LSPE EXPLOSIVE PACKAGE
STOWAGE THERMAL CONSTRAINTS

This ATM presents the study of LSPE High Explosive Package and transport frame stowage thermal constraints subsequent to LM touchdown and prior to lunar deployment.

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1.0 INTRODUCTION

The basic stowage requirement from a thermal standpoint is that the thermal battery and safe-arm timers be at 40°F minimum temperature at the time of the explosive package lunar deployment during EVA-2 and EVA-3. It is necessary that these timers and their lubricant be at this temperature when the astronaut removes the pull pins activating the timers.

A requirement to place the high explosive packages and transport frames in the sun prior to the LRV mission is necessary to assure the minimum +40°F operating temperature at the time of deployment.

Exposure to the sun aboard LRV during an EVA alone will not assure minimum operating temperature at lunar deployment. Packages could be deployed at any time during the EVA. The heavier high explosives (i.e., 6 lb) would require more time than one EVA to reach minimum operating temperature with constant sun exposure.

In addition to the requirement of adequate warmup prior to stowage aboard LRV, EVA activity and LRV interface constraints are defined herein to assure that the LSPE electronics package is above minimum operating temperature immediately upon deployment on the lunar surface.

2.0 SUMMARY

Requirements that the safearm and thermal battery timers be at +40°F minimum operating temperature immediately at the time of their deployment on the lunar surface demands the following thermal requirements and constraints on HE package stowage between EVA-1 and EVA-2.

1. LSPE transport frames and HE packages must be placed on the lunar surface facing the sun a minimum of 10 hours prior to EVA-2

2. Conductive isolation at the LSPE transport frame—Grumman LRV pallet interface is required

3. The LSPE high explosive packages will be at minimum operating temperature at the time of lunar deployment after a maximum shade exposure of 25 minutes on the LRV at anytime during EVA activity.

4. Figure 1 is the minimum temperature profile of the explosive package baseplate based upon the above design provisions and lunar mission constraints.

Phase 1 - Quad III stowage prior to touchdown (see also Figure 2).

Phase 2 - The LSPE transport frames and LM Pallet are removed from LM Quad III and placed on the lunar surface with the LSPE packages facing the sun directly (see also Figures 3, 4, and 5).

Phase 3 - LSPE transport frames are mounted atop the LRV tool pallet during EVA-2 with constant sun exposure. The frames are isolated from the LRV pallet via fiberglass conduction isolators (see also Figures 6, 7 and 8).

Phase 4 - LRV is parked in the shade for no longer than 25 minutes immediately preceding lunar deployment of the high explosive package on the lunar surface (see also Figures 6, 7 and 8).

Phase 5 - High explosive package attaining thermal equilibrium after lunar deployment.

3.0 LSPE HIGH EXPLOSIVE PACKAGE AND TRANSPORT FRAME STOWAGE BETWEEN EVA-1 AND EVA-2

Grumman ICD 22314, Figure 2, represents the LM quad III pallet temperatures, maximum and minimum, throughout the mission until 30 hours after LM touchdown. At 24:40 hours after touchdown the stowed equipment temperature would range between +5°F and 158°F. If the LSPE high explosive packages were removed at this time for the EVA-2 lunar deployment, the +5°F lower temperature would not be acceptable for lunar deployment of the packages.

Removing the LM pallet and attached LSPE transport frames and stowing them in the shade would result in a rapid drop in temperature. This condition would result in HE packages between -60 to -70°F at the start of EVA-2 (see Figure 3).

Removing the LM pallet and LSPE transport frames at some time during EVA-1 and placing the packages, frames and LM pallet in the sun with LSPE high explosive packages facing the sun as indicated in Figure 4 would result in their obtaining a temperature of 133°F by the start of EVA-2 (see Figure 5). It is necessary that the LSPE packages and not the LM pallet be facing the sun. The LSPE high explosive packages and transport frame are designed to absorb heat at low solar angles and the LM pallet is not. It was assumed in this analysis that the LM pallet will be coated with solar reflective paint (i. e., α/ϵ - .24/.90).

The second LSPE transport frame and HE packages should remain on the LM pallet exposed to the sun until its stowage aboard LRV at the onset of EVA-3.

4.0 INTERIM STOWAGE ABOARD LRV DURING EVA'S

Information obtained during the telecon, ref. 2, indicated the possibility that the LRV, during an EVA, could remain parked in the shade for two hours maximum and could drive in the shade for 1/2-hour maximum. Assuming a lunar shade temperature of -300°F, studies were made of LSPE stowage on LRV during EVA-2 in order to determine any LSPE thermal constraints on the LSPE--LRV interface and EVA mission.

The LSPE--LRV interface is atop the LRV tool pallet with direct exposure to the sun.

Studies have been made of time-temperature decays for LSPE high explosive packages exposed to a shaded environment for various methods of LSPE transport frame to LRV pallet thermal couplings. These results are indicated in Figure 7 and 8.

