Preview of the NASA NNWG NDE Sample Preparation Handbook

MSFC - UAHuntsville

UAH

In Cooperation with NASA
Marshall Space Flight Center
Engineering Directorate
Materials & Processes Laboratory
Damage Tolerance Assessment Branch
Non-Destructive Evaluation Team

Non-Destructive Evaluation Sample Preparation Handbook

Draft -This Handbook is for guidance only and should not be cited as a requirement

UAHuntsville
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Cooperative Agreement NNM05AA22A

Prepared by W. Thompson

Abstract Overview of Contents

- Step-by-step “how-to” fabrication documentation of every kind of sample that is fabricated for MSFC by UAHuntsville, including photos and illustrations.
- Tabulation of what kind of samples are being fabricated for what NDE method.
- Detailed instructions/documentation of the inclusion/creation of “defects”.
- Detailed specifications for materials, processes, and equipment.
- Case histories and/or experiences with the different fabrication methods and defect inclusion techniques.
- Discussion of ‘pitfalls’ and difficulties associated with sample fabrication and defect inclusion techniques.
- Discussion of why certain fabrication techniques are needed as related to the specific NDE methods.

NDE Samples

- SOFI Foam (External Tank)
- Solid Carbon-Carbon weave composite (Composite Crew Module)
- Phenolic honeycomb with Aluminum and composite faces (Common Bulkhead, Inter-stage)
- Aluminum honeycomb with composite faces (Common Bulkhead, Inter-stage)
- Flame Trench Simulator
- Friction Stir Welded (Butt Joint welded) Al Plates

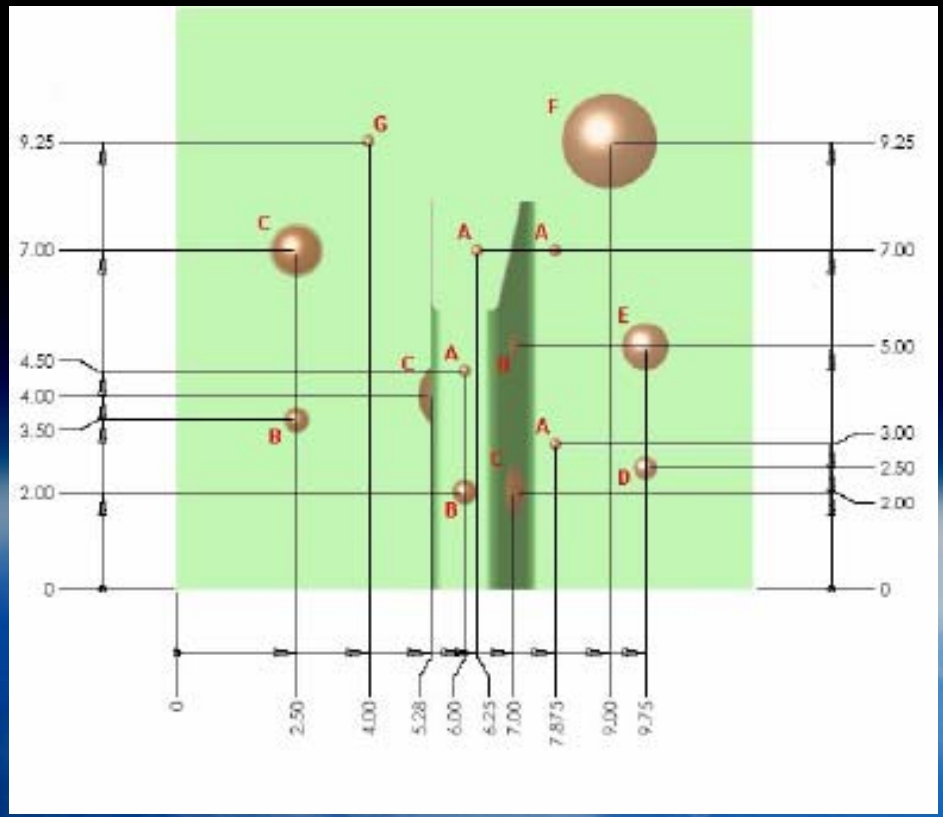
Example content for SOFI Foam

This excerpt pertains to creating more ‘natural’-like voids in the foam.

