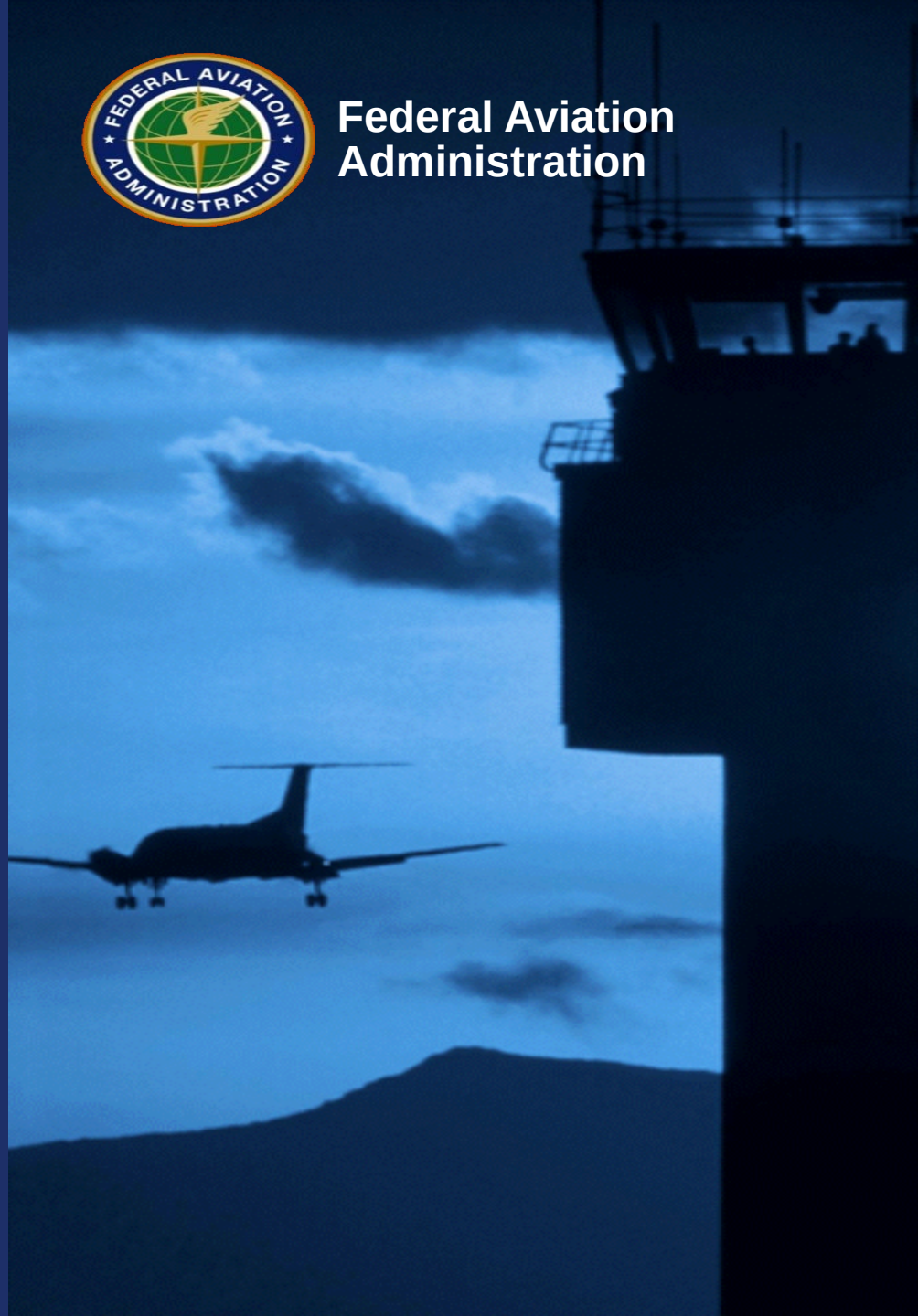
Federal Aviation Administration

Small Scale Fire Test for Component Substitutions in Aircraft Materials



Presented to: International Aircraft Materials Fire Test Forum
Material Change Similarity Task Group

