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**Flexible Thermal Protection Materials for Entry
Systems**

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Background

- **Composite Flexible Blanket Insulation (CFBI)**
 - Silicon Carbide Interlock top fabric
 - Contains reflector shields-- aluminized Kapton
 - Alumina Insulation
 - IML has 2 inch centers to reduce foil/fabric damage
 - Thermally stable (short term) at heat flux rates up to 31 Btu/ft²•s, surface temperatures ~2700°F
 - Density similar to AFRSI-TABI
 - Lower thermal conductivity at high temperatures than AFRSI or TABI
 - Requires ceramic coating for exposure to higher heating rates
 - Vibroacoustic performance of ceramic coating unknown

Background

- **Types of Flexible TPS currently available**
 - **Tailorable Advanced Blanket Insulation (TABI)**
 - Integrally woven with silicon carbide yarn
 - Insulation is alumina or aluminoborosilicate
 - Thermally stable (short term) at heat flux rates up to 31 Btu/ft²•s, surface temperatures ~2700°F
 - Thermal Conductivity approximately similar to AFRSI
 - Better vibroacoustic performance (Interlock version) than AFRSI
 - Density 9-10 lb/ft², approximately similar to AFRSI
 - Requires ceramic coating for exposure to higher heating rates

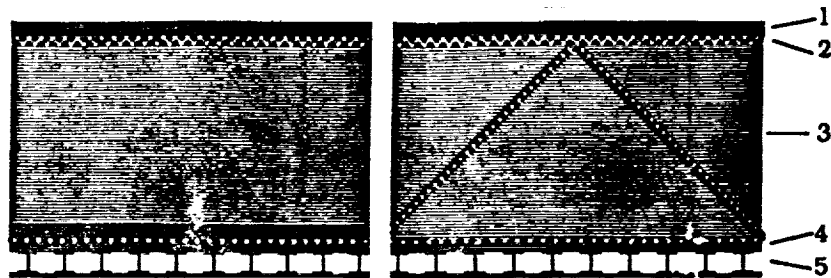
Technology Needs

- High temperature (>1800 °F) *Flexible Coating* for flexible insulations/fabrics
- Flexibility required for TPS installation purposes
- Present coating applied "green" or unfired and rely on entry heat for curing.
- Suitable for fast reentry such as AFE, may not be suitable for slower reentries.
- Prior firing may be required to survive
 - High (>165 dB) vibroacoustic loads
 - High aerodynamic effects
 - Particulate impact and
 - Moisture effects
- Should not provide significant weight penalty (>15%)
- Have suitable emissivity values ≥ 0.85

Technology Needs

- Simple, Lightweight, Durable and Waterproof Insulations
 - Intermediate (~ 2000 °F) temperature applications.
 - Utilize existing AFRSI, TABI or CFBI fabrication technology
 - Use 2 inch centers on AFRSI or CFBI.
 - Utilize metal coated ceramic (Nextel, etc.) OML fabric.
 - Use existing graphite coating technology.
 - Bond metal foil (Ni, etc.) on OML fabric utilizing induction brazing techniques.
 - Provides non-stitched impermeable surface
 - Resistant to moisture/water, high vibroacoustic loads, and aerodynamic effects

Metallic CFBI / TABI



- 1 Metal Surface (Induction Brazed to Fabric)
- 2 Ceramic Fabric with Embedded Woven Wires or Metal coated Fabric
- 3 Ceramic Insulation with Reflective Metal foils (left) or Ceramic Fabric Supports (right)
- 4 Bond (RTV)
- 5 Vehicle Structure

Technology Gaps for Flexible Insulations

- Ceramic Coatings
 - Require high temperature firing-- reduce mechanical properties of fibers/fabrics
 - Weight penalty
 - Reduce flexibility
 - Questionable reusability
 - Low adhesion (unfired)
- Metallic Surfaces
 - Temperature limitation due to oxidation
- Close-out of complex shapes
- Instrumentation, installation and attachment methods

