DATA CHANGE NOTIFICATION FORM
CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

SNA-8-D-027

VOLUME V PART ____

DATE July 21, 1971

PAGE 1 OF 47

AMENDMENT 9

SHORT TITLE OF CHANGE Specific changes and additions to technical data pertaining to Apollo 15 ALSEP, Array A-2.

CHANGE DESCRIPTION

Insert New or Revised Pages as Follows:

D-2-4	D-2-15	D-3-24	D-3-26	D-3-28	D-3-29
D-3-30	D-3-31	D-3-32	D-3-33	D-3-34	D-3-34.1
D-3-35	D-3-36	D-3-37	D-3-74	D-3-77	D-3-78
D-3-82	D-3-83	D-3-84	D-3-84.1	D-3-86.1	D-3-86.2
D-4-1	D-4-3	D-4-3.1	D-4-13	D-5-8	D-5-22
D-5-24.					

NA
CONTRACTOR SUBSYSTEM APPROVAL

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CONTRACTOR MANAGEMENT APPROVAL

PHONE ____

NASA COMMENTS

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CHANGE AUTHORITY PD4 EXT

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ASPO APPROVAL, J. R. SEVIER, CHIEF, OPERATIONS ANALYSIS BR.

DATE 7/20/71

MSC FORM 1794 (AUG 69) REV 2

REVISIONS

REV.	AMEND. NO.	DESCRIPTION	DATE	APPROVAL
	7	Insert revised pages C-3-41, C-3-52, C-4-19, C-4-20, C-5-11, C-5-12, C-5-13	1/25/71	MOB
	8	Add Appendix D for Apollo 15 ALSEP, Array A-2	6/1/71	OAB
	9	Insert new or revised pages D-2-4, D-2-15, D-3-24, D-3-26, D-3-28, D-3-29, D-3-30, D-3-31, D-3-32, D-3-33, D-3-34, D-3-34.1, D-3-35, D-3-36, D-3-37, D-3-74, D-3-77, D-3-78, D-3-82, D-3-83, D-3-84, D-3-84.1, D-3-86.1, D-3-86.2, D-4-1, D-4-3, D-4-3.1, D-4-13, D-5-8, D-5-22, and D-5-24.	7/21/71	OAB

TABLE 2-2

MAJOR COMPONENTS OF ARRAY A-2

Major Components	Part No.	Serial No.
Passive Seismometer		
- Sensor/Shroud Assembly	2348460-8	1
- Stool	2344723	7
Lunar Surface Magnetometer	2330657	7
Solar Wind Spectrometer	2330658	7
SIDE/CCIG	2338104	7
Heat Flow Experiment	2345430-101	6
Laser Ranging Retro-Reflector	2347200-501	4
DTREM II Sensor	2341440	10
Fuel Cask, Mounting	2338660	6
Radioisotope Thermoelectric Generator	6320006	MOD 13
Central Station		
- PSE Electronics	2334670	7
- Central Electronics	2344957-1	8
- Antenna	2330307	11

TABLE 2-3

ALSEP ARRAY A-2 PHYSICAL CHARACTERISTICS

SUBPACKAGE NO. 1	
Dimensions:	25.2" x 27.1" x 21.6"
Weight:	124.86 pounds
SUBPACKAGE NO. 2	
Dimensions:	25.2" x 27.3" x 21.6"
Weight:	104.77 pounds
EQUIPMENT EXTERNAL TO LM	
RTG Fuel Capsule, Cask and Mounting - Weight:	58.7 pounds
LRRR - Dimensions:	25.6" x 27.5" x 13.7"
- Weight:	79.83 pounds
TOTAL ALSEP WEIGHT (Including LRRR):	368.16 pounds

