An Overview of Heritage TPS for Launch Vehicles and Landers

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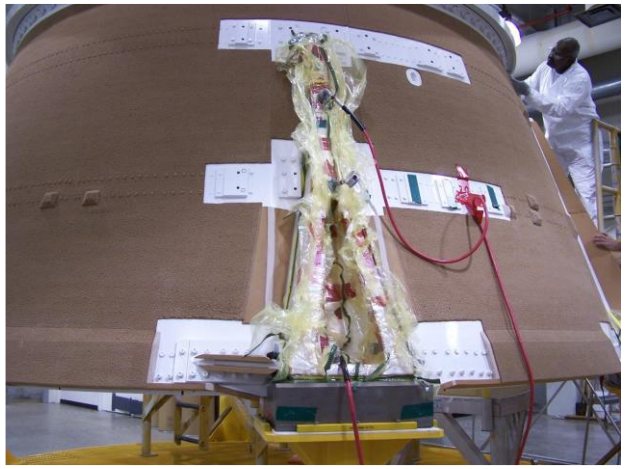
Launch Vehicles – Ascent Heating

Types of TPS



P-50 Sheet Cork
- Composite of ground cork and phenolic binders
- Bonded and vacuum bagged

Ref. - Davis, D., NASA-MSFC
https://ntrs.nasa.gov/citations/20170009022

Marshall Convergent Coating (MCC-1)
- Two part epoxy adhesive filled with ground cork and glass ecospheres.
- Sprayable ablative TPS developed for Space Shuttle.
- Used on SRB and other launch vehicles

Heat Flux Levels

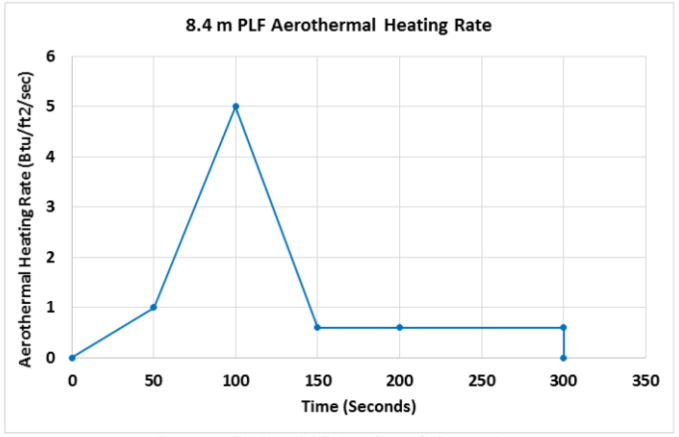


Figure 4. The 8.4m PLF Aerothermal Heating Rate

SLS Payload Fairing Ascent Heating

Ref. - Space Launch System (SLS) Spacecraft Payload Integration and Evolution (SPIE) Payload Fairing (PLF)
Request for Information (RFI)