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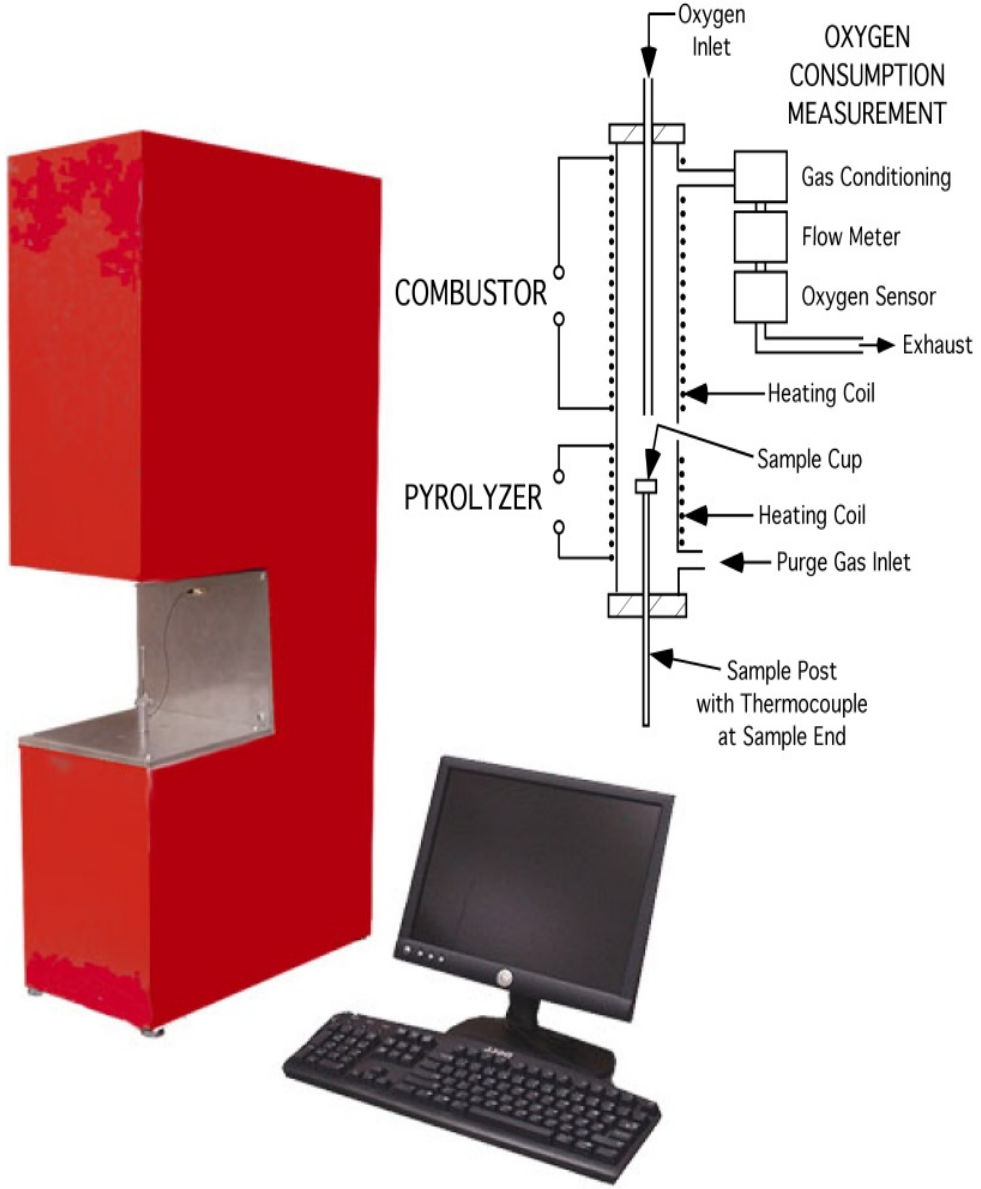
Date: June 11, 2020