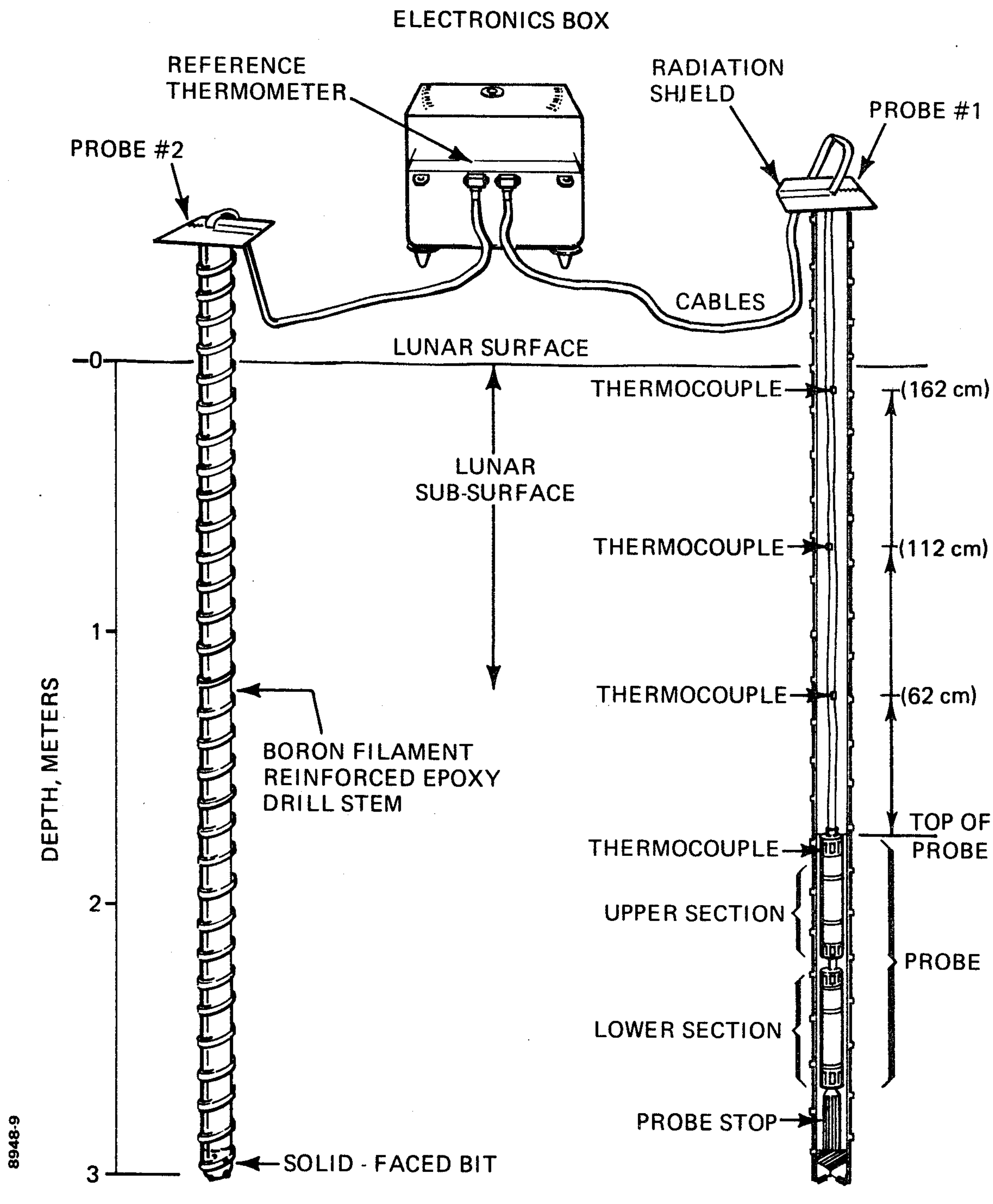

Figure 2-9 Heat Flow Experiment Deployed Configuration

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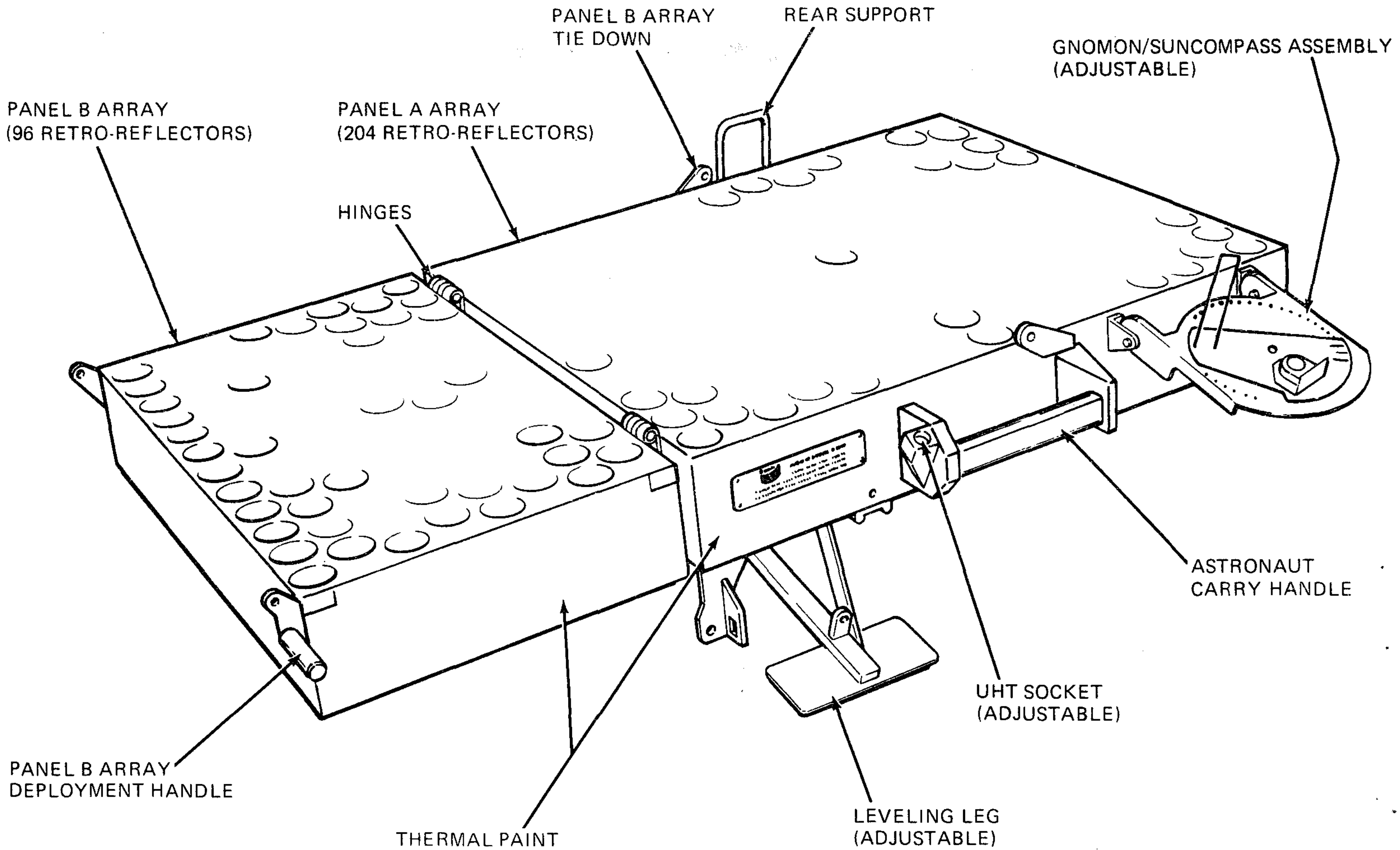

Figure 2-10 Laser Ranging Retro-Reflector Deployed Configuration

TABLE 3.1-11

HEAT FLOW EXPERIMENT (HFE) DEPLOYMENT CONSTRAINTS

Parameter	Constraints
Site Selection	HFE electronics shall be placed 25 to 30 feet north of Central Station (as limited by a 30-foot cable) in an area generally flat and free from debris particularly on the north side.
Alignment	HFE electronics thermal radiator (open side) shall face north (away from the Central Station). Alignment is accomplished when the shadow of the UHT in its socket falls across the alignment decal (see Figure 3.1-9). This decal location assumes a shadow angle of 10.7° at time of deployment. HFE probes shall be placed in holes 15 to 19 feet from the electronics as shown in Figure 3.1-1. It is important that the probes be located at least 17 feet from all other experiments and at least 40 feet from the RTG. The probe cables must not be crossed.
Leveling	HFE electronics shall be leveled within 5° by ensuring that the bubble is free of the case circle. The holes in which the probes are inserted shall be vertical to within 15° as determined during drilling by the level indicator on the Lunar Surface Drill.

