Aging and Contamination Evaluation Status

Insulation Blanket Films

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Aging and Contamination Evaluation Status

Insulation Blanket Films

1) In-service Insulation Blanket Q-Tip Testing Results
   • Testing of in-service blankets
   • Cleaning Evaluation
   • Spray-on Fire Retardant Evaluation

2) Contamination Analysis

3) Artificial Aging Test Method Evaluation

4) Morphology Characterization of PET Film

5) Summary of Results

6) Proposed Next Steps
Aging and Contamination Evaluation Status

In-service Insulation Blankets

Several in-service blankets have been received from airlines and Q-tip tests performed. Q-tip testing is the best discriminator of fire propagation performance; Radiant Panel is too severe for these types of films and Bunsen Burner is not discriminating enough.

<table>
<thead>
<tr>
<th>Model</th>
<th>Delivery Date</th>
<th>Film Covering</th>
<th>Blanket Descriptions</th>
<th>Contamination Level</th>
<th>Number of Blankets Tested</th>
<th>Q-Tip Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>757-200</td>
<td>Jun-85</td>
<td>PET; AN-26</td>
<td>Crown, STA 920 - 940; Bay 9E; Bay 11, Cargo Aft Bulkhead; Cap Strips, STA 520 &amp; 1120</td>
<td>Range from almost clean (stringer cap strips) to heavily contaminated.</td>
<td>7</td>
<td>All failed except a capstrip blanket.</td>
</tr>
<tr>
<td>757-200</td>
<td>Jun-85</td>
<td>PET; AN-26</td>
<td>Sidewall, Crown, Cargo area</td>
<td>Minimal contamination, general dust and dirt.</td>
<td>3</td>
<td>All failed.</td>
</tr>
<tr>
<td>757-200</td>
<td>Feb-85</td>
<td>PET; AN-26</td>
<td>Aft lower lobe, STA 1700</td>
<td>General moderate contamination of dust and dirt. Local edges have smudges of misc material.</td>
<td>4</td>
<td>All failed.</td>
</tr>
<tr>
<td>747-400</td>
<td>May-89</td>
<td>PET; AN-26</td>
<td>Crown, near upper recirculating fan</td>
<td>Minimal contamination, general dust and dirt with some locations of heavy dust due to air circulation.</td>
<td>3</td>
<td>All failed.</td>
</tr>
<tr>
<td>767-200</td>
<td>Dec-87</td>
<td>PET; AN-26</td>
<td>Sidewall areas</td>
<td>Minimal contamination, general dust and dirt.</td>
<td>3</td>
<td>All failed.</td>
</tr>
<tr>
<td>767-300</td>
<td>Mar-93</td>
<td>PET; AN-36W</td>
<td>Unknown</td>
<td>Low to moderate contamination; local contamination of overspray of brownish material.</td>
<td>2</td>
<td>All Failed</td>
</tr>
<tr>
<td>757-200</td>
<td>Feb-85</td>
<td>Metallized Tedlar; AN-16</td>
<td>Replacement blanket for aft lower lobe</td>
<td>Low to moderate contamination; several small locations of misc materials.</td>
<td>2</td>
<td>One of two failed.</td>
</tr>
</tbody>
</table>
CONTROL: Orcon AN-36W – Current BMS 8-142 Class 00 PET; The Q-tip test is a Boeing requirement for qualification of new products. It is not a FAA requirement, but is more discriminating than Bunsen Burner.
Aging and Contamination Evaluation Status
PET Thermal/Acoustic Insulation Cover Film Flammability
- Q-Tip Test -

IN-SERVICE SAMPLE: Orcon AN-26 In-Service PET Blanket; BMS 8-142 Class 00; B757-200, delivered 6/85, Crown blanket, STA 920-940, Outboard surface tested.
Aging and Contamination Evaluation Status

PET Thermal/Acoustic Insulation Cover Film Flammability

- Q-Tip Test -

IN-SERVICE SAMPLE: Orcon AN-26 In-Service PET Blanket; BMS 8-142 Class 00; B757-200, delivered 6/85, Cap Strip Blanket, Inboard & Outboard surfaces tested.

