technical note technical note

Aircraft Rescue and Firefighting Training Fuel Comparative Evaluation

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16. Abstract

Environmental air and water quality regulations are getting more and more stringent. Changes to the regulations are making it difficult for aircraft rescue and firefighting (ARFF) personnel to get quality firefighting training. The environmental regulations are increasing the cost of operating liquid hydrocarbon-based training facilities and forcing several training facilities to close or transition to propane. The Federal Aviation Administration William J. Hughes Technical Center's ARFF research program conducted a comparative evaluation of one of the existing fuels for training (JP8) and two recently developed products produced specifically for firefighting training by Exxon Chemical Company and Envirofuel Incorporated. Both of the new training products showed major improvements in reducing the production of environmentally harmful by-products. Data indicate that the Exxon product produced the least amount of smoke output and contaminated water runoff.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Environmental air and water quality regulations are getting more and more stringent. Changes to the regulations are making it difficult for aircraft rescue and firefighting (ARFF) personnel to get quality firefighting training. The environmental regulations are increasing the cost of operating liquid hydrocarbon-based training facilities and forcing several training facilities to close or transition to propane.

The Federal Aviation Administration William J. Hughes Technical Center's ARFF research program conducted a comparative evaluation of fuels used for training. Three products were tested in comparative burns. One of the existing fuels used in many training facilities is JP8. JP8 was compared to two recently developed products produced specifically for firefighting training by Exxon Chemical Company and Envirofuel Incorporated. Exxon Chemical Company's product has a trade name of Tekflame™. Envirofuel Incorporated's product has a trade name of E III™.

Two types of burn tests were conducted on each fuel; pan fire and running-fuel fire. Pan fire tests were conducted in a 60-sq-ft test pan. Running-fuel tests were conducted in the three-dimensional cascade running-fuel test apparatus. Quantities of fuel burned varied between 5 and 10 gallons per test, depending on the scenario.

Three lab tests were conducted on each fuel; smoke density, total petroleum hydrocarbon (TPH), and volatile organic compounds (VOCs). The smoke density test was conducted in a test cell located in the cargo hold of a Boeing 707 fire test aircraft at the Technical Center. The TPH and VOC tests were conducted by an environmental lab outside the agency.

Both of the new training products showed major improvements in reducing the production of environmentally harmful by-products. Data indicate that the Exxon product produced the least amount of smoke output and contaminated water runoff.

INTRODUCTION

BACKGROUND.

Environmental air and water quality regulations are getting more and more stringent. Changes to the regulations are making it difficult for aircraft rescue and firefighting (ARFF) personnel to get quality firefighting training. The environmental regulations are increasing the cost of operating liquid hydrocarbon-based training facilities and forcing several training facilities to close or transition to propane. Transitioning to propane is a very costly alternative and in many cases economically unfeasible.

Traditional training fuels used for firefighting training were conventional transportation fuels: gasoline, diesel, jet fuel, or combinations of these. When burned, these materials produce thick black smoke that dissipates very slowly. This black smoke can be seen and may travel for miles from the actual burn site, depending on atmospheric conditions. The new products compared in this evaluation are highly refined hydrocarbon-based fuels that significantly reduce the smoke generated at firefighting training facilities. These products generate less smoke during firefighting training burns compared to conventional materials and the smoke that is produced rapidly dissipates.

In addition to the smoke output, the comparison testing also addressed residues left in the water used during the training. The residue consists of unburned fuel and partially combusted by-products. Two Environmental Protection Agency (EPA) test methods were conducted on each fuel for total petroleum hydrocarbon (TPH) and volatile organic compounds (VOCs).

This research effort was a comparison of off-the-shelf products. The chemical composition of the products was not analyzed. The chemical analysis made during this evaluation was targeted toward by-products released in the burning of the fuels.

OBJECTIVES.

The primary objective of this testing was to determine if there would be a benefit to firefighting training facilities to utilize these reduced smoke training fuels to help reduce the environmental impact of live-fire training. On a comparative basis, the fuels were tested to verify the reduced smoke and cleaner water runoff aspects of these fuels.

TEST PROCEDURES.

BURN TESTING. A series of burn tests were conducted to capture video footage of the smoke plume produced by each of the fuels tested as well as the rate of dissipation of the smoke. In each of the burn tests, no effort was made to extinguish the fires. The fires were allowed to self-extinguish to determine quantity of fuels left unburned.

Pan fires were conducted in the 60-sq-ft test article. Tests were conducted using 5- and 10-gallon fuel quantities. In each test, the fuel was ignited by a propane torch. The fires burned until the fuel was expended. Figure 1 shows a 10-gallon pan fire test of all three fuels.