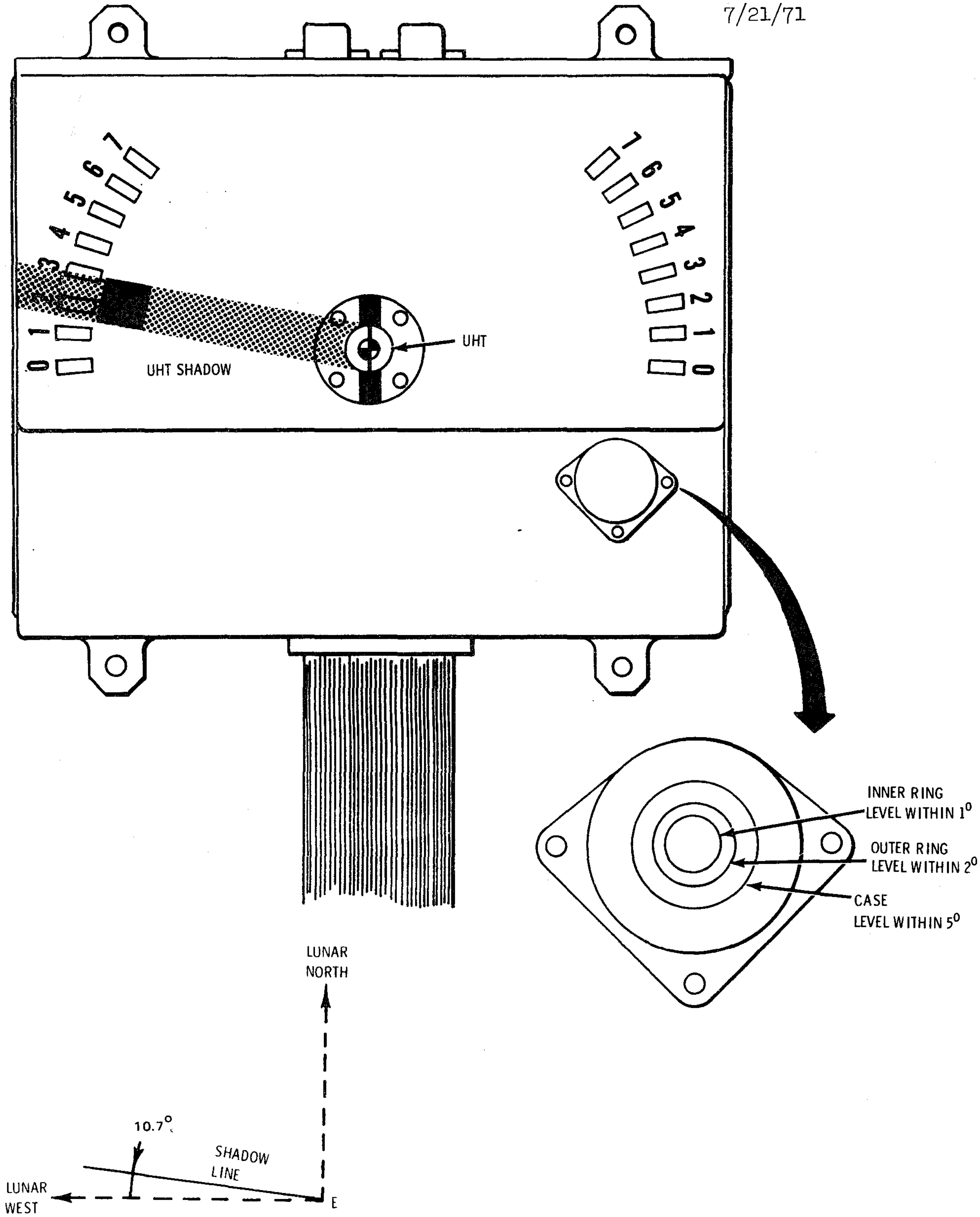

Figure 3.1-9 Heat Flow Electronics Leveling and Alignment

TABLE 3.1-12

LRRR DEPLOYMENT CONSTRAINTS

Parameter	Constraints
Site Selection	LRRR must be deployed a minimum of 300 feet west of LM. A separation from LM of greater than 500 feet is requested to minimize the optical degradation caused by dust fallout following LM ascent.
Alignment	Ensure that the shadowgraph is properly deployed. Alignment is accomplished when the shadow of the gnomon falls across the center alignment mark on the shadowgraph (see Figure 3.1-10). This alignment mark has been established assuming a shadow angle of 10.7° at the time of deployment. If the actual deployment time differs from nominal by more than 8 hours, a contingency setting will be required.
Leveling	Adjust the level of LRRR until the bubble is free of the case ring (5°) as shown in Figure 3.1-10.