Launch Vehicles – Base Heating

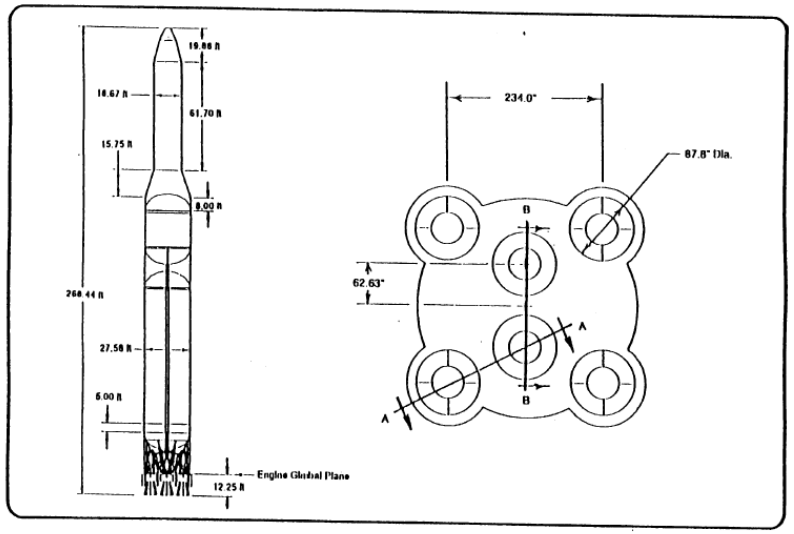
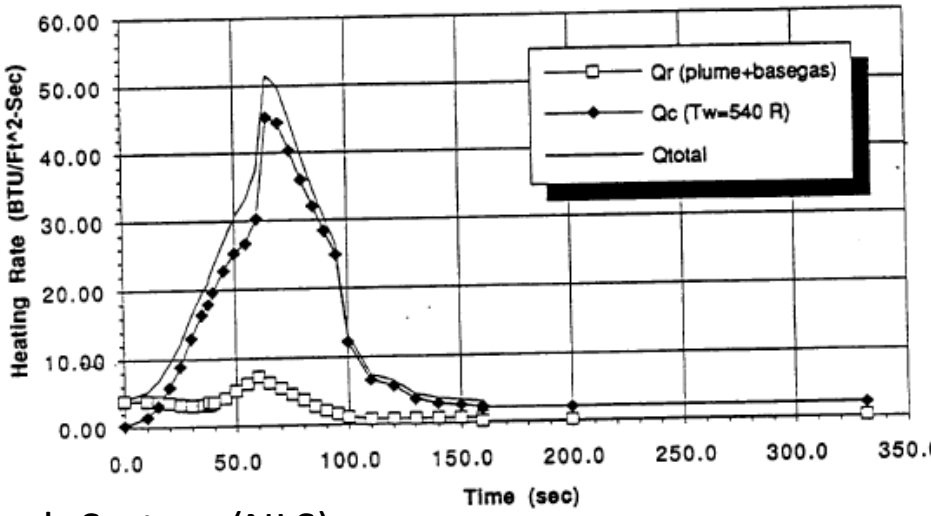
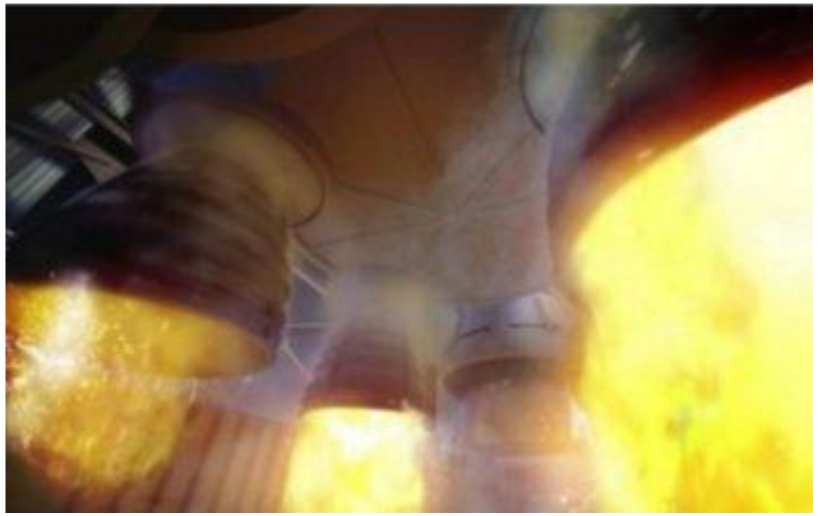


Figure 1: NLS 2 Launch Vehicle Base Geometry



NLS cycle 1 and NLS 2 base heating technical notes. Appendix 3: Preliminary cycle 1 NLS base heating environments. Cycle 1 NLS base heating environments. NLS 2 650K STME base heating environments, NASA-CR-192454, Jan. 1992.

National Launch System (NLS)



