



Space  
Systems Division

LSPE Interim Stowage  
Thermal Constraints

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This ATM provides an answer to Action Item 521, "BxA agreed that if explosive packages are exposed to the sun for 5 hours prior to each EVA, the 40°F timer requirement will be met. BxA to revise applicable ATM with analysis to prove the 5-hour requirement is suitable." In addition interim stowage constraints required for thermal integrity are defined.

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## 1.0 INTRODUCTION

The LSPE High Explosive Package safe-arm and thermal battery timers require operating temperatures at or above +40°F for reliable starting when the astronaut removes the timer pull pins for lunar deployment. Prior to the removal of those pins the LSPE transport frame assembly could be exposed to environments during LM and LRV stowage which necessitates crew activity constraints to assure adequate warming of the timers prior to their activation.

The Grumman document LIS 360-22314 and amendments to it indicate the LM right pallet remaining in Quad III throughout lunar stay might be at -5°F at the time of its removal for stowage on LRV. This cold case temperature remains constant throughout the entire lunar stay. (See figure 1). The LRV cold case EVA time line defined in reference 2 indicates the LSPE transport frames stowed on the LRV pallet could be exposed to 45 minutes of shade immediately prior to lunar deployment of the high explosive package. Thermal analysis of the LRV mission defined in reference 2 by NASA places the LSPE timers at +15°F worst case after 45 minutes of shade exposure (Figure 2).

During the meeting on 17 November 1971 of the LSPE thermal and NASA Crew Procedures Division representatives it was agreed that 5 hours of sun exposure prior to either LRV mission would be adequate for thermal requirements on LSPE timers. This guideline would apply to either stowage of the transport frame atop the LRV pallet or to location of the LM pallet and transport frame on the sunlit lunar surface.

This memo presents the technical support requested by NASA which is a basis for the agreement mentioned.

## SUMMARY

Definite crew activity constraints are required to assure that LSPE high explosive baseplate assemblies and attached timers are above their +40°F minimum operating temperature at the time of their activation during EVA-2 and EVA-3. Present worst case mission environments could place the LSPE high explosive baseplates at +15°F if constraints are not met.

Figure 1

LM-11/LM-12 Thermal Response of Quad III  
Pallets and Mounted Equipment for  
Worst Case Hot and Cold Thermal Design Missions

