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

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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.

Model	Delivery Date	Film Covering	Blanket Descriptions	Contamination Level	Number of Blankets Tested	Q-TipTest Result
757-200	Jun-85	PET; AN-26	Crown, STA 920 - 940; Bay 9E; Bay 11, Cargo Aft Bulkhead; Cap Strips, STA 520 & 1120	Range from almost clean (stringer cap strips) to heavily contaminated.	7	All failed except a capstrip blanket.
757-200	Jun-85	PET; AN-26	Sidewall, Crown, Cargo area	Minimal contamination, general dust and dirt.	3	All failed.
757-200	Feb-85	PET; AN-26	Aft lower lobe, STA 1700	General moderate contamination of dust and dirt. Local edges have smudges of misc material.	4	All failed.
747-400	May-89	PET; AN-26	Crown, near upper recirculating fan	Minimal contamination, general dust and dirt with some locations of heavy dust due to air circulation.	3	All failed.
767-200	Dec-87	PET; AN-26	Sidewall areas	Minimal contamination, general dust and dirt.	3	All failed.
767-300	Mar-93	PET; AN-36W	Unknown	Low to moderate contamination; local contamination of overspray of brownish material.	2	All Failed
757-200	Feb-85	Metallized Tedlar; AN-16	Replacement blanket for aft lower lobe	Low to moderate contamination; several small locations of misc materials.	2	One of two failed.

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PET Thermal/Acoustic Insulation Cover Film Flammability

- Q-Tip Test -

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.

QTip Control AN-36W

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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.

Crown STA 920, OB Surface

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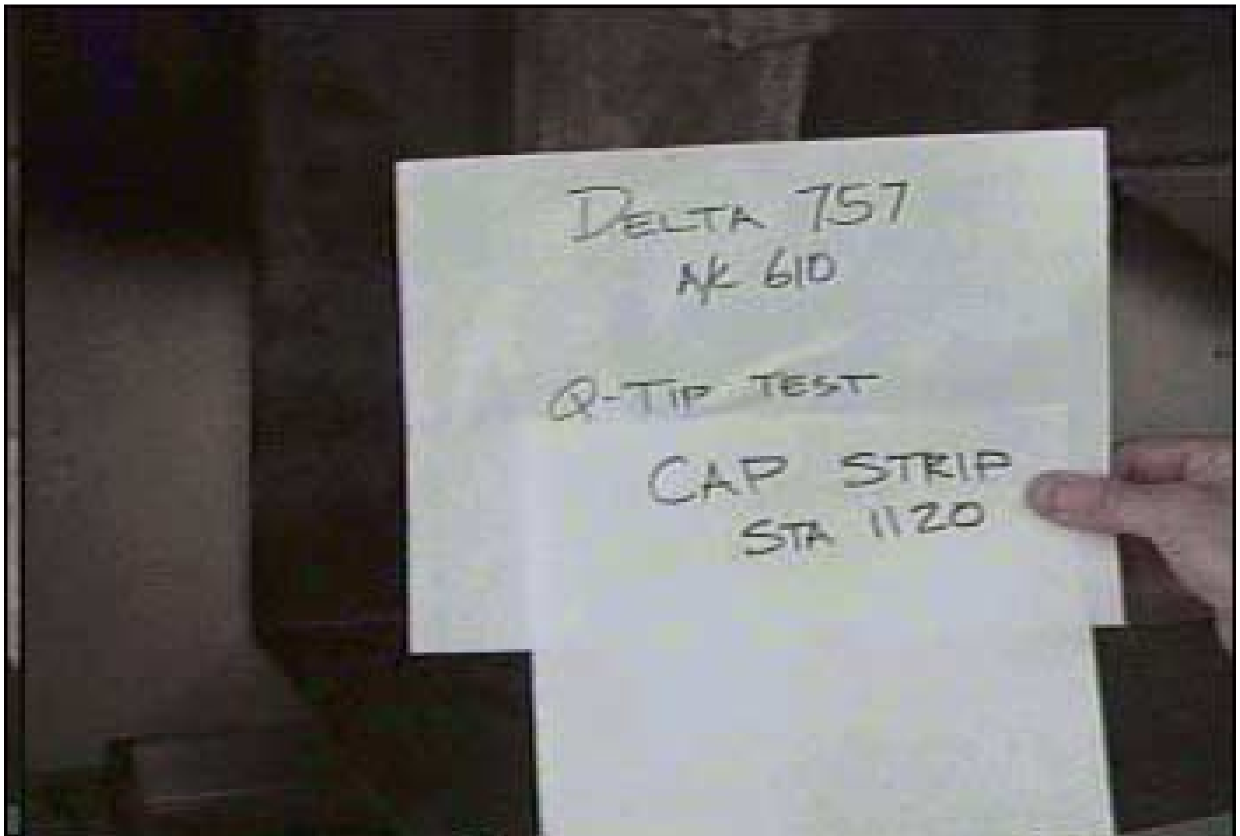
PET Thermal/Acoustic Insulation Cover Film Flammability

- 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.



