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Test and Evaluation of the Effectiveness of a Small Airport Firefighting System (SAFS) in Extinguishing Two- and Three-Dimensional Hydrocarbon Fuel Fires

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16. Abstract

In the near future, many small airports may be categorized as Index A airports by federal codes. This would require that such airports maintain minimum firefighting capability to combat aircraft fires and protect the flying public. Clearly this requirement would result in significant capital investment in organizing, equipping, and training a fire protection team. In an effort to reduce this financial burden, a test program was initiated to evaluate the effectiveness of a low-cost fire suppression system designed specifically for combating aircraft fires at small airports. The low-cost system consists of a unique skid-mounted extinguishing unit containing two low-pressure extinguishing agent tanks and two high-pressure propellant tanks. The system can be easily installed in the cargo bed of a suitable utility truck.

As specified by federal codes, SAFS contains 100 gallons of aqueous film forming foam and 500 pounds of a sodium-based or 450 pounds of a potassium-based dry chemical (Purple K or PKP). SAFS was designed specifically for extinguishing two-dimensional (2-D) hydrocarbon pool fires and three-dimensional (3-D) flowing fuel fires. Testing proved the simultaneous application of compressed air foam and PKP through the dual-agent nozzle onto a combination 2-D and 3-D fire was vastly superior to either of these agents used alone. Likewise, this combination of agents was equivalent in firefighting performance to larger capacity variable stream nozzles using foam alone. Based on the results of performance testing as specified herein, SAFS would provide a substantial firefighting capability to combat 2-D pool fires and 3-D flowing fuel fires at small airports and would provide an effective, easily understood fire suppression capability for apprentice-level fire fighters. SAFS, in its present configuration, is recommended for use at newly categorized Index A airports.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Small Airport Firefighting System (SAFS) tests showed the system to be an effective, inexpensive, and viable alternative to more costly, permanently mounted fire truck systems. Testing revealed that the combination of 3% concentrate compressed air foam (CAF) and dry chemical (PKP) produced by SAFS has excellent fire suppression and knockdown capability when used simultaneously in a coordinated fire attack on a two-dimensional (2-D) pool fire and a three-dimensional (3-D) flowing fuel fire. This combination of agents produced an effective agent stream that rapidly extinguished the fire and prevented reignition and burn back of both the 2-D and 3-D fires. When used in the CAF mode, SAFS produced four times as much foam as the non-air-aspirated variable-stream nozzle.

In the CAF mode, the air-aspirated foam stream was as effective as the non-air-aspirated foam stream. In the CAF and dry chemical mode, the air-aspirated aqueous film forming foam (AFFF) and PKP dual-agent stream performed measurably better than the non-air-aspirated AFFF and PKP dual-agent stream during medium-scale testing, but was slightly slower in extinguishment performance during large-scale testing. In large-scale testing, the difference in extinguishment time could be attributed to the size of the orifices on differing nozzles.

The concept of 2-D pool fire and 3-D flowing fuel fires was relatively new to the volunteer fire fighters. None of the volunteer fire fighters had fought a combination JP-8 static pool 2-D pool fire and 3-D flowing fuel fire. Some large-scale fires were not extinguished due to the lack of knowledge of 2-D and 3-D firefighting concepts. However, the objectives of the test, effectiveness of the equipment, and ease of use with less experienced fire fighters were fully demonstrated.

The water-cooled, FAA-developed Cascading Fuel Fire Test Article was shown to be an effective small-scale fire test and training device fully adequate for screening candidate extinguishing agents and training fire fighters on 2-D pool fires and 3-D flowing fuel fires.

1. INTRODUCTION.

1.1 BACKGROUND.

Many smaller, uncertified airports may soon be categorized under Title 14 Code of Federal Regulations (CFR) Part 139 as Index A airports. As such, 14 CFR Part 139 subparts 315, 317, and 319 will require that each indexed airport organize, equip, and train a fire protection team to protect the flying public. The minimum firefighting equipment and agent required under 14 CFR Part 139 for Index A airports are one vehicle carrying at least 500 pounds of a sodium-based or 450 pounds of a potassium-based dry chemical and water with a commensurate quantity of aqueous film forming foam (AFFF) concentrate to total 100 gallons. At smaller airports, this requirement can result in a significant capital investment in personnel and firefighting equipment. In an effort to reduce the financial burden of capital investment on firefighting equipment, a test program was established to test and evaluate the effectiveness of a low-cost fire suppression unit designed specifically for combating aircraft fires at small airports.

The fire suppression unit chosen for the tests was the Small Airport Firefighting System (SAFS). SAFS is a small, skid-mounted, dual-agent compressed air foam (CAF) fire suppression system containing 100 gallons of premixed AFFF and 500 pounds of Purple K dry chemical (PKP) in separate vessels. It was designed to extinguish two-dimensional (2-D) hydrocarbon pool fires and three-dimensional (3-D) flowing hydrocarbon fires. SAFS can be rapidly placed in the cargo bed of a suitable pickup truck or a trailer and towed to the scene of a fire or placed on standby location in close proximity to aircraft.

1.2 PURPOSE.

The purpose of the tests was to determine the effectiveness of a dual-agent firefighting system for potential use at small airports. The tests compared the use of a dual-agent, non-air-injected variable-stream handline nozzle to an air-injected CAF handline nozzle. Each of these operational modes is available on SAFS. The two handline nozzles were used to compare extinguishment capabilities against 2-D pool fires and 3-D flowing fuel fires in various measurable test situations essential to determining the suitability of the unit for small airport firefighting operations and standby requirements.

A secondary purpose was to determine the suitability of SAFS, as shown in figure 1, for use by other full-time airport fire fighters to combat aircraft fires at small airports. The research initiative was a serious concern because the unit will be used by personnel who will likely be performing other nonrelated airport duties and would respond to emergencies on a part-time basis as opposed to performing regular duties as airport fire fighters. The ability of inexperienced fire fighters to comprehend SAFS dual-agent technologies and use it quickly and easily, much like an individual would with a large flight-line fire extinguisher, is an important test issue.

The medium- and large-scale tests developed for this report were designed to measure the systems operational limits, characterize its operational features, and evaluate SAFS performance when used by entry-level fire fighters.

FIGURE 1. SMALL AIRPORT FIREFIGHTING SYSTEM MOUNTED ON TEST SUPPORT VEHICLE

1.3 OBJECTIVES.

The objectives of this test series were to

- determine overall effectiveness and reliability of the SAFS system.
- determine the appropriate support vehicle for the SAFS system.
- determine the performance of entry-level fire fighters whose skill level is most correctly represented by the level of training expected at small airports.
- compare the effectiveness of two different nozzle types when used in either a dual-agent variable-stream nozzle mode or a dual-agent CAF nozzle mode during 2-D pool fire and 3-D flowing fuel fire operations.
- determine SAFS fire suppression performance, operational performance, and operational limits when used to combat 2-D pool fires and 3-D flowing fuel fires.
- determine SAFS performance when used in a manner that, as closely as possible, simulates the actual crash firefighting and working fire environment expected at small airport aircraft incident or accident sites.
- determine burn back resistance of the foam blanket when mixed with PKP dry chemical during dual-agent application.

- determine the distance at which agent can be discharged.

- determine the maximum agent discharge for the variable-stream and CAF nozzles, with AFFF and AFFF and PKP.

2. METHODS AND PROCEDURES.

SAFS testing was conducted in an environmentally safe, controlled open-air fire burn area designed to test, validate, and prove the acceptability of new and emerging technologies. Each test was conducted in as near an actual crash rescue firefighting working environment as might be encountered at a small airport aircraft crash fire incident or accident. Specifically, this meant conducting test fires in the presence of a variety of hot metal surfaces from which reignition could occur as a result of fuel cascading over heated surfaces or collecting in small pools or debris piles adjacent to a large frame aircraft mock-up.

A minimum of three tests of the two different nozzle types and three different types of fires were conducted. These tests were performed using different and escalating measurable degrees of difficulty for each test protocol. The best two out of three results were averaged to calculate the extinguishment time. If two results varied by more than 25%, two additional tests were conducted and the best three out of five were averaged. Extinguishment time was defined as the time required to completely extinguish all visible fire on or within the contained area, which was measured manually with a stopwatch. Fires occurring outside the test area, inclusive of those that might occur in the aircraft mock-up as described later, were not considered as part of the test.

As much as possible, each test fire was conducted in a calm wind condition. JP-8 jet fuel was used in each test.

2.1 DATA ACQUISITION.

The SAFS was instrumented with three pressure transducers and two flow meters. The pressure transducers measured system, foam tank, and dry chemical tank pressure. The flow meters measured agent flow in gallons per minute (gpm) and air injection into the foam stream in standard cubic feet per minute.

2.2 VOLUNTEERS.

The expected end users of SAFS are small airport, non-journeyman-level fire fighters with minimal experience in aircraft firefighting. To validate the theory that SAFS is easy to use and requires minimal training, volunteer fire fighters were used for all live fire testing. The volunteer fire fighters were local structural fire fighters recruited from a small neighboring town. All volunteers possessed minimal structural firefighting experience and no aviation firefighting experience. Air Force Research Laboratory (AFRL) Fire Research Group staff members, in the course of performing operability and acceptance tests, conducted several preliminary fires. The results of these few fires are included as a comparison between the volunteer group and journeyman-level fire fighters.

2.3 EQUIPMENT.

2.3.1 Test Equipment and Description.

The SAFS design and low weight, 1750 dry weight or 3000 pounds wet, allows the unit to be placed on a cargo flatbed or mounted onto a utility bed of a lightweight truck. In addition, SAFS can be placed on a trailer and towed to an aircraft incident or standby location. This latter method, while more economical, would create a slower response.

The SAFS unit is a skid-mounted extinguishing system easily installed using a forklift. It consists of two low-pressure and two high-pressure tanks. The low-pressure foam tank holds 100 gallons of premixed foam solution and the low-pressure dry chemical tank holds 500 pounds of dry chemical. Two 2500-psi compressed air cylinders provided 200 psi of operating pressure at the pressure regulators for both the foam and dry chemical tanks. Due to the inexperience of the volunteer fire fighters, the foam and dry chemical pressure setting were reduced from 200 psi each to 150 psi and 80 psi, respectively, during the last two fire scenarios involving the larger pool fires (see appendix B for pressure measurements for each fire test). Otherwise, the foam and dry chemical tank pressures were set at 200 psi and 100 psi, respectively. Standard operating pressures set by the manufacturer can be difficult to handle by inexperienced fire fighters and, therefore, were reduced for safety concerns and ease of operation. SAFS was also equipped with an adjustable valve to regulate the expansion ratio of the foam. This valve was set to approximately 50% open for all SAFS testing.

Foam and dry chemical were delivered through a variable-stream dual-agent Hydrochem™ nozzle (figure 2) or a CAF dual-agent Hydrochem™ nozzle (figure 3). The commercially available nozzles were manufacturer by Williams Fire and Hazard Control, Inc., and until recently, were used exclusively for combating pressurized fuel line and wellhead fires. The dual-agent handline was 100 feet in length. The fire fighter selected either foam or dry chemical individually or the simultaneous discharge of both agents to extinguish a 2-D pool fire and 3-D flowing fuel fire. The estimated foam flow rate of the system for each nozzle was 35 gpm with the variable-stream nozzle and 30 gpm with the compressed air foam nozzle. The estimated expansion ratio for each nozzle was 3:1 with the variable-stream nozzle and 6:1 to 8:1 with the compressed air foam nozzle, producing approximately 300 gallons and 600-800 gallons of finished foam solution, respectively. The variable-stream nozzle dry chemical orifice measured 0.75 inch, and the CAF dry chemical nozzle orifice measured 0.63 inch, both with an estimated discharge of 5 pounds per second (pps) or 100 seconds of application time.

FIGURE 2. DUAL-AGENT, VARIABLE-STREAM NOZZLE

FIGURE 3. DUAL-AGENT, COMPRESSED AIR FOAM NOZZLE

2.3.2 Firefighting Agents.

Most aircraft incidents and accidents involve some type of 3-D flowing fuel fires. The potential for ignition of flowing fuel in contact with hot metal surfaces is present in virtually every small aircraft fire situation. The 3-D fires occur when fuel or hydraulic fluid from damaged lines and equipment continuously replenish dry-bay compartments and/or external openings with ignitable aviation fuel. The 2-D pool fire is constantly resupplied by a 3-D flowing fuel column, and generally, will require constant, aggressive agent application for control. These factors make control and extinguishment of combined 2-D pool and 3-D flowing fuel fires virtually impossible when only a 2-D foam agent is applied. The 3-D agents are highly effective knockdown agents but do not possess adequate cooling and burn back resistance to prevent reignition and they are limited in their ability to be thrown (discharged) over long distances.

The MilSpec (MIL-F-24385F) 3% AFFF concentrate used in this test is the most widely used foam agent in the world for extinguishing 2-D ground or surface pool Class B fires. Military and civil aviation crash fire trucks are equipped with foam and water pumps designed specifically for discharging AFFF. AFFF has superior burn back resistance to impinging fire by creating a stable film that quickly spreads across the surface of burning fuel, sealing flammable vapors.

The dry chemical chosen for the test was Purple K (PKP) potassium bicarbonate. PKP possesses superior knockdown capability and is effective against pressurized 3-D flowing fuel fires such as those occurring on wellhead fires. In commercial use, a purple dye is added to the dry chemical to visually aid fire fighters in dispensing agent onto the fire. Similarly, the purple dye aided laboratory personnel in determining how the agent interacted with the AFFF when it was discharged into the combination agent stream. When discharged by itself, the siliconized dry chemical is easily influenced by a slight breeze. A gust of wind can diffuse the agent, rendering it ineffective. A downwind approach was necessary to prevent the agent from being carried away in the wind.

2.3.3 Fire Evaluations.

2.3.3.1 Cascading Fuel Fire Test Article.

The FAA-developed Cascading Fuel Fire Test Article (CFFTA) was provided for the initial small-scale test of the SAFS 3-D operational capability (figure 4). The CFFTA was originally developed by the British Civil Aviation Authority to certify dry chemical extinguishing agents. The FAA took that original design and modified it to incorporate an area with hidden and obstructed fire. The FAA has since been using the device to evaluate primary and complimentary firefighting agents. The device proved useful for evaluating the SAFS on small 3-D flowing fuel fires. The CFFTA is a two-piece stainless steel device with a 72-inch-tall flowing fuel module in the center and a 6- x 6-foot-square pan for containing the flowing fuel on the bottom. The pan rests on four large pedestals designed to elevate the fully loaded article 8 inches above ground surface.

FIGURE 4. CASCADING FUEL FIRE TEST ARTICLE

The column provided the 3-D flowing fuel fire scenario and the pool surface provided the 2-D pool fire scenario common to many aircraft fire incidents. The structural integrity of the article was maintained by flowing water inside the vertical column. Action of the flowing water cooled the column interior, minimizing structural damage to the column. Three to four inches of water were placed in the pan to float the fuel off the bottom of the steel pan. The 12-inch sides of the pan prevented burning fuel and fire suppression agents from running from the pool onto the ground. Fuel was introduced at the top of the column and was allowed to cascade down the device, producing the 3-D flowing fuel fire. The 2-D pool fire was created either by permitting the fuel to run into the pan or by flowing fuel into the pan from an external source such as a preconnected fuel line or hose until a sufficient pool of fuel was formed to sustain a 2-D pool fire. When ignited, usually midway up the flowing fuel column, the flowing fuel fire cascaded down the column into the pan where it ignited the surface fire. Fuel was continuously flowed until the fire was extinguished.

The CFFTA design configuration is representative of the kinds of fires normally associated with fires resulting from fuel spilling or flowing from an enclosed cowling, most often caused by a ruptured fuel line. Many small airport aircraft have reciprocating engines that are protected from exterior damage by the cowling; however, the cowling also serves to contain the fuel, which contributes to the severity of the internal fuel fire. These fires are usually extinguished by inserting a hand-held nozzle into an engine access port located on the cowling. An evaluation of the operational effectiveness of the two different operational dual-agent nozzles (variable stream and compressed air foam) to extinguish an engine nacelle fire could not be undertaken due to this limitation.

A minimum of 24 fires was conducted using the CFFTA (table 1). Sixty gallons of JP-8 jet fuel were flowed into the 6-foot-square pan and then fuel was continuously flowed at a rate of 5 gpm from the top of the vertical column into the pan. Fuel was continuously flowed throughout the test and was turned off when the fire was completely extinguished and the possibility of reignition was eliminated.

TABLE 1. CASCADING FUEL FIRE TEST ARTICLE FIRE TEST MATRIX

Variable-Stream Nozzle			Compressed Air Foam Nozzle		
	Agent Type	No. of Fires	Test No.	Agent Type	No. of Fires
1A-1C	AFFF	3	1D-1F	AFFF	3
2A-2E	AFFF	5			
3A	PKP	1	3B	PKP	1
4A-4C	AFFF/PKP	3	5A-5D	AFFF/PKP	4

2.3.3.2 Cascading Fuel Fire Test Article and 30′ Diameter Ring.

The combination of the CFFTA and a 30-foot (707-sq. ft.) -diameter ring configuration (figure 5) provides a medium-scale 2-D pool fire and a 3-D flowing fuel fire test for the evaluation of SAFS. The fire area in this test corresponds to the Practical Critical Area (PCA) of a Category 1 airport based on the National Fire Protection Association's Standard for Aircraft Rescue and Fire Fighting Services at Airports (NFPA 403). Sample aircraft for this category airport would be a Cessna 206 or a Beech Bonanza 35.

