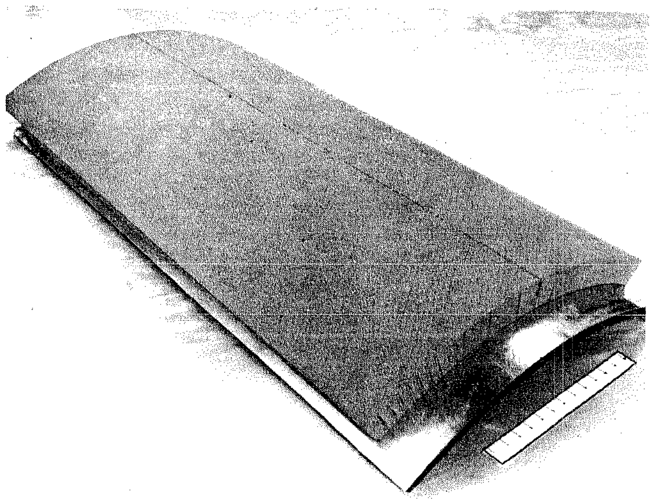
Ablative Heat Shield Materials
SLA-561

MARTIN MARIETTA



SLA-56l Panel for Space Shuttle Heat Shield Study

SLA-56l is a low density (l4 lb/ft^3), low conductivity ablator/insulator. It is available as molded panels with or without honeycomb support or as an ablative barrier layer integrally molded against flat or contoured substrates. The material is also available as a three-component spray mix. SLA-56l is a highly filled elastomeric silicone composition containing cork as one of the filler ingredients. It forms a sturdy, well-adhering, substantially crack-free char during ablation.

Prior Use

SLA-56l has been flight qualified through extensive testing for the following missions:

- Viking lander—Aeroshell heat shield
- Space Shuttle External Tank—Tank interference heating locations, LH_2 aft dome, LO_2 ogive (ascent heat protection)

In addition, SLA-56l has been tested for the following applications:

- Space Shuttle—Orbiter heat shield
- Space Tug—Aerobraking heat shield

Processing—Molded Ablator

Bonding—SLA-561 can be bonded with a silicone adhesive using vacuum bag pressure. Substrates must be cleaned and primed with a silicone primer (DC-1200, or equivalent). Strength of properly prepared bondlines will exceed the tensile strength of SLA-561.

Machining—SLA-561 is readily machined by band sawing, sanding, and grinding techniques.

Repair—Repairs are accomplished by removing damaged portions to the substrate with a plastic scraper, repriming the substrate and bonding a precut plug in place with a room temperature-curing silicone adhesive such as Martin Marietta GX-6300. As an alternative, the cleaned and primed substrate may be wet-coated with GX-6300 adhesive and a room temperature-curing repair mixture may be troweled in place. The repair mix is a three-component system consisting of base mix, curing agent, and diluent. The catalyzed repair mix has a pot life of 45 minutes at 75±10°F. The GX-6300 adhesive is a two-component system with a 60-minute pot life at 75±10°F. After curing, repair patches are faired to the surrounding material by sanding.

Coating—SLA-561 is subject to damage by abrasion. A silicone coating (DC 92-007, or equivalent) may be applied by spraying to minimize handling damage or surface contamination.

Processing—Spray Application

Spray Application of SLA-561.

Shelf Life—The three components of the spray mix are (1) base mix, (2) catalyst, and (3) diluent. The base mix is packaged in sealed polyethylene bags, the catalyst in polyethylene bottles, and the diluent in steel drums. Shelf life of the components is six months at ambient temperature.

Spray Mix Preparation—Mix 96.53 parts by weight base mix, 3.47 parts by weight catalyst, and approximately 126 parts by weight diluent in a Hobart mixer at low speed for approximately 15 minutes. Quantities that can be mixed in a 80-quart Hobart mixing pot are 6683 g base mix, 240.3 g catalyst, and 8750 g diluent. This quantity of material is suitable for spraying from a 15-gallon Binks spray pot. Pot life of the catalyzed spray mix is 4 hours at 75°F.

Substrate Preparation—Clean metal to a water break-free surface. Apply a silicone primer spray (DC-1200 or equivalent) and cure. Apply a 2- to 4-mil spray coat of Martin Marietta GX-3600 silicone adhesive and allow to dry to a tacky state. Apply a second coat of GX-6300 to the tacky coat. Apply the SLA-561 spray while the second GX-6300 coat is tacky.

