Industry Standardization

Flammability Testing of Bonded Inserts: A Case Study

The Sixth Triennial International Fire & Cabin Safety Research Conference

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Flammability Testing of Bonded Inserts

Agenda

- **FAA Draft Policy - Means of Compliance**
- **What is a bonded insert?**
- **Industry Practice – Showing Compliance**
- **Industry Team Validation Proposal**
- **Initial Results**
- **Summary and Next Steps**

Flammability Testing of Bonded Inserts

FAA Draft Policy

Currently, ANM-115-09-XXX is available as an undated draft. Reference item #42 – Bonded Inserts

Part 1, acceptable methods without additional data

Reference Number	Feature / Construction	25.853(a) Bunsen Burner Test Requirement/Similarity	25.853(d) Heat Release and Smoke Test Requirement/Similarity
42	Bonded Inserts	Test adhesive to 12-second vertical.	See Part 2 of this attachment.

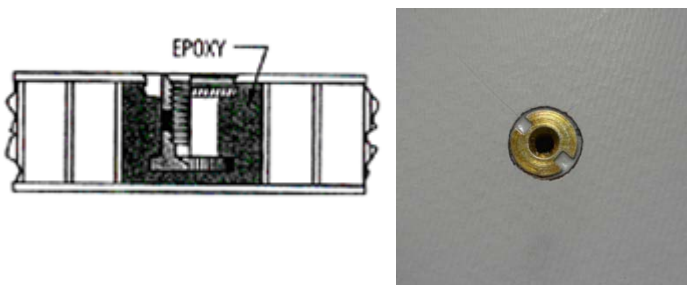
Part 2, methods of compliance that require supporting data

Reference Number	Feature / Construction	25.853(a) Bunsen Burner Test Requirement/Similarity	25.853(d) Heat Release and Smoke Test Requirement/Similarity
42	Bonded Inserts	No test required.	No test required.

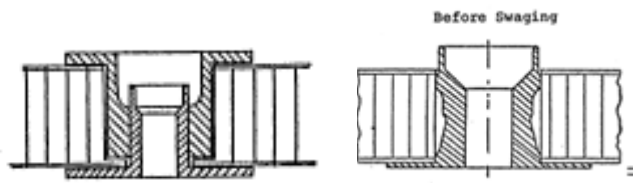
Flammability Testing of Bonded Inserts

What is a Bonded Insert?

- Inserts are defined in the “fastener” category. Two main insert designs are predominant in interior panel fabrication. Inserts can be plastic or metal.
  - Blind Insert: Blind inserts contains an internal retaining nut. Blind inserts are commonly metal construction.
  - “Through” Inserts: Flanged inserts, either one piece or two, and creates a hole “through” the panel for a bolt/screw to be inserted through the panel.



Blind Insert

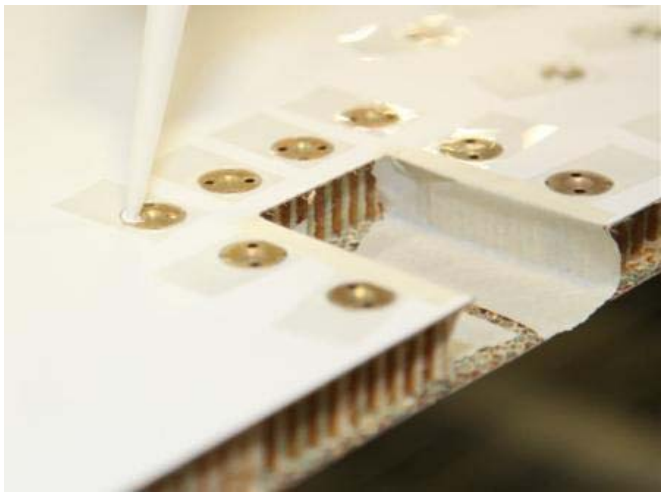


Flanged “Through” Insert

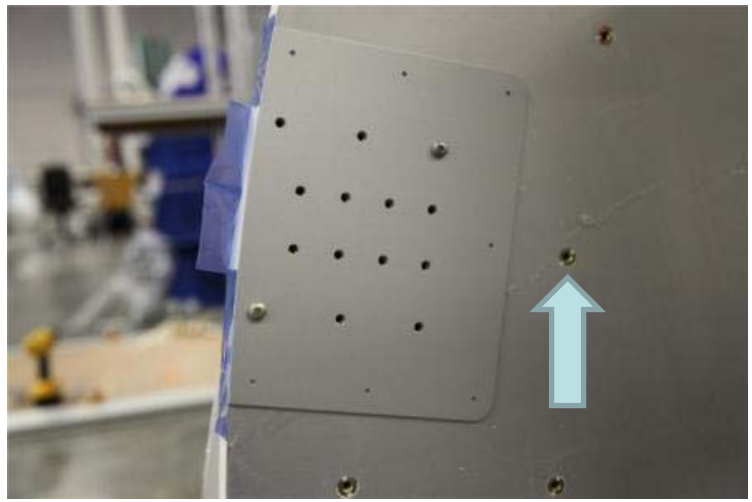
Flammability Testing of Bonded Inserts

What is a Bonded Insert?

