This ATM summarizes the LSPE Design Verification Thermal Vacuum Test of the prototype model including a correlation study of the analytical thermal model.

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SUMMARY

The thermal vacuum test of this prototype model was carried out to verify the design and analysis of the LSPE system. The prototype thermal system performed as expected. Some differences between the prototype DVT and lunar analysis did occur. These differences are indigenous to the Design Verification Test.

The 1/8# high explosive package temperatures at 26 and 60 degree solar angles were 142^{o} and 166^{o}F respectively. These temperatures are within the $+40^{o}$ to $+180^{o}$F operating specification requirements. No adverse effects resulting from thermal battery firing was observed.

The maximum central electronics component to thermal plate gradient observed was 21^{o}F in the 16 channel MUX. This occured during the ambient function. The ambient functional was used as the representative thermal test since heat leak via the coax transmitting cable is nullified during this test. This heat leak will not be a problem when the LSPE central electronics is mated with the ALSEP system.

1.0 SCOPE

The purpose of this report is to document the results and conclusions resulting from the testing of the LSPE Prototype in the BxA Thermal Vacuum Test Chamber.

2.0 INTRODUCTION

The Lunar Seismic Profiling Experiment-Design Verification Thermal Vacuum Tests were performed during the period of 19 December 1971 to 23 December 1971 at the Bendix Aerospace Systems Division. This report presents the thermal data obtained during those tests together with a correlation of the thermal mathematical model with experimental data. This report also includes a description of the test installation and testing conditions.

3.0 BACKGROUND AND PURPOSE

The LSPE (Lunar Seismic Profiling Experiments) consists of eight packages, each containing an explosive charge, and a central-electronics package which is housed within the ALSEP Central Station. The explosive charges weigh from 1/8 to 6 pounds and are approximately equivalent to TNT in energy per pound. These charges will be deployed from the Lunar Rover Vehicle by the astronauts at distances of 500 meters to 3.5 kilometers from an array of four geophones. The charges will be detonated by a r.f. command from the ALSEP Central Station after the astronauts leave the lunar surface.

The LSPE must operate successfully during a lunar environment phase of 94 hours duration. This phase occurs between the lunar sun angles of 26 and 87 degrees. During that time the lunar surface temperature varies from 119°F to 250°F. The sun's radiation incident on the high explosive package has an intensity of 130 watts/ft^2.

The thermal control of the LSPE high explosive package consists of a passive system. Control is achieved through use of multilayer insulation, an electronics baseplate, and spectrally selective coatings on the electronics and high explosive cases. Thermal control of the central-electronics is maintained via mounting to the ALSEP Central Station electronics baseplate.

The objectives of the LSPE Prototype Design Verification Test are to subject the design to the lunar thermal/vacuum environments to verify the thermal math model and to establish the temperature extremes demonstrating the ability of the LSPE design to withstand these extremes without loss of function.

4.0 DESCRIPTION OF TEST CONDITIONS AND TEST INSTALLATION

4.1 Thermal Test Conditions

The LSPE Prototype models were subjected to three simultaneous tests (see Table 4-1). A 1/8# high explosive package was subjected to conditions of lunar surface simulation each representing operating temperature limit extremes or critical phases of the actual mission. The central-electronics was exposed to Qual Design Limit extreme temperatures within an enclosure simulating the ALSEP Central Station. Ten high explosive packages were subjected to operating temperature limit extremes by controlling their enclosure to these limit temperatures.

4.2 1/8# High Explosive Package

4.2.1 Vacuum Chamber (BSX 12255)

Space was simulated within the Bendix 20' x 27' Space Simulation Chamber. A vacuum was maintained at or below 5 x 10^{-6} torr. throughout the test. Deep space was simulated by an aluminum cold shroud (BSX 11997) which was 8 feet in diameter and 4 feet high. Liquid nitrogen at -280 to -300°F was circulated within the cold wall to simulate the -459°F temperature of space. (See Figure 4.2).

4.2.2 Lunar Surface Simulator

The lunar surface was simulated by means of a metal plate (14' x 14') with a 6 inch vertical lip. The surface was mounted horizontally at the south end of the 20' x 27' vacuum chamber.

The surface was coated with black thermal paint to simulate the emissivity of the lunar surface. Surface temperature was controlled by means of infrared heaters beneath the surface. No heat was applied to the surface. No heat was applied to the vertical lips since the box shroud blocked the view of the experiment to the lips. (See Figure 4.3).

4.2.3 Solar Simulation

Solar simulation was achieved by means of three arrays of infrared electric heat lamps. These lamps were arranged in pairs and directed at angles to the horizontal of 26°, 45° and 60° simulating critical mission solar angles. The intensity of incident radiation was determined by measuring the

TABLE 4.1

LUNAR SEISMIC PROFILING EXPERIMENT TEST CONDITIONS

1/8 Pound High Explosive Package (14' x 14' Lunar Surface)

Condition	Lunar Surface Temperature (°F)	Solar Angle (Degrees)	Solar Load (Suns)
1) Minimum Operating Temperature	+128°F	-	-
2) Initial Deployment	+119°F	26°	1.0
3) Intermediate Solar Angle	+192°F	45°	1.0
4) Critical Solar Angle	+224°F	60°	1.0
5) Maximum Operating Temperature (Battery Firing) [1]	+185 F	-	-

Inert High Explosive Packages (N. E. Lunar Surface)

Condition	Plate Temperature (°F)
1) Minimum Operating Temperature	+35°F
2) Maximum Operating Temperature	+190°F

LSPE Central-Electronics (N. W. Lunar Surface)

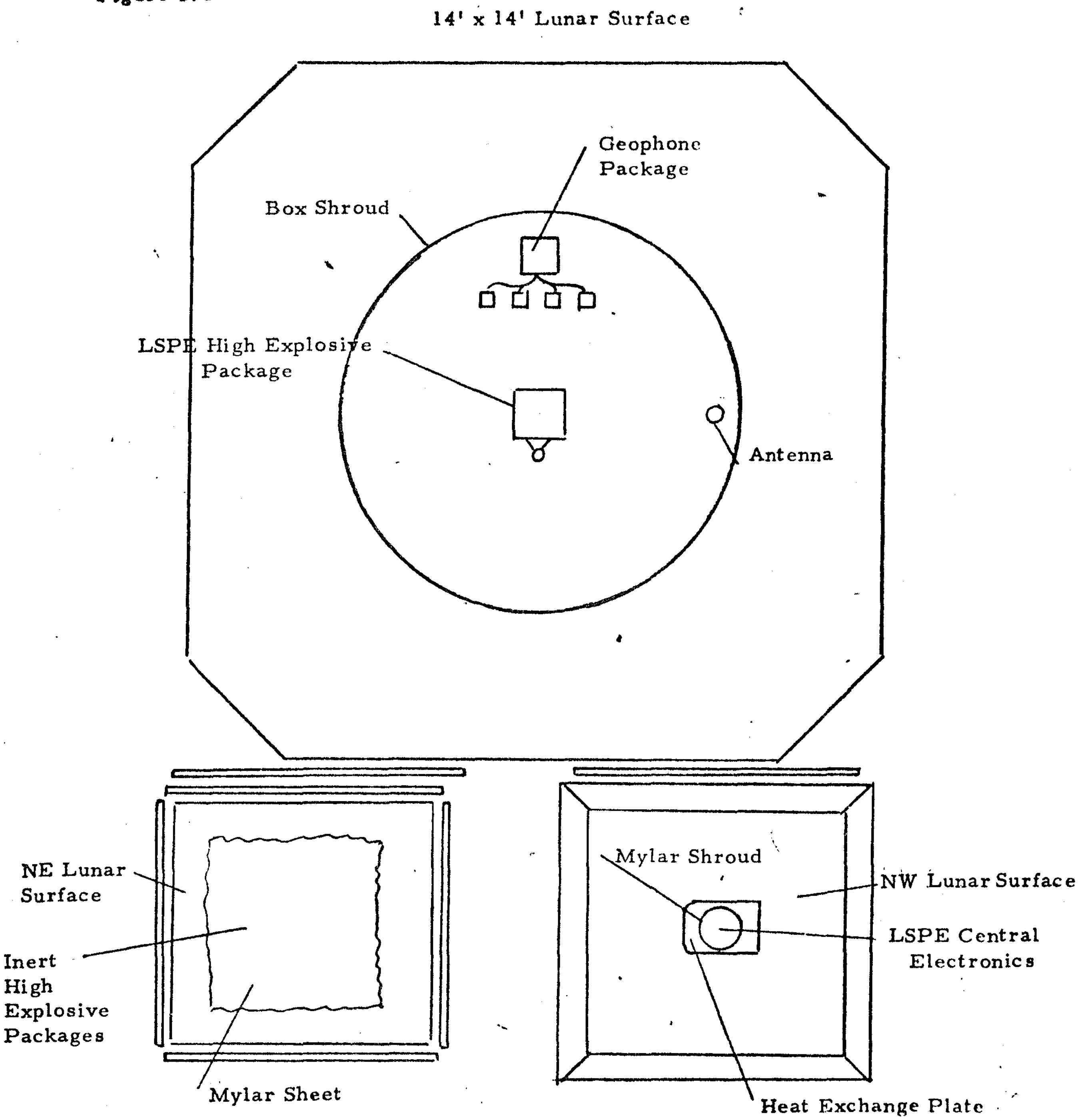
Condition	Plate Temperature
1) Minimum Operating Temperature	26°F
2) Maximum Operating Temperature	+162°F
3) Ambient Test [2] (Battery Firing)	+75°F

1 During this test all surfaces both lunar surface and cold wall were maintained at +185°F.

2 Due to problems with test set it was decided to add the ambient condition during the thermal battery firing phase.

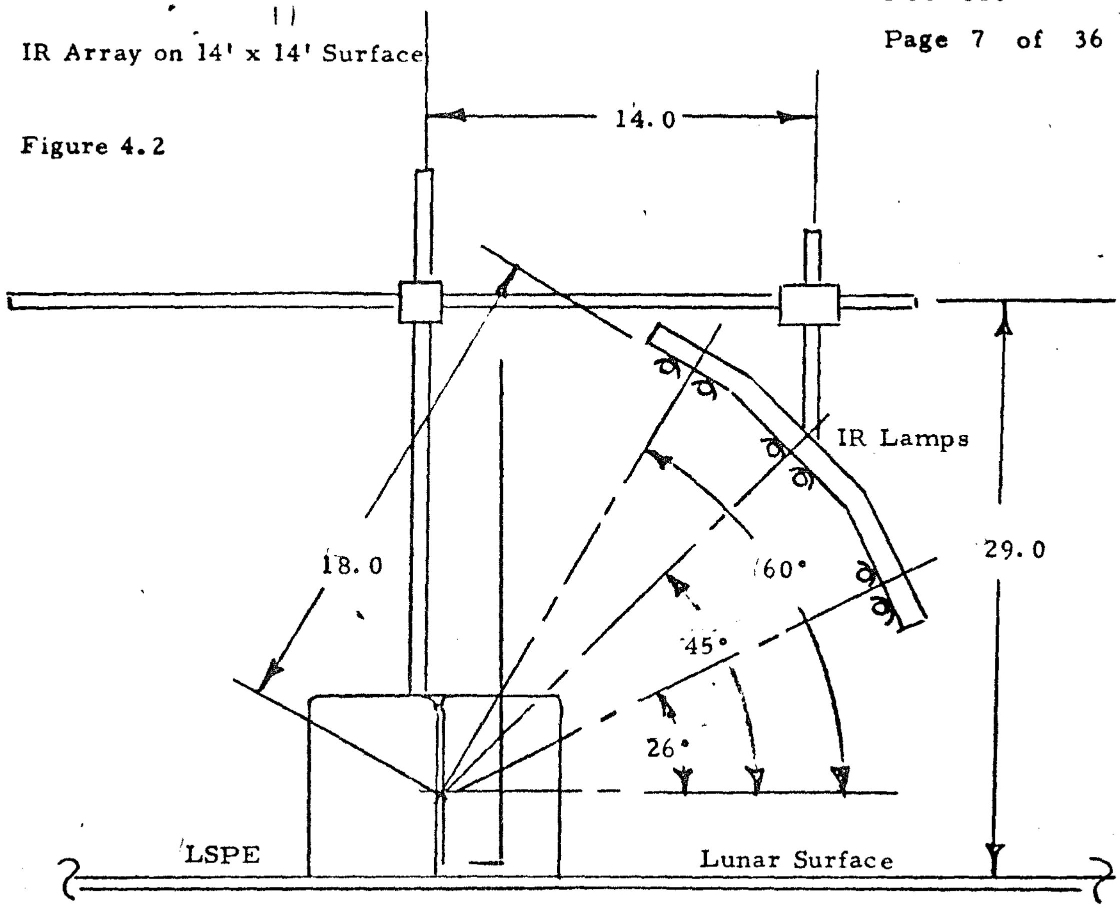
LSPE Design Verification Test Setup
Located in 20' x 27' Chamber

