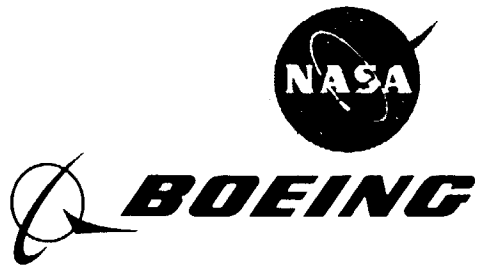


The Evolution of Flexible Insulation as Thermal Protection Systems for Reusable Launch Vehicles:

AFRSI(Advanced Flexible Reusable Surface Insulation) to CRI (Conformal Reusable Insulation)

Marc Rezin, NASA Ames Research Center

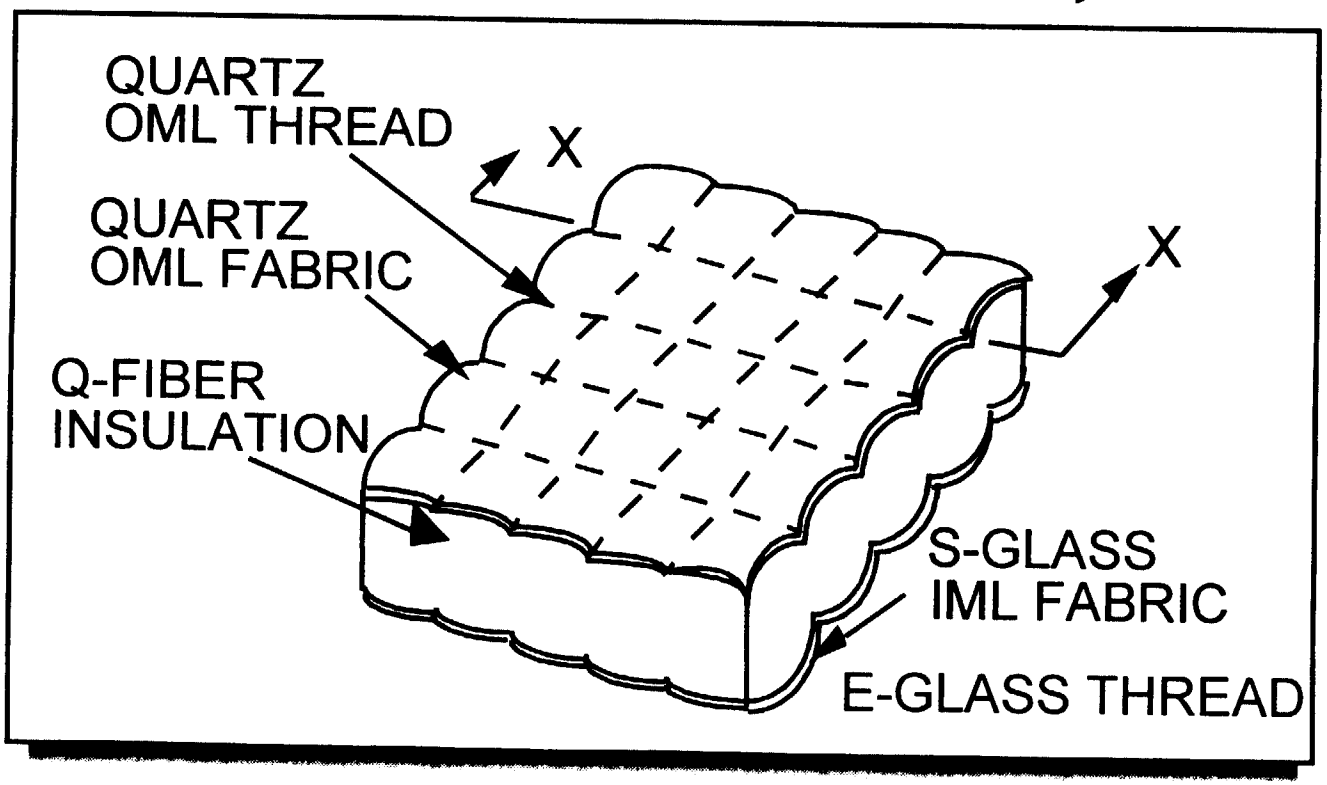
Kris Oka, The Boeing Company

National Space and Missile Materials Symposium

June 25, 2001

ble Reusable Surface

- 1200°F Multi-Mission Life
- 1600°F Single-Mission
- 350 °F Backface Maximum Temperature
- 1 inch thick (up to 2.04 inches thick)



...ed for Use on Shuttle ...1980

Replaced White Tile On Orbital Maneuvering System (OMS) Pods with AFRSI

- **Why AFRSI?**
  - White tiles are fragile
  - Potential for cost savings
- **Technical Concerns & Associated Tests**
  - Structural Integrity – Wind Tunnel
  - Rain & Moisture Effects – Pad Rain
  - Thermal Performance – Arc Jet, Radiant Heat, Guarded Hotplate
  - Sequenced Environmental Effects – Wind Tunnel & Arc Jet
  - Weight
  - Design Details