Example parts:



Inserts around a cutout for a fitting

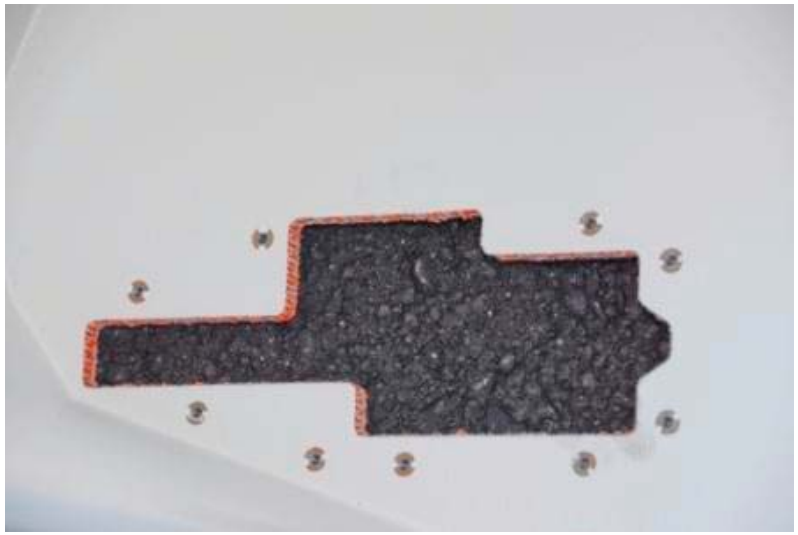


Inserts in center of panel for attaching wire bundles

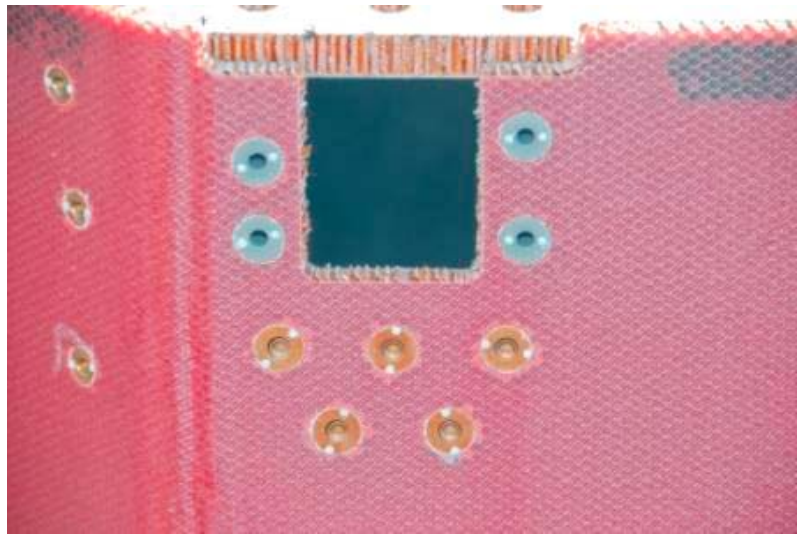
Flammability Testing of Bonded Inserts

What is a Bonded Insert?

Example parts:



Inserts around a cutout for a fitting



Inserts around a cutout for a fitting

Flammability Testing of Bonded Inserts

What is a Bonded Insert?

Example parts:

Inserts along an edge for trim attachment

Lineal inserts for trim/rubstrip

Flammability Testing of Bonded Inserts

Industry Practice - Compliance

- Industry and many regulatory agencies have considered bonded inserts to be “small parts” resulting in no test requirement for both 14 CFR 25.853 (a) and (d), Appendix F, Part I, (a)(1)(v).
- Some industry participants have had internal requirements that the adhesive/potting material meet the 12-second Bunsen burner requirement when tested in a “brick” or a plaque of material.
- Inserts bonded into panels have design attributes that establish inserts as a localized non-exposed feature within the cabin.
- General opinion across industry is that bonded inserts have low probability to negatively impact cabin fire safety when using different types of bonded inserts and adhesives.

Flammability Testing of Bonded Inserts

Industry Practice - Compliance

Design Attributes of Bonded Inserts:

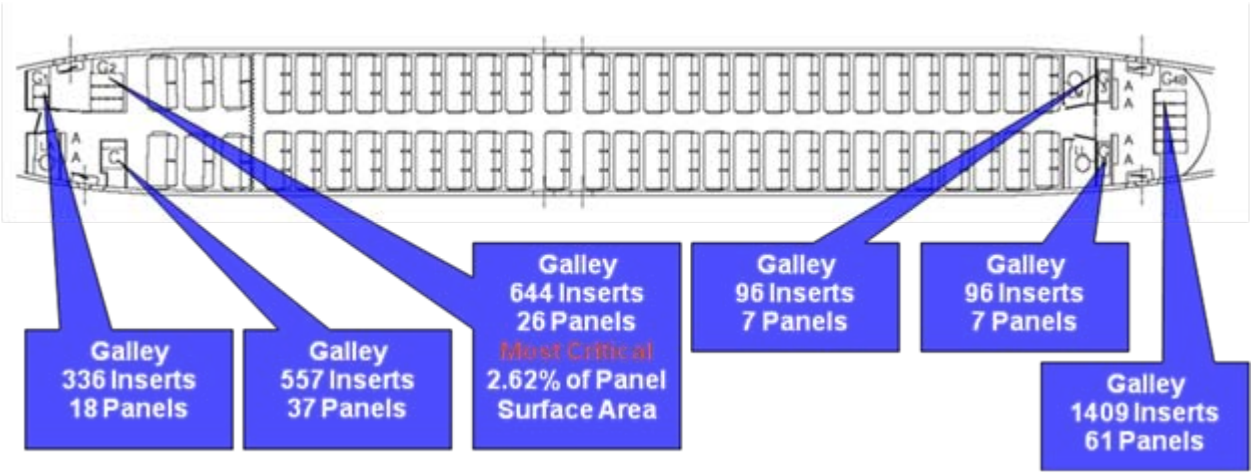
1. **Inserts are not a significant part of the "panel."**
2. **Inserts are discrete "small parts" and traditional usage/spacing does not contribute to flame propagation.**
3. **Bonding material (adhesive / potting compound) is fully embedded within the panel and not exposed.**
4. **Generally no continuous adhesive between two potted inserts. Local areas intended to provide high loading may have close spacing between inserts.**
5. **Inserts are used for attaching other smaller components such as a shelf, bracket, trim detail, etc… and generally require a "linear" application of inserts and thus the quantity of inserts in a local area would not be significant.**
6. **When used to attach parts, the part being attached will physically limit the number of inserts installed on the underlying panel.**
7. **The attached component will fully cover the insert making the insert & bonding material fully shielded.**