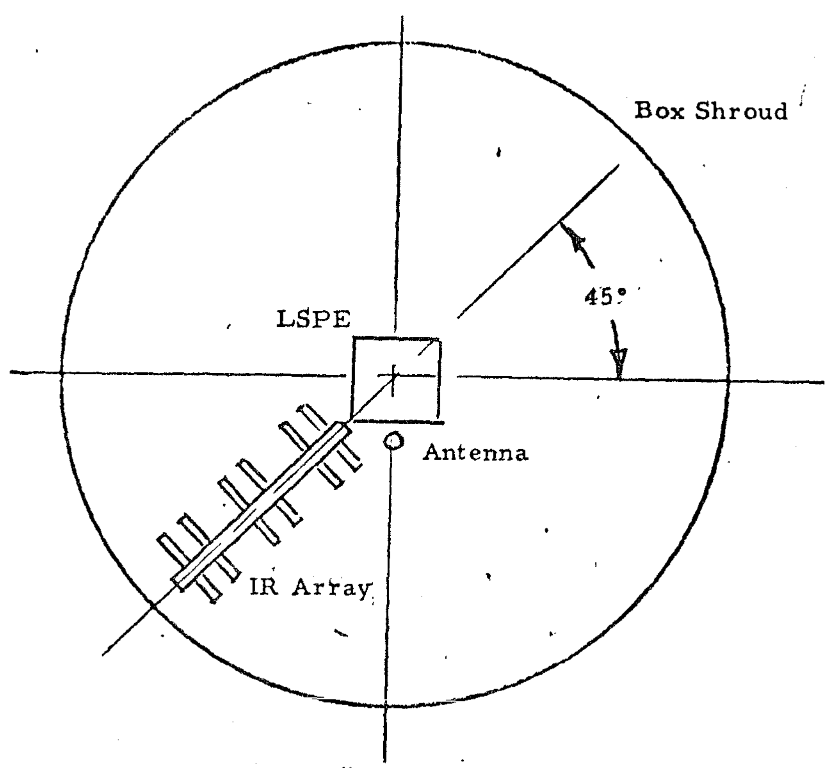
Figure 4.1



IR Array on 14' x 14' Surface

Figure 4.2





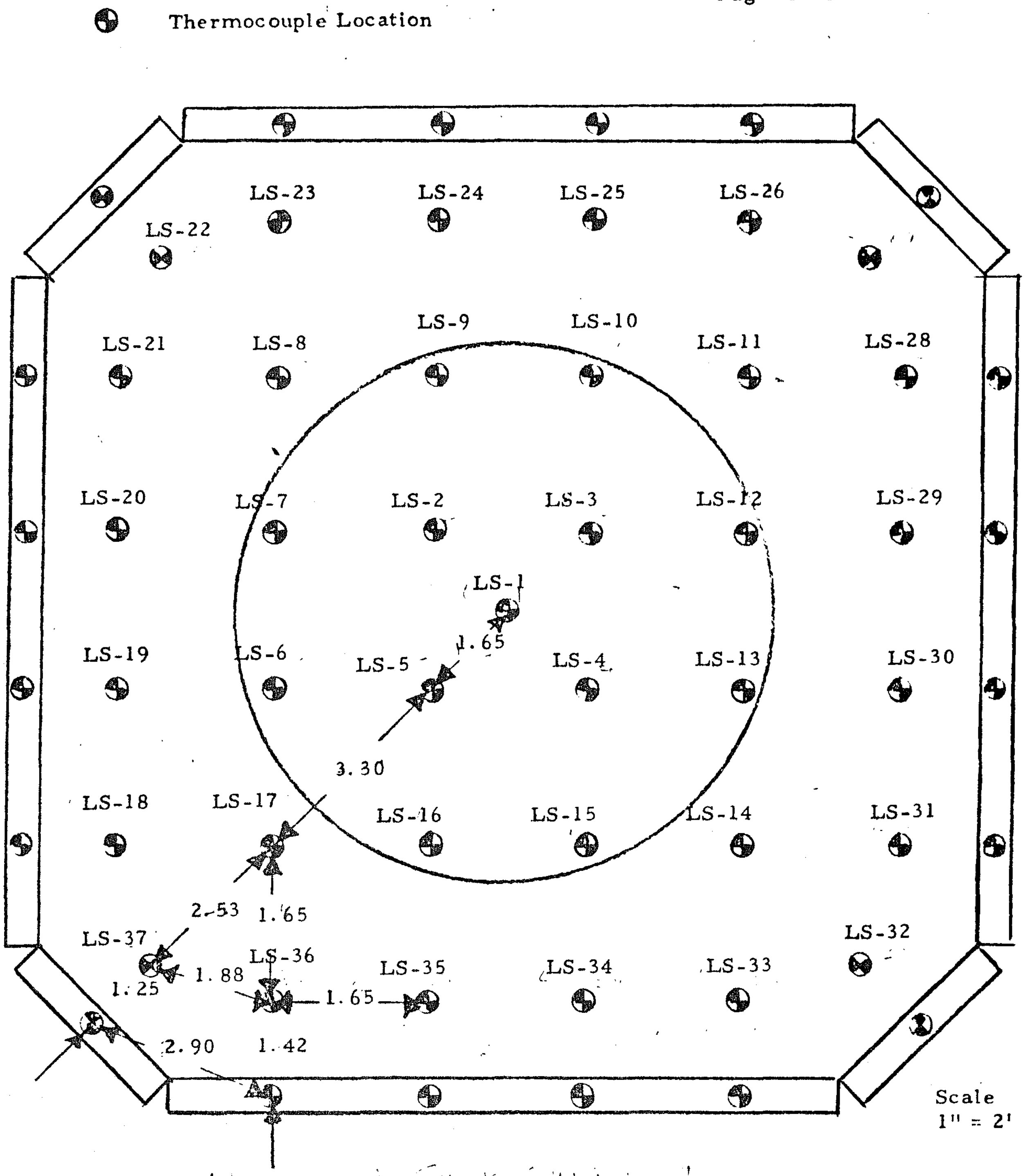


Figure 4.3 14 x 14 Lunar Surface Simulator Thermocouple Locations

intensity of radiation impingent upon a radiometer adjusted to an angle of 45° to the horizontal. (See Figure 4.2). This radiometer was coated black to match the thermal coating of the experiment package.

Intensity of the 26° and 60° solar simulation was obtained by vectoring the energy incident on the 45° radiometer.

4.2.4 Experiment Location

The 1/8# high explosive package was centered directly in the center of the 14' x 14' lunar surface simulator and cold shroud. (See Figure 4.1).

The experiment was rotated with respect to the solar array such that two sides of the package received equal incident energy. Calculations have indicated this to be the maximum temperature condition.

4.2.5 Thermocouple Location

Seven thermocouples were designated to measure the high explosive package temperatures. Six thermocouples were designated to measure the central-electronics temperatures. These thermocouples (LSPE 1 thru LSPE 13) are listed in Table 4.2 and indicated in Figures 4.7, 4.8, and 4.9.

Thermocouples representing the 1/8# high explosive package environment are indicated in Table 4.2. These thermocouples are; the box shroud BS-1 through BS-12, the box shroud lid BSL-1 thru BSL-5 and the lunar surface LS-1 thru LS-37.

Thermocouples representing the temperature of the 10 inert high explosive packages located on the PSE lunar surface (Figure 4.1) are represented by PLS-1 thru PLS-10 and the mylar blanket that covers the packages LSPE-14. These locations are indicated in Figure 4.5.

The ALSEP Central Station environment, enveloping the LSPE Central-Electronics is represented by thermocouples TC-1 thru TC-7. These locations are indicated in Figure 4.6.

TABLE 4.2

THERMOCOUPLE LOCATIONS LSPE DVT

DAS Number	Description	
30	BS-1	Box Shroud
31	BS-2	Box Shroud
32	BS-3	Box Shroud
33	BS-4	Box Shroud
34	BS-5	Box Shroud
35	BS-6	Box Shroud
36	BS-7	Box Shroud
37	BS08	Box Shroud
38	BS-9	Box Shroud
39	BS-10	Box Shroud
40	BS-11	Box Shroud
41	BS-12	Box Shroud
42	LSPE-1	Receiver Housing
43	LSPE-2	Signal Processor Heat Shield
44	LSPE-3	Firing Pulse Generator
45	LSPE-4	Thermal Battery
46	LSPE-5	Detonator Housing
47	LSPE-6	High Explosive Baseplate
48	LSPE-7	Signal Processor
49	LSPE-8	Transmitter
50	LSPE-9	16 Channel Mux
51	LSPE-10	DC/DC Converter
52	LSPE-11	Digital Processor
53	LSPE-12	SDS Amplifier
54	LSPE-13	Electronics Cover
56	LSPE-14	Inert High Explosive Packages
59	45 Degree Radiometer No. 1	
60	45 Degree Radiometer No. 2	
61	LS-1	14 x 14 Lunar Surface (Center Zone)
62	LS-2	14 x 14 Lunar Surface (Center Zone)
63	LS-3	14 x 14 Lunar Surface (Center Zone)
64	LS-4	14 x 14 Lunar Surface (Center Zone)
65	LS-5	14 x 14 Lunar Surface (Center Zone)

TABLE 4.2 (CONTINUED)

