Inter Micro 2007 Abstract Chicago, IL 9-12 July 2007

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Space Shuttle Stiffener Ring foam failure analysis, a non-conventional approach.

The Space Shuttle makes use of the excellent properties of rigid polyurethane foam for cryogenic tank insulation and as structural protection on the solid rocket boosters. When foam applications debond, classical methods of analysis do not always provide root cause of the failure of the foam. Realizing that foam is the ideal media to document and preserve its own mode of failure, thin sectioning was seen as a logical approach for foam failure analysis. Thin sectioning in two directions, both horizontal and vertical to the application, was chosen to observe the three dimensional morphology of the foam cells. The cell foam morphology provided a much greater understanding of the failure modes than previously achieved.

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Solid Rocket Booster Stiffener Ring Foam Failure

Philip M. Howard
July 9, 2007

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SRB Foam Failure

- Numerous foam failure investigation have been initiated by ATK in the past. et al in May 2006 was inconclusive.

1/8 bond coat

Coating Buildup

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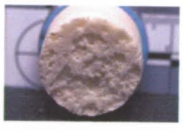
- Foam Failures fall into two categories
  - Adhesive
  - Cohesive
  - Mixture of both



- ATK define the foam failures qualitatively by visual inspection of the presence or absence of foam residue on the de-bonded surface.

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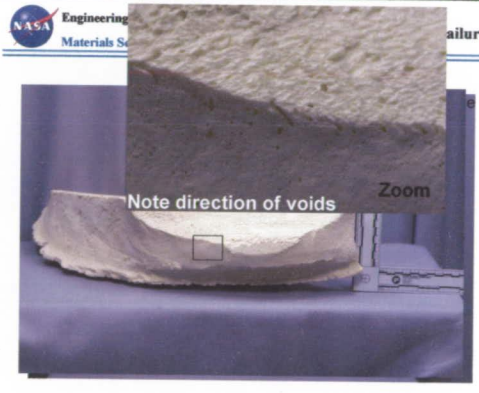
ailure



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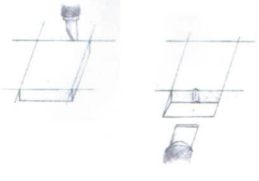
Sectioning of Foam



Plastic slide with double sided tape

1st cut 1 mm section single edge razor

2nd cut 0.5-1mm section double edge razor

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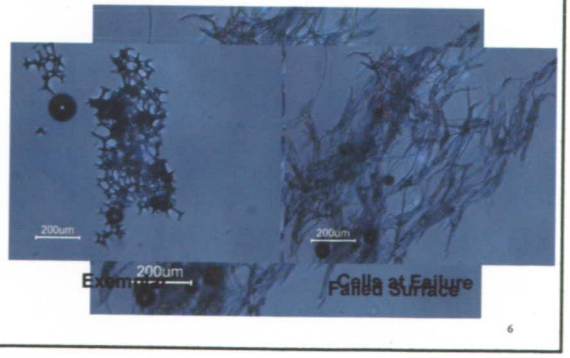
SRB Foam Failure



Exam
Failed Surface

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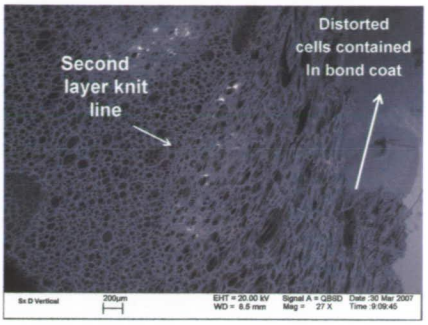
SRB Foam Failure



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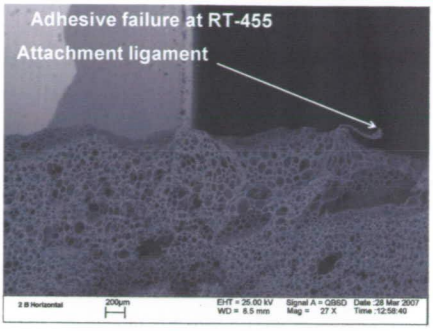

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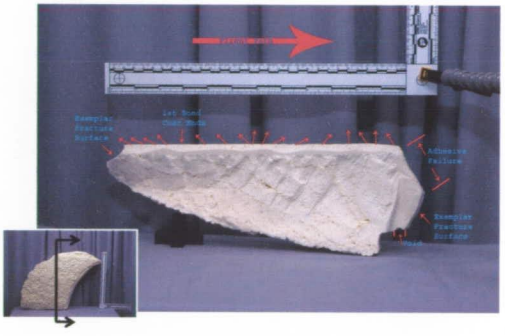
SRB Foam Failure



