results, but what the CAFS unit really produced, so the author had to expose himself to the quite powerful CAFS jet. The data obtained are shown in Table 1 (below).

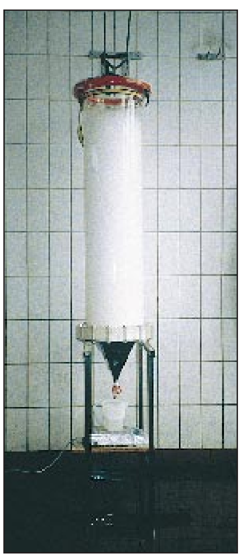
Table 1 — Results of "cold" CAFS trials

Foam quality	Foam agent	Water flow	Air flow	Expansion ratio	25% drain time	50% drain time
Dry	0.5% Class A	32gpm	53cfm	6.1	32 mins	60 mins
Dry	0.5% Class A	31gpm	53cfm	5.7		
Medium	0.5% Class A	130gpm	32cfm	8.3		
Wet	0.5% Class A	113gpm	18cfm	4.9		
Wet	0.5% Class A	132gpm	18cfm	8.9	18 mins	33 mins
Dry	1% arff			5.0		
Dry	1% arff			14.7		
Medium	1% arff			6.1		
Wet	1% arff			4.8	11 mins	20 mins

"Hot" CAFS trials

In Ingolstadt, the former Royal Bavarian Artillery Factory is currently under demolition, and the local fire department has been using it as a makeshift training site. Being aware that the available 20-foot steel ISO intermodal container doesn't perfectly resemble the brick-and-stone construction of German housing, we decided to run four fires with identical set-ups there, using plain water on two fires and CAFS on two others.

The fire load used was 15 wooden palettes, set up like furniture (as a shelf and a bed frame), two car seats, a mattress and two bales of dry straw, with the straw being distributed all over the "furniture." The energy relase of this fire load during the pre-burn is on the order of 2–3 megajoules (or 1,900–2,800btu).



Above left and right: The clear acrylic tube used to collect samples of foam to measure aspiration and drainage time, and the actual sample-taking, with the author on the receiving end.

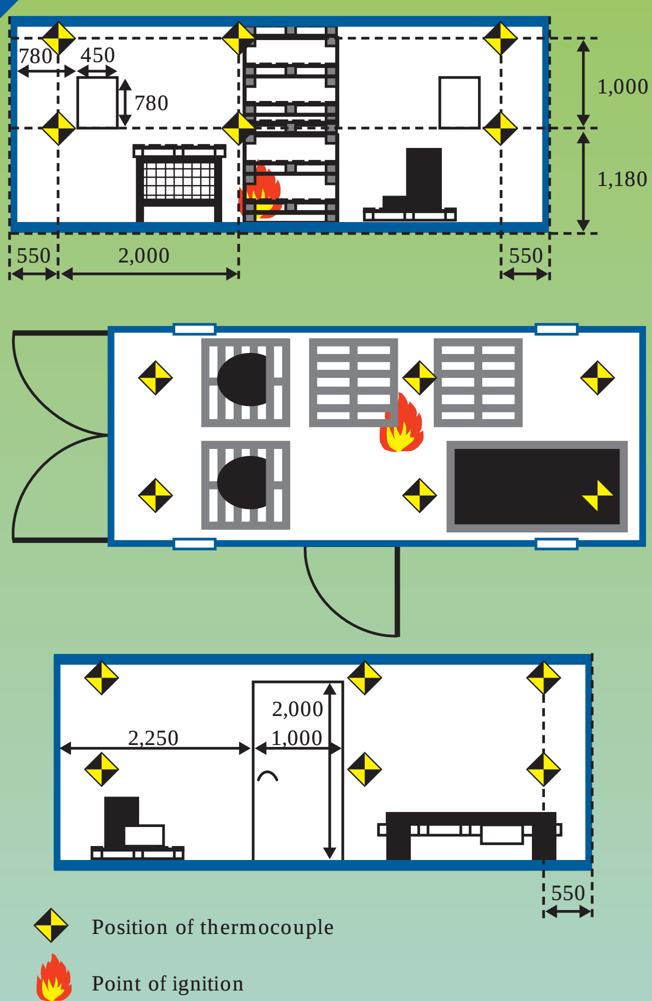
Since the steel container lacked window openings, four rectangular openings were cut into the side walls for proper ventilation. The set-up of the test room can be seen in Figure 2 (opposite). We installed 12 thermocouples in two layers, one about three feet from the ground and the second about six feet from the ground. The aim was to measure not only the quantity of extinguishing agent and the knockdown time, but also the difference in burn room temperature decrease that was observed in the "Salem" trials and is often quoted to promote the use of CAFS.[1]

The fires were ignited by using two liters (half a gallon) of gasoline, a quantity that's minute compared to the solid fire load. The two liters of gasoline were poured into a steel tray, which was placed under the shelf. By using the steel tray we made sure that the gasoline did not soak into the solid fuel and that it would be burned out before the end of the pre-burn time.