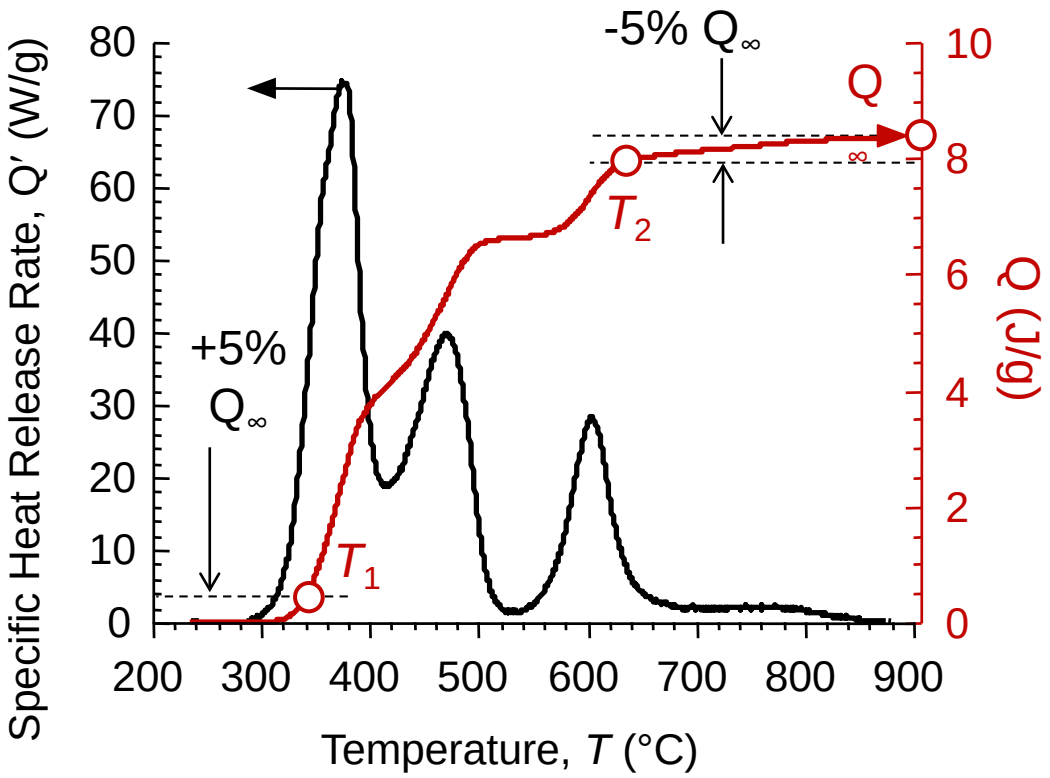
Overview

Task Group Goals:

- **Develop** guidance using the Microscale Combustion Calorimeter (MCC)
- **Utilize** the MCC method to compare the flammability properties
    - Compare currently certified material with changed one
    - Determine if there is a significant change
    - Possible eliminating fire tests for minor changed materials
- **Validate** MCC Similarity Process



MCC procedure for FGC



T_0 = *Standard Temperature = 25°C*
$T_1 \approx$ *Ignition temperature*
T_2 = *Burning temperature*

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

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 $Q(T_\infty) = Q_\infty = h_c$(J/g)
4. Obtain T_1 at 5% deflection from Q(T) baseline, i.e., at $0.05Q_\infty$
5. Obtain T_2 at Q_∞-($0.05Q_\infty$), i.e., $0.95Q_\infty$.
6. Calculate Fire Growth capacity (FGC)

Current similarity approach (2019)

$$\frac{|P_a - P_b|}{P_b} \leq \frac{|X_a - X_b|}{X_b}$$

$$\frac{|P_a - P_b|}{P_b} \leq \frac{2\sigma_{Xb}}{X_b}$$

P_a and P_b are FGC from MCC experiments

X_a and X_b are bench-scale fire properties

σ_{Xb} is the standard deviation for certified material B

14 CFR Bench Scale Fire Tests (Pass/Fail)

OSU Rate of Heat Release Apparatus
(Large Area Materials)
• Peak HRR
• 2-min HR

Radiant Panel
(Thermo-acoustic Insulation)
• Flame propagation distance
• After flame time

Vertical Bunsen Burner
(All other materials)
• Flame time
• Flame drip time
• Burn length