Flammability Testing of Bonded Inserts

Industry Practice - Compliance

Bonded Inserts in the Cabin:

- **Commodities where inserts are common are galleys and lavatories. These commodities can contain many inserts (~100+) as they are assembled using several panels.**
- **The example below illustrates the use of inserts and their relative small area compared to overall cabin.**



- **The surface area of all inserts combined is less than 3% of the total panel surface area. This area is not considered significant under the "large surface area" criteria of the heat release regulation.**

Flammability Testing of Bonded Inserts

Industry Team Validation Plan

- The plan proposed by the Industry Team to validate the “no test” requirement includes:

1. Generate material characterization data:
   - Test a range of common industry adhesive materials and constructions
   - MCC, Bunsen burner, OSU/Smoke Density

2. Correlate to results on larger configurations representative of installed configurations:

   - **Bunsen Burner – In-flight Fire Scenario**
     - Foam block testing
   - **Heat Release/Smoke Density – Post Crash Fire Scenario**
     - OSU/Smoke Density with “attached” components

- This approach is similar to the way a new regulatory requirement is developed.

Flammability Testing of Bonded Inserts

Developing Flammability Requirements

I. Cabin Safety Improvement Requirement Identified

- Accident / Incidents
- Cabin safety Improvement Identified

II. Identification of Targeted Commodities, Criteria/Boundaries, and Available Materials.

- Involves considerable discussion and preliminary testing to define a project approach

III. Material and Panel Characterization

- Bunsen Burner
- OSU
- MCC
- Foam Block
- Radiant Panel

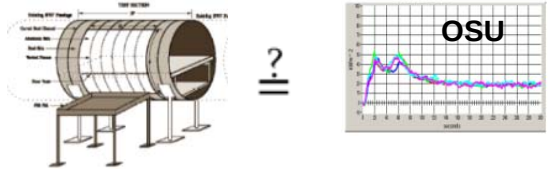
IV. Intermediate/Full Scale Testing

Actual Airplane Level Performance

- Test of actual cabin configurations ensures appropriate levels of fire safety improvement can be realized

V. Correlate Data, Refine Criteria, Establish Preliminary Test Requirements

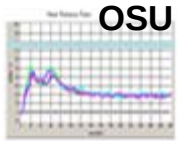
- Involves considerable discussion and analysis, and may result in further testing to define detailed test requirements



VI. Set Requirements:

Lab Scale Test Requirements Defined

- Requirement determined to ensure improvement in fire safety.
  - 65/65?
  - 100/100?
  - Size Criteria
  - No Test
- NPRM



Flammability Testing of Bonded Inserts

Industry Team Validation

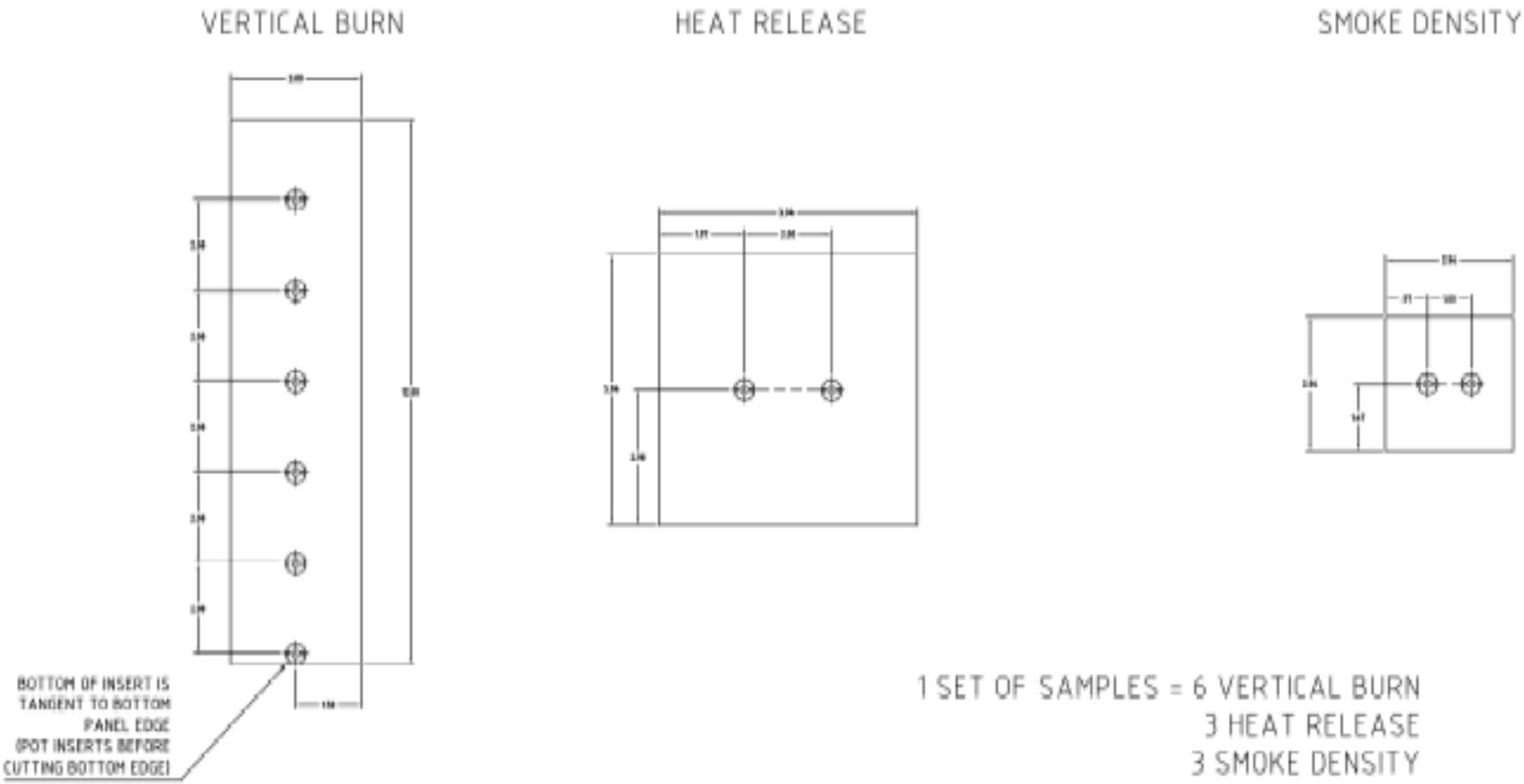
- The industry team has started gathering material characterization test data:
  - Bunsen burner
    - Honeycomb specimens, with inserts
    - Resin plaques
  - Microscale Cone Calorimeter - Resin
  - OSU/Smoke Density
    - Honeycomb specimens, with 2 inserts
    - Honeycomb specimens, with “attached items”
    - Resin plaques
  - Foam Block – Honeycomb panels with rows of inserts