THERMOCOUPLE LOCATIONS LSPE DVT

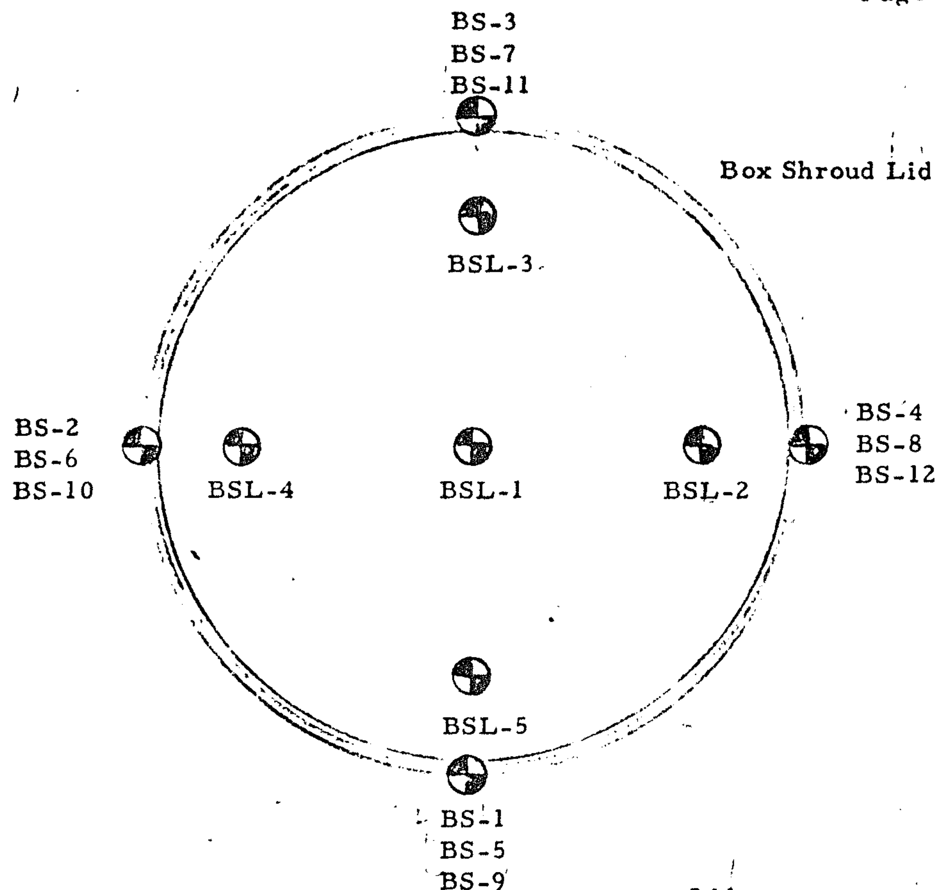
DAS Number	Description	
65	LS-6	14 x 14 Lunar Surface (Middle Zone)
67	LS-7	14 x 14 Lunar Surface (Middle Zone)
68	LS-8	14 x 14 Lunar Surface (Middle Zone)
69	LS-9	14 x 14 Lunar Surface (Middle Zone)
70	LS-10	14 x 14 Lunar Surface (Middle Zone)
71	LS-11	14 x 14 Lunar Surface (Middle Zone)
72	LS-12	14 x 14 Lunar Surface (Middle Zone)
73	LS-13	14 x 14 Lunar Surface (middle Zone)
74	LS-14	14 x 14 Lunar Surface (Middle Zone)
75	LS-15	14 x 14 Lunar Surface (Middle Zone)
76	LS-16	14 x 14 Lunar Surface (Middle Zone)
77	LS-17	14 x 14 Lunar Surface (Middle Zone)
78	LS-18	14 x 14 Lunar Surface (Outer Zone)
79	LS-19	14 x 14 Lunar Surface (Outer Zone)
80	LS-20	14 x 14 Lunar Surface (Outer Zone)
81	LS-21	14 x 14 Lunar Surface (Outer Zone)
82	LS-22	14 x 14 Lunar Surface (Outer Zone)
83	LS-23	14 x 14 Lunar Surface (Outer Zone)
84	LS-24	14 x 14 Lunar Surface (Outer Zone)
85	LS-25	14 x 14 Lunar Surface (Outer Zone)
86	LS-26	14 x 14 Lunar Surface (Outer Zone)
87	LS-27	14 x 14 Lunar Surface (Outer Zone)
88	LS-28	14 x 14 Lunar Surface (Outer Zone)
89	LS-29	14 x 14 Lunar Surface (Outer Zone)
90	LS-30	14 x 14 Lunar Surface (Outer Zone)
91	LS-31	14 x 14 Lunar Surface (Outer Zone)
92	LS-32	14 x 14 Lunar Surface (Outer Zone)
93	LS-33	14 x 14 Lunar Surface (Outer Zone)
94	LS-34	14 x 14 Lunar Surface (Outer Zone)
95	LS-35	14 x 14 Lunar Surface (Outer Zone)
96	LS-36	14 x 14 Lunar Surface (Outer Zone)
97	LS-37	14 x 14 Lunar Surface (Outer Zone)
119	TC-1	NW Lunar Surface (Electronics)

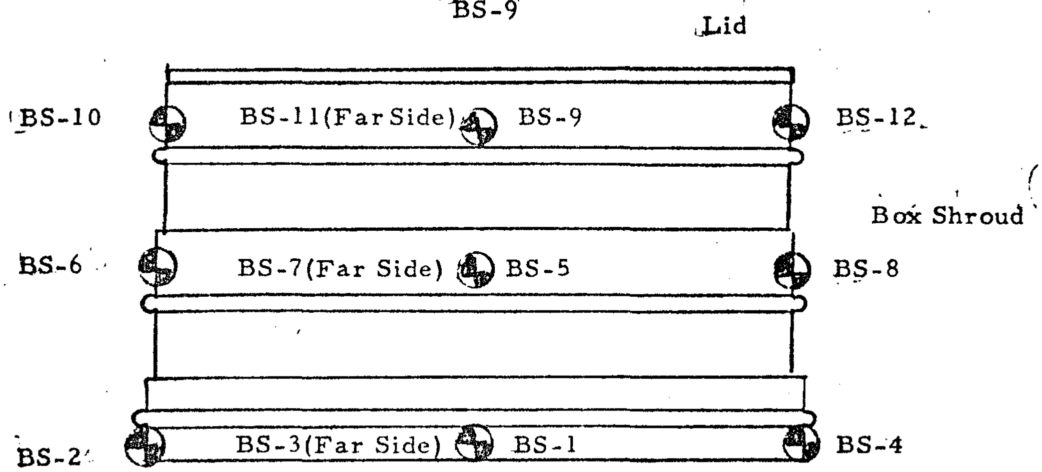
TABLE 4.2 (CONTINUED)

THERMOCOUPLE LOCATIONS LSPE DVT

DAS Number	Description	
120	TC-2	NW Lunar Surface (Electronics)
121	TC-3	NW Lunar Surface (Electronics)
122	TC-4	NW Lunar Surface (Electronics)
123	TC-5	NW Lunar Surface (Electronics)
124	TC-6	NW Lunar Surface (Electronics)
125	TC-7	NW Lunar Surface (Electronics)
126	BSL-1	Box Shroud Lid
127	BSL-2	Box Shroud Lid
128	BSL-3	Box Shroud Lid
129	BSL-4	Box Shroud Lid
130	BSL-5	Box Shroud Lid
137	PLS-1	PSE Lunar Surface (Inert Packages)
138	PSL-2	PSE Lunar Surface (Inert Packages)
139	PSL-3	PSE Lunar Surface (Inert Packages)
140	PSL-4	PSE Lunar Surface (Inert Packages)
141	PSL-5	PSE Lunar Surface (Inert Packages)
142	PSL-6	PSE Lunar Surface (Inert Packages)
143	PSL-7	PSE Lunar Surface (Inert Packages)
144	PSL-8	PSE Lunar Surface (Inert Packages)
145	PSL-9	PSE Lunar Surface (Inert Packages)
146	PSL-10	PSE Lunar Surface (Inert Packages)

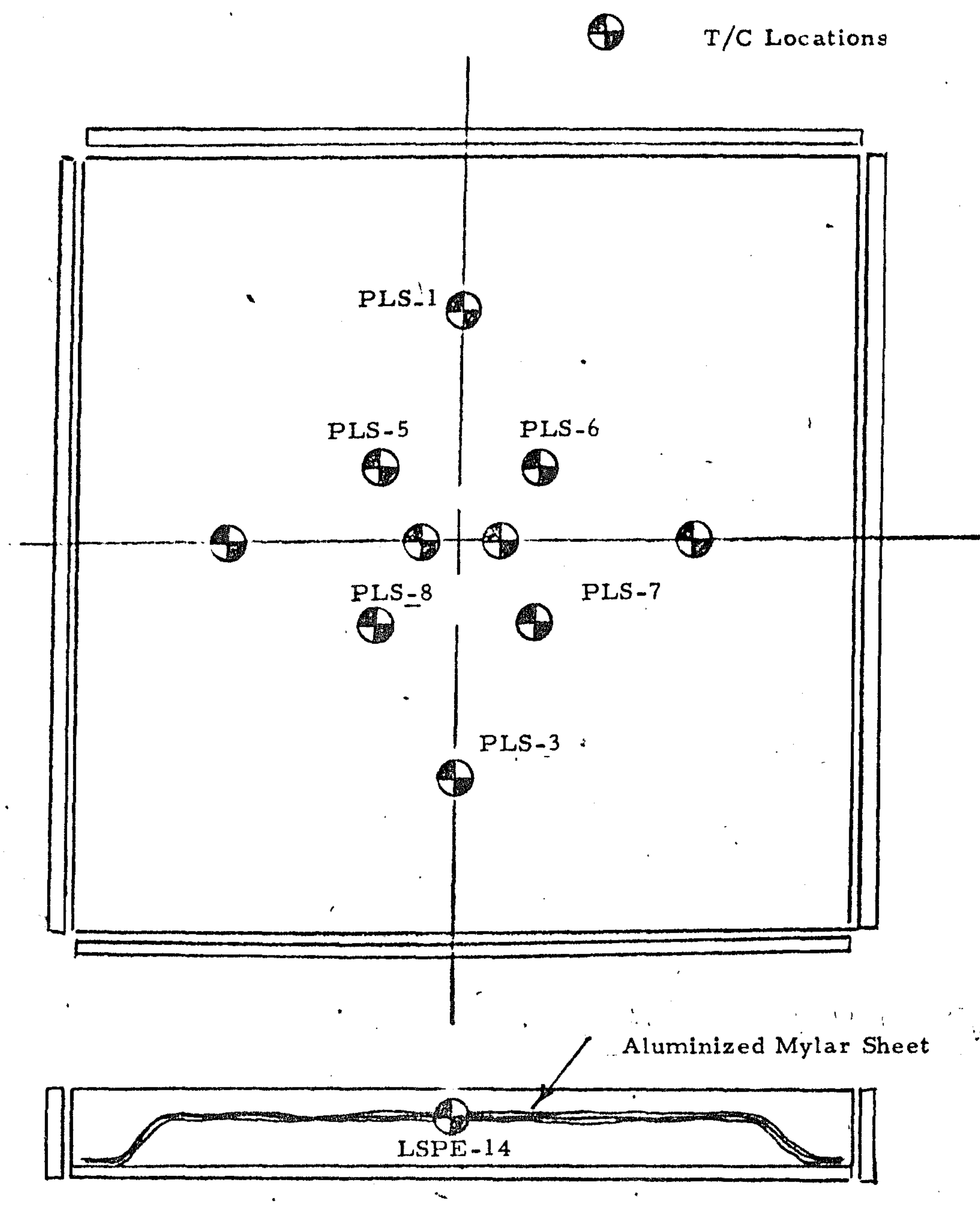
Figure 4.4 Box Shroud Thermocouple Locations