The added element of a 30-foot-diameter ring to enlarge the surface pool fire area created the kind of fire scenario most likely encountered at small airport aircraft fire incidents. At its edges, the CFFTA and 30-foot-diameter ring created a hot surface sufficient to keep the JP-8 jet fuel vaporizing until the foam extinguished the fire and cooled the hot metal. Fire emanating from under the CFFTA also presented a challenge and was considered as part of the test. Three tests of each agent were conducted to determine the unique suppression capability of each fire agent application technique.

FIGURE 5. CASCADING FUEL FIRE TEST ARTICLE AND 30′ DIAMETER RING MEDIUM-SCALE TEST SETUP

The 30-foot-diameter ring was formed by a 6-inch-high steel ring placed on a level concrete slab. This configuration permitted the containment of the fire, the expended foam, and the PKP agent. Approximately 3 inches of water were flowed into the ring to establish a smooth, level surface on which to place the 100 gallons of JP-8 jet fuel. As in previous tests, the pan on the CFFTA was filled with 3 to 4 inches of water and 60 gallons of JP-8 jet fuel. Jet fuel was then flowed onto the CFFTA vertical column at a rate of 5 gallons per minute and allowed to flow throughout the test. The cascading fuel was ignited midway up the fuel column. Fuel within the 30′ ring was ignited immediately following ignition of the CFFTA fuel and allowed to preburn for 30 seconds to insure a steady burn rate. The fire was attacked from upwind in a direct attack upon the fire. Fire fighters were not allowed to enter the ring but could move freely around the periphery of the ring. This was done to allow the firefighting agents to perform while minimizing variables from fire fighter technique. Fire fighters were instructed to attack the ring fire as aggressively as possible using AFFF on the surface pool fire, to conserve the PKP for the CFFTA pool and vertical column fire and complete the extinguishment using the combination of agents. At the conclusion of each test, all water, foam, and fuel were removed from the CFFTA. The test fixture was thoroughly drained, rinsed, and refilled with clean water in preparation for the next test. The test matrix shown in table 2 was used as a guide for conducting the CFFTA and 30′ diameter ring fire tests.

TABLE 2. CASCADING FUEL FIRE TEST ARTICLE AND 30′ DIAMETER RING TEST MATRIX

Variable-Stream Nozzle			Compressed Air Foam Nozzle		
Test No.	Agent Type	No. of Fires	Test No.	Agent Type	No. of Fires
6A-6C	AFFF/PKP	3	7A-7C	AFFF/PKP	3

2.3.3.3 Large-Scale Fire Tests.

The 100-foot (7,854-sq. ft.) -diameter fire burn area (figure 6) was used to evaluate the firefighting performance of SAFS dual-agent systems in a large-scale test environment. The fire area in this test corresponds to the PCA of a Category 6 airport based on NFPA 403. This is equivalent to the FAA Index B under 14 CFR Part 139. A British Aerospace BAE 146-200 is a representative aircraft to this FAA index or NFPA category.

FIGURE 6. LARGE-SCALE FIRE TEST SETUP

This open-air fire environment allowed the fuel to pool and flow as surface winds dictated. Similarly, pressure from the water and foam streams moved the fuel across the surface of water in the same manner that occurs on wide open tarmacs or runways. The movement of the fuel across the water helped to ensure the 3-D flowing fuel fire effect.

Approximately 2 inches of water was flowed into the 100′ diameter burn area to establish a smooth, level surface on which 500-600 gallons of JP-8 jet fuel was flowed. The intent of the spill was to ensure sufficient fuel was flowed in the fire burn area to require fire fighters to maneuver around the aircraft mock-up and throughout the 100′ diameter fire burn area. A 500-gallon fuel spill covers 70% or more of the exposed surface area. The existing aircraft mock-up, including supports, helped maintain a heat sink sufficient to keep the JP-8 jet fuel vaporizing until the AFFF and PKP combination extinguished the fire and cooled the hot metal below its reignition temperature. Test fire fighters were instructed to preposition the SAFS upwind, approach the fire from upwind, and apply the agents or combination of agents uniformly to the fire surface for both knockdown and sealing the surface area to prevent burn back. In addition, fire fighters were instructed to extinguish the fire as rapidly and as safely as firefighting practices would permit. Fires were conducted following the matrix show in table 3.

TABLE 3. LARGE-SCALE FIRE TEST MATRIX

Variable-Stream Nozzle			Compressed Air Foam Nozzle		
Test No.	Agent Type	No. of Fires	Test No.	Agent Type	No. of Fires
8A-8D	AFFF/PKP	4	9A-9E	AFFF/PKP	5

The actual duration of the extinguishment effort was determined to be the length of time it took the volunteer fire fighter to fully extinguish the fire. Extinguishment time began when the agent was first applied to the fire and continued until the fire was fully extinguished. Extinguishment time did not consider discharge time as a function of extinguishment. The amount of agent used in the fire is related to actual nozzle discharge time as discussed elsewhere in this report.

2.3.4 Nonfire Evaluations.

2.3.4.1 Throw Range.

Fourteen throw range tests were conducted to determine the maximum distance the variable-stream and compressed air foam nozzles would project AFFF, PKP, and the combination AFFF and PKP agent. The throw range tests followed the test matrix shown in table 4. The distance from the nozzle tip to the farthest point reached by the agent stream was measured with a measuring tape.

TABLE 4. THROW RANGE TEST MATRIX

Variable-Stream Nozzle			Compressed Air Foam Nozzle		
Test No.	Agent Type	No. of Tests	Test No.	Agent Type	No. of Tests
10A-10C	AFFF	3	11A-11C	AFFF	3
12A-12C	AFFF/PKP	3	13A-13C	AFFF/PKP	3
14A-14B	PKP	2			
19A	P-19/AFFF	3			

SAFS operating pressures were maintained at 150 psi on the AFFF tank and 80 psi on the PKP tank to ensure throw distance data would relate to the actual pressure setting used during live fire testing. The injected air for the CAF nozzle was preset to 50% injection, again, to relate throw distance to actual setting used during live fire testing. To ensure an accurate comparison of the two nozzles, the variable-stream nozzle was adjusted to a straight stream mode. Each of the nozzles were mounted to a workbench and elevated approximately 15 degrees to attain the longest possible reach during discharge. The dual-action clamping mechanism on the workbench ensured the handline and nozzle remained securely in place during discharge. Upon activation of the system, the agent was discharged in a direct downwind path for approximately 5 seconds. Figure 7 shows the workbench and test platform used to stabilize the handline nozzles and measure the elevation of the nozzle angle.

FIGURE 7. HANDLINE AND NOZZLE-MOUNTING PLATFORM

As a comparison for handline operations, three tests of the United States Air Force (USAF) P-19 Crash Truck handline were also conducted (figure 8). Test measurements of the throw distance produced by the P-19 handline nozzle were obtained by following the same test methods described for the SAFS handline nozzles.

FIGURE 8. UNITED STATES AIR FORCE P-19 CRASH TRUCK

Maximum throw distance was determined by measuring the distance from the nozzle tip to the farthest point reached by the agent stream. In addition, measurements were taken of the width of the foam pattern. The foam pattern was measured at the widest point in which the foam mass was judged sufficient to cause fire extinguishment. Neither over spray nor the forward movement of flowing foam was measured.

2.3.4.2 Timed Agent Flow Test.

Testing was conducted to measure the time to empty the foam or dry chemical tank, yet still produce an effective agent stream. An effective agent stream varies over the course of discharge due to changes in the volume of air in the tanks (i.e., more air is dispensed and the decreasing amount of agent is no longer capable of suppressing a fire). This method required the test director to determine when the agent stream was diminished to a point of there being more air than agent. This method, though subjective, produced the best results and was consistent for all timed agent flow tests. The test matrix (table 5) was followed in conducting the timed agent flow tests. As in previous tests, the handline nozzle was clamped to the workbench and the nozzle was fully opened. The system pressure was set to 200 psi, the foam pressure was set to 150 psi, and the dry chemical pressure was set to 80 psi for each test.

TABLE 5. TIMED AGENT FLOW TEST MATRIX

Variable-Stream Nozzle			Compressed Air Foam Nozzle		
Test No.	Agent Type	No. of Tests	Test No.	Agent Type	No. of Tests
15A-15C	AFFF	2	16A-16C	AFFF	2
17A	PKP	1	18A	PKP	1

2.3.5 Test Support Vehicle.

The vehicle shown, in figure 9a was used for this series of tests. It was a commercially available dual-wheel 1 1/2-ton stake body truck with a carrying capacity of 3000 pounds. This vehicle was highly suited for performing SAFS testing in an ambitious test environment. Figure 9b shows how the system can be incorporated into the bed of a similar truck with a utility body.

FIGURE 9a. STAKE BODY TRUCK WITH SAFS

FIGURE 9b. FAA TRUCK WITH UTILITY BODY

3. RESULTS AND DISCUSSIONS.

3.1 DATA ACQUISITION.

Appendix A contains the data collection sheets used for each fire. Appendix B shows the pressure and flow data collected during each fire test. During several CFFTA fire tests, the foam agent flow meter was not operational. This problem was not identified until the second day of testing when the data acquisition files were examined. The problem was corrected and the foam agent flow rate was recorded for the remaining tests.

3.2 VOLUNTEERS.

The results documented during SAFS testing were obtained exclusively with local area volunteer fire fighters. The skill level of the volunteers was varied and, to that end, an effort was made to match a more experienced volunteer with a less experienced volunteer, particularly in the large-scale 100′ diameter fires. Most of the volunteers were engaged in their first hydrocarbon fires. None of the volunteers were familiar with the concept of 2-D pool and 3-D flowing fuel firefighting or were exposed to the FAA-developed CFFTA.

Feedback from the volunteers indicated a preference for the CAF nozzle over the variable-stream nozzle due principally from not having to adjust the CAF nozzle during fire extinguishment. In their view, an adjustment to the variable-stream nozzle had little or no effect on the extinguishment of small- or medium-scale hydrocarbon fuel fires. The CAFS-fixed orifice provided a nozzle stream more than adequate for attacking and controlling static or running fuel fires and the addition of dry chemical in the hose stream hastened fire extinguishment and provided an extra degree of protection. The varying fire conditions required each fire fighter to frequently adjust his or her position and to elevate or depress the nozzle angle sufficiently to achieve a maximum throw to effect the extinguishment. The improving performance of the fire fighters and the growing confidence gained from several CFFTA fires was exhibited in subsequent fires.

3.3 EQUIPMENT.

SAFS was a solid performer throughout testing. Operating in both the air-aspirated and non-air-aspirated modes from the same platform allowed test personnel to more closely examine SAFS's full potential as compared to an evaluation on two differing AFFF delivery systems. AFFF in the CAF mode was clearly as effective as the AFFF stream from the variable-stream nozzle. The volunteer test group readily observed the increased standoff distance created by the CAF hose stream and commented that the increased standoff did not diminish the hose stream performance. The SAFS projected a dual-agent stream further and wider than the variable-stream mode. The increased distance in throw was related to the smaller orifice on the CAF nozzle and the boost received from the addition of the injected air needed to create compressed air foam. The only concern associated with SAFS was the pressure regulators. System pressures were constant, but operating (working) pressures differed between the two operating modes by as much as 50 psi when CAFS and dry chemical were used simultaneously. The CAFS working pressure was superior to the variable-stream nozzle and may be related to the smaller orifice and the increase in pressure received from injected air. The drop in pressure was more than that associated with normal friction loss in the hose and may be attributed to a failure of the pressure regulators to adjust or hold a desired nozzle pressure.

3.4 FIRE EVALUATIONS.

3.4.1 Cascading Fuel Fire Test Article Test Results.

The results of fire tests 1A through 5D are shown in figures 10a and 10b. The average extinguishment time in tests 1A through 1C with the variable-stream nozzle on the CFFTA was 48.3 seconds for all three tests, or 37 seconds if the outlier is discarded. The average improved with the CAF nozzle, with an average extinguishment of 27.5 seconds. The DNE (did not extinguish) in test 1D resulted from the SAFS not being fully charged with air. The average for the second set of variable-stream tests (2A through 2E) was 20.6 seconds, more than 27 seconds less than the first set of tests with the same nozzle. The improved extinguishment times observed during these tests was probably a result of the fire fighters gaining experience using the nozzles in previous tests. Test 1D was not repeated as a result of the improved performance of the agent and agent nozzle in tests 1E through 1F and the likelihood that the results would not change with a succeeding test but merely serve to validate previous tests results.

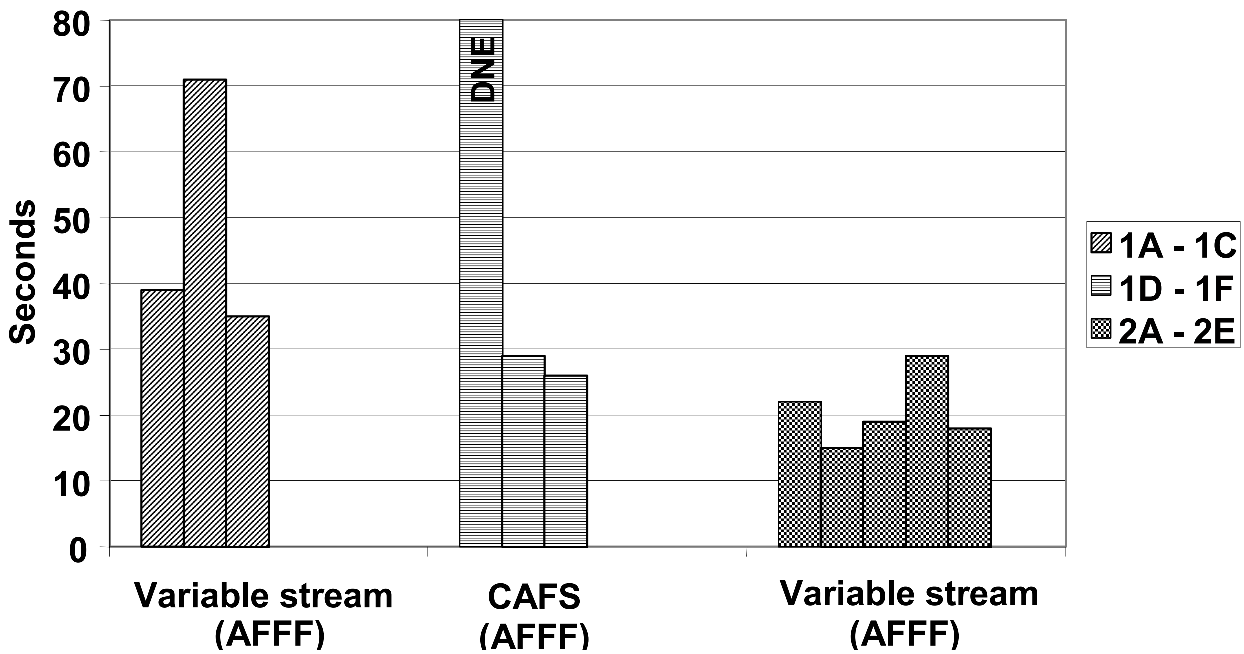

FIGURE 10a. CASCADING FUEL FIRE TEST ARTICLE FIRE TEST RESULTS WITH AFFF

As predicted, the two fires involving the application of PKP resulted in DNEs; therefore, the PKP only fires were terminated. Test procedures called for three fires with each agent; however, the results of the first two fires were accepted as the norm when the dry chemical was not used in conjunction with a liquid agent. The FAA Test Manager agreed with the AFRL Test Director concerning this decision. Both agencies felt that data collected from the first two fires was sufficient. Without the benefit of cooling the hot metal, dry chemical alone cannot reduce the temperature significantly below the reignition threshold. Previous testing has verified these results and has shown that the ineffectiveness in extinguishing these types of fires with PKP alone was regardless of the aggressiveness of the fire fighter or the angle in which the fire was attacked.