CapStrip STA 1120, IB & OB Surface

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- In-service Blanket Q-Tip Test Results -

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.

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- 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)

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- Contamination Analysis of In-service Blankets -

Contamination results, continued:

<u>Microscopy & Microprobe:</u>
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

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- Characterization Analysis -

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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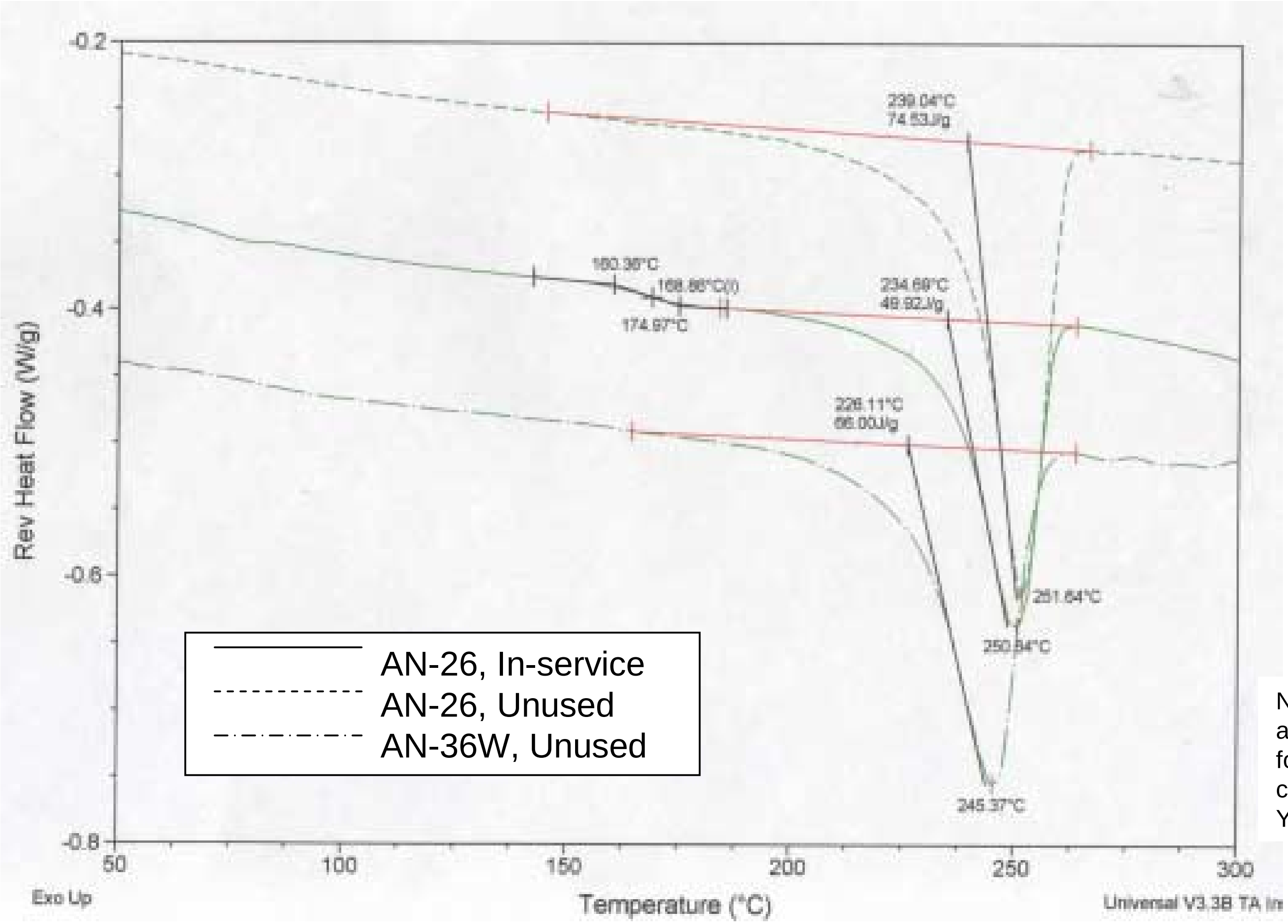
- Characterization Analysis -