… After the panel cools, the stopcocks are opened one at a time to let the air out. Once pressure equilibrium is reached, the catheter can be removed and the void remains inside the foam structure. The bottom figure shows the geometry of the void left behind in the panel. This technique is very labor intensive. The voids that were formed had an interaction at the interface between the outer skin of the catheter and SOFI foam that leaves an extra thick rind compared to natural voids.

More example content for SOFI Foam

This excerpt shows one of the flaw mappings within a SOFI test panel.



… The foam inserts started out as core samples of the same type of foam from which the panels were sprayed. The core plugs were roughly shaped with hand tools, including a vacuum chuck and a radiusing attachment for a metal lathe. The roughly shaped foam inserts were mounted on a vacuum chuck and a radiusing tool was used to shape them into tiny solid disks.

A – 0.25” Substrate De-lamination
B - 0.5” Substrate De-lamination
C - 1.0” Substrate De-lamination
D – 0.25” Mid-Plane De-lamination
E – 0.5” Mid-Plane De-lamination
F – 1.0 “Mid-Plane De-lamination
G – omitted

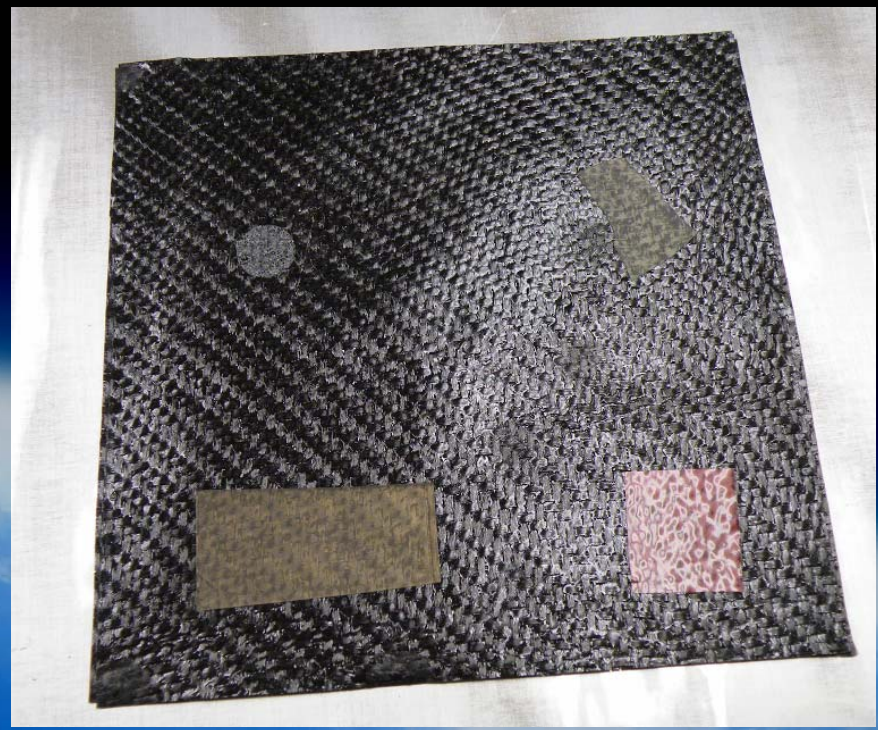
Defects included for SOFI Foam

- De-bonds at the bondline
- Inclusions/foreign object debris (FOD)
- Voids

Example content for solid carbon composites

This excerpt deals with the Fabrication of solid carbon composite test samples.