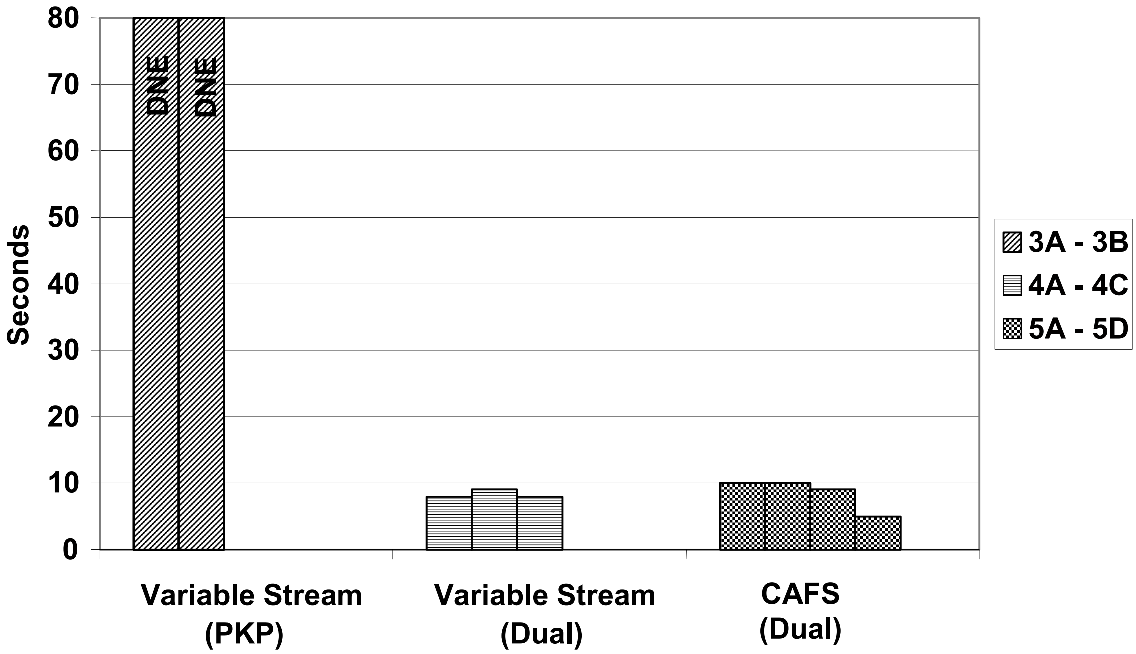

FIGURE 10b. CASCADING FUEL FIRE TEST ARTICLE TEST RESULTS WITH PKP AND AFFF/PKP (DUAL)

No significant difference in extinguishment times was recorded as a result of using the variable-stream versus the CAF nozzle. The average extinguishments times were 8.33 seconds for tests 4A through 4C using the variable-stream nozzle and 8.5 seconds for tests 5A through 5D using the CAF nozzle. However, when results from tests 1A through 1C and 2A through 2E (variable-stream nozzle) and tests 1D through 1F (CAF nozzle) using AFFF alone were compared to PKP in combination with AFFF, the overall average extinguishment times decreased by 22.7 seconds or 73%, and 19 seconds or 69%, respectively, with each nozzle. The combination of agents, AFFF and PKP, provided a significant increase in the knockdown (PKP) and cooling (AFFF) capability to effectively engage and extinguish the 2-D pool fire and 3-D flowing fuel fire and prevent burn back.

The data collection sheets and the flow and pressure data for tests 1A through 5D are shown in appendices A and B.

3.4.2 Cascading Fuel Fire Test Article and 30′ Diameter Ring Fire Tests Results.

The results of the CFFTA and 30′ diameter ring tests are shown in figure 11. The combination of AFFF and PKP using the variable-stream nozzle in tests 6A-6C extinguished the three test fires in an average of 79 seconds. The combination of AFFF and PKP using the CAF nozzle extinguished the three test fires in an average of 50 seconds. On average, using the CAF nozzle with AFFF and PKP decreased extinguishment time by 29 seconds or 37%.

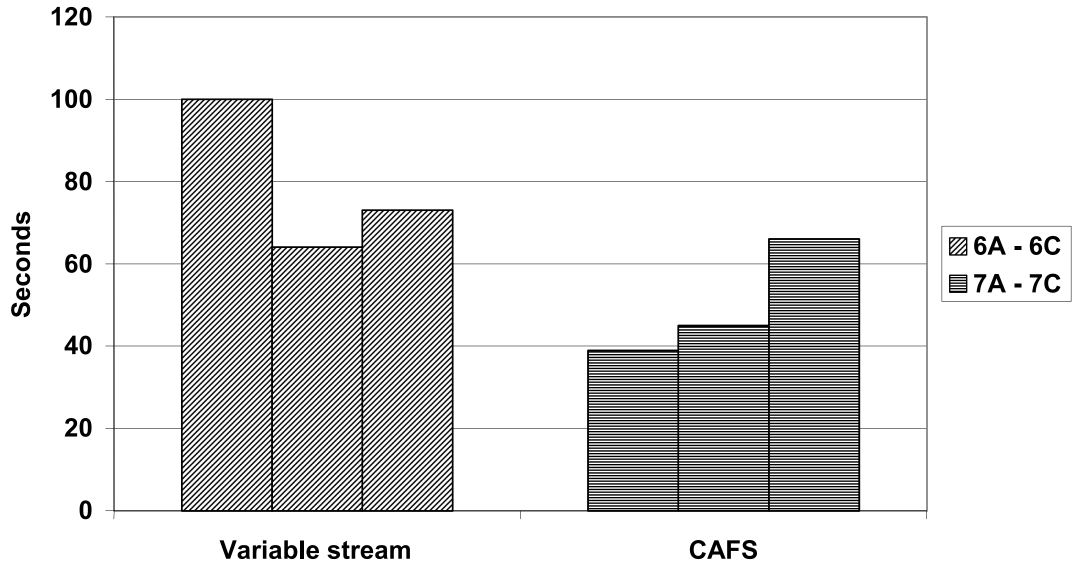

FIGURE 11. CASCADING FUEL FIRE TEST ARTICLE AND 30′ DIAMETER RING TEST RESULTS

As emphasized previously, none of the fire fighters had previously encountered or witnessed a 2-D pool fire and or a 3-D flowing fuel fire. Structural firefighting skills could not be applied to fighting the medium-scale flammable liquid fires. Frequent adjustment of the variable-stream nozzle, common to structural firefighting, may have actually hindered fire extinguishment in tests 6A through 6C. Undoubtedly, the experience gained by the volunteer group in tests 6A through 6C was quickly applied more successfully to tests 7A through 7C. Having a fixed orifice nozzle that provided a constant CAF agent flow at a constant pressure and was more effectively applied to the fire area was more critical to fire extinguishment than a selectable variable-steam agent pattern that projected agent beyond the target area and wasted precious seconds and agents.

From a position approximately 10-15 feet from the ring, the fire fighter could project the hose stream across the full length of the 30′ diameter ring with little or no influence from the ground surface winds. Reaching the top of the CFFTA vertical column with a combination agent hose stream also did not present any difficulty. As the fire fighter approached the ring, fire immediately in front of the fire fighter was protected from extinguishment due to the height of the ring above the fuel surface. This condition did not affect the outcome of the test for the combination agent. Differences in application techniques between the variable-stream nozzle and the CAF nozzle were minor but were satisfactory for each of the agent application techniques and produced an effective extinguishment.

The data collection sheets and the flow and pressure data for tests 6A through 7C are shown in appendices A and B.

Although not a specific function of the approved test plan, the AFRL's in-house, journeyman-level fire fighters conducted some preliminary testing of the SAFS in the CAF mode to ensure its operational readiness and to prepare an orientation for the volunteer group. The results of these initial screenings and operational tests are show in figure 12. AFFF extinguished the three CFFTA and 30′ diameter test fires in an average of 30 seconds. These were timed tests only and data collection sheets and the flow and pressure data were not taken.

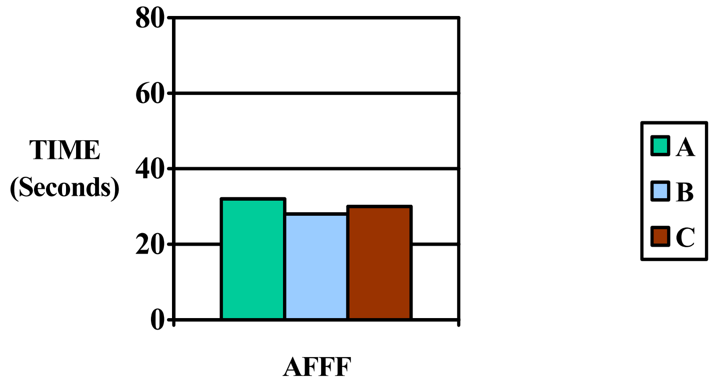

FIGURE 12. CASCADING FUEL FIRE TEST ARTICLE AND 30′ RING TEST RESULTS (AFRL)

3.4.3 Large-Scale Fire Tests.

The results of the large-scale fire tests are shown in figure 13. The results of this series of tests demonstrated that the time of fire extinguishment was significantly different from the time the agent was actually discharged onto the fire.

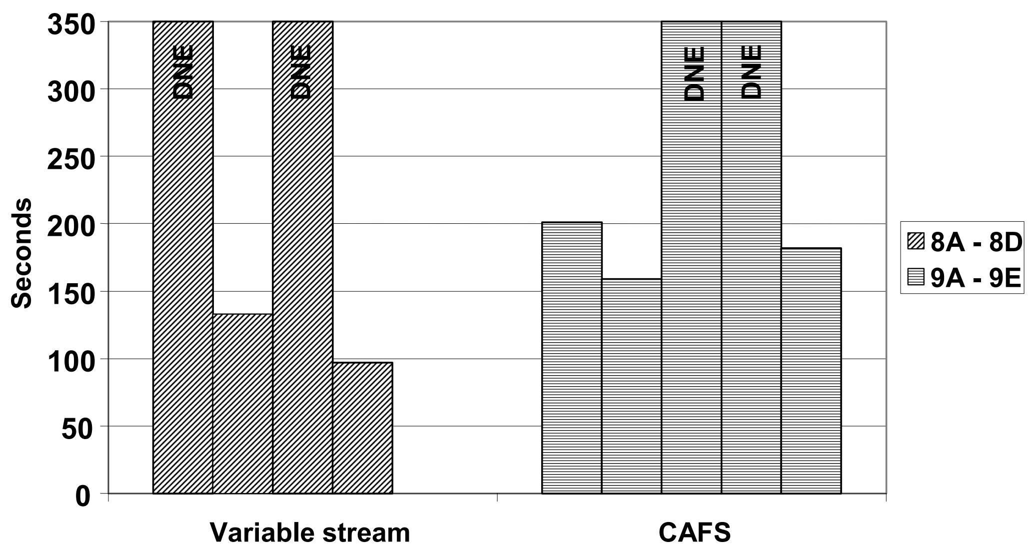

FIGURE 13. LARGE-SCALE FIRE TESTS RESULTS

In tests 8A through 8D involving the use of the variable-stream nozzle, two of the fires resulted in DNEs; however, the volunteer group successfully extinguished as much as 90% of the fire before they were forced to withdraw from the fire area for lack of agent. The percent of fire area extinguished, slightly over 7,000 sq. ft. on average, is directly related to the PCA value of an area equivalent to an Index B airport. Two fires were completely extinguished. Improper decision-making during the initial attack on the fire in tests 8A and 8D caused the overuse of the agent, and eventually, the fire fighters were forced to withdraw from the fire. In tests 8B and 8D, the fire fighters properly assessed the fire, and using an upwind approach, made excellent use of the agent. Of the two successful attempts to extinguish the fire, extinguishment occurred, on average, at 114 seconds.

In tests 9A through 9E using the CAF nozzle, two fires were not extinguished. In tests 9C and 9D, improper decision-making during the initial attack and the overuse of the dry chemical agent resulted in two DNEs. In tests 9A, 9B, and 9E, the fire fighters properly assessed the fire and using an upwind approach, made excellent use of the agent and successfully extinguished the fire. The average time for extinguishment of these three fires was 185 seconds.

The data collection sheets and the flow and pressure data for tests 8A through 9C are shown in appendices A and B.

AFRL's in-house, journeyman-level fire fighters also conducted some preliminary testing of the SAFS system in the CAF mode with a 3500-sq. ft. fire area. These tests were initially conducted to illustrate the operability of the unit in a half-scale fire environment. All of the tests were performed with the system in CAF mode and in conjunction with the aircraft mock-up. Agent was applied almost continuously throughout the fire tests, as it was the full intent of the research staff to extinguish the fire as rapidly as possible. The results of these tests showed that on average, a fairly experienced airport fire fighter was capable of extinguishing the fire within 47 seconds using only AFFF and within an average of 28 seconds using a combination of AFFF and PKP. When compared to the results of the test with the volunteer subjects, these numbers show that in proportion, an experienced fire fighter could extinguish the fire with the CAFS nozzle in approximately one-third the time it took the inexperienced fire fighter.

It is believed that the significant difference in extinguishment time was attributed to several factors. The project fire fighters, having no experience in multidimensional fuel fires such as these, were more apt to misuse the nozzle, resulting in an improper or excessive application technique that would extend the extinguishment time and possibly result in a DNE. It is important to recognize that while the resulting times for the tests were higher than those of the experienced firefighter, several fires were either extinguished entirely or close to 90% extinguished, which relates to a fire that is much larger than would be expected at a typical Index A airport. Considering the large variation in skill levels of the volunteer fire fighters, greater emphasis was put on the ability to completely extinguish the fire rather than extinguishment times. It is also important to note that in the CAF's configuration, of those fires that were extinguished, a sizeable amount of unused agent was still available for maintenance of the fire.

3.4.4 Nonfire Evaluations.

3.4.4.1 Throw Distance.

The results of the throw range tests are shown in table 6. SAFS produced an effective firefighting agent stream in both the variable-stream nozzle mode and CAF nozzle mode. The variable-stream nozzle produced an average AFFF agent steam measuring 77 feet 5 inches from the nozzle tip to the farthest point of discharge. The effective agent pattern width was measured at 3 feet 5 inches. Figure 13 shows the AFFF throw range test foam pattern produced in test 10A.

TABLE 6. THROW RANGE TEST RESULTS

Variable-Stream Nozzle			Compressed Air Foam Nozzle		
Test No.	Agent	Distance/Width	Test No.	Agent	Distance/Width
10A	AFFF	77′2″/2′4″	11A	CAF	83′3″/5′10″
10B	AFFF	77′8″/3′5″	11B	CAF	86′2″/4′10″
10C	AFFF	77′4″/3′6″	11C	CAF	85′1″/5′5″
12A	AFFF/PKP	98′6″/5′5″	13A	CAF/PKP	109′3″/7′5″
12B	AFFF/PKP	97′6″/7′3″	13B	CAF/PKP	113′6″/6′8″
12C	AFFF/PKP	96′4″/6′6″	13C	CAF/PKP	108′5″/7′5″
14A	PKP	49′ est)			
14B	PKP	47′ (est)			
19A	P-19/AFFF	137′3″/7′4″			
19B	P-19/AFFF	137′6″/7′3″			
19C	P-19/AFFF	137′3″/7′6″			

The CAF nozzle produced an average AFFF agent steam measuring 84 feet 2 inches from the nozzle tip to the farthest point of discharge and 5 feet 4 inches in pattern width. The difference between the distances produced by the two nozzles was related to both the smaller orifice on the CAF nozzle and the injected air on the CAF system. In the variable-stream nozzle mode, foam tank pressure was recorded at 95 psi. In the CAF nozzle mode, foam pressure was recorded at 110 psi. This increase in foam tank pressure was sufficient to produce an increase of nearly 7 feet in throw range and over 2 feet in agent pattern width.

In the dual-agent mode, the variable-stream nozzle produced an average AFFF and PKP agent steam measuring 97 feet 5 inches from the nozzle tip to the farthest point of discharge. The effective agent pattern width was measured at approximately 6 feet 5 inches. The CAF nozzle produced an average AFFF and PKP agent steam measuring 110 feet 4 inches feet from the nozzle tip to the farthest point of discharge and an effective AFFF and PKP agent pattern width measuring approximately 7 feet 3 inches. The increase in throw range for the CAF nozzle resulted from (1) the smaller orifice on the CAF nozzle, (2) the injected air on the CAF foam system as described earlier, and (3) the boost received from the additional air pressure provided by the dry chemical system. Overall foam tank pressure was increased to 115 psi, which was sufficient to increase the average throw distance by 13 feet. Figure 14 shows the results of the agent throw range test recorded for test 10B. Figure 15 shows the results of the agent throw range test recorded for test 13A.

FIGURE 14. AQUEOUS FILM FORMING FOAM PATTERN VARIABLE-STREAM NOZZLE

FIGURE 15. AQUEOUS FILM FORMING FOAM/PKP CAF NOZZLE

Two attempts to determine the actual throw distance of the dry chemical agent were inconclusive at the 15-degree elevation. At this elevation, PKP was easily influenced by slight surface winds after being discharged. PKP throw range was measured at approximately 48 feet but because of the 7-mph surface winds at the time of the test, a definite agent throw range and pattern width was difficult to actually measure. Unquestionably, the agent was delivered more effectively and at greater distances in combination with the AFFF stream.

The distances and agent pattern widths produced by the CAF handline nozzle compared favorably with the AFFF variable-stream handline nozzle measured on the USAF P-19 Crash Truck. This particular P-19 had recently been tested and certified as meeting NFPA Standards 412 and 414. Operating at 240 psi and producing 95 gpm, the P-19 AFFF variable-stream handline nozzle produced an average agent stream measuring 137′ 4″ from the nozzle tip to the farthest point of discharge and an effective agent pattern width of 7′ 4″. The actual throw range test results for the P-19 variable-stream handline nozzle are shown in table 6.

3.4.4.2 Timed Agent Flow Tests.

The results from the timed agent flow tests are shown in table 7. Foam tank pressure was recorded at 150 psi static and 95 psi flowing for each AFFF test. The injected air was set to 50 percent. In each of the foam tests, the CAF nozzle provided an additional 2 minutes or more of firefighting time compared to the variable-stream nozzle. The additional firefighting time resulted from the smaller orifice of the CAF nozzle, reduced flow rate of the CAF nozzle, and the addition of injected air. Equally important, the CAF system produced four times the foam mass as did the variable-stream nozzle.

