EM41 Non-Metallics Branch

Polymeric Materials Application and Testing for Space Missions

The EM41 Non-metallics polymers team performs polymeric materials screening, characterization, development, qualification, verification and validation testing for flight hardware and in-space applications. They perform insight, testing and application of polymeric materials for launch vehicles and space environments. Personnel have a deep understanding of the technologies associated with cryogenic insulation, high temperature thermal protection materials, paints, primers, coatings, and adhesive materials.

Numerous TPS material characterization tests can also be performed by the Lab. The team has both internal and partner test capabilities to subject polymeric materials to Aerospace and Space environments Material properties, response and performance are tested within environments from the launch pad, through the launch environment and into space..

A primary role of the team is to select materials and organize test regimen then analyze test results. Test regiment are established to confirm the materials meet the performance requirements levied by customers within the environments that are expected for the mission.

Thermal Protection


Thermal Protection System Development Facility

Flight Hardware Application and Process Development

- TPS Development Facility:
- Designed to develop environmentally compliant TPS materials and processes
- Supports large-scale automated and/or manual material application in various orientations (20’ x 27’ x 70’)
- Foam machining capability to +/- 0.015” with photogrammetry support
- apply primers, paints, and spray on foam insulation (SOFI) in a single environmentally controlled facility for both test and flight hardware
- Spray Process environment sensitivity Application Testing with Humidity and Temperature variation


Spray Applications


Flight Vehicles

Test Articles

Mobile Capability


MAF Support

Coatings


Coatings Development Facility (9' x14' x 26’)


Application


Coatings Development


Flight Hardware


Atmospheric testing partnership
KSC Beach and Launch Pad Test sites

Coatings Application Facilities:

- Designed to develop coatings materials and processes.
- Humidity and temperature controlled for process window development
- Supports large-scale automated and/or manual coatings applications in various orientations for large hardware
  (20’ x 27’ x 70’) in TPS Facility
- Ability to apply primers, topcoats and other paints in medium sized coating Facility (9' x14' x 26’)
- Painting of solid motors and medium sized flight hardware
- Application of test panels for coatings test programs
- Sprayable ablator development laboratory
- Abrasive blast equipment, ovens and fluid handling equipment
- Automated Cleaning Facility (Water jet Coating/Ablator removal)

Subject Matter Expertise

Environments	Functional Needs	Application methods	Cure Methods
Cryogenic	Surface Modification	Manual	Thermal
Extreme Heat	Thermal control	Robotic	UV
Space	Corrosion protection	Spray, Brush, Roll	Ambient
Lunar / Mars	Wear / Tribological	Immersion	Plural Component
Launch and Ascent	Coating Removal	Powder	Moisture
Hypersonic	Radiation	Electrodeposition	
	Surface Preparation		

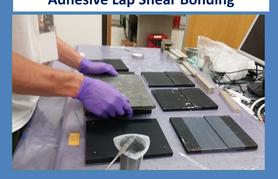
Adhesives and Adhesive Bonding

Adhesive Bonding Expertise and Capabilities

- Development of adhesive bonding processes for spacecraft, space telescope, and launch vehicle production
- Bonding of industry standard and unique adhesive test specimens
- Development of specialized adhesive bond tests for unique applications and substrates
  - Mars Ascent Vehicle, Near Earth Asteroid Scout
- Performing adhesive bonding operations for flight hardware applications
  - Space Launch System Launch Vehicle Stage Adapter,
  - Modal testing
- Adhesive material characterization for programmatic downselection
  - Imaging X-ray Polarimetry Explorer mirror, Core Stage TPS Tiecoat Sealant

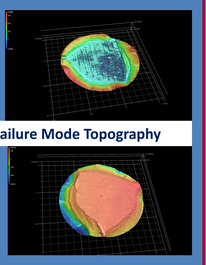

Ablative Cork
Tension Specimens

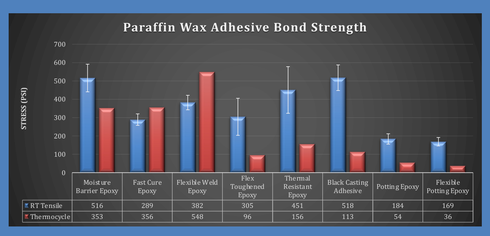
- Flatwise Tensile
- Peel Strength
- Thermal Constraint
- Adhesive Interface
  Digital Image Correlation
- Single lap Shear
- Reflective Control Devices
- Adhesive Tensile Dog bones