Both Pallets Stowed

LRV Pallet Removed at T/D + 5 Hrs

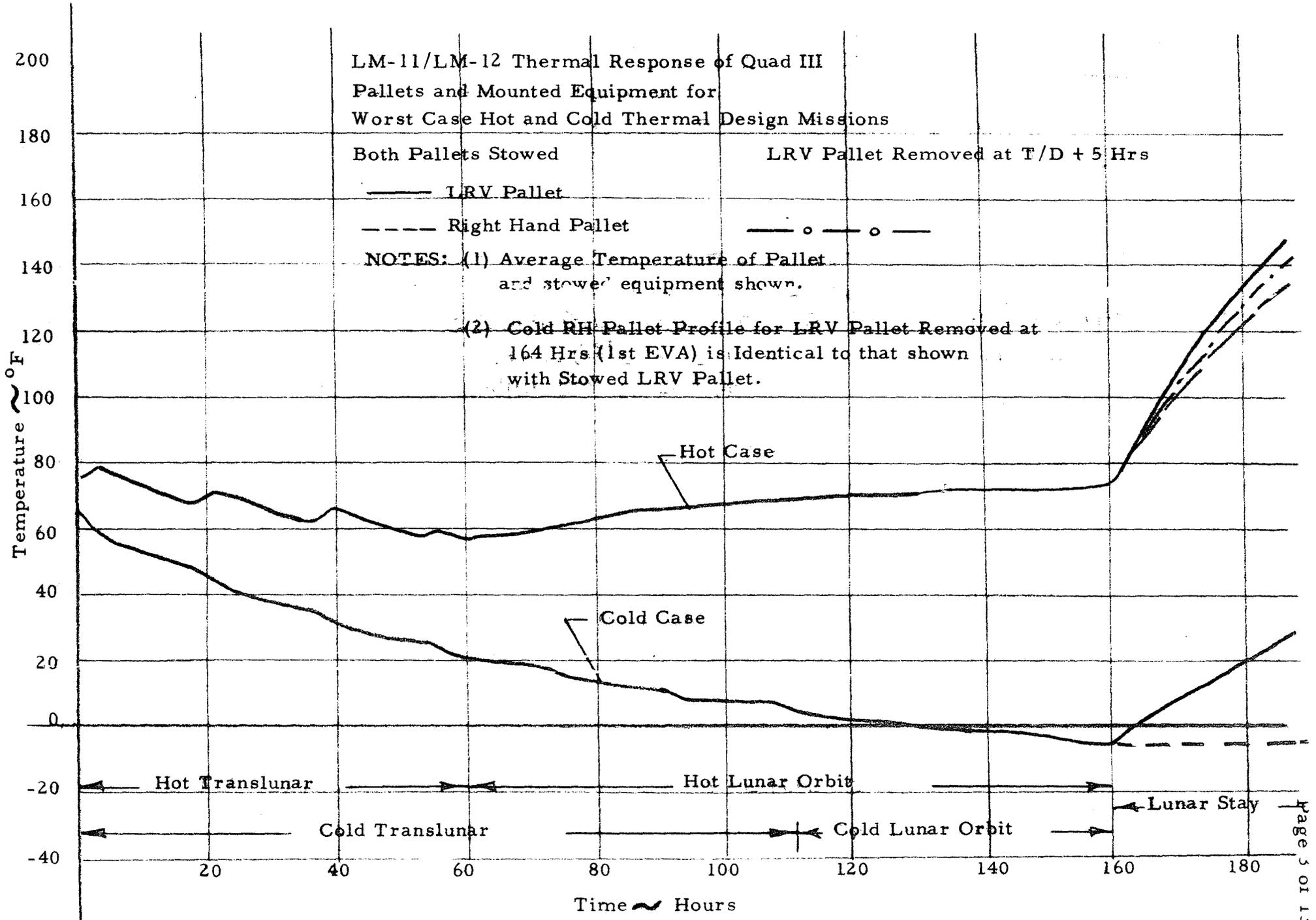
—— LRV Pallet

- - - - Right Hand Pallet

— o — o —

NOTES: (1) Average Temperature of Pallet  
and stowed equipment shown.

(2) Cold RH Pallet Profile for LRV Pallet Removed at  
164 Hrs (1st EVA) is identical to that shown  
with Stowed LRV Pallet.



LSPE Transport Frame Assembly Stowed  
Atop LRV Tool Pallet during EVA-2 Traverse.  
Includes 45 minute LRV Shade Requirement.