TABLE 7. TIMED AGENT FLOW TEST RESULTS

Variable-Stream Nozzle			Compressed Air Foam Nozzle		
Test No.	Agent Type	Time	Test No.	Agent Type	Time
15A	AFFF	2 min 48 sec	16A	AFFF	4 min 58 sec
15B	AFFF	2 min 44 sec	16B	AFFF	5 min 3 sec
17A	PKP	3 min 8 sec	18A	PKP	4 min 6 sec

In a single, head-to-head test of the dry chemical system, the variable-stream nozzle dispensed 500 pounds of PKP in 3 minutes and 8 seconds. The CAF nozzle dispensed the same amount of PKP in 4 minutes and 6 seconds. Dry chemical tank pressure was set to 150 psi static and recorded 120 psi flowing for each nozzle test. The extended firefighting time recorded for the CAF nozzle is directly related to the differences in the size of the orifices on the two nozzles. The variable-stream nozzle orifice is 0.75 inch and dispensed at a rate of 2.6 pps. The orifice on the CAF nozzle is 0.625 inch and dispensed at a rate of 2.0 pps.

3.4.5 Test Support Vehicle.

The 1 1/2-ton stake body vehicle (figure 9a) used in this test series was highly suited for test purposes. Installation of the unit in the vehicle's cargo bed did not require any special vehicle preparation. The crew compartment was sufficient for a single, fully attired fire fighter and computerized data gathering equipment. SAFS dual-agent handline reel and operating controls were easily accessible. The absence of sideboards hastened reservicing operations. However, there was a complete lack of storage capability for breathing apparatus, ladders, aircraft skin-penetrating devices, and other essential fire equipment. This would represent a serious limitation for fire emergency response personnel at Index A airports. The vehicle shown in figure 9b with the extended crew compartment would be preferable to the stake body vehicle because of its increased storage capacity, superior utility, and compatibility with the operational needs of responding fire crews. The preferred vehicle must be capable of not only transporting SAFS to an aircraft accident scene but also storing and transporting firefighting and rescue equipment, including personal protective equipment, self-contained breathing apparatus, and a small ladder. A dual-wheel, extended or crew cab vehicle would be highly preferable to the standard stake body truck used throughout the SAFS testing.

4. CONCLUSIONS.

4.1 EQUIPMENT.

The Small Airport Firefighting System (SAFS) used in this test series proved to be very dependable throughout testing. More than 60 tests of the unit in varying operating modes were conducted. The failure rate of the unit was zero, and it remained 100% operational throughout testing. Multiple users operating in a variety of differing circumstances did not cause a failure of the unit. Frequent movement of the unit due to reservicing or prepositioning for a future fire test did not result in damage to the unit. Limited exposure to the elements did not diminish the unit's operational performance. This kind of performance can accurately be compared to a wall-mounted, hand-held, or wheeled flight-line fire extinguisher whose readiness must be absolute.

Pressure regulators on both the aqueous film forming foam (AFFF) and Purple K (PKP) tanks failed to hold operating pressure, resulting in a loss of nozzle working pressure when the nozzles were opened. This drop was more than that associated with normal friction loss in a hose and may be attributed to a failure of the pressure regulators to adjust or hold a desired nozzle pressure. An optimum nozzle working pressure was not actually confirmed during the tests. The drop in working pressure was obvious but did not hinder firefighting operations. It is conceivable, but yet to be established, that the installation of pressure regulators that maintain a preset pressure would contribute to a faster extinguishment.

4.2 TEST SUPPORT VEHICLE.

The commercially available, cargo-carrying vehicle (figure 1) used to transport SAFS to the test site was satisfactory for hauling and testing but was not suitable for the perceived small airport firefighting mission. This would represent a serious limitation for fire emergency response personnel at Index A airports. The vehicle shown in figure 9b with the addition of an extended crew compartment would be preferable to the stake body vehicle because of its increased storage capacity, superior utility, and compatibility with the operational needs of responding fire crews.

4.3 VOLUNTEER FIRE FIGHTERS.

Small-scale tests using the Cascading Fuel Fire Test Article (CFFTA) helped the fire fighters, prepare the volunteer fire fighters to combat flowing fuel hydrocarbon fires on a larger scale. The fire fighters, possessing mostly limited structural firefighting experience, were not familiar with the extinguishing capability of AFFF or dry chemical agents on Class B fires since neither of these agents was available in their fire department. None of the fire fighters had previously encountered or witnessed a (2-D) pool fire and (3-D) flowing fuel fire or had seen or used SAFS or an equivalent piece of equipment. Some fire fighters grasped the concept of dual-agent firefighting without difficulty, while others did not.

4.4 AIR FORCE RESEARCH LABORATORY FIRE FIGHTERS.

Although not specifically outlined as a test parameter, a comparison of the volunteer group to Air Force Research Laboratory's (AFRL) in-house test group showed that SAFS can be a powerful firefighting apparatus when properly understood and employed in a direct attack on the fire. As to be expected, the proficiency of the AFRL fire fighters to attack and extinguish fires in the CFFTA and 30′ diameter combined fuel fires and the 3500-sq. ft. fuel fires were superior to the volunteer group. All of the fires fought by staff members were extinguished quickly and efficiently without wasting any agent.

4.5 FIRE TESTING.

The compressed air foam (CAF) nozzle proved superior to the variable-stream nozzle. A 50% setting on the air-injected CAF nozzle increased finished foam production and resulted in a very effective agent stream. When used in conjunction with PKP, this combination of agents proved superior to the non-air-aspirated AFFF and PKP combination in medium-scale testing. Ninety percent of the fire fighters who used both the variable-stream nozzle and the CAF nozzle preferred the CAF nozzle because they did not have to adjust the CAF nozzle during fire extinguishment. In their view, an adjustment to the variable-stream nozzle had little or no effect on the extinguishment of small- or medium-scale hydrocarbon fuel fires. The CAF-fixed orifice provided a nozzle stream more than adequate for attacking and controlling static or running fuel fires and adding a dry chemical to the hose stream hastened fire extinguishment and provided an extra degree of protection.

The large-scale fire tests, including those that were not extinguished, confirmed the operational limits of SAFS. SAFS, when operated in the CAF mode, produced enough AFFF and PKP to extinguish a 100′ diameter surface pool fire, knockdown the leading edge of the fire and provide a foam blanket sufficient to prevent reignition and burn back of the fire when the fuel source was exposed and lying in close proximity to the large-scale aircraft mock-up. Improper or excessive application techniques during the initial attack on the fire in tests 8A, 8C, 9C, and 9D caused the overuse of the agent and, eventually, the fire fighters were forced to withdraw from the fire for lack of extinguishing agent.

The large-scale tests also helped to define the differences between actual extinguishment time and actual agent application time. In large-scale fires, fire fighters must advance fire hoses to a point in which the hose stream can be effective against the fire front. Because the fire was extinguished in front of the fire fighter and the hose steam no longer reached the fire, the hose was advanced again. This action was repeated several times to effect an extinguishment and served to lengthen the actual extinguishment time. Extinguishment time began when the agent was first applied to the fire and continued until the fire was extinguished. Yet, extinguishment time did not reflect the amount of agent that was being used in the fire. Agent was not applied throughout the fire but was applied as the hose advanced to a suitable location in which to discharge the agent. Therefore, the actual duration of the extinguishment effort considered the length of time to fully extinguish the fire.

4.6 NONFIRE TESTING.

In the dual-agent mode, the fixed orifice CAF nozzle produced an effective AFFF and PKP agent steam and pattern width clearly superior to the variable-stream nozzle. The increased throw range for the CAF nozzle resulted from the smaller orifice on the CAF nozzle and the addition of injected air into the foam stream. The absence of a variable-stream pattern on the CAF nozzle limits the fire fighters choices of attack. SAFS produced an effective CAF and PKP stream sufficient to permit an appropriate standoff in large-scale fire operations.

5. RECOMMENDATIONS.

5.1 EQUIPMENT.

SAFS, in a CAF configuration, is highly recommended for use at Index A airports. SAFS was operational 100% of the time, even with daily use and movement.

SAFS' pressure regulators on both the AFFF and PKP tanks must be replaced with pressure regulators that maintain operating pressure at a desired working pressure. The drop in working pressure did not hinder firefighting operations, but it is conceivable that the installation of pressure regulators that maintain a preset pressure would contribute to a faster extinguishment and a more reliable discharge of agent.

5.2 SMALL AIRPORT FIREFIGHTING SYSTEM TRANSPORT VEHICLE.

The operational capability of the Index A airport fire fighters would be enhanced by adapting SAFS to a commercially available, dual-wheel extended cab vehicle with a service body suitable for storing and transporting additional equipment. This type of vehicle would more appropriately provide the capability needed to fulfill the needs of fire response personnel.

APPENDIX A—SMALL AIRPORT FIREFIGHTING SYSTEM DATA SHEETS

Test No:	1A
Date:	21-May-01
Time:	

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 39	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	6 mph
Wind Direction:	
Temperature (deg F):	82
Humidity:	68
Barometric Pressure:	32.5

Observations:

Test No:	1B			
Date:	21-May-01			
Time:				

Test Type:	Pool	Pool/Cascade	**Cascade**	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	**60 gal + 5gpm**	
Pre-burn Time (sec):	30	45	**60**	
Foam Agent Type:	None	**3% AFFF**		
System Pressure:	200	Injection Valve, % Open	**0**	50
Dry Chemical:	**None**	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	**Variable Stream**
Extinguish Time (sec):	Timer 1: 71	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	7 mph
Wind Direction:	
Temperature (deg F):	82
Humidity:	68
Barometric Pressure:	32.5

Observations:

Test No:	1C			
Date:	21-May-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 35	Timer 2:	Timer 3:	

Meterological Data:	
Wind Velocity:	6 mph
Wind Direction:	
Temperature (deg F):	82
Humidity:	65
Barometric Pressure:	32.5

Observations:

Test No:	1D			
Date:	21-May-01			
Time:				

Test Type:	Pool	Pool/Cascade		Cascade
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm		60 gal + 5gpm
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: DNE	Timer 2:	Timer 3:	

Meterological Data:	
Wind Velocity:	5 mph
Wind Direction:	
Temperature (deg F):	80
Humidity:	71
Barometric Pressure:	32.5

Observations:

Test No:	1E
Date:	21-May-01
Time:	

Test Type:	Pool	Pool/Cascade		Cascade
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm		60 gal + 5gpm
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 29	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	7 mph
Wind Direction:	
Temperature (deg F):	87
Humidity:	69
Barometric Pressure:	32.5

Observations:

Test No:	1F				
Date:	22-May-01				
Time:					

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 26	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	0-2 mph
Wind Direction:	220
Temperature (deg F):	83
Humidity:	72
Barometric Pressure:	30.25

Observations:

Test No:	2A			
Date:	21-May-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 22.06	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	7 mph
Wind Direction:	
Temperature (deg F):	86
Humidity:	69
Barometric Pressure:	32.5

Observations:

Test No:	2B			
Date:	21-May-01			
Time:				

Test Type:	Pool	Pool/Cascade		Cascade
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm		60 gal + 5gpm
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 15.38	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	11 mph
Wind Direction:	
Temperature (deg F):	84
Humidity:	70
Barometric Pressure:	32.5

Observations:

Test No:	2C			
Date:	21-May-01			
Time:				

Test Type:	Pool	Pool/Cascade		**Cascade**
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm		**60 gal + 5gpm**
Pre-burn Time (sec):	30	45	**60**	
Foam Agent Type:	None	**3% AFFF**		
System Pressure:	200	Injection Valve, % Open	**0**	50
Dry Chemical:	**None**	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	**Variable Stream**
Extinguish Time (sec):	Timer 1: 18.87	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	9 mph
Wind Direction:	
Temperature (deg F):	86
Humidity:	71
Barometric Pressure:	32.5

Observations:

Test No:	2D
Date:	22-May-01
Time:	

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	29.22	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	0 mph
Wind Direction:	170
Temperature (deg F):	82
Humidity:	75
Barometric Pressure:	32.5

Observations:

Test No:	2E				
Date:	22-May-01				
Time:	0930				

Test Type:	Pool	Pool/Cascade	Cascade	

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60	

Foam Agent Type:	None	3% AFFF	

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	18.41	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	0 mph
Wind Direction:	200
Temperature (deg F):	83
Humidity:	81
Barometric Pressure:	32.5

Observations:

Test No:	3A			
Date:	22-May-01			
Time:	1000			

Test Type:	Pool	Pool/Cascade		Cascade
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm		60 gal + 5gpm
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1:	DNE	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	0 mph
Wind Direction:	200
Temperature (deg F):	83
Humidity:	80
Barometric Pressure:	32.5

Observations: At 2:40 dry chem started to run out

Test No:	3B				
Date:	22-May-01				
Time:					

Test Type:	Pool	Pool/Cascade	Cascade	

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60	

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	DNE	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	0 mph
Wind Direction:	200
Temperature (deg F):	86
Humidity:	76
Barometric Pressure:	32

Observations:

Test No:	4A			
Date:	22-May-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 8.22	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	0 mph
Wind Direction:	200
Temperature (deg F):	88
Humidity:	86
Barometric Pressure:	32

Observations:

Test No:	4B				
Date:	22-May-01				
Time:	1130				

Test Type:	Pool	Pool/Cascade	Cascade	

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60	

Foam Agent Type:	None	3% AFFF	

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW	

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	8.78	Timer 2:		Timer 3:

Meterological Data:	
Wind Velocity:	0 mph
Wind Direction:	220
Temperature (deg F):	89
Humidity:	90
Barometric Pressure:	31.5

Observations:

Test No:	4C
Date:	22-May-01
Time:	

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 7.50	Timer 2:	Timer 3:	

Meterological Data:	
Wind Velocity:	0 mph
Wind Direction:	200
Temperature (deg F):	89
Humidity:	85
Barometric Pressure:	31.5

Observations:

Test No:	5A
Date:	22-May-01
Time:	1345

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 9.97	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	4 mph
Wind Direction:	230
Temperature (deg F):	89
Humidity:	81
Barometric Pressure:	31.5

Observations:

Test No:	5B			
Date:	22-May-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	10.12	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	13 mph
Wind Direction:	190
Temperature (deg F):	85
Humidity:	80
Barometric Pressure:	31.5

Observations:

Test No:	5C			
Date:	22-May-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 9.35	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	9 mph
Wind Direction:	220
Temperature (deg F):	88
Humidity:	79
Barometric Pressure:	31.5

Observations:

Test No:	5D			
Date:	22-May-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade	
Type of Fuel:	JP-8			
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm	
Pre-burn Time (sec):	30	45	60	
Foam Agent Type:	None	3% AFFF		
System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 5.25	Timer 2:	Timer 3:	

Meterological Data:

Wind Velocity:	5 mph
Wind Direction:	210
Temperature (deg F):	88
Humidity:	75
Barometric Pressure:	31.5

Observations:

Test No:	6A
Date:	4-Oct-01
Time:	

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	100.00	Timer 2:	Timer 3:

Meterological Data:	
Wind Velocity:	3
Wind Direction:	85
Temperature (deg F):	75
Humidity:	49
Barometric Pressure:	36

Observations:

Test No:	6B			
Date:	4-Oct-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade
Type of Fuel:	JP-8		
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm
Pre-burn Time (sec):	30	45	60
Foam Agent Type:	None	3% AFFF	
System Pressure:	200	Injection Valve, % Open	0 / 50
Dry Chemical:	None	PKW	
Dry Chem Flow Rate:	5pps		
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem / Variable Stream
Extinguish Time (sec):	Timer 1: 64.00	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	6.5
Wind Direction:	65
Temperature (deg F):	84
Humidity:	50
Barometric Pressure:	30.03

Observations:

Test No:	6C				
Date:	4-Oct-01				
Time:					

Test Type:	Pool	Pool/Cascade	Cascade
Type of Fuel:	JP-8		
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm
Pre-burn Time (sec):	30	45	60
Foam Agent Type:	None	3% AFFF	
System Pressure:	200	Injection Valve, % Open	0 / 50
Dry Chemical:	None	PKW	
Dry Chem Flow Rate:	5pps		
Agent Delivery Syst:	AEF Skid	Nozzle: CAF Hydrochem	Variable Stream
Extinguish Time (sec):	Timer 1: 73.00	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	6
Wind Direction:	85
Temperature (deg F):	88
Humidity:	75
Barometric Pressure:	30.03

Observations:

Test No:	7A			
Date:	4-Oct-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade
Type of Fuel:	JP-8		
Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm
Pre-burn Time (sec):	30	45	60
Foam Agent Type:	None	3% AFFF	

System Pressure:	200	Injection Valve, % Open	0	50
Dry Chemical:	None	PKW		
Dry Chem Flow Rate:	5pps			
Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	39.00	Timer 2:		Timer 3:

Meterological Data:

Wind Velocity:	4
Wind Direction:	195
Temperature (deg F):	87
Humidity:	75
Barometric Pressure:	31.05

Observations:

Test No:	7B			
Date:	4-Oct-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	45.00	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	8.5
Wind Direction:	195
Temperature (deg F):	86.9
Humidity:	76
Barometric Pressure:	31

Observations:

Test No:	7C			
Date:	4-Oct-01			
Time:				

Test Type:	Pool	**Pool/Cascade**	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	**60/100 gal + 5 gpm**	60 gal + 5gpm

Pre-burn Time (sec):	30	45	**60**

Foam Agent Type:	None	**3% AFFF**

System Pressure:	200	Injection Valve, % Open	0	**50**

Dry Chemical:	None	**PKW**

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	**CAF Hydrochem**	Variable Stream

Extinguish Time (sec):	Timer 1:	66.00	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	7.8
Wind Direction:	195
Temperature (deg F):	86.1
Humidity:	76
Barometric Pressure:	30.01

Observations:

Test No:	8A
Date:	24-May-01
Time:	1030

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	DNE	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	3 mph
Wind Direction:	340
Temperature (deg F):	91
Humidity:	48
Barometric Pressure:	30.02

Observations:	pre-burn 1:25

Test No:	8B			
Date:	23-May-01			
Time:				

Test Type:	**Pool**	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	**500 gal**	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	**60**

Foam Agent Type:	None	**3% AFFF**

System Pressure:	200	Injection Valve, % Open	**0**	50

Dry Chemical:	None	**PKW**

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	**Variable Stream**

Extinguish Time (sec):	Timer 1:	133.41	Timer 2:	Timer 3:

Meterological Data:	
Wind Velocity:	6 mph
Wind Direction:	250
Temperature (deg F):	83
Humidity:	51
Barometric Pressure:	31.05

Observations:	pre-burn 1:25

Test No:	8C			
Date:	5-Oct-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	DNE	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	6 mph
Wind Direction:	130
Temperature (deg F):	83.8
Humidity:	66
Barometric Pressure:	31.05

Observations: pre-burn 1:25

Test No:	9A			
Date:	24-May-01			
Time:				

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	201.03	Timer 2:	Timer 3:

Meterological Data:	
Wind Velocity:	0 mph
Wind Direction:	310
Temperature (deg F):	84
Humidity:	60
Barometric Pressure:	30.03

Observations:	pre-burn 1:25

Test No:	9B			
Date:	24-May-01			
Time:	1030			

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	201.03	Timer 2:		Timer 3:

Meterological Data:

Wind Velocity:	5 mph
Wind Direction:	270
Temperature (deg F):	91
Humidity:	50
Barometric Pressure:	31.05

Observations:	pre-burn 1:25

Test No:	9C			
Date:	24-May-01			
Time:				

Test Type:	**Pool**	Pool/Cascade	Cascade
Type of Fuel:	JP-8		
Fuel Amount:	**500 gal**	60/100 gal + 5 gpm	60 gal + 5gpm
Pre-burn Time (sec):	30	45	**60**
Foam Agent Type:	None	**3% AFFF**	
System Pressure:	200	Injection Valve, % Open	0 / **50**
Dry Chemical:	None	**PKW**	
Dry Chem Flow Rate:	5pps		
Agent Delivery Syst:	AEF Skid	Nozzle: **CAF Hydrochem**	Variable Stream
Extinguish Time (sec):	Timer 1: DNE	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	5 mph
Wind Direction:	270
Temperature (deg F):	91
Humidity:	50
Barometric Pressure:	31.05

Observations: pre-burn 1:25

Test No:	9D
Date:	24-May-01
Time:	

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	DNE	Timer 2:	Timer 3:

Meterological Data:

Wind Velocity:	5 mph
Wind Direction:	270
Temperature (deg F):	91
Humidity:	50
Barometric Pressure:	31.05

Observations:	pre-burn 1:25

Test No:	9E
Date:	5-Oct-01
Time:	

Test Type:	Pool	Pool/Cascade	Cascade

Type of Fuel:	JP-8

Fuel Amount:	500 gal	60/100 gal + 5 gpm	60 gal + 5gpm

Pre-burn Time (sec):	30	45	60

Foam Agent Type:	None	3% AFFF

System Pressure:	200	Injection Valve, % Open	0	50

Dry Chemical:	None	PKW

Dry Chem Flow Rate:	5pps

Agent Delivery Syst:	AEF Skid	Nozzle:	CAF Hydrochem	Variable Stream

Extinguish Time (sec):	Timer 1:	97.00	Timer 2:		Timer 3:

Meterological Data:

Wind Velocity:	3.5
Wind Direction:	105
Temperature (deg F):	76
Humidity:	82
Barometric Pressure:	29.95

Observations:	pre-burn 1:25

APPENDIX B—SMALL AIRPORT FIREFIGHTING SYSTEM FLOW AND PRESSURE DATA

Note: for the following graphs, all air injection measurements are shown in standard cubic feet per minute and foam flow measurements are shown in gallons per minute.