MDSC, Reversing Heat Flow



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

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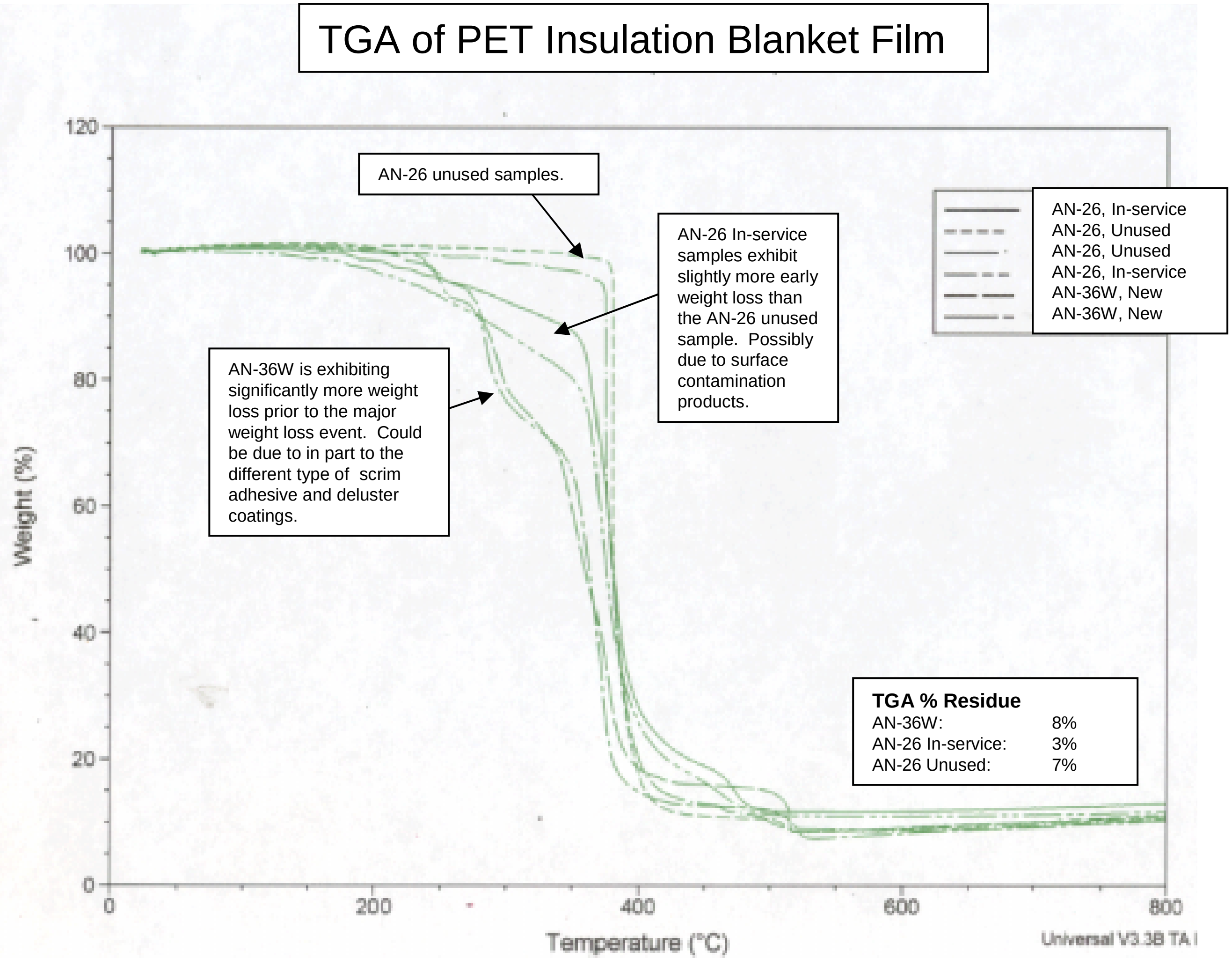
- Characterization Analysis; TGA -



