Material Change Similarity Task Group

Microscale Combustion Calorimetry

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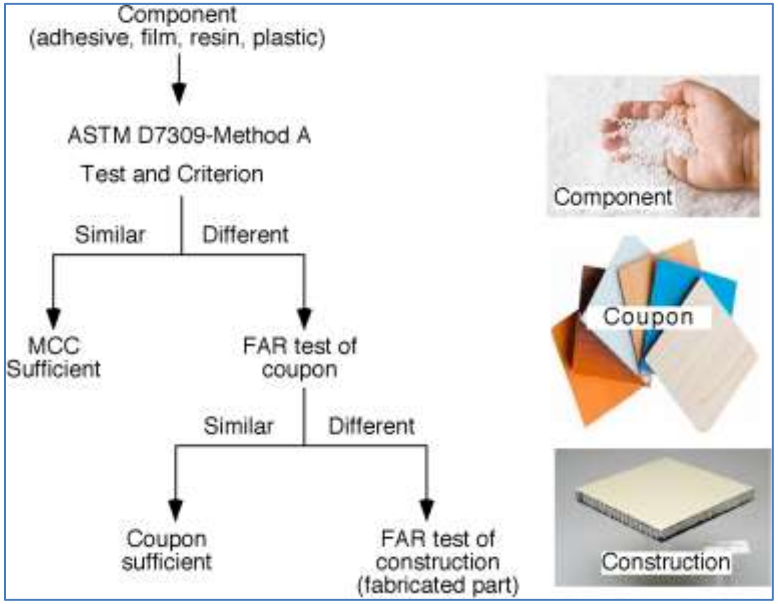
FAA International Aircraft Materials Fire Test Forum

Material Change Similarity Task Group

Overview - Task Group Goal

- Develop guidance using the Microscale Combustion Calorimeter (MCC)
  - Determine the flammability performance characteristics of a material.
- Utilize the MCC method to compare the flammability properties
  - Compare currently certified material with those of the material that has been changed
  - Determine if there is a significant change in the fundamental flammability properties.
  - Data supports a similarity determination of the material change, thus eliminating the need to assess the specific FAR flammability requirements for all the different part configurations where this material is used.
- Validate MCC Similarity Process:
  - Develop case studies to validate the process.



Pass / Fail FAA Flammability Tests

(≥ 2-Parameters)

OSU Rate of Heat Release
(Large Area Materials)

- Peak HR
- 2-min Total HR

Vertical Bunsen Burner
(All materials)

- Burn length
- After Flame time
- Flame Drip time

Radiant Panel
(Thermal-acoustic Insulation)

- Flame Propagation
- After Flame time

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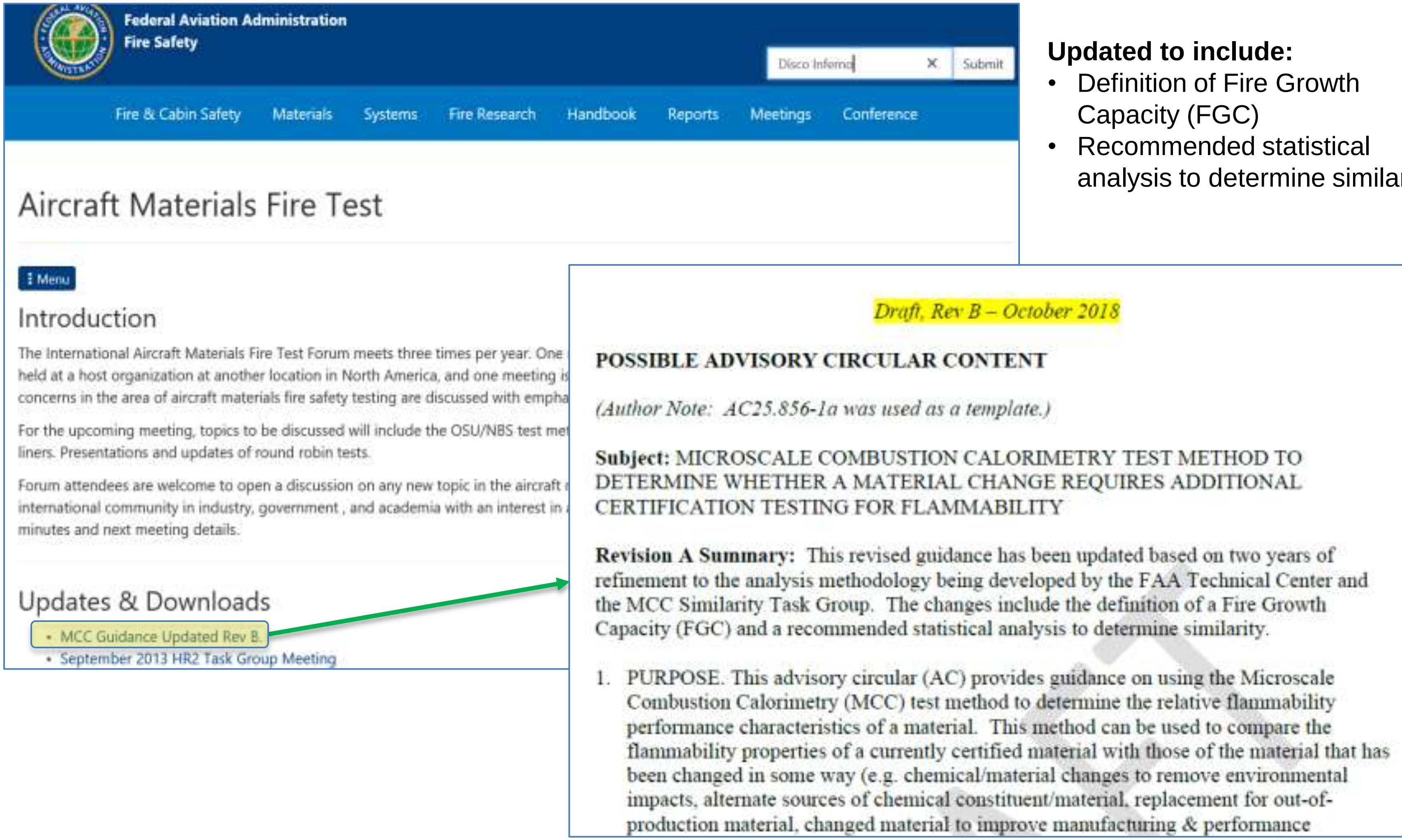
Updated Guidance Released