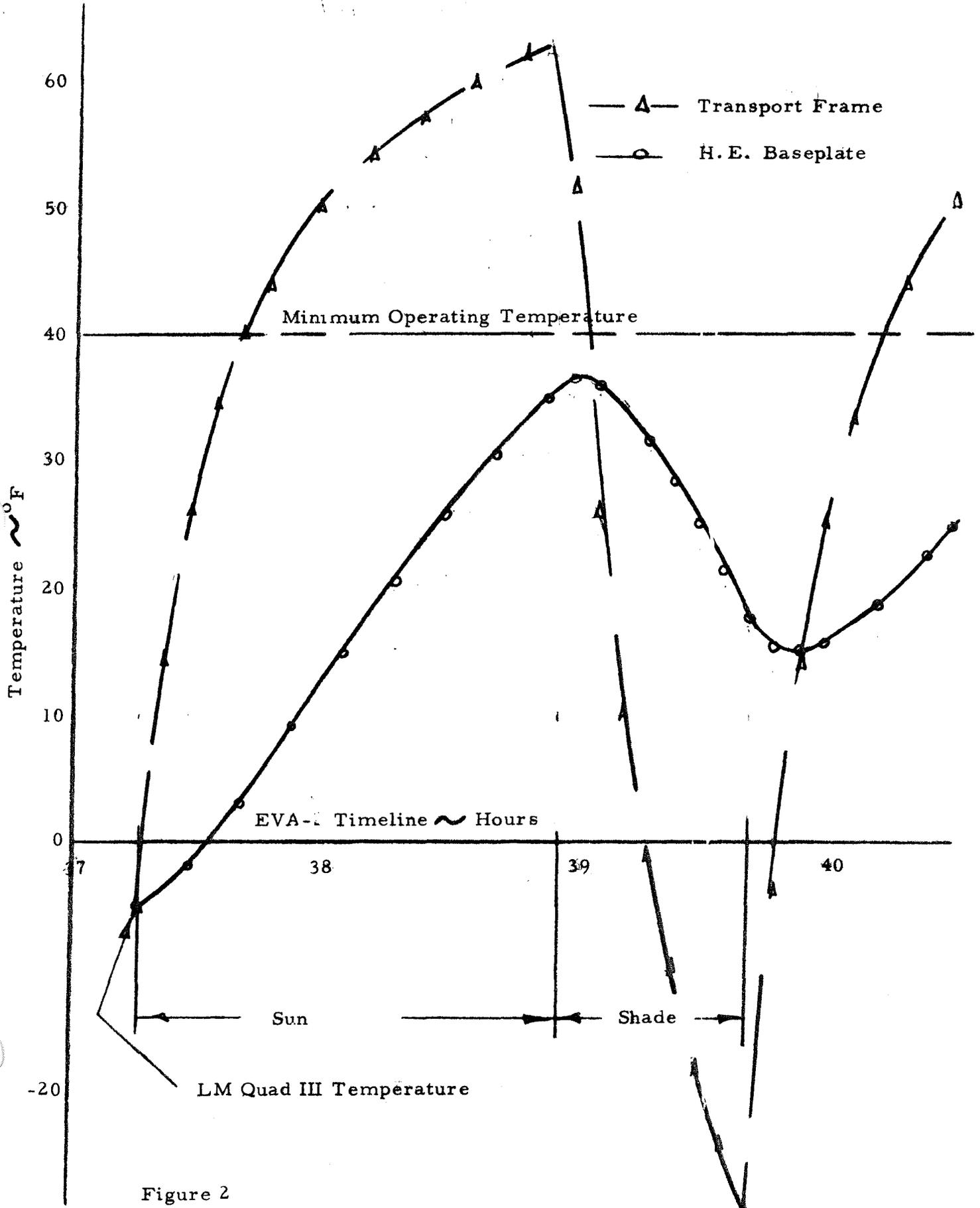


Figure 2



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An agreement between BxA and NASA Crew Procedures Div. that the LSPE Transport Frame Assemblies would be stowed in the sun either on the LM Pallet or LRV Pallet 5 hours prior to any deployment activity is adequate to assure LSPE thermal integrity. Should the LM Pallet be placed in the sun 5 hours prior to the LRV mission the LSPE will drop to +45°F during subsequent LRV shade exposure. If the LSPE Transport Frames are stowed on the LRV Tool Pallet 5 hours prior to the mission the LSPE will again drop to +45°F during shade exposure.

Additional placement constraints placed on interim stowage include:

- 1) Placement of LM Pallet in the sun facing the sun.
- 2) Placement at least 10 feet from LM footpad.
- 3) Misalignment of pallet with incident sun less than  $\pm 45^\circ$  to the pallet normal.
- 4) Placement if on LRV Tool Pallet must be in the sun.

### 3.0 LM RIGHT HAND PALLET STOWAGE

#### 3.1 LM Pallet Analysis

Analysis has been completed which determines constraints to be imposed on the placement of the LM pallet and attached LSP Transport Assemblies prior to their stowage on LRV. The analysis includes the following studies:

- 1) The effects of the sunlit side of LM on the temperatures of a dust degraded LM Pallet and Transport Frame Assembly.
- 2) The effects of Transport Frames stowed with the LM Pallet back surface facing the sun.
- 3) Parameter studies of Transport Assemblies and the LM Pallet exposed to the sun incident at various angles. These studies include the effects of a Transport Frame view to a sunlit and a shaded lunar surface.

**Bendix**

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4) LM Pallet and LSPE Assembly temperatures after 5 hours of sun exposure.