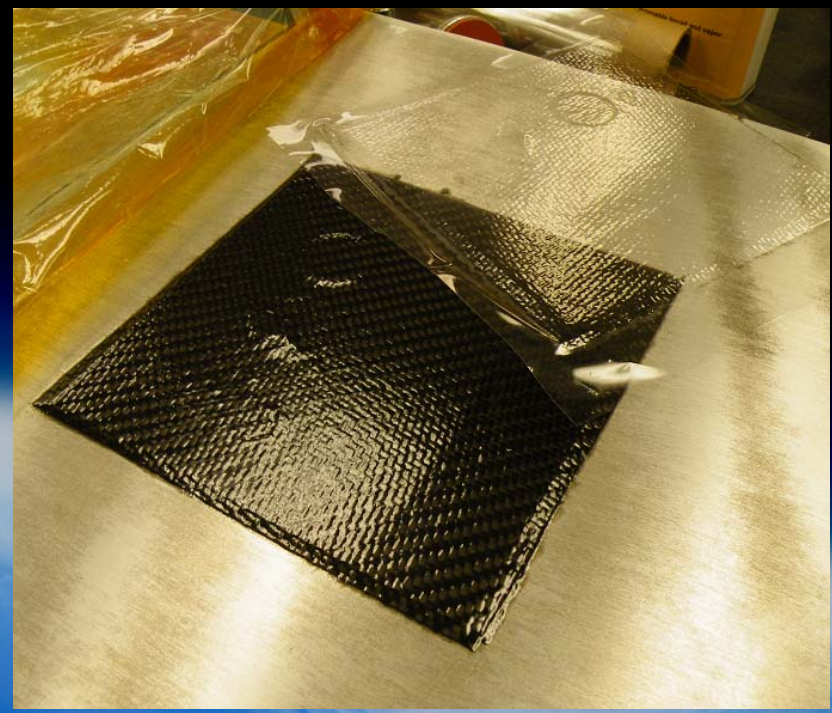
… When handling, or especially cutting carbon fiber, gloves should be worn to prevent irritation. The dust that is created when cutting or sanding carbon can be dangerous. It is said that the particles can become lodged in the lungs and are not easily removed by coughing. The resins that are in carbon fiber may also present a hazard when they are inhaled. The particles in carbon dust can also get on your clothes and then transfer to anything around you.



More example content for solid carbon composites

Another excerpt dealing with the Fabrication of solid carbon composite test samples

- *3k 2x2 twill weave was used in all panels mentioned in this document.*
- *Each panel is 12” square and 8 layers deep with flaws between the fourth and fifth layers.*
- *Use ¾ inch thick aluminum “tooling plates” treated with Frekote release agent and a release film layer to facilitate breaking the panels free.*
- *Cut the layers before beginning the lay up process. Cutting pre-impregnated carbon is easier while the epoxy is very cold, and less sticky.*
- *Use a pre-cut guide to size and cut each layer for uniformity.*



Defects included for Solid Composite Composites

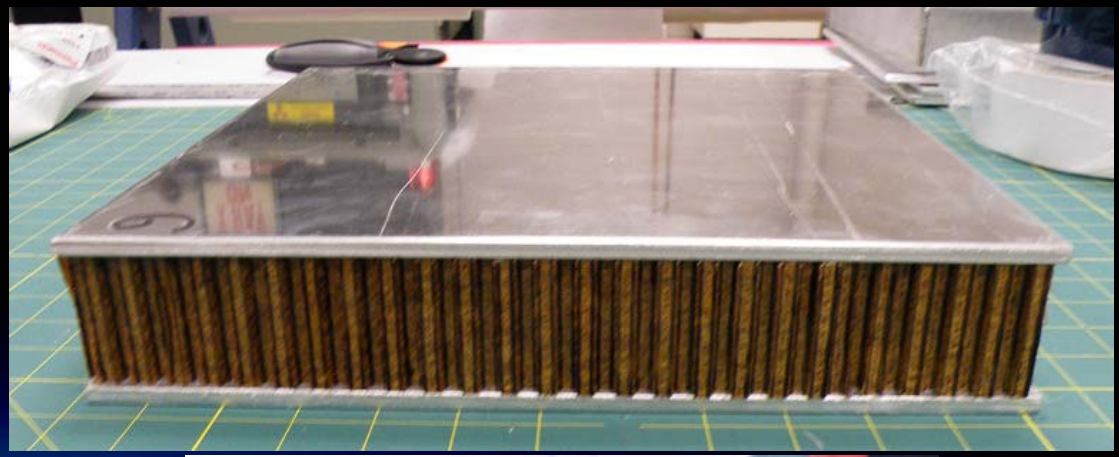
Fiber breaks (cuts)

