A Case Study: Evaluation of Flame Retardant Coatings for Aerospace Applications

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MATERIALS DEVELOPMENT IN AEROSPACE

✈ Materials being developed for aerospace applications must meet a large set of engineering requirements:

- Flammability
- Cost
- Aesthetics
- Mechanical
- Weight
- Processing

✈ Some requirements often work against others.

OPTIMIZING MATERIALS FOR AEROSPACE APPLICATIONS

- What's the problem ?
- Defining the best set of engineering requirements
- Commercially available materials
- Optimal methods of characterization
  - Flammability / environmental / physical durability
- Development schedule/Cost

CASE STUDY: IN-SERVICE INSULATION BLANKETS

Problem:

- In-Service Investigations
  - Flammability, contamination, aging
- Flammability testing
  - Q-tip, Bunsen burner, radiant panel
- Highly variable test results
  - Burn length/self-extinguishing time

Flammability properties impacted by aging and/or contamination ?

SOLUTION STRATEGY

Reconstitute material flame retardant properties

- ✈ Spray-on flame retardant (FR) coating
  - Compatible with customer process
    - Ease of use
    - Equipment compatible
  - Suitable for complex surface
  - Low material cost
  - Weight neutral with remove & replace

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PHASE I: EVALUATE COMMERCIAL FLAME RETARDANT COATINGS

Engineering Requirements for coating:

- Good adhesion
- Flammability requirements
  - Low smoke & toxic gas emission
  - Radiant panel test
- Physically durable and flexible
  - Consistent mechanical / flammability properties with aging
- Water resistant and non-absorbent over time
- Non-conductive and non-corrosive
- Minimal weight impact
- Relative ease of application and cure

INTUMESCENT COATINGS

- Constituents
  - Acid source, blowing agent, and carbon source
- Advantages
  - Weight and volume savings
  - Competitive costs
  - Good insulation against static heat source
  - Commercially available
  - Hazmat/Toxicity
- Disadvantages
  - Non-durable intumescent foam
  - Non-uniform coating thickness
  - Equipment/process requirements

KEY TEST REQUIREMENT: RADIANT PANEL

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≤ 3 sec After Burn

≤ 3 in Burn length

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CONSISTENT RADIANT PANEL RESULTS OBTAINED

Commercial FR coating applied to in-service insulation blanket

PHASE I SUMMARY

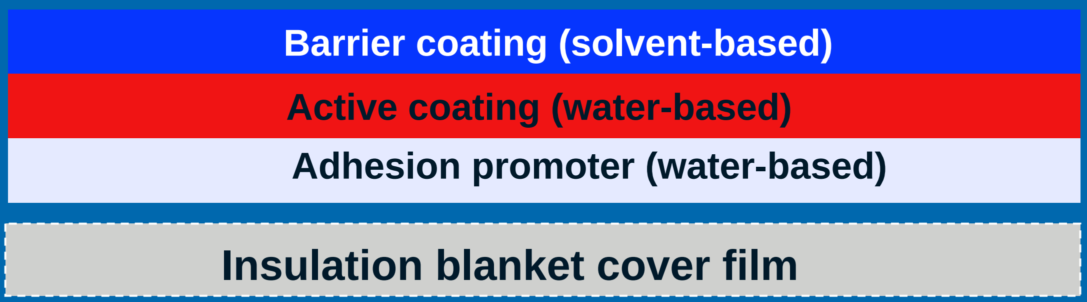
Property Requirements met:

- Radiant panel & smoke emission requirements
- Water soluble & non-toxic
- HVLP spray application
- Non-conductive & non-corrosive
- Minimal weight impact

Property Requirements **NOT** met:

- Water resistant only after long cure (> 1 month)
- Loses some flexibility with aging
- Elevated temperature cure