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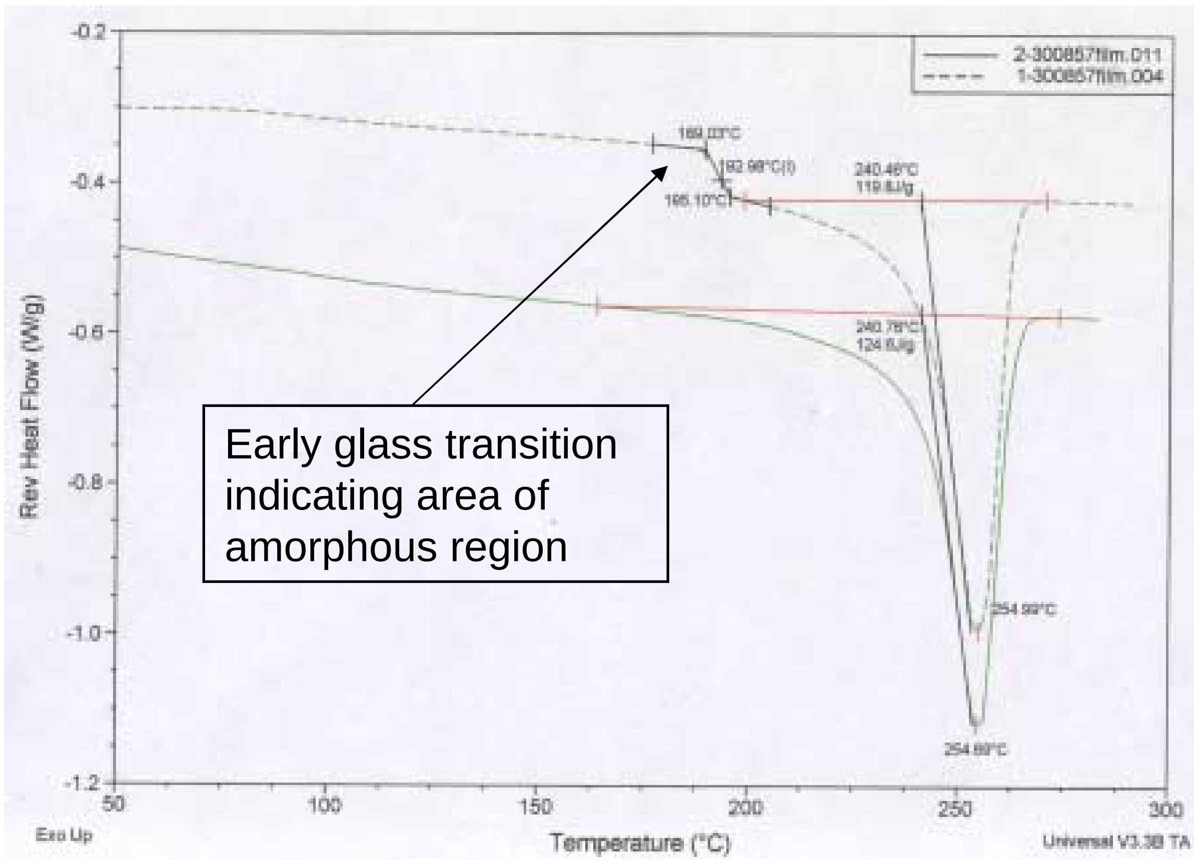
-Characterization Analysis –

MDSC, Reversing Heat Flow; Two locations on new AN-36W



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

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-Characterization Analysis; MDSC -

Orcon AN-36W

	MDSC Results					
Sample Description	Sample No.	Endotherm Peak (Onset), ºC**	Total Heat Flow, J/g	Reversing Heat Flow, J/g	Non-Reversing Heat Flow, J/g	Initial Crystallinity, J/g
Orcofilm AN-36W BMS 8-142V Type XI Class 00 Orcon Corp. Lot # 4140	1A,B 2A,B 3A,B 4A,B 5A,B 6A,B 7A,B 8A,B 9A,B 10A,B 11A,B	249.8 (231.4), 249.1 (231.8) 249.2 (230.9), 249.9 (230.5) 249.4 (231.9), 249.9 (231.7) 249.2 (230.2), 249.3 (231.4) 250.1 (232.5), 249.2 (232.6) 250.0 (231.3), 249.5 (231.7) 249.8 (232.0), 249.9 (231.0) 250.0 (232.0), 249.2 (231.6) 249.7 (231.8), 249.9 (232.4) 249.8 (231.0), 250.2 (232.0) 250.4 (232.3), 249.5 (232.4) Average: 250ºC (232ºC)	37.7, 28.7 31.0, 30.4 40.0, 33.8 28.5, 41.7 32.4, 30.3 29.4, 27.9 41.4, 34.9 37.1, 32.6 32.5, 37.0 38.6, 39.0 35.6, 34.2 Average 34 J/g	73.8, 89.3 81.3, 79.3 80.1, 79.4 72.1, 96.1 80.0, 81.3 72.7, 73.9 90.6, 84.1 77.3, 83.1 80.4, 94.0 91.2, 87.2 86.7, 85.3 Average: 83 J/g	34.3, 41.3 44.1, 45.3 31.6, 40.8 37.7, 48.0 46.4, 49.6 39.6, 48.6 42.3, 45.2 34.6, 46.2 39.6, 46.6 40.7, 43.3 43.6, 45.5 Average: 43 J/g	39.5, 48.0 37.2, 34.0 48.5, 38.6 34.4, 48.1 16.8, 31.7 33.1, 25.3 48.3, 38.9 42.7, 36.9 40.8, 47.4 50.5, 43.9 43.1, 39.8 Average: 39 J/g