Spray Equipment—Use Binks spray equipment and a waterfall spray booth.

Tank: 5 to 60 gallon pot with agitator. Use a tank liner for ease of cleaning. The SLA-561 material in the spray pot must be kept under constant agitation during the entire application procedure.

Gun: Binks 7E2 spray gun with a No. 45 (0.25 in. dia orifice) fluid nozzle and a No. 291 air cap.

Fluid Hoses: Nylon or Teflon line. *Do not use rubber.*

Pot Pressure: 15 psi

Atomization pressure: 25 psi

Spray Application—Hold tip of spray gun approximately 8 inches from the substrate surface. Apply spray in layers of approximately 60 mils. Hold overlap time between layers to no more than 5 minutes. Material loss due to gun checkout, overspray, and tank residue is approximately 50%.

Cure—Spray-applied SLA-561 shall be cured for 24 hours at ambient temperature (70 to 100°F), followed by 48 hours at 135 to 150°F.

Finishing/Repair—Same as for molded ablator.

Safety Precautions—Solvents in spray mix are flammable. All spray equipment must be grounded to dissipate static charge. Use air motors only. Electrical installations in spray booth must be explosion proof. Operators must use breathing apparatus while spraying. Skin contact with spray mix should be avoided because solvents are irritating to the skin. Use normal dust control procedures during machining of cured SLA-561.

Material Characteristics

Color	Brown to dark grey
Appearance	Homogenous material with uniformly distributed visible filler particles.
Density	14.0 ± 1 lb/ft^3 molded SLA-561 14.5 ± 1 lb/ft^3 molded SLA-561 in honeycomb 18.0 ± 1 lb/ft^3 sprayed SLA-561
Hardness	>30 (Shore A)
Workmanship	Free of blisters, nodules, delamination, contamination, and voids greater than 1/32-inch diameter
Substrate Adhesion (spray-applied SLA-561)	Bondline adhesive and cohesive strength exceeds the tensile strength of SLA-561

Nominal Material Properties

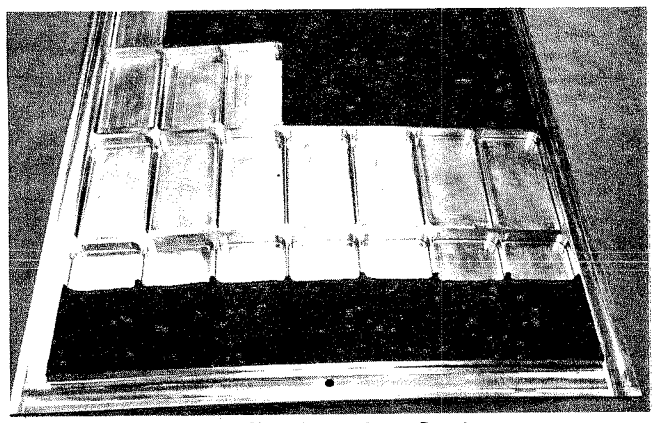
Tensile Strength (ASTM D-638, Type I)	60 psi at 75°F
Elongation	2.5% at 75°F
Stress-Strain Properties	See figure opposite.
Compression Strength	72 psi at 75°F
Thermal Expansion	16.9×10^{-6}. in./in./°F between -150° and +300° F
Thermal Conductivity (ASTM C-177)	0.38 Btu-in./hr-ft^2-°F at 75°F and 760 torr
Specific Heat	0.30 Btu/lb-°F at 212°F
Emittance (Total Normal)	Virgin Ablator - 0.58 Charred Ablator - 0.97

Ablation Characteristics

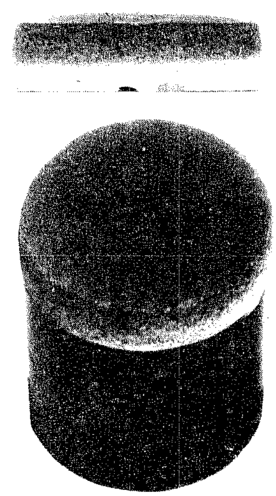
Char Residue	56%
Ablation Temperature	815°F (temperature at which half the weight loss that occurs during conversion from virgin ablator to char has been reached)
Effective Heat of Ablation (based on ablator weight required to limit backface temperature rise to 200° F)	8100 Btu/lb for 50 sec @ Btu/ft^2-sec; 2600 Btu/lb for 250 sec @ 6 Btu/ft^2-sec
Pyrolysis Kinetics	Preexponential Constants; $A = 2.78 \times 10^{-10}$ sec^{-1} Activation Energy; $E = 3.78$ cal/mole Reaction Order; $n = 3$
Char Recession Threshold	See chart on back page.