3.2 Proximity of Lunar Stowed Pallet to LM

The temperatures of the LSPE Transport Frame Assembly in close proximity to the Lunar Module would be affected by either the sunlit or the shaded surface of the LM. Effects of the shaded surface are considered in the next sections.

In consideration of the sunlit area of the LM surface, the assumption was made that this area was covered with aluminized Kapton. If the LM Pallet is stowed on the lunar surface on the sunlit side of LM, the LSPE will be facing the sun and the back surface of the LM Pallet will view the LM. Figure 3 depicts these effects on the high explosive baseplate temperatures of a 100% dust degraded assembly placed at various distances from the LM footpad.

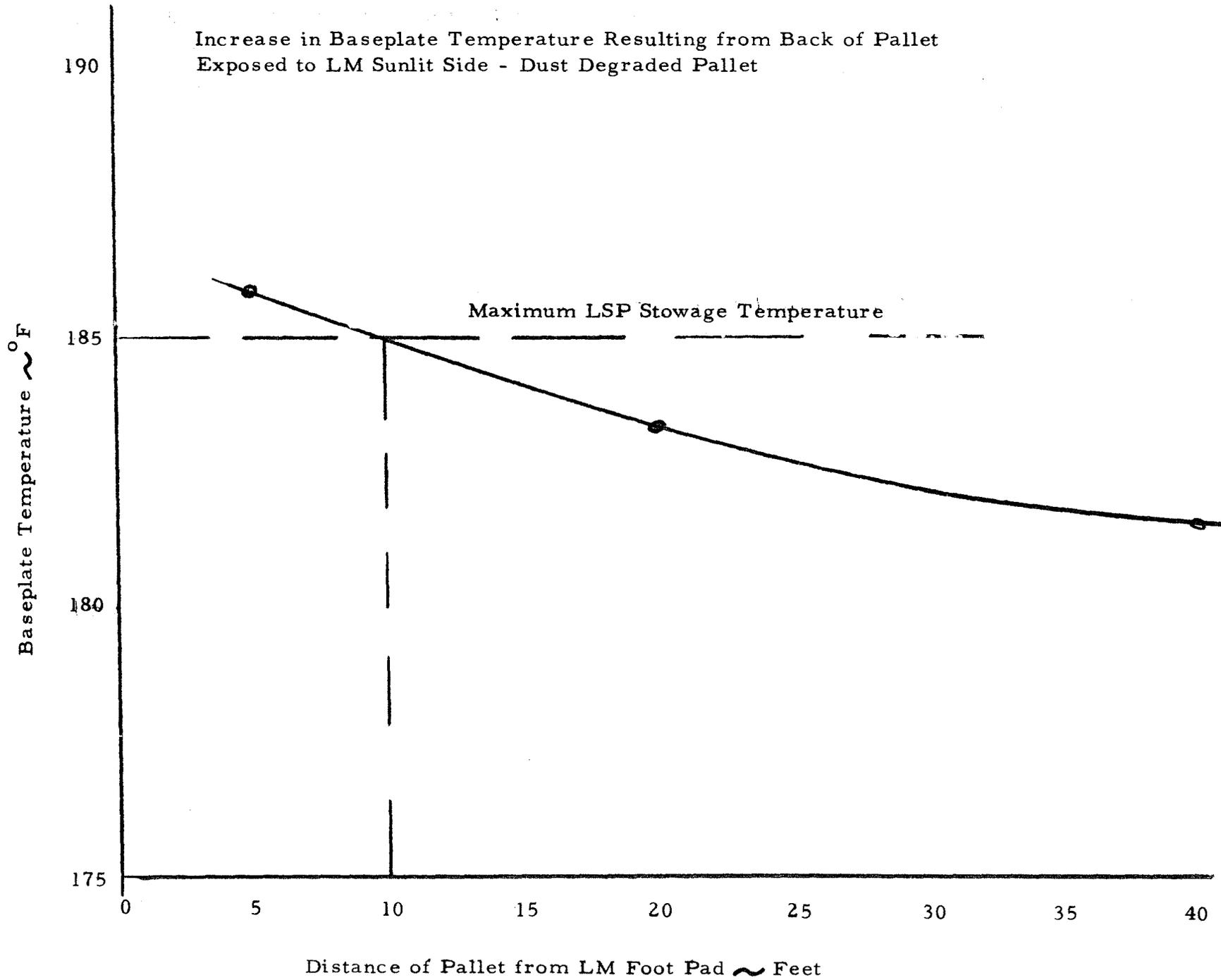
A pallet placed within 10 feet of the LM footpad will result in baseplate temperatures in excess of the LSPE maximum non-operating temperature limits.