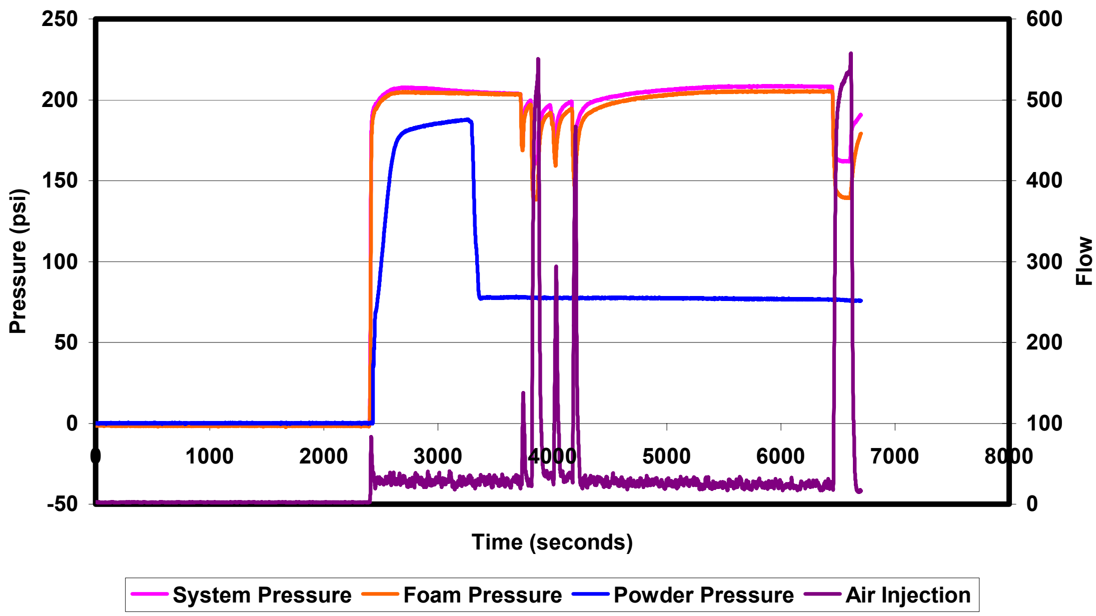

FIGURE B-1. FLOW AND PRESSURE DATA, TEST 1A

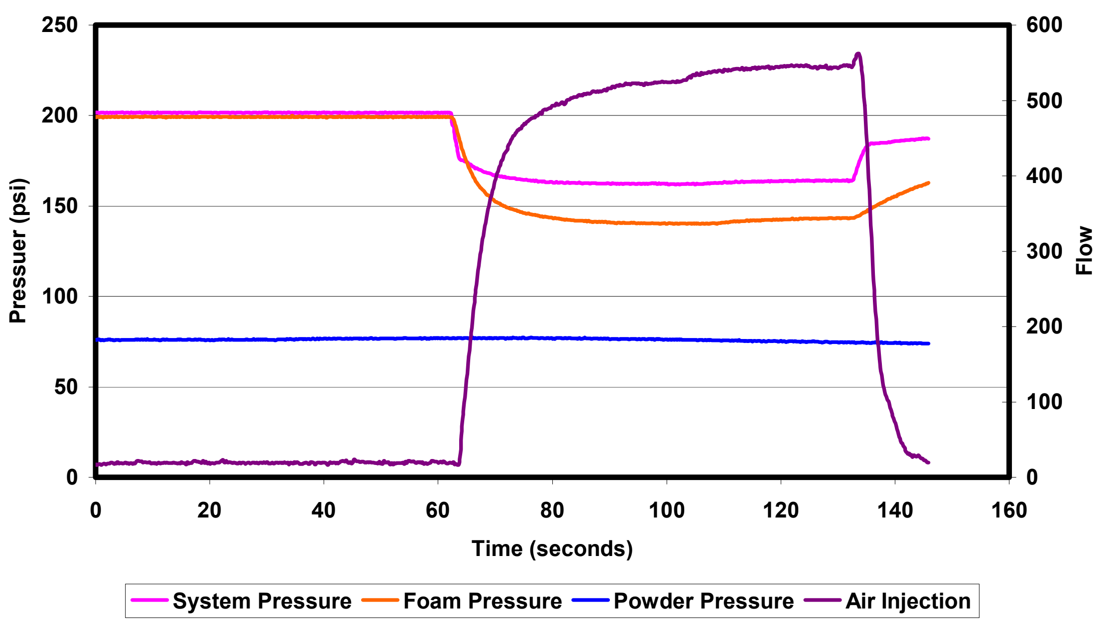

FIGURE B-2. FLOW AND PRESSURE DATA, TEST 1B

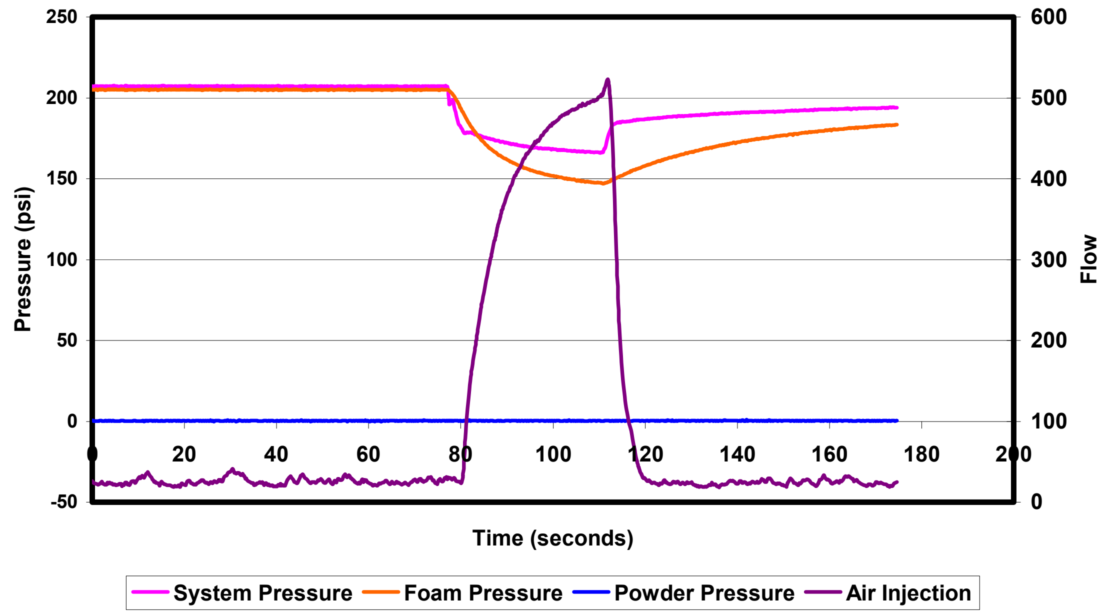

FIGURE B-3. FLOW AND PRESSURE DATA, TEST 1C

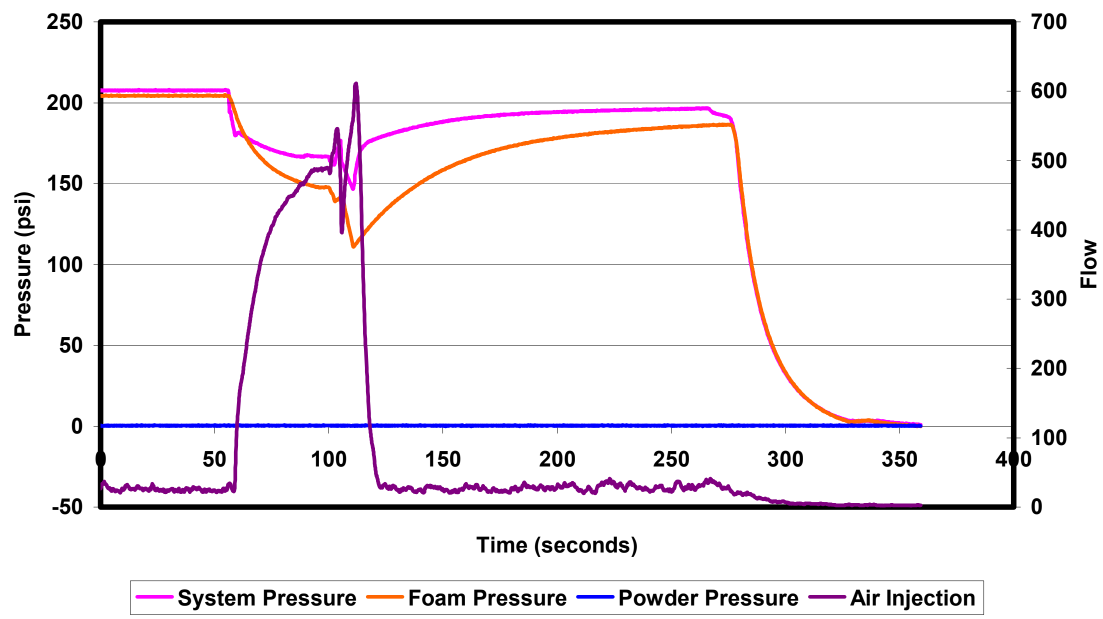

FIGURE B-4. FLOW AND PRESSURE DATA, TEST 1D

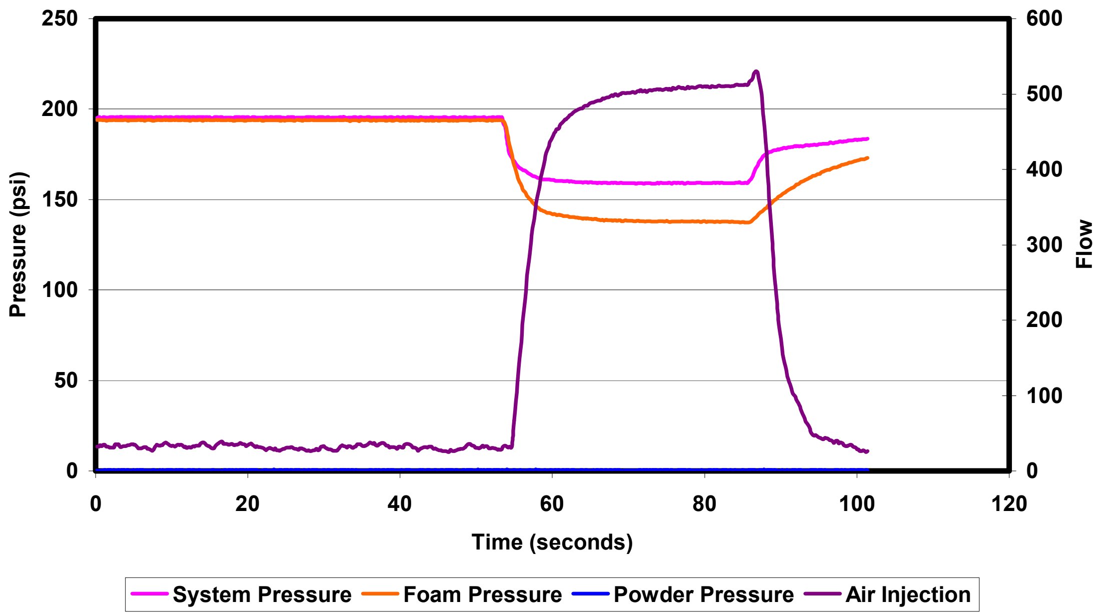

FIGURE B-5. FLOW AND PRESSURE DATA, TEST 1E

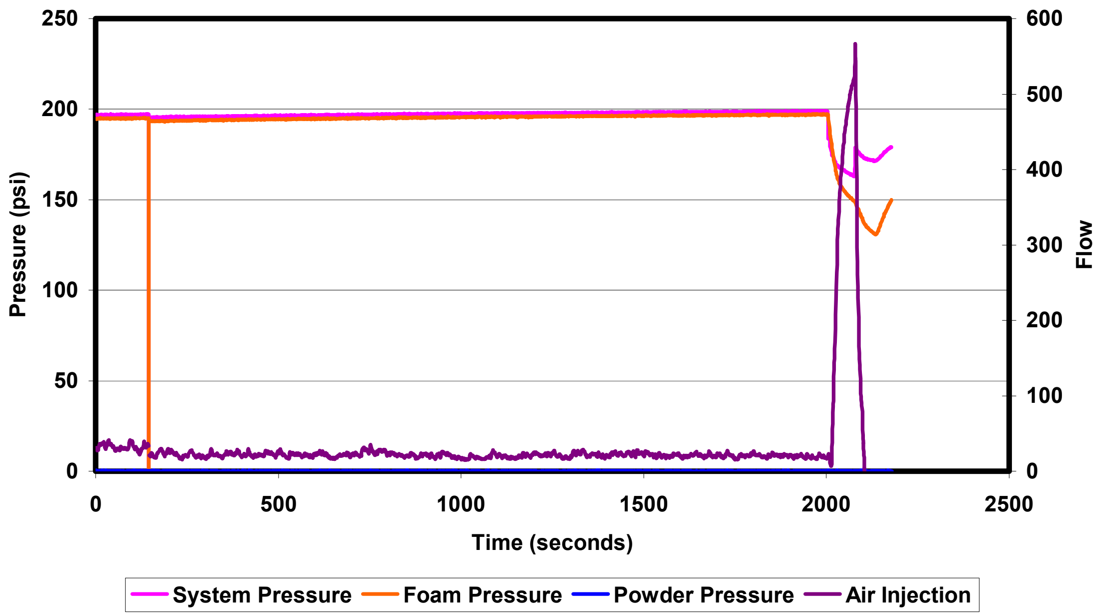

FIGURE B-6. FLOW AND PRESSURE DATA, TEST 1F

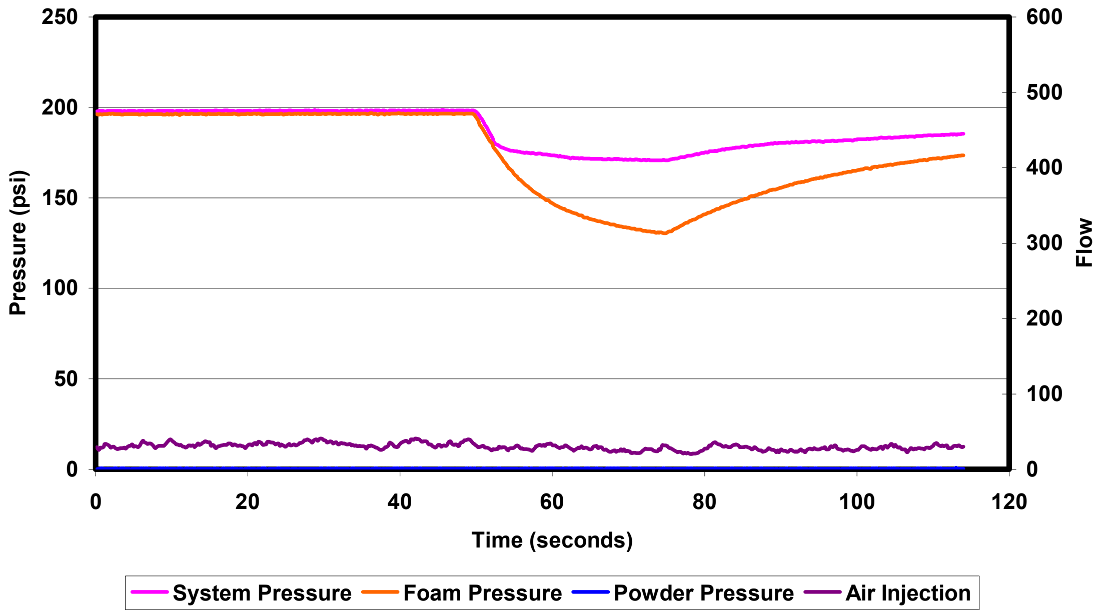

FIGURE B-7. FLOW AND PRESSURE DATA, TEST 2A

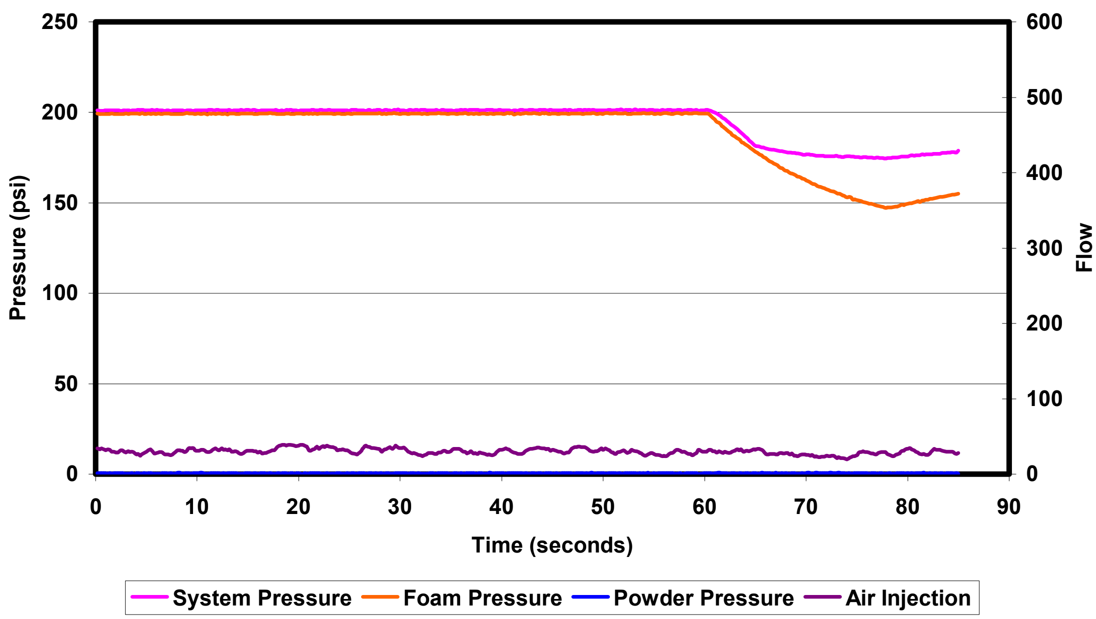

FIGURE B-8. FLOW AND PRESSURE DATA, TEST 2B

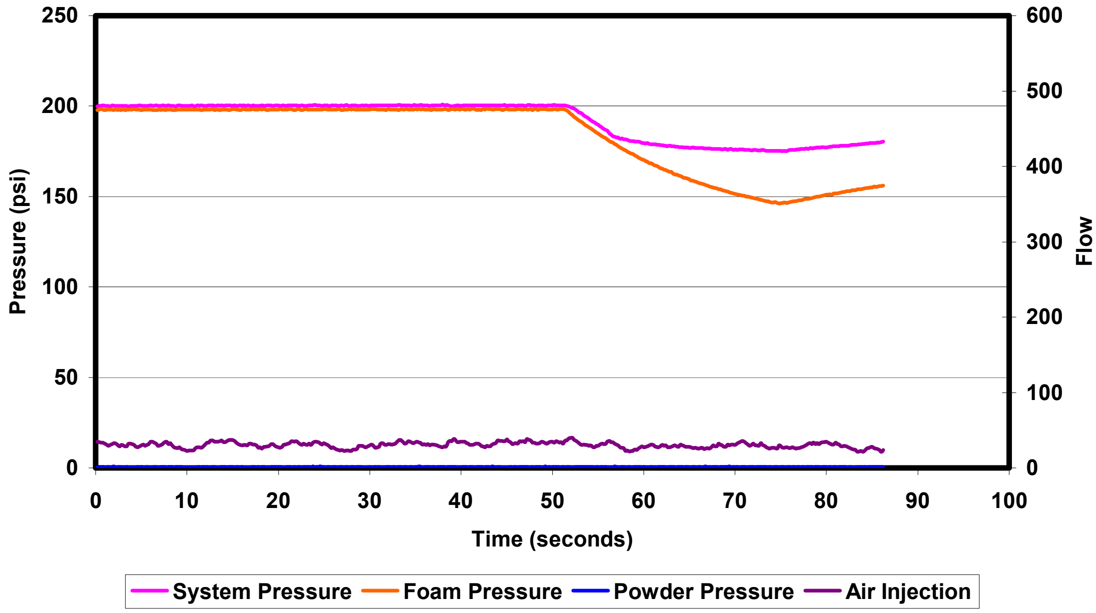

FIGURE B-9. FLOW AND PRESSURE DATA, TEST 2C

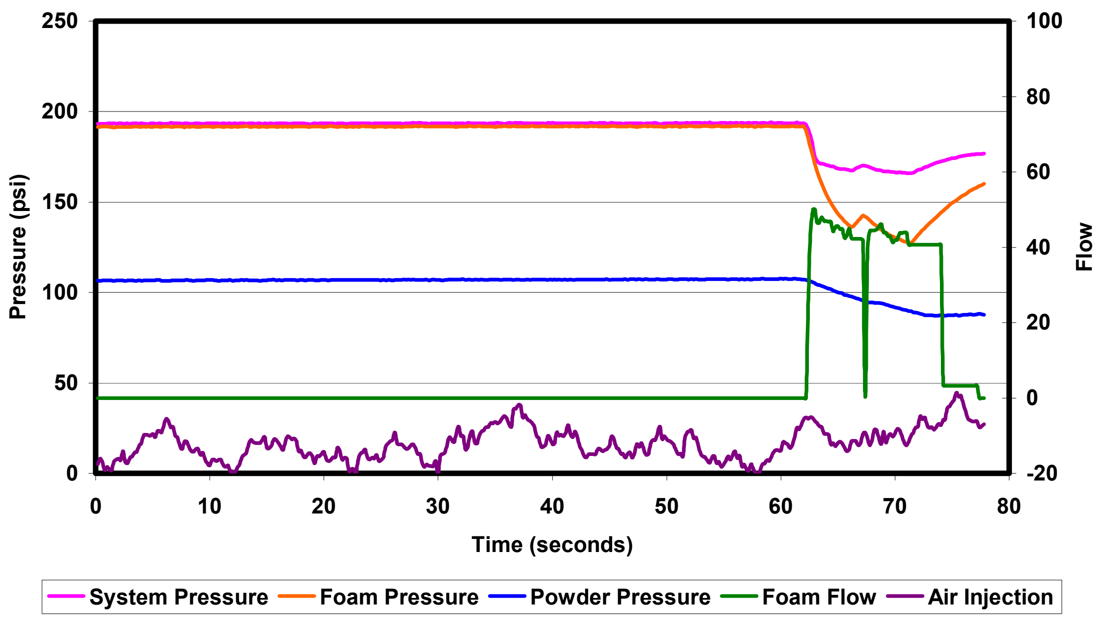