*New case added in 2020

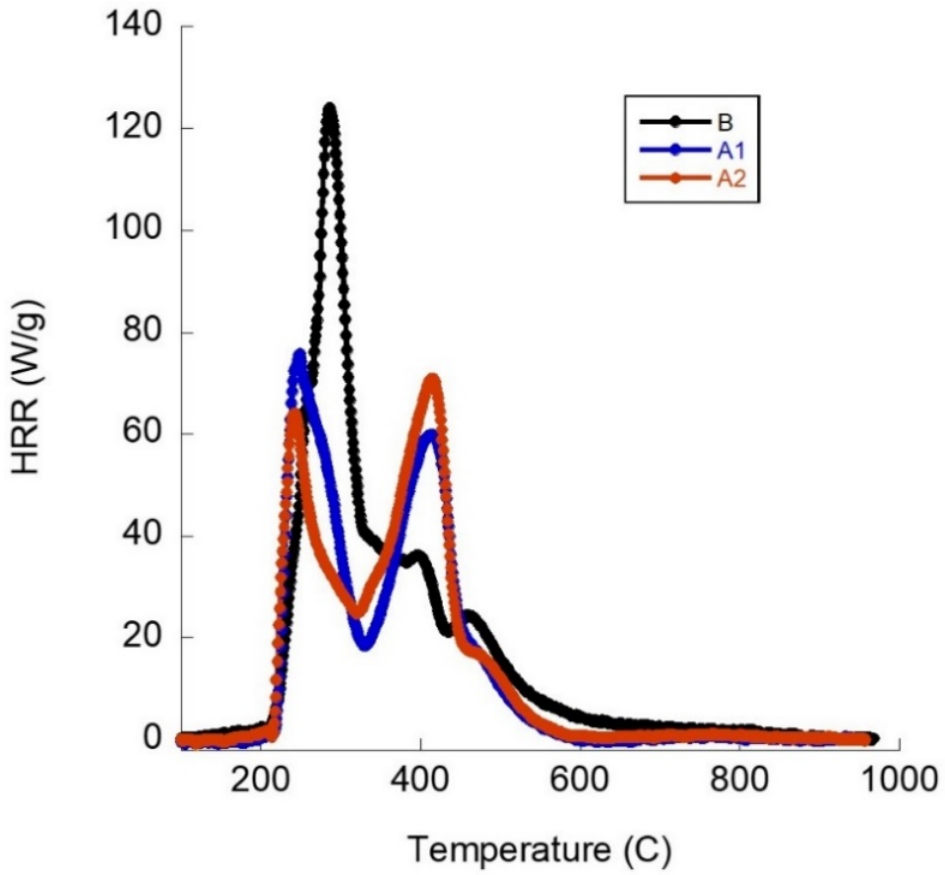
Validation case studies

Twelve industry case studies completed to validate MCC Similarity guidance:

- Phenolic resin systems
- Adhesives & potting compounds
- Decorative laminates
- Thermoplastics
- Paints/coatings
- Insulation blankets

Case study example/adhesive film

- ✓ Sample B is the certified material
- ✓ The change is the flame retardant
- ✓ OSU tests were done on a 2 ply phenolic laminate



Test results

Name	FGC (J/g-K)	pHRR (kW/m²)	2 min HR (kW-min/m²)
Sample B	104 ± 2	45.5 ± 3.7	44.1 ± 1.1
Sample A1	102 ± 3	44.4 ± 1.6	39.7 ± 1.1
Sample A2	101 ± 7	41.3 ± 1.6	42.4 ± 1.0

$$\frac{|P_a - P_b|}{P_b} \leq \frac{|X_a - X_b|}{X_b} \qquad \frac{|P_a - P_b|}{P_b} \leq \frac{2\sigma_{Xb}}{X_b}$$

Name	pHRR (kW/m²)	2 min HR (kW-min/m²)	pHRR (kW/m²)	2 min HR (kW-min/m²)
Sample B vs Sample A1	0 ≤ 0	0 ≤ 0.1	0 ≤ 0.2	0 ≤ 0
Sample B vs Sample A2	0 ≤ 0.1	0 ≤ 0	0 ≤ 0.2	0 ≤ 0