3.3 Effects of Incident Sun Misalignment on the LM Pallet

Stowing the LM Pallet on the sunlit side of the LM will result in higher LSPE equilibrium temperatures than locating it on the shade side since the LSPE Transport Frame Assemblies would get a direct lunar view of the shaded surface. Furthermore as the LM Pallet misalignment with incident sun increases some of the LSPE high explosive packages become shaded by adjacent packages. These factors are included in the results of a misalignment study of LM Pallet lunar stowage presented in Figure 4.

Figure 4 depicts the high explosive baseplate temperatures 5 hours subsequent to stowage of the LM Pallet on the lunar surface. The temperature at the time of stowage was  $-5^{\circ}\text{F}$ . As indicated Pallets facing a shaded lunar surface must be limited to  $\pm 45$  degrees misalignment and those facing a sunlit surface are limited to  $\pm 30$  degrees.

Increase in Baseplate Temperature Resulting from Back of Pallet  
Exposed to LM Sunlit Side - Dust Degraded Pallet



Distance of Pallet from LM Foot Pad ~ Feet

Figure 3

Effects of LM Pallet and LSPE Transport Frame  
Misalignment After 5 Hours of Sun Exposure During  
EVA-1. Initial Stowage Temperature  $-5^{\circ}\text{F}$ .