[Image of handwritten note]

Delta 757
N8 610

Q-Tip Test

Cap Strip
STA 1120

CapStrip STA 1120, IB & OB Surface
Summary:

- In-service blankets made with AN-26 PET do not generally meet Q-tip requirements, regardless of contamination level as evaluated by visual means.

- Samples that do not appear visibly contaminated can display the same fire propagation behavior as a severely contaminated blanket.

- Testing of one AN-36W PET blanket indicate failing Q-tip results.

- One sample of a metallized Tedlar blanket failed the Q-tip test.
Aging and Contamination Evaluation Status

- Contamination Analysis of In-service Blankets -
  Reported at March 2003 Working Group

Laboratory Tests Performed:
1) FTIR Analysis performed on solids removed from the surface and on solvent soluble debris
2) Polarized Light Microscopy to Identify solid contaminants
3) Microprobe for elemental analysis

Results:
FTIR Examination:
Hydrocarbon waxy materials (industry CICs)
Hydrocarbon materials (BMS 3-26 CICs)
Hydrocarbon materials (Industry hydraulic fluids & Skydrol)
Hydrocarbon materials (some types of insecticides)
Silicone based materials (adhesives/sealants/cured elastomers)
Epoxy based materials (adhesives/composite material residue)
Contamination results, continued:

**Microscopy & Microprobe:**
- Rubber/elastomer fragments
- Metallic shavings
- Dark particles (dirt)
- Mineral grains including quartz, calcite/CaCOs, clay fines and other misc. minerals
- Misc. resinous materials
- Fiberglass fibers, some with polymer coating/binder
- Cellulose fibers
- Synthetic fibers, various colors (cloth type fibers, Dacron, Nylon…)
- Mammal hair/fur, insect parts
- Plant tissue, pollen grains, seeds
- Paint flakes

**Contamination Update:**
Several more samples have been evaluated with no significant difference in types of contamination.
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- Characterization Analysis -

**Approach:**
Characterization of the PET film is necessary to correlate material change (morphology) with aging, correlated to flammability performance (Q-Tip results).

**PET Characterization Tests:**
- DSC
- TGA
- Polarized Microscopy
- “Shrinkage” Tests
- Chemical Analysis

New PET Film
+ Aged PET Film
+ In-service PET Film

Data Identifying Change in Material with Time

Correlation

Q-Tip Test Results
Theorized Mechanism:

*PET Film “Shrinkage” = Fire Propagation Resistance*

- The mechanism by which unaged PET films are resistant to flame propagation is the PET film “shrinks” away from a flame source, and any fire retardants included in scrim adhesives or other coatings (e.g. deluster).

- This “shrinkage” mechanism is believed to be attributable to the morphology of PET (crystalline and amorphous regions) and residual thermal stresses inherent in these types of polymers.

- Both morphology changes and the relaxation of internal stresses over time may be contributing to the lack of shrinkage away from a flame source.

- The in-service environment is causing this “shrinkage” mechanism to change.
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- Characterization Analysis -

The following methods are being evaluated as ways to characterize the PET film.

- DSC; Differential Scanning Calorimetry
- TGA; Thermal Gravimetric Analysis
- Polarized Light Microscopy
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- Characterization Analysis -

MDSC, Reversing Heat Flow

Note: Curves are shifted apart for clarity. Each curve uses same Y-axis units.
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- Characterization Analysis; TGA -

AN-26, In-service
AN-26, Unused
AN-36W, New

AN-36W is exhibiting significantly more weight loss prior to the major weight loss event. Could be due to in part to the different type of scrim adhesive and deluster coatings.

AN-26 in-service samples exhibit slightly more early weight loss than the AN-26 unused sample. Possibly due to surface contamination products.