Aging and Contamination Evaluation Status

-Characterization Analysis; MDSC –

Unprocessed PET Film

	MDSC Results					
Sample Description	Sample No.	Endotherm Peak (Onset), ºC**	Total Heat Flow, J/g	Reversing Heat Flow, J/g	Non-Reversing Heat Flow, J/g	Initial Crystallinity, J/g
Unprocessed PET Film	12A,B 13A,B 14A,B 15A,B 16A,B 17A,B 18A,B 19A,B 20A,B 21A,B 22A,B	255.1 (241.1), 255.0 (239.6) 254.4 (241.3), 254.7 (240.9) 254.4 (239.9), 255.1 (240.8) 254.6 (242.2), 255.6 (241.5) 254.8 (241.6), 255.6 (241.7) 255.6 (242.4), 254.5 (240.9) 255.0 (242.0), 255.1 (241.1) 255.0 (240.5), 254.6 (240.8) 254.9 (239.4), 255.4 (241.8) 254.8 (241.0), 254.5 (239.9) 255.2 (240.9), 255.7 (241.2) Average: 255ºC (241ºC)	54.5, 51.0 47.3, 42.9 51.2, 52.6 61.9, 56.6 61.8, 34.2 44.2, 49.2 46.5, 56.8 53.0, 51.1 63.9, 51.1 58.4, 60.8 55.2, 50.8 Average: 53 J/g	119.6, 117.8 103.7, 95.9 117.8, 118.7 120.5, 123.3 132.1, 81.3 104.2, 120.5 109.3, 138.5 119.4, 121.9 139.4, 111.1 124.6, 140.8 124.0, 124.0 Average: 119 J/g	57.9, 63.6 60.5, 45.5 70.8, 67.4 65.8, 66.3 68.1, 48.2 57.3, 62.2 56.8, 76.6 70.3, 65.0 65.7, 57.8 71.9, 76.1 65.6, 71.7 Average: 64 J/g	61.7, 54.2 43.2, 50.4 47.0, 51.3 54.7, 57.0 64.0, 33.1 46.9, 58.3 52.5, 61.9 49.1, 56.9 73.7, 53.3 52.7, 64.7 58.4, 52.3 Average: 54 J/g

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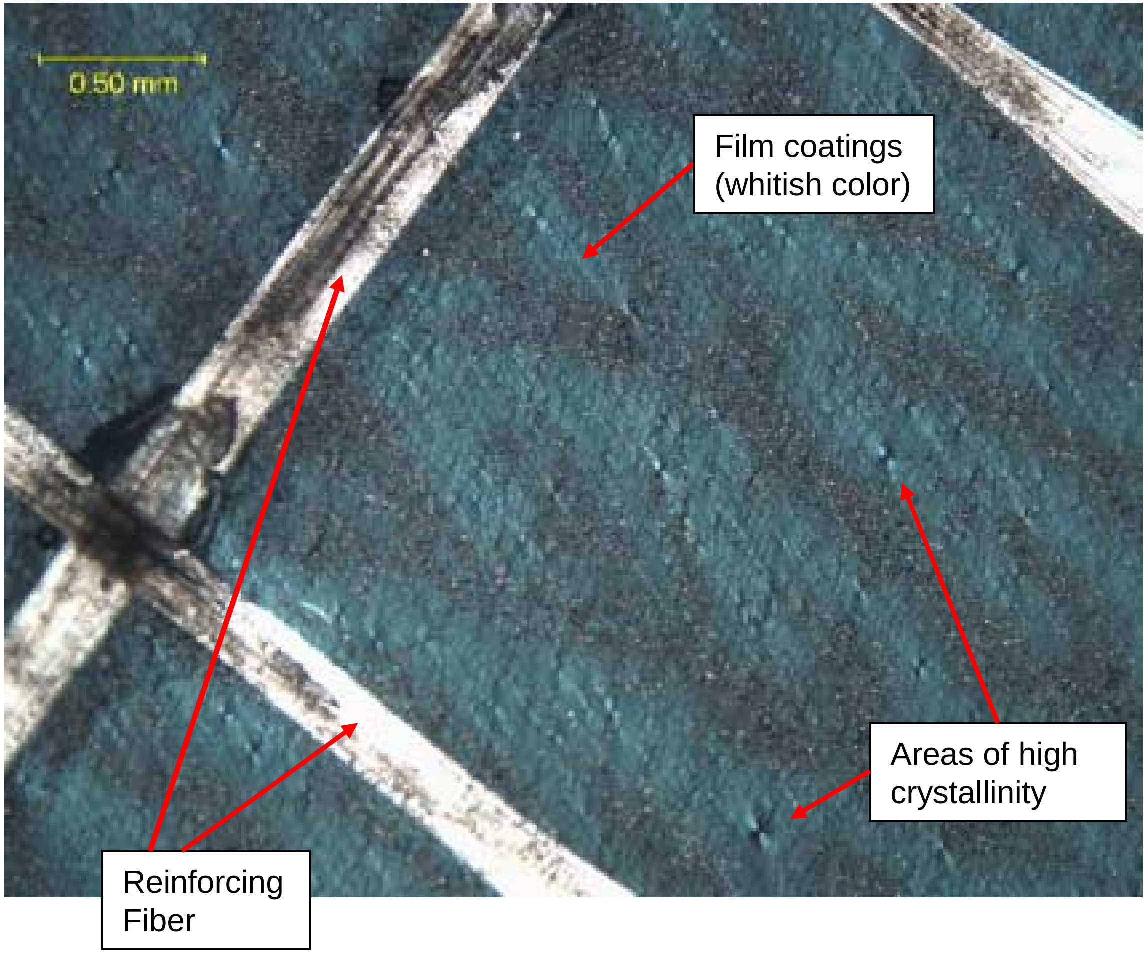
- Characterization Analysis; Polarized Photomicroscopy -