Adhesive Lap Shear Bonding

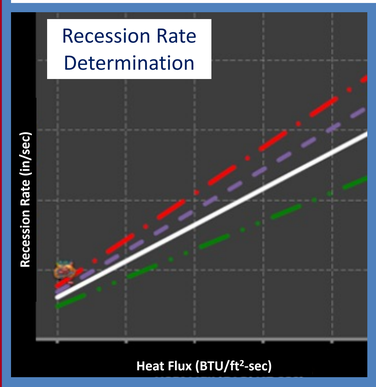
Case Study of Hybrid Rocket Concept using Adhesive

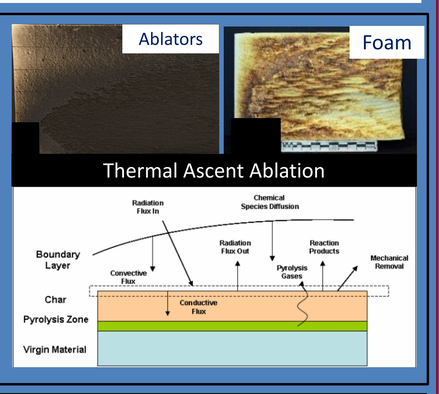
- Early iterations of the concept development considered hybrid propulsion system with a Paraffin wax based solid fuel
- The Wax Propellant had a high coefficient of thermal expansion
- Propellant pulled from casing liner during cool down
- A test matrix composed of 8 candidate adhesives was developed to vet their effectiveness as wax hybrid motor adhesives
- Testing included circular flat-wise tension samples and bonded thermal constraint samples
- Thermal constraint test developed to establish capability of an adhesive system under cyclical thermal loading


Wax Failure Mode Topography



Thermal Recession Testing, Measurement and Rate Prediction

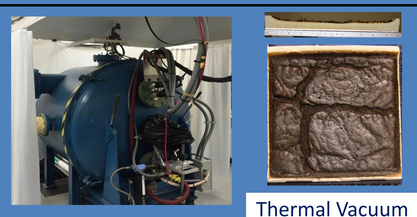




Thermal Exposure Tests

Thermal Ascent (AKA: Hot Gas) - is a test that subjects panels to high velocity airflow heating which simulates a Mach 4 aerothermal environment during flight. The test panels can be subjected to heating rates measured as BTU/ft²-sec.

Thermal Vacuum- is a test that subjects panels to variable atmospheres from Atmospheric pressure to vacuum level and an infrared heat load measured in BTU/ft²-sec. This can be used to simulate the effect of heat loads at different altitudes from the launch pad into space.


Thermal Vacuum

Polymeric Material Expertise

Full range of Subject Matter Expertise for

- Development, Qualification, Specification, and batch certification of polymeric Materials
- Material Obsolescence
- Process Development and hardware applications
- Ascent Heating and Recession characterization
- Cryogenic and Ascent TPS (Thermal Protection Systems)
- Pour and spray foam testing capabilities.
- TPS materials bonding lab
- Ablatives Development Lab
- Adhesive Bond Testing and Fixtures
- Performance Coatings Development and processing for:
  - Electrostatic Dissipation,
  - Weather Barriers,
  - Corrosion protection,
  - Hydrophobic surfaces,
  - Surface modification

Examples of Testing Methods Used

Internal

- Plug Pulls
- Compression
- Mandrel Bend
- Ball Impact
- Film thickness
- Hardness
- Foam Reactivity
- Density
- Adhesive test fixtures
- Salt Spray
- Cyclic Salt Spray
- Weight per gallon
- Percent solids

Partnerships

- Bond Tension (-423F to 200F+)
- Gradient Cryo-flex
- Mono-strain
- Compression
- Thermal Vacuum Testing
- Thermal Ascent Testing
- Microscopy
- Chemistry: TGA-FTIR, DSC, DMA,TMA, TGA, et al.
- Launch Pad Exposure
- MISSE
- Outgassing
- Atomic Oxygen
- Radiation Damage
- Industry Standard Test Methods

Types of Properties Obtained

- Strength data
- Hydrolytic stability
- Impact data
- Thermal conductivity
- Ablation Temperature
- Electrical Conductivity
- Static Dissipation
- Coefficient of thermal Expansion
- Specific Heat
- Weight loss
- Substrate temperatures
- Emissivity / solar adsorption
- Chemical Resistance
- Material Finger Printing
- Reactivity
- Friability
- Foam Closed Cell content
- Corrosion Susceptibility
- Surface Tension

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