PHASE II: USE 3 PART COATING SYSTEM TO COMPLETE PROPERTY REQUIREMENTS



All 3 components applied separately with HVLP spray gun or brush

- Adhesion promoter
  - Latex-based, flame retarded adhesive
- Active coating
  - Spray-on Intumescent
- Barrier coating
  - Provides resistance to moisture and durability
- Coverage/configuration control addressed by coloration

Barrier Coating Evaluations

Tough meeting both water resistance and radiant panel

ENCOURAGING RESULTS WITH ACRYLIC BARRIER

- Quick drying, completely water resistant, & flexible
- Consistent Q-tip and flaming block test results

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FR-COATED INSULATION BLANKETS: POST-FIRE

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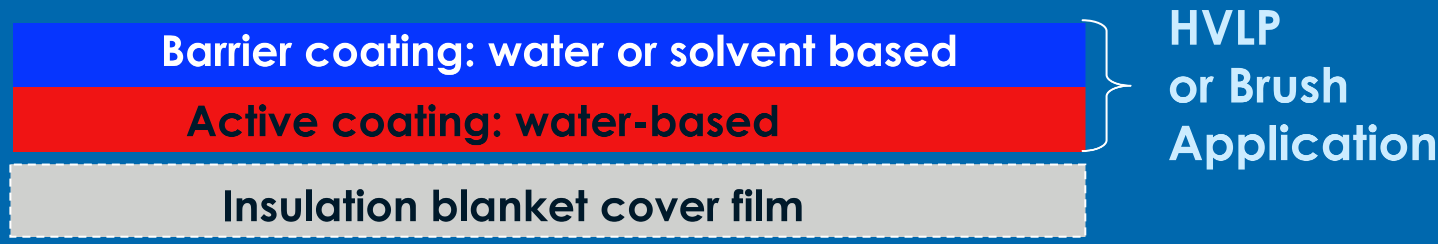
3 PART FR COATING CRITICAL ISSUES

- Active coating: Elevated Temperature Cure is costly
  - New version FX-100 cures at room temperature
- Barrier coating: Inconsistent radiant panel test results

PHASE II SUMMARY

- Acceptable coating properties
  - Water resistance
  - Durability
  - Non-conductive / non-corrosive
  - Cost / weight
  - Smoke density & toxicity
- Unacceptable coating properties
  - Inconsistent radiant panel test results
  - Elevated temperature cure
  - Multiple spray processes

PHASE III
TWO-PART FR COATING SYSTEM



- Consistent customer pull for key coating properties
  - Easy / flexible application method
  - Short cure times / no elevated temperature cure
  - Haz Mat concerns: Low toxicity
- Key Engineering requirements
  - Radiant panel, smoke density & toxicity requirements
  - Durable / flexible / low aging impact
  - Water resistant

Radiant Panel Testing Results: 2-Coat System

- Spray-on coating system: inconsistent radiant panel results

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BARRIER COATING ISSUES

- Water-Based formulations
  - Low toxicity
  - Meets radiant panel requirements
  - Questionable water resistance
- Solvent-based formulations
  - Good water resistance
  - Flexible
  - Inconsistent radiant panel results
    - Entrapped volatiles ?