TGA % Residue
AN-36W: 8%
AN-26 In-service: 3%
AN-26 Unused: 7%
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-Characterization Analysis –
MDSC, Reversing Heat Flow; Two locations on new AN-36W

Note: Curves are shifted apart for clarity. Each curve uses same Y-axis units.
## Aging and Contamination Evaluation Status

-Characterization Analysis; MDSC - Orcon AN-36W

<table>
<thead>
<tr>
<th>Sample Description</th>
<th>Sample No.</th>
<th>Endotherm Peak (Onset), °C**</th>
<th>Total Heat Flow, J/g</th>
<th>Reversing Heat Flow, J/g</th>
<th>Non-Reversing Heat Flow, J/g</th>
<th>Initial Crystallinity, J/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orcofilm AN-36W</td>
<td>1A,B</td>
<td>249.8 (231.4), 249.1 (231.8)</td>
<td>37.7, 28.7</td>
<td>73.8, 89.3</td>
<td>34.3, 41.3</td>
<td>39.5, 48.0</td>
</tr>
<tr>
<td></td>
<td>2A,B</td>
<td>249.2 (230.9), 249.9 (230.5)</td>
<td>31.0, 30.4</td>
<td>81.3, 79.3</td>
<td>44.1, 45.3</td>
<td>47.2, 54.0</td>
</tr>
<tr>
<td></td>
<td>3A,B</td>
<td>249.4 (231.9), 249.9 (231.7)</td>
<td>40.0, 33.8</td>
<td>80.1, 79.4</td>
<td>31.6, 40.8</td>
<td>48.5, 38.6</td>
</tr>
<tr>
<td></td>
<td>4A,B</td>
<td>249.2 (230.2), 249.3 (231.4)</td>
<td>28.5, 41.7</td>
<td>72.1, 96.1</td>
<td>37.7, 48.0</td>
<td>34.4, 48.1</td>
</tr>
<tr>
<td></td>
<td>5A,B</td>
<td>250.1 (232.5), 249.2 (232.6)</td>
<td>32.4, 30.3</td>
<td>80.0, 81.3</td>
<td>46.4, 49.6</td>
<td>16.8, 31.7</td>
</tr>
<tr>
<td></td>
<td>6A,B</td>
<td>250.0 (231.3), 249.5 (231.7)</td>
<td>29.4, 27.9</td>
<td>72.7, 73.9</td>
<td>39.6, 48.6</td>
<td>33.1, 25.3</td>
</tr>
<tr>
<td></td>
<td>7A,B</td>
<td>249.8 (232.0), 249.9 (231.0)</td>
<td>41.4, 34.9</td>
<td>90.6, 84.1</td>
<td>42.3, 45.2</td>
<td>48.3, 38.9</td>
</tr>
<tr>
<td></td>
<td>8A,B</td>
<td>250.0 (232.0), 249.2 (231.6)</td>
<td>37.1, 32.6</td>
<td>77.3, 83.1</td>
<td>34.6, 46.2</td>
<td>42.7, 36.9</td>
</tr>
<tr>
<td></td>
<td>9A,B</td>
<td>249.7 (231.8), 249.9 (232.4)</td>
<td>32.5, 37.0</td>
<td>80.4, 94.0</td>
<td>39.6, 46.6</td>
<td>40.8, 47.4</td>
</tr>
<tr>
<td></td>
<td>10A,B</td>
<td>249.8 (231.0), 250.2 (232.0)</td>
<td>38.6, 39.0</td>
<td>91.2, 87.2</td>
<td>40.7, 43.3</td>
<td>50.5, 43.9</td>
</tr>
<tr>
<td></td>
<td>11A,B</td>
<td>250.4 (232.3), 249.5 (232.4)</td>
<td>35.6, 34.2</td>
<td>86.7, 85.3</td>
<td>43.6, 45.5</td>
<td>43.1, 39.8</td>
</tr>
</tbody>
</table>