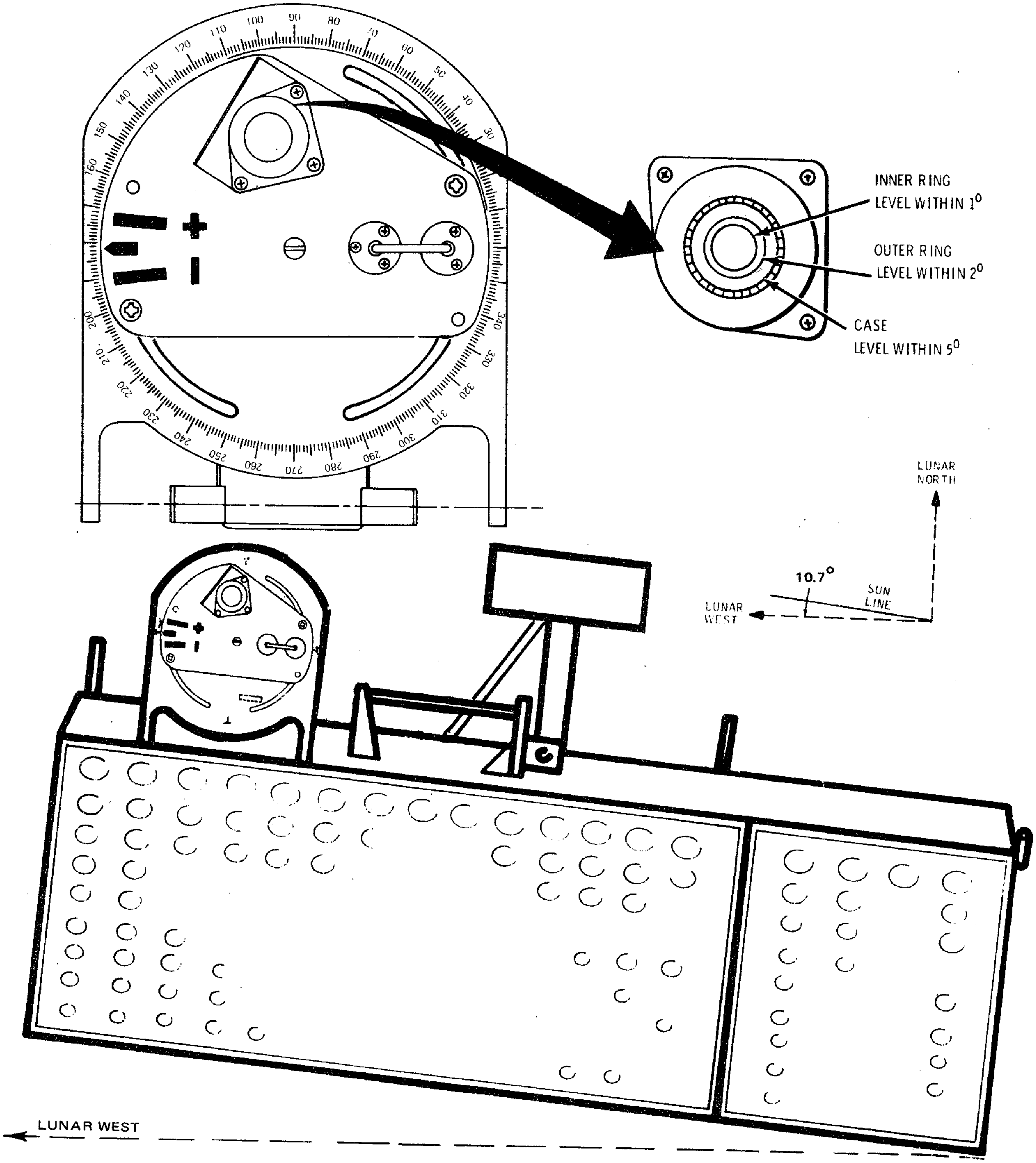

Figure 3.1-10 Laser Ranging Retro-Reflector (LRRR)
Leveling and Alignment

3.2 CENTRAL STATION OPERATIONAL DATA

Seventy-six engineering parameters provide information on the status and performance of the Central Station and the Radioisotope Thermoelectric Generator (RTG). These can be classified as follows:

Central Station

. 13 structure temperatures	Table 3.2-1
. 19 module temperatures	Table 3.2-2
. 23 electrical parameters	Table 3.2-3
. 13 configuration status	Table 3.2-5
. 6 DTREM	Section 3.9
2 RTG Temperatures	Table 3.2-4

Not included in the above list of parameters or in the discussion which follows are data on certain downlink characteristics available only on special request from the MSFN receiving station, namely:

- received signal strength
- command verification word content
- downlink carrier frequency

The range of values expected for each Central Station parameter during normal lunar surface operations is given in Tables 3.2-1 through 3.2-3.

TABLE 3.2-1

STRUCTURAL TEMPERATURE DATA

Meas. No.	Frame	DESCRIPTION	Normal Oper. Range (°F)		Nominal (Refce Fig.)	Red-Line Limits (4) (°F)	
			Low	High		Low	High
AT-1	27	Sunshield (No. 1)	-300	+160	3.2-1	-350 (M)	+304 (M)
AT-2	42	Sunshield (No. 2)	-300	+160	3.2-1	-350 (M)	+304 (M)
AT-3	4	Thermal Plate (No. 1)	+1	+118	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-4	28	Thermal Plate (No. 2)	-3	+115	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-5	43	Thermal Plate (No. 3)	-8	+129	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-6	58	Thermal Plate (No. 4)	+2	+135	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-7	71	Thermal Plate (No. 5)	+8	+124	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-8	59	Primary Structure No. 1 (East)	-210	+200	3.2-3	-350 (M)	+304 (M)
AT-9	87	Primary Structure No. 2 (West)	-210	+200	3.2-3	-350 (M)	+304 (M)
AT-10	15	Primary Structure No. 3 (Bottom)	-210	+160	3.2-4	-350 (M)	+304 (M)
AT-11	88	Power Dump Module	-215	+270	3.2-4a	-350 (M)	+304 (M)
AT-12	60	Insulation (Inner)	-12	+115	3.2-2	-350 (M)	+304 (M)
AT-13	72	Insulation (Outer)	-160	+150	3.2-3	-350 (M)	+304 (M)

Note 4: Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit.
See Section 4.3

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TABLE 3. 2-2(a)