NOTE: Current test methods were not developed to evaluated localized features. Results need to be taken in context and used for general comparison only, and not compared to the regulation requirements. This is particularly important with the heat release/smoke density test methods developed to address large exposed surface areas of panels.

Flammability Testing of Bonded Inserts

Industry Team Validation

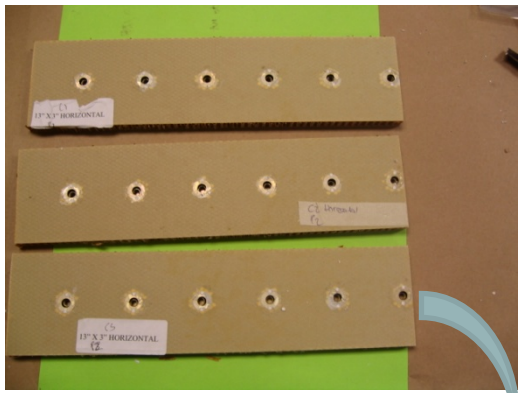
- Bunsen Burner, Heat Release (OSU), and Smoke Density Test Configurations:



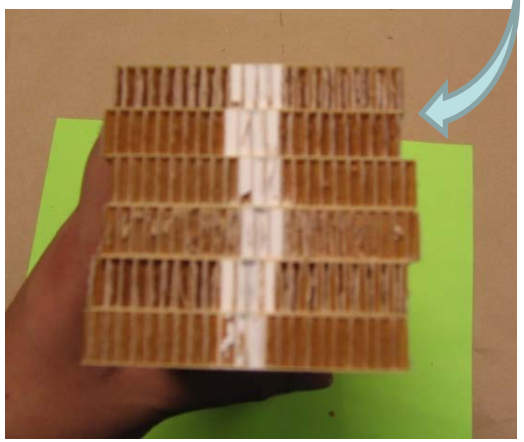
Flammability Testing of Bonded Inserts

Industry Team Validation

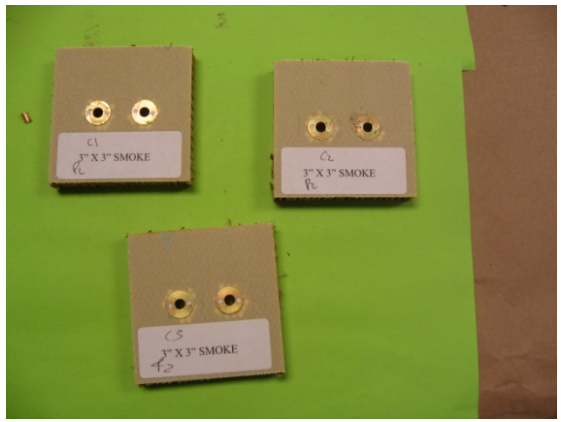
- Bunsen Burner, Heat Release (OSU), and Smoke Density Test Configurations:



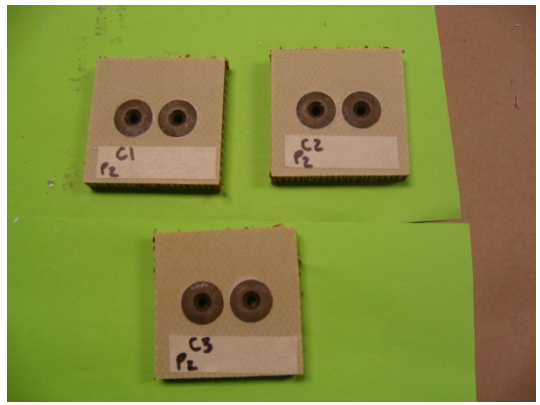
Blind inserts - BB



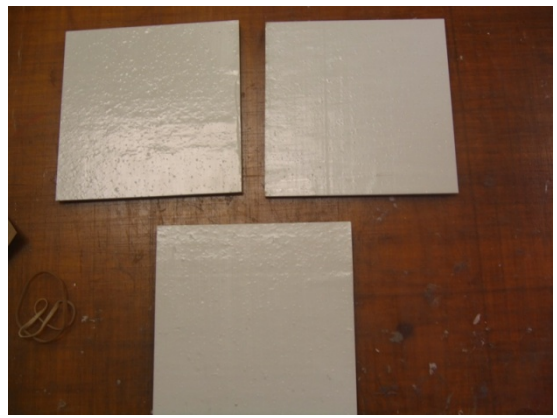
Blind insert
Exposed Edge for test



Blind/flush inserts –
Smoke Density



2-Piece Plastic “Through” Inserts

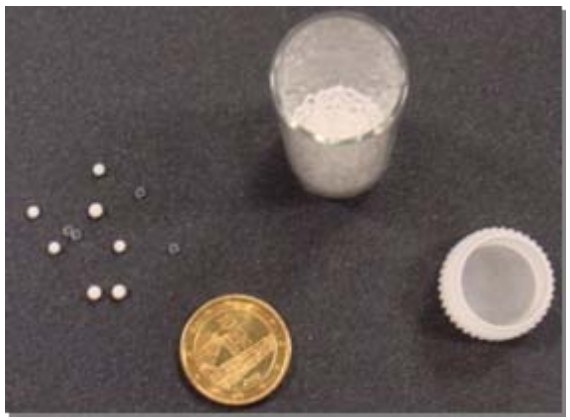


Adhesive Plaque - OSU

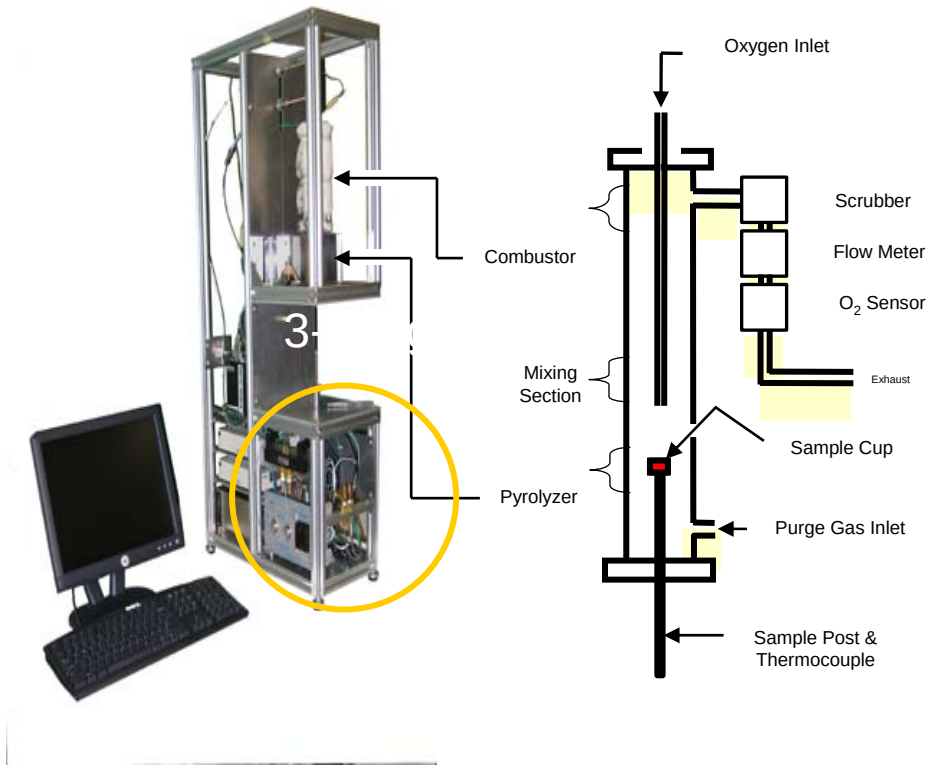
Flammability Testing of Bonded Inserts

Industry Team Validation

- Microscale Cone Calorimeter –
  - Uses small quantity of resin



Sample Size – 5mg



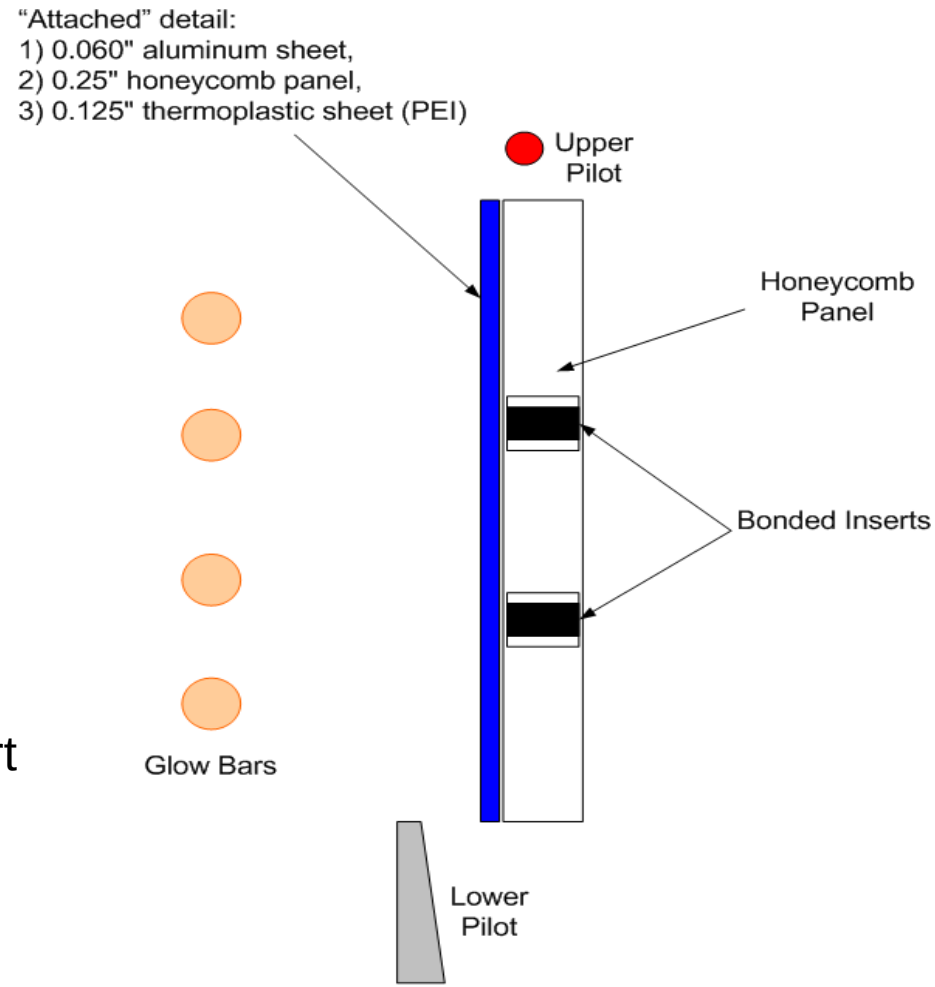
Flammability Testing of Bonded Inserts

Industry Team Validation

Heat Release with Attached Items: Post Crash Fire Scenario

Assess heat release properties of installed configurations:

Rationale:
- Inserts are used to attach other parts.
- The other part covers the inserts and are no longer exposed.
- The attached item will shield the insert from direct heat impingement



OSU Configuration – Bonded Inserts with Attached Panel

Flammability Testing of Bonded Inserts

Industry Team Validation

Foam Block Test Configurations: In-Flight Fire Scenario

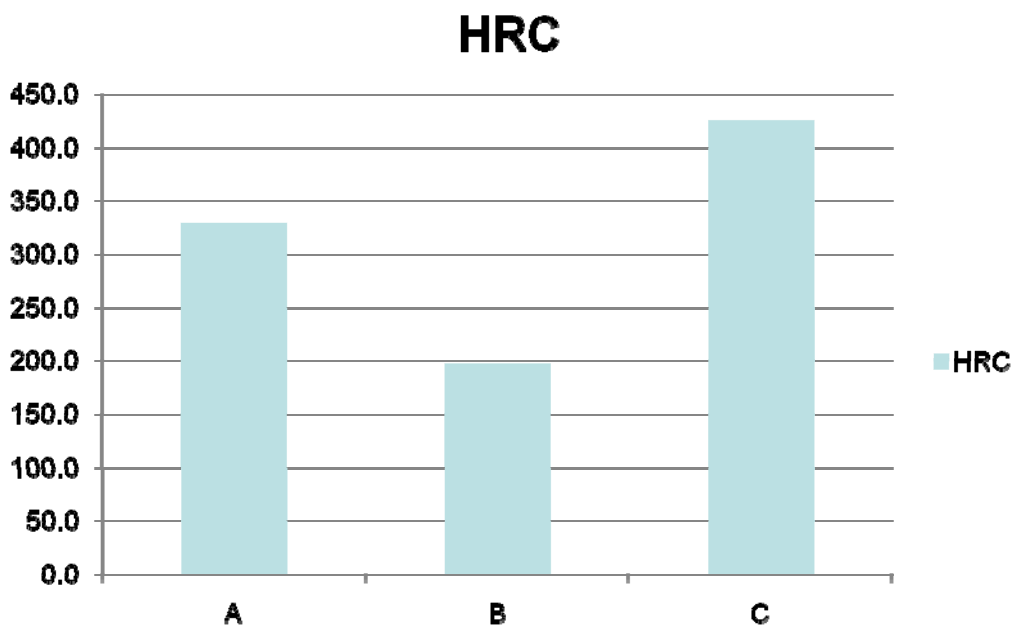
- The foam block test will assess ignition and flame spread to determine if and how inserts contribute to a fire scenario. The foam block test is robust enough to provide the test data necessary to assess fire performance of in-flight.

Flammability Testing of Bonded Inserts

Initial Data

- MCC Data
  - Variation between different adhesives
  - Did not see this variation in honeycomb OSU and VBB samples

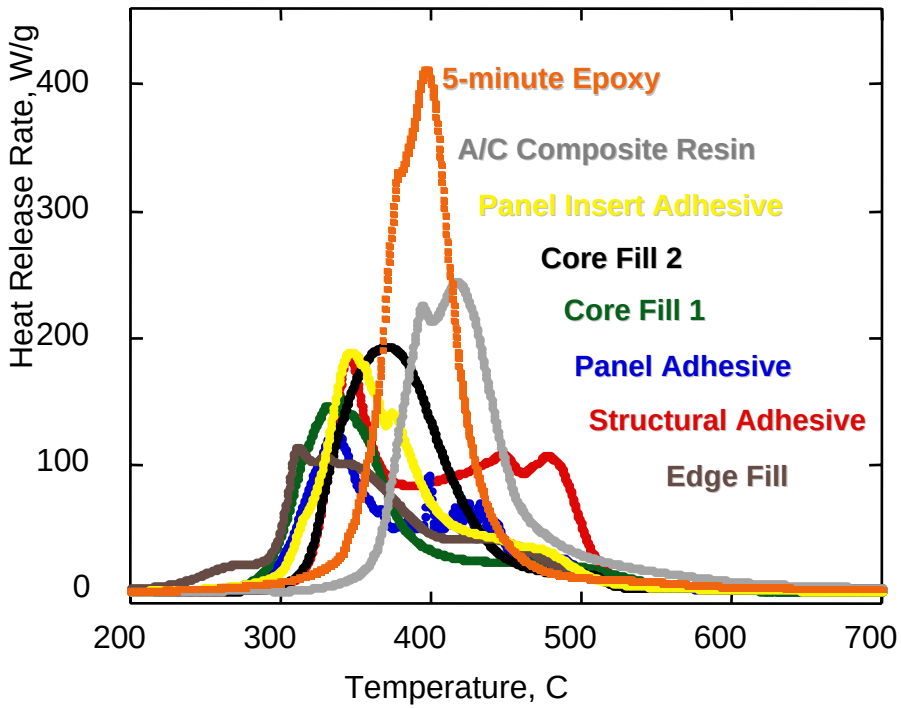
	HRC	HR	Char Yeild		
A	328.0	15.6	29.9	A= 318FR	
B	196.00	15.20	35.8	B = Epocast 1618	
C	425.00	27.40	6.7	C = Epibond 420	