SLS Core Stage Base
Cork P-50

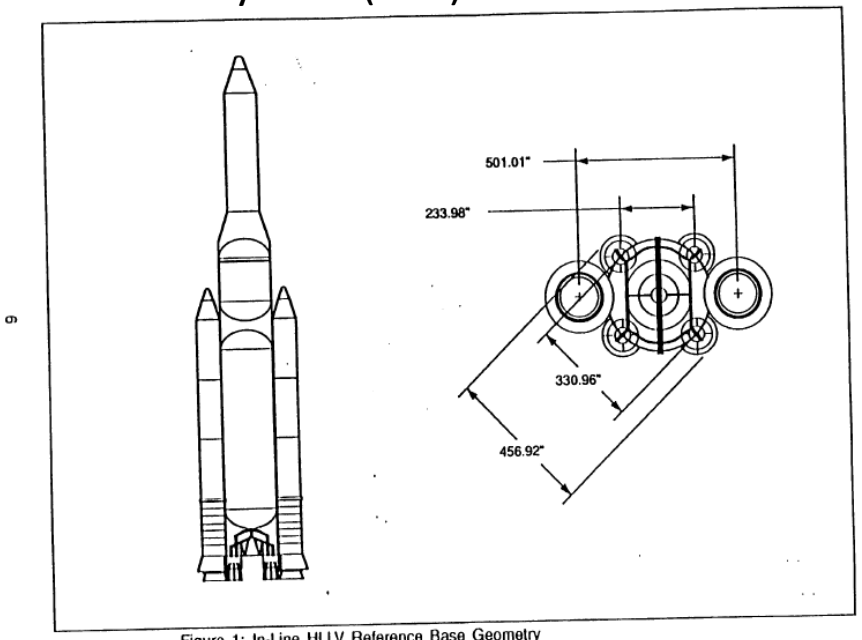


Figure 1: In-Line HLLV Reference Base Geometry

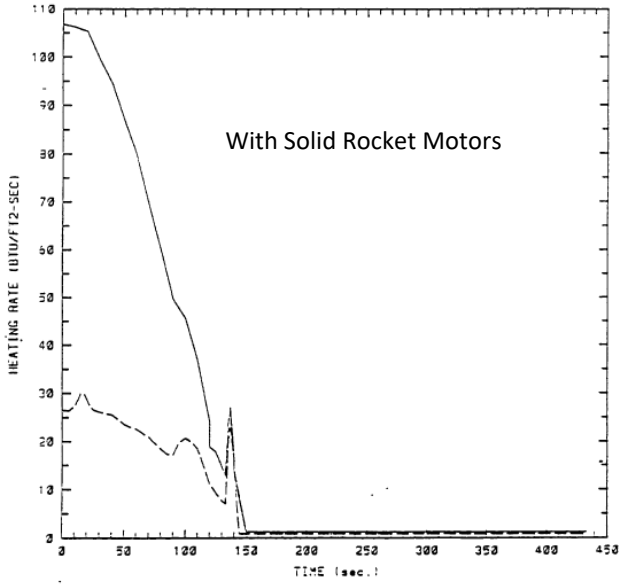
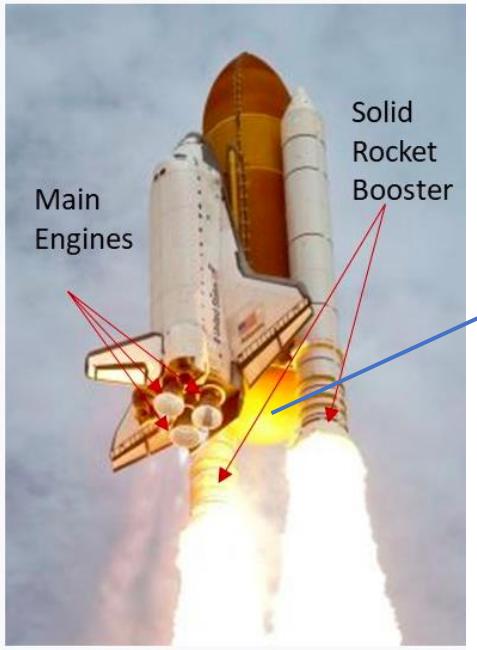


Figure 5: Radiation and Total Base Heating — HLLV Core Base Heat Shield Body Point 101

