Material Change Similarity Task Group

Microscale Combustion Calorimetry

March 10-11, 2020
Mobile, AL

Task Group Co-leaders:
Dr. Richard Lyon, FAATC
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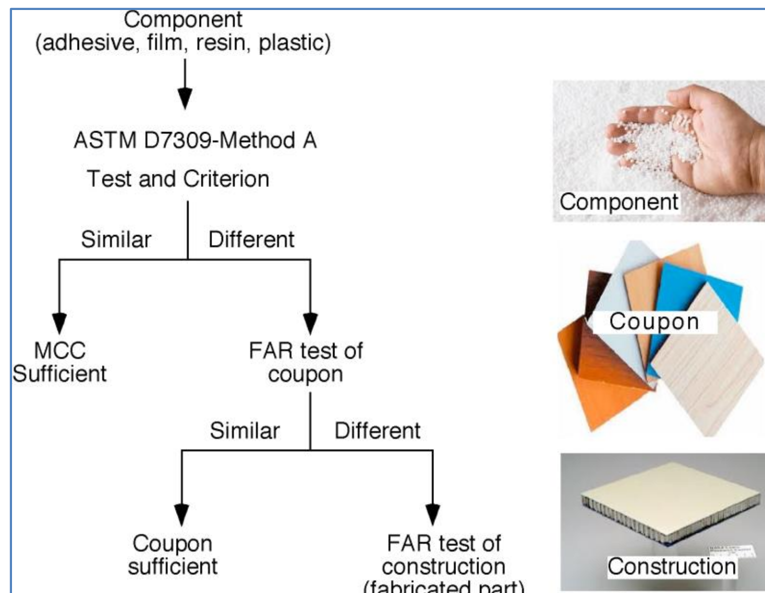
Overview - Task Group Goal

- Develop guidance using the Micro-scale Combustion Calorimeter (MCC)
  - Determine the flammability performance characteristics of a material.

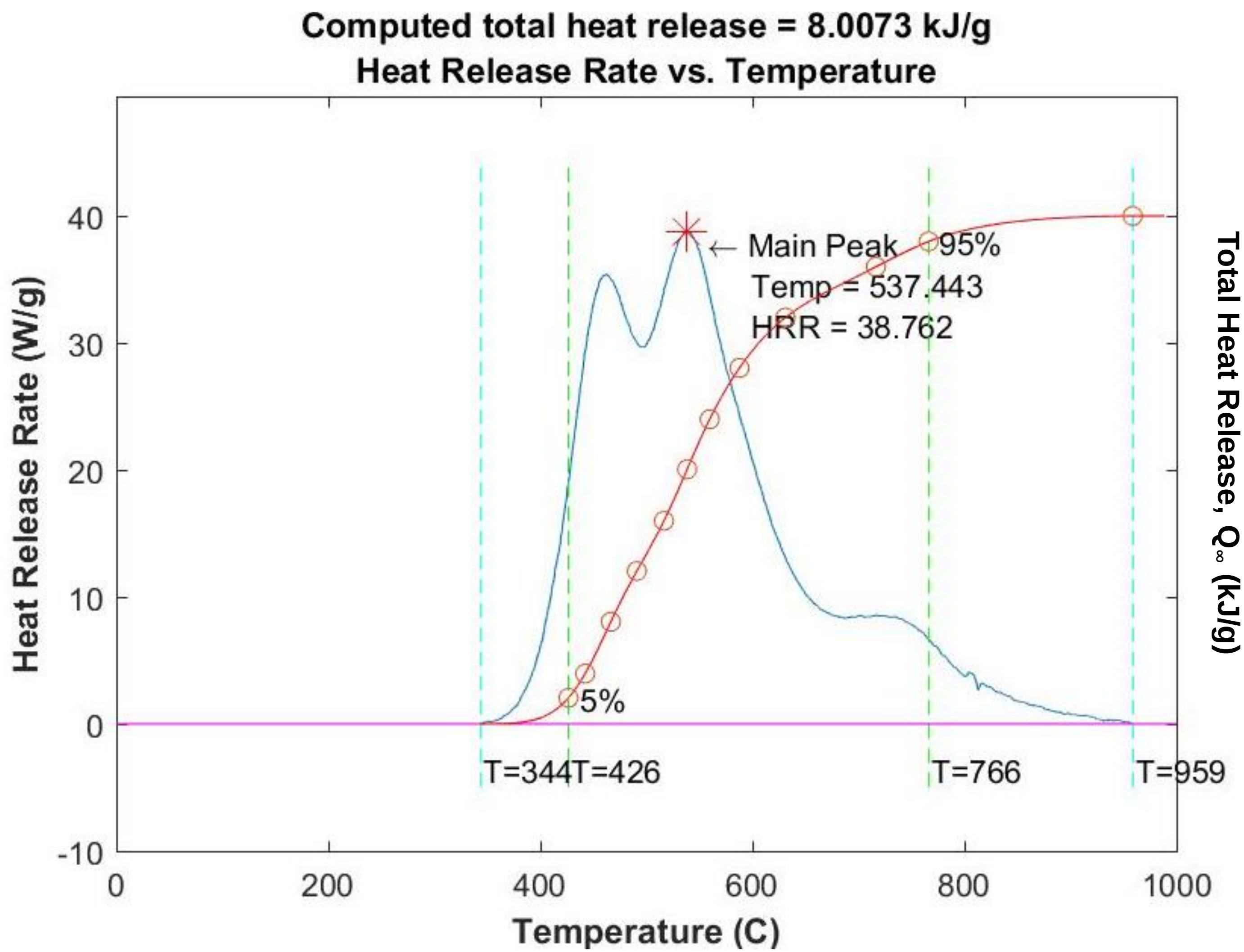
- Utilize the MCC method to compare the flammability properties
  - Compare currently certified material with those of the material that has been changed
  - Determine if there is significant change in the fundamental flammability properties with respect to fire test results.
  - Data supports a similarity 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.