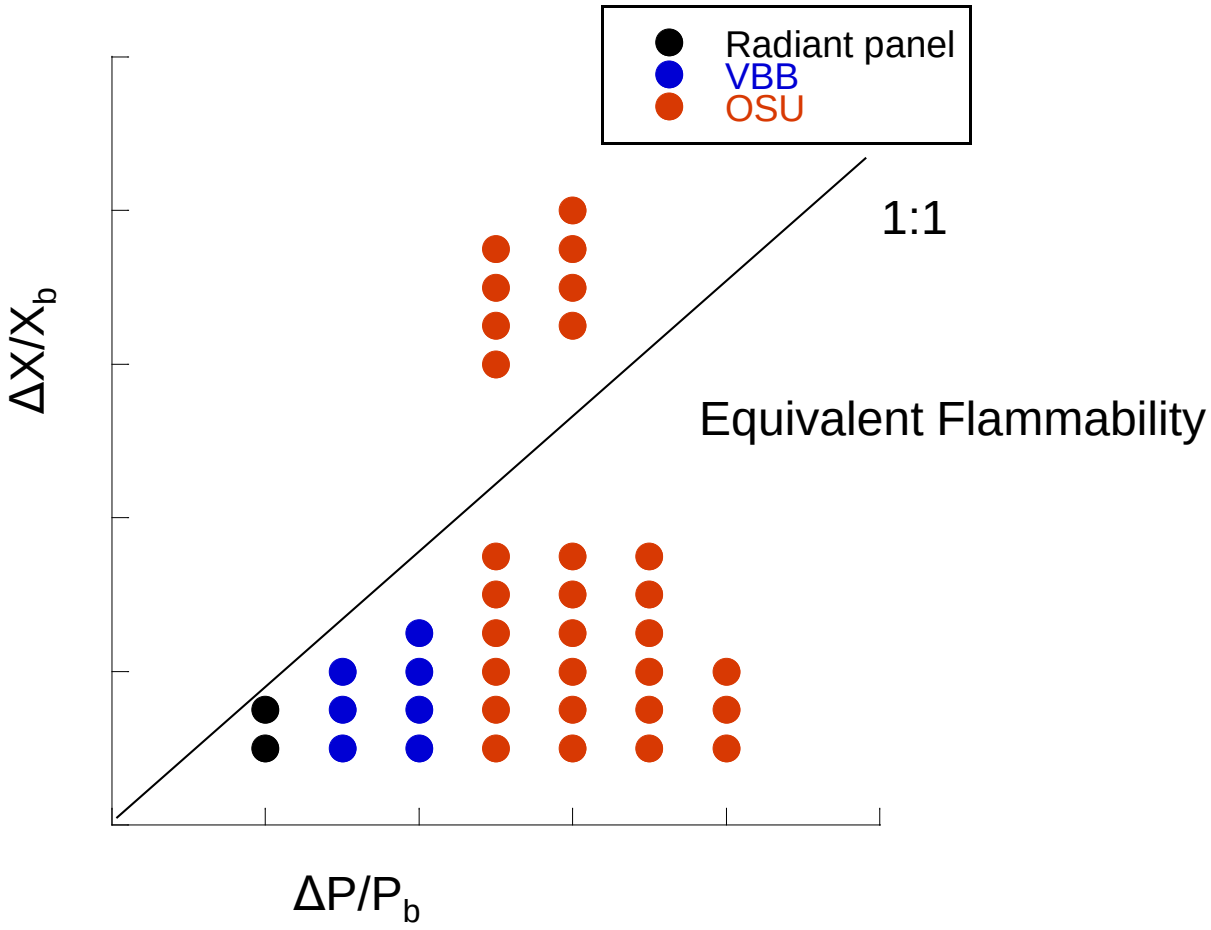
Case studies results

- Case studies were grouped by the type of 14 CFR 25 tests.
- Radiant panel test is presented by only one case study.
- Vertical Bunsen Burners results are presented in three case studies.
- The majority of the 14 CFR 25 tests in this validation study are OSU tests that are presented by ten case studies.
- Some of the case studies include the results for multiple laboratories.

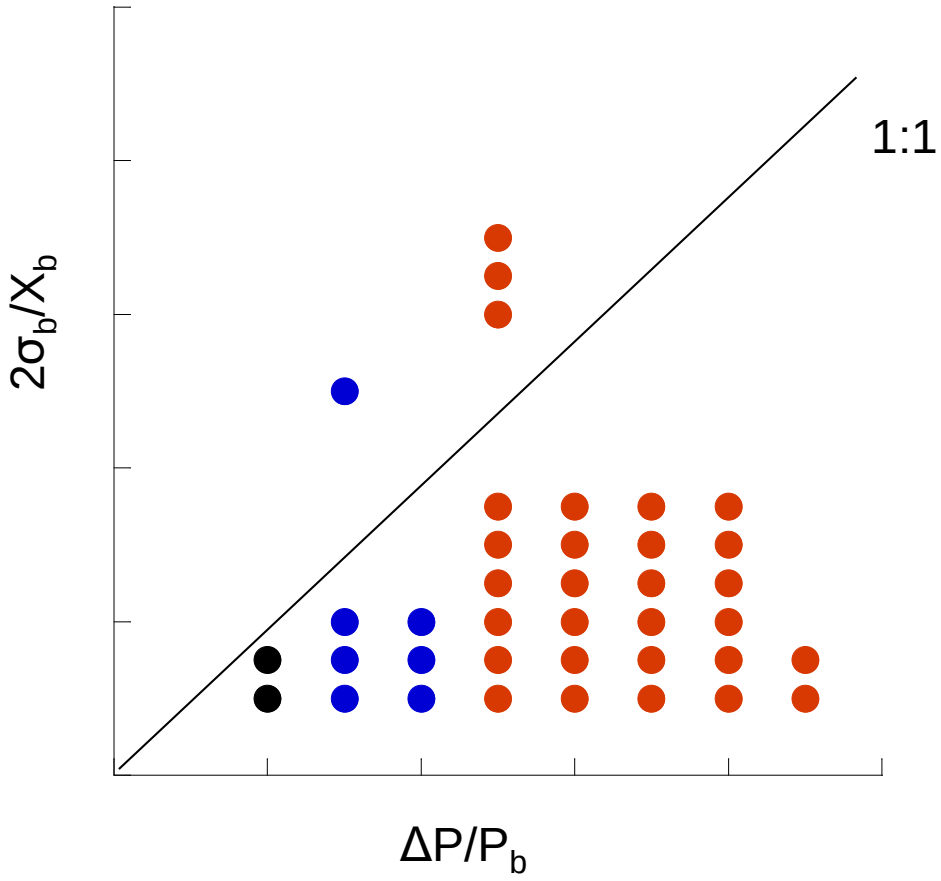
Similarity criteria applied to Vertical Bunsen Burner test results.