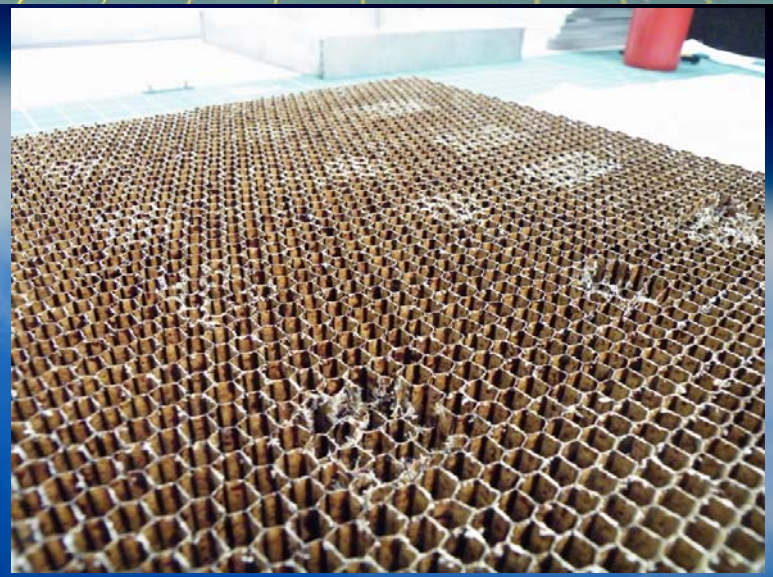
- Porosity (embedded silica micro-balloons)
- Inclusions/foreign object debris (FOD)
- Delaminations
- *pre-cured tab indentions*
- *pull-tab indentions*
- *cut-outs*