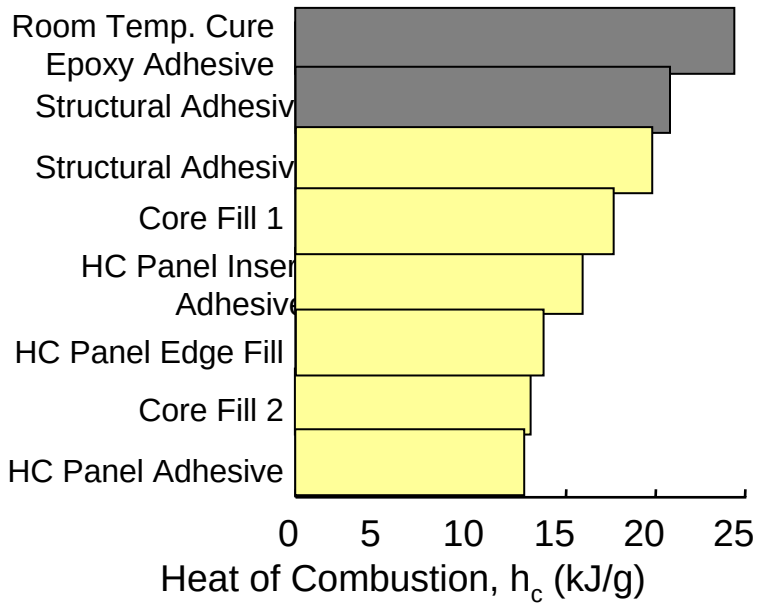


Flammability Testing of Bonded Inserts

Initial Data

- MCC Data – FAA Information (Rich Lyon presentation March 2010)
  http://www.fire.tc.faa.gov/pdf/materials/March10Meeting/lyons-0310-adehsives.pdf





Flammability Testing of Bonded Inserts

Initial Data

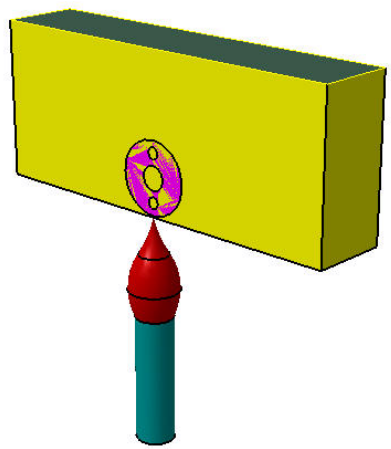
- Bunsen Burner:
  - No effect on burn length. Burn length is dependant on base panel. Does not propagate between inserts.
  - 12-second vertical results often acceptable
  - 60-second vertical extinguishing times vary for different adhesives.

POTTING: EPOCAST 1618

	F1			F2		
RUN #	EXT TIME	LENGTH	DRIP	EXT TIME	LENGTH	DRIP
RUN 1	0	2.0	ND	0	0.2	ND
RUN 2	3.7	1.7	ND	0	0.2	ND
RUN 3	80.6	2.0	ND	0	0.1	ND
AVG	**28.1**	**1.9**	**ND**	**0.0**	**0.2**	**ND**

POTTING: EPIBOND 420

	F1			F2		
RUN #	EXT TIME	LENGTH	DRIP	EXT TIME	LENGTH	DRIP
RUN 1	60+	3.6	ND	0	0.2	ND
RUN 2	60+	2.2	ND	2.5	0.2	ND
RUN 3	60+	2.1	ND	0	0.3	ND
AVG	**60+**	**2.6**	**ND**	**0.8**	**0.2**	**ND**



Flammability Testing of Bonded Inserts

Initial Data

- Heat Release & Smoke Data – Honeycomb with inserts
  - Minimal impact with inserts exposed
  - Similar performance of three different adhesives
  - Similar performance between metal and plastic inserts

