Increasing Fire Suppression Effectiveness with the Use of Class A Foam or Compressed Air Foam Systems

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ABSTRACT

Over the past 30 years, the City of Massillon has experienced community growth through annexation and development. In 2010, the City of Massillon Fire Department increased its EMS service model to include EMS transport services. The changes occurred while staffing in the fire department remained relatively the same. The problem investigated during this research was how to maintain or increase fire suppression effectiveness while faced with increased services and community growth. The purpose of the research was to determine if implementing Class A foam or compressed air foam system (CAFS) capability would assist fire fighters with fire suppression tasks.

A descriptive research method was used to answer the following questions. What are the advantages and disadvantages of Class A foam and CAFS including their corresponding effects on firefighter safety and efficiency? What are the cost factors associated with Class A foam and CAFS? What other departments use or have used Class A foam or CAFS and do they realize the advantages and disadvantages described in the literature review? How would the implementation of Class A foam or CAFS effect fire suppression activities in the Massillon Fire Department? A literature review of past studies and known information was employed and a survey of fire departments in Ohio was conducted to help answer these questions.

The results of the research showed CAFS could potentially help improve fire suppression activities but at a significant cost. The research led to the recommendation of implementing class A foam capability immediately, while awaiting results from an ongoing study of the effects of CAFS usage. This study is scheduled for a July 2013 completion. This new research data could provide additional, current, information which may lead to recommending CAFS usage in the future.

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INTRODUCTION

Statement of the Problem

The City of Massillon, Ohio has experienced considerable growth over the past 30 years in terms of both geographical size and population. Annexation, housing developments, and the diversification of industry and commercial properties have increased the demands place on the Massillon Fire Department. Call volume continues to increase, average response time is rising due to the expanding boundaries, and the amount of time units are tied up on emergency runs is becoming longer as a result of the expansion of EMS services provided. These demands are being met with the same average number of on duty personnel today as in the early 1980's, when the growth began.

Today's economic environment prevents fire chiefs and local administrators from increasing daily staffing levels. The recent economic downturn has likely affected the general fund budgets of most local governments. The Massillon Fire Department's expansion of EMS, by providing EMS transport service, was not only to improve the service to citizens, but also increase revenue for fire department operations through billing for transport. However, those additional dollars have been allocated for other city needs. The Massillon Fire Department thus has maintained the funding it had prior to expanding its service, preventing any increase in operational personnel to offset the increase in services provided.

Fire suppression is a coordinated effort of firefighting teams, assigned different tasks that collectively extinguish fire. These tasks include: (a) establishing Incident Command, (b) securing a water supply, (c) deploying attack hose lines, (d) conducting search and rescue, (e) performing forcible entry and ventilation, and (f) the establishment of a Rapid Intervention Team (R.I.T.). The purpose of National Fire Protection Association Standard 1710 (NFPA 1710)

Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments (NFPA, 2010) focuses on the efficiency and effectiveness of services provided by fire departments staffed with career personnel with regard to protecting civilians in their jurisdiction and the health and safety of the firefighters providing the protection. According to NFPA 1710, a minimum of 13 to 14 firefighters are needed on the initial response to a low hazard residential structure fire to complete these tasks. Additional personnel are required if aerial devices are deployed or when responding to medium or high hazard occupancies.

Most fire departments, including the Massillon Fire Department, cannot meet the personnel criteria of the standard on a daily basis. Elected officials will not secure or authorize the necessary funds to meet the standard. Nor are they required to since the status of NFPA 1710 is a non binding recommendation. In order to become a requirement, an authority having jurisdiction would have to adopt the standard through legislation. Currently, local and state governments have elected not to do so.

The Massillon Fire Department's initial response to a structure fire is two engines and an EMS squad with a total of 8 to 9 personnel. The crew of the EMS squad is assigned fire suppression tasks. The remaining company is assigned as the "fill" company and relocates to Station One, covering the rest of the city. Unless another emergency call was received, the fill company is available to respond to the fire scene if directed to do so by the incident commander. This would bring the total initial response up to 11 personnel. When personnel are handling EMS runs they are unavailable for a structure fire response. This decreases the personnel available for an initial structure fire response to between 6 and 8 and possibly less depending on the number of EMS calls occurring at any given time.

At a structure fire, incident commanders prioritize the assignment of tasks according to the available personnel initially arriving on a fire ground and the fire conditions showing on arrival. Since available firefighters are less than the NFPA 1710 recommended number, some support tasks are delayed or never accomplished. At times, crews must double up on tasks which immediately decreases the efficiency of those crews and exposes personnel to higher risks of injury. When fewer on duty firefighters are available, i.e. tied up on EMS calls, incident commanders must prioritize to a greater degree furthering the inability to accomplish some support tasks or even primary tasks. The inability to initiate these tasks has the potential to negatively impact the safety of residents and firefighters. This may also lead to higher property damage.

Elected officials and citizens constantly expect the fire department to provide the same or better services effectively with minimal or no increase in required funding. *The problem that this research project addressed was how can the Massillon Fire Department maintain or increase its effectiveness of first due companies during fire suppression while faced with community growth and increased services.*

Purpose of the Study

NFPA 1710 allows the use of equivalent systems, methods, or approaches to attempt to meet or exceed the standard (NFPA, 2010). Hiring additional staffing was not an option as a result of limited funding. As such, other means of improving fire suppression efficiency needed to be explored. One area in particular was advancements in technology. *The purpose of this research project was to identify and describe if utilizing Class A foam or compressed air foam systems (CAFS) would improve the Massillon Fire Department's first due engine company's suppression capabilities.* Readers will be provided information for making decisions regarding the use of Class A foam or CAFS as a means of providing more efficient, effective fire protection and creating safer working environments for firefighters. Administrators can use the report to determine if it is cost effective to implement either capability within the Massillon Fire Department. Firefighters will gain knowledge of Class A foam and compressed air foam system capabilities and drawbacks as well as information for continued research efforts in the future.

Research Questions

The following questions were answered by this descriptive research:

1. What are the advantages and disadvantages of class A foam and compressed air foam systems and their corresponding effects on firefighter safety and efficiency?
2. What are the costs associated with Class A foam and CAFS?
3. What other departments use or have used Class A foam or CAFS and do they realize the advantages and disadvantages described in the literature review?
4. How would the implementation of Class A foam or CAFS effect fire suppression activities in the Massillon Fire Department?

BACKGROUND AND SIGNIFICANCE

The Massillon Fire Department is staffed with forty-eight (48) career positions when at full strength. Three personnel are assigned to staff positions working a forty hour week. These positions include the Fire Chief, Fire Prevention Officer (Captain), and Fire Inspector who complete administrative duties and provide fire prevention, fire investigation and education services. The remaining forty-five (45) personnel work a three platoon 24/48 hour schedule and are assigned to the operations division providing fire suppression, EMS transport, hazardous material, and several special rescue disciplines (Massillon Fire Department, 2011).

These services are provided to the City of Massillon which is located in western Stark County in northeastern Ohio. Population according to the 2010 census was 32,149 living within 19.210 square miles. The median age of the population is also increasing. Median family income is estimated at $48,136 with a median home value of $98,500 (US Census Bureau, 2010). The city has a strong mix of residential, commercial, and industrial occupancies.

The fire department operates out of four stations. Station 1 serves as the department's headquarters and is staffed with a minimum of four personnel including an assistant chief (shift commander) and three cross trained firefighter paramedics. Two of the firefighter paramedics are assigned in a "combo" style and ride the EMS transport unit or the engine depending on the type of call. The assistant chief and the third firefighter paramedic are assigned to the engine. Until 2011, Station 2, Station 3, and Station 4 were staffed as "combo" companies with two personnel, a captain paramedic and a firefighter paramedic staffing both an engine and an EMS ALS first responder unit. On January 1, 2011, in conjunction with adding a second transport unit, staffing at Station 2 was increased to three by adding a second firefighter paramedic. This increased the minimum daily staffing to eleven (11) however, minimum daily staffing remains below the 1992 level of twelve (12).

The City of Massillon has nearly doubled in size since 1984 growing from 9.747 to 19.210 square miles in 2011. This growth has caused the city limits to expand mostly to the south and west (City of Massillon, 2011). As this land has been developed, the number of responses to these areas has escalated resulting in an increase in the average response time from three minutes to close to four minutes. The locations of all existing fire stations were established prior to any of this growth causing response times of seven to eight minutes for first due companies to the newly developed parts of the city (Massillon Fire Department, 2009 – 2011). A fire can intensify substantially in this time period making extinguishment more difficult for the first due companies.

The population has increased 5.6 % since 1990. The western wards of the city have experienced a greater increase in population than the older wards corresponding with the above mentioned development of annexed areas. The City is also experiencing a rise in the aging population as evidenced by the increase in percentage of those 65 and older (US Census Bureau, 2010).

The growth and development of the city and the changes in population demographics have attributed to the 70% increase in call volume for the fire department since 1990. With additional annexation petitions and development plans on the table, one could reason the trend will only continue in the future as the City continues to grow (Table 1).

Table 1

Community growth and fire department activity trends

Year	Population	Pop. 65 and older	Geographical Size [a]	Total Runs [b]	Average Response Time [c]
1990	31,007	15.8 %	13.427	2486	2:47
2000	31,325	16.1 %	17.124	3338	3:08
2010	32,149	16.8 %	19.210	4235	3:48
2011	32,149	16.8 %	19.210	4445	3:58

Note. Data retrieved from U.S. Census Data and Massillon Fire Department records.
[a] square miles. [b] includes EMS runs. [c] minutes : seconds.

In 1982 the fire department added Advanced Life Support capability by training Firefighter/EMTs to become paramedics. The EMS service model was a first responder system where a fire department EMS unit responded and began treatment and then transferred care over to a private ambulance company who transported the patient to the hospital (Studer, 2009). In 2010, the fire department began providing EMS transport service on a limited basis by placing one EMS transport unit into service. Private ambulance companies continued to support this service model by handling second runs and transporting to hospitals outside of Massillon in non emergency situations.