Case #/ Samples	$\frac{\lvert P_a - P_b \rvert}{P_b} \leq \frac{\lvert X_a - X_b \rvert}{X_b}$ X = Burn length, (in)	$\frac{\lvert P_a - P_b \rvert}{P_b} \leq \frac{2\sigma_{Xb}}{X_b}$ X = Burn length, (in)
Case #1 1.1 1.2	 0.1 ≤ 0.2 0.1 ≤ 0.1	 0.1 ≤ 0.2 0.1 ≤ 0.1
Case #2 2.1 2.2 2.3 2.4	 0.1 ≤ 0.1 0.1 ≤ 0.1 0.1 ≤ 0.1 0.1 ≤ 0.1	 0.1 ≤ 0.3 0.1 ≤ 0.1 0.1 ≤ 0.2 0.1 > 0 *
Case #5	0.1 ≤ 0.5	0.1 ≤ 0.2

Similarity criteria applied to fire test results.

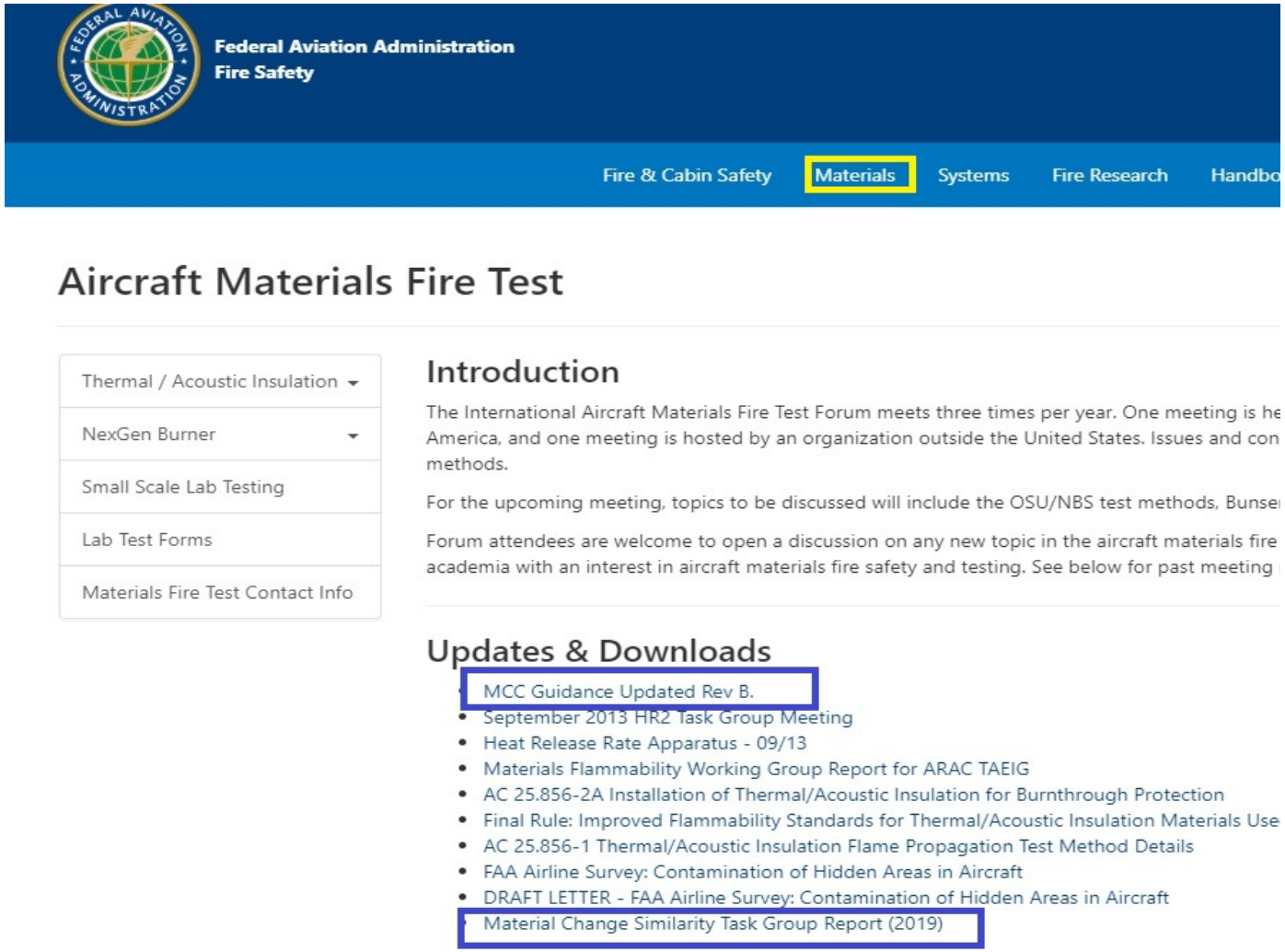


A/B basis



B basis

https://www.fire.tc.faa.gov/materials.asp



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

MATERIAL CHANGE SIMILARITY TASK GROUP REPORT

9th Triennial International Aircraft Fire and Cabin Safety Research Conference
Resorts Hotel and Casino, Atlantic City, New Jersey,
October 31, 2019

Task Group Chairmen: Rich Lyon (FAA) and John Harris (Boeing)
Date: October 31, 2019, 3:30-5PM.
Attendees: Approximately 20

SUMMARY OF PROGRESS TO DATE

The stated goal of the Material Change Similarity Task Group is to explore the possibility that a small-scale test could be used to determine whether a change in the composition of a cabin material would be a minor change with respect to the flammability of the part as measured in 14 CFR 25 fire tests and, if so, to formalize the procedure. The Task Group has down-selected the small-scale test method to ASTM D7309 microscale combustion calorimeter/MCC [1], adopted the MCC Fire Growth Capacity/FGC as the component metric [2], and conducted a coupon-level validation

