National Aeronautics and Space Administration

Marshall Space Flight Center
Nonmetallic Materials

Engineering Solutions for Space Science and Exploration

Technicians manually applying SOFI to flight hardware.

Technicians insulating a 24" solid rocket motor case in 4707

4765 TPS Development Facility Spray Booth

Nonmetallic Materials research, technology, and process engineering support are core capabilities of Marshall Space Flight Center's (MSFC) Materials and Processes Laboratory.

The Laboratory develops nonmetallic materials, processes, and products to be used in space exploration application and manufacturing. Research and development is performed in the laboratory, field, and flight experiments. Laboratory personnel have a deep understanding of the technologies associated with cryogenic insulation, paints, primers, coatings, adhesives, seals, ablators, thermal vacuum testing, large scale thermal protection system processing capabilities, ceramics, in-space resource utilization (ISRU), solid rocket nozzles, solid rocket insulation, solid rocket propellant, and subscale solid rocket motor processing.

The Laboratory's Thermal Protection System (TPS) Development Facility was designed to develop environmentally compliant TPS materials and processes for current and future space programs. The facility provides the ability to apply both primers and spray on foam insulation (SOFI) materials to large-scale test articles in various orientations. Numerous TPS material characterization tests can also be performed by the Lab. Capabilities range from low fidelity in-process tests such as density, plug pull, and reactivity testing to higher fidelity thermal vacuum tests that expose TPS materials to vacuum levels and heating rates that mimic a launch vehicle's ascent through the atmosphere and into space.

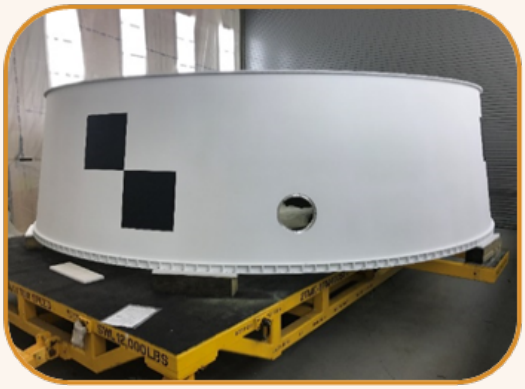
The Lab's involvement in nonmetallics includes subscale solid rocket motor material selection, testing, and processing. To address material obsolescence issues, the Laboratory investigates alternative material replacements. A material's ability to protect against the harsh, erosive solid rocket motor plume, environments can be tested in the unique Plasma Torch Test Bed (PTTB). The Laboratory also manages manufacturing of subscale solid rocket motors that are used to validate TPS material and process changes before being implemented on full-scale hardware.

The branch has been heavily involved in nonmetallic materials research, development, applications, and testing. This work includes research associated with the development of carbon-carbon (C-C), ceramic matrix composite, and TPS materials. The use of these materials range from large-liquid rocket engines to winged hypersonic vehicles to advanced ceramic fuel elements for nuclear thermal propulsion.

Capabilities

TPS and Coatings Development and Processing Facility:

- 30- × 30- × 85-ft Class I Div. I rated (able to utilize flammable materials) temperature and humidity controlled spray booth with associated heating, ventilation, and air conditioning (HVAC) equipment. Provides:
  - 20- × 27- × 70-ft hardware capability.
  - Temperature limits of 65–130 °F
  - Temperature dependent relative humidity ranges of 5%–75%.
- 9-axis Fanuc M710iC 70 robotic system (with tower and track).
- Two-part dispense system along with a nitrogen drum pressurization capability.
- Portable new delivery system (PNDS) two-part foam dispense system for manual sprays.
- Heated test panel holder (capable of holding six 2- × 2-ft test panels).
- Horizontal process tooling, vertical process tooling, and an associated TPS transporter.
- Data acquisition and remote viewing capability.
- Onsite cold-storage coolers required for processing of HFC-245fa based cryoinsulation materials.
- Additional processing facilities include a large bay TPS application tent for 27.5' high x 27.5' wide hardware and a 2nd manual coatings booth 10' wide x 9' tall doors x 26' long



Painted flight hardware.

Insulating cryogenic tank used for vibration and acoustic

TPS Materials Testing:

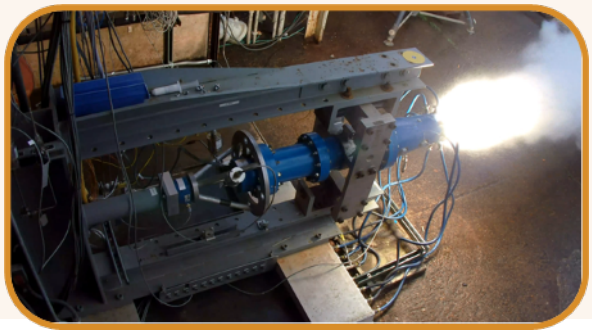
- Pour foam testing capabilities with multiple foam molds available.
- Bonding lab with the ability to adhesively bond TPS materials.
- In-process testing including portable tensile (plug pull), density, and reactivity testing.
- FOAMAT foam reactivity test equipment.
- Machining equipment, cure ovens, and tooling for specimen preparation.
- Thermal Vacuum Test Facility:
  - Pressure profiling (0–10 mmHg).
  - Radiant heat profiling: Quartz lamps (90 kW) (20 Btu/ft²sec calorimeter sensors).
  - Data acquisition (50 scans/sec).

Subscale Solid Rocket Motor Processing and Manufacturing:

- Subscale motor processing area for laying up insulation and motor assembly tasks.
- PTTB is an internationally unique ablation test bed that offers reliable, statistically proven data at a fraction of the cost of subscale motors or other test beds. The PTTB successfully simulates mission environments via high-temperature plasma jets that provide thermal and erosive testing of flight materials and screening of new materials.

Carbon-Carbon, Ceramic Matrix Composite, and TPS Materials Development

- Various ovens and furnaces (capable of 760-1,700 °C operating temperatures).
- Astro high-temperature furnace (2,500 °C, 4-in diameter × 6-in hot zone).
- Ajax tocco induction furnace facility (2,600 °C, 2.8-in diameter × 6-in hot zone).



Solid Fuel Torch

Key Benefits

> Unique combination of facilities and experience

> Advanced research capabilities

For more information, please visit www.nasa.gov/centers/marshall/about/business.html

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George C. Marshall Space Flight Center
Huntsville, AL 35812
www.nasa.gov/marshall

www.nasa.gov

Lee Allen, EM41 Branch Chief
lee.r.allen@nasa.gov
256-544-4218

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