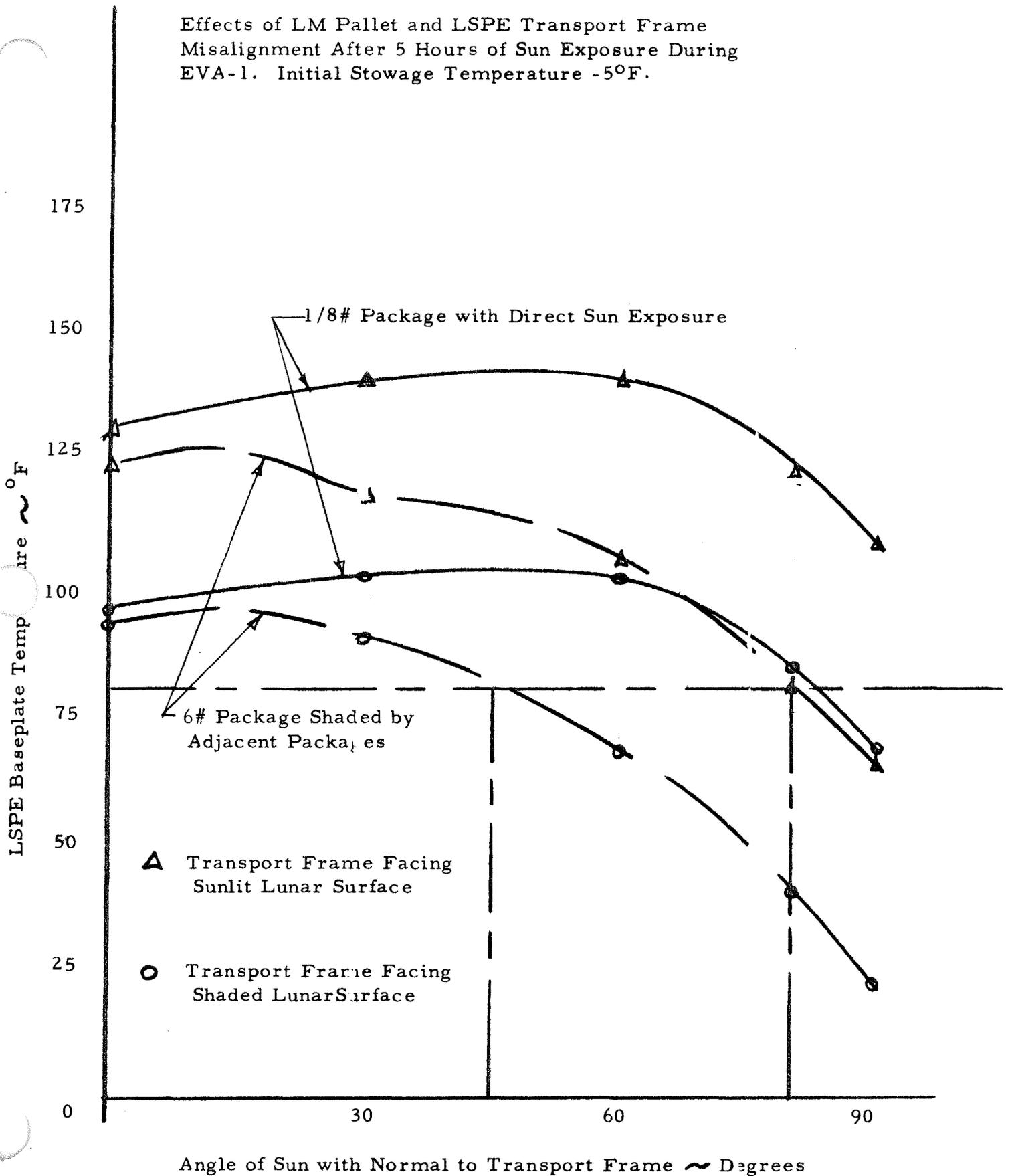


Figure 4



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The governing criterion for this constraint is attaining a baseplate temperature which will assure survival of the LSPE during subsequent LRV shade requirements.

Figure 5 is a time-temperature profile of the 6# high explosive package for both the 45 degree misalignment with shaded lunar surface and the 80 degree misalignment with a sunlit lunar surface. Both 6# packages are shaded by adjacent packages.

After 5 hours of sun exposure the temperatures of the baseplates for the 45 and 80 degree misaligned package will be 80°F. This is adequate as an initial LRV stowage temperature to assure a +45°F baseplate temperature after shade exposure on LRV (See Figure 6).

#### 4.0 LRV PALLET STOWAGE

Stowage of the LSPE Transport Frame Assembly will be atop the LRV tool Pallet. The analysis described in this memo includes stowage at an initial temperature of -5°F with 5 hours of sun exposure prior to exposure of the LRV to 45 minutes of shade.

Two environment conditions are considered, a hot and cold case. The cold case considers stowage 5 hours prior to EVA-2. Sun is incident on the side of the LRV and the end of the LSPE Transport Frame Assembly. The hot case considers stowage 5 hours prior to EVA-3. Sun is incident on the front of the LRV and the side of the LSPE Transport Frame Assembly. The hot case assumes a package exposed to sunlight on both its top and side. The cold case assumes sun only on its top.

Figure 6 indicates a time-temperature profile of a 1/8# high explosive package.

The high explosive baseplate during the EVA-2 cold case warms from -5°F to 78°F in 5 hours, then drops to 45°F after 45 minutes of shade exposure. An equilibrium temperature of 99.5°F is attained by mission end. During the EVA-3 hot case the baseplate attains 148°F during the initial 5 hours of exposure, then drops to 94°F as a result of 45 minutes of shade exposure. An equilibrium temperature of 161°F is attained by mission end.

Six Pound High Explosive Package Stowed on a Pallet in Sun during EVA-1. Package is Partially Shaded. Adjacent Packages and Misaligned to the Incident Sun.