8' Diameter by 4' Height

Figure 4.5 PSE Lunar Surface With Inert Packages - Thermocouple Locations



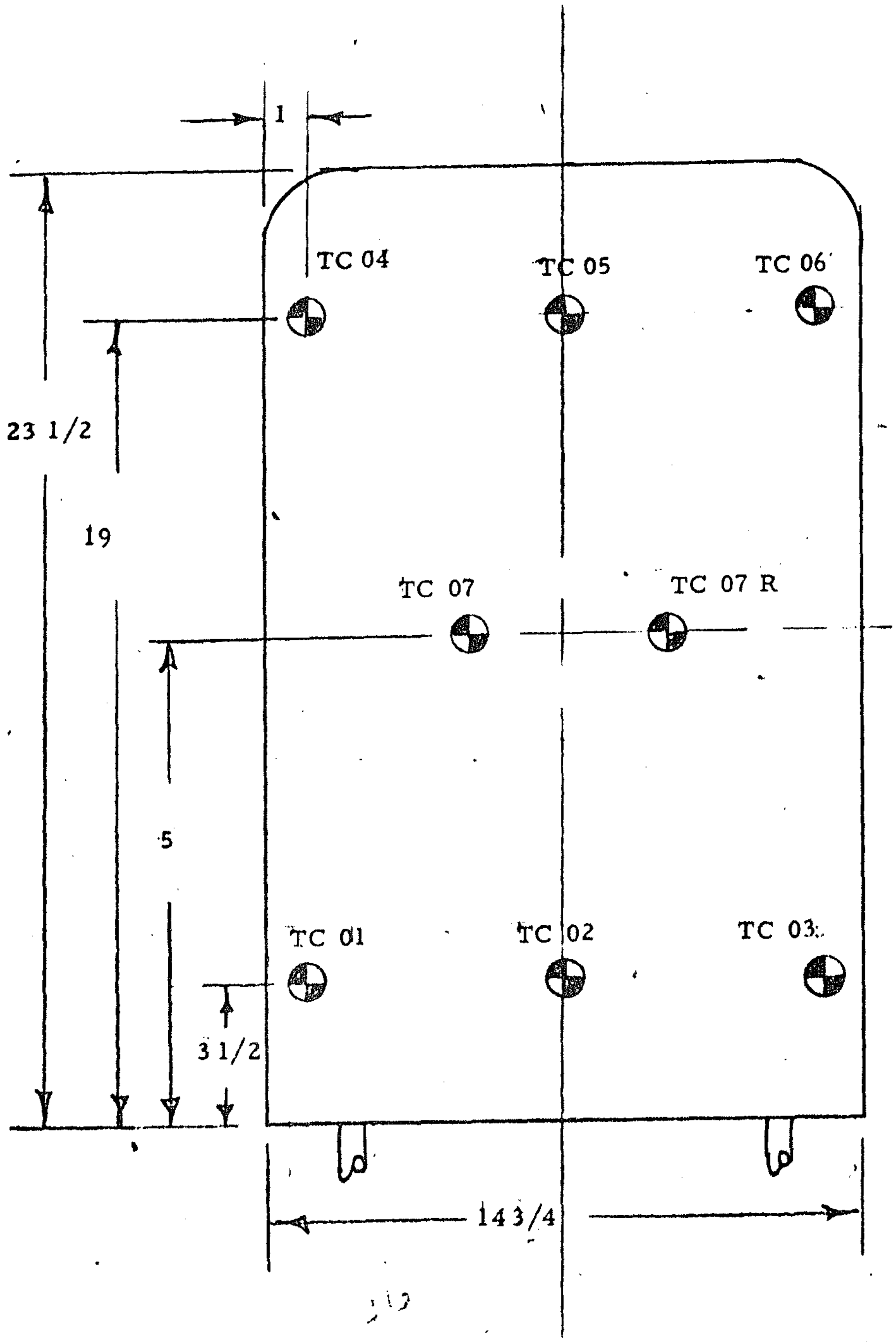


Figure 4.6 NW Lunar Surface (Electronics)

T/C Locations

Note: All Dimensions in Inches

Figure 4.7 High Explosive Baseplate Assembly With Thermocouple Locations

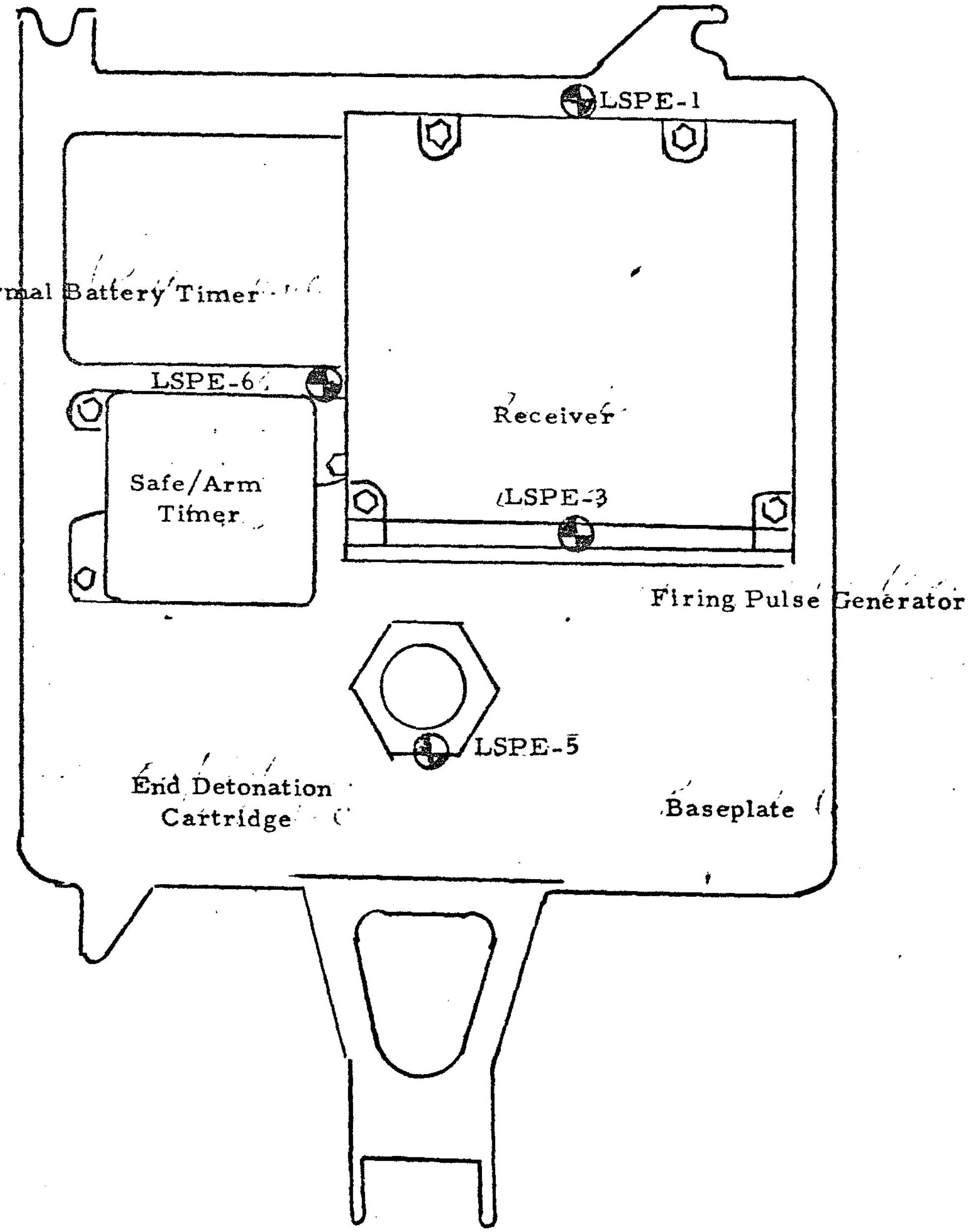
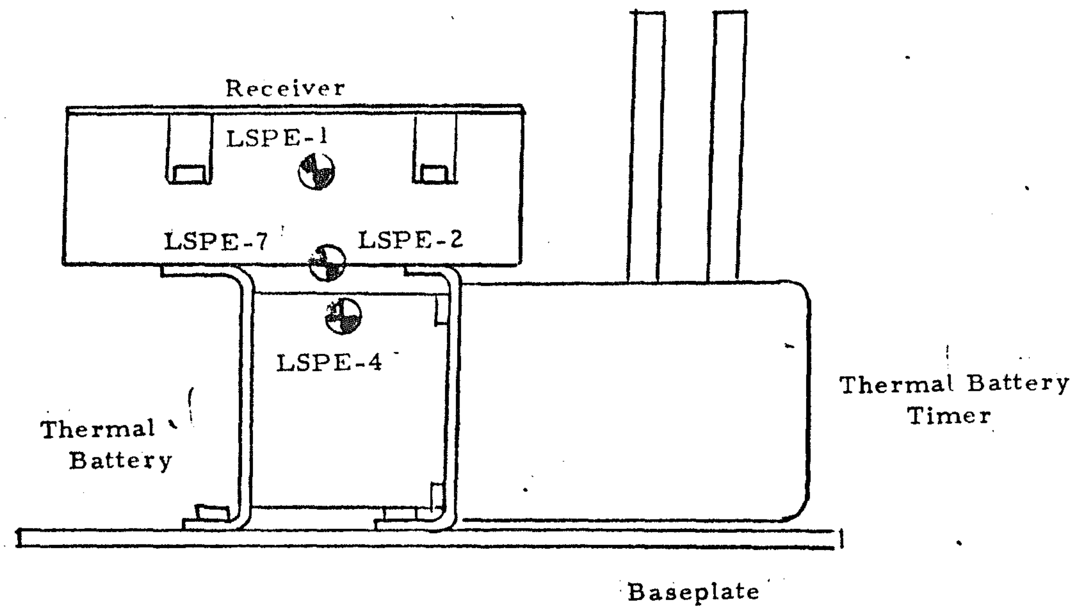
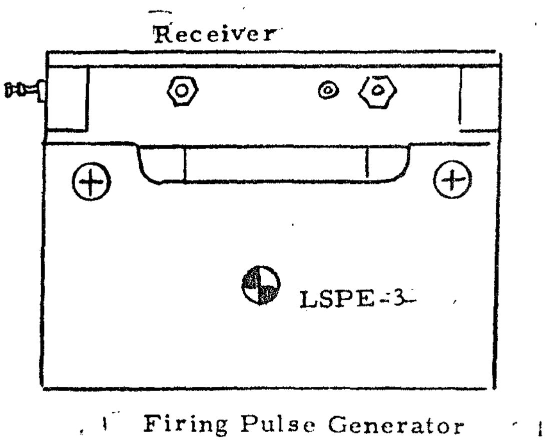