Average: 250°C (232°C)

Average: 34 J/g

Average: 83 J/g

Average: 43 J/g

Average: 39 J/g
# Aging and Contamination Evaluation Status

## -Characterization Analysis; MDSC – Unprocessed PET Film

<table>
<thead>
<tr>
<th>Sample Description</th>
<th>Sample No.</th>
<th>Endotherm Peak (Onset), °C**</th>
<th>Total Heat Flow, J/g</th>
<th>Reversing Heat Flow, J/g</th>
<th>Non-Reversing Heat Flow, J/g</th>
<th>Initial Crystallinity, J/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unprocessed PET Film</td>
<td>12A,B</td>
<td>255.1 (241.1), 255.0 (239.6)</td>
<td>54.5, 51.0</td>
<td>119.6, 117.8</td>
<td>57.9, 63.6</td>
<td>61.7, 54.2</td>
</tr>
<tr>
<td></td>
<td>13A,B</td>
<td>254.4 (241.3), 254.7 (240.9)</td>
<td>47.3, 42.9</td>
<td>103.7, 95.9</td>
<td>60.5, 45.5</td>
<td>43.2, 50.4</td>
</tr>
<tr>
<td></td>
<td>14A,B</td>
<td>254.4 (239.9), 255.1 (240.8)</td>
<td>51.2, 52.6</td>
<td>117.8, 118.7</td>
<td>70.8, 67.4</td>
<td>47.0, 51.3</td>
</tr>
<tr>
<td></td>
<td>15A,B</td>
<td>254.6 (242.2), 255.6 (241.5)</td>
<td>61.9, 56.6</td>
<td>120.5, 123.3</td>
<td>65.8, 66.3</td>
<td>54.7, 57.0</td>
</tr>
<tr>
<td></td>
<td>16A,B</td>
<td>254.8 (241.6), 255.6 (241.7)</td>
<td>61.8, 34.2</td>
<td>132.1, 81.3</td>
<td>68.1, 48.2</td>
<td>64.0, 33.1</td>
</tr>
<tr>
<td></td>
<td>17A,B</td>
<td>255.6 (242.4), 254.5 (240.9)</td>
<td>44.2, 49.2</td>
<td>104.2, 120.5</td>
<td>57.3, 62.2</td>
<td>46.9, 58.3</td>
</tr>
<tr>
<td></td>
<td>18A,B</td>
<td>255.0 (242.0), 255.1 (241.1)</td>
<td>46.5, 56.8</td>
<td>109.3, 138.5</td>
<td>56.8, 76.6</td>
<td>52.5, 61.9</td>
</tr>
<tr>
<td></td>
<td>19A,B</td>
<td>255.0 (240.5), 254.6 (240.8)</td>
<td>53.0, 51.1</td>
<td>119.4, 121.9</td>
<td>70.3, 65.0</td>
<td>49.1, 56.9</td>
</tr>
<tr>
<td></td>
<td>20A,B</td>
<td>254.9 (239.4), 255.4 (241.8)</td>
<td>63.9, 51.1</td>
<td>139.4, 111.1</td>
<td>65.7, 57.8</td>
<td>73.7, 53.3</td>
</tr>
<tr>
<td></td>
<td>21A,B</td>
<td>254.8 (241.0), 254.5 (239.9)</td>
<td>58.4, 60.8</td>
<td>124.6, 140.8</td>
<td>71.9, 76.1</td>
<td>52.7, 64.7</td>
</tr>
<tr>
<td></td>
<td>22A,B</td>
<td>255.2 (240.9), 255.7 (241.2)</td>
<td>55.2, 50.8</td>
<td>124.0, 124.0</td>
<td>65.6, 71.7</td>
<td>58.4, 52.3</td>
</tr>
</tbody>
</table>

Average: 255°C (241°C) Average: 53 J/g Average: 119 J/g Average: 64 J/g Average: 54 J/g
Aging and Contamination Evaluation Status