Example content for Phenolic Honeycomb with Aluminum Faces

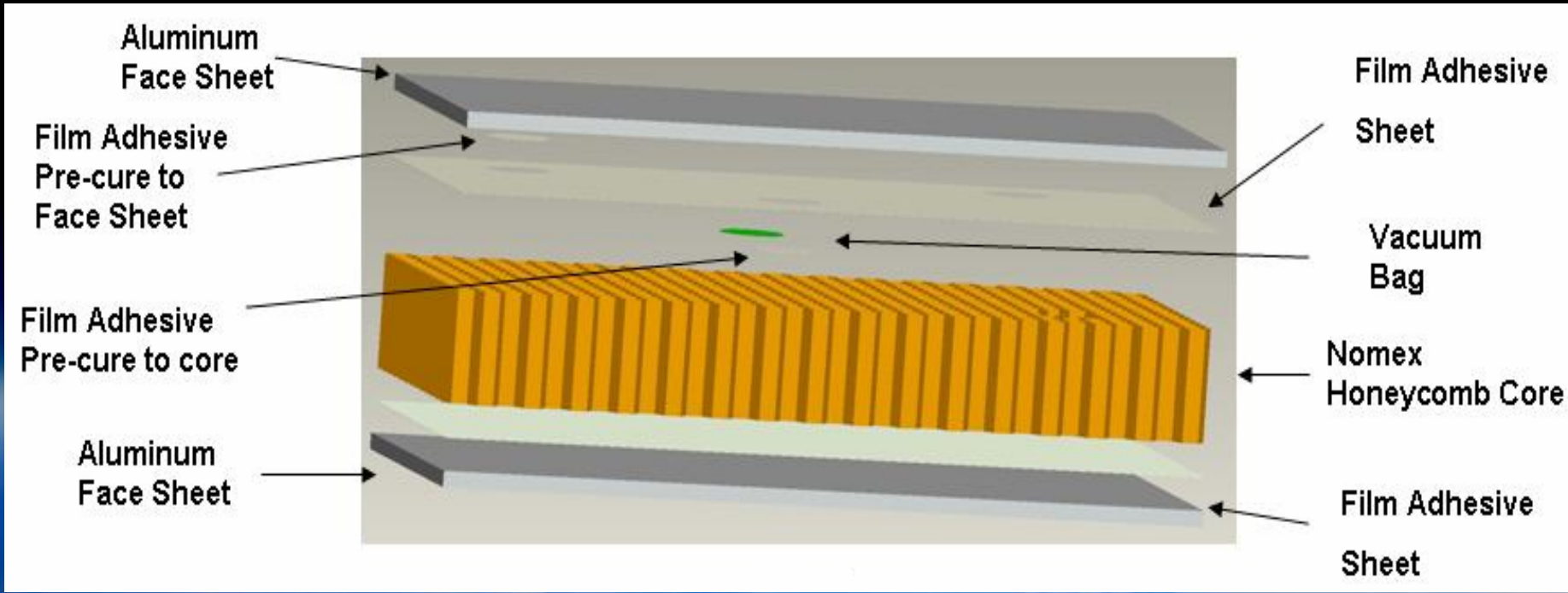
This excerpt discusses "milled core" defects in phenolic Honeycomb

… Phenolic honeycomb is easily 'machined', however, creating a known-depth defect can be difficult. Honeycomb machined with a CNC mill to simulate de-bonds is shown in the image (to the right). Note the 12 slight visual indications of the milled areas.





More example content for Phenolic Honeycomb with Aluminum Faces



Solid model rendering will be used to aid in the visualization of sample lay-ups and fabrication methods

Defects included for Phenolic Honeycomb with Aluminum Faces

- Inclusions/foreign object debris (FOD)

- De-bonds
  - *Pre-cure (to face/ to core)*
  - *Milled Core*
  - *Shim*
  - *Edge shim*