Work-in-progress documents

1) FAA Tech Note on Baseline Correction

2) FAA Tech Note on Physical Basis for Using FGC as a microscale flammability metric

3) FAA Tech Note on Similarity Criterion and Industry Case Studies

4) Revision of ASTM D7309 ballot to include baseline correction (presupposes item 1)

5) Draft Advisory Circular (presupposes items 1-4)

Conclusions

- FAA-industry working group has been developing a process to compare materials
- Current approach involves using Fire Growth Capacity (FGC) parameter in MCC to determine the similarity
- Good agreement between MCC tests and fire tests in numerous case studies
- Next steps: review by FAA regulatory officials for approval and release of updated guidance

Similarity criteria applied to Radiant Panel test results.

Case # / Samples	$\frac{\lvert P_a - P_b \rvert}{P_b} \leq \frac{\lvert X_a - X_b \rvert}{X_b}$		$\frac{\lvert P_a - P_b \rvert}{P_b} \leq \frac{2\sigma_{Xb}}{X_b}$	
	X = After flame time, (seconds)	X = Flame propagation distance, (inches)	X =After flame time, (seconds)	X = Flame propagation distance, (inches)
Case # 11 B-A1	0 ≤ 0	0 ≤ 0.3	0 ≤ 0	0 ≤ 0
Case # 11 B-A2	0 ≤ 0	0 ≤ 0	0 ≤ 0	0 ≤ 0

Similarity criteria applied to OSU test results.