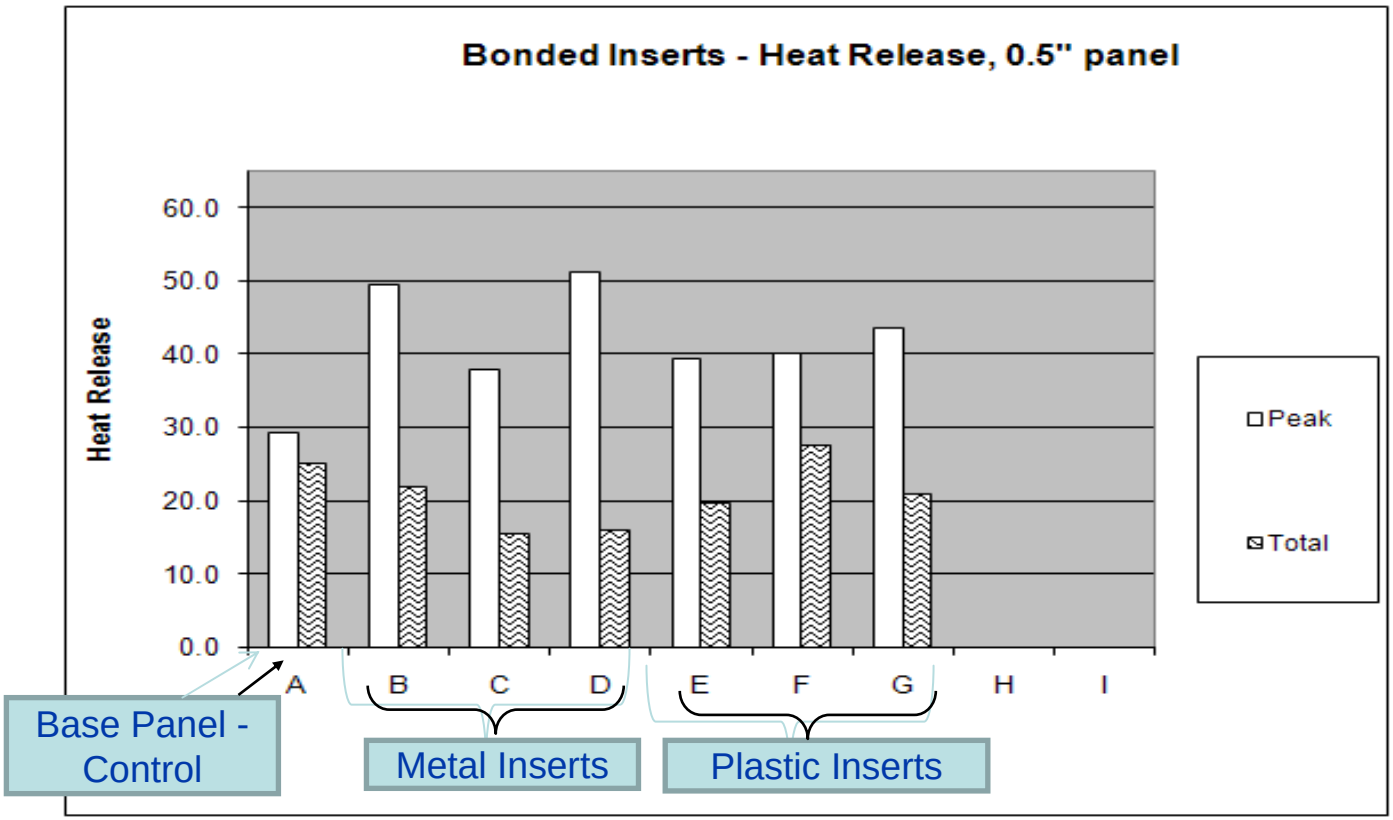
	0.5" Panel		
	Peak	Total	
A	29.2	25.0	A = Control, **Panel 0.5"**
B	49.38	21.75	B = 2 Insert, metal (Adhesive 318)
C	37.91	15.32	C = 2 Insert, metal (Adhesive 1618)
D	51.01	15.89	D = 2 Insert, metal (Adhesive 420)
E	39.21	19.51	E = 2 Insert, non-metal (Adhesive 318)
F	39.98	27.47	F = 2 Insert, non-metal (Adhesive 1618)
G	43.40	20.96	G = 2 Insert, non-metal (Adhesive 420)
H	In-Work	In-Work	H = 2 insert w/attached panel, alum sheet
I	In-Work	In-Work	I = 2 insert w/attached panel, compostie panel

Graph on next page

Flammability Testing of Bonded Inserts

Initial Data

- Heat Release & Smoke Data – Honeycomb with inserts (data table)
  - Different adhesives and inserts behave similarly
  - Higher peak heat release, lower total heat release



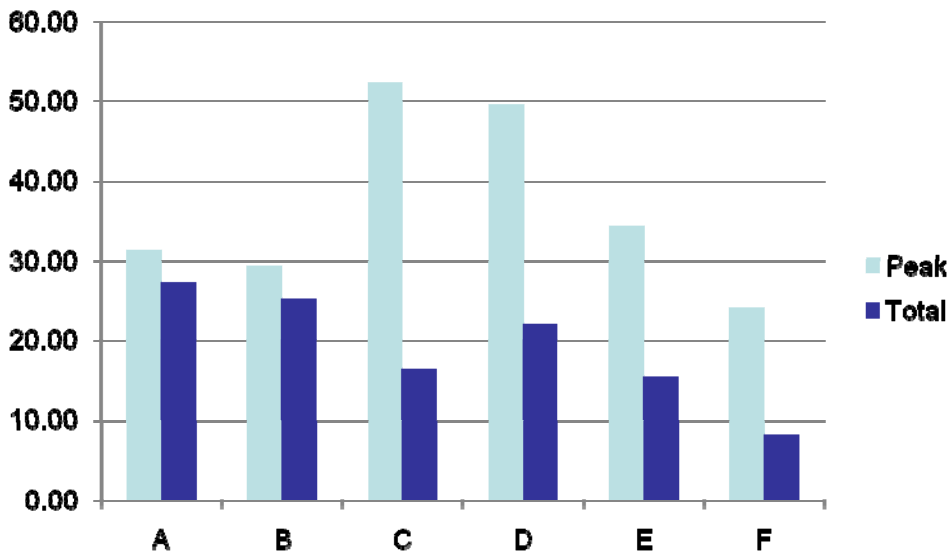
Flammability Testing of Bonded Inserts

Initial Data

- Heat Release & Smoke Data – Honeycomb with inserts, Panel Thickness

Metal Insert with 318 Adhesive			
	Peak	**Total**	
A	31.11	27.04	A = Control, **Panel 0.25"**
B	29.2	25.0	B = Control, **Panel 0.5"**
C	52.07	16.16	C = 2 Insert, metal, 0.25"
D	49.38	21.75	D = 2 Insert, metal, 0.5"
E	34.22	15.16	E = 2 insert, metal, 0.75"
F	23.84	8.03	F = 2 Insert, metal 1.0"

- Similar results below 0.5”
- Similar results above 0.5”



Flammability Testing of Bonded Inserts

Industry Team Validation

- Foam Block:
  - Evaluate poor performing materials and good performing materials
  - Compare to Bunsen burner and heat release test results
  - Determine if correlation exists
  - Determine final justification of “no test” requirement

Flammability Testing of Bonded Inserts

Summary

- Using bonded inserts is a common panel assembly method.
- Inserts are small localized features, non-exposed by design.
- Industry team is confirming there is no cabin safety impact on flame propagation and heat release properties of installed configurations.
- Initial data indicates:
  - No correlation between resin properties and honeycomb configurations
  - No impact on flame propagation (burn length) – in-flight fire scenario
  - No significant impact on heat release – post crash fire scenario
- Need to complete foam block and OSU with “attached features”
- After completing the data analysis, the Industry Team report will be submitted to the FAA for approval and validation of the draft policy.