Direct coupling of the Transport Frame with the LRV results in a lower equilibrium temperature atop the LRV pallet and a longer warm period in the event of exposure of the LRV to shade. The baseplate equilibrium temperature of the LSPE directly mounted to the LRV pallets is 64°F. Isolating the transport frame through heat conduction isolation increases this temperature to 80°F. Adding a multilayer insulation blanket between the transport frame and LRV pallet would further increase the equilibrium temperature to 88°F.

Isolating the transport frame results in more rapid warming of the LSPE packages subsequent to a shade exposure. A transport frame directly coupled to the pallet would require one hour of direct sun exposure to bring the high explosive baseplate to minimum operating temperature, whereas, a decoupled frame would require only 25 minutes. Thermally decoupling the LSPE thermal behavior independent of LRV thermal behavior. Present LRV temperatures are the writers assumptions based on assumed conditions in lieu of incomplete LRV temperature data.

Total isolation of the transport frame and package by enclosing them in a multilayer shroud would be required to ensure protection of the packages for the quoted 2-1/2 hours of shade exposure during the EVA.

Shade exposure in excess of 25 minutes at any time during an EVA must be followed by a minimum time of exposure in the sun to bring the LSPE packages back to their minimum operating temperature prior to deployment of the first package. A study was made to determine this time of exposure in the sun. The transport frame was assumed to be conductively isolated from the LRV pallet. The frame and package were assumed mounted atop the pallet with minimum exposure of sun on top of the packages and end of the transport frame. The frames were assumed to be stowed on LRV at the initial 133°F temperature discussed in Section 3.0 and allowed to come to equilibrium atop the LRV pallet before being exposed to the sun. The results are given in Figure 6. Corresponding heat up (minimum sun) exposure time for a given shade exposure is plotted. As an example, for the 2-1/2 hours of shade predicted in ref. 2, a sun exposure of 1-1/2 hours in the direct sunlight would be required to bring packages to the minimum operating temperature for deployment.

References:

1. Grumman ICD 22314, Figure 2

2. Telecon NASA/MSC, Contact Report No. 9712-230, 3/2/71.

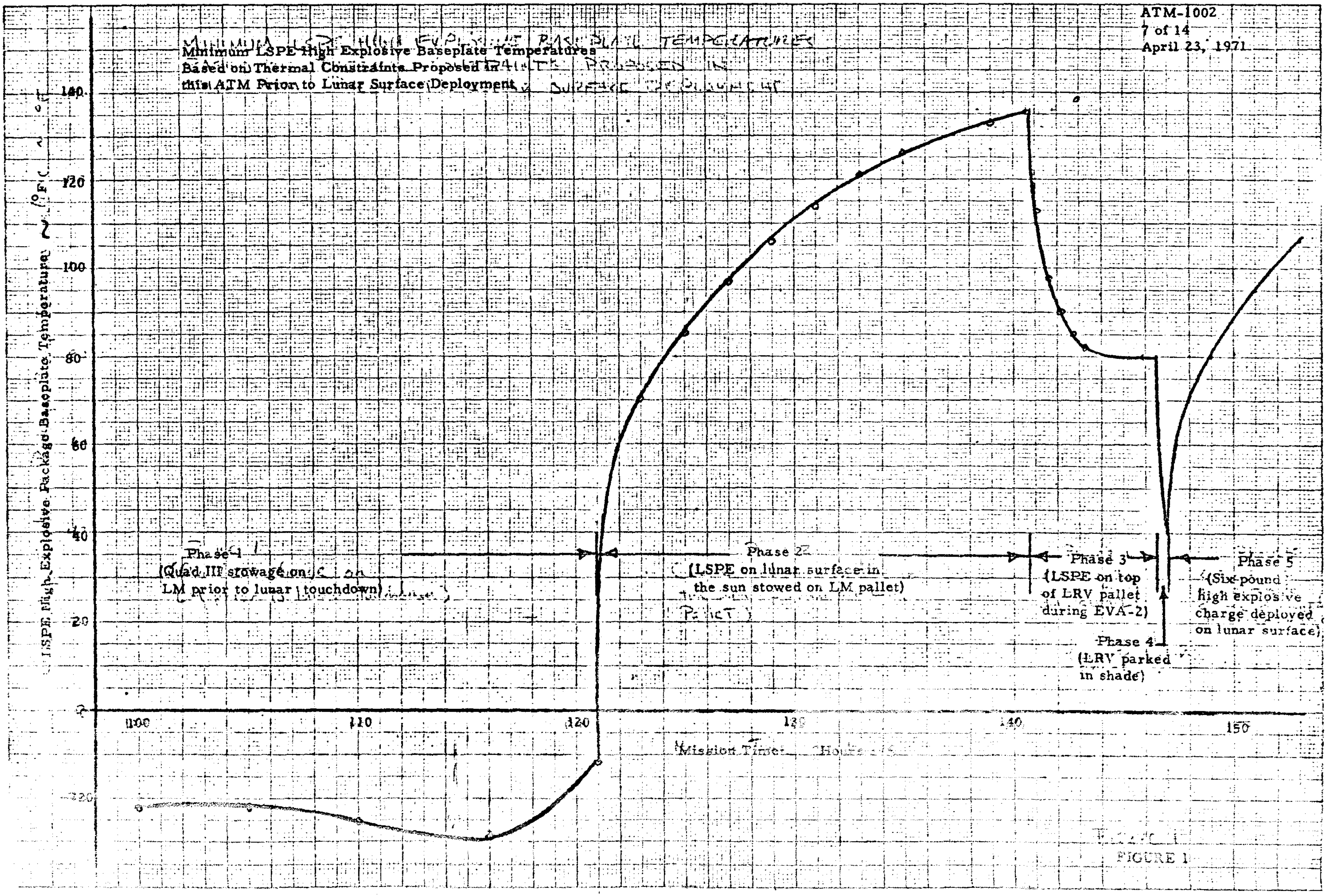
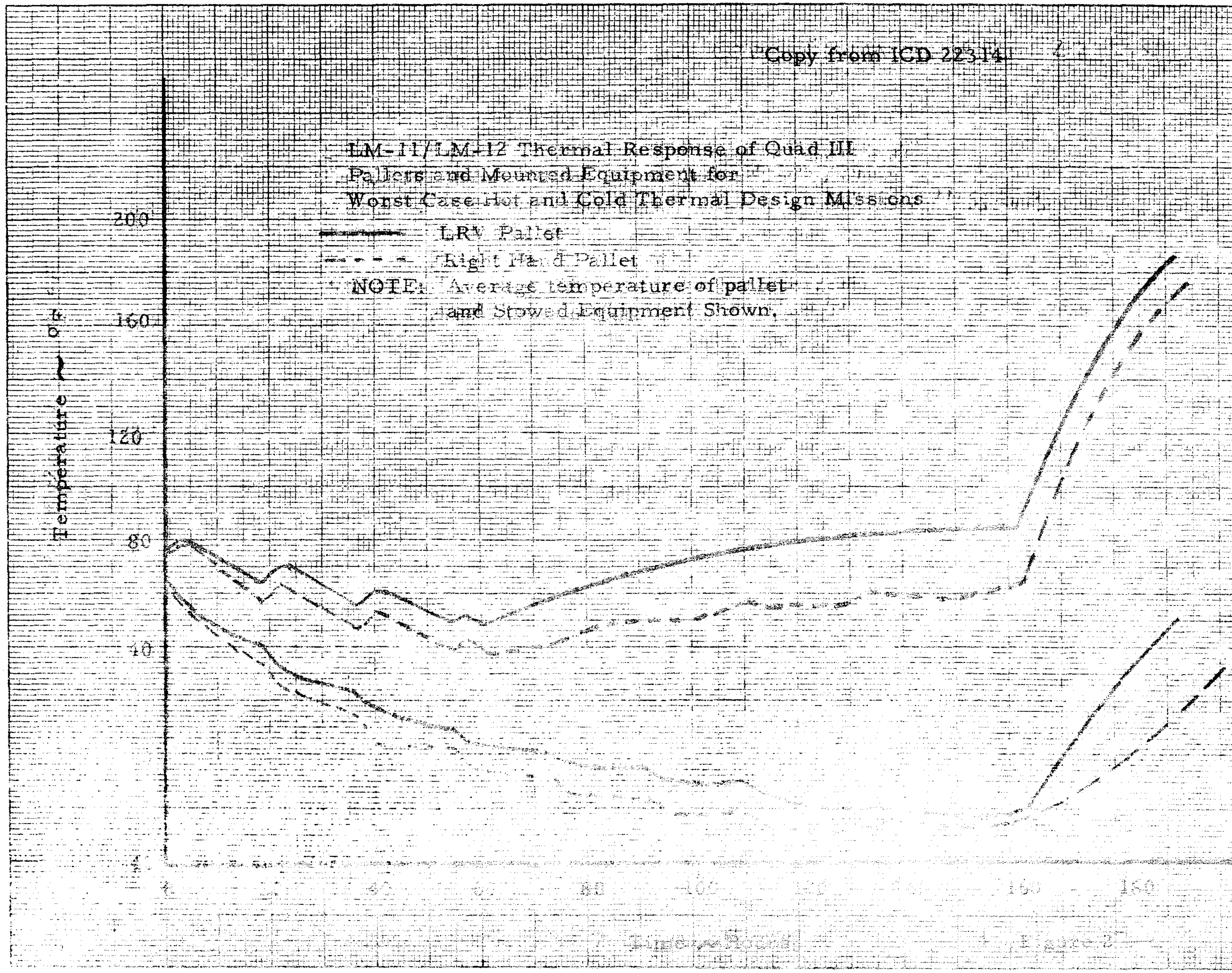

Minimum LSPE High Explosive Baseplate Temperatures
Based on Thermal Constraints Proposed in
this ATM Prior to Lunar Surface Deployment
LSPE High Explosive Package Baseplate Temperature ~ °F
140
120
100
80
60
40
20
0
-20
100
110
120
130
140
150
Mission Time ~ Hours
Phase 1
(Quad III stowage on
LM prior to lunar touchdown)
Phase 2
(LSPE on lunar surface in
the sun stowed on LM pallet)
Phase 3
(LSPE on top
of LRV pallet
during EVA-2)
Phase 4
(LRV parked
in shade)
Phase 5
(Six-pound
high explosive
charge deployed
on lunar surface)