ELECTRONIC MODULE TEMPERATURE DATA

Meas. No.	Frame	DESCRIPTION	Normal Oper. Range (°F)		Nominal (Ref^ce. Fig.)	Red-Line Limits (4) (°F)	
			Low	High		Low	High
AT-21	16	Receiver A Crystal	+10	+135	3. 2-2	-22 (M)	+180 (M)
AT-22	17	Receiver B Crystal	+10	+135	3. 2-2	-22 (M)	+180 (M)
AT-23	18	Transmitter A Crystal	+10	+135	3. 2-2	-10 (T) -50 (M)	+158 (T) +190 (M)
AT-24	19	Transmitter A Heat Sink	+10	+135	3. 2-2	-10 (T) -50 (M)	+158 (T) +190 (M)
AT-25	31	Transmitter B Crystal	+10	+135	3. 2-2	-10 (T) -50 (M)	+158 (T) +190 (M)
AT-26	32	Transmitter B Heat Sink	+10	+135	3. 2-2	-10 (T) -50 (M)	+158 (T) +190 (M)
AT-27	33	Analog Data Processor (Base)	0	+125	3. 2-2	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-28	34	Analog Data Processor (Internal)	0	+150	3. 2-2	-10 (T) -40 (M)	+170 (T) +205 (M)
AT-29	46	Digital Data Processor (Base)	0	+125	3. 2-2	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-30	47	Digital Data Processor (Internal)	+5	+135	3. 2-2	-10 (T) -40 (M)	+170 (T) +205 (M)

Note 4: Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit.
See Section 4. 3

TABLE 3.2-2(b)

ELECTRONIC MODULE TEMPERATURE DATA

Meas. No.	Frame	DESCRIPTION	Normal Oper. Range (°F)		Nominal (Ref^ce Fig.)	Red-Line Limits (4) (°F)	
			Low	High		Low	High
AT-31	48	Command Decoder (Base)	0	+125	3.2-2	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-32	49	Command Decoder (Internal)	0	+125	3.2-2	-10 (T) -40 (M)	+160 (T) +205 (M)
AT-33	61	Command Demodulator	+5	+130	3.2-2	-10 (T) -40 (M)	+160 (T) +205 (M)
AT-34	62	Power Distr. Unit (Base)	0	+130	3.2-2	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-35	63	Power Distr. Unit (Internal)	+35	+155	3.2-2*	-10 (T) -40 (M)	+160 (T) +205 (M)
AT-36	64	PCU 1 (Oscillator)	+10	+145	3.2-2*	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-37	76	PCU 2 (Oscillator)	+10	+145	3.2-2*	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-38	77	PCU 1 (Regulator)	+10	+180	3.2-2**	-10 (T) -40 (M)	+190 (T) +205 (M)
AT-39	78	PCU 2 (Regulator)	+10	+180	3.2-2**	-10 (T) -40 (M)	+190 (T) +205 (M)

Note 4: Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit. See Section 4.3

*Add 35°F to value in Fig. 3.2-2.
**Add 70°F to value in Fig. 3.2-2.