Example content for Alumium Honeycomb with Composite Faces

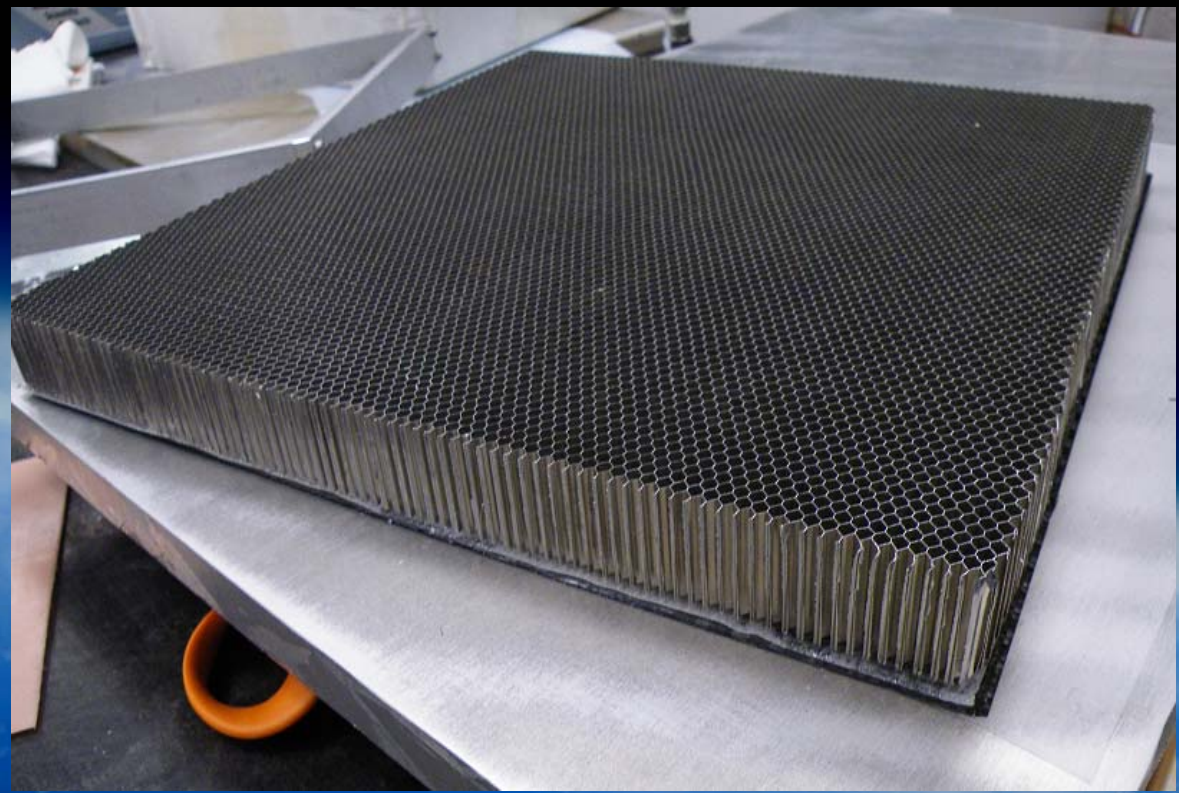
This excerpt reveals one of the difficulties of working with aluminum honeycomb

… Using a CNC mill produces good results in simulating de-bonds for honeycomb structures. When working with aluminum, galling and tearing must be prevented. In this case, a waterproof frame is constructed in order to freeze the panel's honeycomb section to facilitate milling.

More example content for Alumium Honeycomb with Composite Faces

Another excerpt discussing aluminum honeycomb

… Sharp edges must be avoided when handling the aluminum honeycomb, even a normal laboratory glove can provide some protection against cuts.



Defects included for Alumium Honeycomb with Composite Faces

- Inclusions/foreign object debris (FOD)
- De-bonds
  - *Pre-cure (to face/ to core)*
    - *Milled Core*
      - *Shim*
      - *Edge shim*