In 2011, a second fire department EMS transport unit was placed into service at Station 2. Staffing at that station was increased by one to facilitate a single company response on EMS calls in that district as opposed to the two unit response in the other districts. The fire department also began transporting patients to two additional hospitals located in the City of Canton which added 8 to 15 miles onto the transport distance. The effects of adding the second EMS transport unit and the two hospitals in Canton to the EMS service model were:

1. 26 % increase in the average time to complete an EMS call (Table 2)
2. 84% decrease in number of transports turned over to private ambulance companies (Fire Department now handles these calls) (Table 2)
3. 16% increase in the number of second runs (two or more calls occurring at same time)

The amount of time where companies are unavailable to respond to a structure fire is increasing. This places a greater burden on Incident Commanders and personnel arriving on first due companies to safely and effectively perform fire suppression tasks.

Table 2

Effects of implementing EMS transport service

Year[a]	Number of EMS runs[b]	Number of Patients transported by MFD[c]	Number of patients transported by Others	Number of patients age 65 and older	Average time to complete an EMS run[d, e, f]
2009	3018	0	2683	1065	19:48
2010	3090	2001	782	1191	29:08
2011	3356	2874	152	1221	36:42

Note. Data collected from Massillon Fire Department records

[a] 2010 began EMS transport with one ALS transport unit; 2011 added second ALS transport unit. [b] EMS run greater than total number of patients transported due to patients refusing treatment or transport, no patient found on arrival, accidental medical alarms, and D.O.A.s. [c] Massillon Fire Department. [d] Measured from time of call until back in service. [e] Includes all EMS run (transport and non-transport). [f] minutes:seconds.

The City has placed an overtime reduction policy in effect due to the economic status of the general fund resulting in stringent call back parameters of off duty personnel. A call back of off duty personnel is activated only after the conformation of a working fire by initial arriving companies. The time period to get off duty personnel back to the station is 12 to 20 minutes. Only one neighboring fire department is career staffed, the remaining departments comprise of combination part-time and volunteer or volunteer only. As a result, the majority of mutual aid companies are at least ten minutes away. The City has had brief discussions with surrounding communities regarding automatic aid. However no agreements have been reached.

The growth and development of the City, the addition of transporting to the EMS model, and the changes in the demographics of the City are potentially reducing the effectiveness of first due companies' fire suppression efforts. *The potential impact this study could have on the Massillon Fire Department is a change in the tactics deployed by first due companies during fire suppression with the implementation of Class A foam or CAFS.* When completed, administrators will have the information needed to make decisions regarding the utilization of Class A foam or compressed air foam systems for fire attack. Firefighters will have a better understanding of the characteristics of class A foam and CAFS. The tax payers could possibly see a more efficient fire department through effective use of their tax dollars.

LITERATURE REVIEW

The *Report on Residential Fireground Field Experiments* (National Institute of Standards and Technology (NIST), 2010) details the results of more than 60 full-scale fire experiments conducted to study the efficiencies and effectiveness of different sized crews or companies assigned to complete fire suppression tasks at a low hazard residential structure fire. The study compared crew sizes ranging from two to five personnel. The breakdown of total firefighters responding to each scenario based experiment is displayed in Table 3. Three engine companies, one truck company, and a chief, with an aide, were deployed for each experiment simulating a normal initial response to a residential structure fire.

Table 3

Breakdown of total responding personnel based on crew size

Number personnel per crew	Total on 3 Engines	Total on 1 Truck Company	Chief and Aide	Total # Personnel on scene
2	6	2	2	10
3	9	3	2	14
4	12	4	2	18
5	15	5	2	22

Note: Data from *Report on Residential Fireground Field Experiments* (NIST 2010)

Each scenario based experiment measured the time it took the different sized crews to complete 22 different fireground tasks commonly performed on low hazard structure fires. Concurrently, measurements of temperature and toxicity inside the structure were recorded to evaluate the tenability of the environment for potential occupants and firefighters. The experiments took into consideration the arrival time of the first due engine company and staggered arrival times of other responding companies. This report provided quantitative data for use by the NFPA 1710 Technical Committee to update and further develop NFPA 1710 (NIST, 2010).

Data from the experiments showed four person crews completed all 22 tasks seven minutes faster than two person crews and slightly more than five minutes faster compared to three person crews. There was no appreciable difference in overall time to complete all tasks when comparing four and five person crews responding to a low hazard residential structure fire. In particular, data from one area of performance measurement, time to water on fire, indicated four person crews were 16% faster than two person crews and 6% faster than three person crews with respect to initial application of water onto the fire. In other terms, it took two person crews 87 seconds longer to advance the attack hose and begin extinguishment (NIST, 2010).

One significant finding that sticks out from the experiments was "The fire modeling showed clearly that two person crews cannot complete essential fireground tasks in time to rescue occupants without subjecting them to an increasingly toxic atmosphere (NIST, 2010, p. 11)." The report also indicates, due to limitations of the experiments, operating at night or in extremely hot weather may induce additional challenges that could increase the times required to complete the tasks. Neither of these conditions was evaluated during the experiments.

The tactics deployed during the experiments were traditional fire suppression methods including the use of plain water fire streams for fire extinguishment. Although most of the tactics used follow procedures contained in basic firefighting texts, there was no mention of advanced technology used during the scenarios. One area which could have been explored was the use of Class A foam and compressed air foam in place of the plain water fire streams.

Compressed air foam systems (CAFS) have been around since the 1930's when the British Royal Navy began using CAFS for shipboard fire suppression. In the 1940's and 50's, the British Royal Air Force and the U.S. Navy implemented CAFS technology for fire protection. The American civilian fire service however, did not seriously look at CAFS technology until the 1970's when the Texas Forestry Service searched for ways to fight severe range fires in large areas with limited water supply. CAFS technology for use in the structural firefighting arena did not gain momentum until the early 1990's after data from live burn test fires were developed. The results showed that CAFS and class A foam provided benefits to structural firefighting. Some departments that began using CAFS in the 1990's found the early model equipment was hard to operate and caused a safety issue. This led to the opinion that the benefits of CAFS was not worth the trouble (Colletti, 1998).

Compressed air foam consists of three parts: (a) water, (b) foam concentrate, and (c) air. These three components are mixed in a compressed air foam system consisting of a water pump, foam concentrate proportioning device, and an air compressor which are controlled by switches and valves at the pump panel (Mahoney, Rickman, & Wallace, 2008). Today's CAFS are more user friendly and are engineered with the technology to apply their use to structural firefighting compared to previous CAFS models (Colletti, 1998). In *A Compelling Argument*, John Lund (2010, Focus on Foam p. 14) states "today's direct-inject foam systems are accurate and so easy to run that a probie can do it."

The literature review showed that the advantages and disadvantages of Class A foam and CAFS have been well documented over the past twenty years based on numerous live fire tests and in-field studies. Several sources agree the main advantages of class A foam and CAFS are:

- faster knockdown and extinguishment times
- quicker absorption of heat
- less total water usage
- lighter and more maneuverable hose lines
- longer stream reach
- less time required for overhaul
- reduced chances for rekindle
- clings to the fuel's surface
- products of combustion are reduced

(Cavette, 1999; Colletti, 2009; International Fire Service Training Association (IFSTA), 2003; & Mahoney et al., 2008).

Cavette (2001) describes one of the first tests completed on the effects of class A foam and CAFS during structural fire suppression in *Bubbles beat water.* The tests discussed are referred to as the Palmdale test and were conducted by the Los Angeles County Fire Department in 1990. The tests were performed in three houses that had the same floor plan and dimensions. The same furniture layout was added to each house to mimic the contents of a small residential structure. The tests took place over a two day period in similar weather conditions and with the same personnel and apparatus performing the suppression task. The results showed that class A foam was more effective than plain water in suppression of the fires. CAFS was shown to improve on class A foam performance and was quantified as more than four times as effective as plain water (Table 4).

Table 4

Results from Palmdale test

Extinguishing Method	Time to knockdown	Total water used
Plain water	50 seconds	75 gallons
Class A foam solution	25 seconds	44 gallons
CAFS	11 seconds	16 gallons

Note: Data from Bubbles Beat Water (Cavette, 2001)

Another measurement obtained in the Palmdale test was the speed at which the environment cooled during and immediately after knockdown. CAFS again was shown to be four times as effective as plain water. The temperature was reduced from 600 degrees Fahrenheit to 200 degrees Fahrenheit in 6 minutes and three seconds following application of plain water. CAFS reduced the temperature over the same range in 1 minute and 28 seconds. Class A foam was slightly longer than CAFS at 1 minute and 45 seconds. Initial temperature reduction also began much earlier with class A foam and CAFS than with plain water (Cavatte, 2001).

Other benefits observed but not measured during the test showed less water damage to the structure and contents as well as less contaminated water runoff. The participants noted reduced products of combustion inside and outside of the structure resulting from quicker knockdown times. The firefighters on the attack line were able to begin their suppression efforts 35 feet from the building due to the longer stream reach of the CAFS stream (Cavette, 2001).

In 1992 and early 1993 the United States Fire Administration (USFA) conducted a field test utilizing Engine 37 of the Boston Fire Department. In their Technical Report Series *Compressed Air Foam for Structural firefighting: a Field Test* (1994), Engine 37 was used to evaluate the effectiveness of CAFS. Engine 37 was the busiest engine company in Boston with a response district that had a dense population and was widely diversified containing multi-family residential buildings, busy commercial districts, college and university buildings and a number of other occupancies. Throughout the test period, Engine 37 was dispatched to any working structure fire in the City of Boston in order to provide the most opportunities to evaluate the effectiveness of CAFS in a wide variety of urban fire situations.

During the test period, Engine 37 responded to 218 fires and placed CAFS into operation 146 times in conjunction with structure, vehicle, and trash fires. The operations were further broken down with CAFS used for direct offensive attack 99 times and overhaul 47 times. In addition, the CAFS line was used several times as a backup line or in concert with other lines operating during fire suppression. During the test period, the CAFS hand line became the standard attack line used in almost all operational fires. The observations and opinions of the firefighters deploying the CAFS lines were recorded on field test evaluation forms and included comments from firefighters and officers (USFA, 1994).

The vast majority of the responses were positive. In 119 of 146 times the technology was used, CAFS was found more effective than water with an additional 26 occurrences where CAFS was as effective as water. On only three occasions, CAFS proved to be less effective than water (USFA, 1994). The report does not describe what the fire situations were for each occurrence or where CAFS was deemed not as effective as water.