REFORMULATED BARRIER COATING

✈ Consistent Radiant Panel Results

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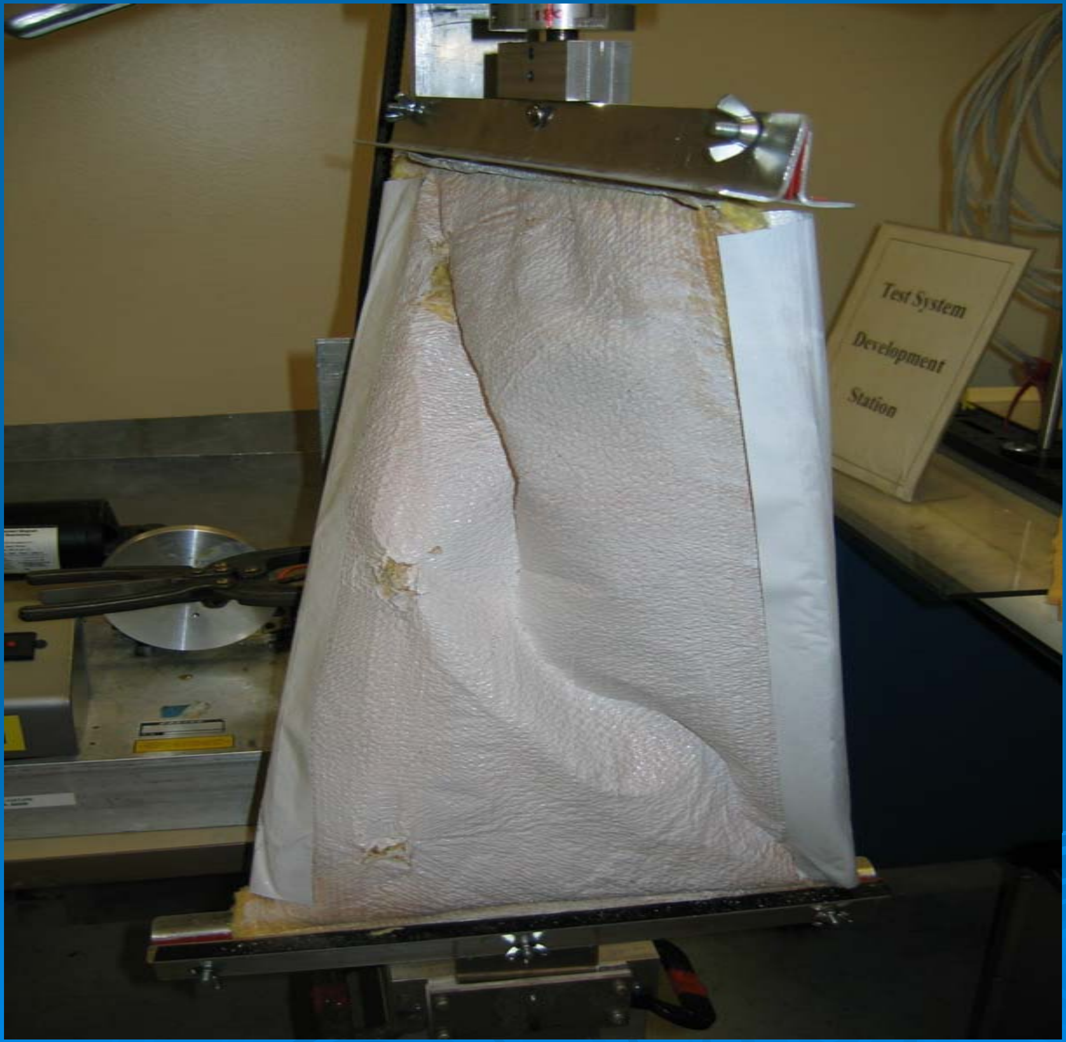
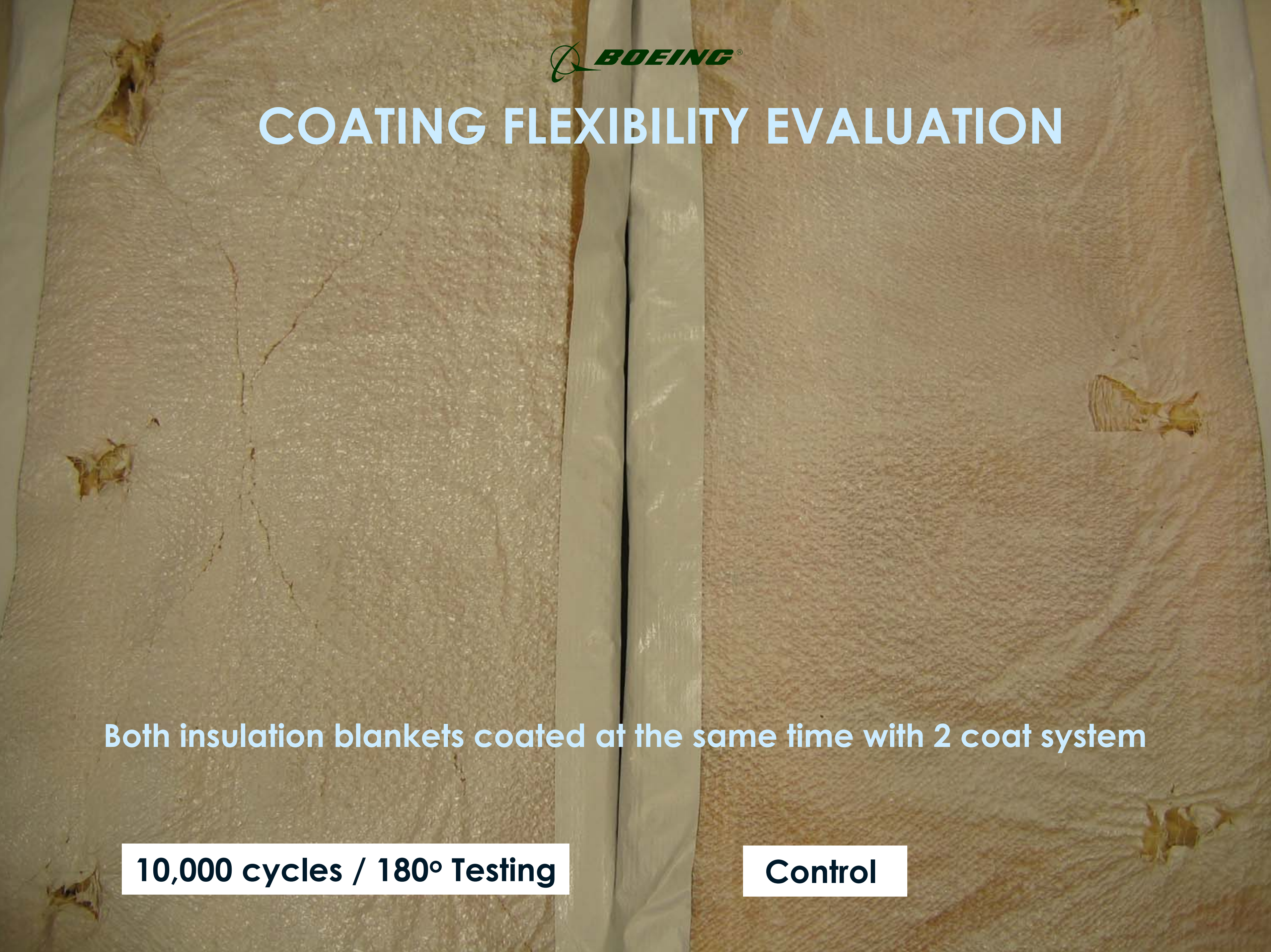
COATING FLEXIBILITY EVALUATION