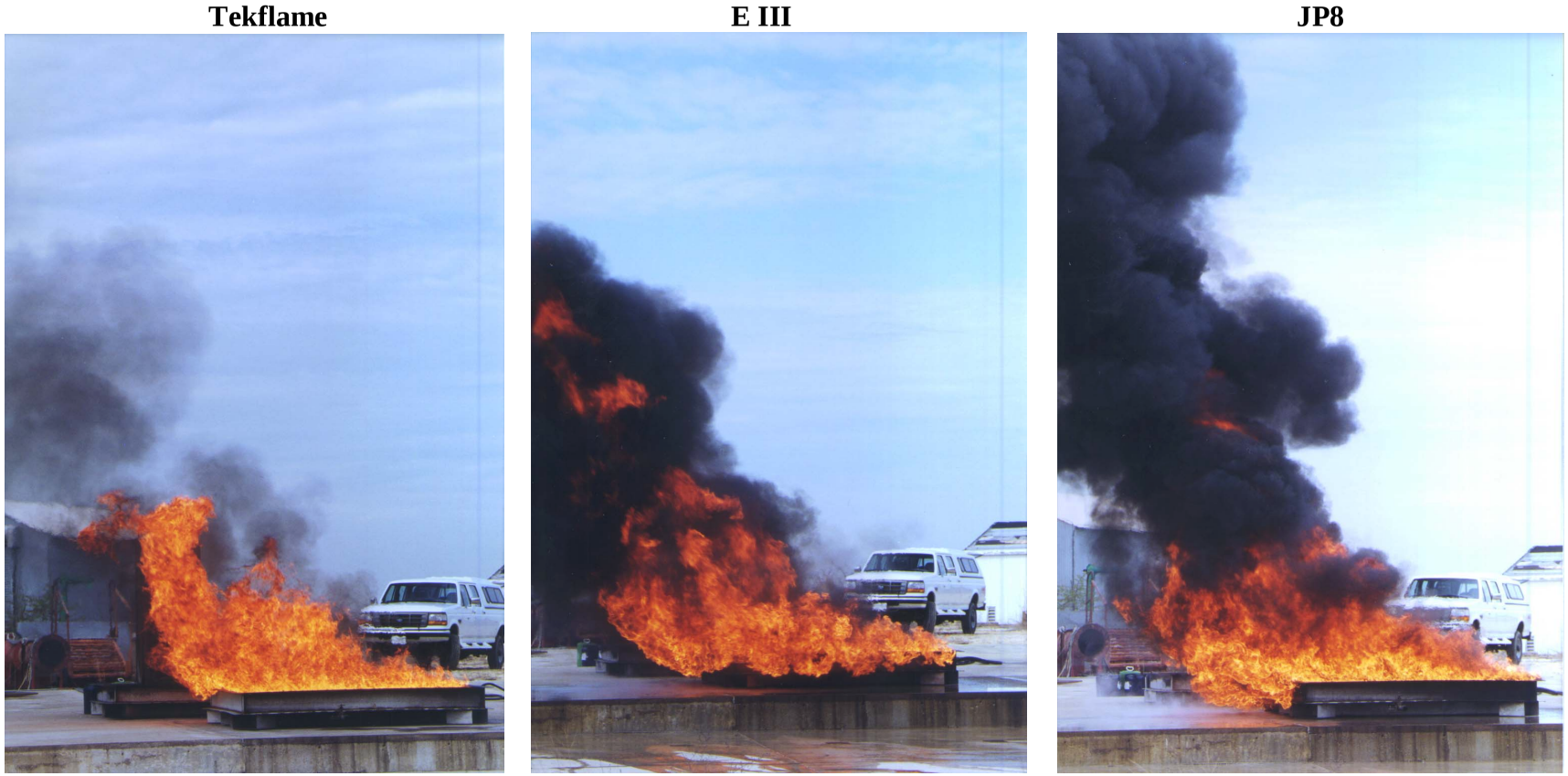

FIGURE 1. TEN-GALLON PAN FIRE TEST OF ALL THREE FUELS

Burn tests were also conducted using a three-dimensional running-fuel cascade test article (see figure 2). In these tests, 10 gallons of fuel was used. The fuel flow rate was 3 gallons per minute (GPM). The total fuel flow duration was 3 minutes 20 seconds of which 1 minute 15 seconds was prefuel prior to ignition. The prefuel duration allows for the fuel to propagate across the water surface of the containment pan.