Other observations concur with the advantages listed above. Hose line movement was found to be easier than a water filled hose line by a vast majority of firefighters. A very high percentage of firefighters determined kinking of the hose was not a problem. It was also noted, there were no problems with the CAFS equipment in over 90 percent of the incidents where it was used (USFA, 1994).

One difference pointed out in the Boston field test in contrast to the tests performed in Los Angeles County is the penetration capability of a CAFS stream being weaker in comparison to a water stream. The mass and velocity of a water stream is much higher than the expanded foam bubbles of a CAFS stream and thus has a stronger penetrating power. Comments mentioned tactics were changed due to the limited “punch” of a CAFS stream. The report did not say how they changed. However, it indicated this did not create any problems during any of the fires (USFA, 1994). During the Palmdale test, it was noted that the fire attack team began their efforts at a greater distance due to the stream throw of the CAFS line being 33 percent longer than either the foam/water solution or plain water (Cavette, 2001).

Additional advantages result in the greater effectiveness of water when class A foam and CAFS are used. Less water used and quicker knockdown times lead to reduced property damage caused by fire and water. Less water used and the more effective use of the water applied result in reduced contaminated water runoff (Cavette, 1999; Colletti, 2009; Mahoney et al., 2008).

The disadvantage that shows up most in the reviewed literature is the cost of including a CAFS on new apparatus and the cost to maintain the equipment, materials, and personnel trained to use the system during fire suppression (Cavette 1999; IFSTA, 2003; Mahoney et al., 2008; & Stern & Routley, 1996). Other disadvantages according to IFSTA (2003) and Mahoney et al. (2008) include:

- creation of slippery surfaces
- strong possibly erratic nozzle reaction when initially opened
- obscures tripping hazards
- obscures vision
- class A foam concentrates are corrosive

During the field test in Boston (USFA, 1994) observations were made in regards to creating slippery conditions. They noted firefighters who were familiar with CAFS did not have a problem with the slippery surfaces while those new to CAFS found the slippery surfaces difficult. They also discussed the obscured vision when foam covered the face piece and after gaining knowledge and understanding, found the foam could be removed with a gloved hand.

Stern & Routley (1996) discuss the possibility for increased mechanical failures and human errors due to the additional procedures and equipment required to produce compressed air foam. Colletti (2008) states there is anywhere between five to eight additional steps pump operators must perform when using CAFS, however, it was noted some CAFS manufactured today are automatic and are easy to operate with decreased human intervention. He expands on that thought and finds most problems occurring with the utilization of CAFS can be corrected with training and education.

The advantages stated above and measured in the live fire tests and field studies result in additional advantages regarding firefighter safety and the efficiency of fire suppression operations. Briese (2010) breaks down the advantages and how they affect firefighters. Quick knockdown times, lighter hose lines, and less time performing overhaul result in reduced physical stress on firefighters. The longer reach of the stream, less kinking of hose lines, and the effective exposure protection of CAFS decrease the risks to firefighters. The faster heat reduction and fewer products of combustion allow for a safer working environment.

Less water used also provides a safer work environment by reducing the load water applied for extinguishment places on structural components (IFSTA, 2003). The National Institute of Occupational Safety and Health compiled data from 1979 to 2002 concerning firefighter deaths caused by structural collapse. During that time, over 65% of the fatalities due to structural collapse happened during fire attack (Brooks, 2007).

Stern & Routley (1996) discuss two dangerous fire situations, unstable structures and lightweight construction, where the use of CAFS would enhance firefighter safety and efficiency. The longer reach of CAFS streams would permit suppression teams to remain outside of the collapse zone. They discuss the reduced weight added to the structure by the use of foam thus decreasing the possibility of a structural collapse. The quick and enhanced fire suppression capability of CAFS could provide more effective fire suppression operations in structures with modern construction features such as trusses and lightweight construction.

A risk to firefighters specifically using CAFS was discovered after two firefighters died in the line of duty while attacking a structure fire in Germany. On December 15, 2005, while working on an upper floor of a two story structure, the firefighters became trapped when fire broke out behind them and caused their CAFS filled hose line to burst. After the fire, testing completed by the police crime lab found at temperatures just less than 400 degrees Fahrenheit, hose lines filled with compressed air foam failed significantly quicker than hose lines filled with plain water. Time measurements found hose lines filled with plain water failed after several minutes where hose lines filled with compressed air foam failed in one minute or less. The failures were observed when exposed to glowing embers as well as radiant heat. They determined the cause of this phenomenon was the decreased water content in a compressed air foam hose and the foam's reduced heat capacity (De Vries, 2007).

Early use of class A foam for structural firefighting presented questions concerning the effect it would have on the investigation of fire origin and cause. During the field test conducted by the Boston Fire Department, one fire investigator complained the foam prohibited the ability to determine the point of origin due to foam covering the area. The report adds another opinion stating foam assists with investigations by keeping the layout of the fire room intact and protecting physical evidence, unlike traditional hose streams. A chemist with the Boston Fire Department observed analysis procedures would need evaluated to determine methods of differentiating foam from accelerants when securing and testing evidence (USFA, 1994). Stern and Routley (1996) confirmed the need for developing new methods of investigating fires where class A foam was used.

In *CAFS and its Impact in Fire Scene Investigations*, Brian Geraci (2006) discusses research conducted by the Montgomery County Fire and Explosive Investigation Unit evaluating the effects of CAF on origin and cause determination. They were interested in three areas where class A foam could impact investigations:

1. the effect on accelerant detecting canines
2. concealing scene hazards or creating slippery surfaces
3. time required for foam dissipation to allow investigation to begin.

Their research included contacting 21 people from 17 fire departments in the U.S. asking the question “Do you believe that CAFS has an effect on your origin and cause examination and/or your accelerant detection canine (Geraci, 2006, paragraph 7)?” A majority of the respondents were fire investigators and one-third of them answered yes. The collective issue these respondents had was the extended time it took foam to dissipate after excessive application of the foam during suppression efforts. The quantity of foam caused some hesitation on the part of the canine. However, no issues of foam masking or degrading any accelerants were noted by a forensic laboratory. The respondents also indicated the foam destroyed less of the scene than water and in some cases protected areas where accelerants were located (Geraci, 2006).

The next step was conducting two test fires in a testing lab using an accelerant that served as a medium for measuring performance of a detection canine. After allowing the fires to burn for one minute past flashover, they were extinguished using compressed air foam. Once the fire was extinguished, investigators and a detection canine completed the procedures to determine the cause and origin of the fire. At the completion of the tests, those involved had the opinion that compressed air foam did not affect the ability of the canine nor hinder the investigative process.

However, there still needs additional evaluation regarding foam's effect in lab analysis of evidence samples.

The study did produce some recommendations on how to move forward with investigating fires extinguished with CAFS including additional training for both firefighters and fire investigators regarding proper application procedures. Other recommendations stated are performing a more comprehensive scene safety search, ensuring a control sample of the foam is collected and given to the lab and securing a material safety data sheet on the foam being used by their department (Geraci, 2006).

The biggest disadvantage stated above was the initial cost to purchase the necessary equipment. According to IFSTA (2003) CAF systems can add up to $50,000.00 to the cost of new apparatus. One option Klassen (2011a, 2011b) describes as a means to reduce cost, is retrofitting current apparatus with a CAFS or if a piece of apparatus has a recently retrofitted CAFS, that system can be removed and installed in the new apparatus. He uses the term "re-retrofitting" in describing the second method. By retrofitting, departments can realize significant savings when implementing CAFS technology (2011a).

Colletti (2008) mentions retrofitting high capacity CAFS can be difficult if not impossible due to the space demands of the components. Boston experienced this when they conducted their field study. Engine 37 was retrofitted with a CAFS by the department's mechanics who observed the space behind the pump panel was limited and made installation difficult. The limited space also made maintenance and repairs cumbersome (USFS, 1994).

Lund (2010) and Roberts (2010) stated the cost of class A foam concentrate runs between $60.00 and $75.00 for five gallons. Lund (2010) goes further and applies the cost to the use during fire attack stating most room and content fires would cost the department less than five dollars for concentrate. Ongoing training and reevaluation will result in demands from the budget due to replenishing the concentrate used during training (IFSTA, 2003).

Colletti (1998) discusses how it has taken decades for CAFS technology to take hold in the structural fighter fighting arena. He states most CAFS purchased in the early 1990's were made with forestry and urban interface firefighting in mind not structural firefighting. Today, with the advances in CAFS design, the thought process is moving toward purchasing CAFS equipped apparatus geared to structural firefighting.

A majority of fire departments in the United States have adopted the use of Class A foam based on the benefits that have been well documented (Lund, 2010). He goes on to ask why the remaining fire departments have not incorporated Class A foam into their standard tactics. Carringer (2009) states that of all the new pumping apparatus being manufactured today, only four percent have CAFS included in the specifications. He believes misconceptions about CAFS are still present today which explains the low number of CAFS installed on new apparatus.

The literature review has shown there are many advantages associated with the use of Class A foam and CAFS. Many tests have been conducted to measure the effectiveness of these technologies as a tool in structural firefighting. The literature review also showed there are some disadvantages to CAFS technology, most notably the cost of implementation. Some of the disadvantages were found to be more of a nuisance.

The effects of CAFS on fire suppression efficiency and firefighter safety were described as positive. The improvements made to the equipment have made CAFS a very versatile tool for firefighters battling a wide range of suppression and exposure protection applications (Colletti, 2008). Lund (2010, FF 16) states "foam will never replace a single firefighter; it is simply a tool that helps us do our jobs more safely and effectively".

PROCEDURES

This research project began with a literature review of the advantages and disadvantages of class A foam and CAFS as well as the cost factors associated with implementing their use. Literature including text books, periodicals, case studies and reports were gathered from multiple resources including inter-library loan, the internet, the author, and other members of the fire service community.

A survey (Appendix 1) was distributed electronically though the use of Survey Monkey to a total of 581 fire departments, equally representing five regions in the state of Ohio. The five regions were northwest, northeast, southeast, southwest, and central Ohio. The departments were randomly selected from a database maintained by the Ohio Fire Chiefs Association. The sampling represents 48% of the fire departments in Ohio and range from career, volunteer, paid-on-call, to combination departments. The sampling also represents departments who provide fire protection/suppression in urban, suburban, and rural communities.