FIGURE 1


"Copy from ICD 22314"
LM-11/LM-12 Thermal Response of Quad III
Pallets and Mounted Equipment for
Worst Case Hot and Cold Thermal Design Missions"
LRV Pallet
Right Hand Pallet
NOTE: Average temperature of pallet
and Stowed Equipment Shown.
Temperature ~ °F
200
160
120
80
40
0
20
40
60
80
100
120
140
160
180
Time ~ Hours
Figure 2

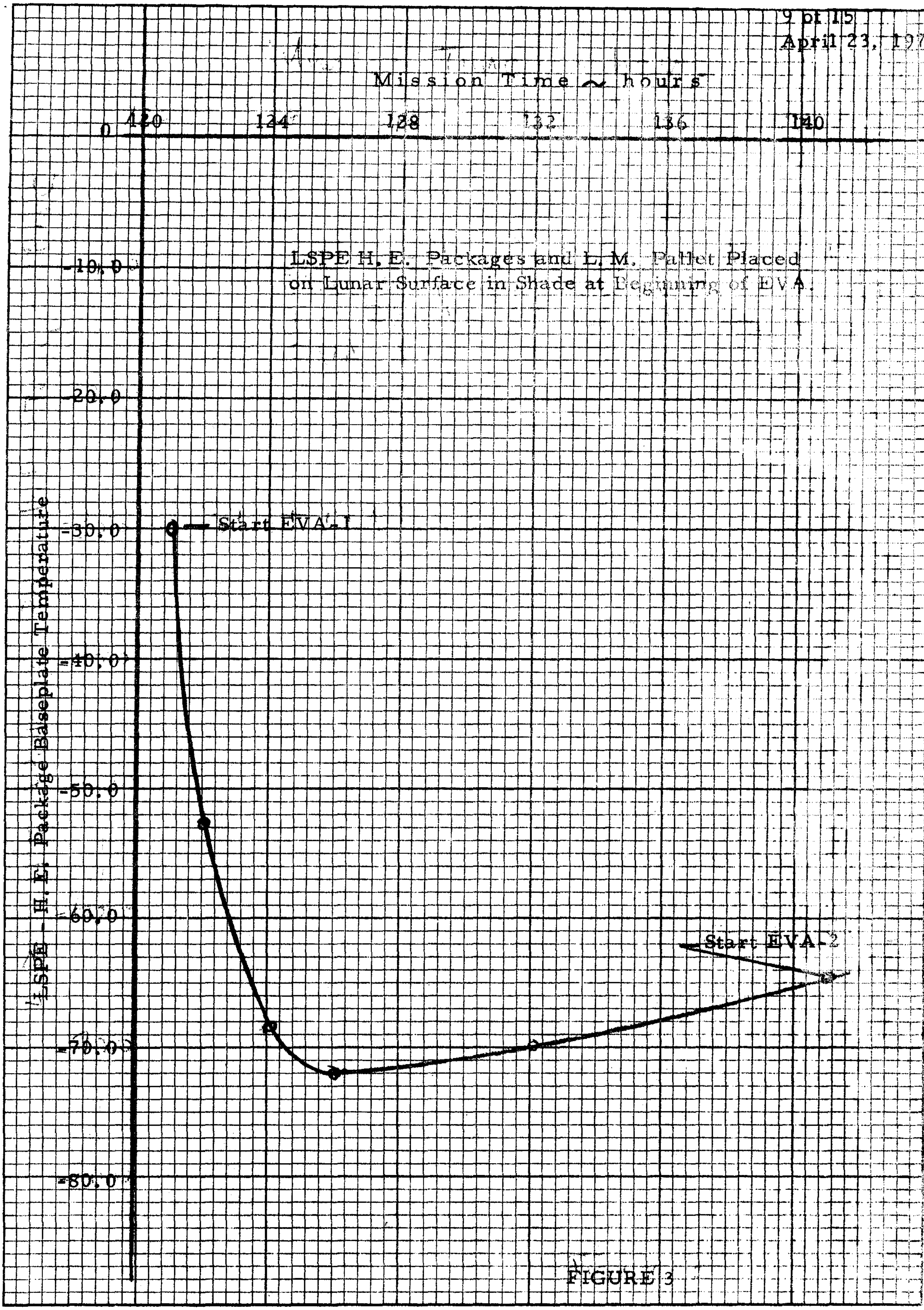

Mission Time ~ hours
0
120
124
128
132
136
140
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
LSPE H. E. Packages and L. M. Pallet Placed on Lunar Surface in Shade at Beginning of EVA.
Start EVA-1
Start EVA-2
LSPE - H. E. Package Baseplate Temperature

FIGURE 3

LM Pallet and LSPE Transport Frames
Deployed in the Sun after removal from
LM Quad III.