Highest Payoff Areas for Flexible Insulations

- Low cost fibers for high-temperature applications
- Simplify fabrication procedures for insulations
- Effective coatings-- use with low cost fibers

CURRENT HEAT SHIELD MATERIALS THERMAL LIMITS

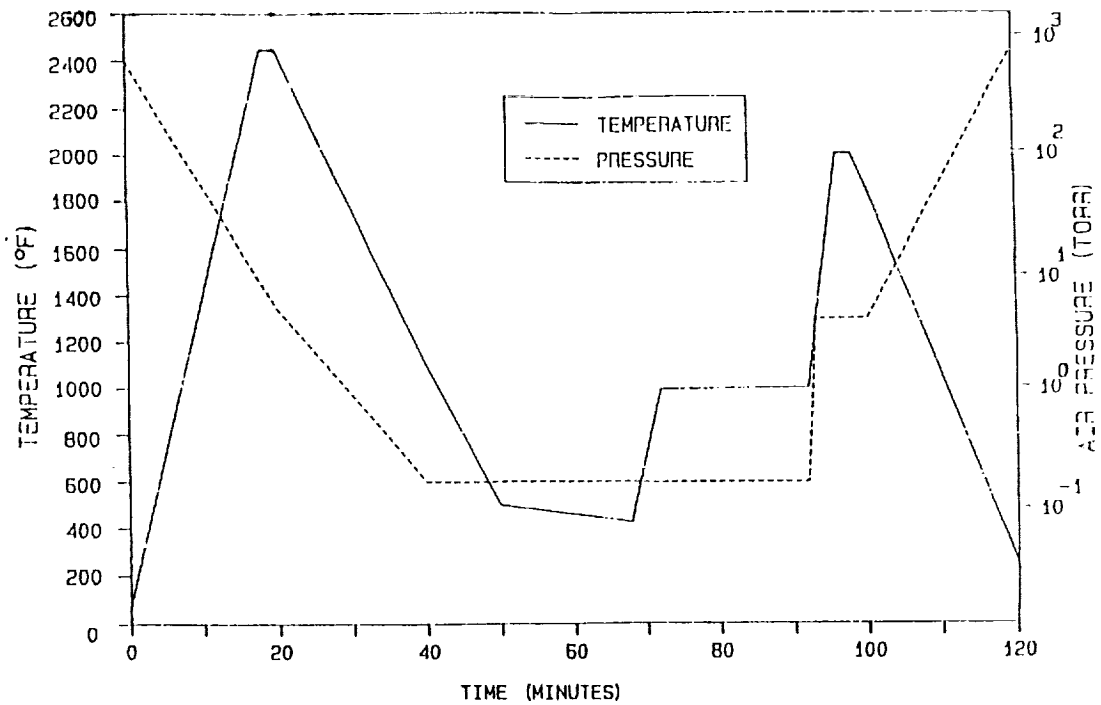
MATERIAL	MAXIMUM USE TEMPERATURE, °F		EMITTANCE (@ °F)	MAXIMUM HEAT FLUX CAPABILITY* BTU/FT ² ·SEC	EQUIVALENT USE TEMPERATURE, °F**
	MULTIPLE FLIGHT	SINGLE FLIGHT			
FLEXIBLE ORGANIC					
FRSI	700	800	.9(800)	1.4	865
PBI	900+	1100	.9(1100)	2.7	1125
AFRSI, TABI, CFBI					
SILICA	1200	2000	.43(2000)	4.4	1480
NEXTEL	> 2000	> 2000	.48(2000)	> 7.5	1820
NICALON	2000	> 2400	.58(2000)	> 30	
RIGID CERAMIC INSULATION					
LI-900	2500	2700	.9(2500)	60	2980
LI-2200	2600	2800		(80)	
		(2900 FOR AFE)			
FRCI-12	2600	2800	.9(2500)	70	3115
AETB-12/TUPI	2500	2700**		60	
AETB-12/RCG	2600+**	2800+**		70	
ASMI	2600+**	2900**		80	
AETB-B/RCG	2600**	2800+**		70	
METAL					
TITANIUM	1000		.8	1.7	1000
RENE 41	1600			8.9	1600
INCONEL 617	2000			14	2000
RCC/ACC	3000		.8	55 (F.C.) 100 N.C.	3000 3560