Draft, Rev B – October 2018

POSSIBLE ADVISORY CIRCULAR CONTENT

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

Subject: MICROSCALE COMBUSTION CALORIMETRY TEST METHOD TO DETERMINE WHETHER A MATERIAL CHANGE REQUIRES ADDITIONAL CERTIFICATION TESTING FOR FLAMMABILITY

Revision A Summary: This revised guidance has been updated based on two years of refinement to the analysis methodology being developed by the FAA Technical Center and the MCC Similarity Task Group. The changes include the definition of a Fire Growth Capacity (FGC) and a recommended statistical analysis to determine similarity.

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

Updated to include:

- Definition of Fire Growth Capacity (FGC)
- Recommended statistical analysis to determine similarity.

Motivation

Code of Federal Regulations 14 (FAA) Part 21 (Certification Procedures)

Excerpt from draft guidance: Change Classification

2.c. An applicant may propose to incorporate this methodology into their overall compliance plan, including establishing how changes are identified as either major or minor under § 21.93.

§21.93 Classification of changes in type design (paraphrased)

(a) Changes in type design (e.g., B737-100, -200, -300, -400, -500 and A340-200, -300, -500, -600) are classified as minor and major. A “minor change” is one that has no appreciable effect on the weight, balance, structural strength, reliability, operational characteristics, or other characteristics affecting the airworthiness of the product. All other changes are “major changes” and require re-certification of the airplane.

§21.95 Approval of minor changes in type design.

(a) Minor changes in a type design may be approved under a method acceptable to the FAA before submitting to the FAA any substantiating or descriptive data.

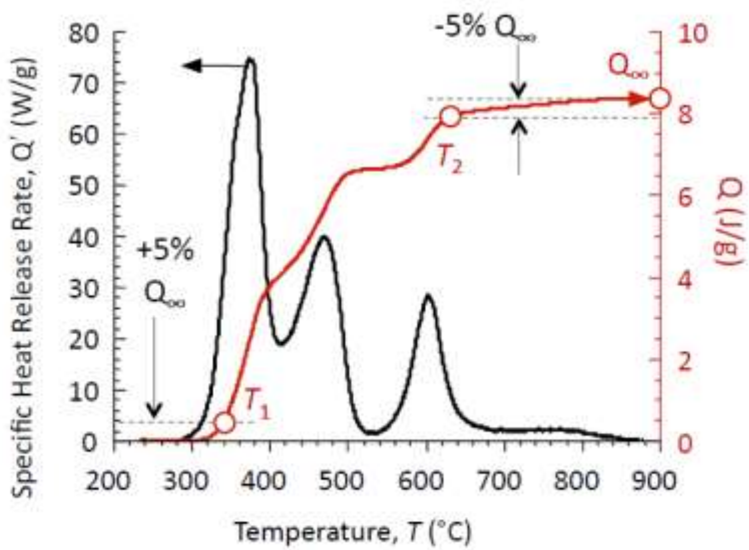
§21.97 Approval of major changes in type design.

(a) An applicant for approval of a major change in type design must—

(1) Provide substantiating data and necessary descriptive data for inclusion in the type design;...