Figure 4.8 High Explosive Package Thermocouple Locations





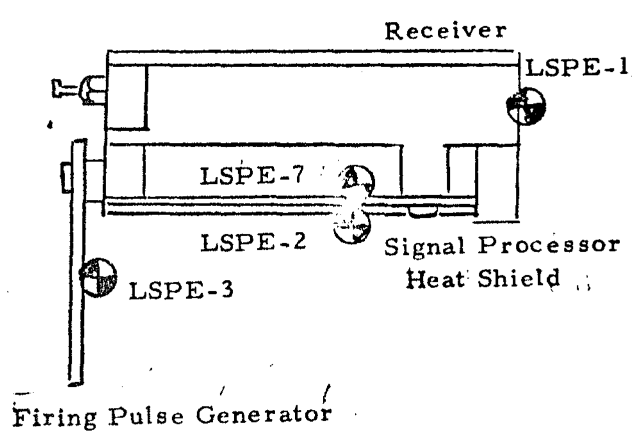
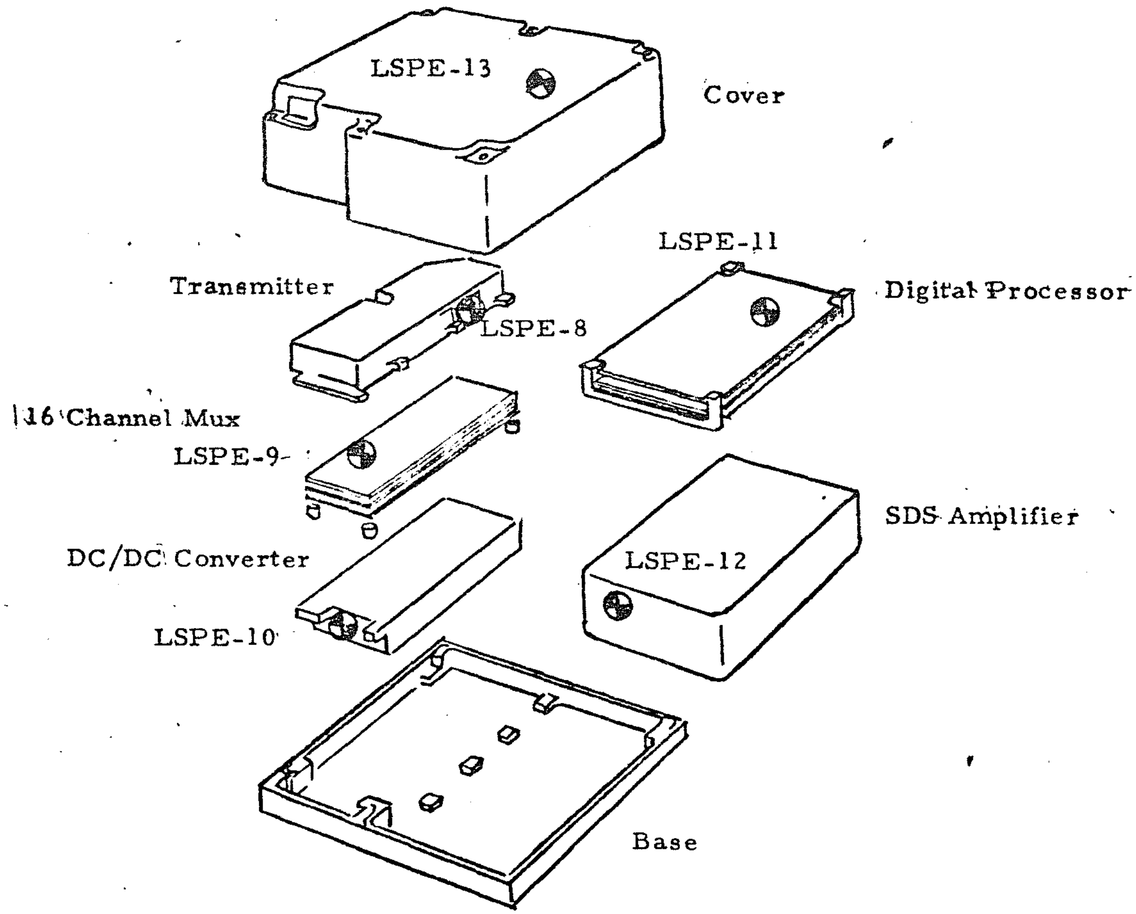


Figure 4.9 Central Station Electronics Thermocouple Locations



5.0 RESULTS AND DISCUSSION

5.1 Factors Affecting Correlation of the Analytical Model with Test Data

5.1.1 Lunar Surface and Coldwall to Experiment View Factors (Explosive Package)

The finite dimensions of the lunar surface simulator and box shroud results in experiment view factors differeing from those view factors experienced on the actual lunar surface. View factors to the lunar surface simulator and box shroud are indicated in Table 5.1. Utilizing these values provides an accurate model of DVT setup.

Conditions of radiant exchange taking place between the package and the lunar surface are subject to considerable error when the view factor to the lunar surface and cold wall varies from actual conditions. Condition 1 for example, subjected to the lunar surface simulation indicated in Table 4.1, results in a +27°F high explosive baseplate temperature, whereas, the same package located on the infinite plane would have attained +35°F. This sensitivity is inherent on all vertical radiating surfaces and will be present on flight hardware. This test should point out the dependence of the high explosive package on its local environment.

5.1.2 Absorptance of 3M-401-A10 White Coating (Explosive Package)

Heat absorbed on the white coated surfaces including the top of the electronics cover and the baseplate handle extension, exceeds that of actual solar irradiation. The white coating tends to absorb a higher percent of incident energy in the long wavelength spectrum (infrared). Since quartz lamps emit both visible and infrared the total effective absorbtance increases from 0.25 to 0.42.

This phenomenon has little effect on the insulated electronics cover, however, increased absorbtion on the baseplate handle extension increases the baseplate temperature 1.5°F during the critical solar angle condition.

5.1.3 Power Dissipation (Central Electronics)

The total power dissipation assumed for the central electronics math model correlation study was 4.63 watts. Component breakdown was as indicated in Table 5.2.

TABLE 5.1

EXPERIMENT VIEW FACTORS

Surface	Lunar Surface Simulator	Lunar Surface	Cold Wall	Space
Electronics Case (Top)	0.0	0.0	1.0	1.0
Electronics Case (White Stripe)	0.472	0.5	0.528	0.5
Electronics Case (Black Stripe)	0.478	0.5	0.522	0.5
High Explosive Case	0.486	0.5	0.514	0.5

TABLE 5.2

PROTOTYPE CENTRAL ELECTRONICS POWER DISSIPATION

Transmitter	0.475 watts
Digital Processor	1.165 watts
SDS Amplifier	0.745 watts
16 Channel Mux	0.487 watts
DC/DC Converter	1.760 watts

5.1.4 Antenna Cable Heat Leak (Central Electronics)

Examination of the correlated test data in Table 5.5 indicates a discrepancy in the transmitter housing and MUX board temperatures in comparison to the analysis. This occurs for the hot and cold functionals but not the ambient condition. This discrepancy is attributed to heat leak through the antenna coax cable which couples directly to the transmitter housing. Since the transmitter heat sinks to the 16 channel MUX, this cable also effects the MUX board temperatures. Correlation was accurate during the ambient test since the entire cable was at the same temperature as the controlled temperature of the LSPE thermal plate.

This discrepancy will not effect flight hardware since this heat leak will be eliminated. The prototype antenna cable was connected directly to the transmitting antenna exposing the coax cable directly to the environment. When the LSPE is mated with ALSEP, the cable will be connected to the ALSEP bulkhead providing a barrier to heat leak.

5.2 Graphical Summary of Results

5.2.1 Inert H.E. Package Temperature Profile (Figure 5.1)

Figure 5.1 is a profile of the temperature excursion of the 10 "inert" prototype high explosive package. Minimum and maximum temperatures imposed were +33°F and +190°F.

5.2.2 Simulator Environment (Figure 5.2)

Figure 5.2 indicates the lunar simulator environment which the 1/8# high explosive package was subjected to. This includes both the coldwall and lunar surface simulator temperature.

5.2.3 1/8# High Explosive Baseplate Temperatures (Figures 5.3 and 5.4)

Figures 5.3 and 5.4 included thermocouples located on seven components mounted on the high explosive package baseplate. The temperature excursion included a bracketing of the operating specification temperatures, +25° and +185°F; also three intermediate temperatures, 142°, 163° and 166°F. These simulate solar angles of 26 degrees, 45 degrees and 60 degrees.

Figure 5.1

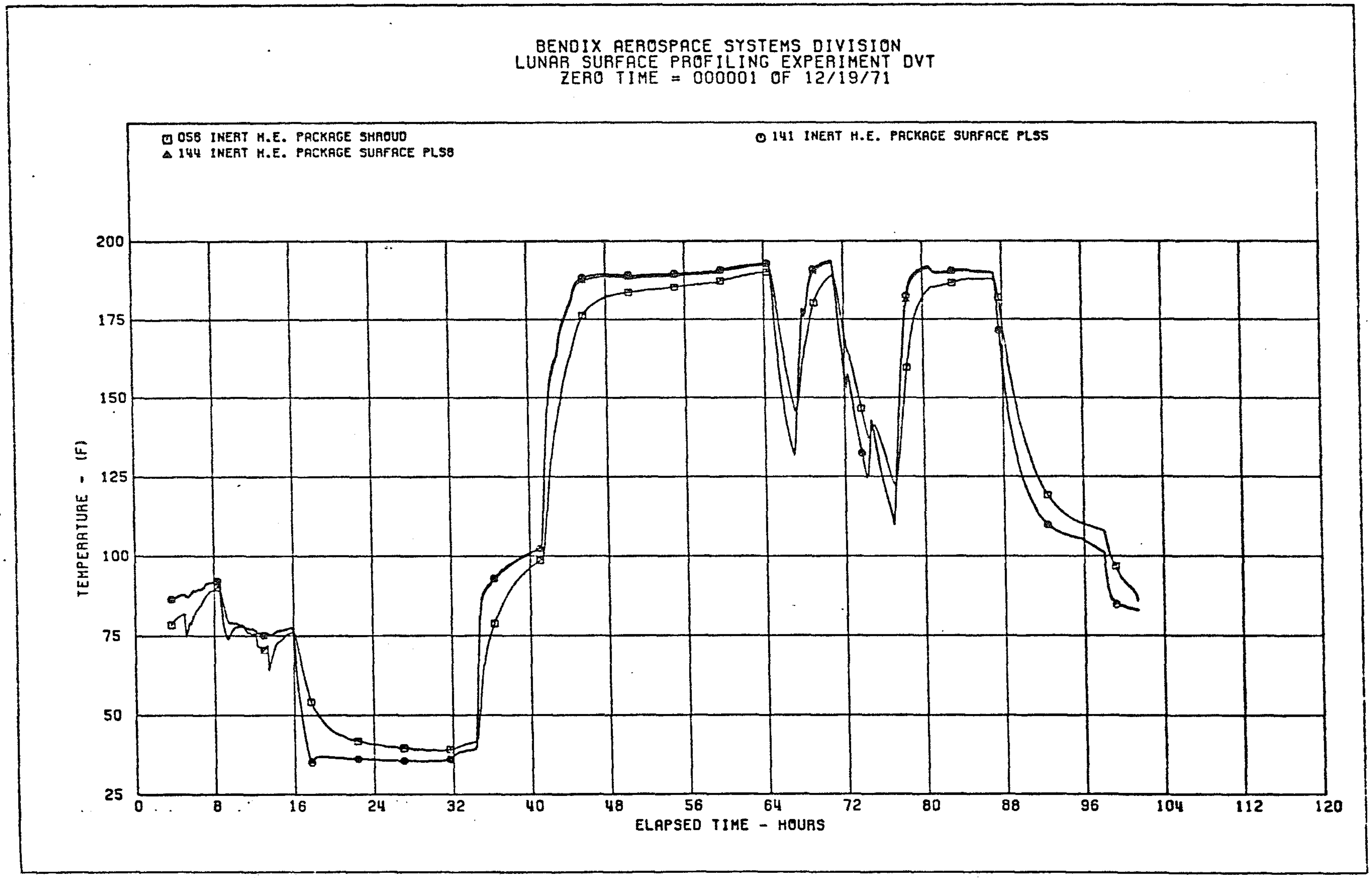

BENDIX AEROSPACE SYSTEMS DIVISION
LUNAR SURFACE PROFILING EXPERIMENT DVT
ZERO TIME = 000001 OF 12/19/71
056 INERT H.E. PACKAGE SHROUD
144 INERT H.E. PACKAGE SURFACE PLS8
141 INERT H.E. PACKAGE SURFACE PLS5
TEMPERATURE - (F)
ELAPSED TIME - HOURS
200
175
150
125
100
75
50
25
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120