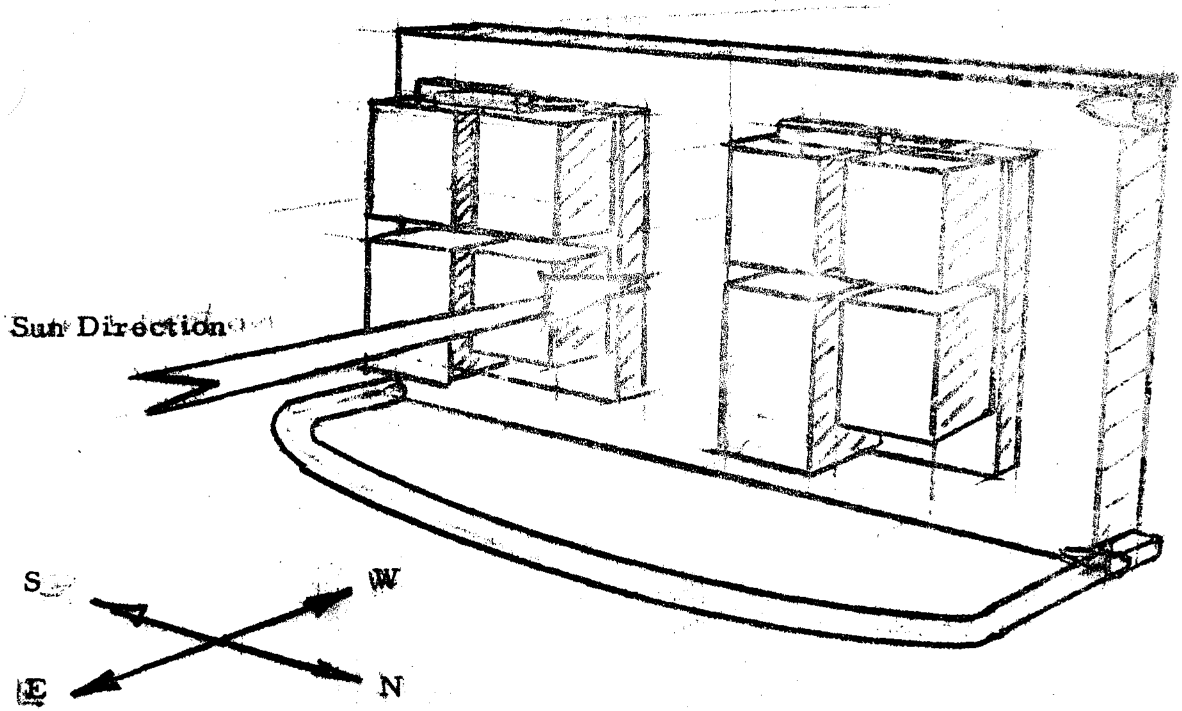
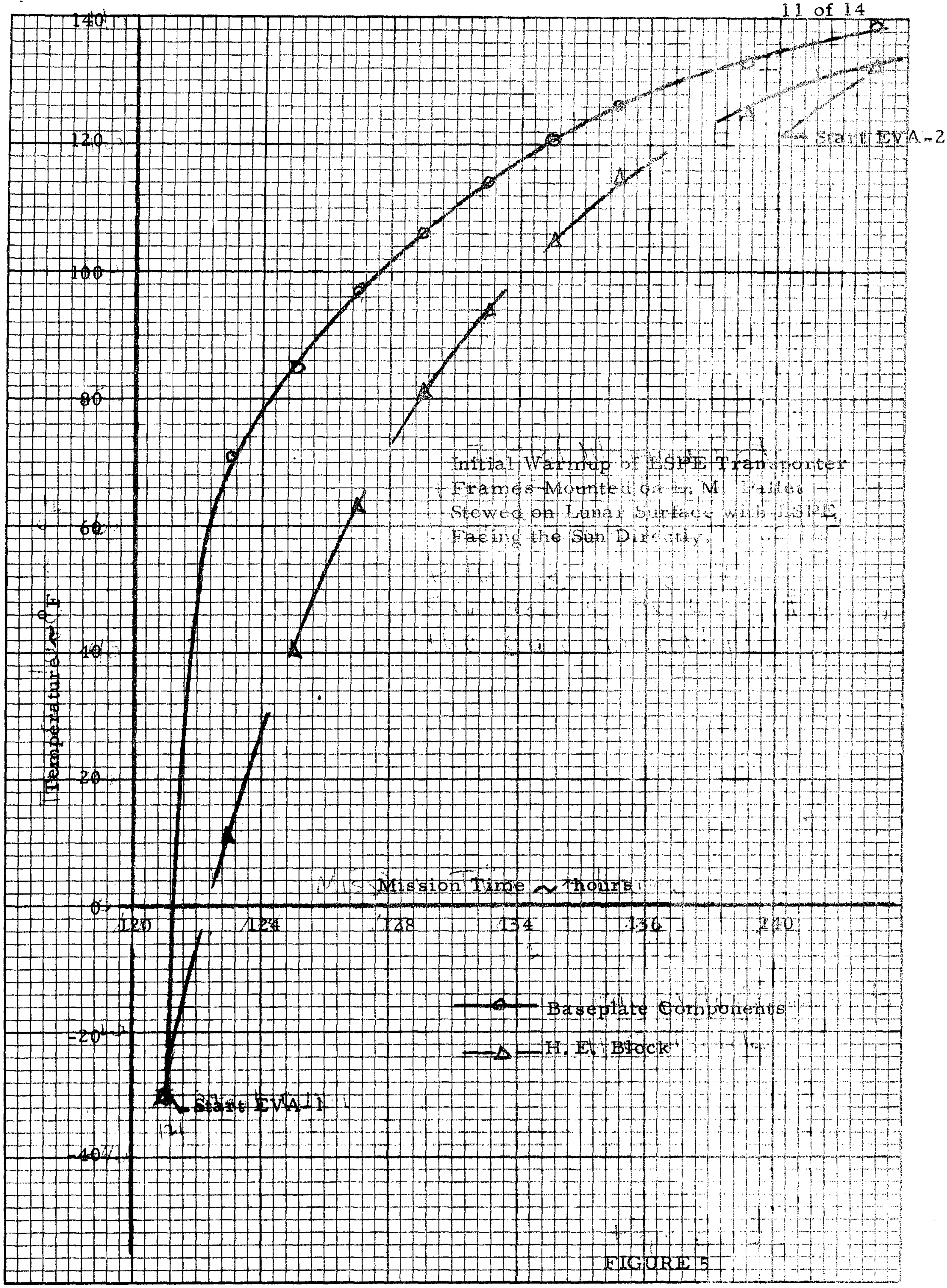