MCC Calculations

Parametric Representation of Flammability Fingerprint for Comparison Purposes



1. Measure specific heat release rate Q′ versus temperature *T* as per ASTM D7309 (5 replicates)
2. Integrate Q′/β versus *T* to obtain Q versus *T*, i.e., Q(*T*).
3. Obtain total heat release $Q(T_\infty) = Q_\infty$ (J/g)
4. Obtain T_1 at 5% deflection from Q(T) baseline, i.e., at $0.05Q_\infty$
5. Obtain T_2 at $0.95Q_\infty$.
6. Calculate Fire Growth Capacity, FGC = HRC + IGC,

$$FGC = \frac{Q_\infty}{T_2 - T_1} + \frac{Q_\infty}{T_1 - T_0} = \left(\frac{Q_\infty}{T_2 - T_1}\right)\left(\frac{T_2 - T_0}{T_1 - T_0}\right)$$

T_0 = Room Temperature = 25°C
T_1 = Ignition temperature
T_2 = Burnout temperature

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Excerpts form draft guidance:
Fire Growth Capacity

6.a. If the MCC result for the fire growth capacity (FGC) of a new or changed component is statistically indistinguishable from FGC of the original (certified) component in accordance with Section 8 of this document, the new material/component is considered to be similar with respect to flammability

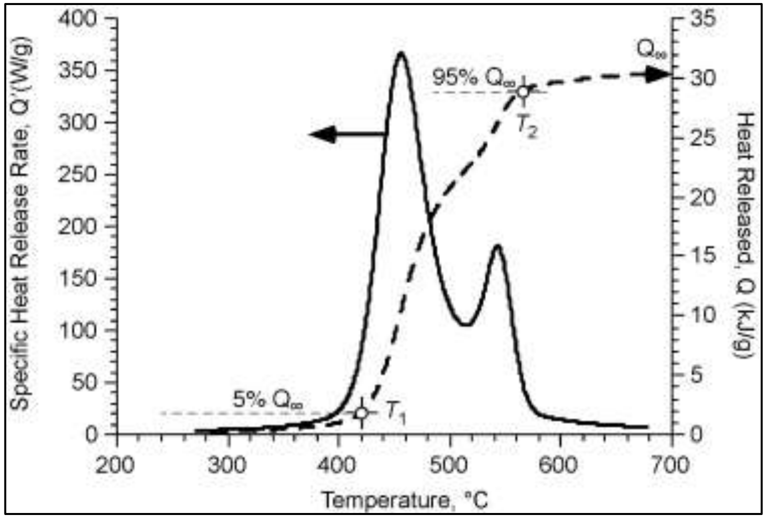

Figure 1. MCC Test of a Plastic Showing the Three Properties Q_∞, T_1 and T_2 Used to Compute FGC of Components.

7.e. A sample calculation of FGC using Figure 1 as the flammability diagram for a 5 mg sample of a changed component is as follows. The maximum/total/ integrated heat release in Figure 1 is the intersection of the time integral of Q', shown as a dashed line in Figure 1, with the right hand ordinate at T_∞. For Figure 1 this value is, $Q_\infty = 30.2$ kJ/g. The ignition temperature is the abscissa value (temperature) of the dashed line at which 5% of the total heat has been released. In Figure 1, $T_1 = 420°C$ at $0.05Q_\infty = 1.5$ kJ/g. The temperature at which 95% of the heat has been released is the abscissa value of the dashed line at $0.95Q_\infty = 28.7$ kJ/g. In Figure 1, $T_2 = 564°C$. From these 3 properties compute, FGC of the sample of the changed component using Equation 1,

$$FGC = \frac{30.2\,kJ/g}{564°C - 420°C} \times \frac{564°C - 25°C}{420°C - 25°C} = 286\frac{J}{g - °C} = 286\frac{J}{g - K}$$

Excerpt from draft guidance: Statistical Analysis Calculation

8.f. A sample calculation comparing two grades of the same high temperature plastic using the similarity criterion is as follows. Five samples of plastic component 1 were tested ($n_1 = 5$) in the MCC with mean and standard deviation, $\langle FGC \rangle_1 = 43 \pm 2$ J/g-K. Five samples of plastic component 2 were also tested ($n_2 = 5$) in the MCC, with $\langle FGC \rangle_2 = 59 \pm 2$ J/g-K. From Equation 2, $s_p = 2$ J/g-K and, $|t| = 12.65$ by Equation 3. In Table 1, $t_{0.05} = 2.306$ for $n_1 = n_2 = 5$, so $|t| > t_{0.05}$, and the null hypothesis is rejected. That means that random error cannot account for the difference in FGC between plastic component 1 and plastic component 2, so they are considered to be different with respect to flammability in the MCC. The MCC results are therefore insufficient to demonstrate similarity.

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Activities since October 2018:

- New MCC baseline correction approach developed by FAATC:
  - ASTM D7309 Committee meeting in April
  - Round Robin testing planned for later this year
- Industry case studies in-work to validate MCC Similarity guidance:
  - Phenolic resin systems
  - Adhesives & potting compounds
  - Decorative laminates
  - Thermoplastics
  - Paints/coatings

Next Steps

- Complete case-studies
- Review by FAA regulatory focals for approval
- Adoption of new process