Based on the literature review, some regions of the United States have embraced this technology faster than other regions. The survey was limited to fire departments in Ohio to ascertain how this region of the country has or has not embraced the technology of CAFS. The survey provided data showing what percentage of departments is using class A foam and/or CAFS technology and what advantages and disadvantages they experienced.

A total of 135 surveys were completed and the data was compiled using the data analyzing tools incorporated in Survey Monkey. The results of the survey along with the literature review were used to determine if class A foam or CAFS technology could improve the efficiency of fire suppression efforts within the Massillon Fire Department.

Definition of Terms

Company. A group of fire department members under the supervision of an officer that is trained and equipped to perform assigned tasks usually identified as an engine, ladder, rescue, squad or multipurpose company operating from one piece of apparatus and arriving at the incident on that apparatus (NFPA 2010).

Combo Company. A group of fire department members trained and equipped to perform assigned tasks under the direct supervision of an officer and respond to the incident scene in the type of apparatus (fire or EMS) respective to the type of emergency (fire or EMS)

Limitations of the Study

The scope of this research was limited to compressed air foam systems and its use with class A foam on structural fires and other class A type materials due to the time constraints of the assignment. The City of Massillon Fire Department does not have a significant Class B fire threat. The Massillon Fire Department is also fortunate to have an industrial fire brigade within six miles of its borders that has extensive Class B capabilities and can provide mutual aid assistance in a short period of time.

RESULTS

The survey was started by 140 departments with 135 of them completing the survey. The vast majority of respondents, 94.8%, were fire chiefs and 75.6% had more than 25 years of experience in the fire service. Most of the responses came from fire departments with 75 or fewer members with the largest group of respondents consisting of 26 to 50 members. There were several respondents who had more than 75 members. However, no respondent represented a department with more than 150 members. Slightly over half of the respondents were from suburban areas. Only 11% serve in the urban setting. The two largest groups responding were combination departments at 47% of respondents followed by career departments which represented 29.9% of participants. Volunteer, paid on call, and part time departments were represented by 13.4%, 6.7%, and 3% of the respondents respectfully.

Of the 140 participants who started the survey, 73.6% have never used CAFS while 20.7% are current users. Departments who discontinued using CAFS were represented by 5.7% of the respondents. The percentages change very little when compared with urban, suburban, or rural areas served (Figure 1). While a large majority does not use CAFS, the survey found 80.6% of those who have never used CAFS do have class A foam capability. All respondents who had stopped using CAFS technology continued to operate with class A foam.

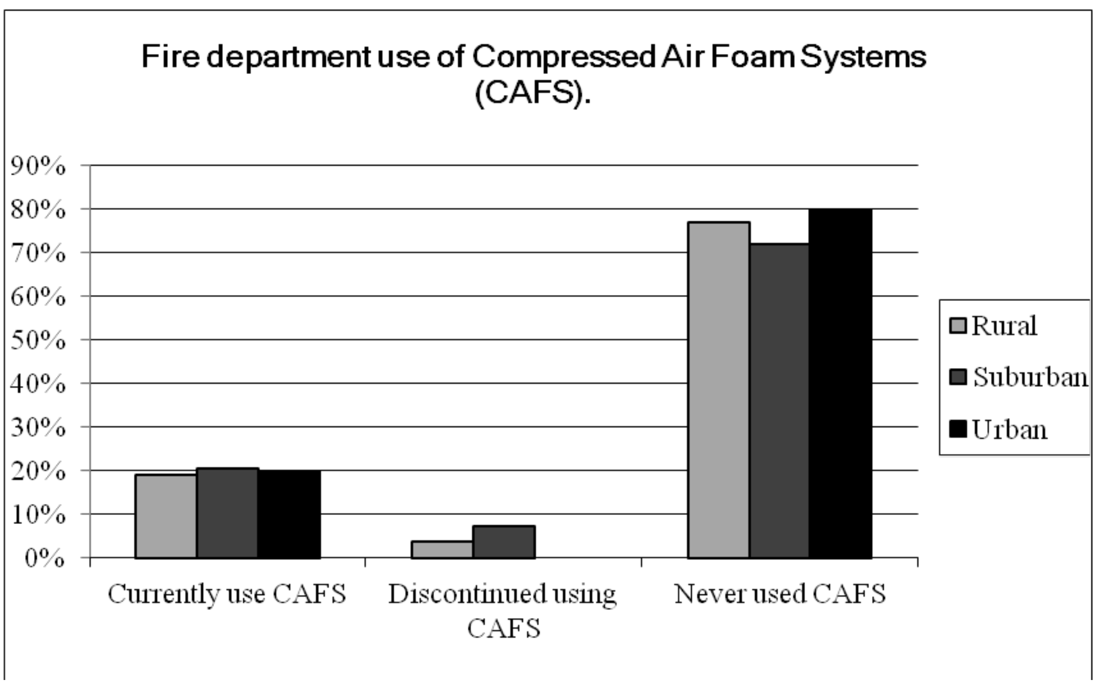

Figure 1

Fire department use of CAFS compared with type of area served.

Departments currently using CAFS and those who stopped using it experienced similar advantages in its use, noting less water required for extinguishment, quicker knockdown times, reduced chances for rekindles, and lighter more maneuverable hose lines. They also agreed that cost incurred in acquiring and maintaining the CAFS as well as retaining proficiency of personnel were the two primary disadvantages in its usage (Appendix 2).

Of the respondents currently using CAFS, 85.2%, have not experienced any noticeable change in the number of firefighter injuries. A decrease in property loss due to fire was experienced by 19 out of 26 responding CAFS users. Seven of these users noted significant decrease in loss. No respondents experienced any increase in firefighter injuries or property loss after they implemented CAFS technology.

The largest percentage of respondents currently using CAFS incurred an average additional $30,000 to $40,000 increase in cost when acquiring new apparatus with CAFS included. The results showed a majority of departments who more recently implemented CAFS incurred less cost to implement than departments who have been using CAFS for more than 10 years. For departments using CAFS, costs for maintenance, supplies, and training ranged from $4000.00 or less annually. Apparatus down time for CAFS maintenance issues was less than one week in 25 out of 27 departments, or 92.6% of current users. One department experienced down time for one to two weeks and one other department for three to four weeks. There was no reported down time longer than four weeks in any given year.

Of the departments who ceased the use of CAFS, 71% served suburban areas, and 57% were career departments. The majority of departments, who stopped using CAFS, did so within two to four years of implementation. The top three reasons provided for stopping usage were: (a) equipment problems, (b) the number of fires did not justify continuing the use of CAFS, and

(c) maintaining firefighter competency using CAFS (Figure 2). If cost in CAFS capabilities would be reduced, 42.9% of those agencies responding indicated they would return to its usage. However, another group of agencies representing 42.9% of departments who discontinued using CAFS indicated they would not return to CAFS usage for any of the possible reasons provided including reduced cost (Appendix 3).

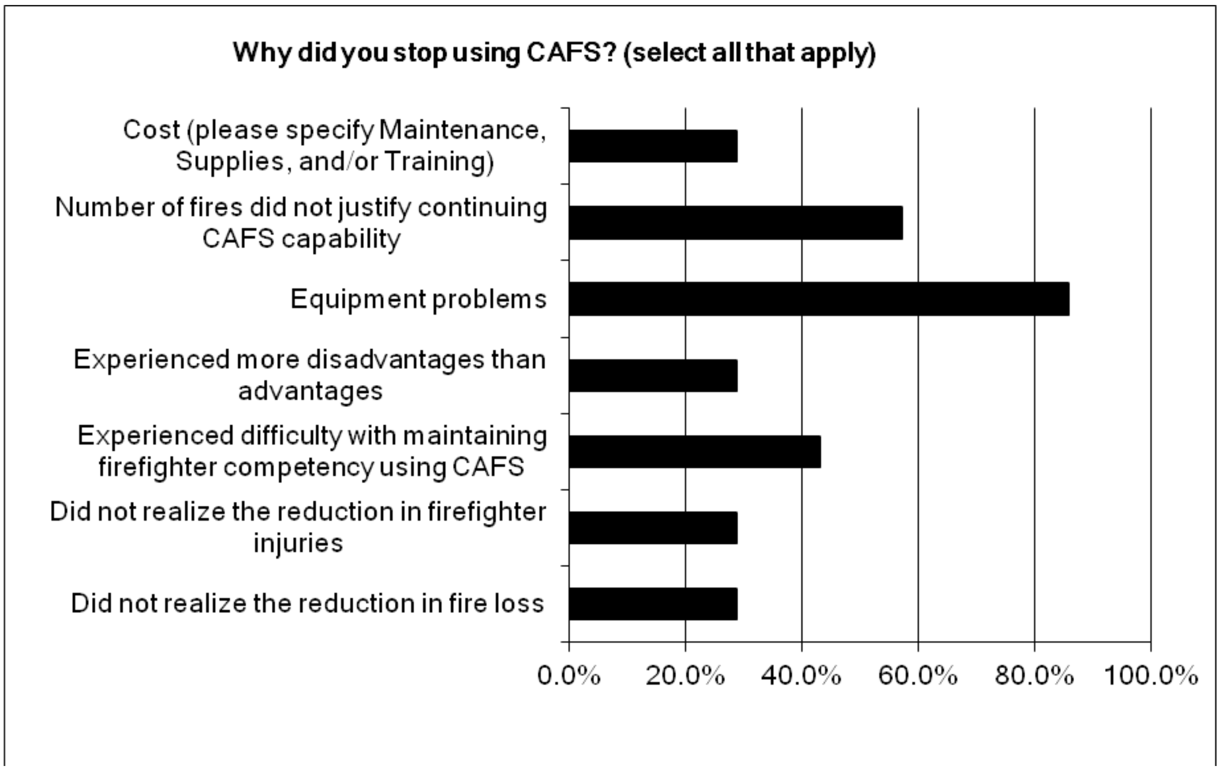

Figure 2

Reasons departments stopped using CAFS.