# of AFRSI: STS-6,

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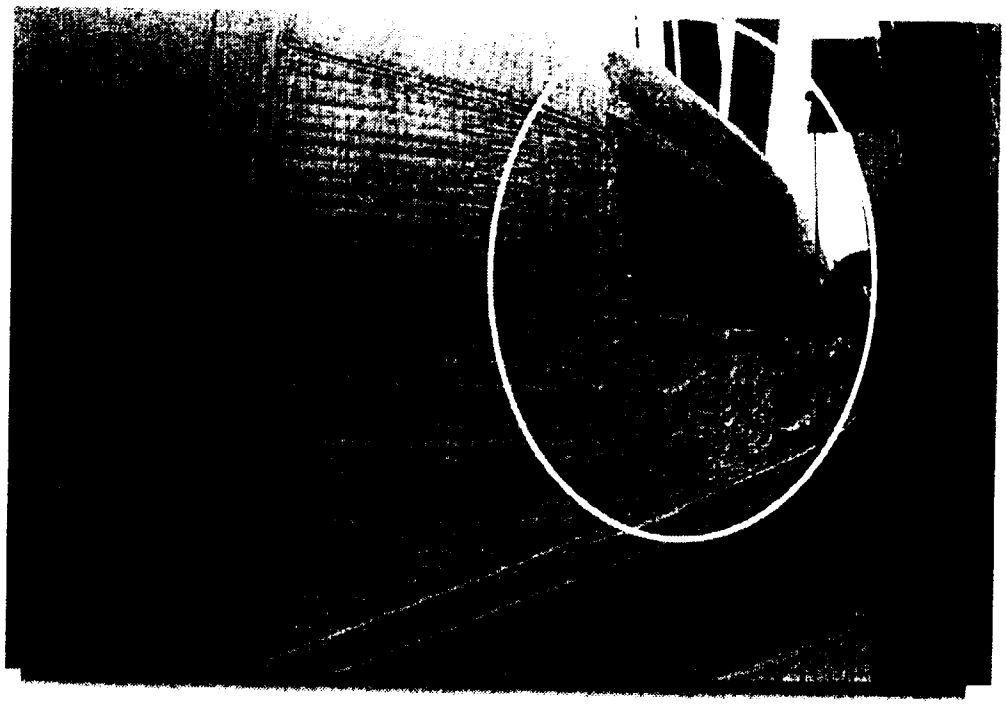
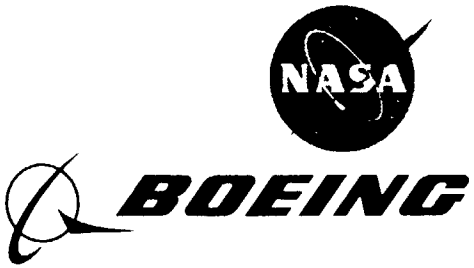
OMS Pod

Pre-Flight



Post-Flight – Damaged AFRS

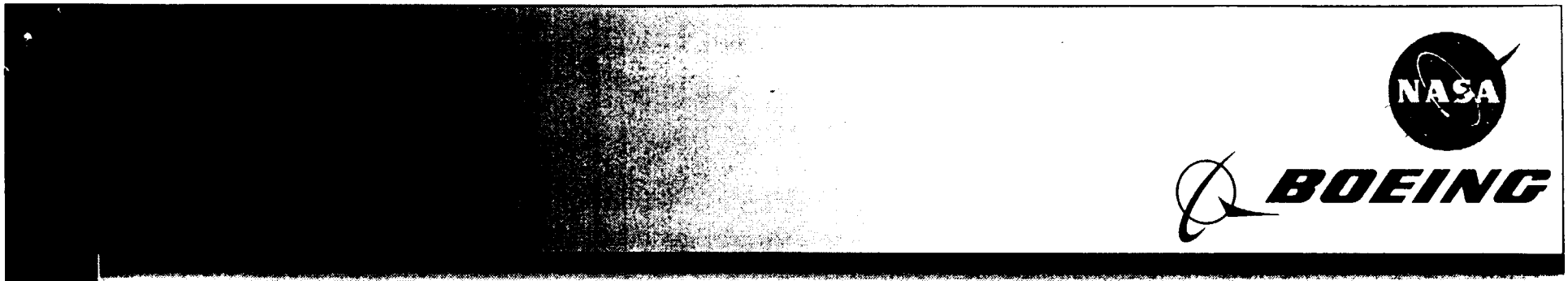
Activities



- Conducted Combined Environments Testing – Hot Wind Tunnel Testing at Arnold Engineering Development Center (AEDC)
  - Demonstrated Worst Case
- Accelerated Ceramic Coating Development – C-9 Silica Based Coating for AFRSI
  - Prevent Fiber-to-Fiber Abrasion from Buffeting
- Performed Aerodynamic Analysis of OMS