Case #/ Samples	$\frac{\lvert P_a - P_b \rvert}{P_b} \leq \frac{\lvert X_a - X_b \rvert}{X_b}$		$\frac{\lvert P_a - P_b \rvert}{P_b} \leq \frac{2\sigma_{Xb}}{X_b}$	
	X = Peak HRR, (kW/m^2)	X = 2 min THR, (kW-min/m^2)	X = Peak HRR, (kW/m^2)	X = 2 min THR, (kW-min/m^2)
Case #1				
1.1	0.1 ≤ 0.1	0.1 ≤ 0.1	0.1 ≤ 0.1	0.1 ≤ 0.1
1.2	0.1 ≤ 0.1	0.1 ≤ 0.1	0.1 ≤ 0.1	0.1 ≤ 0.1
Case #2				
2.1	0.1 > 0*	0.1 > 0*	0.1 ≤ 0.1	0.1 ≤ 0.2
2.2	0.1 ≤ 0.1	0.1 ≤ 0.1	0.1 ≤ 0.1	0.1 ≤ 0.1
2.3	0.1 > 0*	0.1> 0*	0.1 ≤ 0.1	0.1 ≤ 0.1
2.4	0.1 > 0*	0.1 > 0*	0.1 ≤ 0.3	0.1 ≤ 0.1
Case #3				
3.1	0 ≤ 0	0 ≤ 0.1	0 ≤ 0.2	0 ≤ 0
3.2	0 ≤ 0.1	0 ≤ 0	0 ≤ 0.2	0 ≤ 0
Case #4	0 ≤ 0	0 ≤ 0	0 ≤ 0.1	0 ≤ 0.2
Case #6				
6.1.1	0.1 ≤ 0.3	0.1 ≤ 0.3	0.1 ≤ 0.5	0.1 ≤ 0.4
6.1.2	0.1 > 0*	0.1 ≤ 0.6	0.1 ≤ 0.3	0.1 ≤ 0.6
6.2.1	0.3 ≤ 0.3	0.3 ≤ 0.3	0.3 ≤ 0.5	0.3 ≤ 0.4
6.2.2	0.3 > 0*	0.3 ≤ 0.6	0.3 ≤ 0.3	0.3 ≤ 0.6

Similarity criteria applied to OSU test results cont.

Case #7	0.1 ≤ 0.1	0.1 ≤ 0.4	0.1 ≤ 0.1	0.1 ≤ 0.3
Case #8	0 ≤ 0	0 ≤ 0.1	0 ≤ 0.1	0 ≤ 0.1
Case #9 Lab A 9.1.a 9.2.a 9.3.a Lab B 9.1.b 9.2.b 9.3.b	 0 ≤ 0.2 0.1 ≤ 0.2 0.3 > 0* 0 ≤ 0.3 0.2 ≤ 0.2 0.3 ≤ 0.4	 0 ≤ 0.6 0.2 ≤ 1.8 0.3 ≤ 0.8 0 ≤ 0 0.2 ≤ 1.2 0.3 ≤ 0.8	 0 ≤ 0.5 0.2 ≤ 0.5 0.1 ≤ 0.5 0 ≤ 0.2 0.2 ≤ 0.2 0.3 > 0.2	 0 ≤ 2.5 0.2 ≤ 2.5 0.3 ≤ 2.5 0 ≤ 1 0.2 ≤ 1 0.3 ≤ 1
Case #10 Lab A Lab B	 0.1 ≤ 0.4 0.1 ≤ 0.1	 0.1 ≤ 0.7 0.1 ≤ 0.4	 0.1 ≤ 0.6 0.1 ≤ 0.2	 0.1 ≤ 0.4 0.1 ≤ 0.3
Case #12 Lab A 12.1.a 12.2.a Lab B 12.1.b 12.2.b Lab c 12.1.c 12.2.c	 0.1 > 0.1 0.2 ≤ 0.2 0.2 ≤ 0.3 0.2 ≤ 0.2 0.2 ≤ 0.3 0.1 > 0.1	 0.2 > 0.1 0.2 ≤ 0.7 0.2 ≤ 0.2 0.2 ≤ 0.6 0.2 ≤ 0.4 0.2 ≤ 0.6	 0.2 ≤ 0.2 0.2 ≤ 0.2 0.2 ≤ 0.2 0.2 ≤ 0.2 0.2 ≤ 0.3 0.2 ≤ 0.3	 0.2 ≤ 0.3 0.2 ≤ 0.3 0.2 > 0.1 0.2 > 0.1 0.2 ≤ 0.2 0.2 ≤ 0.2