

TPSF Work with NASA Missions



Overview of Thermal Protection System (TPS) Manufacturing at NASA's TPS Facility (TPSF)

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Artemis 1 Heatshield Integration



Artemis I Heatshield Configuration

Additional Partnerships



Space Shuttle Orbiter

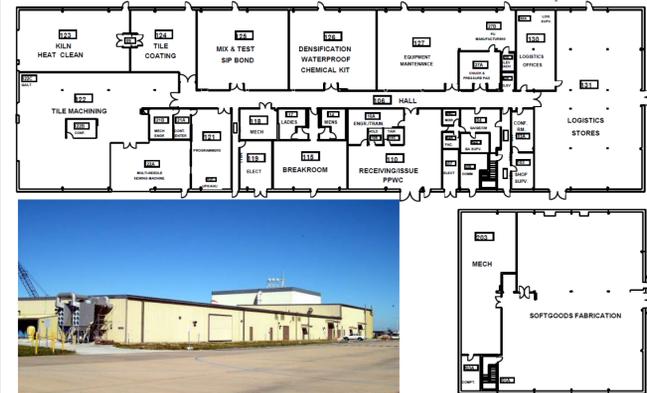


Sierra Space Dream Chaser



NASA X-38 Experimental Re-Entry Vehicle

TPSF Facility K6-794 at NASA KSC NASA TPS Facility Capabilities



TPSF Overview

- Primary function to manufacture flight hardware used in the orbiter TPS and Thermal Control System TCS
- Government owned and contractor operated on-site and NASA Kennedy Space Center (KSC)
- Provided real-time support to Space Shuttle Orbiter
- Offers widest range of TPS manufacturing and repair capabilities within a single facility

Tile Production Unit Fabrication

- Core Competencies:
 - Fabrication of ceramic billets including AETB-8 (X-38, Orion), LI-2200 (Orbiter), and HTP-6 (Hughes)
- Tools:
 - Multiple casting towers
 - Vee blenders (2 ft³ & 1 ft³)
 - Fiber mixer/extractor
 - Wet vacuum system



Casting Tower and Vee Blender

Machining

- Core Competencies:
 - Machinists skilled with non-metallic materials, composites, traditional machining methods, and NC machine operation
- Tools:
 - OSHA certified machines to process ceramics and composites



Machining and High Temperature Processing

Bonding

- Core Competencies:
 - Molding manufacturing
 - Molding of polyurethane Kydex, lexan, and polyethylene foam
- Tools:
 - Temperature and humidity controls
 - Vacuum tables
 - General purpose laboratory equipment



Tile Bonding to Airframe

High Temperature Processing

- Core Competencies:
 - Surface preparation
 - Application of ceramic and epoxy coatings
 - Application by spraying
 - Firing
 - Thermal processing
- Tools:
 - Roller mill and jar mills
 - Spray booths
 - Spray equipment
 - Masking
 - Five high purity 2500 F kilns
 - One high purity 2650 F kiln
 - Two 50 ft³ 1250 F Class A ovens
 - One 2 ft³ Class A oven
 - Two forced air 600 F ovens



Custom Softgood Sewing Machine and TCS Blanket Buildup

TPS/TCS Softgoods Manufacturing

- Core Competencies:
 - 2D CAD drafting
 - Hand fabrication of TPS seals
 - Fabrication of Thermal Control System Blankets
 - Molding and stiffening
- Tools:
 - 16 customized sewing machines adapted to sew with ceramic polymer and metallic threads

Waterproofing and Densification

- Core Competencies:
 - Operation of ceramic waterproofing ovens
 - Application of coatings
 - Heat curing
- Tools:
 - Four chemical vapor deposition ceramic waterproofing ovens
 - Four explosion proof vent hoods
 - One Class A oven
 - Three conventional 600 F ovens



CVD Ceramic Waterproofing Ovens

Our Experience

- Space Shuttle Orbiter Program
- Orion EFT-1 Flight Test
- Sierra Space Dream Chaser
- Current Artemis Missions
- NASA X-38 Re-Entry Vehicle
- Boeing X-37 OTV

Our Commitments

- Extend TPS manufacturing capability and expertise to DoD partners
- Improve thermal management solutions for hypersonic applications
- Enable DoD access to critical knowledge to improve national security

[1] P. Agrawal, "Returning to the Moon: NASA's Artemis Mission", International Women's Day, March 2023, Sunnyvale, CA.

[2] M. Stewart, W. Koenig, R. Harris, "Thermal Protection Systems Technology Transfer from Apollo and Space Shuttle to the Orion Program", AIAA Space Forum, September 2018, Orlando, FL.

[3] M. Boyd, "Thermal Protection System Facility", Additive Manufacturing Thermal Protection System (AMTPS) Workshop 2.0, March 2023, Oak Ridge, TN.

[4] J. Honeycutt, J. Blevins, S. Cobb, W. Bryan, "NASA's Space Launch System: Artemis I Results and the Path Forward", AIAA Science and Technology Forum, January 2024, Orlando, FL.

[5] W. Koenig, M. Stewart, R. Harris, "Orion Heat Shield Manufacturing Producibility Improvements for the EM-1 Flight Test Program", IEEE Aerospace Conference, March 2018, Big Sky, MT.

EFT-1 Mission with Orion Vehicle



Orion EFT-1 Flight Test Overview



Orion EFT-1 Heatshield Post-Flight

Artemis I Mission with Orion Vehicle



Artemis I Concept of Operations



Artemis I Flight Test Overview