Material Change Similarity Task Group Status

AC Guidance Proposal Using the Microscale Combustion Calorimeter

Materials Fire Test Working Group
June 7-8, 2016

Rich Lyon, FAA Tech Ctr
Dan Slaton, Boeing
Material Change Similarity Task Group

Presentation Outline:

Background
Process Flow Chart
Proposed approach for new AC
Next Steps
Material Change Similarity Task Group

Process Proposal:

1. Material Change
2. Test the Current certified Material and New Formulation
3. Analysis of data (ASTMD7309)
4. New formulation is equivalent in flammability performance

Minor Change

Designation: D7309 – 13

ADVISORY CIRCULAR

(Author Note: AC25.856-1a was used as a template.)

Subject: MICROSCALE COMBUSTION CALORIMETRY TEST METHOD FOR DETERMINING WHETHER A MATERIAL CHANGE CAN BE CLASSIFIED AS A MINOR CHANGE FOR FLAMMABILITY

1. PURPOSE. This advisory circular (AC) provides guidance on using the Microscale Combustion Calorimetry (MCC) test method to determine the relative flammability performance characteristics of a material. This method can be used to compare the flammability properties of a currently certified material with those of the material that has been changed in some way (e.g. chemical/material changes to remove environmental impacts, alternate sources of chemical constituent/material, replacement for out-of-production material, changed material to improve manufacturing & performance properties, etc…) to determine if there is a significant change in the fundamental flammability properties. Once determined to have similar flammability properties at the material level, this data supports a minor determination of the material change, thus eliminating the need to assess the specific flammability properties of all the different part configurations where this material is used.
c. Components of aircraft interior materials that can be considered for a minor change determination by MCC testing are those whose properties can be adequately represented by a 5-10 milligram sample. Examples of these include adhesives, potting compounds, coatings, films, plastics, resins, rubber, textile fibers used in different design configurations. At the present time it is common practice to fabricate flammability test samples of all the different design configurations using the new/modified material or new component and perform a full complement of FAA flammability tests (Bunsen burner, OSU heat release, Smoke Optical density, Flame Propagation, etc…) for the different configurations using the material. This approach of fabricating and testing large numbers of test configurations is very expensive. The MCC offers a standard method and procedure to compare the fire properties of a new component with those of an existing component in a certified configuration. If the fire properties of the new component are similar to the original component, and the fabricated part containing this new component is otherwise unchanged, it is expected that the flammability properties of the changed part will be equivalent to the certified part, and that the substitution of the new component for the original component is a small (minor) change - eliminating the need to perform extensive configuration tests.
5. DEFINITIONS.

a. A component is any substance used in the construction of an aircraft cabin material whose fire properties are adequately represented by the 5-10 mg sample used in ASTM D7309. Examples of suitable components are adhesives, potting compounds, coatings, films, paints, plastics, resins, elastomers, rubber, fibers, wire jackets, etc..

b. Similar is understood to mean that the MCC fire properties that scale with flammability, heat release capacity (HRC) and total heat release (HR) of a new component are less than or equal to the original component to within the reproducibility limits set forth in ASTM D 7309.
Material Change Similarity

Draft Advisory Circular

Component (adhesive, film, resin, plastic)

ASTM D7309 (MCC)
HRC \leq HRC_0
and
HR \leq HR_0

Yes
Minor Change

No
Test Construction that Substantiates the Part
Material Change Similarity

Next Steps:
1) Review draft AC, provide inputs
2) Industry to identify certain data available to validate the process
3) Final draft AC to FAA – October 2016
4) FAA to propose new AC 2017 (concurrent with NPRM)
Backup charts
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Background:

March 2014:
- Dick Hill presented “FAA Initiatives in Flame Retardant Replacements.”
  - Develop approach to evaluate flame retardant replacements and define similarity.

June 2014:
- Dan Slaton presented outline of possible approaches for Task Group.
  - Proposed approach to establish “minor change.”
  - Defined initial scale that demonstrates similarity / equivalency.
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Background (cont):

October 2014:

– Rich Lyon presented background of MCC activities and similarity approaches.

### Similarity

A certified Configuration A is *changed* to Configuration B.

From a certification standpoint, these configurations will be equivalent with regard to safety (similar) if the certification data that substantiates Configuration A also substantiates Configuration B.

*In other words A and B are similar if the changes to A, whatever they are, do not impact the original basis for certification.*

### Predictive Capability of ASTM D 7309

**Material Properties in Pass / Fail Fire Tests**

<table>
<thead>
<tr>
<th>Explanatory Variable, $X$</th>
<th>Predictive Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{\infty}$</td>
<td>Heat of Combustion</td>
</tr>
<tr>
<td>$\eta_c$</td>
<td>Heat Release Capacity</td>
</tr>
<tr>
<td>$HRP$</td>
<td>Heat Release Parameter</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Volatile Fraction</td>
</tr>
<tr>
<td>$T_P$</td>
<td>Peak Pyrolysis Temperature</td>
</tr>
</tbody>
</table>

Predictive Capability

0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1
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Background (cont):

- February 2015 – INTERFLAM – Materials and Fire Conference
  - Rich Lyon presented “Practical Aspects of MCC.”
  - MCC probability of passing FAR 25 HRR based on sample Mass.
  - Proposed using MCC for quality control and product surveillance.