The survey found 85.9% of departments who have never used CAFS are familiar with today's CAFS technology. Only 8.3% of those departments plan on implementing CAFS technology, all in conjunction with their next apparatus purchase. No departments were considering retrofitting current apparatus. The majority of respondents, 54.8%, are unsure about moving toward using CAFS while another 36.9% have decided not to implement CAFS technology. The biggest reason for deciding against CAFS, 54.8%, was cost followed by 48.4%, who believe CAFS would not provide any benefit over current operations.

A summary report of data collected from the survey is contained in Appendix 4. Appendix 5 contains responses in which participants were able to provide opinions for clarification or additional information on the subject of class A foam and/or CAFS.

A survey of manufacturers was developed to see if a trend regarding the number of new apparatus equipped with CAFS was changing. However it was not put forward after discussions with representatives from the apparatus industry. A sales representative from a major fire apparatus manufacturer, Dan Herb (personal communication, December 14, 2011), stated the trend has not changed in his company over the past five to eight years. It was also learned that some in the apparatus industry are not convinced in the efficiency of CAFS technology. This individual stated an unpublished study sponsored by apparatus manufactures contradicts some of the findings of the studies mentioned in the literature review. No copy of this study could be found or produced. This author also attempted to secure specific data from the Fire Apparatus Manufacturers Association. However, the association politely declined any data advising it is furnished to its members only.

DISCUSSION

The literature review and the survey results presented similar findings regarding the advantages and disadvantages of CAFS. The biggest advantage experienced by departments responding to the survey was less water usage. The use of CAFS in the civilian fire service was not seriously evaluated until the 1970's when limited water supplies led the Texas Forestry

Service to search for additional means of fighting severe range fires in large areas (Colletti, 1998). Previous research completed by Stephen E. Lohr (2002), recommended the use of CAFS in areas of his department's jurisdiction where water supply and/or other resources were insufficient to meet required fire flow rates. He did not mention if CAFS should be considered in areas where resources were sufficient to meet the required flow. The Massillon Fire Department provides fire protection in an area with an excellent municipal water supply. Adding the cost of CAFS to an apparatus purchase would not be a fair use of taxpayer dollars to gain this particular advantage. If the area served by the Massillon Fire Department was more rural with limited water supplies, the benefits versus cost argument would be a lot easier to make.

When looking at the advantages and disadvantages of CAFS there are two sides to the equation; the properties of class A foam and the induction of compressed air. The advantages, faster knockdown times, reduced chances for rekindle, and less time required for overhaul, relate more to the properties of class A foam itself. During the Palmdale test conducted by the Los Angeles County Fire Department, the results showed that class A foam was twice as effective as plain water for fire suppression. The use of CAFS improved the performance of class A foam and was found four times as effective as plain water. The tests also showed class A foam reduced the temperature in the fire room nearly as quickly as the use of CAFS (Cavette, 2001). By adding air into the foam solution at the pump discharge, CAFS adds the advantage of lighter more maneuverable hose lines to the advantage list.

The survey showed higher response rates for disadvantages associated with CAFS versus those linked to the properties of class A foam. The two highest response rates were cost to acquire and maintain as well as maintaining personnel proficiency in using CAFS. Cost was also the biggest reason departments who never used CAFS decided against the technology.

Equipping a new apparatus with a CAFS could add as much as $50,000.00 to the purchase price of a unit (IFSTA, 2003). Adding a non CAFS, class A foam system on a new apparatus will also result in a higher purchase price. The cost difference between a CAFS and a class A foam system was not part of this research.

The other disadvantages, obscured vision, obscured trip hazards, slippery surfaces, and corrosiveness of foam concentrate are related to the properties of class A foam. Whether applied through a CAFS or non CAFS equipped pump, these disadvantages will be present to some degree. According to the survey results, these disadvantages were experienced less than the cost and training associated with CAFS usage. The literature review discussed how some of the disadvantages were more of a nuisance rather than an actual hindrance to class A foam or CAFS usage.

This author was surprised at the low percentage of responding departments who stopped using CAFS. Discussions with firefighters from the immediate area surrounding the Massillon Fire Department led to the opinion that this number would be higher. However, the survey found very few departments who implemented CAFS elected to cease its usage. It was noted the majority of the departments that did cease the use of CAFS matched the demographics of the Massillon Fire Department.

The number one reason why departments stopped using CAFS was equipment problems. The survey did not determine the type of equipment or the manufacturer used by these departments nor how long ago the departments stopped. It is unknown, based on this research, if the equipment problems were from mechanical failure, operator error, or a combination of both. It is also unknown, what generation of CAFS equipment was being used by departments in relationship to problems encountered.

The second leading reason departments stopped using CAFS was the number of fires occurring in their districts did not justify continuing with CAFS technology. The number of fires per year the Massillon Fire Department experiences is steadily declining. With the advancements in fire codes, installation of more smoke detectors, and increased fire prevention efforts this trend should continue. The research did not determine how many fires per year each department responded to, which lends to a more subjective reasoning. The survey also did not determine what types of fires each department evaluated when establishing justification for stopping the use of CAFS. Did they look only at structural fires or all types of fires? In *Compressed Air Foam for Structural Firefighting: a Field Test* (USFA, 1994), members of the Boston Fire Department found the advantages of CAFS was most prevalent when extinguishing vehicle and dumpster fires.

The survey found most departments have never used CAFS but are familiar with today's CAFS technology. The survey also revealed, over 80% of these departments do have class A foam capability. According to Lund (2010), a majority of fire departments in the United States have adopted the use of class A foam for structural fire suppression. However, only four percent of new apparatus manufactured today come equipped with CAFS (Carringer, 2009). Carringer (2009) believes the reason for the low percentage is there are still misconceptions about CAFS.

The studies reviewed for this research project were completed 20 years ago when CAFS utilization in structural fire suppression was in the early stages. Today's CAFS equipment has improved and is more automated than equipment used during those studies and field tests (Colletti, 1998 & Lund, 2010). The Fire Protection Research Foundation is currently conducting a project led by California Polytechnic State University. The purpose of the study, *Capabilities and Limitations of Compressed Air Foam Systems (CAFS) for Structural Firefighting* (NFPA, 2011), is to provide improved awareness of the effectiveness and safety considerations of today's CAFS for fire suppression. This new study may well provide better documentation and insight to the advantages and disadvantages of CAFS. The findings of the study should be available in July 2013. The final report may reduce some of the perceived misconceptions concerning CAFS and allow fire officials and elected leaders to make better informed decisions regarding implementation of CAFS.

The research has shown the use of CAFS has still not taken hold in the fire service as some originally believed. Most departments have elected to implement class A foam for structural firefighting. Although documentation reflects the theory CAFS and/or class A foam do not lessen the required number of firefighters responding to a fire, it does show the fires are extinguished quicker with less effort expended for overhaul (Lund, 2010). Reducing the physical demands on the firefighters available to respond and giving them the technology to better perform their tasks is a good reason to implement the advanced technology.

This author believes moving toward either a class A foam system or CAFS would allow the Massillon Fire Department to increase fire suppression efficiency by reducing extinguishment time and overall scene time. The question that fire department administrators and elected officials must answer is; which direction gives us more bang for our buck? If current operations are used as a basis, how much more efficient would we be through implementing class A foam at a certain cost? Then, how much more efficiency would be gained by adding CAFS to the equation and at what additional cost above a class A foam system? The Massillon Fire Department is currently not in a financial position to purchase new apparatus. This will allow time for The Fire Protection Research Foundation to conclude their study which could help officials answer these questions when determining what capabilities and equipment to include on future apparatus for the city.

RECOMMENDATIONS

The Massillon Fire Department should begin preparations to implement, at the very least, non CAFS class A foam capability. Based on the research, implementing this technology would enable the Massillon Fire Department to increase fire suppression effectiveness while dealing with effects of increased services and community growth. This recommendation should keep costs of implementation down, easing the burden on currently strapped capital improvement fund dollars. Further research is needed to determine what additional equipment is required and the actual associated cost. The data indicates it is not beneficial to retrofit CAFS onto existing apparatus. Additional research should establish the feasibility of retrofitting a class A foam system onto current apparatus.

If future growth of the city creates large non-hydrant areas, then Massillon Fire Department officials should give serious consideration to adding CAFS technology to fire suppression tactics deployed. The addition of CAFS capability needs to occur in conjunction with purchasing new apparatus. This should be accomplished by replacing apparatus in districts that will arrive on the scene first in the new areas. Grants for new apparatus should continue to be applied for, especially if this development occurs prior to any economic recovery in the city's budget. It is not recommended to retrofit any current apparatus due to the difficulties experienced by others and reported in the literature review.

The Massillon Fire Department and those who wish to conduct future research should wait until The Fire Protection Research Foundation has concluded its current investigation on the capabilities and limitations of CAFS. This will allow for more current data to assist with their decision making. When completed, the data should be used by department administrators to ascertain if increasing class A foam effectiveness through CAFS would be cost effective.

The research points out that class A foam and CAFS does not take the place of firefighters, but rather is a tool to increase their fire suppression effectiveness (Lund, 2010). As a result, the City of Massillon and its fire department leaders should work cooperatively with surrounding communities to develop automatic aid agreements that benefit all parties, especially the people we have sworn to protect. This recommendation should provide the additional personnel required on a fire scene for suppression activities. The process will require determining not only response parameters but also training issues, operating procedures, and equipment compatibilities.

Future research efforts should be directed at producing scientific data of how class A foam and CAFS affect the required fire flow formulas used today. Should these formulas be modified and if so, how? Other efforts could investigate the characteristics of CAFS implementation including training programs or methods, standard operating procedures, number of fires per year, and type of equipment used by departments who have been successful compared to departments who chose to stop using CAFS.