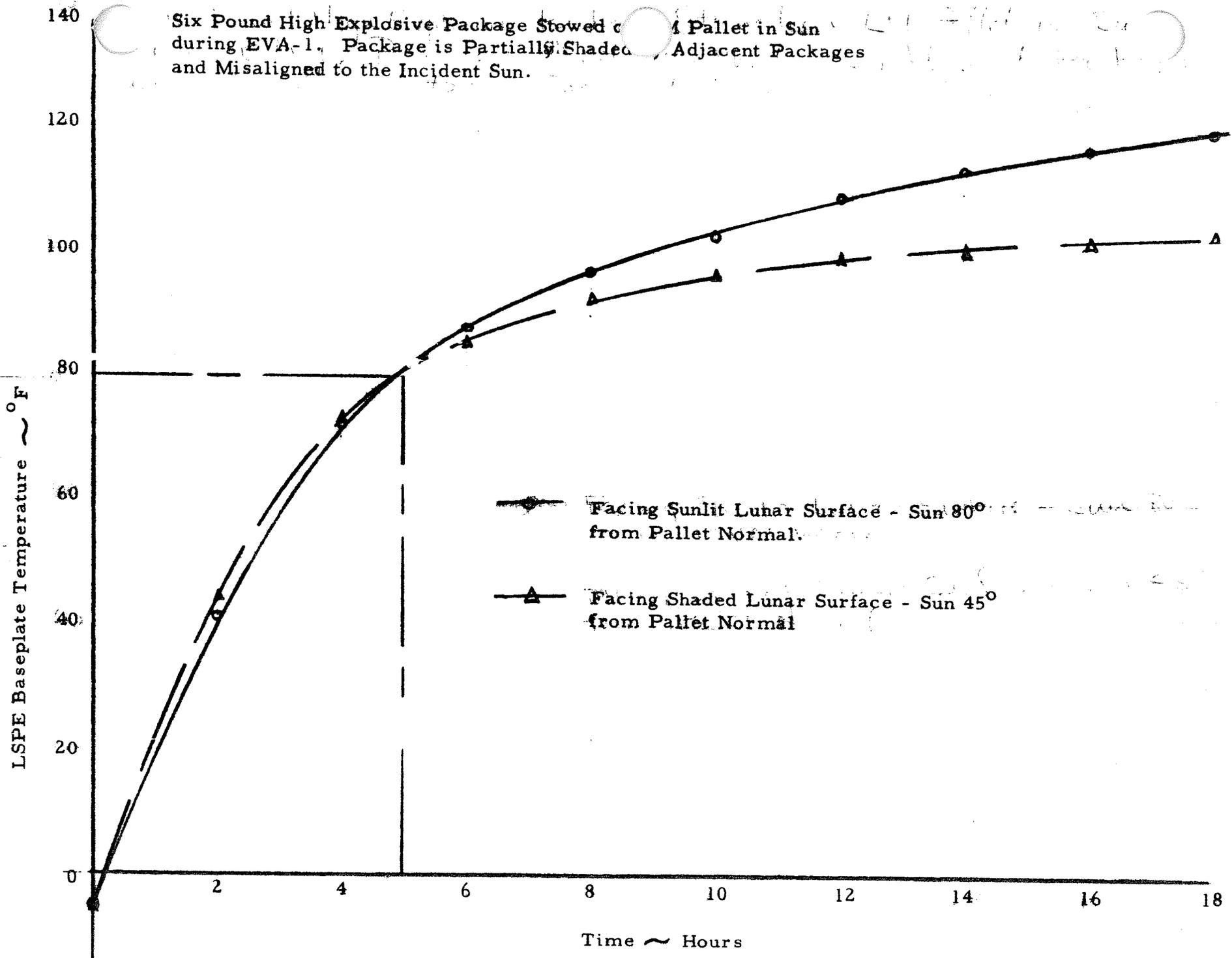


Figure 5

Minimum and Maximum LSPE Mission Profiles Aboard the LRV Tool Pallet. Mission Profile Assumes 5 Hours of Sun Exposure Prior to the Shade Exposure. Requirement of 45 Minutes.