- February 2015 – FAA Fire Test Working Group
  - Proposed “minor change” process
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Background (cont):

- **May 2015**
  - UL Fire Retardants in Plastics Conference

- **October 2015 – FAA Fire Test Working Group**
  - UL Presentation – Assessing Material Consistency Using MCC

- **June 2016 – FAA Fire Test Working Group**
  - Rich Lyon presented case studies comparing MCC to FAR Flam Test results
Material Change Similarity

ASTM D7309 – Reproducibility Limit

### TABLE 2 Peak Heat Release Rate (W per g)

<table>
<thead>
<tr>
<th>Material</th>
<th>Average</th>
<th>Repeatability Standard Deviation</th>
<th>Reproducibility Standard Deviation</th>
<th>Reproducibility Limit</th>
<th>Reproducibility Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>468.6</td>
<td>8.8</td>
<td>28.9</td>
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<td>80.9</td>
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<td>PP</td>
<td>1083.6</td>
<td>22.8</td>
<td>89.3</td>
<td>64.0</td>
<td>250.1</td>
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<tr>
<td>HIPS</td>
<td>714.9</td>
<td>23.4</td>
<td>64.7</td>
<td>65.6</td>
<td>181.1</td>
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<tr>
<td>PC</td>
<td>526.9</td>
<td>25.0</td>
<td>54.1</td>
<td>70.0</td>
<td>151.4</td>
</tr>
<tr>
<td>PPSU</td>
<td>205.2</td>
<td>6.6</td>
<td>19.0</td>
<td>18.5</td>
<td>53.3</td>
</tr>
</tbody>
</table>

*The average of the laboratories’ calculated averages.*

### TABLE 3 Heat Release Capacity (J per g-K)

<table>
<thead>
<tr>
<th>Material</th>
<th>Average</th>
<th>Repeatability Standard Deviation</th>
<th>Reproducibility Standard Deviation</th>
<th>Reproducibility Limit</th>
<th>Reproducibility Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>471.0</td>
<td>9.0</td>
<td>26.7</td>
<td>25.1</td>
<td>74.7</td>
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<tr>
<td>PP</td>
<td>1095.3</td>
<td>32.5</td>
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<td>91.0</td>
<td>242.0</td>
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<tr>
<td>HIPS</td>
<td>715.0</td>
<td>23.0</td>
<td>59.1</td>
<td>64.5</td>
<td>165.5</td>
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<tr>
<td>PC</td>
<td>529.5</td>
<td>25.3</td>
<td>48.2</td>
<td>70.9</td>
<td>134.9</td>
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<tr>
<td>PPSU</td>
<td>208.8</td>
<td>7.4</td>
<td>18.0</td>
<td>20.8</td>
<td>50.5</td>
</tr>
</tbody>
</table>

*The average of the laboratories’ calculated averages.*
# Material Change Similarity

**ASTM D7309 – Reproducibility Limit**

## TABLE 4 Total Heat Release (kJ per g)

<table>
<thead>
<tr>
<th>Material</th>
<th>Average</th>
<th>Repeatability Standard Deviation</th>
<th>Reproducibility Standard Deviation</th>
<th>Repeatability Limit</th>
<th>Reproducibility Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>23.5</td>
<td>0.2</td>
<td>1.4</td>
<td>0.6</td>
<td>3.8</td>
</tr>
<tr>
<td>PP</td>
<td>41.5</td>
<td>0.8</td>
<td>2.3</td>
<td>2.3</td>
<td>6.4</td>
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<tr>
<td>HIPS</td>
<td>34.2</td>
<td>0.3</td>
<td>1.7</td>
<td>0.9</td>
<td>4.7</td>
</tr>
<tr>
<td>PC</td>
<td>21.0</td>
<td>0.3</td>
<td>1.3</td>
<td>0.8</td>
<td>3.6</td>
</tr>
<tr>
<td>PPSU</td>
<td>11.9</td>
<td>0.3</td>
<td>1.0</td>
<td>0.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>

*The average of the laboratories’ calculated averages.

## TABLE 5 Peak Heat Release Temperature (°C)

<table>
<thead>
<tr>
<th>Material</th>
<th>Average</th>
<th>Repeatability Standard Deviation</th>
<th>Reproducibility Standard Deviation</th>
<th>Repeatability Limit</th>
<th>Reproducibility Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>390.4</td>
<td>2.1</td>
<td>8.2</td>
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<td>23.0</td>
</tr>
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<td>PP</td>
<td>481.1</td>
<td>2.0</td>
<td>8.8</td>
<td>5.7</td>
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<td>HIPS</td>
<td>456.0</td>
<td>2.2</td>
<td>8.4</td>
<td>6.1</td>
<td>23.6</td>
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<tr>
<td>PC</td>
<td>525.3</td>
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<td>6.5</td>
<td>31.8</td>
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<td>PPSU</td>
<td>606.6</td>
<td>1.8</td>
<td>15.1</td>
<td>5.1</td>
<td>42.3</td>
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</table>

*The average of the laboratories’ calculated averages.

## TABLE 6 Char Yield (%)

<table>
<thead>
<tr>
<th>Material</th>
<th>Average</th>
<th>Repeatability Standard Deviation</th>
<th>Reproducibility Standard Deviation</th>
<th>Repeatability Limit</th>
<th>Reproducibility Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>0.18</td>
<td>0.23</td>
<td>0.32</td>
<td>0.64</td>
<td>0.91</td>
</tr>
<tr>
<td>PP</td>
<td>0.21</td>
<td>0.19</td>
<td>0.34</td>
<td>0.53</td>
<td>0.96</td>
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<tr>
<td>HIPS</td>
<td>8.22</td>
<td>0.90</td>
<td>1.24</td>
<td>2.53</td>
<td>3.46</td>
</tr>
<tr>
<td>PC</td>
<td>19.38</td>
<td>0.91</td>
<td>1.62</td>
<td>2.54</td>
<td>4.52</td>
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<td>PPSU</td>
<td>41.25</td>
<td>1.36</td>
<td>2.54</td>
<td>3.60</td>
<td>7.12</td>
</tr>
</tbody>
</table>

*The average of the laboratories’ calculated averages.