Why Use MCC Method?

MCC method can identify material component heat release properties



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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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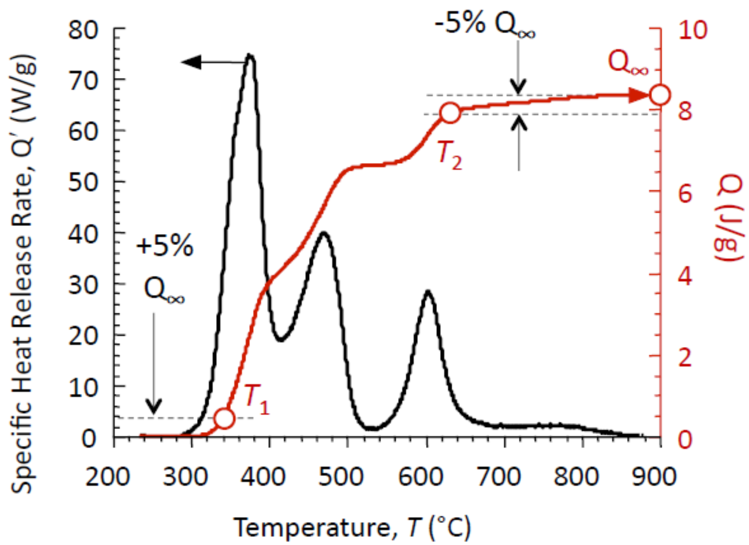
Activities since November 2019:

- MCC baseline correction developed by FAATC
- Baseline correction incorporated into beta-version of Boeing MCC Tool data reduction software – results consistent with FAA results
- Baseline correction submitted as ASTM D7309 ballot
  - ASTM D7309 Committee meeting in April
  - ASTM Inter-Lab Study (ILS) planned for this year
- Industry case studies completed to validate MCC Similarity guidance:
  - Phenolic resin systems
  - Adhesives & potting compounds
  - Decorative laminates
  - Thermoplastics
  - Paints/coatings
- Task Group Report-out: (R. Lyon)