Figure 4.



140
120
100
80
60
40
20
0
-20
-40
Temperature ~ °F
Mission Time ~ hours
120
124
128
134
136
140
Start EVA-2
Start EVA-1
Initial Warmup of ESPE Transporter Frames Mounted on L. M. Pallet Stowed on Lunar Surface with ESPE Facing the Sun Directly.
Baseplate Components
H. E. Block

FIGURE 5

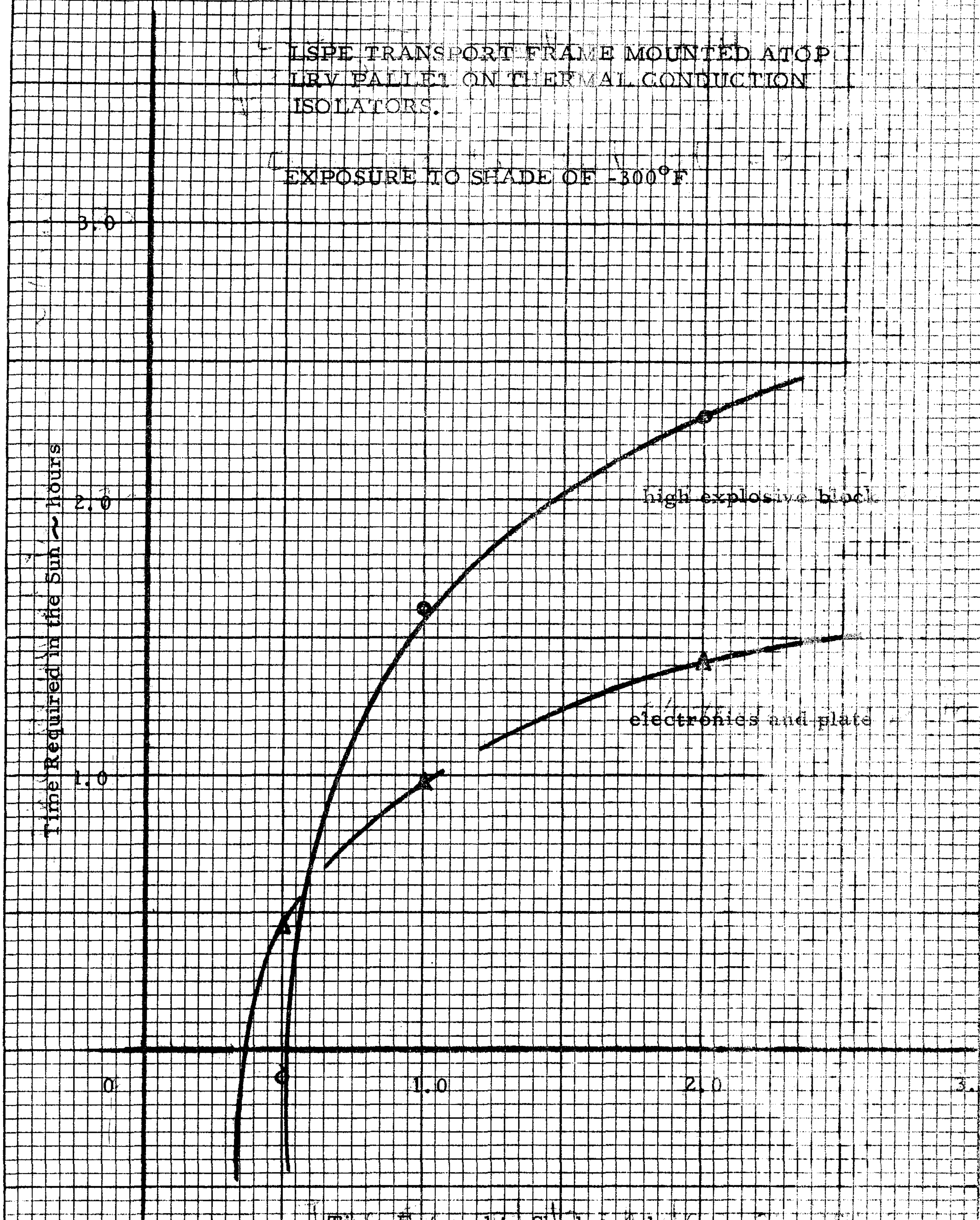

LSPE TRANSPORT FRAME MOUNTED ATOP
LRV PALLET ON THERMAL CONDUCTION
ISOLATORS.
EXPOSURE TO SHADE OF -300°F
3.0
2.0
1.0
0
1.0