[illegible]S Pod
[illegible]on

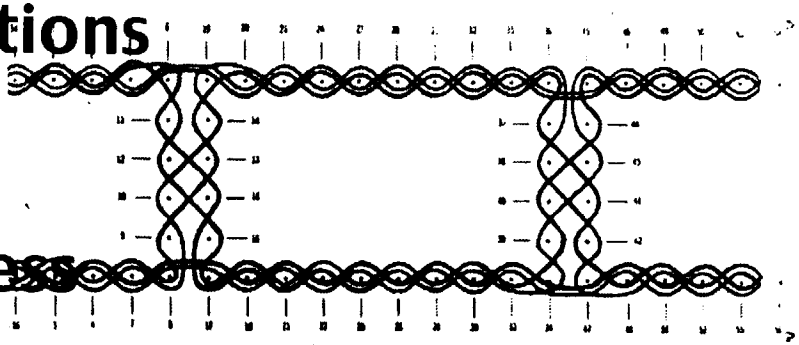
Add picture of tile on OMS pod

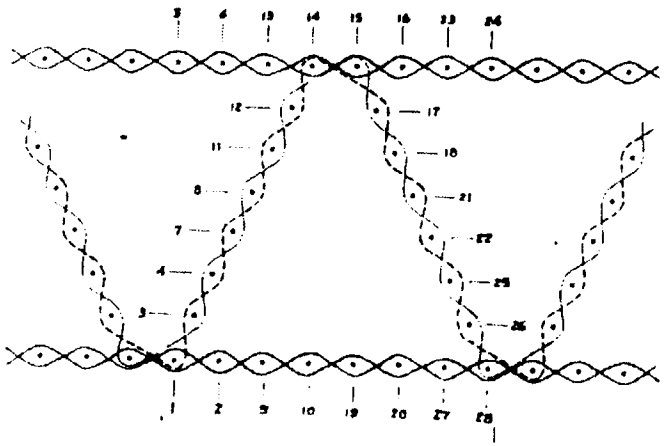


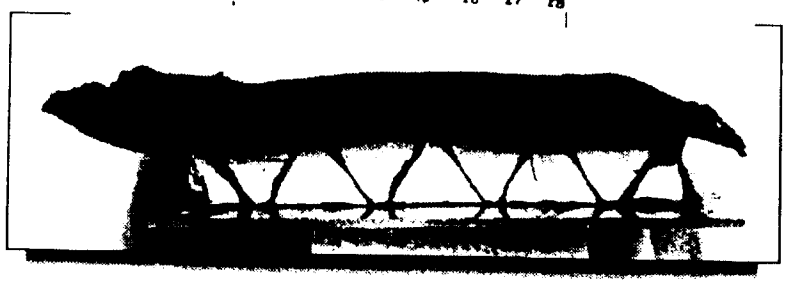
Windward Blanket Development

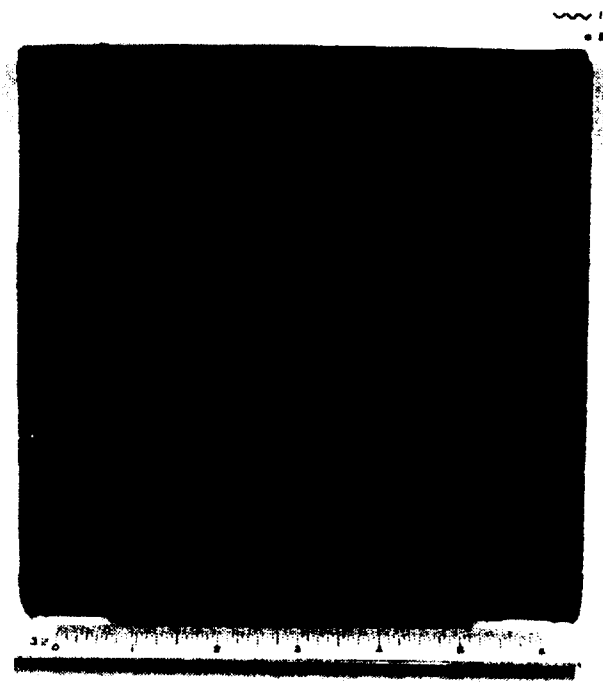
nced Blanket

- 3D Architecture Configurations
- Nicalon (silicon carbide)
- Q-felt Batting
- Complex Fabrication Process