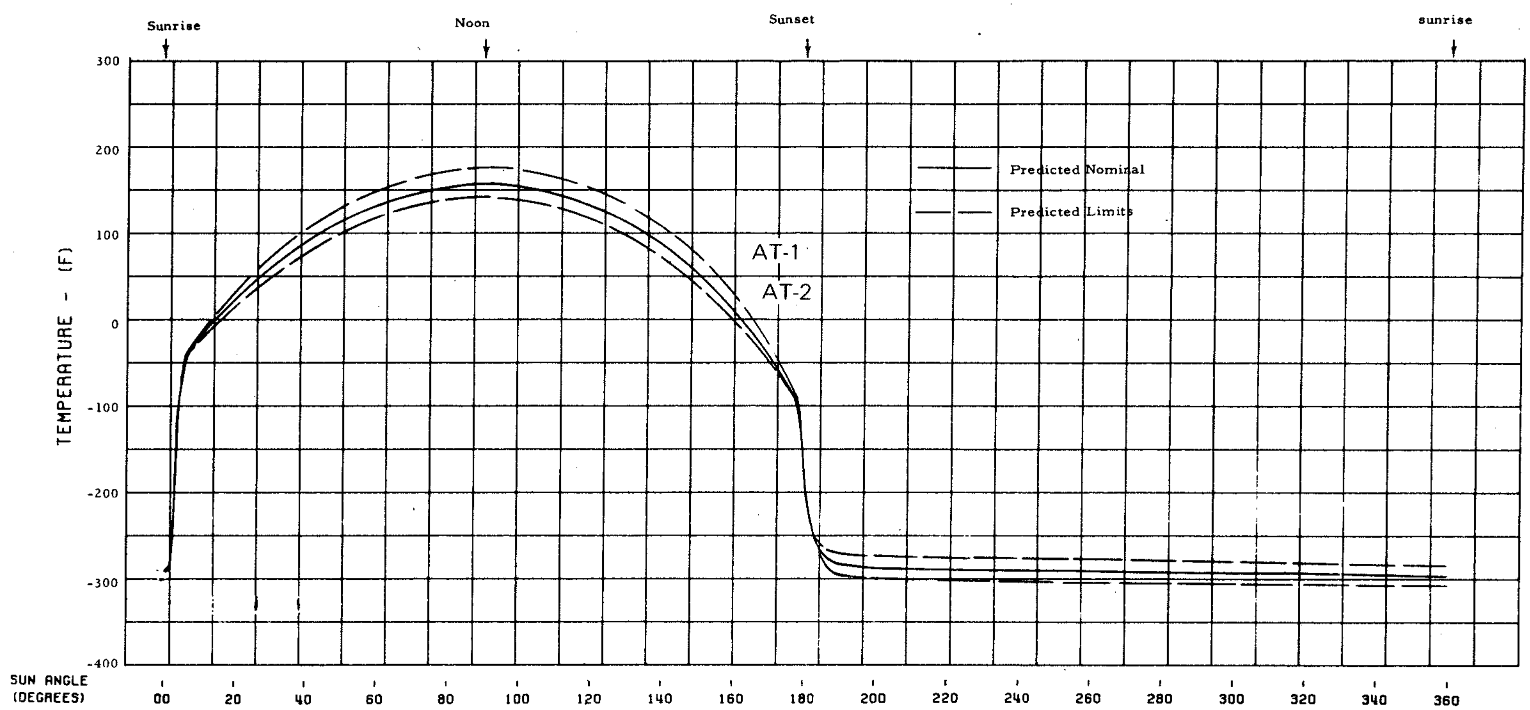

Figure 3.2-1 Normal Sunshield Temperatures

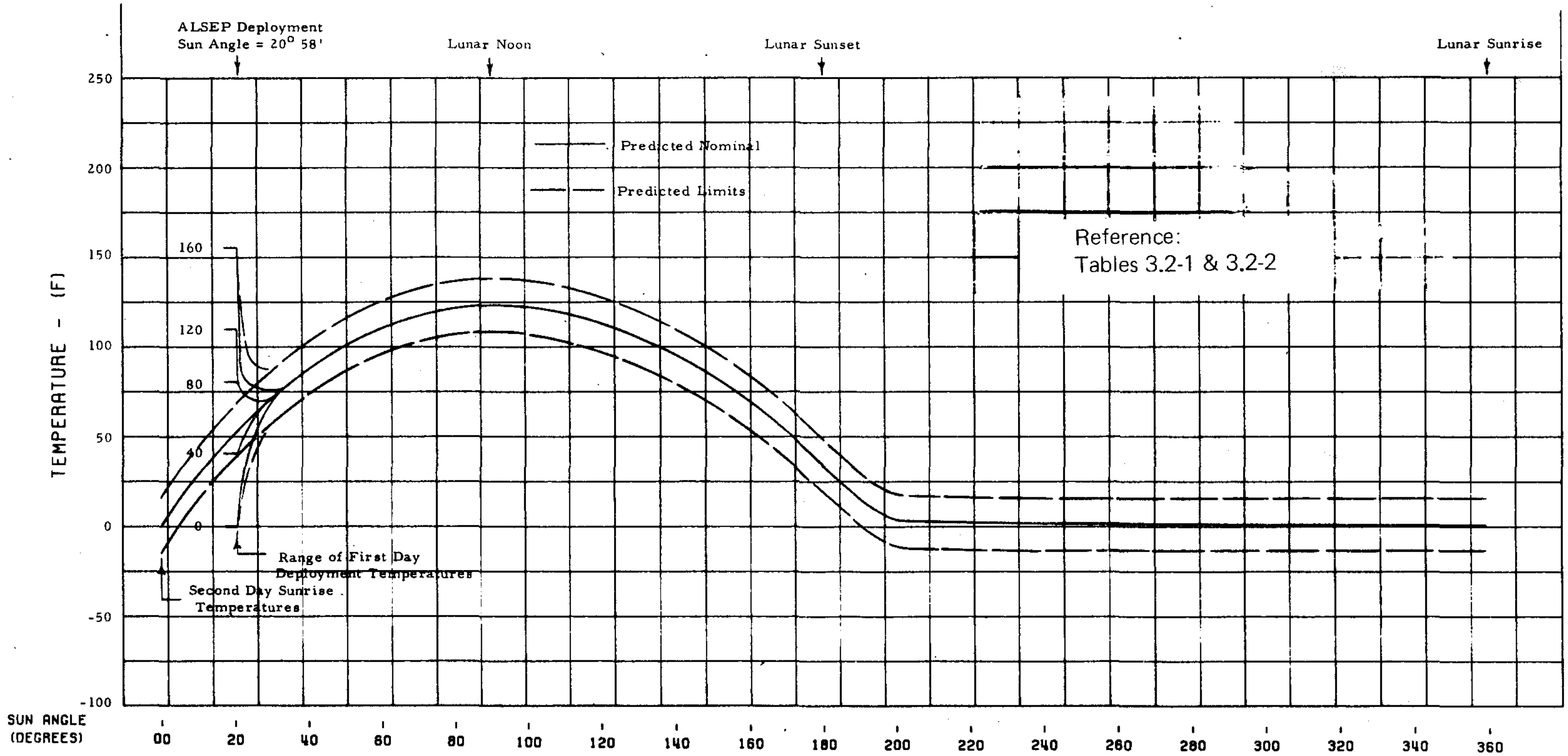

Figure 3.2-2 Normal Thermal Plate Temperatures (Average)

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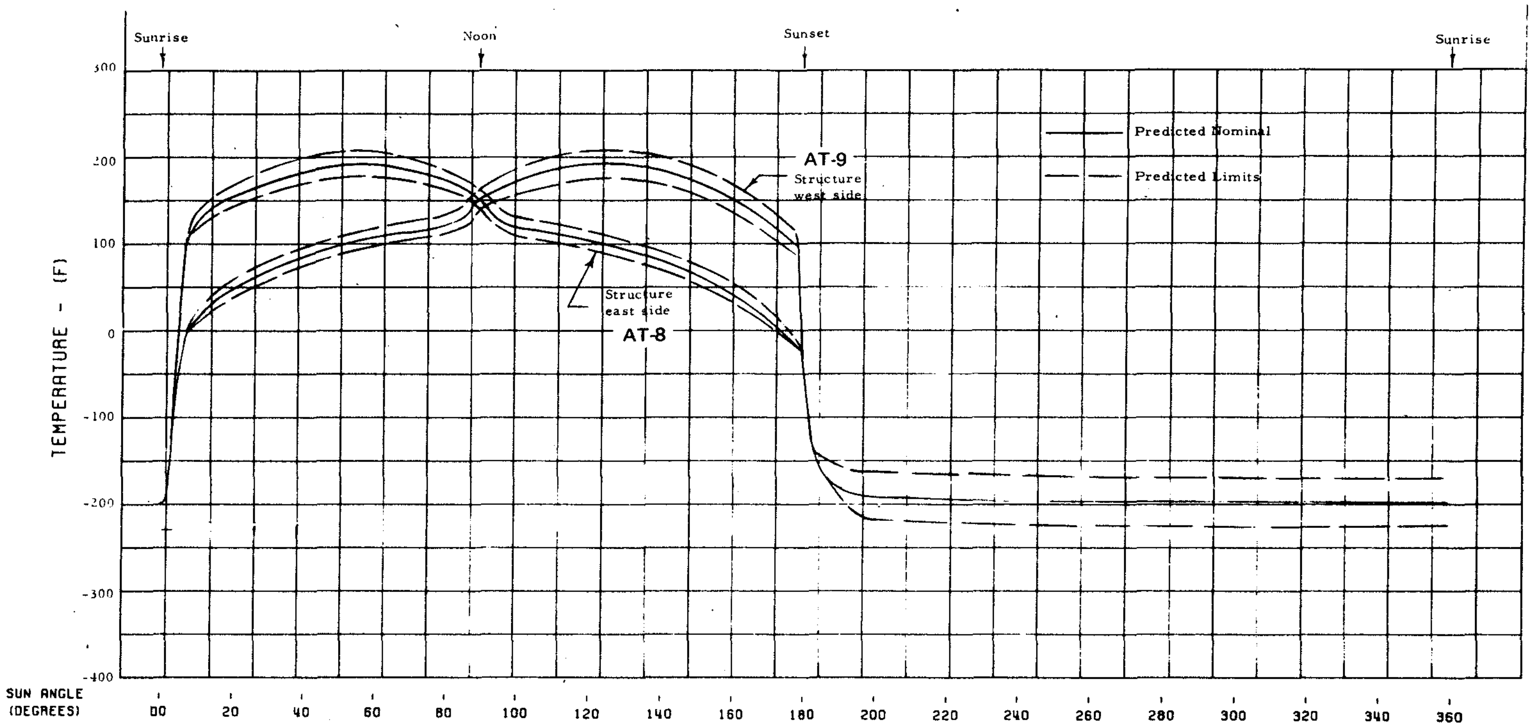