2.0
3.0
high explosive block
electronics and plate
Time Required in the Sun ~ hours
Time Exposed to Shade ~ hours

FIGURE 6

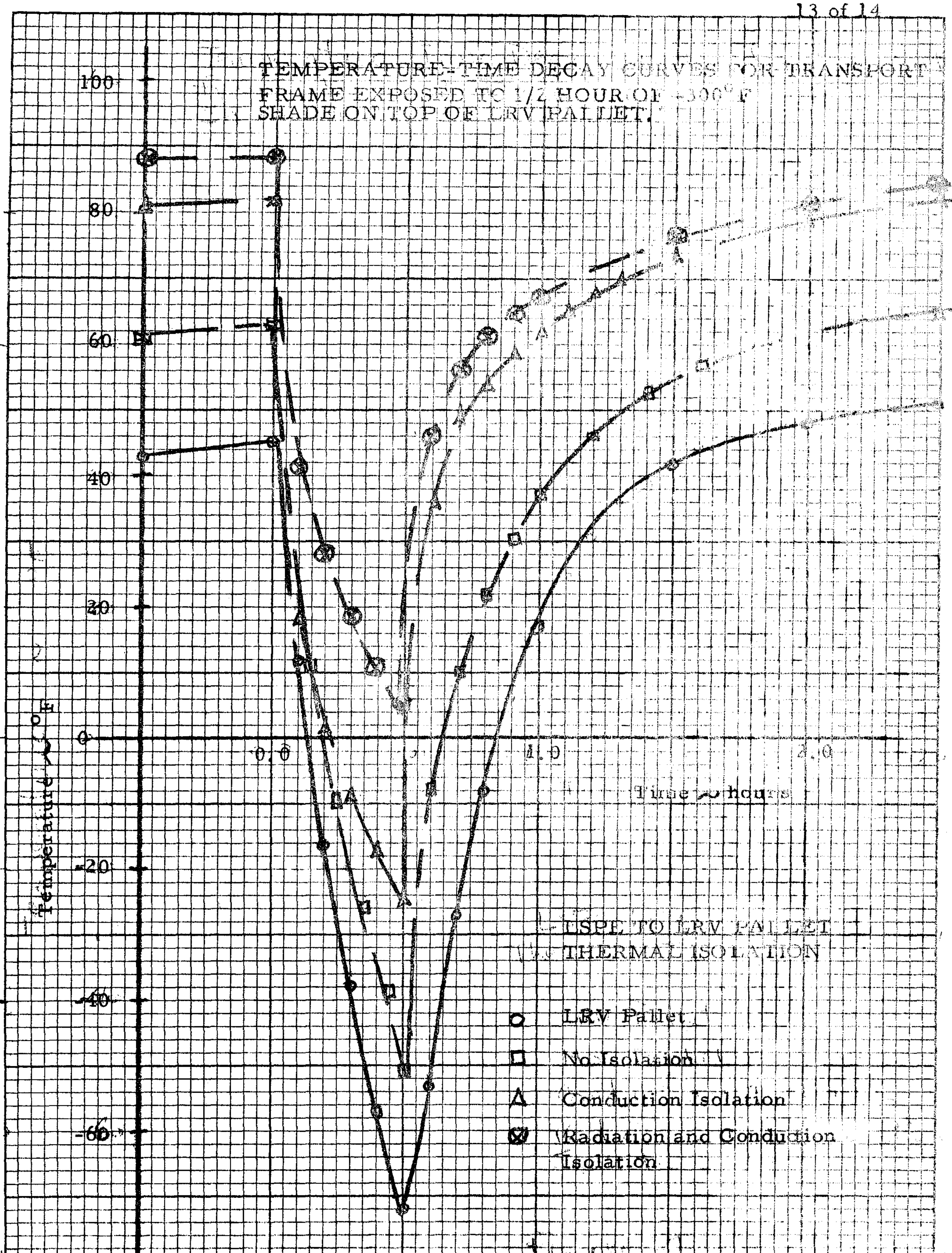

TEMPERATURE-TIME DECAY CURVES FOR TRANSPORT FRAME EXPOSED TO 1/2 HOUR OF -300° F SHADE ON TOP OF LRV PALLET.
100
80
60
40
20
0
-20
-40
-60
-80
0.0
1.0
2.0
Time ~ hours
Temperature ~ °F
LSPE TO LRV PALLET THERMAL ISOLATION
LRV Pallet
No Isolation
Conduction Isolation
Radiation and Conduction Isolation