FIGURE 2. THREE-DIMENSIONAL RUNNING-FUEL CASCADE TEST ARTICLE

ENVIRONMENTAL LABORATORY TESTING. A series of fuel residue tests were conducted following a series of pan fires. Samples of residues in the water used in testing the fuels were analyzed by an environmental testing firm using EPA method 418.1 TPH. This test detects the amount of unburned petroleum fuel in water.

Another series of environmental tests was conducted to determine the residue composition. In addition to the amount of residue produced, the composition of the residue is important because of the impact it can have if hazardous compounds such as benzene was present. EPA method 8260 VOC was used in this testing to determine the amount of VOCs present in waste water.

SMOKE DENSITY TESTING. Tests were conducted inside a 910-ft^3 Boeing 707 cargo compartment (see figure 3). Five tests were conducted for each fuel type. Eighty milliliters of each fuel was poured into a 7 1/16-in.-diameter round pan with 200 ml of water. The pan was heated on a hot plate on the floor of the cargo compartment until the fuel reached its flash point and was able to be ignited (see figure 4). Data were collected for 5 minutes after ignition. There was sufficient fuel to continue burning longer than the required 5 minutes for the data collection.

FIGURE 3. LASER SMOKE DENSITY CHAMBER

FIGURE 4. SMOKE DENSITY TEST CONFIGURATION

The laser smoke meter was mounted on the ceiling of the cargo compartment approximately 7 feet forward of the fuel pan. The laser beam traveled the full width of the cargo compartment. The thermocouple was placed 5″ above the center of the pan.

RESULTS

The pan fire and running-fuel fire tests conducted on each type of reduced smoke fuel showed a reduction in smoke output. Video data showed the Exxon product had the most significant reduction in smoke output. The running-fuel tests conducted using the three-dimensional cascade test apparatus produced an even cleaner burn than the pan fires due to a better airflow through the fire, which caused a more thorough burn. The data indicate that using reduced smoke fire training fuels would significantly reduce the environmental burden on firefighting training facilities.

Also evident in this series of tests was the rapid dissipation of the smoke produced by the burning training fuels. The Tekflame product showed the most rapid dissipation followed by the E III product. What little smoke plume was produced by the Tekflame product almost immediately dissipated into the air. The smoke produced by the JP8 remained in a concentrated cloud and was carried by the wind for several miles away from the fire test facility.

In the three lab tests (smoke density, TPH, and VOCs), the reduced smoke fuels outperformed the JP8. Data from the two EPA test methods are shown in table 1. The Exxon product out performed the others in the TPH testing, while E III had the lowest number of volatiles.

TABLE 1. ENVIRONMENTAL PROTECTION AGENCY TEST METHOD RESULTS

Fuel	VOC - EPA 8260 (ppb)	TPH - EPA 418.1 (mg/l)
Tekflame	186.3	< 0.9
E III	120.9	1.4
JP8	1,061.5	470

Table 2 lists the average and minimum percentage of light transmission (LT) per foot and the average temperature for each test. As can be seen in table 2 and figures 5 to 7, data from the smoke density testing indicated that the Tekflame product had the lowest smoke output. The light detector in the smoke meter responds to infrared energy. That is the reason the smoke meter data starts to rise during the later part of the 5-minute tests. The hot air in the compartment heats an optical filter which affects the smoke meter readings. The smoke data loses accuracy after about the first minute, but the relative differences between the different fuels are similar.

The data also indicates the two reduced smoke fuels burn at a higher temperature which contributes to the efficiency and thoroughness of the burning of these products.

TABLE 2. SMOKE DENSITY DATA

Run	Fuel	Avg. Smoke (%LT/ft)	Minimum Smoke (%LT/ft)	Average Temp (°F)
	JP8	85.9	76.2	896
2	JP18	87.8	76.8	871
3	JP8	84.5	71.9	835
4	JP8	84.8	72.8	853
5	JP8	86.2	73.5	829
Avg.		85.8	74.2	857
6	Tekflame	92.2	89.1	1069
7	Tekflame	91.5	88	1075
8	Tekflame	93.6	90.9	1073
9	Tekflame	96.9	93.1	1006
10	Tekflame	97.4	93.8	1183
Avg.		94.3	91.0	1081
11	E III	93.6	88.0	1195
12	E III	91.1	85.0	1041
13	E III	90.5	83.9	1183
14	E III	90.6	84.5	1063
15	E III	90.0	83.1	976
Avg.		91.2	84.9	1092