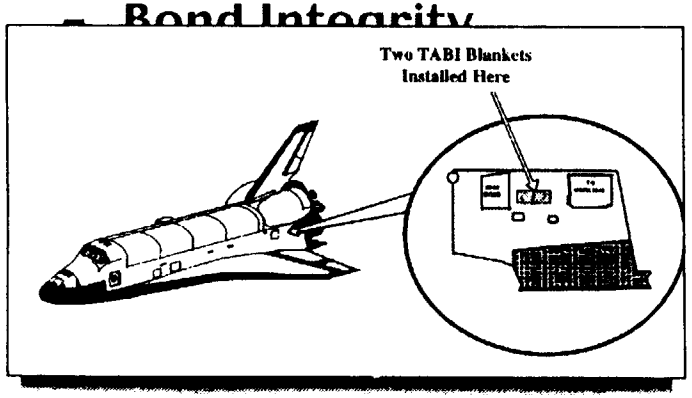


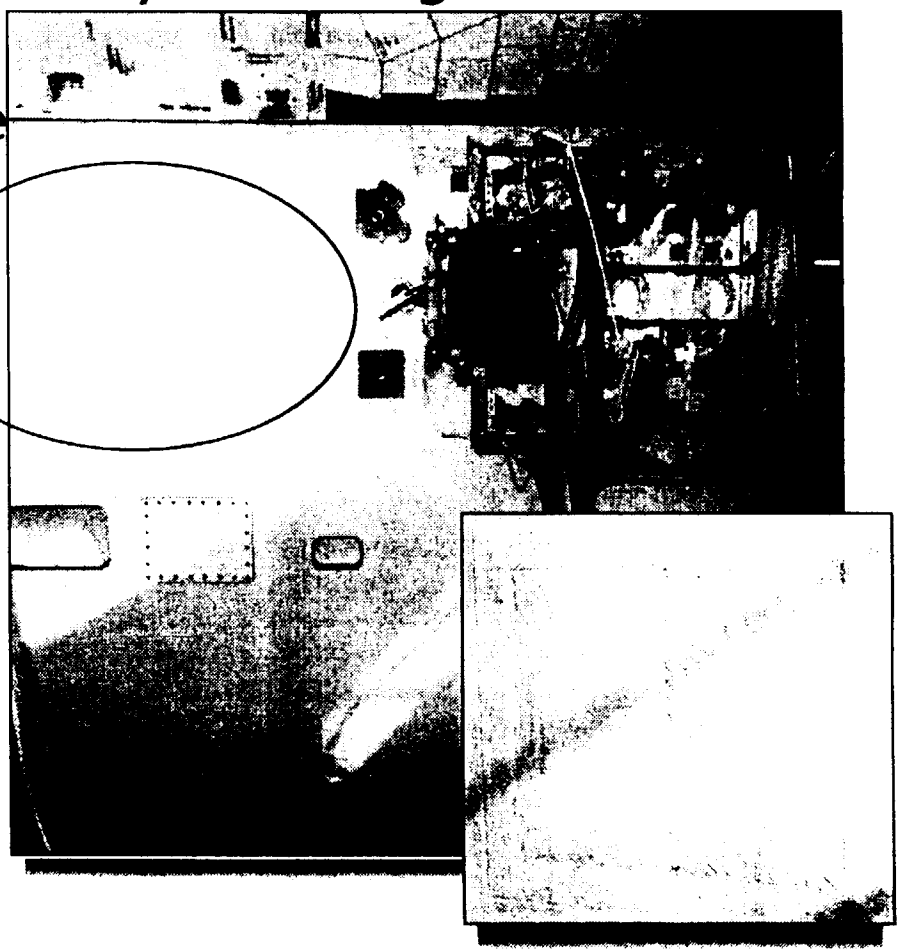




TABI – X-33 Phase I Flight Demo on OV-104

- Demonstrate Resistance to High Acoustic Levels (~145dB) and Dimensional Stability Under Flight Air Flow Conditions
- 3 Flights on Aft Fuselage Side
  - STS-76, STS-79, STS-81
- Certification Based on
  - Thermal Conductivity (GHP)
  - Aeroacoustic (TBARS)
  - Bond Integrity