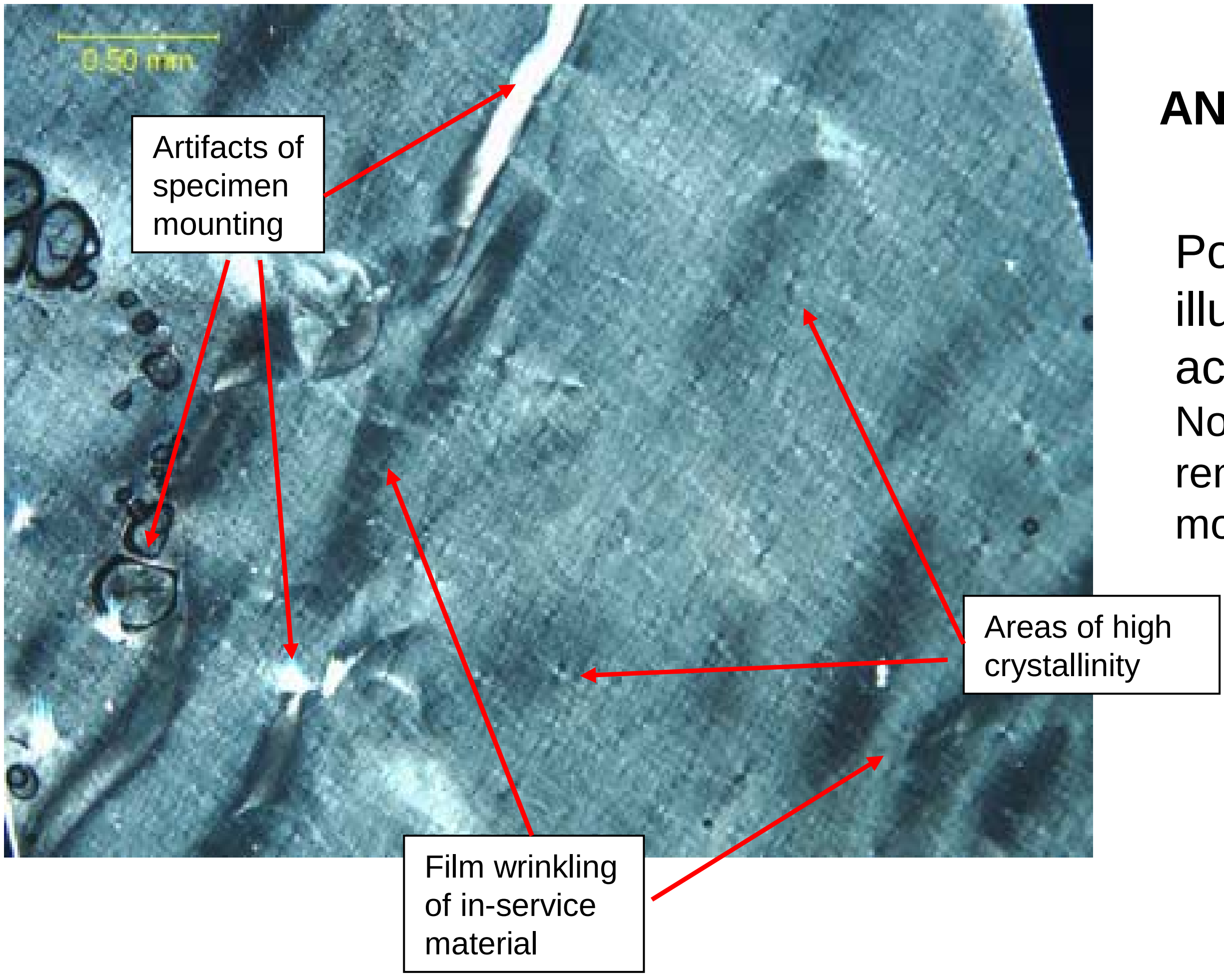


AN-36W New

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

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.

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- Cleaning Evaluation of PET Insulation Blanket Film –
Q-Tip Results

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.

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- 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:
- <u>Adhesion properties:</u> Determine adhesion properties of a range of contaminated blankets.
- <u>Aging Susceptibility:</u> Determine temperature, humidity and thermal cycling.
- <u>Corrosion effect on Aluminum:</u> Determine effect on aluminum structure.