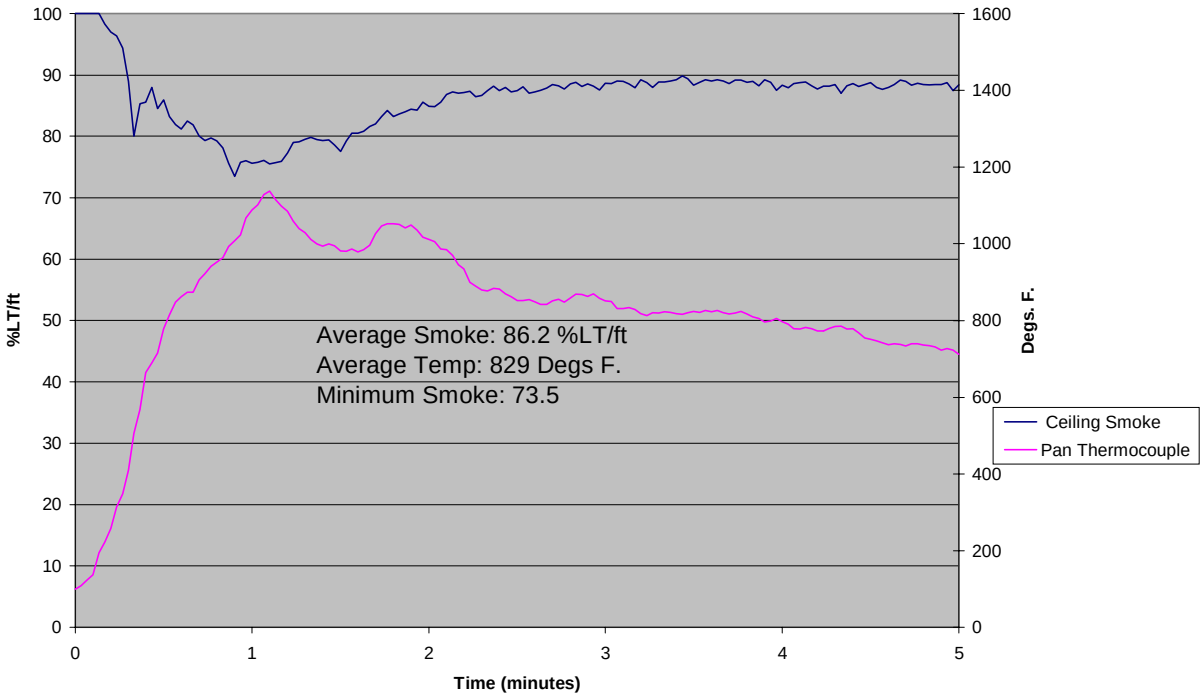

FIGURE 5. SAMPLE JP8 SMOKE DENSITY DATA

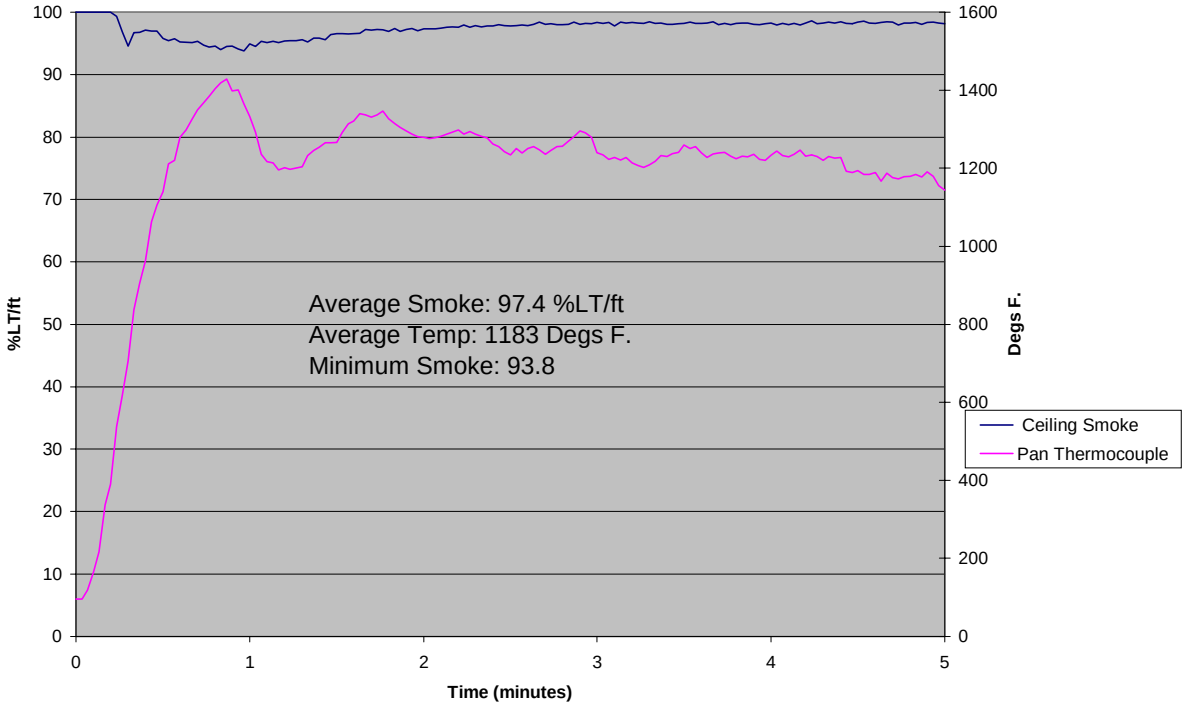

FIGURE 6. SAMPLE TEKFLAME SMOKE DENSITY DATA

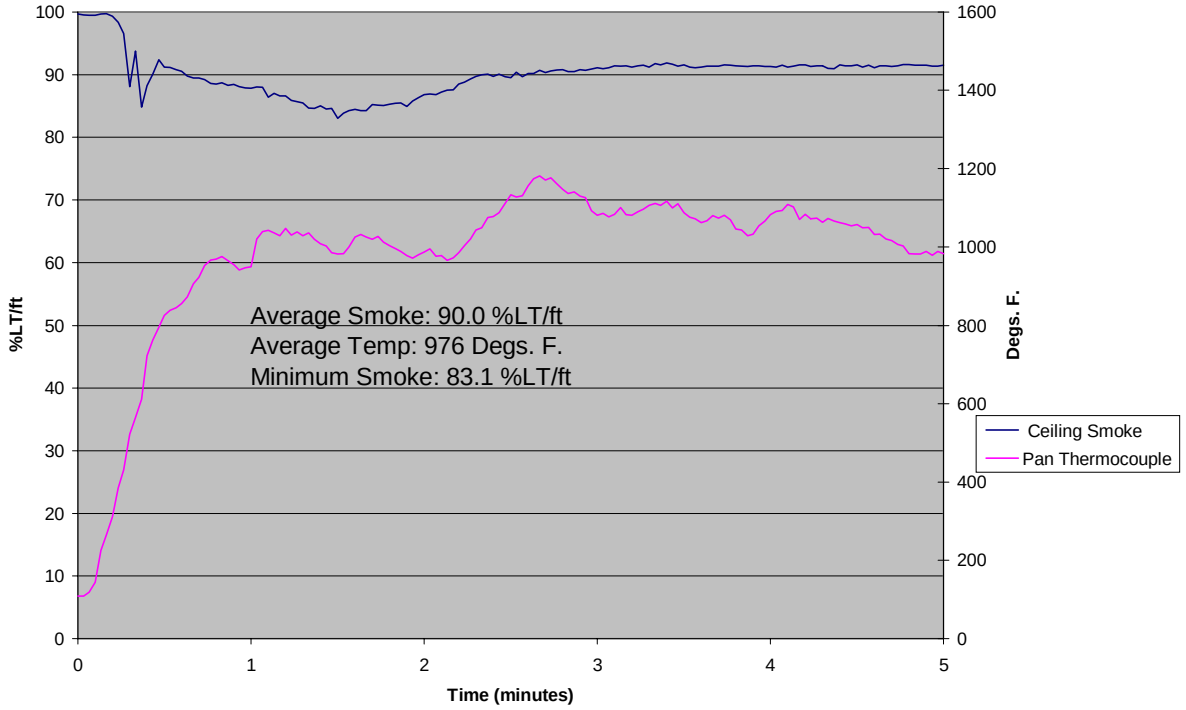

FIGURE 7. SAMPLE E III SMOKE DENSITY DATA

CONCLUSIONS

The by-products generated by burning conventional fuels such as gasoline, diesel, and jet fuel during firefighting training operations include undesirable pollutants that are emitted into the air and waste water systems. Increasing environmental restrictions on firefighting training facilities continue to pressure the facilities to reduce black smoke, waste water contamination, and other related pollution.

Results from the data analysis from this testing show that there would be a benefit to firefighting training facilities in using these reduced smoke training fuels to help reduce the environmental impact of live-fire training. On a comparative basis, the fuels tested reduced the smoke output and accelerated its dissipation into the air. The fuels also produced less residual water contamination in the runoff produced during the burning of these fuels.