Experimental Study on the Efficiency of Heptafluoropropane in Extinguishing Wood Stack and Oil Pool Fires

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Abstract. To study the efficiency of Heptafluoropropane (FM200) as fire extinguishing agent, several tests were done in ISO9705 room. It was observed that FM200 was effective on extinguishing both wood stack fire and oil pool fire, and all the fires were extinguished in 5 s. And FM200 could prevent the wood stack from burning again. Then, heat release rate and temperature in the fire room were depressed to a great extent by ejecting FM200. But it should be pay attention that the great pressure of the nozzle when FM200 be ejected in fire room may disturbed the flame and result in temperature rising for some bigger fires.

Introduction
Halon was used in varied fire occasions for many years. However, Halon was forbidden to use for it would destroy the ozonosphere [1-3]. Heptafluoropropane (FM200) was used more and more widely for its efficiency, insulation and harmlessness [4-6]. Many study works were done on the characteristic of heptafluoropropane [7-10].

To study the efficiency of FM200 as fire extinguishing agent, several tests were done in ISO9705 room with wood stack and oil pool fires. The heat release rate and temperature distribution in fire room with and without FM200 ejected in was recorded.

Test
Tests were done in ISO9705 room, in which many main parameters in fire scenarios could be obtained, and the protecting zones formed.

Setup
Test room size: 3.6 m×2.4 m×2.4 m. A single ventilation opening was in the front wall and connected with a smoke collecting hood, shown in Figure 1.
Measurement

Two thermocouple trees respectively C and M vertically placed in test room. Tree C was in the corner of test room, and was 0.3m apart from the two walls. Tree M was in the centreline of test room. There were 6 points on every tree, shown in Table 1.

<table>
<thead>
<tr>
<th>Thermocouples on tree C</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (m)</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
<td>1.4</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Thermocouples on tree M</td>
<td>M1</td>
<td>M2</td>
<td>M3</td>
<td>M4</td>
<td>M5</td>
<td>M6</td>
</tr>
<tr>
<td>Height (m)</td>
<td>2.2</td>
<td>1.9</td>
<td>1.5</td>
<td>1.1</td>
<td>0.7</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Fire Source

There were two oil pools and two wood stacks in the tests. Small oil pool was 320mm × 320mm × 150mm with 7 L diesel and large oil pool was 700mm × 700mm × 150mm with 35 L diesel. Wood stacks were arranged in cross with nailed joints. For small wood stack, each piece of wood was 305 mm × 38 mm × 38 mm, and distributed in 15 mm separation with 6 columns by 8 levels. While, for large wood stack, each piece of wood was 450 mm × 50 mm × 50mm, and distributed in 30 mm separation with 6 columns by 4 levels. The two oil pools and wood stacks provided two fire scenarios: fire I and fire II, shown in Table 2.

<table>
<thead>
<tr>
<th>Fire source</th>
<th>Component</th>
<th>Fuel details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire I</td>
<td>Small oil pool / Small wood stack</td>
<td>Diesel, 7 L / Spruce</td>
</tr>
<tr>
<td>Fire II</td>
<td>Large oil pool / Large wood stack</td>
<td>Diesel, 35 L / Spruce</td>
</tr>
</tbody>
</table>

Fire Extinguishing Agent

Heptafluoropropane (FM200) was used in the tests. A jar of FM200 (70 L, 20.5 kg) was ejected in every test.

Process

Tests with and without extinguishing agent ejected were done for comparison. Every test was done twice for insurance. The time of fire extinguished was recorded in Table 3. The oil pool and wood stack were ignited at the same time. Extinguishing agent was ejected when the heat release rate rose and maintained to maximum. It can be seen that FM200 was effective on extinguishing pool fire and wood fire in the test. The time of fire extinguished was recorded by infrared video recorder, shown in Table 3.