Case studies completed using MCC parameter: Fire Growth Capacity (FGC)

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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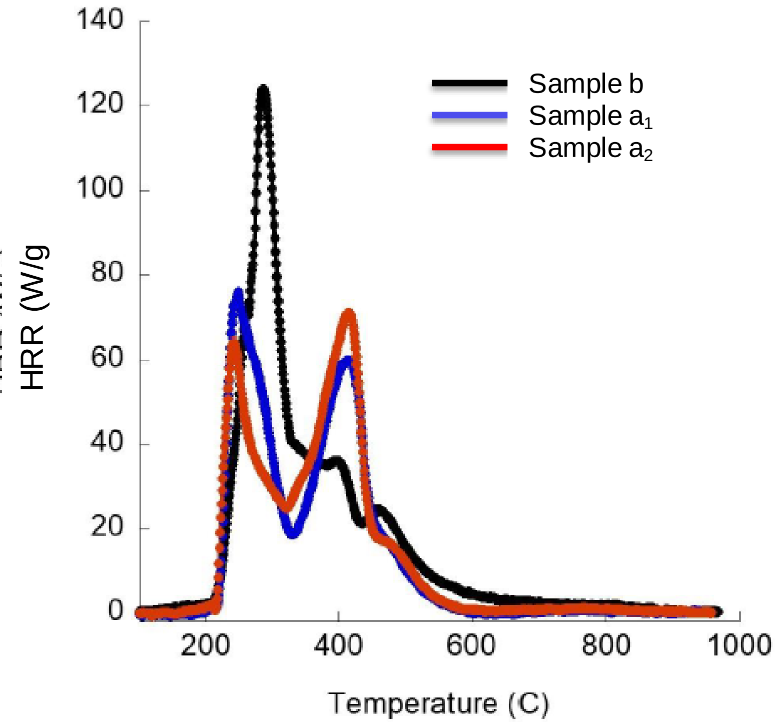
Example: Case study example/adhesive film

- ✓ 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/m^2)	2 min HR ($kW\text{-}min/m^2$)
Sample b	104 ± 2	45.5 ± 3.7	44.1 ± 1.1
Sample a_1	102 ± 3	44.4 ± 1.6	39.7 ± 1.1
Sample a_2	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/m^2)	2 min HR ($kW\text{-}min/m^2$)	pHRR (kW/m^2)	2 min HR ($kW\text{-}min/m^2$)
Sample b vs Sample a_1	Yes	Yes	Yes	Yes
Sample b vs Sample a_2	Yes	Yes	Yes	Yes

Analysis

Safronava Triennial Presentation (View in slide show mode)

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Updated Guidance Released

Summary of coupon level case studies

Case #	Changed Component	Coupon	pHRR (kW/m^2)	2min HR ($kW\text{-}min/m^2$)	Burn length (mm)	pHRR (kW/m^2)	2min HR ($kW\text{-}min/m^2$)	Burn length (mm)
			$\frac{\lvert P_a - P_b \rvert}{P_b} \le \frac{\lvert X_a - X_b \rvert}{X_b}$			$\frac{\lvert P_a - P_b \rvert}{P_b} \le \frac{2\sigma_{Xb}}{X_b}$		
1	Decorative Laminate color (grey vs dark brown)	1.1 Decorative laminate alone	Yes	Yes	Yes	Yes	Yes	Yes
		1.2 Decorative laminate on standard panel	Yes	Yes	Yes	Yes	Yes	Yes
2	Decorative laminate adhesive film FR components	2.1 Declam adhesive on fiberglass panel	No*	No*	Yes	Yes	Yes	Yes
		2.2 Declam adhesive on phenolic panel	Yes	Yes	Yes	Yes	Yes	Yes
		2.3 Declam adhesive on carbon fiber panel	No*	No*	Yes	Yes	Yes	Yes
		2.4 Declam adhesive on stow bin panel	No*	No*	Yes	Yes	Yes	No*
3.1	Adhesive film FR components (Sample 1 vs sample 2	Adhesive+ décor laminate + 2 ply phenolic	Yes	Yes	N/A	Yes	Yes	N/A
3.2	Adhesive film FR components (Sample 1 vs sample 3)	Adhesive+ décor laminate + 2 ply phenolic	Yes	Yes	N/A	Yes	Yes	N/A
4	Resin systems for use in ECS ducting	Resin + 2 ply aramid fiber laminate	Yes	Yes	N/A	Yes	Yes	N/A
5	Polymer supplier	Thermoplastic part	N/A	N/A	Yes	N/A	N/A	Yes