- Characterization Analysis; Polarized Photomicroscopy -

Polarized Microscopy illustrating the crystallinity across the PET film. (4X)

AN-36W New

Film coatings (whitish color)

Areas of high crystallinity

Reinforcing Fiber

Film coatings (whitish color)

Areas of high crystallinity

Reinforcing Fiber
Aging and Contamination Evaluation Status
- Characterization Analysis; Polarized Photomicroscopy -

AN-26 In-service

Polarized Microscopy illustrating the crystallinity across the PET film. (4X)
Note: Reinforcing fibers were removed to improve mounting flatness.
Aging and Contamination Evaluation Status

- Characterization Analysis Results -

Conclusions:
1) DSC & TGA methods have not been shown to be viable for developing a correlation between morphology differences and Q-tip results. There is significant variation in crystallinity across all samples (new, unused, in-service, and artificially aged).

2) Polarized microscopy illustrates the variation in crystallinity across all samples. This method will not likely provide accurate quantitative results.

Continuing Work:
1) Polarized microscopy methods are being evaluated using quantitative methods to identify the level of residual thermal stress within the PET materials.

2) Further evaluation of DMA and GC Mass Spec methods.
Testing performed:
In-service blankets were cleaned and then Q-tip tested. Cleaned with the following:

1) Water
2) Isopropyl alcohol.

Conclusion:
Cleaning of moderately contaminated, in-service PET blankets does not improve the resistance to Q-tip flame propagation.
Aging and Contamination Evaluation Status

- Spray-on Fire Retardant Evaluation –
  Q-Tip Results

**Testing performed:**
One coat of fire retardant was applied to contaminated in-service blankets. The blankets were not cleaned prior to application of the fire retardant coating. Coating was allowed to dry overnight.

**Conclusions:** Q-tip results indicate that application of a spray-on fire retardant to moderately contaminated blankets, provides resistance to flame propagation. The performance appears to restore the original flame resistance of new material.

**Future Work:**
- **Adhesion properties:** Determine adhesion properties of a range of contaminated blankets.
- **Aging Susceptibility:** Determine temperature, humidity and thermal cycling.
- **Corrosion effect on Aluminum:** Determine effect on aluminum structure.
- **Effect on Electrical Components:** Determine effect on electrical connectors/components.
- **Optimize application locations:** Determine if a full coverage is needed or if localized areas/strips can be applied.
- **Airline input on viability:** Determine impact to apply during D checks.
Aging and Contamination Evaluation Status

- Aging Studies on PET Insulation Blanket Film -

The following aging tests were initiated in January 2003 using new AN-36W and AN-47W (Orcon) insulation blanket film:

- **Isothermal Thermal Aging (AN-36W):**
  Isothermal Aging at 120F, 140F, 160F, and 200F.

- **Humidity Chamber Aging (AN-36W):**
  Isothermal Aging at 120F/100%RH, 140F/100%RH, and 160F/100%RH

- **Thermal Cycle Testing of Sealed Insulation Blanket (AN-47W):**
  Thermal cycling from –65F to 120F for 1200 cycles (3 blocks).
  Periodic injection of H₂O into the sealed insulation blanket to maintain constant water in contact with the film.

{NOTE: Based on the “Kevlar” cycle. Developed to correlate in-service microcracking with laboratory testing.}
## Aging and Contamination Evaluation Status

- **Q-tip Test Results on Artificially Aged Samples** -

<table>
<thead>
<tr>
<th>Aging Method</th>
<th>Exposure Time</th>
<th>Q-Tip Results (Compared to Un-aged Film)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oven; 200F</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Days</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td>100 Days</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td>200 Days</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td>270 Days</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td><strong>Humidity Chamber; 160F/100%RH</strong></td>
<td>5 Days</td>
<td>No Change</td>
</tr>
<tr>
<td>100 Days</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td>200 Days</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td>270 Days</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td><strong>Thermal Cycling Chamber; -65F – 120F (AN-47W)</strong></td>
<td>400 Cycles</td>
<td>Not Tested Yet</td>
</tr>
<tr>
<td>800 Cycles</td>
<td>Not Tested Yet</td>
<td></td>
</tr>
<tr>
<td>1200 Cycles</td>
<td>No Change (film shrinkage behavior is different)</td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion:**
- Artificially aged samples show passing Q-tip results.
- Q-tip test results indicate all material is self-extinguishing and does not propagate flame.
Aging and Contamination Evaluation Status

-Thermal Cycle –

One Block is 400 Cycles.