We used the container's back doors only to load the fuel and unload the debris. Access for firefighting was made only through the side door near thermocouples 2 and 8. Fifteen minutes was selected as the pre-burn time, although fire two did not really pick up, so we gave it a pre-burn time of 16 minutes.

There was another reason for running these fire trials the way we did. In fall 1997, the University of Wuppertal ran 20

Figure 2



Two side views and a top view of the iso intermodal shipping container used for the "hot" cafs trials, showing both the fire loading set up to resemble furniture and the double layer of thermocouples. All dimensions shown are in millimeters. The overall internal dimensions were 5.890 × 2.315 × 2.180 meters (19.4 × 7.6 × 7.2 feet); external dimensions

The 20-foot shipping container loaded with fuel and ready for ignition.

room fire trials (the "Tremonia" trials) in which plain water, Class A foam and a firefighting gel (requiring 3% proportioning) were used, and we thought it might make sense to try to compare the overall results. The data obtained during the 20 trials is so large that its processing is still under way. We hope to be able to publish the results in early 1999.

For fighting the Ingolstadt trial fires, we used a 42mm attack line with a German smoothbore nozzle with an 11mm (approx. 7⁄16-inch) orifice. Class A foam agent was proportioned at 0.5% in trials three and four. The CAFS unit did have some problems matching the air flow to the water flow, but this was only realized the day after the trials. We could determine that the air flow during the CAFS trials had been lower than it should have been. However, since the quantities of extinguishing agent with this impaired CAFS unit were significantly lower than the quantities with plain water, we decided not to re-run the CAFS trials.

During the trials with water, we used a mechanical water meter at the discharge side of the fire pump to measure the quantity of water used. This, of course, isn't possible when you run CAF through the hoses. Instead, we used the CAFS unit's electronic measuring devices. Furthermore, before each foam trial, we filled up the vehicle's water tank until it flowed over, and re-filled it with the water clock coupled into the hydrant line to the suction side of the pump until the tank flowed over again, so that we could confirm (or discard) the values obtained from the CAFS unit. (See Table 2.)

The extinguishing time was measured using a stopwatch from the beginning of firefighting operations until the nozzleman reported "Fire out," as he would have done in a real emergency situation. (See Table 3.)

As outlined in previous papers, I like to derive a third value, the "extinguishing work," as a product from the quantity of the extinguishing agent and the time required to blacken out the fire. The extinguishment work must not be confused with "work" in the physical sense, which is defined as the product of force and distance.

Extinguishment work is a derived ("artificial") value representing a firefighter's effort in putting out a fire. By concluding that the time of extinguishment is also the time that a firefighter exposes himself to a hostile environment and heat stress, it helps to better differentiate between the various possible efficacies of firefighting agents:

Long time × large quantity = Poor agent

Medium time × medium quantity = Average agent
Short time × large quantity = Average agent
Long time × small quantity = Average agent

Short time × small quantity = Efficient agent

In these trials, the values for the extinguishment work shown in Table 4 were determined. It's obvious that, under the constraints given in these trials, CAFS is far superior to plain water, requiring less extinguishing agent, less time and less extinguishment work to blacken out fires.

Table 2 — Extinguishing agent quantity

Trial	Agent quantity, as measured by: Mechanical water clock	CAFSMaster
Water 1	380 liters (100 gallons)	
Water 2	242 liters (64 gallons)	
CAFS 3	66 liters (17 gallons)	50 liters (13 gallons)
CAFS 4	106 liters (28 gallons)	82 liters (22 gallons)

Table 3 — Time to extinguishment

Trial	Water 1	Water 2	CAFS 3	CAFS 4
Time to extinguish (minutes:seconds)	7:45	5:30	2:50	4:30

Table 4 — Extinguishment work

Trial	Liters × minutes	Gallons × minutes
Water 1	2,945	778
Water 2	1,331	352
CAFS 3	186	49
CAFS 4	477	126

Analysis of burn room temperatures

There are three aspects of analyzing the burn room temperatures:

1) It has to be ensured that the fires have been comparable, in other words, that the attack team has faced more or less the same situation in the burn room when starting to fight the fire.
2) The time to "Fire out" is basically determined by the nozzleman's "gut feeling." The burn room temperatures have to be looked into to ensure that he didn't just stop with the fire having been extinguished only halfway.
3) Given the use of different extinguishing agents, it's of interest to find out whether the velocity of the temperature reductions in the burn room after firefighting has commenced correlate with the difference in extinguishing agent.

The easiest way to quantify the energy releases in the burn room during the pre-burn time is to sum up each temperature measured at each thermocouple during the pre-burn. This approach is only legitimate if all other constraints of the trials (fire load, distribution of the fire load, geometry of the burn room, etc.) are constant. Of the 12 thermocouples installed, only eight delivered readings during all trials, so only these values can be taken into account. (See Table 5.)