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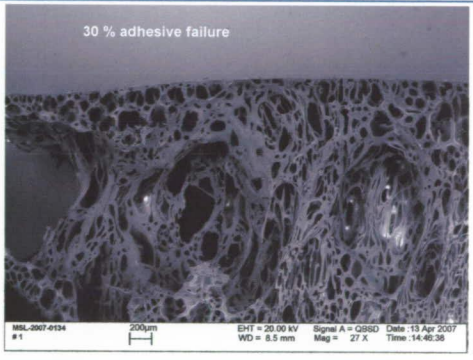
25 PSI



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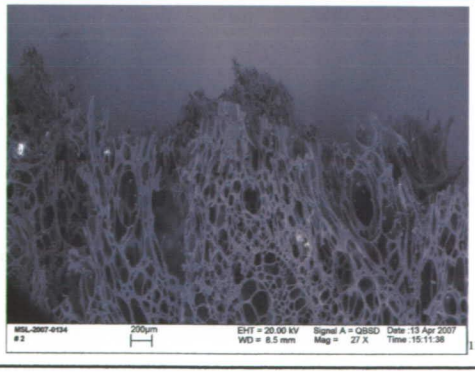
50 PSI



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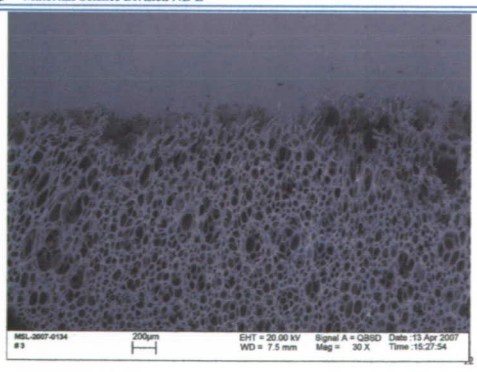
78 PSI



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SRB Foam Failure

The foam bond coat displayed two modes of failure:

- Cohesive failure was observed next to the SRB substrate due to severely deformed foam cells in the bond coat
- Adhesive failure was observed at the RT-455 Epoxy interface.
- 78 % surface of the foam application failed

The observed morphology of the fracture surfaces indicates that the bond coat was not fully cured before other forces were applied, e.g. the expansion forces of the second coat distorted the bonding cells.

Work is ongoing; possible contributing causes under consideration include:

- Inadequate cure time of the bond coat
- Substrate temperature

This cross section method is applicable to any foam de-bonding incidents.

- SRB, External Tank and Atlas V

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SRB Foam Failure

Support Slides

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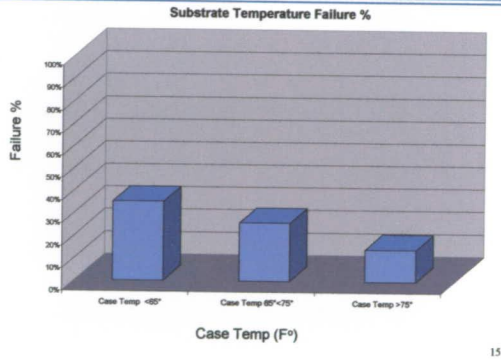
SRB Foam Failure



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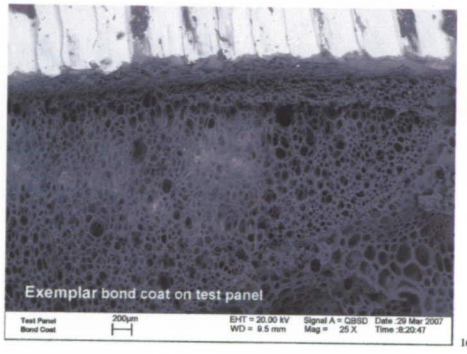
SRB Foam Failure



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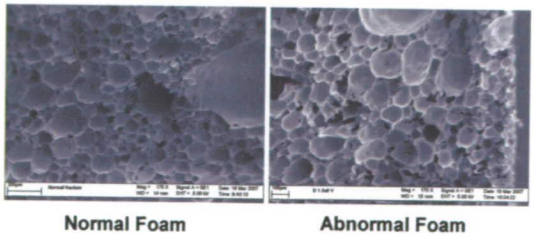
SRB Foam Failure

SEM Fracture Analysis of foam

Normal to the failure and gold coated



Normal Foam **Abnormal Foam**

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