FIGURE B-10. FLOW AND PRESSURE DATA, TEST 4A

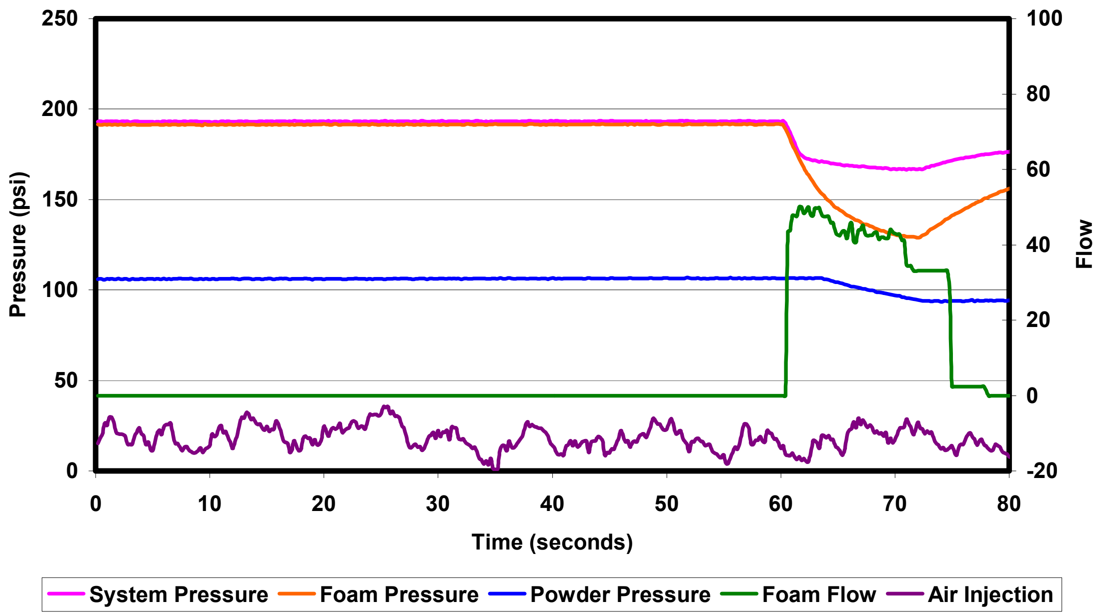

FIGURE B-11. FLOW AND PRESSURE DATA, TEST 4B

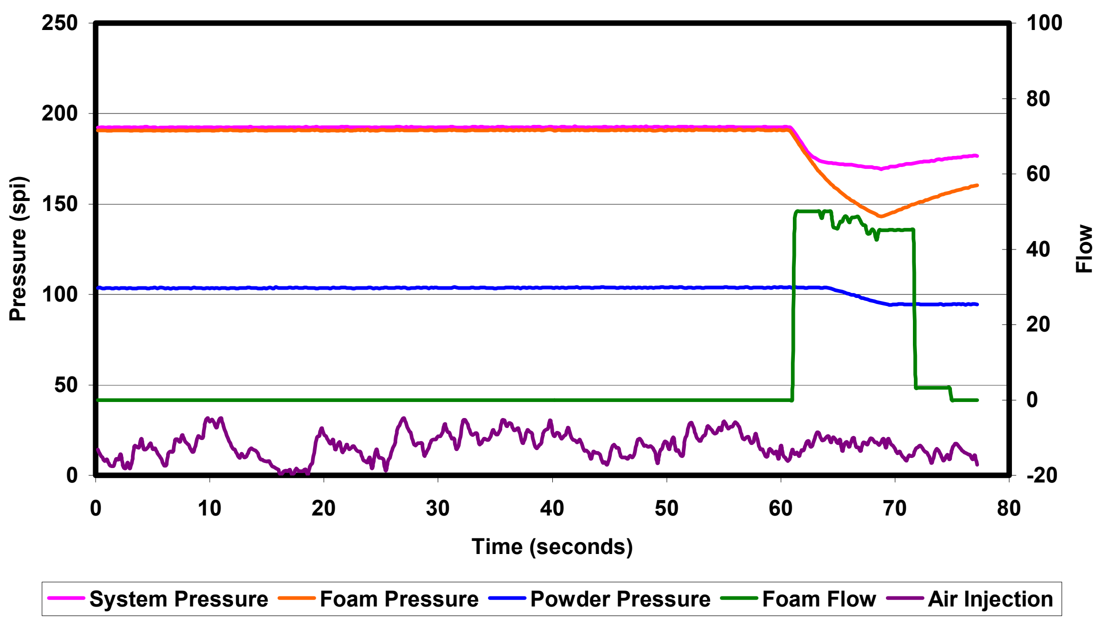

FIGURE B-12. FLOW AND PRESSURE DATA, TEST 4C

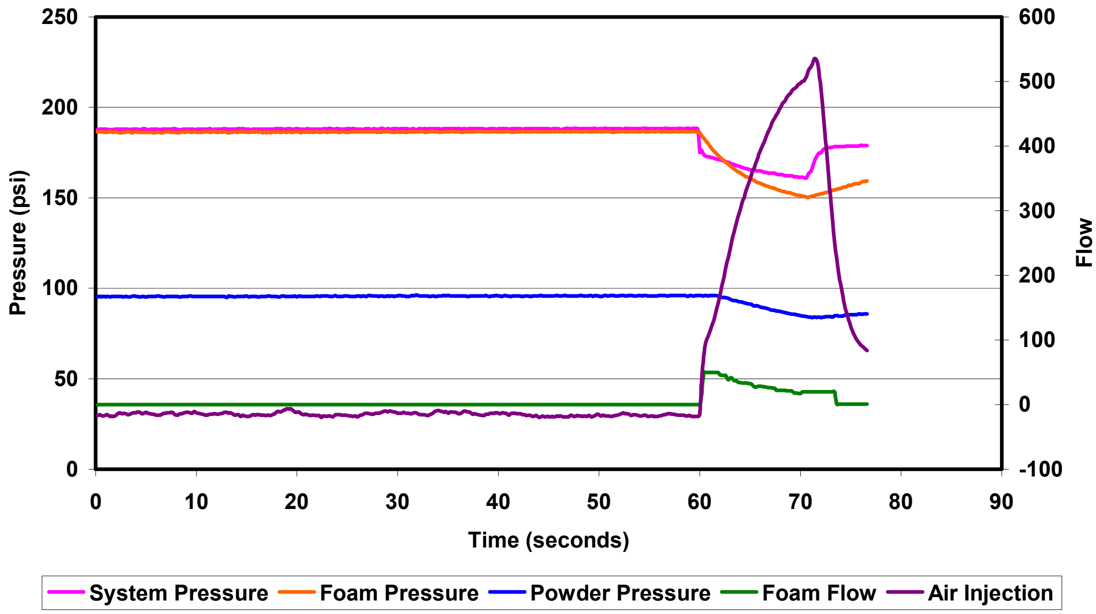

FIGURE B-13. FLOW AND PRESSURE DATA, TEST 5A

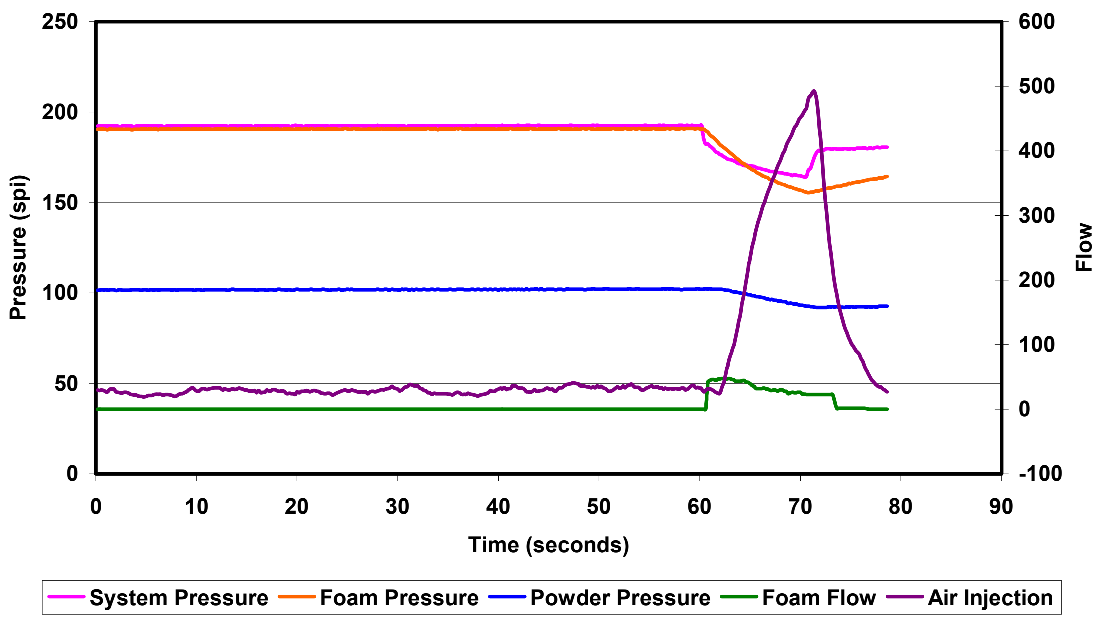

FIGURE B-14. FLOW AND PRESSURE DATA, TEST 5B

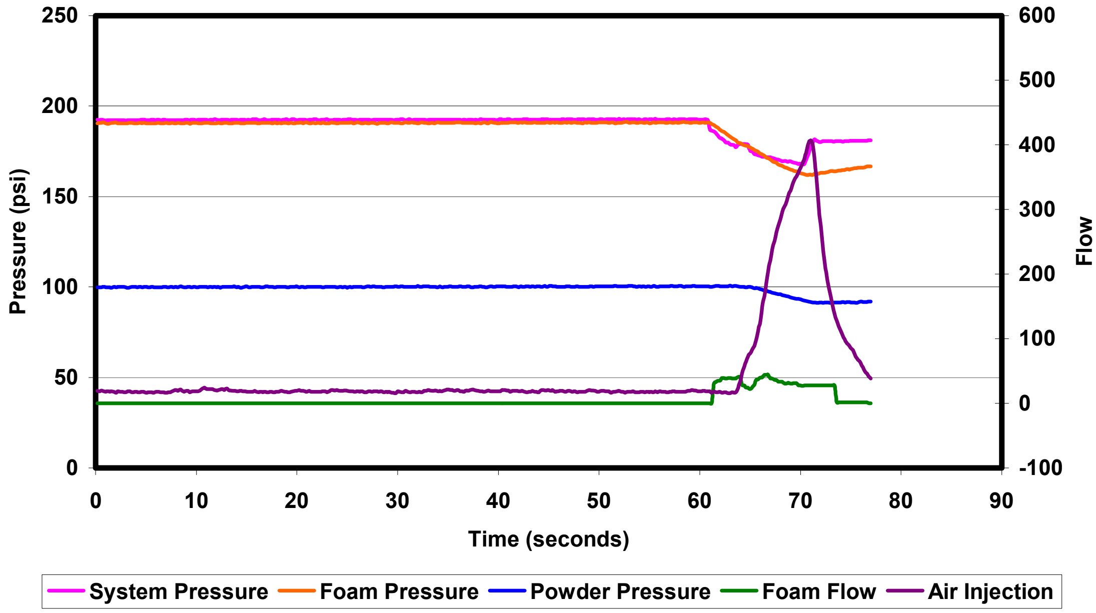

FIGURE B-15. FLOW AND PRESSURE DATA, TEST 5C

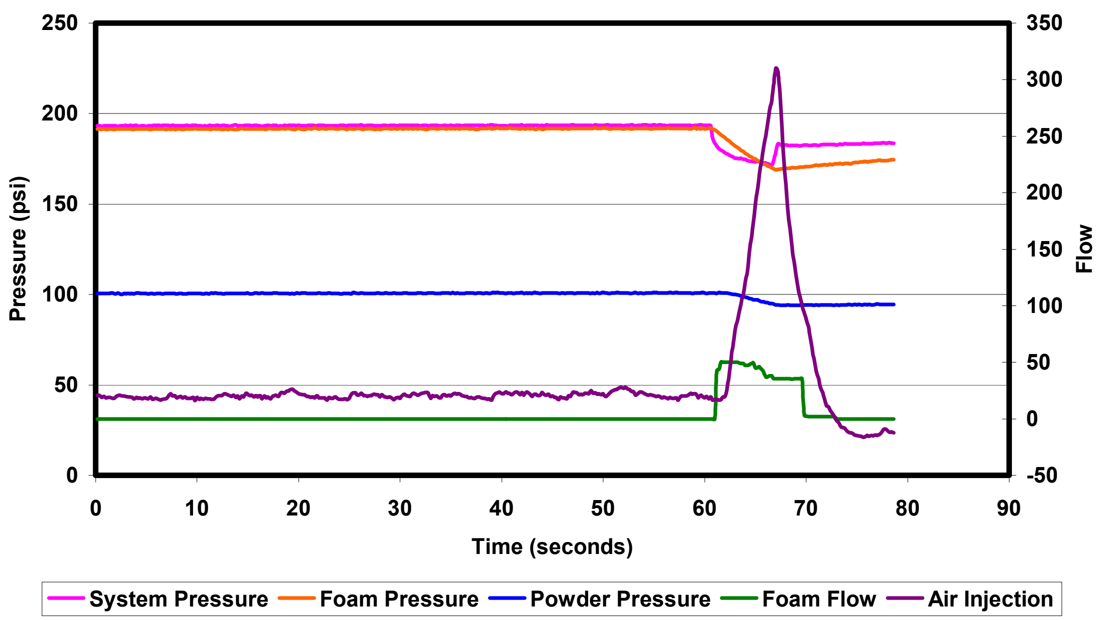

FIGURE B-16. FLOW AND PRESSURE DATA, TEST 5D

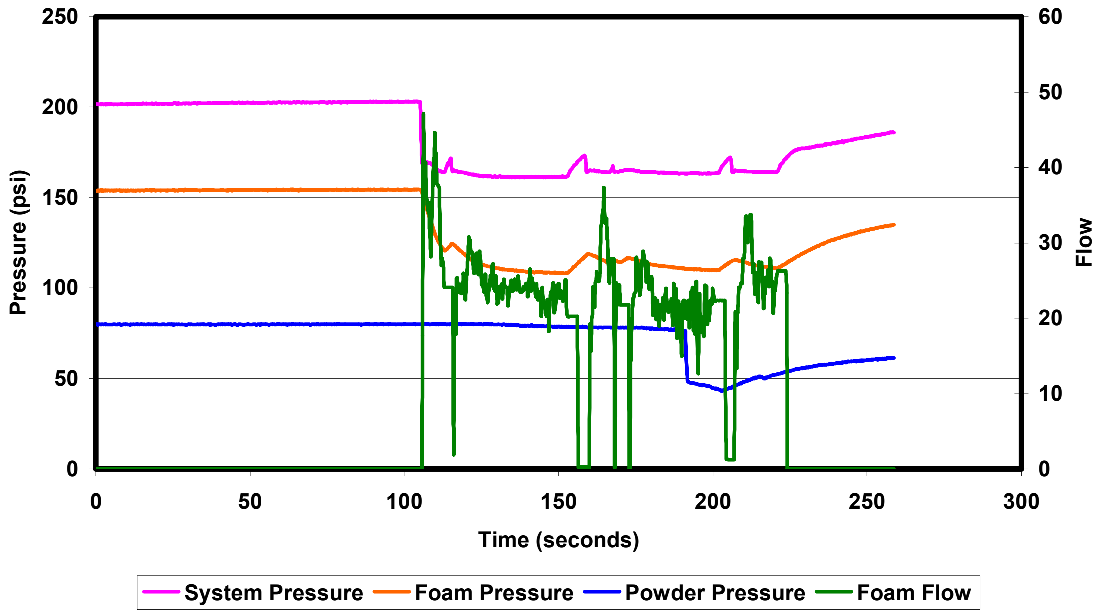

FIGURE B-17. FLOW AND PRESSURE DATA, TEST 6A

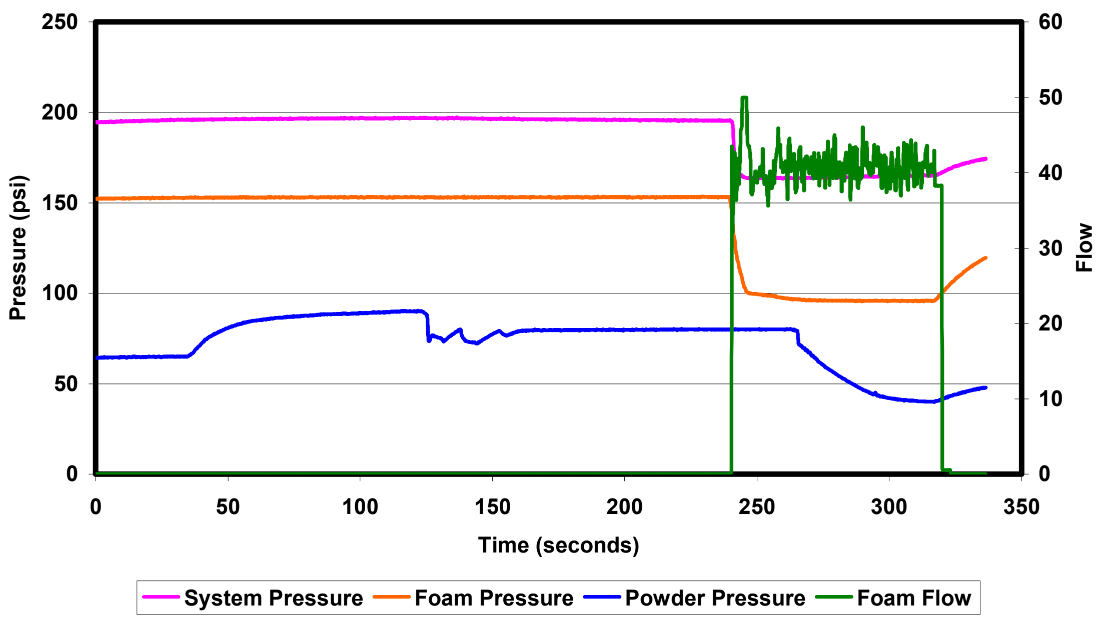

FIGURE B-18. FLOW AND PRESSURE DATA, TEST 6B

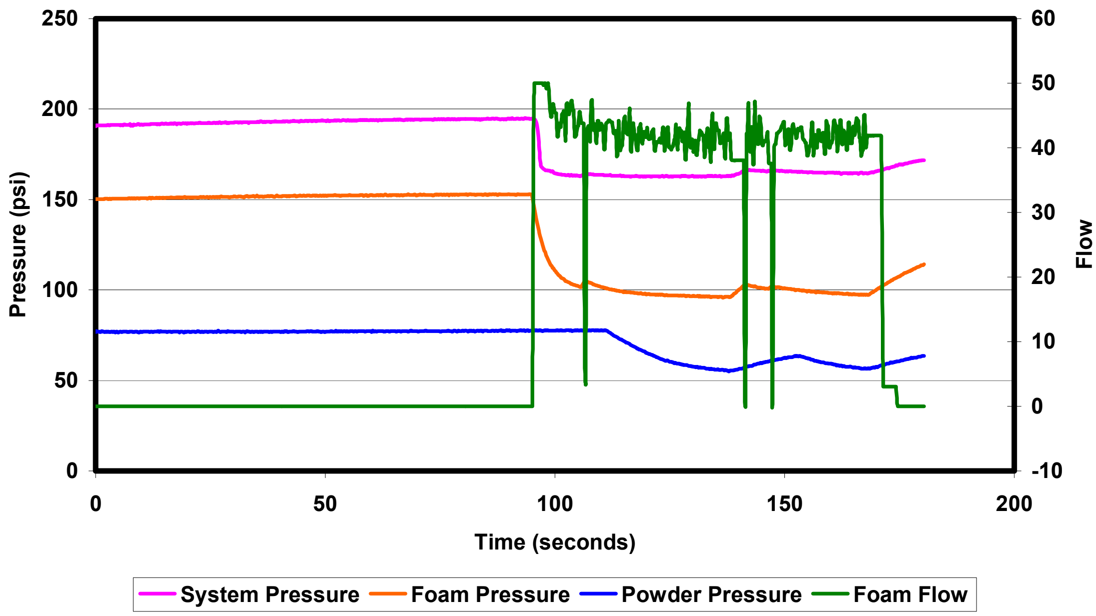

FIGURE B-19. FLOW AND PRESSURE DATA, TEST 6C

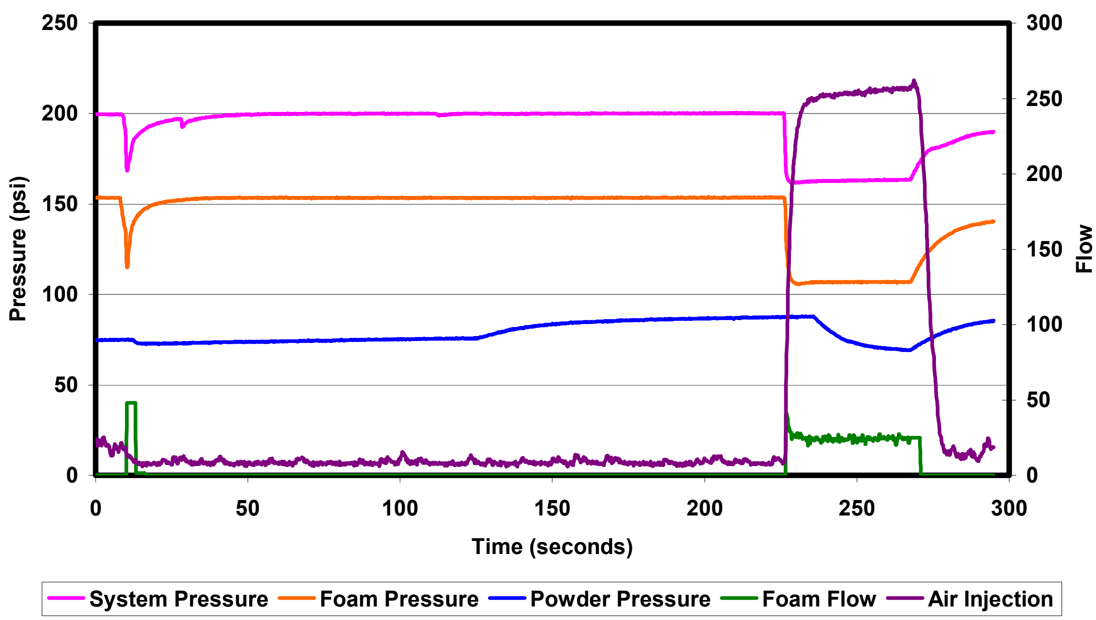