<table>
<thead>
<tr>
<th>Test No.</th>
<th>FM200</th>
<th>Fire source</th>
<th>The time of ejected</th>
<th>The time of fire extinguished</th>
<th>How long for ejecting</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td></td>
<td>I</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>I2</td>
<td></td>
<td>I</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>I1</td>
<td></td>
<td>II</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>I2</td>
<td></td>
<td>II</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>F-I1</td>
<td>Without</td>
<td>I</td>
<td>600s</td>
<td>3s</td>
<td>57s</td>
</tr>
<tr>
<td>F-I2</td>
<td></td>
<td>I</td>
<td>600s</td>
<td>4s</td>
<td>61s</td>
</tr>
<tr>
<td>F-II1</td>
<td></td>
<td>II</td>
<td>300s</td>
<td>3s</td>
<td>66s</td>
</tr>
<tr>
<td>F-II2</td>
<td></td>
<td>II</td>
<td>300s</td>
<td>2s</td>
<td>58s</td>
</tr>
</tbody>
</table>
Results

Heat Release Rate

Heat release rate (HRR) with and without extinguishing agent in the tests were shown in Figure 2. It can be seen in Figure 2(a) that the HRR curves were close to each other in the two tests with one fire scenario. That means the tests were repeatable and credible. When the fire was larger (such as fire II), there were two peak values in the heat release rate curve, for the oil flooded out of the pool in burning, then the burning area was enlarged and the second peak appeared. The HRR curves after FM200 ejected were shown in Figure 2(b), it can be seen that the curve of heat release rate in every test was declined rapidly, and it fallen to nearly zero at 200s after extinguishing agent ejected.

![Figure 2. Heat release rate.](image)

Temperature

As the tests were repeatable, temperature curves of four tests (I1, II1, F-I1 and F-II1) were shown in Figure 3-Figure 6. Figure 3 and Figure 4 were temperature on thermocouple trees C and M under fire scenarios I and II without extinguishing. In Figure 3, the distributions of temperature on thermocouple trees C and M were similar and accordant with the heat release rate in Figure 2(a). Temperature distribution were layered vertically and ascend with height. Temperature distribution in test room under fire scenario II were shown in Figure 4. It can be seen that temperature was higher than its in Figure 3 for the fire source II was larger than fire source I. Especially temperature at M1 ascended nearly 500°C for M1 was on the centreline and to the top of the test room. Temperature curves of C1-C6 were close to each other in Figure 4(a), that means hot smoke distribution was nearly uniform at the corner of fire room.

![Figure 3. Temperature of test I1.](image)

Figure 5 and Figure 6 were temperature on thermocouple trees C and M under fire scenarios I and II with extinguishing. It can be seen in Figure 5 that extinguishing agent was ejected when the temperature field was steady. Temperature on thermocouple trees C and M declined swiftly to about 100°C when extinguishing agent ejected. It can be concluded that FM200 was effective on depressing
temperature in fire room. Temperature at some thermocouple points at the bottom of test room (such as M3-M6 and C6) climbed a little after extinguishing agent ejected for the strong airflow of ejection disturbed the temperature field and blew the hotter smoke to the bottom of the test room. But that didn’t affect the downtrend of the whole temperature field.

For tests under larger fire scenario (fire source II), temperature in test room was depressed to about 150 °C sharply by extinguishing agent FM200, shown in Figure 6. It can be seen that temperature in test room rose suddenly when extinguishing agent ejected before declined. The reason for temperature rise may be the great pressure of the nozzle disturbed hot smoke and flame, and then temperature climbed. But the temperature rise was just a moment, and then it dropped soon.

![Figure 4. Temperature of test II1.](image)

![Figure 5. Temperature of test F-II1.](image)

![Figure 6. Temperature of test F-III1.](image)

**Conclusions**

A series of test with and without extinguishing agent were done in ISO9705 room with oil pool and wood stack as fire source. The extinguishing agent was FM200. Some conclusions can be obtained from the tests:
(1) Heptafluoropropane (FM200) was effective on extinguishing both A fire (wood stack fire) and B fire (oil pool fire), and all the fires were extinguished in 5s. FM200 could prevent both the two configurations of wood stack in fire scenarios I and II from burning again.

(2) Heat release rate and temperature in the fire room were depressed to a great extent by ejecting FM200. Then the fire room was safe relatively for salvaging.

(3) For some bigger fires (such as fire scenario II), the great pressure of the nozzle may disturb the flame and result in temperature rising for a short while. Therefore, it should be paid attention to for firemen working when FM200 was ejected in fire room.

Acknowledgement

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References


