EXAMINATION REQUEST

At the request of Special Agent/Certified Fire Investigator (SA/CFI) Richard Chandler, the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Fire Research Laboratory (FRL) performed experiments to determine whether a 2 gallon gasoline container filled with a diesel-gasoline mixture can produce a flame jet from the open mouth of the container when poured over an open flame.

BACKGROUND

On September 19th, 2010 a fire occurred in the back yard of the residence located at 3306 Deerwood Road, New Haven, Michigan. The following case details are according to statements made by Majd Al-Shara during a recorded interview on September 20th, 2010 [1]. Mr. Al-Shara was pouring diesel fuel from a 2 gallon gasoline container onto flaming wooden logs in a fire pit. As Al-Shara was pouring, his six year-old daughter Aliaa, who was standing in the vicinity of the fire pit, became engulfed in flames. The gasoline container did not have a spout in-place at the time of the fire. Al-Shara was unsure of exactly how his daughter caught fire. Aliaa suffered 2nd and 3rd degree circumferential burns to 95% of her body and passed away several days after the incident.

There was no documented thermal damage to the gasoline container (Blitz® Manufacturing, model #50810), which was found on the scene with approximately 400 ml of liquid remaining in the container [2]. A sample of the liquid found in the container was analyzed and determined to be a gasoline/heavy petroleum distillate mixture [3]. Al-Shara stated that the diesel fuel mixture within the container was collected as he purged contaminated fuel pump lines as part of his job [1]. Based on a phone conversation with the forensic chemist from Michigan State Police Forensic Science Laboratory, the liquid mixture appeared to be primarily a heavy petroleum distillate consistent with diesel fuel mixed with a relatively smaller proportion of gasoline. The gasoline analyzed in the sample appeared to be evaporated or “weathered” gasoline, meaning that a portion of the original gasoline sample had evaporated [2].

APPROACH

Sixteen tests were conducted at the FRL in the Large Burn Room (LBR) on December 8th through December 10th 2010. For safety purposes, an apparatus was constructed that allowed the gasoline container to be remotely poured from an enclosure. The model #50810 2 gallon gasoline container found on the scene is no longer produced by Blitz® Manufacturing. A similar Blitz® 2 gallon...
gasoline container, model #2XCG, was used for testing. The gasoline container was secured to a wooden box that was attached to a 2.54 cm (1 inch) diameter steel pipe. The pipe extended through the enclosure wall and was fitted with a handle that allowed it to be rotated, thus pouring liquid from the container. The container was positioned above a natural gas tube burner that served as the pilot flame for the testing. A window was installed in the side of the enclosure to allow a clear line of sight to the gasoline container and natural gas burner. A photo of the test setup is depicted in Figure 1.

For each test, the container was secured to the pouring apparatus and then filled with a pre-measured amount of liquid from a graduated cylinder. The natural gas burner below the container was then ignited. The container was slowly tilted until the liquid began to pour out. The rate of pour was slightly slower than that required to produce a solid stream of liquid just below the mouth of the container. The pour continued until either flame jetting occurred, or until no liquid remained in the container. When flame jetting did occur, the test was stopped and the remaining liquid in the container was poured into a graduated cylinder and recorded.

The first four tests consisted of 100% gasoline, while the remaining thirteen tests were conducted with a mixture of gasoline and diesel, or 100% diesel. The gasoline used for testing was 25% evaporated gasoline, meaning that it was evaporated to 75% of its original mass prior to testing. The length of the flame jet was estimated using pole stands placed every 0.5 meter (1.64 ft). Three tests were conducted with a mannequin the size of the child placed in front of the gasoline container. The purpose of the mannequin was to document the potential for ignition and sustained burning of cotton clothing from the flame jet. For details regarding testing setup and other testing parameters, reference the report of test [4].

**RESULTS**

The results of all seventeen tests are presented in Table 1.
Table 1: Summary of all seventeen tests.