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APPENDIX 1 – SURVEY: FIRE DEPARTMENT USE OF CAFS

1. Describe your department's use of Compressed Air Foam Systems (CAFS).

_____Currently use CAFS (go to question 2)

_____ Discontinued using CAFS (go to PAGE 3)

_____Never used CAFS (go to PAGE 5)

2. What are the main advantages of using CAFS experienced by your department? (select all that apply)

_____Faster Knockdown times

_____Less water usage

_____Lighter and more maneuverable hose lines

_____Longer stream reach

_____Less time required for overhaul

_____Reduce chances for rekindle

_____Reduced byproducts of combustion

_____Clings to the fuel's surface

_____Other (please list)____

3. What are the main disadvantages of using CAFS experienced by your department? (select all that apply)

_____Creation of slippery surfaces

_____Obscured vision

_____Strong nozzle reactions

_____Obscured tripping hazards

_____ Complications with fire investigation

_____Cost to acquire and maintain

_____ Corrosiveness of Class A foam concentrates

_____ Other (please list)____

4. Have you experienced a decrease or increase in the occurrence of firefighter injuries after implementing CAFS technology?

_____Significant DECREASE

_____DECREASE

_____No noticeable change

_____INCREASE

_____Significant INCREASE

5. Have you experienced a decrease or increase in property loss after implementing CAFS technology?

_____Significant DECREASE

_____DECREASE

_____No noticeable change

_____INCREASE

_____Significant INCREASE

6. Adding a CAFS to your apparatus purchase added how much to the cost?

_____Less than $20,000

_____$20,001 to $30,000

_____$30,001 to $40,000

_____$40,001 to $50,000

_____Greater than $50,000

7. What is the annual cost involving the use of your CAFS?

Maintenance $_________________

Supplies $_________________

Training $_________________

OR Total estimated for all 3 $_______________

8. How much time per year is each CAFS equipped apparatus out of service for maintenance and repair associated with the CAFS?

_____________ Days / Weeks / Months

9. How long has your department used CAFS?

_____ Less than 3 years _____6 to 9 years

_____3 to 6 years _____Longer than 10 years

10. Do you plan to increase your CAFS capability in the future?

_____Yes

_____No

_____All current Class A engines in department's fleet equipped with CAFS

Go to PAGE 6

Questions for "Discontinued using CAFS".

11. What advantages of CAFS did your department experience when you used CAFS? (select all that apply)

_____Faster Knockdown times _____Less water usage

_____Lighter and more maneuverable hose lines _____Longer stream reach

_____Less time required for overhaul _____Reduce chances for rekindle

_____Reduced byproducts of combustion _____Clings to the fuel's surface

_____ Other (please list)____

12. What disadvantages of CAFS did your department experience when you used CAFS? (select all that apply)

_____Creation of slippery surfaces _____Obscured vision

_____Strong nozzle reactions _____Obscured tripping hazards

_____Corrosive Class A foam concentrates _____Cost to acquire and maintain

_____ Other (please list)____

13. How long did you use CAFS before deciding to stop?

_____Less than 2 years _____6 to 8 years

_____2 to 4 years _____8 to 10 years

_____4 to 6 years _____Longer than 10 years

14. Why did you stop using CAFS? (select all that apply)

_____Cost (Please specify) _____Maintenance _____Supplies _____Training

_____Did not realize the reduction in fire loss

_____Did not realize the reduction in firefighter injuries

_____Experienced difficulty with maintaining firefighter competency using CAFS (Go to 15)

_____Experienced more disadvantages than advantages

_____Equipment problems

_____Number of fires did not justify continuing CAFS capability

_____Other (Please list) ____

15. If your department is a combination department, which class of personnel did you experience the difficulty with maintaining competency?

_____Career personnel

_____Part-time / Volunteer personnel

_____Both classes of personnel

16. Did you maintain Class A Foam capability without CAFS?

_____Yes

_____No

17. Select any reasons you would return to CAFS capability. (select all that apply)

_____Reduction in costs

_____Increase in department funding

_____Improvement in CAFS equipment

_____Improved training on use of CAFS

_____Legislation giving ISO credit for CAFS capability

_____Decrease in staffing

_____Will NOT return to using CAFS technology

Go to PAGE 6

Questions for “Never used CAFS” from question 1.

18. Are you familiar with today’s CAFS technology?

_____Yes (go to question 19)

_____No (go to question 20)

19. Do you plan on implementing CAFS technology in the future? (If Yes, go to question 21)

_____Yes – in conjunction with next apparatus purchase

_____Yes – through retrofitting current apparatus

_____Yes – through a combination of new apparatus and retrofitting current apparatus

_____No (go to question 20)

20. Why did you decide against CAFS capability? (select all that apply)

_____Too costly

_____Limited number of fires

_____Do not agree with the technology

_____Do not feel CAFS would provide any benefit over current operations

21. Do you have Class A Foam capability without CAFS?

_____ Yes, we currently have Class A Foam capability without CAFS

_____.Yes, we are moving to Class A Foam capability without CAFS

_____ No

22. Do you plan to research CAFS capability during the process of purchasing your next fire apparatus?

_____Yes

_____No

Go to next page.

Demographic questions answered by all who completed survey.

23. Describe the size of your department.

_____Less than 25 members

_____26 to 50 members

_____51 to 75 members

_____76 to 100 members

_____101 to 125 members

_____126 to 150 members

_____Greater than 150 members

24. Describe your department's category.

_____Career

_____Part-time

_____Paid on Call

_____Volunteer

_____Combination

25. Describe the area served by your fire department.

_____Urban

_____Suburban

_____Rural

_____Urban / Wildland interface

26. What is your rank?

_____Fire Chief

_____Deputy / Division / Assistant Chief

_____Battalion Chief

_____Captain / Lieutenant

_____Firefighter

27. How many years of experience do you have in the fire service?

______ Years

28. Do you think the State of Ohio should pursue legislation granting ISO credit for departments that have CAFS capability?

_____Yes

_____No

29. If you have any additional comments, please include them here.

____

____

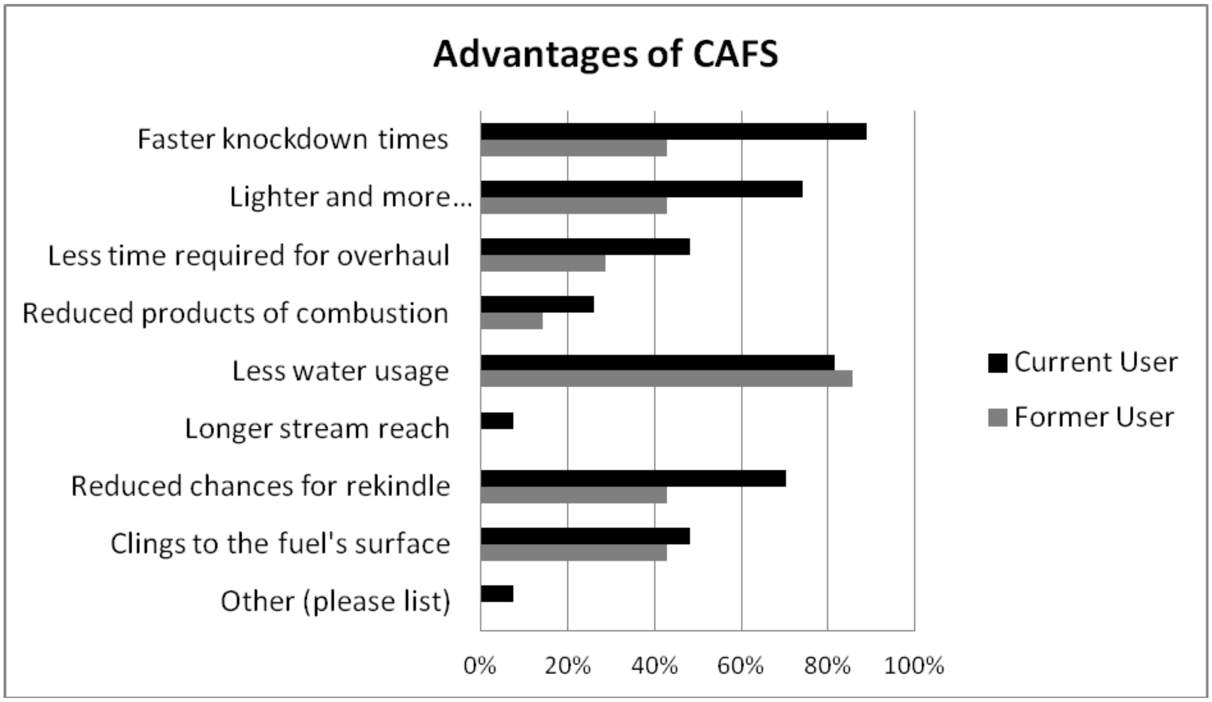
____

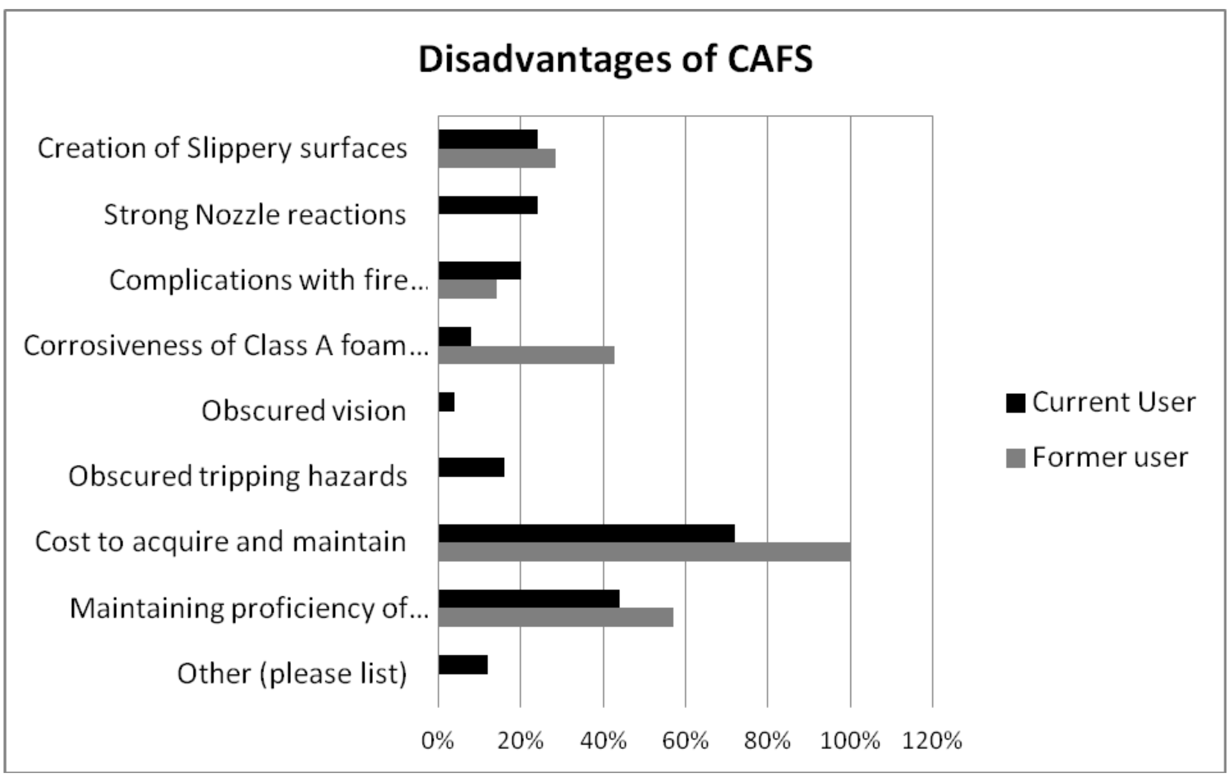
____

If you would like an electronic copy of this survey, please include your e-mail address here: ____.