FIGURE B-20. FLOW AND PRESSURE DATA, TEST 7A

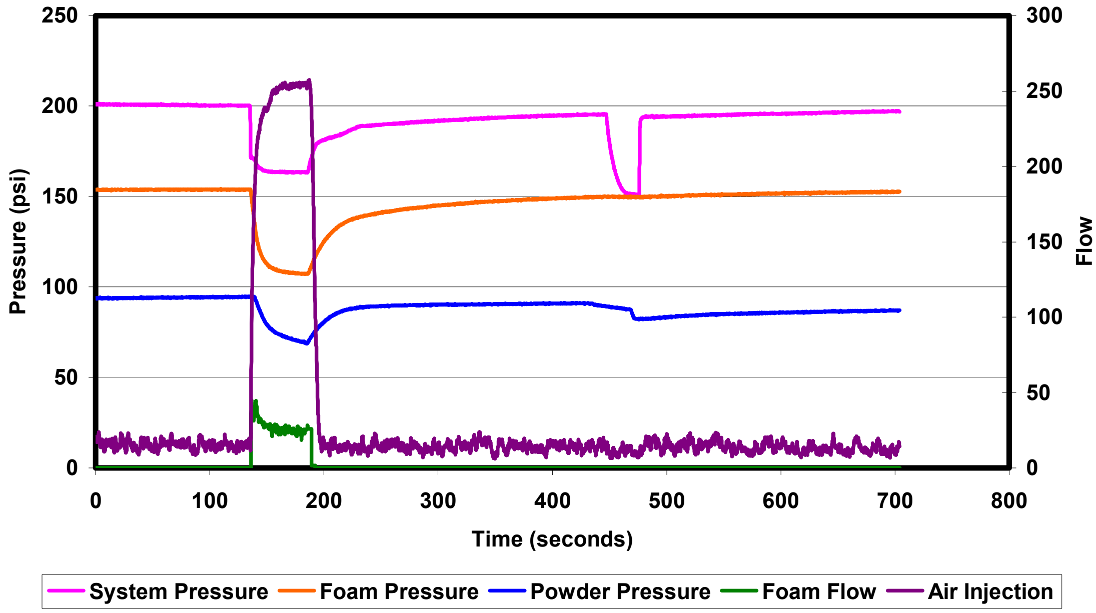

FIGURE B-21. FLOW AND PRESSURE DATA, TEST 7B

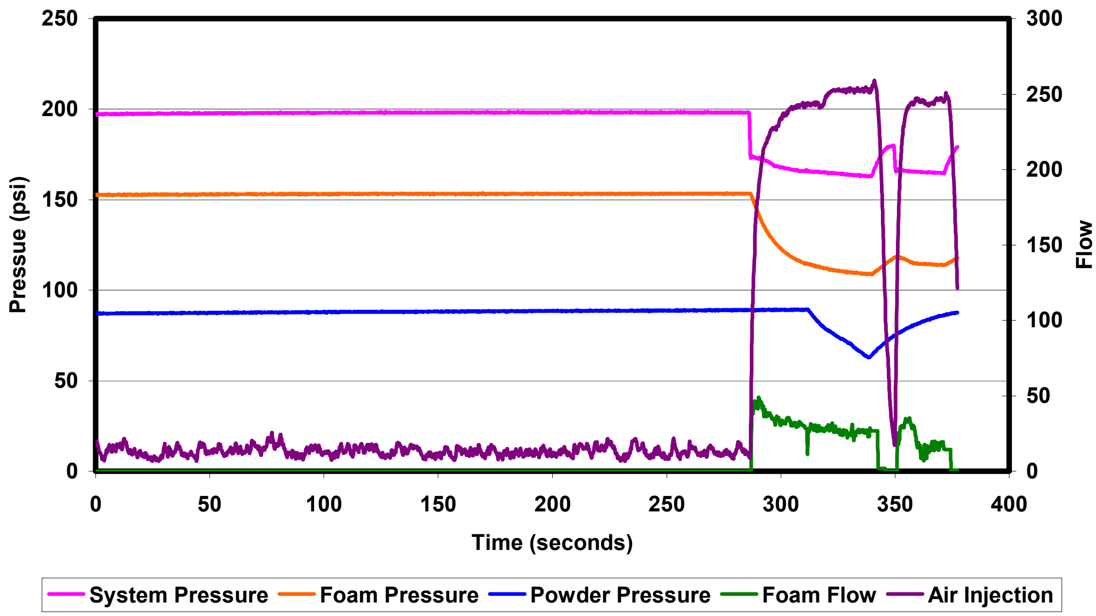

FIGURE B-22. FLOW AND PRESSURE DATA, TEST 7C

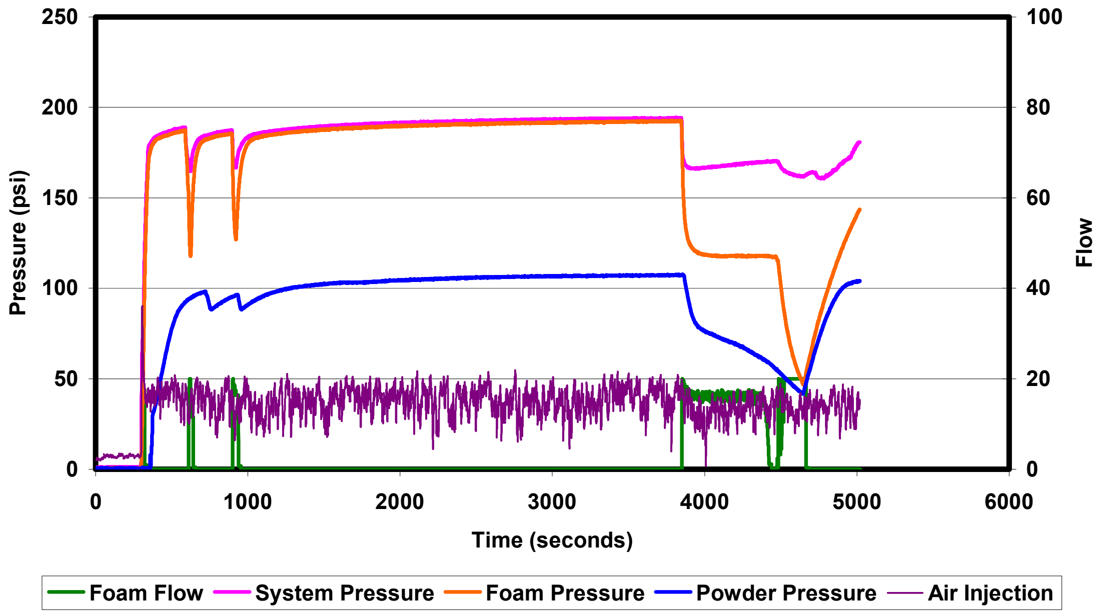

FIGURE B-23. FLOW AND PRESSURE DATA, TEST 8A

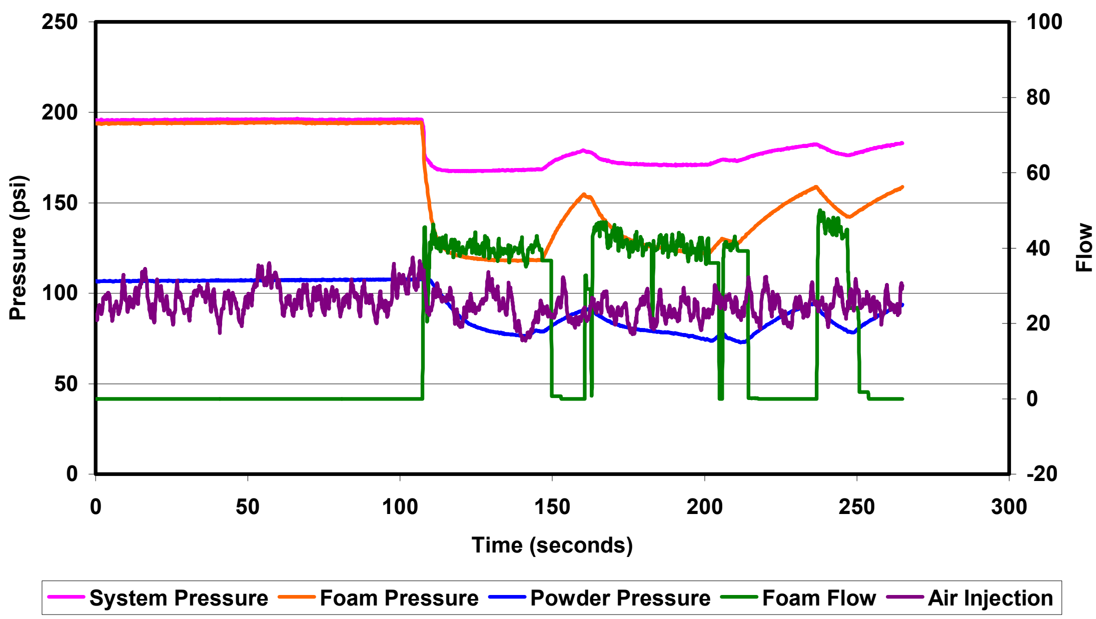

FIGURE B-24. FLOW AND PRESSURE DATA, TEST 8B

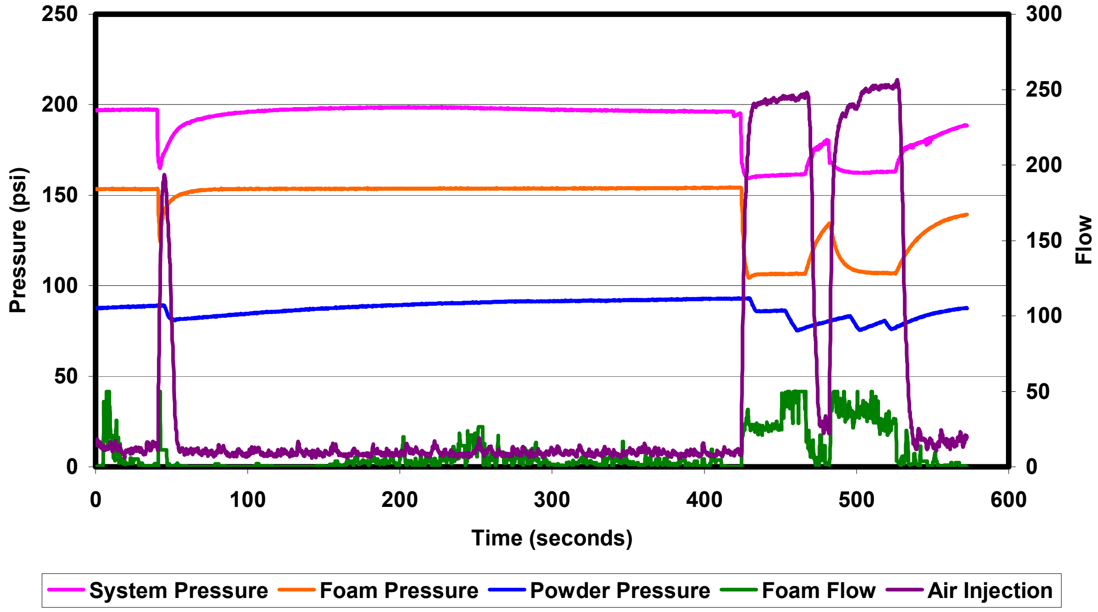

FIGURE B-25. FLOW AND PRESSURE DATA, TEST 8C

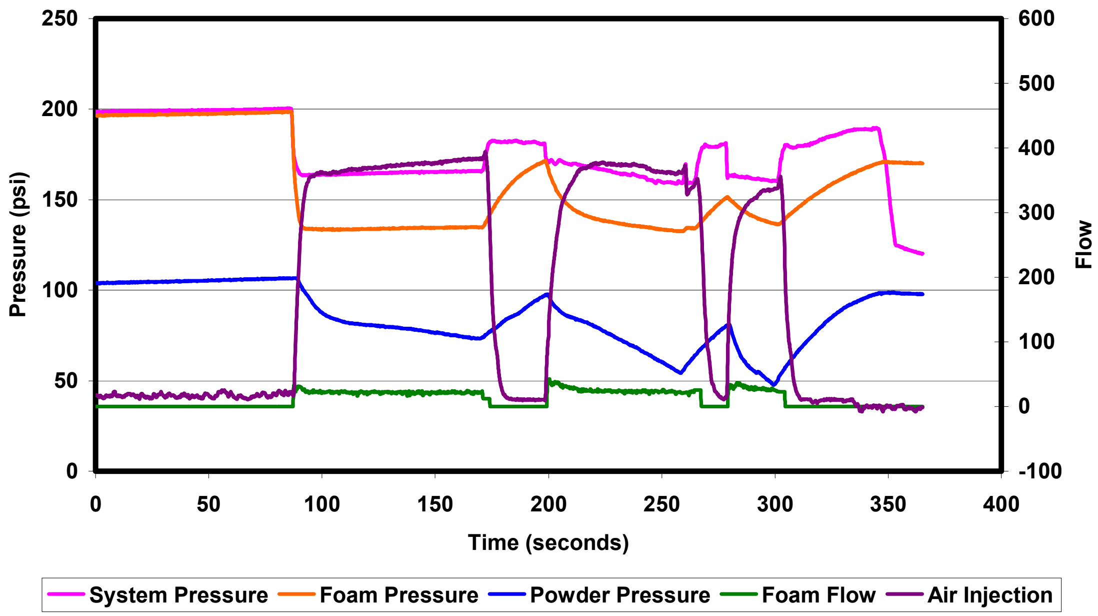

FIGURE B-26. FLOW AND PRESSURE DATA, TEST 9A

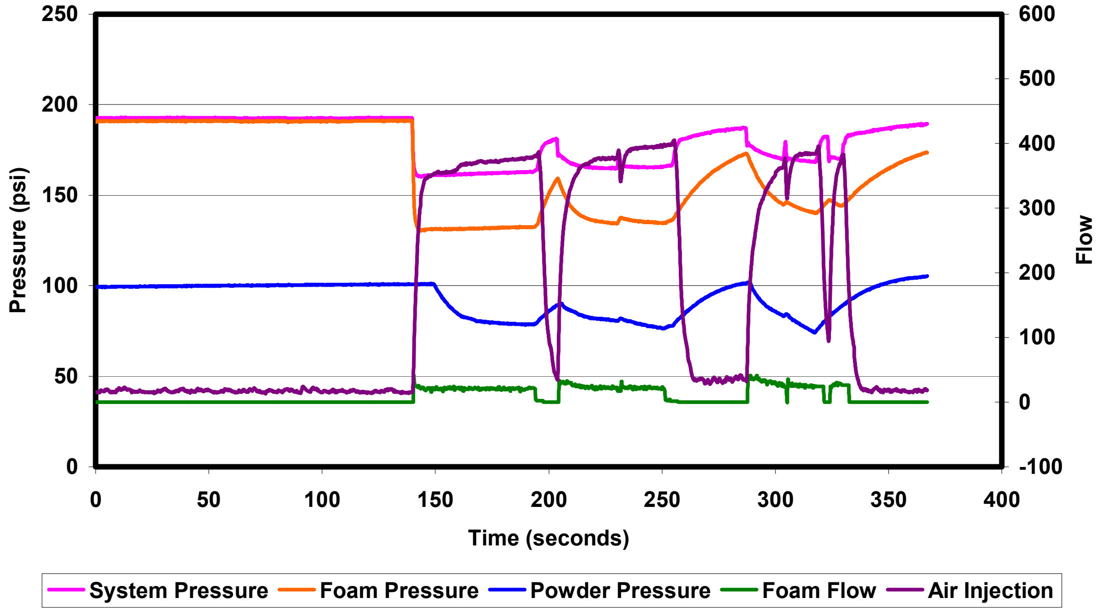

FIGURE B-27. FLOW AND PRESSURE DATA, TEST 9B

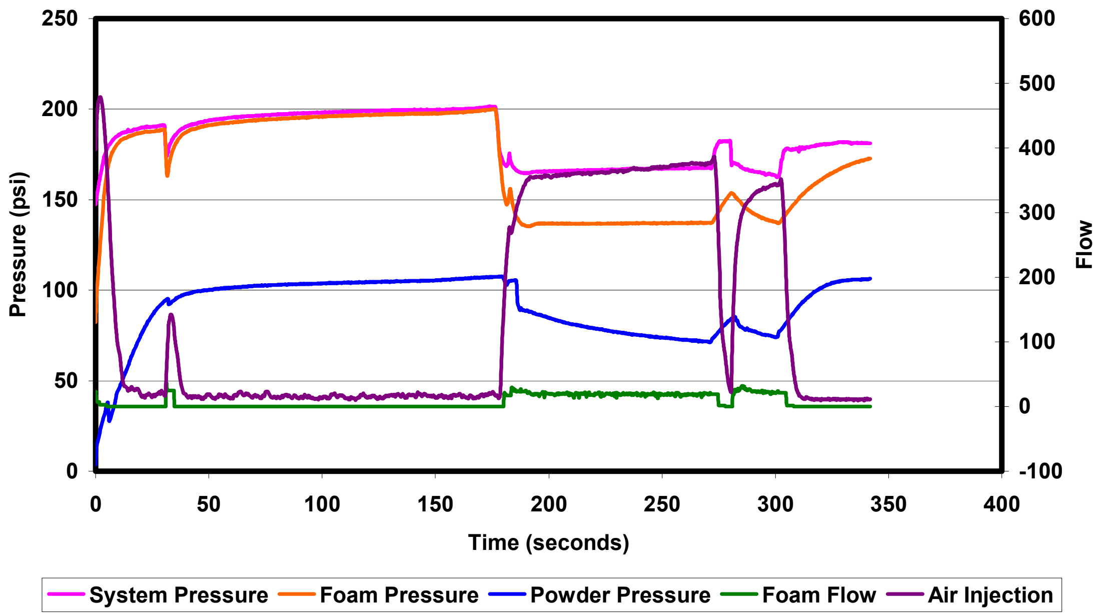

FIGURE B-28. FLOW AND PRESSURE DATA, TEST 9C

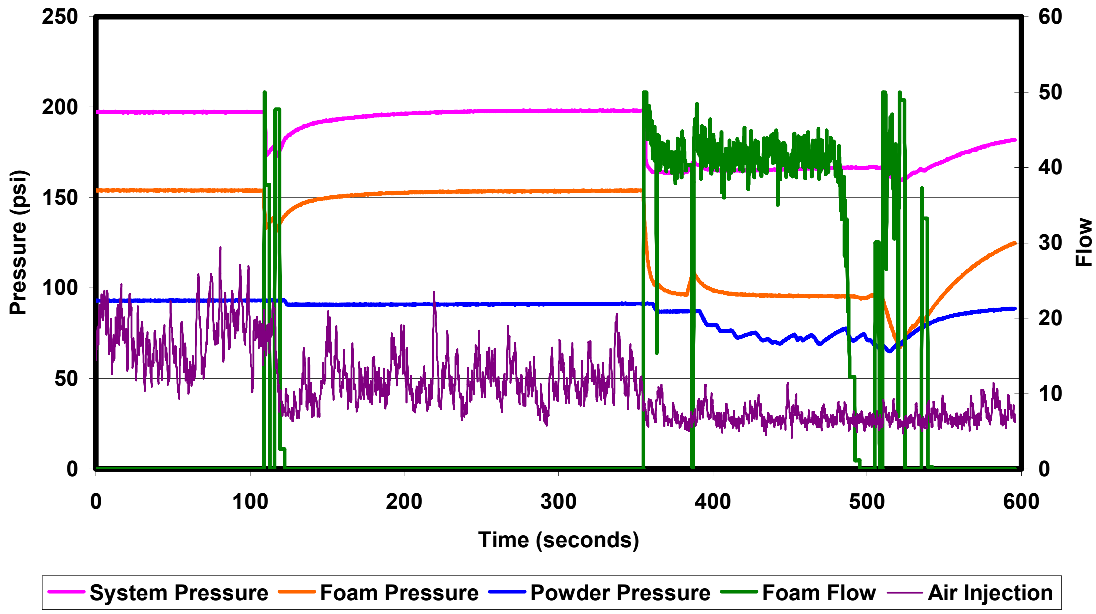

FIGURE B-29. FLOW AND PRESSURE DATA, TEST 9E