<table>
<thead>
<tr>
<th>Test #</th>
<th>Test ID</th>
<th>% Ratio of Gasoline to Diesel</th>
<th>Volume of Gasoline (ml)</th>
<th>Volume of Diesel (ml)</th>
<th>Flame Jetting Occurred?</th>
<th>Approx. Length of Flame Jet (Meters)</th>
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For tests conducted with 100% gasoline, the flame jet reached a maximum horizontal length of approximately 3 meters (9.84 feet) at a volume of 150 milliliters (ml) of gasoline in the container. Three tests were conducted at a ratio of 90% diesel/10% gasoline. A horizontal flame jet of up to 2.5 meters (8.2 feet) occurred with a total initial liquid volume of 1500 ml at this ratio. The longest flame jet was approximately 4 meters (13 feet) and occurred with a ratio of 75% diesel/25% gasoline with a total initial liquid volume of 800 ml. Figure 2 depicts the 4 meter flame jet. Flame jetting was not observed when the diesel concentration was 95% or 100%. The residual amount of liquid that remained in the container post flame jetting varied based on the original starting volume of liquid. The recorded amount of residual liquid can be found in the report of test [4].

Tests 14, 15 and 16 were conducted with a mannequin placed in front of the gasoline container. In Test 14, the mannequin was placed approximately 1.88 meters (6.16 feet) away from the mouth of the container, as depicted in Figure 3. At this distance, the mannequin became completely engulfed in the flame jet as shown in Figure 4, however sustained combustion of the cotton clothing did not occur. Tests 15 and 16 were conducted with the mannequin placed approximately 1.32 meters (4.33 feet) and 1.3 meters (4.26 feet) in front of the container respectively. In both of these tests, the
mannequins were again engulfed in the jetting flame and their clothing continued to burn after the momentary flame jet subsided as depicted in Figure 5.

**ANALYSIS**

The flame jetting effect was documented in 13 out of 17 tests featuring a 2 gallon gasoline container that had no spout and contained either pure gasoline, or a mixture of gasoline and diesel. This phenomenon occurred with gasoline to diesel ratios as low as 10% gasoline/90% diesel. The horizontal length of flame jet produced varied based on liquid volume and mixture. However, the longest jet was approximately 4 meters (13 feet) long. When flame jetting did occur, no obvious thermal damage to the gasoline container was evident post jetting.

When a mannequin was placed in front of a jetting gasoline can, the flames produced were observed completely encompassing the body of the mannequin at separation distances of approximately 1.3 meters (4.26 feet), 1.32 meters (4.33 feet) and 1.88 meters (6.16 feet). With the mannequin located at 1.3 meters (4.26 feet), and 1.32 meters (4.33 feet), liquid from within the can was propelled out with the flame jet and deposited on both the mannequin and the mannequin’s clothing. This liquid ignited and continued to burn on the mannequin after the momentary flame jet self-extinguished. At a separation distance of 1.88 meters (6.16 feet), sustained burning was not observed on the mannequin or the mannequin’s clothing after the jetting event.

**CONCLUSION:**

Testing indicates that it is possible for a 2 gallon gasoline container filled with a diesel-gasoline mixture to produce a flame jet from the open mouth of the container when poured over an open flame. The flame jet was observed extending as far as 4 meters (13 feet) horizontally. The flame jet is capable of propelling ignited liquid out of the gasoline container and depositing it on a person that is 1.32 meters (4.33 feet) away, creating sustained burning after the momentary flame jet self-extinguishes. No thermal damage to the gasoline container was evident as a result of the flame jetting effect.

**REFERENCES:**


**PHOTOGRAPHS AND VIDEO:**

All tests were recorded with both video and still photography. Copies of the video and photos are retained in the Test Report case jacket [4].
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Figure 1: Gasoline container in pouring apparatus with shelter in the background. (5732_168484.JPG)

Figure 2: Flame jet produced by 25% Gasoline/75% Diesel mixture with a total liquid volume of 800 ml. (Still image @ 1:38 from 5748_Far_4_168586.mp4)
Figure 3: Mannequin placed 1.88 meters (6.16 feet) in front of gasoline can.  
(Still image @ 1:28 from 5755_Side_3_168742.mp4)

Figure 4: Still image from test 14 showing mannequin engulfed in flame jet.  
(Still image @ 2:20 from 5755_Side_3_168742.mp4)
Figure 5: Residual burning of mannequin and clothing post flame jetting in test 15.
(Still image @ 2:12 from 5757_Side_3_168816.mp4)