Environmental Resistance

92 hr at 275°F in N_2	2.1% weight loss 0.21% linear shrinkage
94 hr at 160°F in vacuum	1.8% weight loss 0.32% linear shrinkage

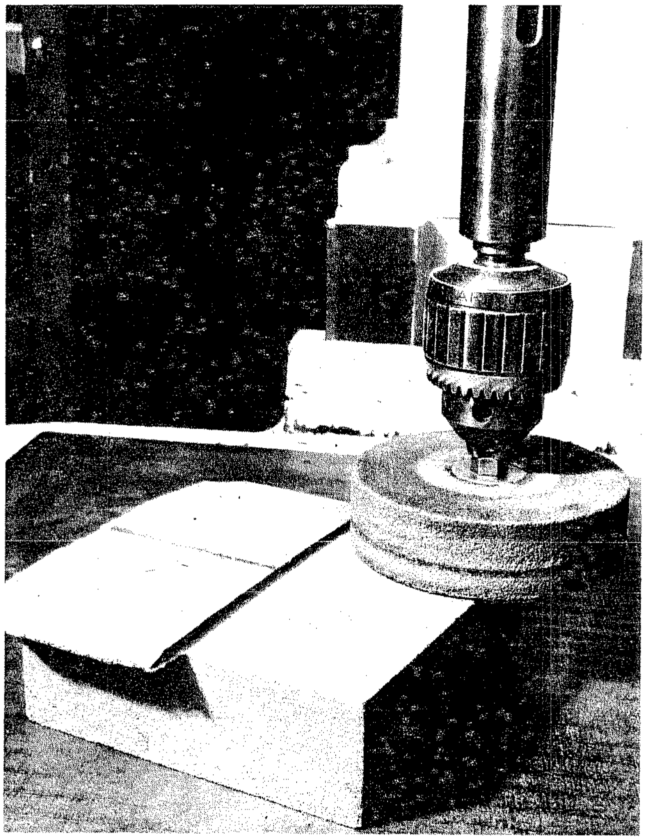


SLA-561 Sprayed on Stiffened Aluminum Panel

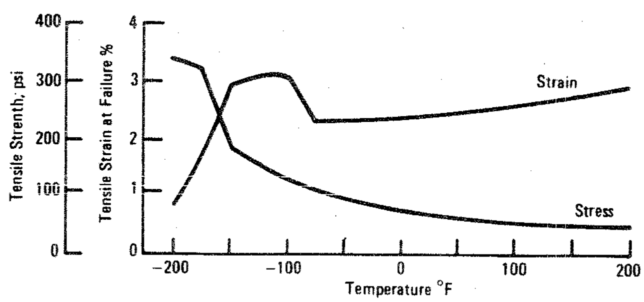


Heating Rate: 21 Btu/ft^2-sec
Exposure Time: 150 sec

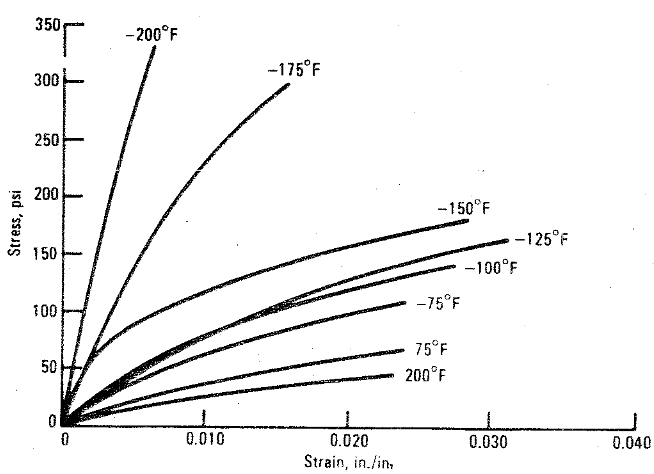
SLA-561 Char



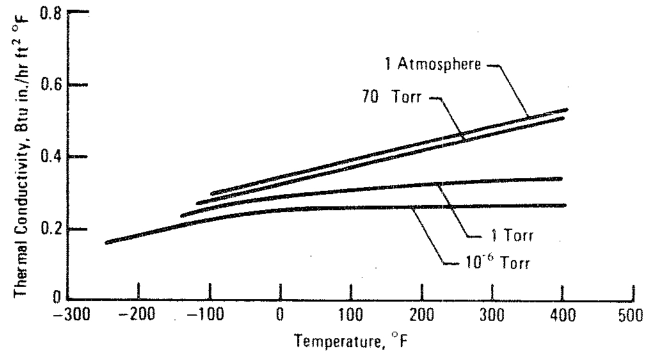
Machined SLA-561 Surface



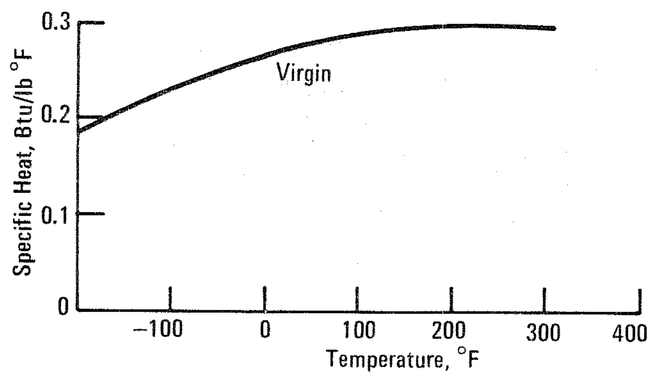
Tensile Properties of SLA-561



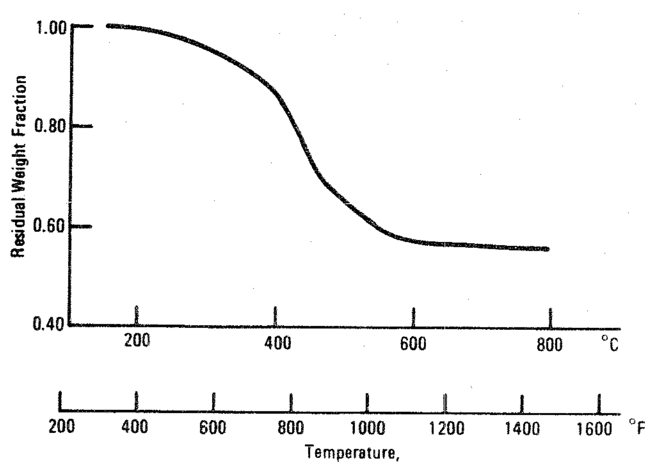
Stress-Strain Curves for SLA-561



Thermal Conductivity of SLA-561

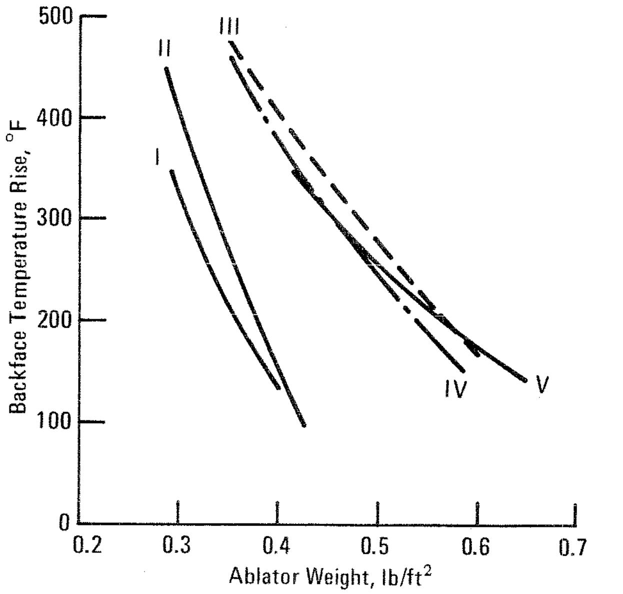


Specific Heat of SLA-561

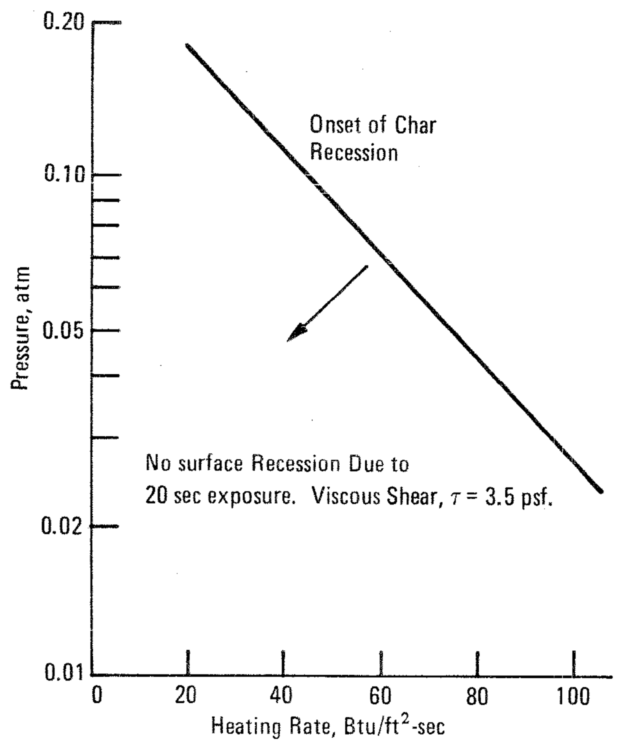


Thermogravimetric Analysis Plot for SLA-561 (6°C/min Heating Rate in Argon)

Test Condition	I	II	III	IV	V