Twist / Flex
Test Method



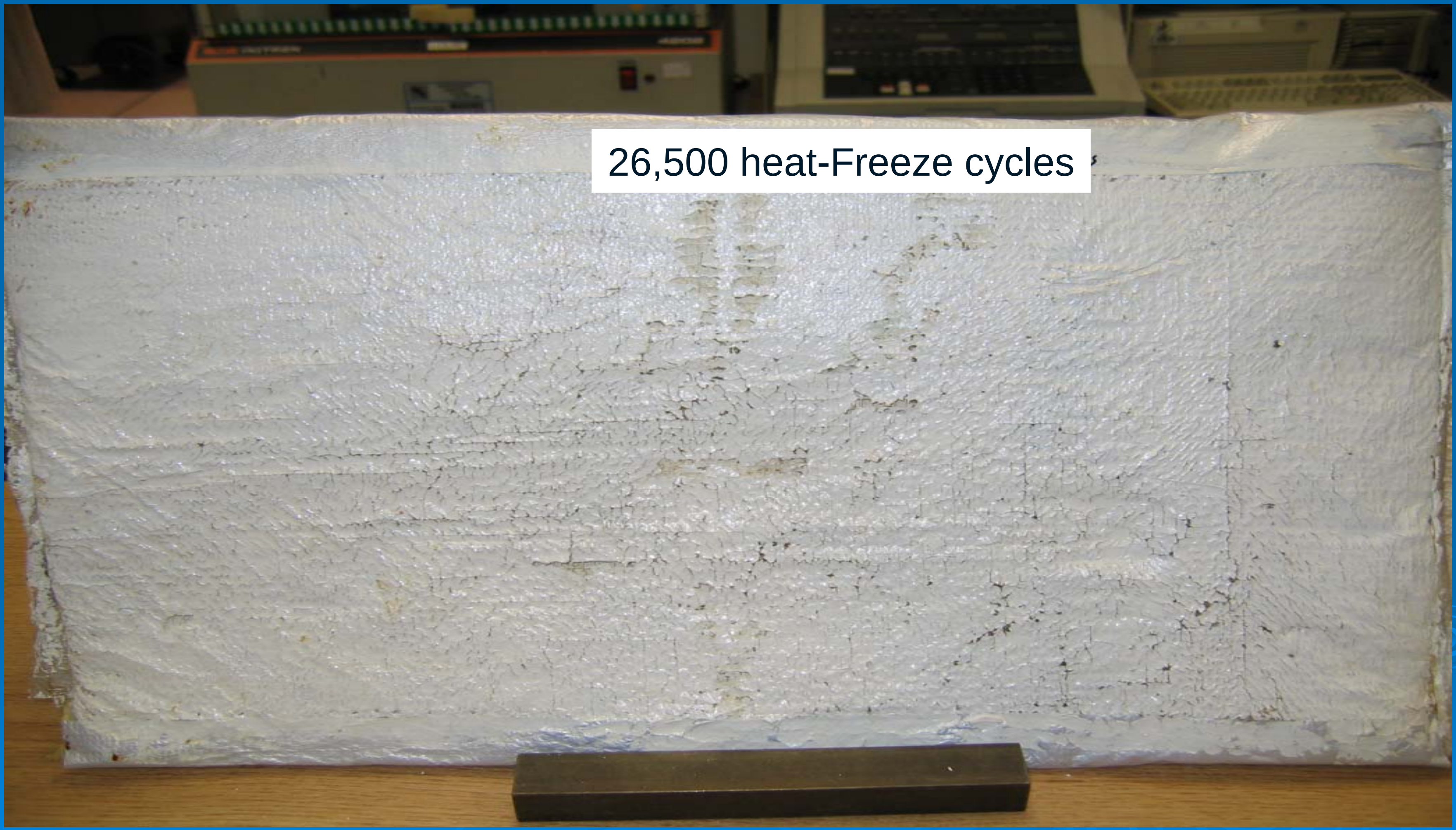
COATING FLEXIBILITY EVALUATION



Both insulation blankets coated at the same time with 2 coat system

ACCELERATED AGING: 26,000 FREEZE-HEAT CYCLES

AGED COATINGS EXHIBITS CRACKING



TWO PART FR COATING SUMMARY

Engineering requirements met:

- Ease of application, cure temp/time
- Non-conductive, non-corrosive, water resistance
- Smoke density & toxicity, radiant panel
- Low weight, cost

Engineering requirements NOT met:

- Cracking / chipping still an issue
  - **Twist and flex**
  - **Environmental aging**

FUTURE DEVELOPMENTAL WORK

- New formulations:
  - Barrier
  - Active
- Further research with suppliers
- Single application coating development