Example content for Phenolic Honeycomb with Composite Faces

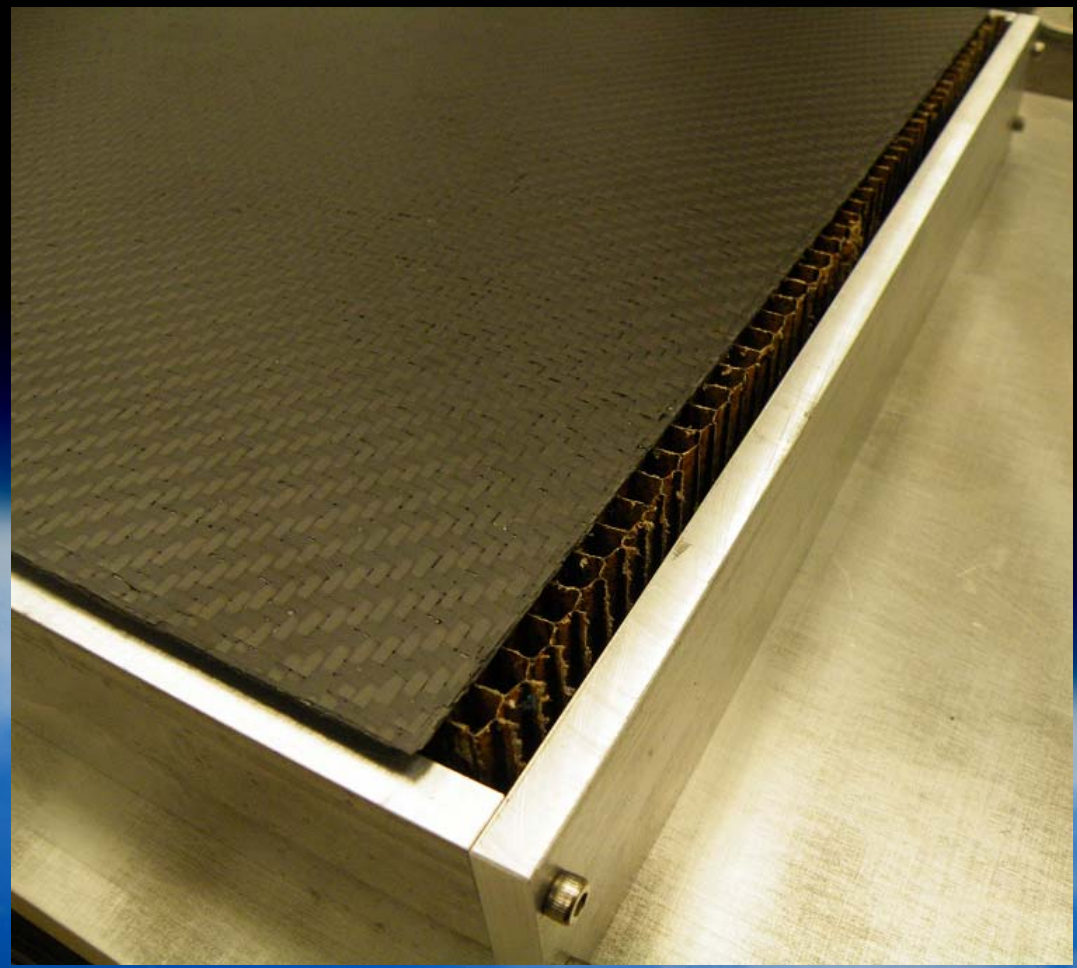
Excerpt discussing fabrication of pre-cured defects for phenolic honeycomb with composite faces

…pre-curing adhesive to the core or to the face-sheet with holes cut out in the adhesive layer provides a tight, un-bonded defect with no foreign material inserts. This can mimic either core or face-sheet bondline failures .

More example content for Phenolic Honeycomb with Composite Faces

This excerpt describes difficulties in making layered Honeycomb samples.

… an appropriate mold enclosing the perimeter of the test panel's geometry is needed to prevent the vacuum bag from tearing against the edges and corners of the face sheets.



Defects included for Phenolic Honeycomb with Composite Faces

- Inclusions/foreign object debris (FOD)
- De-bonds
  - *Pre-cure (to face/ to core)*
  - *Milled Core*
  - *Shim*
  - *Edge shim*

Example content for Flame Trench Simulation

Excerpt discussing Flame Trench mock up

... Quickrete High-strength concrete, mixed in 3’ x 5’ forms. Forms from 1x6s and particle board.