Figure 5.2

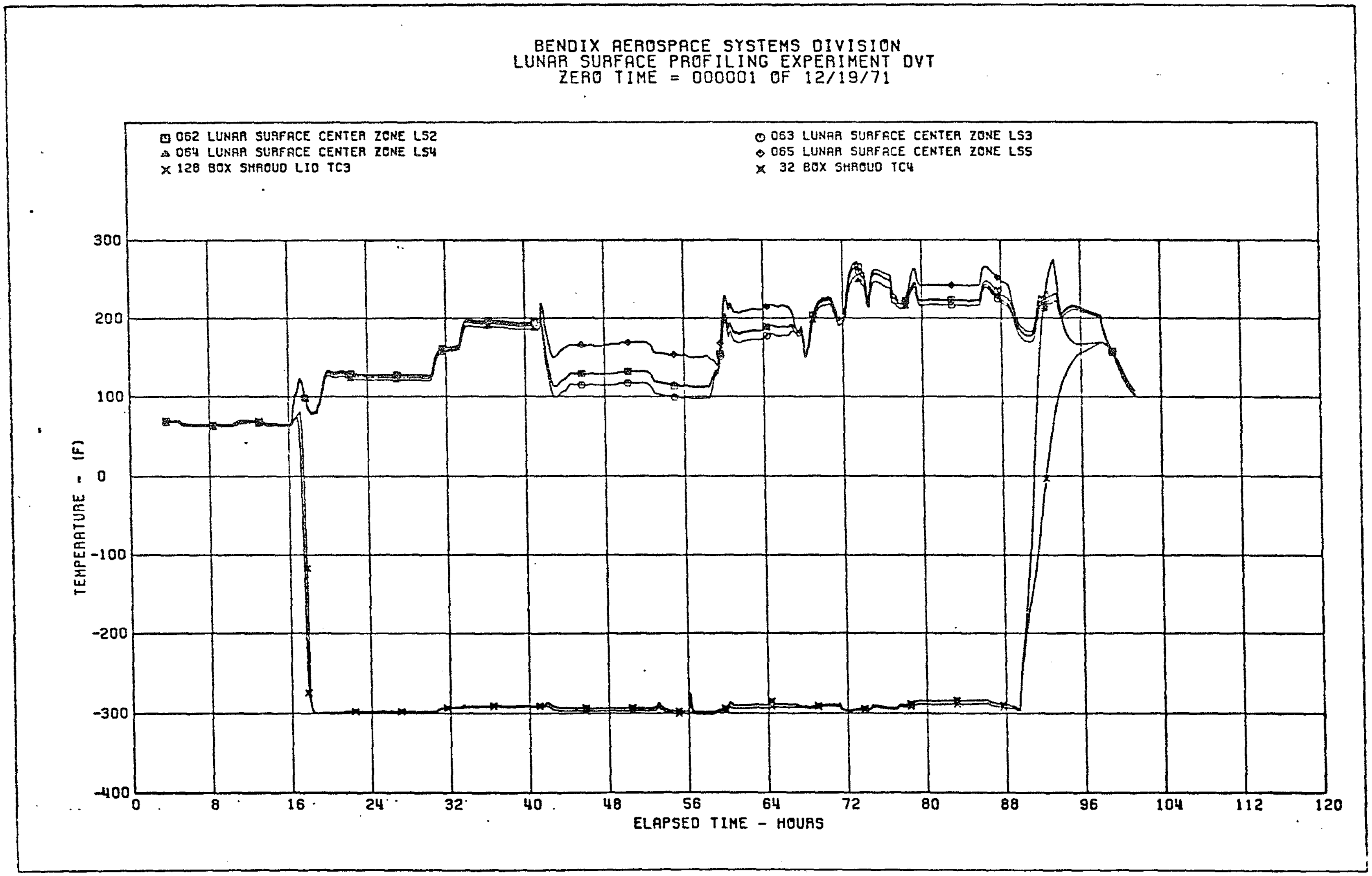

BENDIX AEROSPACE SYSTEMS DIVISION
LUNAR SURFACE PROFILING EXPERIMENT DVT
ZERO TIME = 000001 OF 12/19/71
062 LUNAR SURFACE CENTER ZONE LS2
063 LUNAR SURFACE CENTER ZONE LS3
064 LUNAR SURFACE CENTER ZONE LS4
065 LUNAR SURFACE CENTER ZONE LS5
128 BOX SHROUD LID TC3
32 BOX SHROUD TC4
TEMPERATURE - (F)
300
200
100
0
-100
-200
-300
-400
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
ELAPSED TIME - HOURS

Figure 5.3

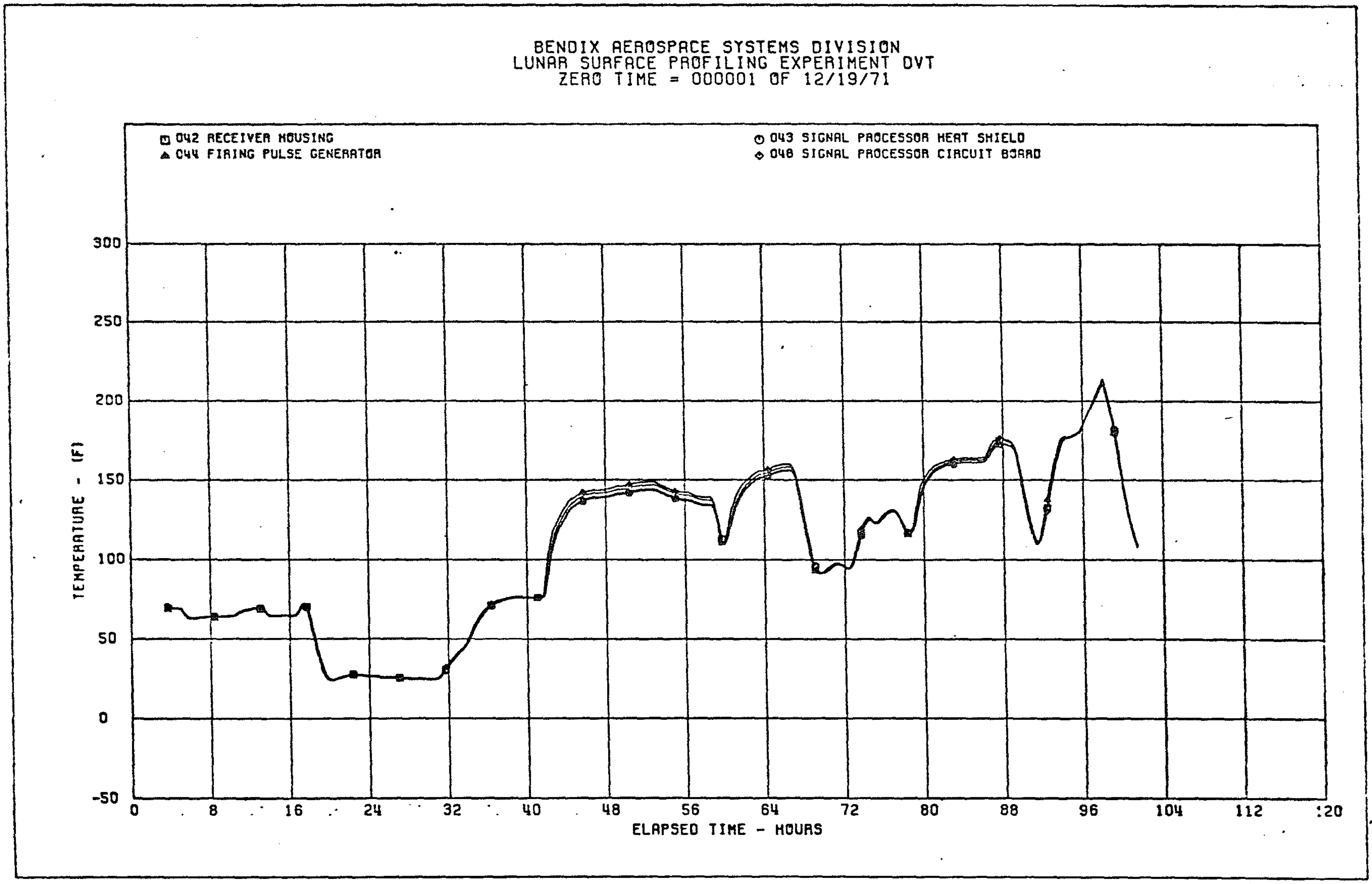
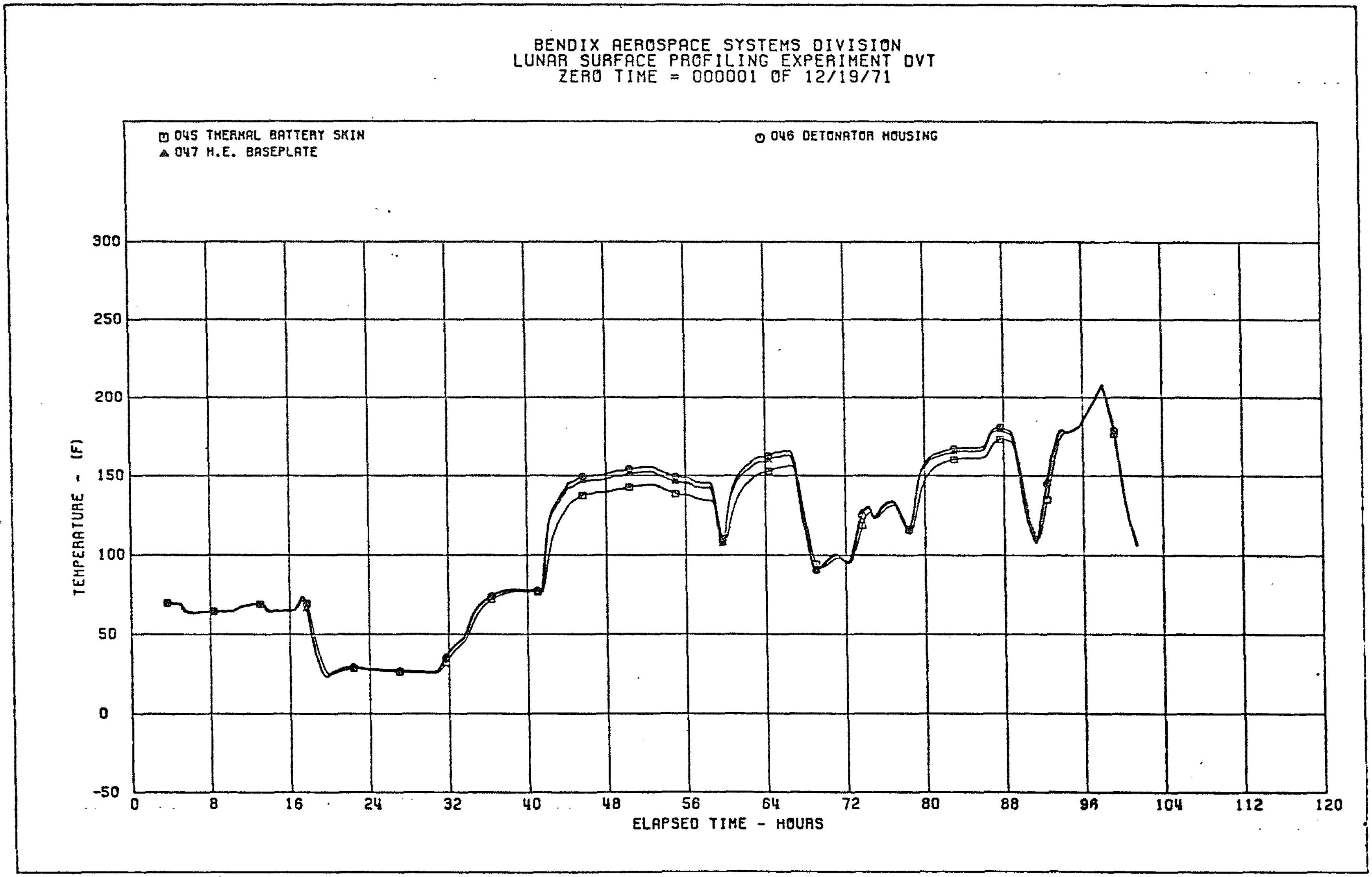

BENDIX AEROSPACE SYSTEMS DIVISION
LUNAR SURFACE PROFILING EXPERIMENT DVT
ZERO TIME = 000001 OF 12/19/71
042 RECEIVER HOUSING
044 FIRING PULSE GENERATOR
043 SIGNAL PROCESSOR HEAT SHIELD
048 SIGNAL PROCESSOR CIRCUIT BOARD
TEMPERATURE - (F)
300
250
200
150
100
50
0
-50
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
ELAPSED TIME - HOURS

Figure 5.4


BENDIX AEROSPACE SYSTEMS DIVISION
LUNAR SURFACE PROFILING EXPERIMENT DVT
ZERO TIME = 000001 OF 12/19/71
045 THERMAL BATTERY SKIN
047 H.E. BASEPLATE
046 DETONATOR HOUSING
TEMPERATURE - (F)
300
250
200
150
100
50
0
-50
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
ELAPSED TIME - HOURS

Note that the maximum gradient within the package occurs during the 26 degree solar angle. This 9°F gradient occurs when one side of the package receives direct sunlight.