Space Shuttle Base Heating & TPS

Orbiter Base
AETB Ceramic Tiles

External Tank
SOFI Insulation



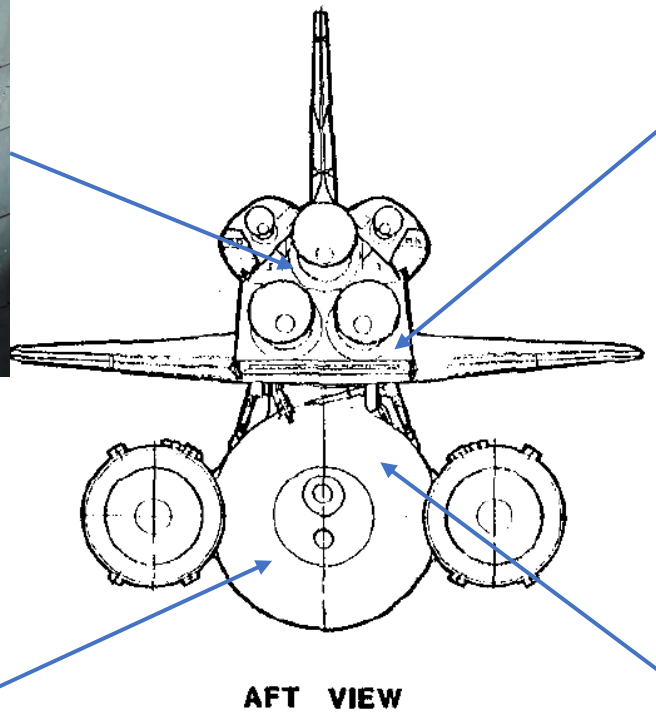


Fig. 1 Shuttle Base Configuration

Greenwood, T. et al, 'Space Shuttle base heating', AIAA-83-1544.

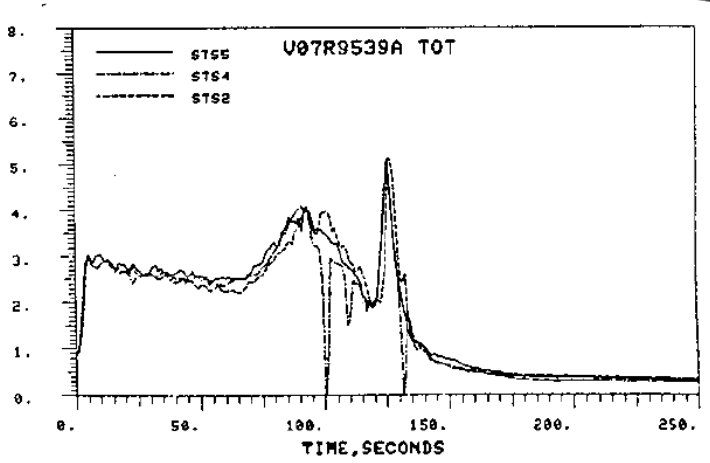


Fig. 16 Orbiter Heat Shield Flight Data

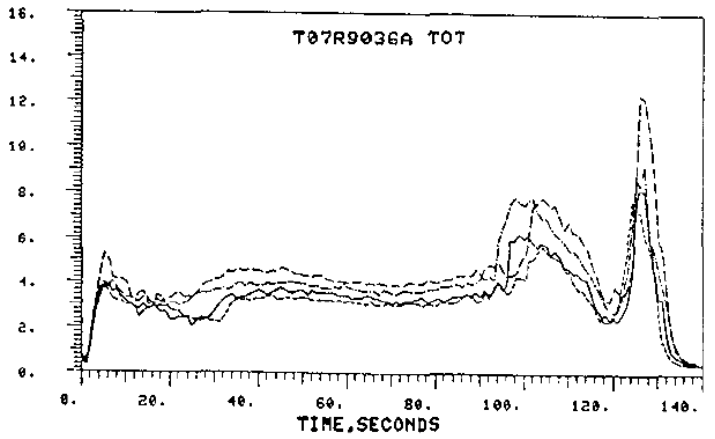


Fig. 12 ET Aft Dome Flight Data

Space Shuttle External Tank TPS

External Tank TPS Materials

SLA-561 Ablator
- mixture of silicone resins highly filled with cork particles, silica glass eccospheres, silica fibers, and phenolic microballoons
- bonded onto the prepared structure
- used on vehicle interface attachments, at high heat areas on the ogive, and down the length of the ET
- during flight the ascent environments cause the SLA-561 to ablate and char.

NCFI 24-124 Sprayed On Foam Insulation (SOFI)
- Isocyanurate closed cell rigid foam system with higher temperature stability than conventional urethane foams
- Applied via automated sprayer
- covers the entire acreage of the tank, constituting 77% of the total foam used on the tank
- SOFI is applied over SLA-561 ablator when both highly efficient insulation and high heating capability is required

NCFI 24-57 SOFI
- slightly different formulation than NCFI 24-124
- provides improved temperature stability for the aft dome engine plume heat environment

BX-265 Polyurethane Foam
- Manually sprayed polyurethane foam that was characterized, qualified, verified, validated, and implemented in Dec. 2001as a replacement for BX-250
- used on the tank's "closeout" areas

PDL 1034 Polyurethane Foam
- hand-poured polyurethane foam used for filling odd-shaped cavities

WG30-500 Graphite fiber / Cytec Rigidite 506 Phenolic Resin System
- used to manufacture the composite nosecap