Heating Rate, Btu/ft^2-sec	60	60	21	7.5	6
Enthalpy, Btu/lb	7200	2150	1875	1100	2500
Stagnation Pressure, atm	0.010	0.165	0.080	0.028	0.003
Exposure Time, sec	50	50	150	250	250

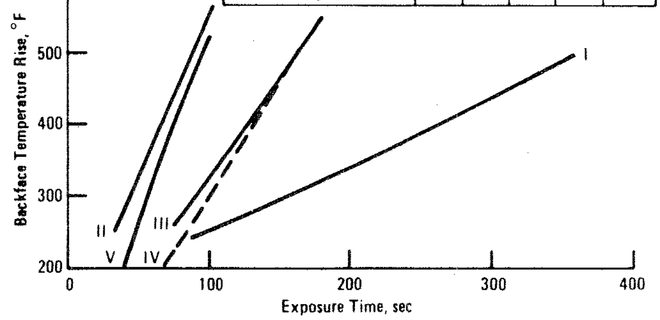


Relationship between Backface Temperature Rise and Ablator Weight for SLA-561



Char Recission Threshold for SLA-561

Test Condition	I	II	III	IV	V
Heating Rate, Btu/ft^2-sec	2.3	6.5	12.6	25.2	35.0
Enthalpy, Btu/lb	1050	2130	2070	3170	3530
Stagnation Pressure, atm	0.003	0.004	0.007	0.008	0.008
Ablator Weight, lb/ft^2	0.35	0.23	0.45	0.59	0.45



Relationship between Backface Temperature Rise and Length of Exposure for SLA-561

Bibliography

Seiferth, R. W. *Ablative Heat Shield Design for Space Shuttle.* Report NASA CR-132282, 1973.

Strauss, E. L. "New Ablative Heat Shield Materials for Mars Landers." *1967 SAE Transactions,* Society of Automotive Engineers, Inc., New York, N.Y.

Strauss, E. L. "Superlight Ablative Systems for Mars Lander Thermal Protection." *J. Spacecraft,* 4(10), pp 1304-9, October 1967.

Strauss, E. L. "Performance of Superlight Ablators in Simualted Mars Entry, Including Micrometeoroid Damage." *J. Spacecraft,* 5(11), pp 1357-60, November 1968.

Strauss, E. L. "Ablative Thermal Protection for Space Tug Multipass, Aerobraking Entry." *J. Spacecraft,* 12(6), pp 346-50, June 1975.

Strauss, E. L. and Sparhawk, H. E. *Ablative Heat Shields for Planetary Entry Vehicles.* Paper 68-8-5, American Astronautical Society, Space Projections from the Rocky Mountain Region, Denver, Colorado, July 1968.

Strauss, E. L. *Vacuum Outgassing of Ablative Heat Shield Materials for Planetary Spacecraft.* Technical Papers Volume XVII, 29th Annual Technical Conference, Society of Plastics Engineers, Washington, D.C., May 1971.