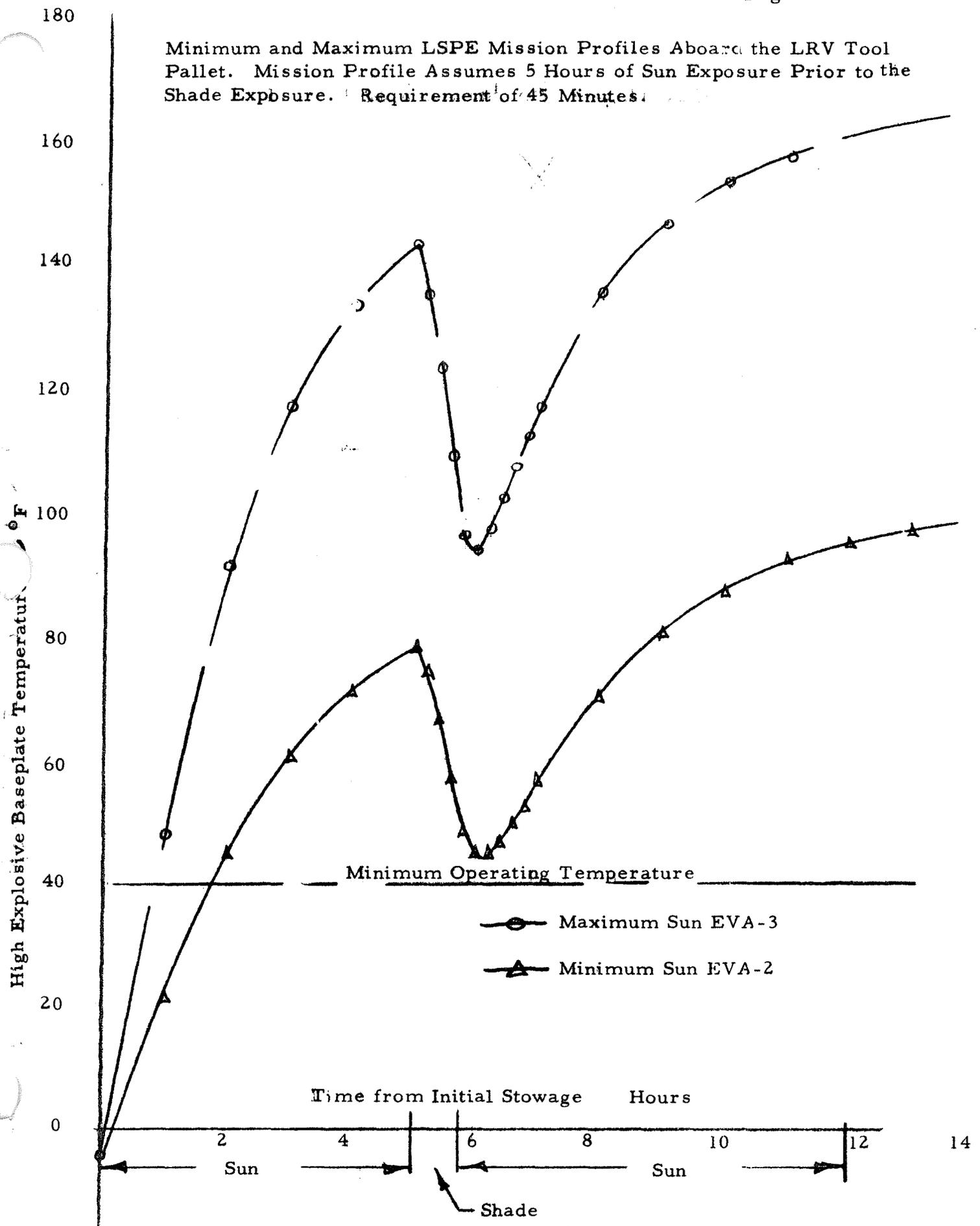


Figure 6



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The 5 hour initial sun exposure is adequate to assure LSPE base-plates and timers remain above +40°F during 45 minutes of LRV mission shade exposure. The EVA-3 hot mission temperature 161°F is below the 180°F maximum operating temperature specification limit.

5.0 INTERIM STOWAGE CONSTRAINTS

5.1 LM Pallet Stowage Between EVA's

- 1) A minimum of 5 hours sun exposure is required prior to any deployment activity.
- 2) Pallet must not be placed in the LM shadow.
- 3) The back of the pallet must not face the sun.
- 4) The Pallet must be at least 10 feet from the LM footpad.
- 5) Misalignment of the incident sun with a normal to the pallet front must be limited to  $\pm 45^\circ$ .

5.2 LRV Stowage Between EVA's

- 1) A minimum of 5 hours sun exposure is required prior to any deployment activity.
- 2) Transport frames must be stowed in the sun.
- 3) The preferred orientation of transport frames is with sunlight on the side