Figure 3.2-3 Normal Primary Structure Side Temperatures

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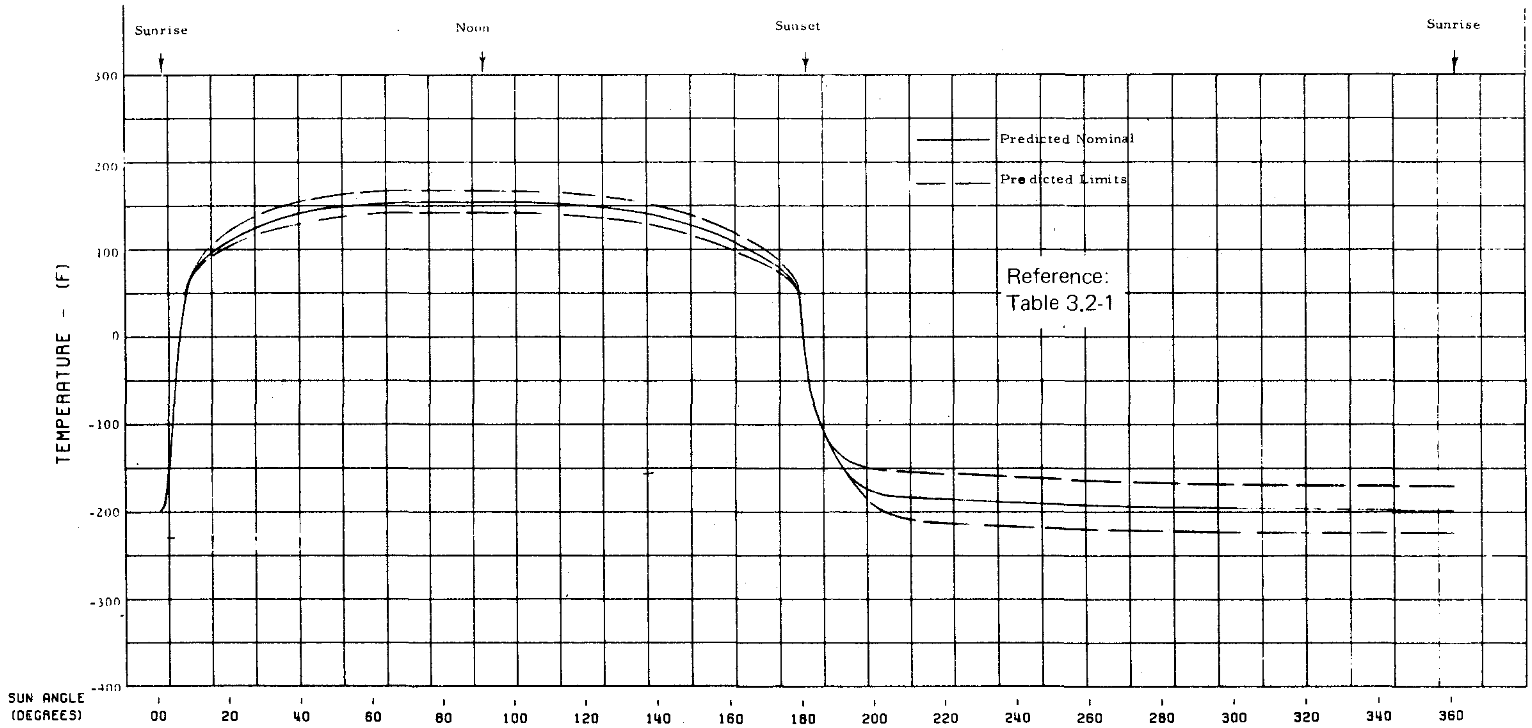