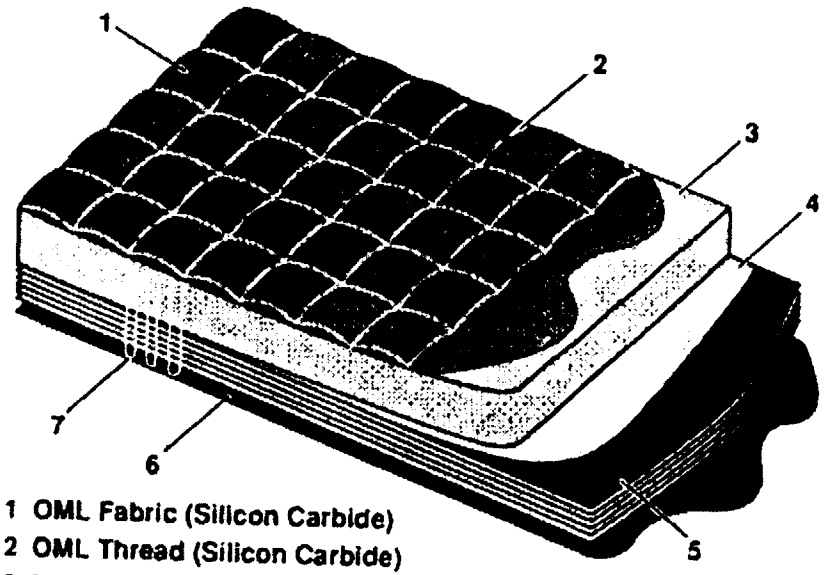




Flexible Blanket (CFBI)

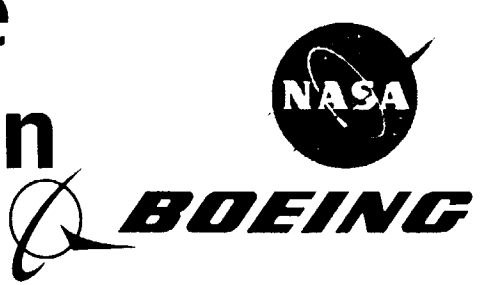
- Nextel or Nicalon Facesheet
- Alumina or Q-Felt Ba
- Reflective Layer

Add picture of CFBI



1 OML Fabric (Silicon Carbide)
2 OML Thread (Silicon Carbide)
3 Insulation (Alumina Batting)
4 Scrim Cloth (Aluminoborosilicate)
5 Reflective Shield (Aluminized Polyimide)
6 IML Fabric (Aluminoborosilicate)
7 IML Thread (Aluminoborosilicate)

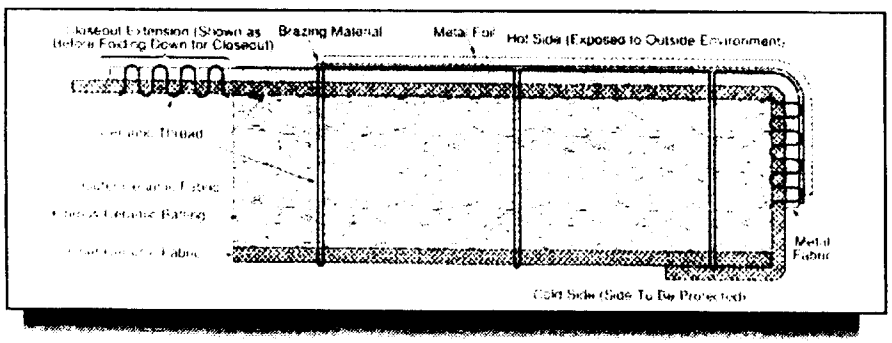
Advanced Flexible Surface Insulation

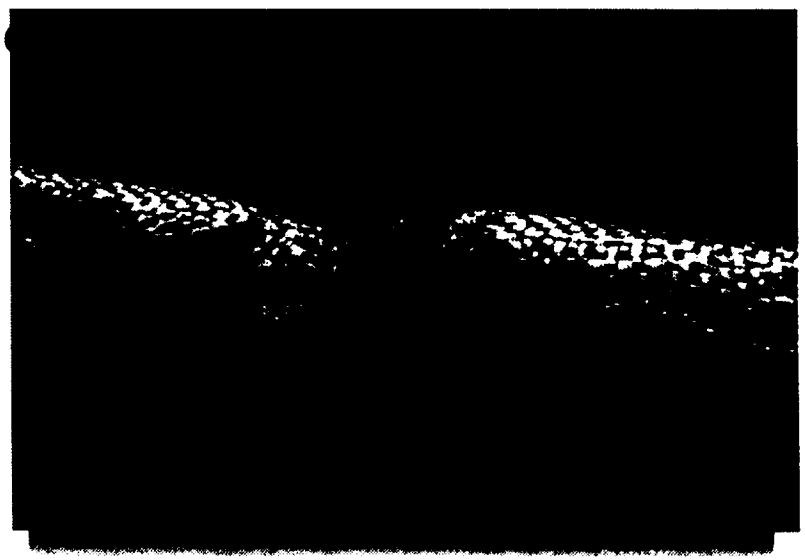


Developed by NASA Ames – U.S. Patent 5,811,168

The material is composed of

- **Hybrid Nextel 440 – Inconel – Gold alloy outer fabric**
- **Alumina insulation**
- **Nextel 440 inner fabric sewn together with Nextel 440 thread.**
- **An Inconel foil (4 – 8 mil typical) is brazed on the surface of the blanket after th**