- <u>Effect on Electrical Components</u>: Determine effect on electrical connectors/components.
- <u>Optimize application locations:</u> Determine if a full coverage is needed or if localized areas/strips can be applied.
- <u>Airline input on viability:</u> 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 H_20 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.}

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- Q-tip Test Results on Artificially Aged Samples -

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

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

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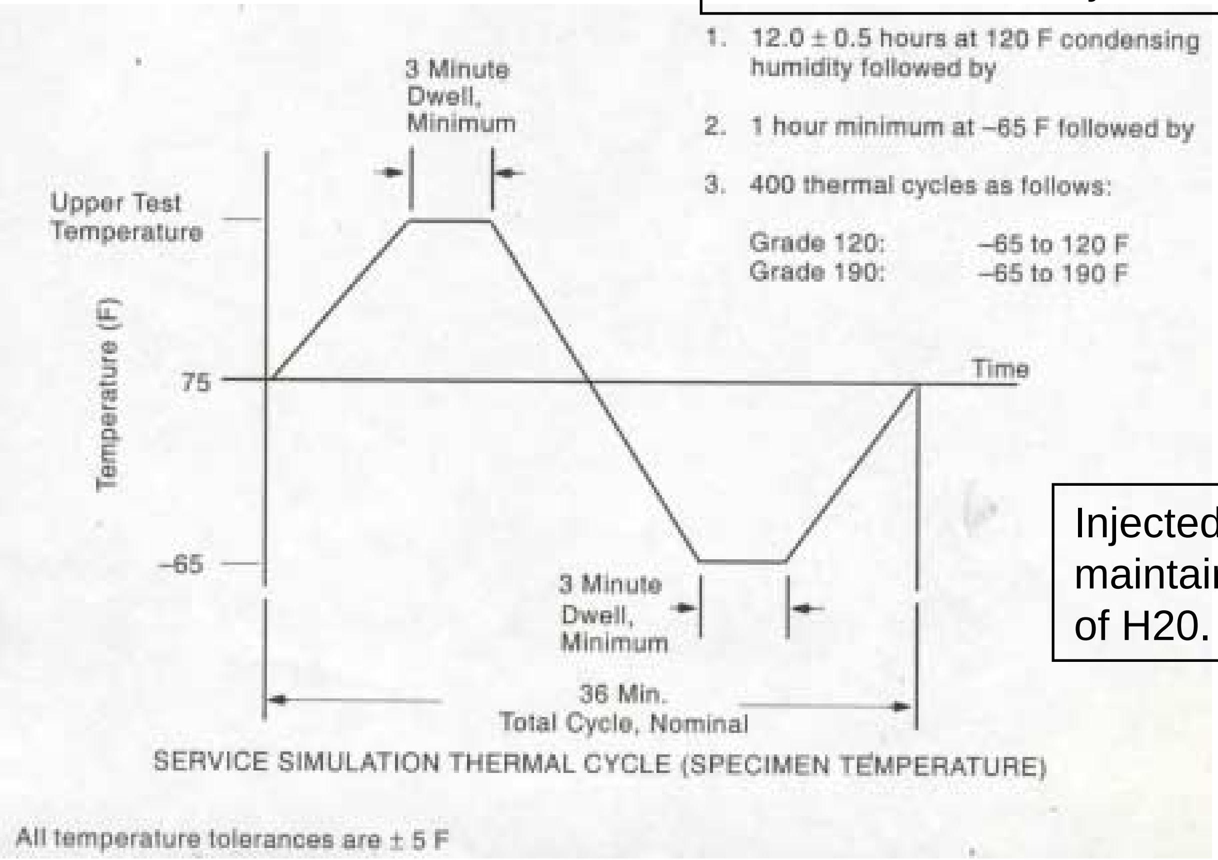
-Thermal Cycle –

One Block is 400 Cycles.