The spike which occurs at 98 hours is the result of the thermal battery firing which is subsequent to the lunar mission termination.

5.2.4 Thermal Battery Temperature (Figure 5.5)

Figure 5.5 indicates the thermal battery skin temperature within minutes of the ignition of the battery. Although the DAS was in continuous scan mode, a scan was taken every 15 seconds. Plotting the 15 second data indicates a possible peak occuring between scans which could exceed that plotted in Figure 5.5. This peak could be between 450° and 500°F, however, within 30 seconds the temperature has dropped to 390°F.

5.2.5 H.E. Baseplate Temperatures Subsequent to Battery Firing (Figure 5.6)

Although it is somewhat academic since the explosive charge ignites within seconds of the thermal battery firing, temperature data was recorded for all baseplate components subsequent to the battery firing. The maximum temperature occurs in the receiver housing which is not only mounted atop the thermal battery, it dissipates power seconds before charge ignition. This maximum temperature is 237°F, some 25 minutes after the battery firing.

Note that the signal processor board and aluminized heat shield, which is located 1/8" away from the thermal battery are adequately protected by the heat shield.

Table 5.3 indicates the component temperatures at 30 and 60 seconds subsequent to firing. Component temperatures have increased no more than 1°F within the 30 seconds which is the expected firing time interval.

5.2.6 Central Electronics Temperatures (Figure 5.7 and 5.8)

Figures 5.7 and 5.8 indicate the temperature excursion of the central electronics component thermocouples which are indicated in Figure 4.9. Cold functional occurred at 38 hours, hot functional at 75 hours, and ambient functional at 90 hours into the test.

Figure 5.5

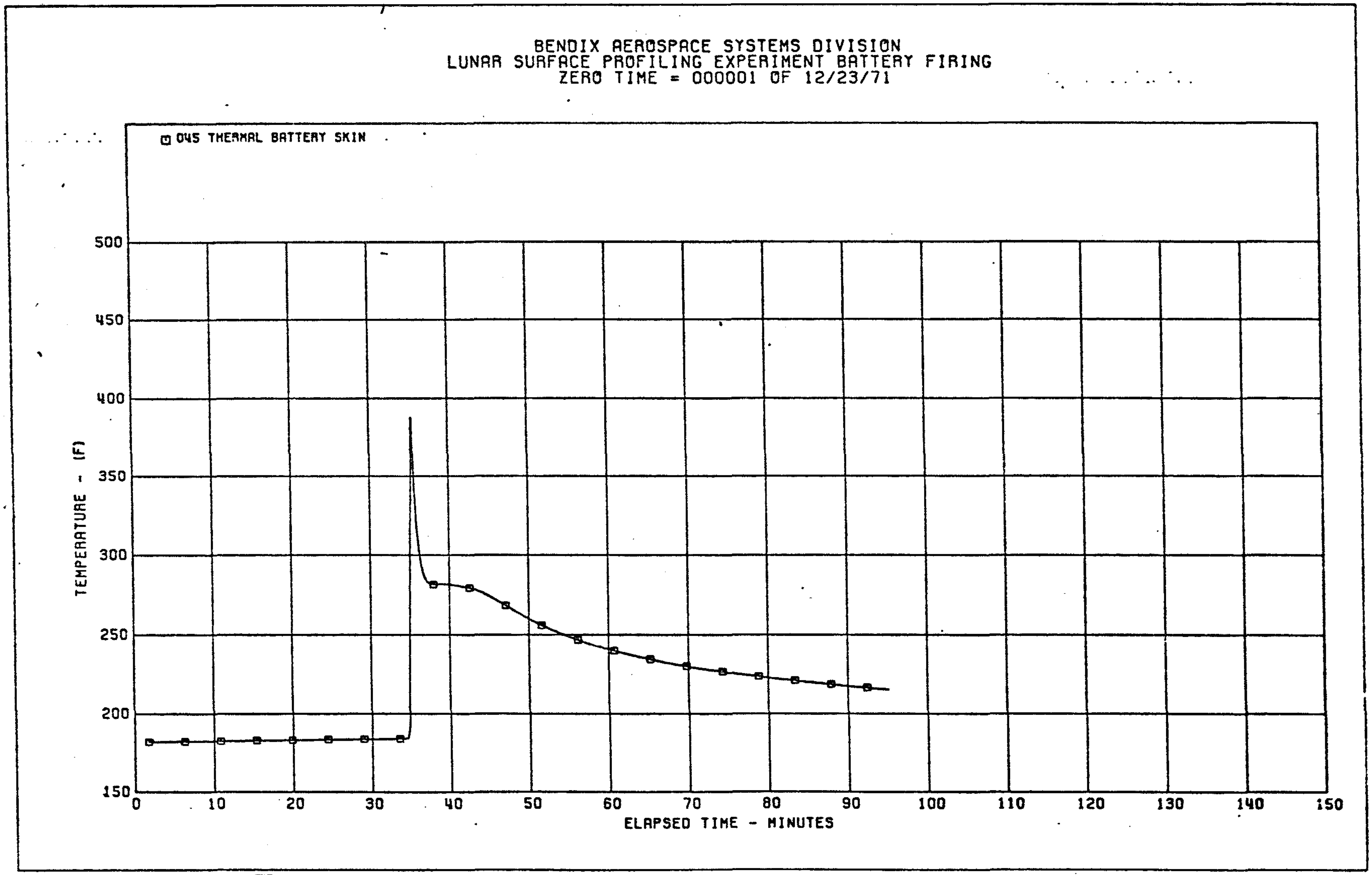

BENDIX AEROSPACE SYSTEMS DIVISION
LUNAR SURFACE PROFILING EXPERIMENT BATTERY FIRING
ZERO TIME = 000001 OF 12/23/71
045 THERMAL BATTERY SKIN
TEMPERATURE - (F)
150
200
250
300
350
400
450
500
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
ELAPSED TIME - MINUTES

Figure 5.6

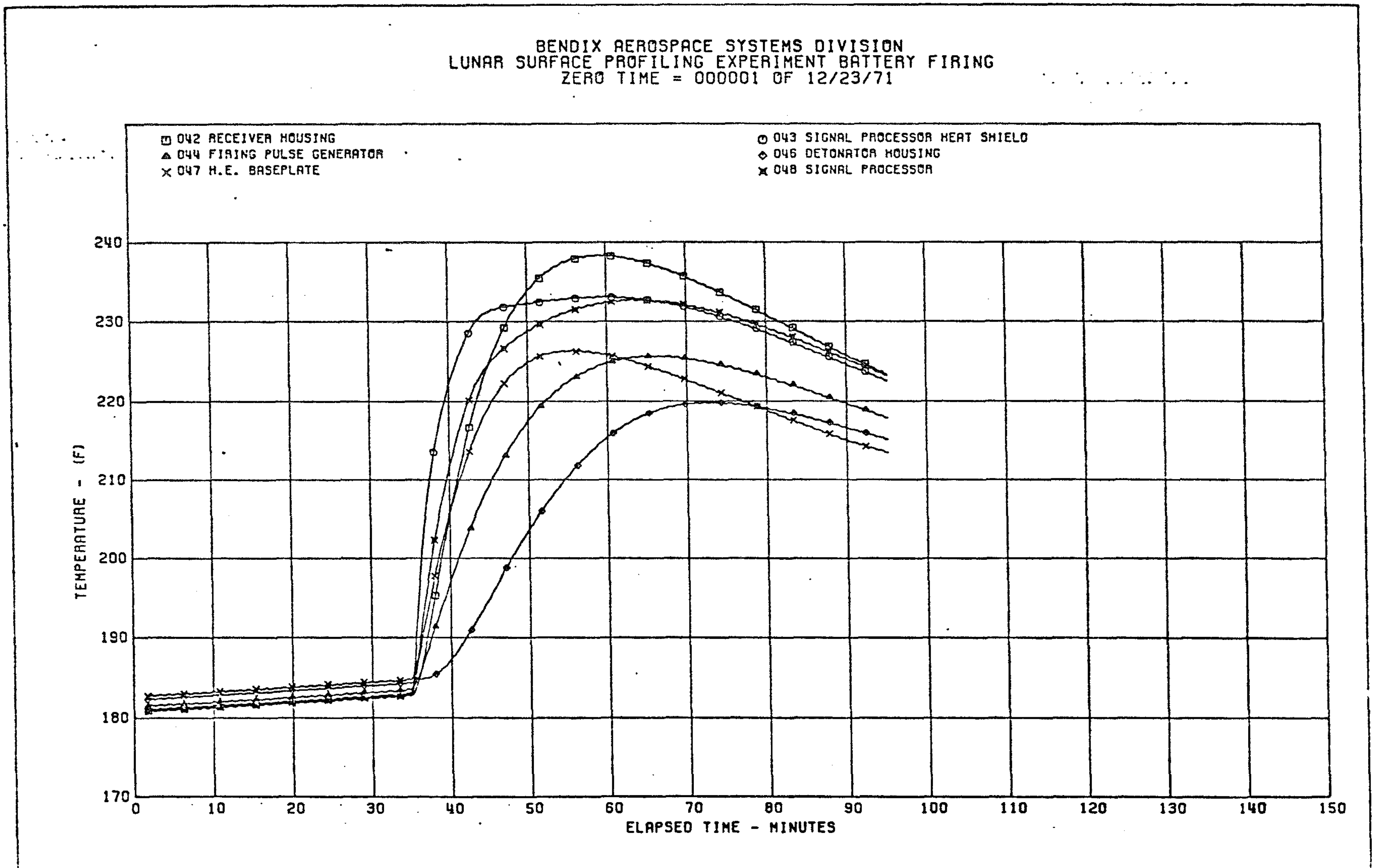

BENDIX AEROSPACE SYSTEMS DIVISION
LUNAR SURFACE PROFILING EXPERIMENT BATTERY FIRING
ZERO TIME = 000001 OF 12/23/71
042 RECEIVER HOUSING
044 FIRING PULSE GENERATOR
047 H.E. BASEPLATE
043 SIGNAL PROCESSOR HEAT SHIELD
046 DETONATOR HOUSING
048 SIGNAL PROCESSOR
TEMPERATURE - (F)
ELAPSED TIME - MINUTES
170
180
190
200
210
220
230
240
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

TABLE 5.3

HIGH EXPLOSIVE BASEPLATE TEMPERATURES SUBSEQUENT TO THERMAL BATTERY FIRING

	Time (Seconds)		
Component	0	30	60
Receiver Housing	183°F	183°F	184°F
Signal Processor Heat Shield	183°	184°	190.5°
Firing Pulse Generator	183°	184°	185°
Thermal Battery	184°	313°	344°
Detonator Housing	184°	185°	185°
Baseplate	185°	185°	187°
Signal Processor Board	183°	184°	186.5°