Current Programs

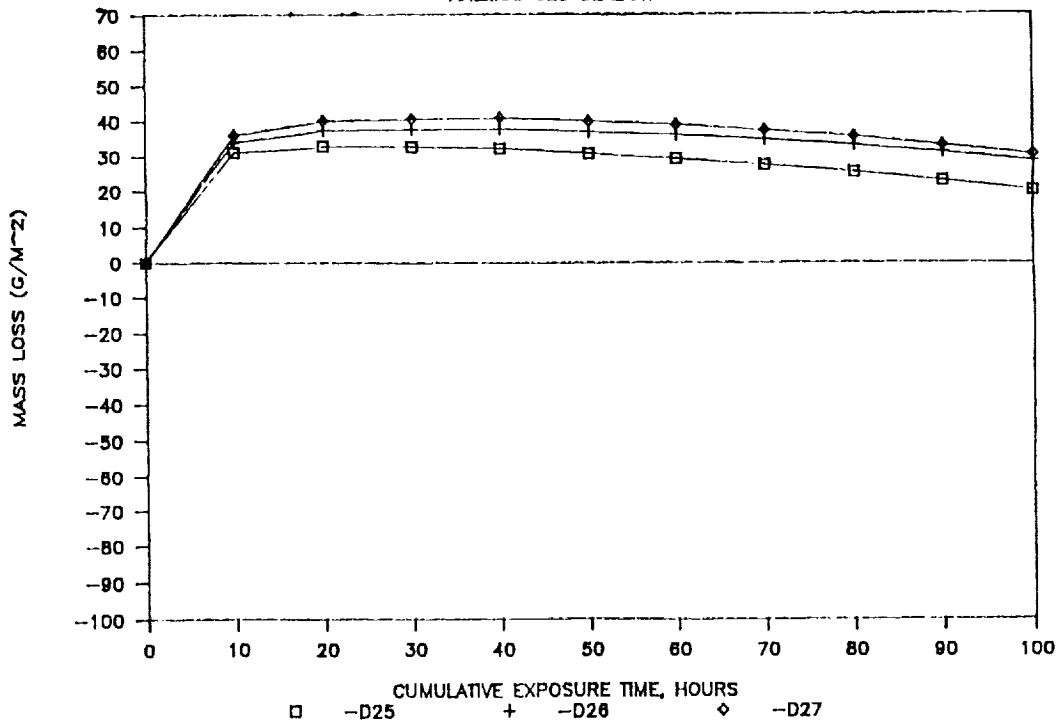
- **Aeroassist Flight Experiment**
 - Evaluate thermal performance of advanced Rigid and Flexible Insulations and Reflective Coating
 - Lighter than baseline materials
 - Rigid insulations perform well
 - Flexible insulations require ceramic coating
 - Reflective Coating effective at >15% radiative
- **NASP**
 - High and low temperature insulations
 - Attachment/standoff methodology critical-- affects thermal performance

**10.3.7 Recent Advanced Carbon-Carbon Efforts at LTV
by Garland B. Whisenhut, LTV Missiles and Electronics Group**

TEST PROFILE #2



GD MEDIUM CYCLE AREMCO 623 SEALANT



CONCLUSIONS

- o ACC SUBSTRATE FABRICATION TECHNOLOGY IN GOOD SHAPE.
- o ACC COATING IMPROVEMENTS SATISFACTORY BUT ADDITIONAL WORK NEEDED.
- o NON-DESTRUCTIVE TEST TECHNIQUES TO MONITOR HARDWARE DURING OPERATIONAL LIFE NEEDED.
- o COST REDUCTION APPROACHES A HIGH PRIORITY.