These values show that all four trials, especially Water 1 and CAFS 4, are very comparable regarding the pre-burn. The next step is now more than obvious: To set the work required for extinguishment in relation to the energy releases during the pre-burn time. (See Table 6.)

Interpretation of these values works with the same logic as that of the extinguishment time: The smaller the number, the better the extinguishment agent and/or method. The derived figure of "relative extinguishment work" has the advantage of giving a value for the extinguishment work in relation of the energy releases during the pre-burn. In other words, it takes into account if you have fought a relatively "hot" fire with little foam in a short time, versus a "cool" fire with much water, requiring a longer span of time, as is the case in these trials.

I'm quite aware that we're moving a bit far into statistics here, but this is exactly what your town councilors and administrators do every day. They look into demographic data or figures of road traffic density in terms of vehicles and their gross weight and/or passengers per lane per minute versus time of day and make their decisions based on these figures. Why should the fire service stand back from these methods to justify their purchasing proposals?

Table 5 — Temperature sums during pre-burn

Trial	Temperature reading sums (Kelvins)
Water 1 (15 minutes pre-burn)	1,804,733
Water 2 (16 minutes pre-burn)	1,570,149
CAFS 3 (15 minutes pre-burn)	1,371,486
CAFS 4 (15 minutes pre-burn)	1,812,864

The second aspect of analyzing the burn room temperatures was to investigate a possible difference of temperature changes after extinguishment has begun. Several findings were made. First, the temperature sums of the initial eight minutes after opening the nozzle do not vary much between the extinguishing agents. Furthermore, the gradients of the various measurements of temperature change versus time, that is, the slopes of the temperature-versus-time graphs, vary significantly. The result is that these trials could not confirm the findings of the often-quoted "Salem" trials.

We believe that the reason for this is the thermal behavior of the blank steel of our burn container as opposed to the wooden walls of the "Salem" burn rooms. It doesn't make a difference whether you hit a hot steel surface with water or foam, because either will vaporize almost instantly. Furthermore, the steel walls are impervious to fire and don't burn. Something that doesn't burn, of course, can't be soaked and extinguished with wet water or foam.

However, the bottom line is that Class A foam, both nozzle-aspirated or compressed-air, has proved its superiority in various testing environments in the United States as well as during our own research.[2] As I noted before, the analysis of the data on the other 20 "Tremonia" trials we've run is still under way, but preliminary results also indicate the superiority of nozzle-aspirated Class A foam over plain water. These scientific data are backed up by the experience of the firefighters in Ingolstadt, who managed to control a fierce attic fire in a home for the mentally disabled with virtually no water damage, using a blitz attack from the outside first and then an interior attack.

Fire insurance companies are displaying a sincere interest into the Class A foam technology. While no decisions have been made yet, it might end up with fire insurance companies sharing part of the extra costs for Class A foam equipment.

The German fire service was confronted with Class A foam for the first time in 1994, when we performed demonstrations during the Interschutz trade show in Hannover. I am too conservative myself to accept new technologies simply because they're promoted aggressively in four-color brochures.

Having spent four years in our Class A foam project and having run all the trials personally, however, I have to say that Class A foam technology is the obvious, inevitable and necessary next step toward efficient fire suppression. Refusing to use Class A foam seems to me like refusing to use hydraulic rescue tools and still responding to car accidents with only crowbars and cutting torches.

Table 6 — Relative extinguishment work

Trial	(liters × minutes)/ Kelvins	(gallons × minutes)/ Kelvins
Water 1	163.0×10^{-5}	43.1×10^{-5}
Water 2	84.8×10^{-5}	22.4×10^{-5}
CAFS 3	13.6×10^{-5}	3.57×10^{-5}
CAFS 4	26.3×10^{-5}	6.95×10^{-5}

Which system a fire department uses, be it nozzle-aspirated or compressed-air foam, is up to their community's risks and their budgets. I'm very satisfied with fire departments in Europe now adopting Class A foam technology, and I'm very curious as to what this will lead to in a few years. FC

Notes:
1. Colletti, Dominic J., "Quantifying the effect of class A foam in structure firefighting: The Salem tests." Fire Engineering, February 1993, Pennwell Publications, Tulsa, Okla.

2. Pohl, K. D.; H. de Vries; and S. Noje-Knollmann, "Class-A-Foam." Fire Professional, Vol. 3, Issue 4, Winter 1995/96, ESC Publications Ltd., South Petherton, Somerset, United Kingdom.

A member of the German fire service for 17 years, Holger de Vries is a fire protection engineer at the University of Wuppertal, holding a master's in safety engineering and fire and explosion protection from that institution. He is currently a volunteer leading firefighter and safety officer with Wuppertal Fire and Rescue Department and a live fire instructor at a training site in Dortmund.