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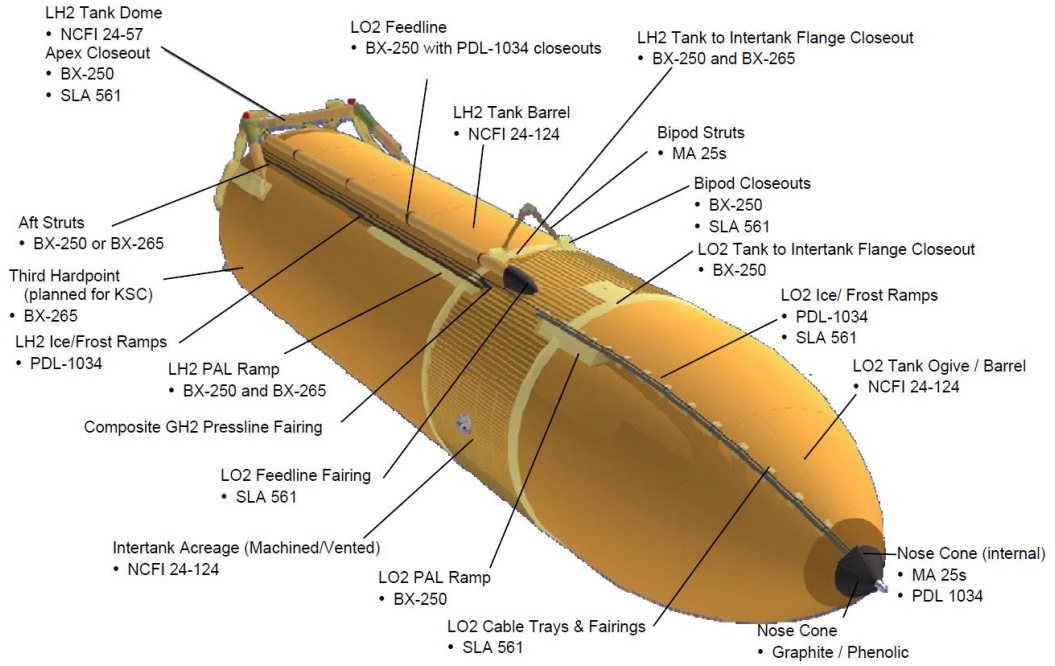
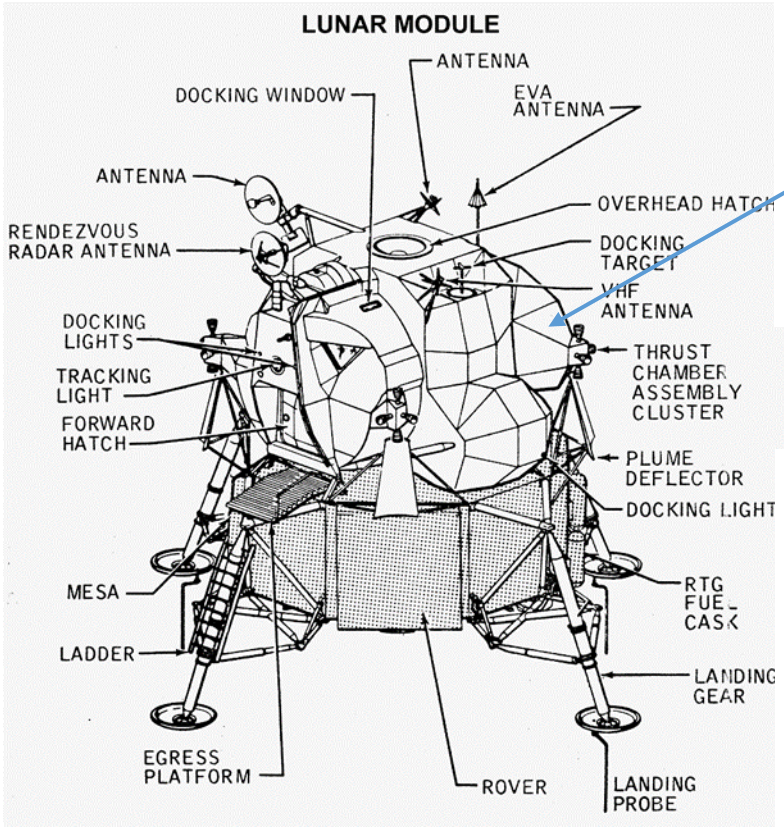