nformal Reusable (CRI) Products

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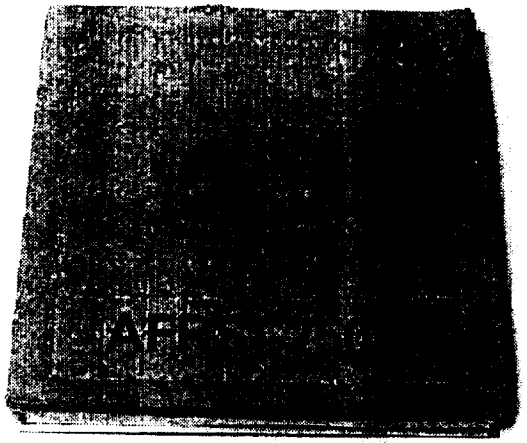
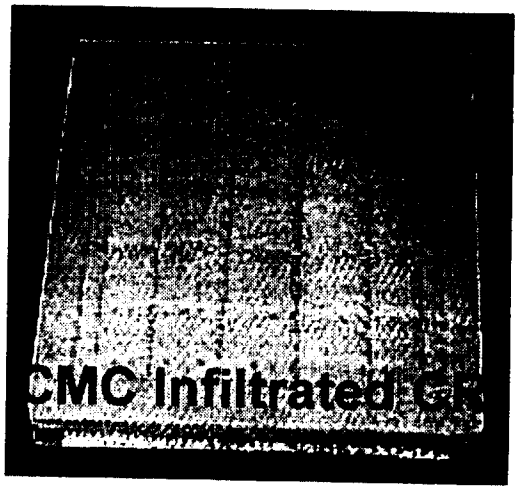
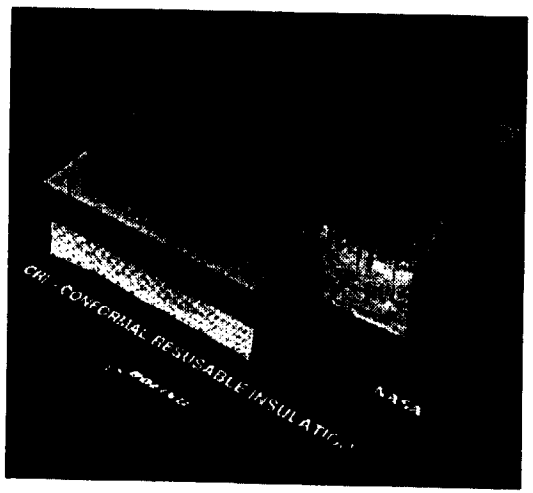
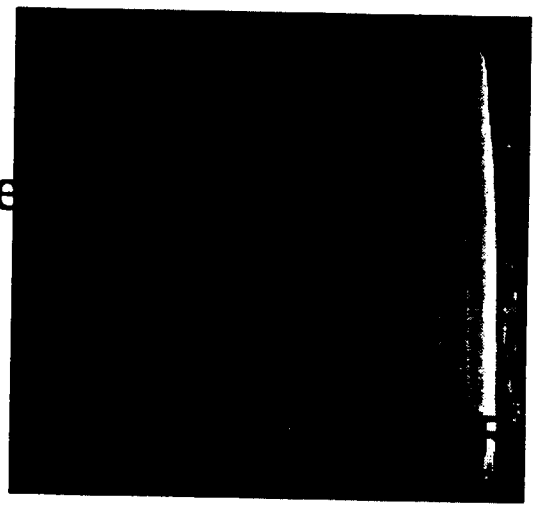