Thank you for your time and assistance.

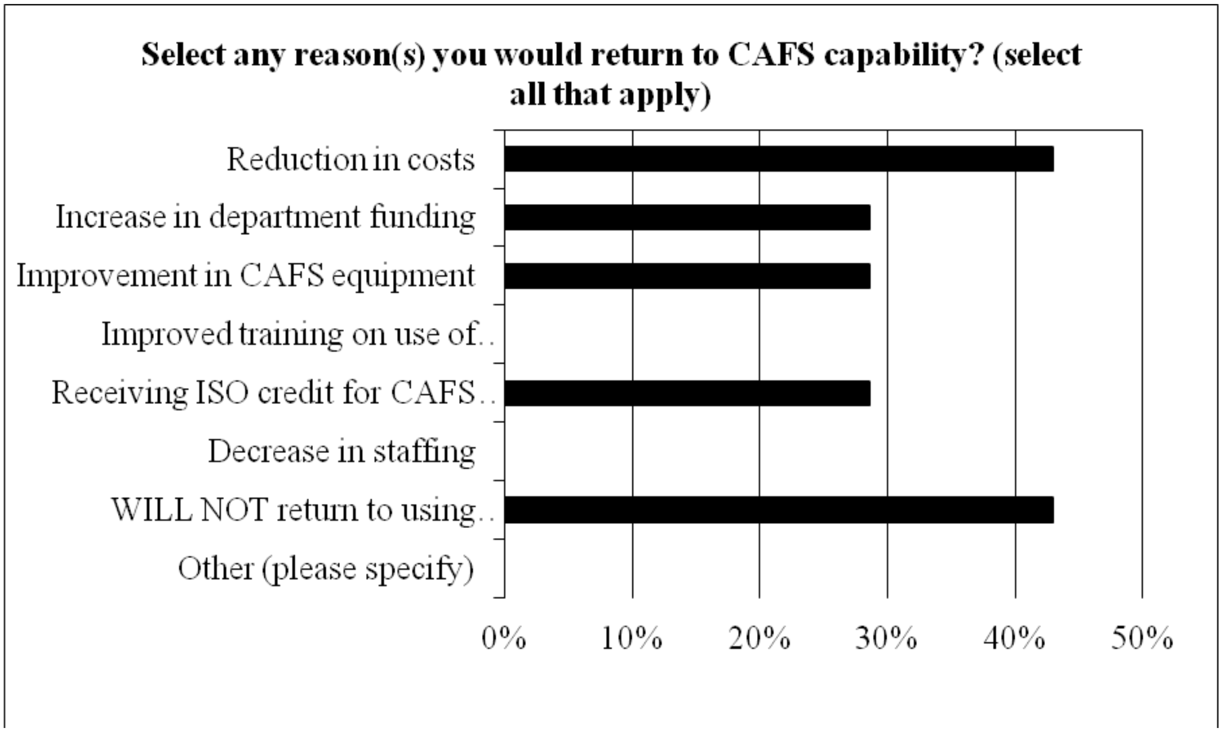
APPENDIX 2 – ADVANTAGES AND DISADVANTAGES OF CAFS





Advantages and disadavantages of CAFS experienced by users and former users.

APPENDIX 3 – REASONS FOR RETURNING TO CAFS



Reasons departments who stopped using CAFS would return to the technology

APPENDIX 4 – SURVEY RESULTS (SUMMARY REPORT)

1. Describe your department's use of Compressed Air Foam Systems (CAFS).

Answer Options	Response Percent	Response Count
Currently use CAFS	20.7%	29
Discontinued using CAFS	5.7%	8
Never used CAFS	73.6%	103
	answered question	140
	skipped question	0

2. What are the main advantages of using CAFS experienced by your department? (select all that apply)

Answer Options	Response Percent	Response Count
Faster knockdown times	88.9%	24
Lighter and more maneuverable hose lines	74.1%	20
Less time required for overhaul	48.1%	13
Reduced products of combustion	25.9%	7
Less water usage	81.5%	22
Longer stream reach	7.4%	2
Reduced chances for rekindle	70.4%	19
Clings to the fuel's surface	48.1%	13
Other (please list)	7.4%	2
	answered question	27
	skipped question	113

3. What are the main disadvantages of using CAFS experienced by your department? (select all that apply)

Answer Options	Response Percent	Response Count
Creation of slippery surfaces	24.0%	6
Strong nozzle reactions	24.0%	6
Complications with fire investigation	20.0%	5
Corrosiveness of Class A foam concentrates	8.0%	2
Obscured vision	4.0%	1
Obscured tripping hazards	16.0%	4
Cost to acquire and maintain	72.0%	18
Maintaining proficiency of personnel	44.0%	11
Other (please list)	12.0%	3
	answered question	25
	skipped question	115

4. Have you experienced a decrease or increase in the occurrence of firefighter injuries after implementing CAFS technology?

Answer Options	Response Percent	Response Count
Significant DECREASE	11.1%	3
DECREASE	3.7%	1
No noticeable change	85.2%	23
INCREASE	0.0%	0
Significant INCREASE	0.0%	0
	answered question	27
	skipped question	113

5. Have you experienced a decrease or increase in property loss after implementing CAFS technology?

Answer Options	Response Percent	Response Count
Significant DECREASE	26.9%	7
DECREASE	46.2%	12
No noticeable change	26.9%	7
INCREASE	0.0%	0
Significant INCREASE	0.0%	0
	answered question	26
	skipped question	114

6. Approximately how much additional cost did you incur by including CAFS in your apparatus purchase?

Answer Options	Response Percent	Response Count
Less than $20,000	25.9%	7
$20,001 to $30,000	11.1%	3
$30,001 to $40,000	33.3%	9
$40,001 to $50,000	22.2%	6
Greater than $50,000	7.4%	2
	answered question	27
	skipped question	113

7. What is the annual cost involving the use of your CAFS?

Answer Options	Response Percent	Response Count
Maintenance	54.2%	13
Supplies	54.2%	13
Training	37.5%	9
OR Total estimated for all 3	54.2%	13
	answered question	24
	skipped question	116

Number	Maintenance	Supplies	Training	OR Total estimated for all 3
1				2000
2				insignificant thus far
3	500	1000	Minimal	
4	2000	1000		
5				$3000.00 estimated
6				3000
7	$1000 for two	2500	$0 include on ongoing	3500
8	1000	2500	250	
9				$1200-$1500
10	300	600	0	
11		1800		
12	500	1000		
13				2000
14				1200
15				less than 300 per yr
16	150	500	0	750
17	200			
18	1000			
19	400	1000	450	
20	500	1000	500	
21	Less than $1,000.00	No more than conventional foam system	on-duty refresher	1000
22		600		600
23	0	Approx. $2000 annually	0	
24				2000

8. How much time per year is each CAFS equipped apparatus out of service for maintenance and repair associated with the CAFS?

Answer Options	Response Percent	Response Count
Less than 1 week	92.6%	25
1 to 2 weeks	3.7%	1
3 to 4 weeks	3.7%	1
More than 4 weeks	0.0%	0
	answered question	27
	skipped question	113

9. How long has your department used CAFS?

Answer Options	Response Percent	Response Count
Less than 3 years	18.5%	5
3 to 6 years	51.9%	14
6 to 9 years	22.2%	6
Longer than 10 years	7.4%	2
	answered question	27
	skipped question	113

10. Do you plan to increase your CAFS capability in the future?

Answer Options	Response Percent	Response Count
Yes	70.4%	19
No	22.2%	6
All current Class A engines in department's fleet are equipped with CAFS	7.4%	2
	answered question	27
	skipped question	113

Questions for “Discontinued using CAFS” from question 1.

11. What advantages of CAFS did your department experience when you used CAFS? (select all that apply)

Answer Options	Response Percent	Response Count
Faster knockdown times	42.9%	3
Lighter and more maneuverable hose lines	42.9%	3
Less time required for overhaul	28.6%	2
Reduced products of combustion	14.3%	1
Less water usage	85.7%	6
Longer stream reach	0.0%	0
Reduced chances for rekindle	42.9%	3
Clings to the fuel's surface	42.9%	3
Other (please list)	0.0%	0
	answered question	7
	skipped question	133

12. What disadvantages of CAFS did your department experience when you used CAFS? (select all that apply)

Answer Options	Response Percent	Response Count
Creation of slippery surfaces	28.6%	2
Strong nozzle reactions	0.0%	0
Corrosive Class A foam concentrates	14.3%	1
Complications with fire investigation	42.9%	3
Obscured vision	0.0%	0
Obscured tripping hazards	0.0%	0
Cost to acquire and maintain	100.0%	7
Maintaining proficiency of personnel	57.1%	4
Other (please list)	0.0%	0
	answered question	7
	skipped question	133

13. How long did you use CAFS before deciding to stop?

Answer Options	Response Percent	Response Count
Less than 2 years	14.3%	1
2 to 4 years	57.1%	4
4 to 6 years	14.3%	1
6 to 8 years	0.0%	0
8 to 10 years	14.3%	1
Longer than 10 years	0.0%	0
	answered question	7
	skipped question	133

14. Why did you stop using CAFS? (select all that apply)

Answer Options	Response Percent	Response Count
Did not realize the reduction in fire loss	28.6%	2
Did not realize the reduction in firefighter injuries	28.6%	2
Experienced difficulty with maintaining firefighter competency using CAFS	42.9%	3
Experienced more disadvantages than advantages	28.6%	2
Equipment problems	85.7%	6
Number of fires did not justify continuing CAFS capability	57.1%	4
Cost (please specify Maintenance, Supplies, and/or Training)	28.6%	2
	answered question	7
	skipped question	133

15. If your department is a combination department, which class of personnel did you experience the difficulty with maintaining competency?