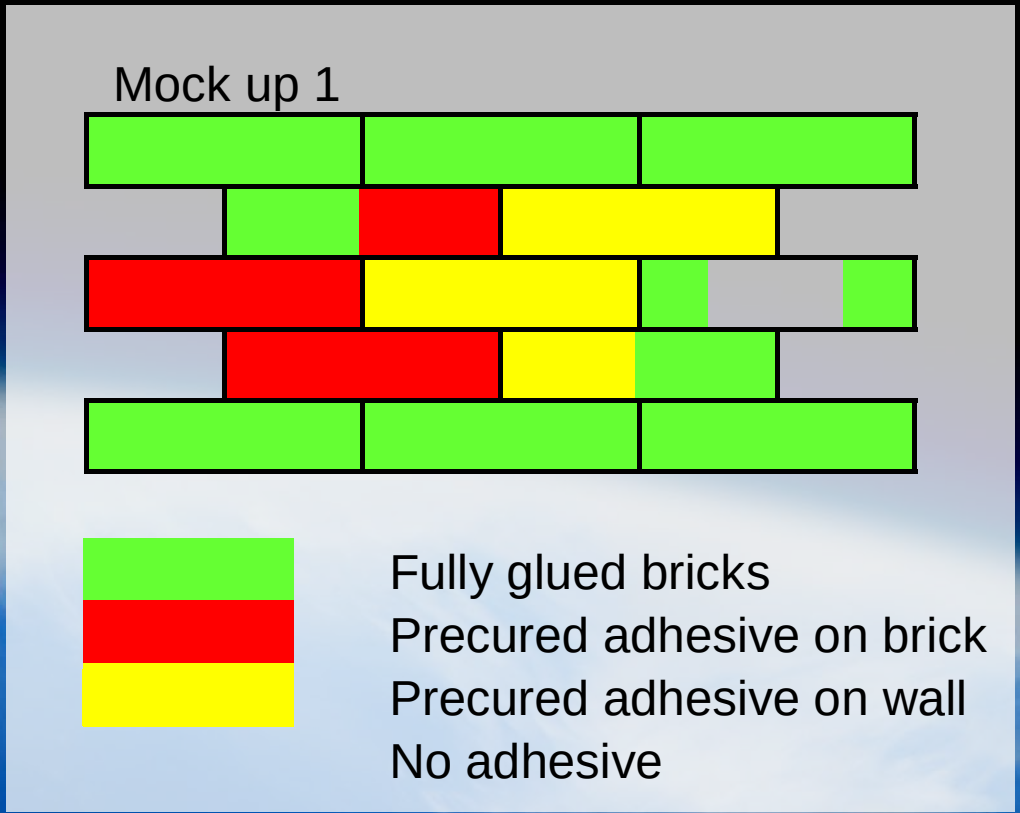
- Bricks from actual flame trench at Kennedy

1st sample built with 5/8” mortar between cement and bricks, & EdocoBurk Burkepoxt NS adhesive - 5/8 square notch trowel.

2nd sample used 1/4” glue thickness, & MASTER BOND EP21TPHTQ adhesive - ¼” x 3/16” V-notch trowel¼” x 3/16” V-notch trowel.

More example content for Flame Trench Simulation

Diagram indicating flaw map for the 1st Flame Trench mock up



Defects included for Flame Trench Simulation

- Pre-cured adhesive on bricks
- Pre-cured adhesive on wall
- No adhesive

Excerpt from the sample versus structural element and NDE method table

Structural Elements Simulated	Samples	Typical Defects	Typical NDE Method
Crew-Composite Module	Solid Carbon Composite Laminate	• Delaminations • Kissing-bonds • Resin-rich Areas • Foreign Material Inclusions • Porosity	• **Thermography** • **Phased-Array Ultrasound** • **Laser Shearography** • **terahertz** • **Radiography**
Interstage	Solid Carbon Composite Laminate	• Delaminations • Kissing-bonds • Resin-rich Areas • Foreign Material Inclusions • Porosity	• **Thermography** • **Phased-Array Ultrasound** • **Laser Shearography** • **terahertz** • **Radiography**
Interstage	Aluminum Honeycomb & Carbon Composite "sandwich"	• Delaminations • Kissing-bonds • Foreign Material Inclusion • Honeycomb Damage	• **Thermography** • **Phased-Array Ultrasound** • **Laser Shearography** • **Radiography**

Status of the Handbook
As of November 17th, 2009

• Procure materials and supplies	~ 100% complete
• Design test sample matrix	~ 100% complete
• Fabricate test samples	~ 98% complete
• NDE testing of test samples	~ 95% complete
• Images and illustrations	~ 95% complete
• text and body of Handbook	~ 88% complete
• estimated total project	~ 95% complete