Figure 5.7

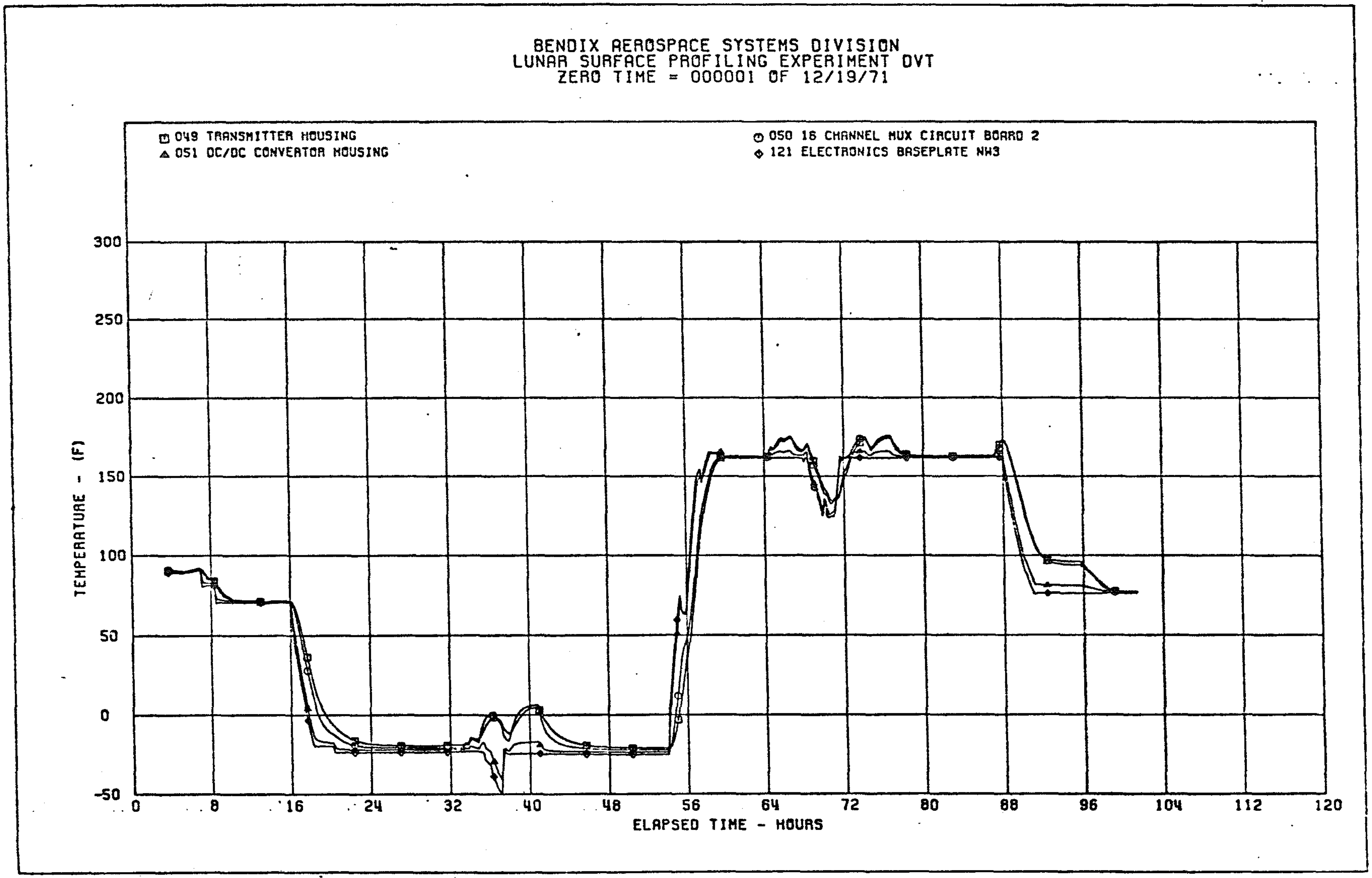
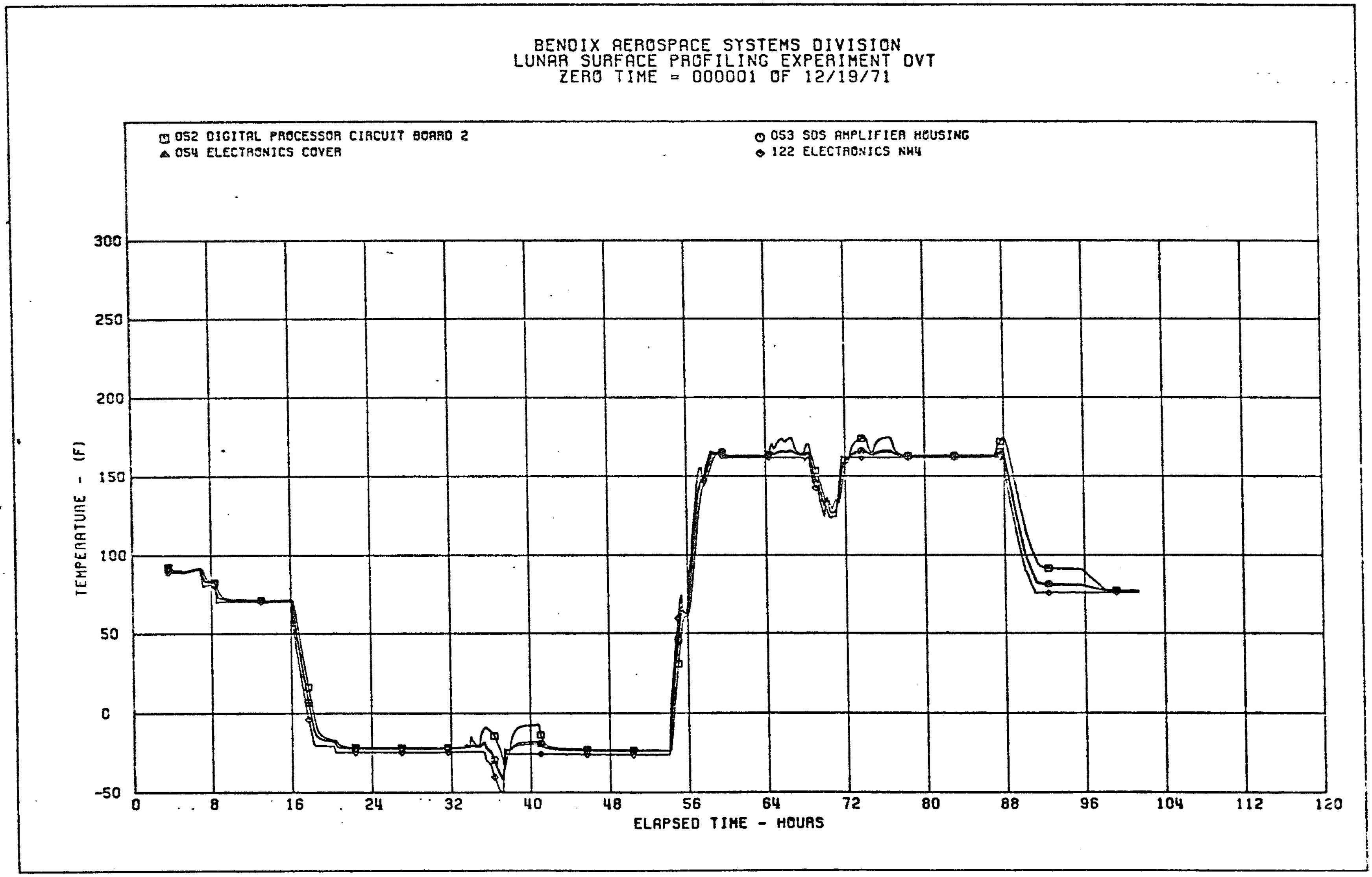

BENDIX AEROSPACE SYSTEMS DIVISION
LUNAR SURFACE PROFILING EXPERIMENT DVT
ZERO TIME = 000001 OF 12/19/71
049 TRANSMITTER HOUSING
051 DC/DC CONVERTOR HOUSING
050 16 CHANNEL MUX CIRCUIT BOARD 2
121 ELECTRONICS BASEPLATE NW3
TEMPERATURE - (F)
300
250
200
150
100
50
0
-50
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
ELAPSED TIME - HOURS

Figure 5.8


BENDIX AEROSPACE SYSTEMS DIVISION
LUNAR SURFACE PROFILING EXPERIMENT DVT
ZERO TIME = 000001 OF 12/19/71
052 DIGITAL PROCESSOR CIRCUIT BOARD 2
054 ELECTRONICS COVER
053 SDS AMPLIFIER HOUSING
122 ELECTRONICS NW4
TEMPERATURE - (F)
300
250
200
150
100
50
0
-50
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
ELAPSED TIME - HOURS

As indicated by the plots, the maximum electronics baseplate to component gradients occur in the transmitter and MUX. This is a result of mounting the transmitter atop the 16 channel MUX which has a poor conduction path to the baseplate. Maximum gradients are as follows: transmitter housing 19°F, 16 channel MUX 21°F, DC/DC converter 6°F, Digital Processor 16°F, and SDS amplifier housing 6°F. These data are taken for the ambient function since this condition eliminates the error due to the coax cable heat leak (See para. 5.1.4).

5.3 Test Data Correlation with Analytical Model (Tables 5.4 and 5.5)

Tables 5.4 and 5.5 summarize the analytical correlation study. The column marked (analytical) in each case is the computer model result of the given condition.

Correlation of the 1/8th high explosive package baseplate was accurate within 2°F of test data. Correlation of the central electronics components were accurate with 3°F for the ambient function, however, errors as much as 11°F were induced as a result of the coax cable heat leak (see para. 5.1.4).

TABLE 5.4

EXPLOSIVE PACKAGE TEST TEMPERATURES

Condition	Lunar Surface	Cold Wall	Receiver Housing	Signal Processor Heat Shield	Firing Pulse Generator	Thermal Battery	Detonator Housing	Baseplate	Signal Processor
	Temperautre °F								
1. (Minimum Operating Spec)[1]	128	-300	25	25	25	26	26	27	25
(Analytical)	128	-300	-	-	-	-	-	28	-
2. (Background)	192	-300	76	76	76	77	78	78	76
(Analytical)	192	-300	-	-	-	-	-	78	-
3. (26° Solar Simulation)	119	-300	137	133	139	134	145	142	134
(Analytical)	119	-300	-	-	-	-	-	141	-
4. (45° Solar Simulation)	192	-300	158	156	160	156	166	163	157
(Analytical)	192	-300	-	-	-	-	-	162	-
5. (60° Solar Simulation)	224	-300	163	161	164	161	168	166	162
(Analytical)	224	-300	-	-	-	-	-	164	-
6. (Maximum Operating Spec)[2]	212	153	183	183	183	184	184	185	183

1 These values were obtained by utilizing the Bendix Thermal Analyzer Computer Program.

2 All surfaces other than the 14' x 14' center zone were ~~cut~~ off during this test.

TABLE 5.5

LSPE CENTRAL-ELECTRONICS TEST TEMPERATURE

Temperature °F

Condition	Baseplate	Transmitter Housing	16 Channel Mux Board	DC/DC Converter Housing	Digital Processor Board	SDS Amplifier Housing	Cover
1. (Cold Functional)	-26	4	5	-18	-7	-18	-19
(Analytical)	-26	-7	-2	-23	-8	-20	-
2. (Hot Functional)	162	175	176	166	175	166	165
(Analytical)	162	181	185	165	180	168	-
3. (Ambient Firing Phase)	75	94	96	81	91	81	80
(Analytical)	75	94	98	78	93	81	-

6.0 CONCLUSIONS

All discrepancies between anticipated temperatures and actual values can be accounted for. These differences are not anticipated during actual lunar operation.

Deployment of the experiment on a lunar surface simulator of larger dimensions is recommended to minimize the discrepancy in the lunar view factor to the package. This is an important consideration in that the experiment's thermal control is significantly affected by its radiant exchange with the local surroundings.

It is further recommended that any additional testing with a test setup similar to the LSPE central electronics include a guard heater or similar provisions to minimize or eliminate heat leak via the coax cable.