Injected and maintained 40 grams of H20.

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.

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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.

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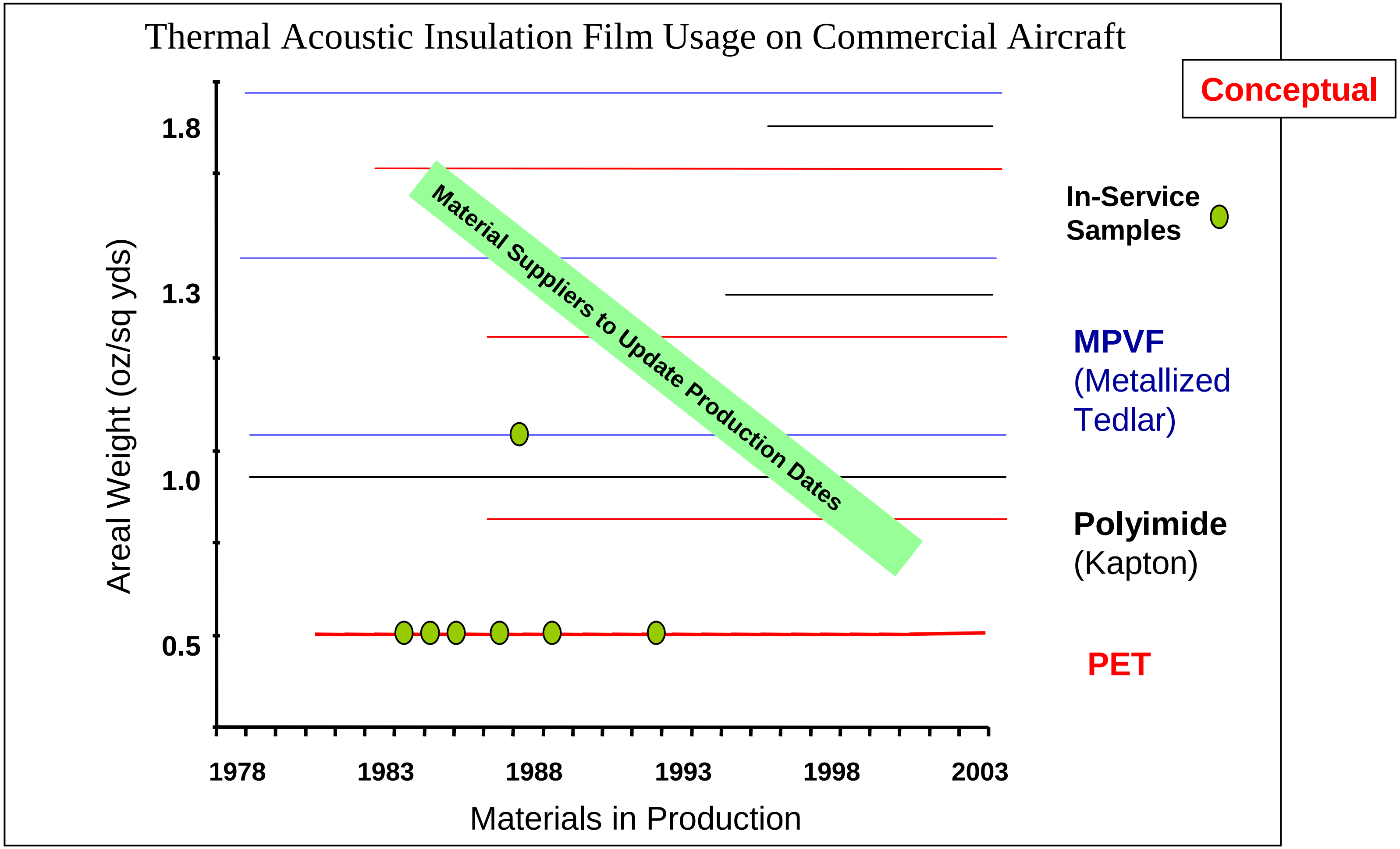
Proposed Future Next Steps:

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



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.

Aging and Contamination Evaluation Status

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.