Answer Options	Response Percent	Response Count
Career personnel	0.0%	0
Part-time / Volunteer personnel	0.0%	0
Both classes of personnel	0.0%	0
Not a combination department	100.0%	1
	answered question	1
	skipped question	139

16. Did you maintain Class A foam capability without CAFS?

Answer Options	Response Percent	Response Count
Yes	100.0%	6
No	0.0%	0
	answered question	6
	skipped question	134

17. Select any reason(s) you would return to CAFS capability? (select all that apply)

Answer Options	Response Percent	Response Count
Reduction in costs	42.9%	3
Increase in department funding	28.6%	2
Improvement in CAFS equipment	28.6%	2
Improved training on use of CAFS	0.0%	0
Receiving ISO credit for CAFS capability	28.6%	2
Decrease in staffing	0.0%	0
WILL NOT return to using CAFS technology	42.9%	3
Other (please specify)	0.0%	0
	answered question	7
	skipped question	133

Questions for “Never used CAFS” from question 1.

18. Are you familiar with today's CAFS technology?

Answer Options	Response Percent	Response Count
Yes	86.5%	90
No	13.5%	14
	answered question	104
	skipped question	36

19. Do you plan on implementing CAFS technology in the future?

Answer Options	Response Percent	Response Count
Yes - in conjunction with next apparatus purchase	7.9%	7
Yes - through retrofitting current apparatus	0.0%	0
Yes - through a combination of new apparatus and retrofitting current apparatus	0.0%	0
Unsure at this time	53.9%	48
No	38.2%	34
	answered question	89
	skipped question	51

20. Why did you decide against CAFS capability? (select all that apply)

Answer Options	Response Percent	Response Count
Too costly	50.0%	17
Limited number of fires	32.4%	11
Too complicated to apply and maintain proficiency of personnel	35.3%	12
Do not agree with technology	5.9%	2
Do not feel CAFS would provide any benefit over current operations	50.0%	17
	answered question	34
	skipped question	106

21. Do you plan to research CAFS technology during the process of purchasing your next fire apparatus?

Answer Options	Response Percent	Response Count
Yes	42.9%	6
No	57.1%	8
	answered question	14
	skipped question	126

22. Do you have Class A foam capability without CAFS?

Answer Options	Response Percent	Response Count
Yes, we currently have Class A foam capability without CAFS	80.6%	83
Yes, we are moving to Class A foam capability without CAFS	1.9%	2
No	17.5%	18
	answered question	103
	skipped question	37

Demographic questions (answered by all respondents)

23. Describe the size of your department.

Answer Options	Response Percent	Response Count
Less than 25 members	18.0%	24
26 to 50 members	58.6%	78
51 to 75 members	14.3%	19
76 to 100 members	6.0%	8
101 to 125 members	0.8%	1
126 to 150 members	2.3%	3
More than 150 members	0.0%	0
	answered question	133
	skipped question	7

24. Describe the type of your department.

Answer Options	Response Percent	Response Count
Career	29.9%	40
Part-time	3.0%	4
Paid on call	6.7%	9
Volunteer	13.4%	18
Combination	47.0%	63
	answered question	134
	skipped question	6

25. Describe the area served by your department.

Answer Options	Response Percent	Response Count
Urban	11.1%	15
Suburban	50.4%	68
Rural	38.5%	52
Urban / Wildland interface	0.0%	0
	answered question	135
	skipped question	5

26. What is your rank?

Answer Options	Response Percent	Response Count
Fire Chief	94.8%	127
Deputy / Division / Assistant Chief	3.0%	4
Battalion Chief	0.0%	0
Captain / Lieutenant	1.5%	2
Firefighter	0.7%	1
	answered question	134
	skipped question	6

27. How many years of experience do you have in the fire service?

Answer Options	Response Percent	Response Count
Less than 5	0.0%	0
5 to 10	1.5%	2
11 to 15	3.7%	5
16 to 20	7.4%	10
21 to 25	11.9%	16
More than 25	75.6%	102
	answered question	135
	skipped question	5

28. Do you think the fire service should pursue the granting of ISO credit for having CAFS capability?

Answer Options	Response Percent	Response Count
Yes	60.0%	81
No	40.0%	54
	answered question	135
	skipped question	5

APPENDIX 5 – RESPONSES FROM QUESTION 29

Question 29. If you have any additional comments, please include them here.

1. CAFS seems to be double the money, compared to Foam Pro System which we have of 4 engines with it on. (3/26/2012)

2. CAFS is a very good tool for fast knock down and water shortage areas, but expensive. (3/24/2012)

3. Our CAFS system is manufactured by Pierce, it is on a 2006 Pierce engine, only maintenance involved that costs money is oil and filter change and we have not reached the hours of use to require that. Excellent system, best investment we ever made. (3/24/2012)

4. Foam is here to stay. We need to implement it as soon as possible into our SOP's for structural fire fighting. (3/23/2012)

5. We also have class A foam, non CAFS on our 2 newest engines/pumpers that seem to be used more regularly than the CAFS unit. Seems to be directly related to comfort/simplicity of using non CAFS vs. CAFS. (3/22/2012)

6. We have a large number of mansion type home that we protect. The addition of the CAFS has easily saved their value in property loss and water damage reduction. Which is important for us when looking at the amount of potential losses in our community. (3/22/2012)

7. Foam is expensive and hinders the investigation of Arson. (3/21/2012)

8. We use Williams Around the foam pump device that works very well to convert any pump into a foam delivery system. We have had such great experience with this device that we had our last engine equipped with one built into our pump panel. This can be used for Class A or B delivery which is important to us with our large petro/chemical industries we have in our location. (3/21/2012)

9. ISO needs to restructure its entire evaluation to keep up with the times. Some of its methods are not realistic for smaller departments. (3/21/2012)

10. We use captive air CAFS. Less maintenance. (3/21/2012)

11. I believe in Class A Foam, but believe the simpler the concept the better. We run Class A on all our structure fires. (3/21//2012)

12. I like the idea of granting ISO credit to improve the water supply component in non-hydranted areas. (3/21/2012)

13. It is critical to have staff buy-in. Our personnel fully embrace CAFS and routinely demonstrate proficiency. (3/21/2012)

14. The cost of the system and nozzles are the only things preventing us from going to CAFS system. (3/21/2012)

15. As stated we only have a 60 gal system on our rescue. We do intend however to spec CAFS on all future engines. (3/21/2012)

16. N/A. (3/21/2012)

17. We have used Class A foam without CAFS since 1998 on all structure fires and have seen a noticeable decrease in property damage with very few rekindles. In 2006 we added a CAFS engine. At this point we have not seen a noticeable difference in property saved using CAFS over straight class A without CAFS. I would like to see a ISO credit for Class A foam with or without CAFS. (3/21/2012)

18. You may want to review my research project from Class 7, “Compressed Air Foam in Limited Staffing Fire Attack” and the article I wrote in Fire Chief Magazine July 2011, No Contest. (3/21/2012)

19. CAFS is great when it works. We have had a lot of system failures associated with the system. Generally these have been covered by the manufacturer. (3/21/2012)

20. We have not had any issues using CAFS any increase in maintenance or anything else. Now note we do not have a lot of fires in any given year. 89 in 2011 103 in 2010. (3/21/2012)

21. We currently have one engine with a FoamPro System with foam dedicated to two (2) preconnected 1 ¾" and one 2 ½" outlet. (3/21/2012)

22. Class A capabilities (of any type) should be considered as long as the department can prove (either through training or use) that it is proficient in its use. (3/21/2012)

23. We are currently using the Foampro injected class A system on our engines, very simple to operate, simply turn it on and walk away. Some of the problems we see with most of the CAFS systems are the monitoring and adjusting the water and air pressures to assure the foam is being generated properly and the complexity of the compressor systems. The foam works great when it works and is applied properly, reliability has been an issue in the past as well. If the CAFS systems are manufactured in such a way the pump operator can press one button and be done then the CAFS would be a lot more attractive, the Foampros have never failed on the 15 years we have been operating with them, the CAFS is not quite there yet. (3/21/2012)

24. In regard to the previous question about ISO credit for CAFS, I would like to see ISO credit for Class A Foam use, not just for CAFS. (3/21/2012)

25. Cost of the system is prohibitive. CAFS will not become a mainstay until the expense of the system becomes reasonable for the typical department. (3/21/2012)

26. It is like any other tool in our tool box. CAFS has a niche and can only be used in that niche at a pretty costly expense for the number of times used. (3/21/2012)

27. If credit is given it should be only extra credit. Many FDs in the state and nationwide have no chance of even purchasing a new engine, not to mention a 30-40K option on it. Should be no penalty for not having it, or not having foam capabilities in general. (3/21/2012)

28. None at this time. (3/21/2012)

29. From experience with mutual aid depts. that run CAFS, when it works, it works great. However, as complex as the systems are and the significant cost, I am of the opinion that Class A foam without CAFS gives us more “bang for our buck” without the operational problems. (3/21/2021)

30. We have had mixed reviews on our CAFS use. There have been times when the foam actually insulates some hot spots and prevents the use of TIC (thermal imaging camera) from being effective. Like everyone, the UFD has had a very difficult time financially over the past several years which dictates that our priorities be changed. We feel that CAFS has minimal benefits and therefore, it has not been a priority. (3/21/2012)

31. Love the idea of CAFS but we can’t afford to retrofit, and have no budget for new apparatus. Our fleet’s average age is 28 years old. (3/21/2012)

32. We have only had CAFS system for just over year, and only 3 structure fires to base experience. (3/21/2012)