Distance Weave Pre



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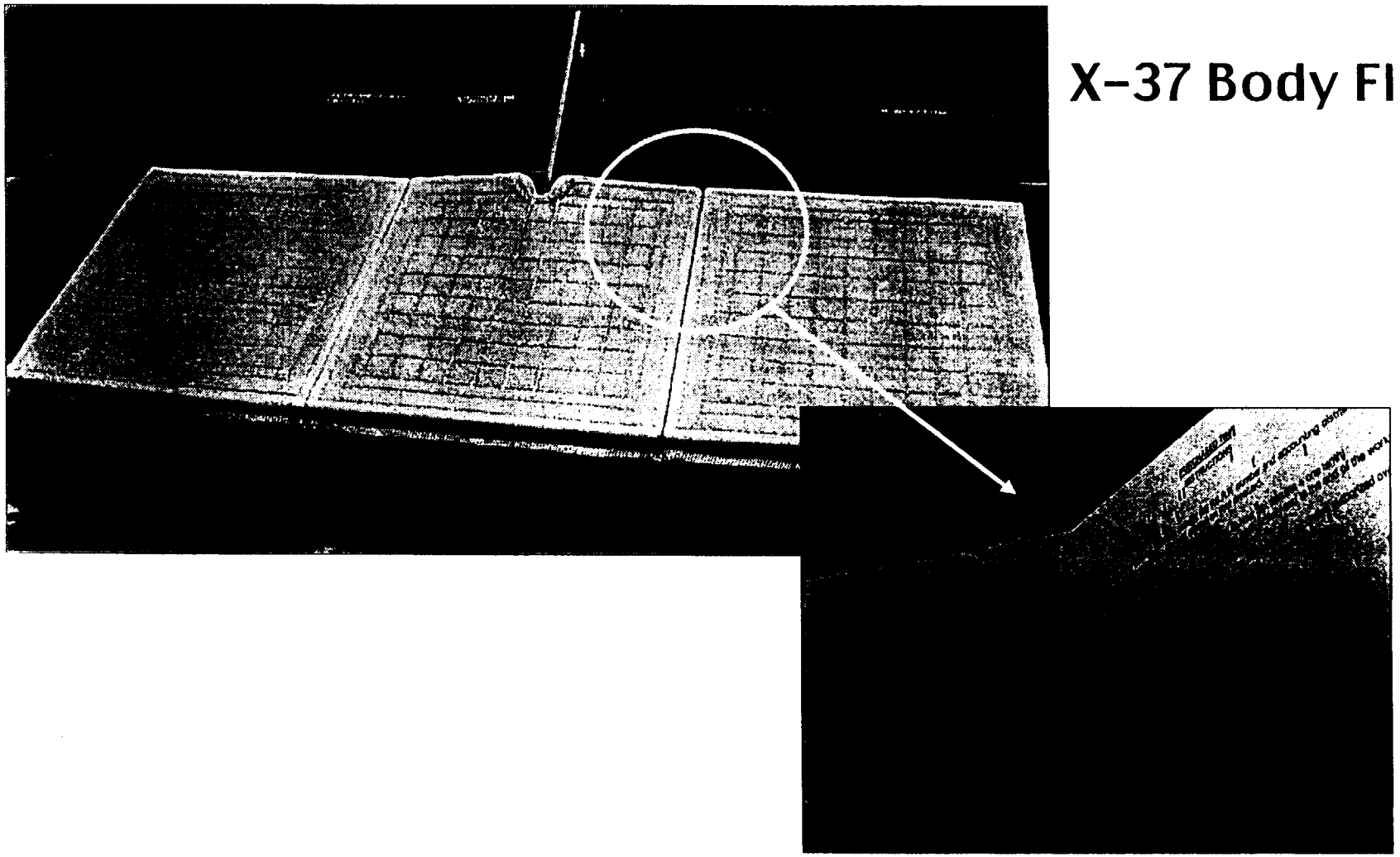

X-37 Body Fla

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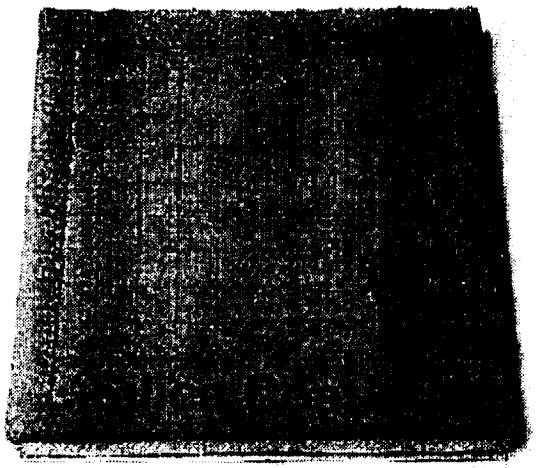