No = anomalous result because ΔX or $\sigma_{Xb} = 0$*

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Summary of coupon level case studies

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

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

Case #	Changed component	Coupon	pHRR (kW/m^2)	2min HR ($kW\text{-}min/m^2$)	Burn length (mm)	pHRR (kW/m^2)	2min HR ($kW\text{-}min/m^2$)	Burn length (mm)
6	Phenolic resin chemistry * Also tested 2 ply system in MCC	6.1 2 ply laminates	Yes	Yes	N/A	Yes	Yes	N/A
		6.2 6 ply laminates	Yes	Yes	N/A	Yes	Yes	N/A
7	Phenolic	2 ply phenolic laminates	Yes	Yes	N/A	Yes	Yes	N/A
8	Adhesive minor formulation change	0.047 in Kydex 6565 + adhesive + 0.032 in Al	Yes	Yes	N/A	Yes	Yes	N/A
9	Processing conditions	Thermoplastic specimen						
9.1	Reference material along with recycylate and additional pigment in 2 concentrations	**Lab A** Sample 1 vs Sample 2	Yes	Yes	N/A	Yes	Yes	N/A
9.2		Sample 1 vs Sample 3	Yes	Yes	N/A	Yes	Yes	N/A
9.3		Sample 1 vs Sample 4	No*	Yes	N/A	Yes	Yes	N/A
9.4 2 labs		**Lab B** Sample 1 vs Sample 2	Yes	Yes	N/A	Yes	Yes	N/A
		Sample 1 vs Sample 3	Yes	Yes	N/A	No	Yes	N/A
		Sample 1 vs Sample 4	Yes	Yes	N/A	No	Yes	N/A

No* - This is an anomalous result because ΔX or $\sigma_{Xb} = 0$

ASTM revisions needed to support Material Change Similarity

- Baseline correction incorporated into ASTM D7309
- FGC parameter incorporated (following technical publication)

Other ASTM Activities

- Inter-Lab Study (ILS) of MCC method by participating labs
  - Provides a measure of repeatability & Reproducibility (r & R)

Road map to Advisory Circular

1. ASTM ballot for D7309 submitted (Feb 14, 2020) Done
2. Inter-Lab Study (ILS) scope, participants, and schedule defined (April – May 2020)
3. Publication of scientific paper on Fire Growth Constant (Lyon et al) (mid-April 2020)
4. FAATC publishes report on remaining case studies (mid-April 2020)
5. ASTM ballot on baseline correction closed with all comments addressed (May 2020)
6. ILS planning (May 2020)
7. New ASTM ballot incorporating FGC parameter (July 2020)
8. ILS: Preliminary testing & analysis (August 2020)
9. Revised ASTM specification incorporating baseline correction (August 2020 – after re-ballot)
10. ILS study data completed (November 2020)
11. ILS summary/report out at ASTM D20.03 subcommittee (November-December 2020)
12. ASTM D7309 revised with all corrections and with FGC parameter (November-December 2020)
13. MCC Task Group/FAATC concurrence to FAA Transport Standards on AC draft guidance (1Q 2021)
14. Completion of AC draft defining guidelines for material similarity using the MCC method (2Q 2021)
15. Advisory Circular (AC) released by FAA (1Q 2022)

Note: Road map presents aggressive ASTM schedule with little buffer