Note: 2000 cycles is equivalent to an airplane life cycle; ~ 50,000 cycles. Cycle developed to evaluate composite matrix cracking. Used in-service exterior aramid fiber/epoxy honeycomb parts to correlate actual flight cycles with simulated flight cycles.

Injected and maintained 40 grams of H2O.
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- Photographs of thermal cycled blankets –

Staining on the inside of the film. Could be glass batting sizing.
Aging and Contamination Evaluation Status

- Photographs of thermal cycled blankets –

**AN-47W**
Control; Unaged

**AN-47W**
1200 thermal cycles

Film appears to stick to glass batting.
Aging and Contamination Evaluation Status

Summary of Results to date:

**Q-Tip Test Results:**
- Nineteen out of twenty in-service blankets made with AN-26 PET film failed to meet Q-tip requirements. Samples had a wide range of contamination levels.
- Two of two in-service blankets made with AN-36W PET film failed to meet Q-tip requirements.
- One of two tests on in-service blankets made with metallized Tedlar (AN-16) failed the Q-tip test.

**Characterization Results:**
- The DSC & TGA methods have not been shown viable for developing a correlation between morphology and Q-tip results. Variation across all samples is significant.
- Polarized Light Microscopy illustrates the variation in crystallinity across all samples tested.
Aging and Contamination Evaluation Status

Summary of Results to date:

Cleaning Results:
• Cleaning of in-service PET insulation blankets with water and isopropyl alcohol did not improve fire propagation results of moderately contaminated PET blankets.

Spray-on Fire Retardant Results:
• Application of a spray-on fire retardant shows promise in providing resistance to flame propagation on moderately contaminated in-service blankets.
• The performance appears to restore the original flame resistance of new material.

Laboratory Aging Results:
• Artificially aged samples (isothermal, humidity and thermal cycling) meet Q-tip requirements.
• Results of thermal cycled blankets (AN-47W) show a slight change in flame behavior although the film remains resistant to flame propagation.
Aging and Contamination Evaluation Status

Proposed Future Next Steps:

In-service blanket analysis: Continue to evaluate in-service blankets from all ages, thicknesses and types of films to determine level of flammability performance degradation across the fleet.

![Thermal Acoustic Insulation Film Usage on Commercial Aircraft](image-url)
Aging and Contamination Evaluation Status

Proposed Future Next Steps:

Contamination Survey:
• Summarize Airline input to the Contamination Survey.

Cleaning Evaluations:
• Perform more cleaning tests over a wider range of contamination types and levels.

Analytical Test Method Evaluation:
• Further work with polarized microscopy, DMA and other methods.
• Initiate teaming with academia to understand aging evaluation approaches.

Spray-on Fire Retardant Evaluation:
• More testing of spray-on fire retardants to determine if they can consistently eliminate fire propagation on in-service insulation blankets.
• Define testing to determine adhesion properties, corrosion and aging environment susceptibility (temp/humidity), effect on electrical components and optimization of application locations.
Task Group Working Meeting Outline
(Thursday 9:00)

1) Identify a small group (8 – 10) to meet a couple times prior to next meeting to prioritize tasks and deliverables.

2) Review March 2003 “Proposed Tasks.”

3) Review Current “Proposed Tasks.” Define the details for a plan for assessing the fleet.

4) Determine plan for summarizing submitted Contamination Survey Forms.