FIGURE 7

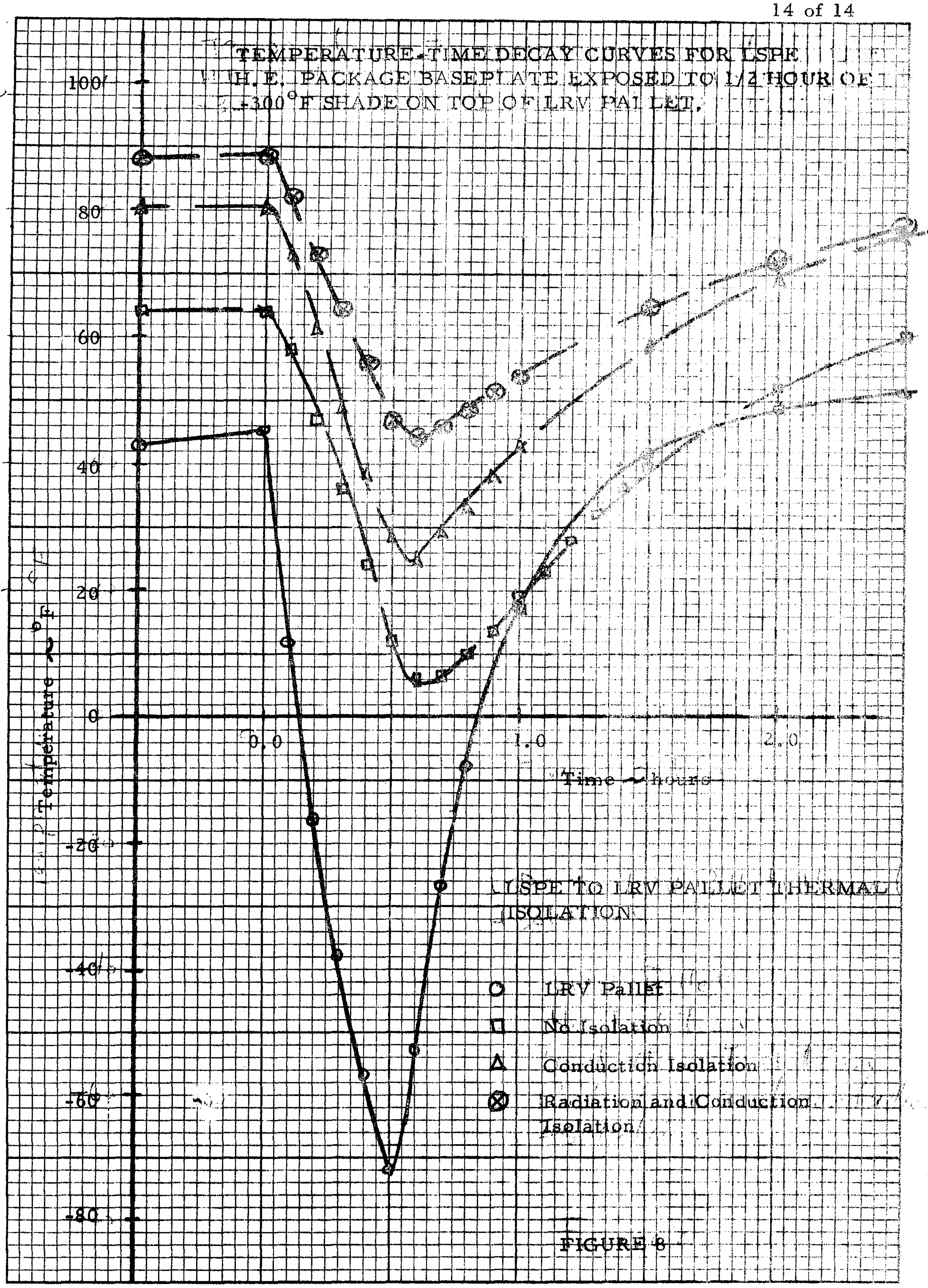

TEMPERATURE-TIME DECAY CURVES FOR LSPE
H. E. PACKAGE BASEPLATE EXPOSED TO 1/2 HOUR OF
+300°F SHADE ON TOP OF LRV PALLET.
100
80
60
40
20
0
-20
-40
-60
-80
Temperature ~ °F
0.0
1.0
2.0
Time ~ hours
LSPE TO LRV PALLET THERMAL
ISOLATION
LRV Pallet
No Isolation
Conduction Isolation
Radiation and Conduction
Isolation

FIGURE 8