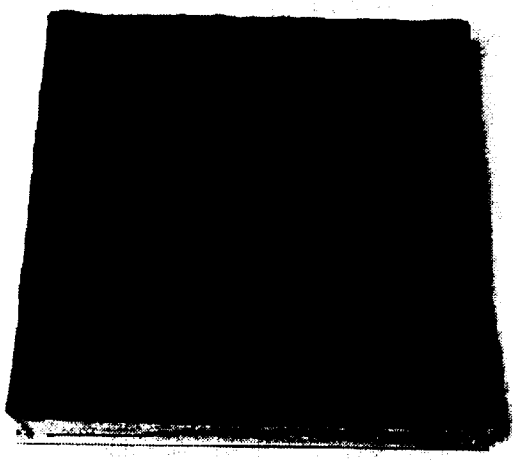

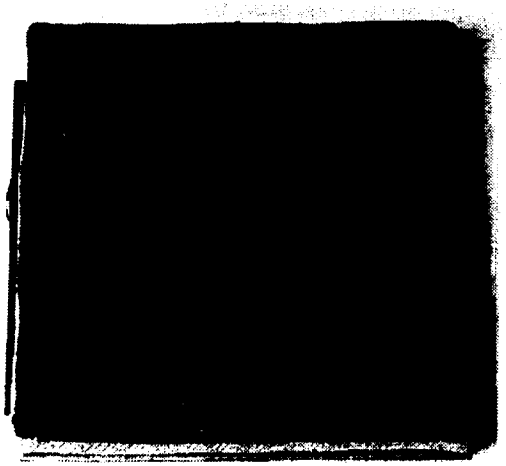

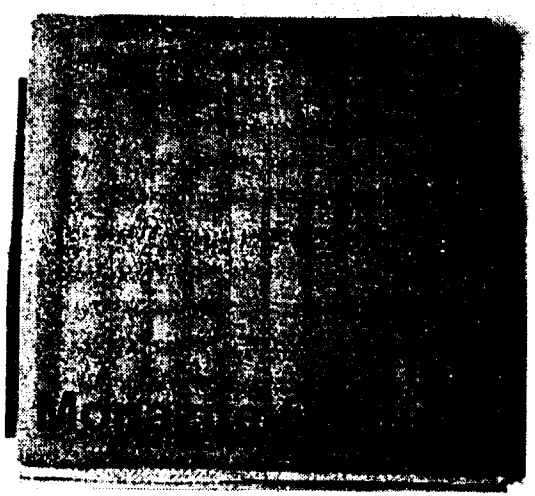

Demo

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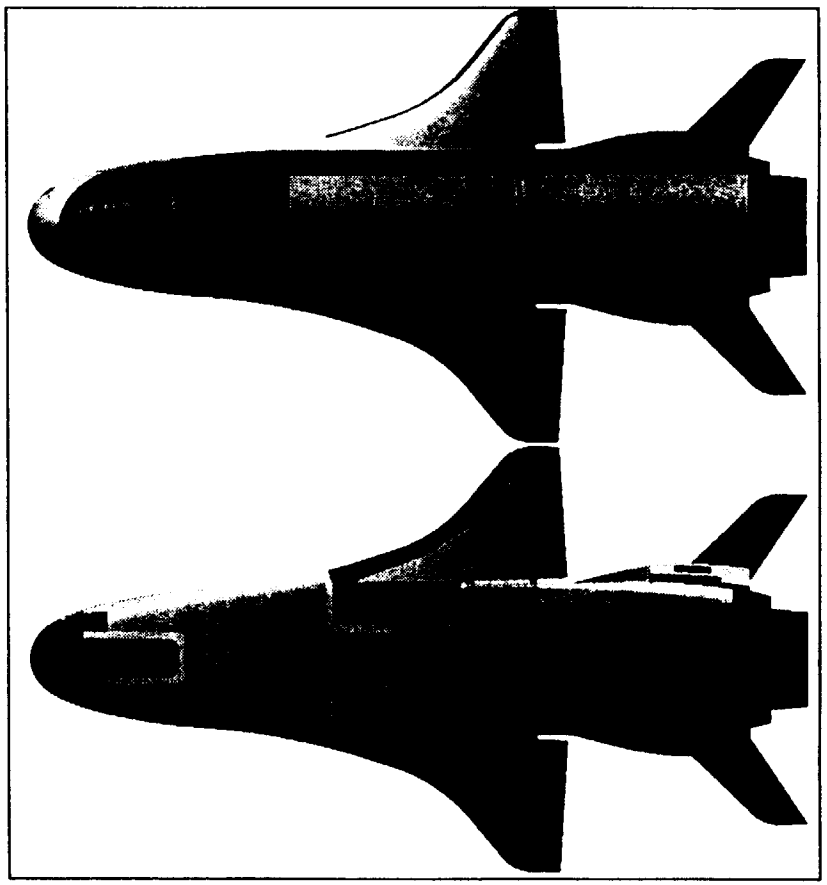
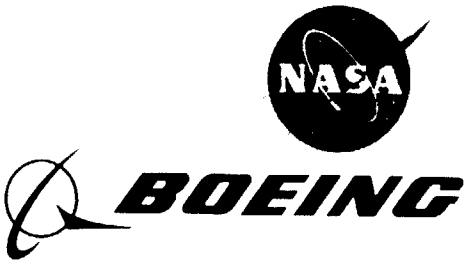
LEGEND

Max Temp (F)

2,200	CRI (0.50)
2,200	CRI (1.90) + SIP (0.090) Category 2 MB0135 -110 Type II, CL 1
750	FRSI CL 1 (0.16)
750	FRSI CL 2 (0.32)
1,500	AFRSI CL 4 (0.58)
1,500	AFRSI CL 2 (0.75)
1,800	HTA (1.40)
2,300	LI-900
2,300	AETB-12
2,300	AETB-8
3,000	BAHT-18
2,300	LOW RHO/K
	TPS EXPERIMENT PANEL



g Remarks



- AFRSI Remains One of the Most Cost-Effective TPS for Leeward Applications
- Windward Blankets Offer Significant Parts Count Reduction Over Ceramic Tiles & Metallic TPS
- Development Approach for Windward Blankets – *Needs to come from tile lessons learned as well as*