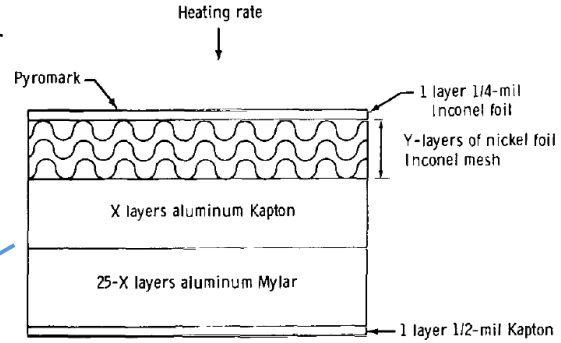
Source: Muratone, slide 5

Dreggors, Kirsten, "Alternative Foam Treatments For The Space Shuttle's External Tank" (2005). Electronic Theses and Dissertations, 2004-2019. 548

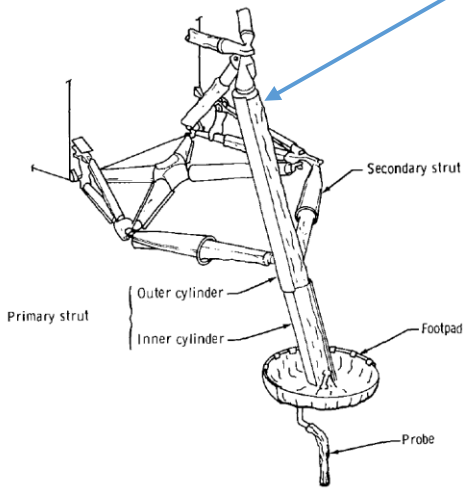
Landers – Engine Plume-Induced Heating

RCS Thermal Shield
LM Thermal Protection for
Heating > 1.0 BTU/ft2-sec

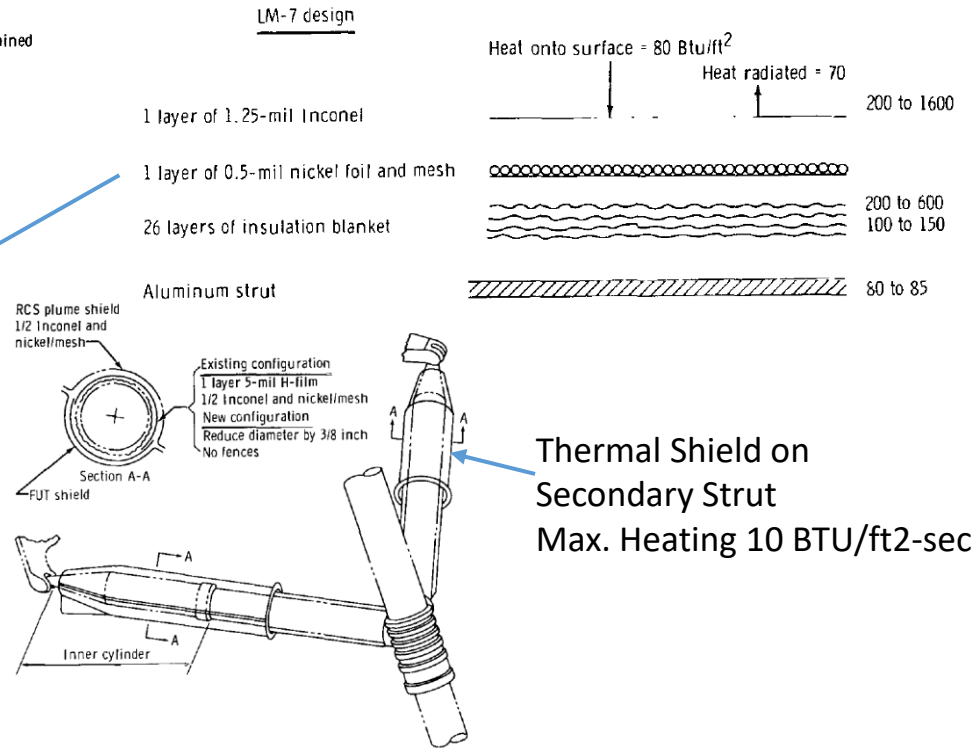




Note: Number of layers of Kapton is determined from duty cycle at given heat flux.



(a) Overall landing gear.



(b) Secondary strut.

Thermal Shield on
Secondary Strut
Max. Heating 10 BTU/ft2-sec

Taylor, J., 'Apollo Experience Report – Thermal Protection from Engine-Plume Environments,' NASA TN D-6844