Figure 3.2-4 Normal Primary Structure Bottom Temperatures

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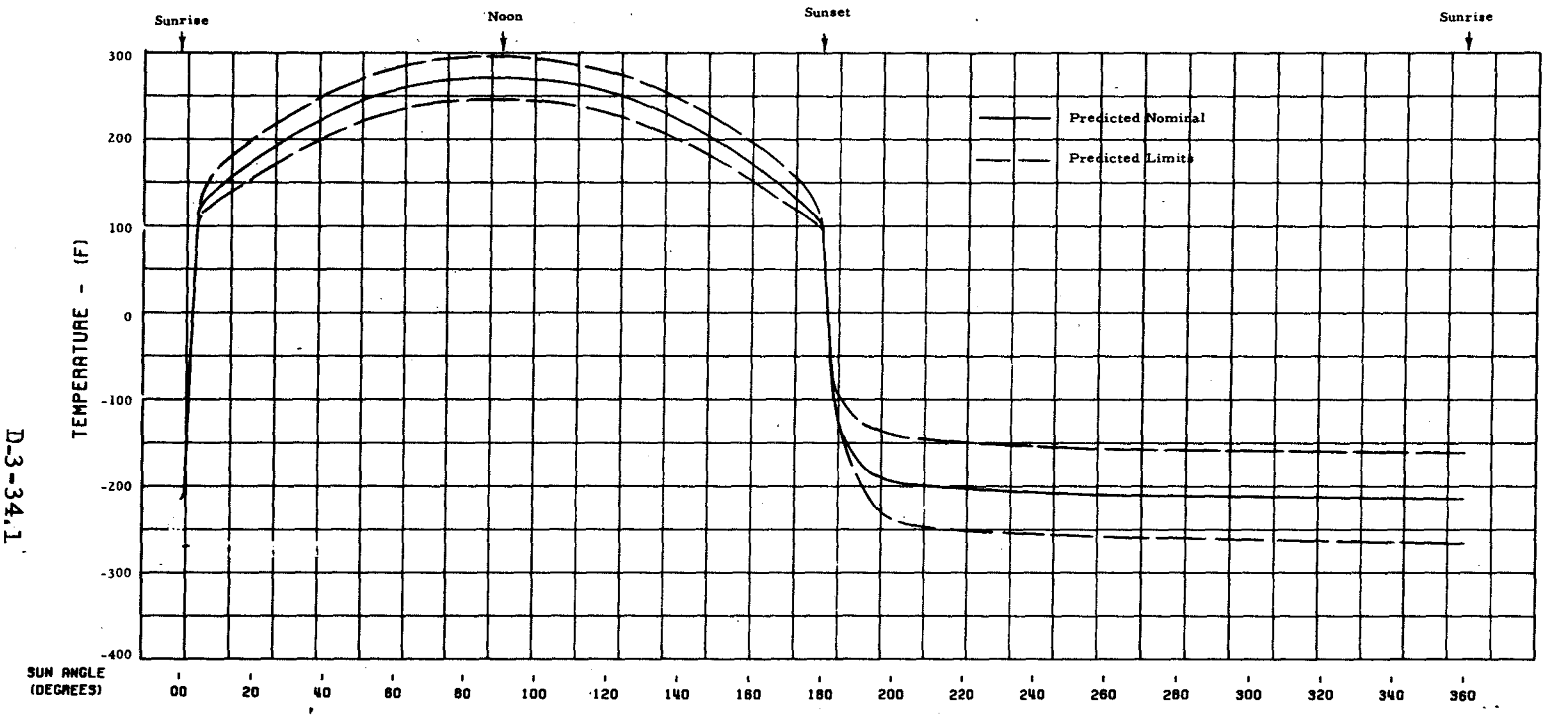

Figure 3.2-4a Normal PDM Temperatures

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7/21/71

TABLE 3.2-3(a)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits[4]	
			Low	High		Low	High
AE-1	2	ADC Calibr. Voltage (volts)	0.24	0.26	0.25	0.22 (T) 0.00 (M)	0.28 (T) 5.00 (M)
AE-2	3	ADC Calibr. Voltage (volts)	4.72	4.78	4.75	4.70 (T) 0.00 (M)	4.80 (T) 5.00 (M)
AE-3	1	PCU Input Voltage (volts)	15.8	16.2	16.0	15.0 (T) 0.0 (M)	17.5 (T) 21.5 (M)
AE-4	5	PCU Input Current (amps)	3.9	4.7		3.5 (T) 1.4 (M)	- 5.2 (M)
AE-5	44/8	PCU 1 Reserve Current (amps)	0.3	2.7		0.1 (T) 0.0 (M)	- 3.4 (M)
AE-6[1]	40/13	PCU 2 Reserve Current (amps)	0.3	2.7		0.1 (T) 0.0 (M)	- 3.4 (M)

NOTE 1: Redundant function not normally active

NOTE 4: Red-Line Limit Legend - (M) Measurement Limit, (T) Test Limit. See Section 4.3.

TABLE 3.2-3(b)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits (4)	
			Low	High		Low	High
AE-7	20	PCU Output Voltage (volts)	28.5	29.1	29	28.5 (T) 0.0 (M)	29.4 (T) 35.2 (M)
AE-8	35	PCU Output Voltage (volts)	14.9	15.4	15	14.8 (T) 0.0 (M))	15.4 (T) 18.2 (M)
AE-9	50	PCU Output Voltage (volts)	11.9	12.1	12	11.8 (T) 0.0 (M)	12.1 (T) 15 (M)
AE-10	65	PCU Output Voltage (volts)	4.8	5.4	5	4.8 (T) 0.0 (M)	5.4 (T) 6.0 (M)
AE-11	79	PCU Output Voltage (volts)	-11.9	-12.7	-12	-11.8 (T) - 8.2 (M)	-12.7 (T) -15.5 (M)
AE-12	80	PCU Output Voltage (volts)	-5.9	-6.2	-6	-5.8 (T) -1.3 (M)	-6.2 (T) -7.5 (M)

NOTE 4: Red-Line Limit Legend--(M) Measurement Limit, (T) Test Limit. See Section 4.3

TABLE 3.2-3(c)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	DESCRIPTION	Normal Operating Range Low	Normal Operating Range High	Nominal	Red-Line Limits[4] Low	Red-Line Limits[4] High
AE-13[2,3]	21	Receiver Input Level (dbm)	-66	-99	-	-60 (M)	-120 (M)
AE-14[3]	36	Receiver LO Level (dbm)	4.5	7.5	-	0 (M)	8.0 (M)
AE-15[3]	51	Transmitter A RF Power (dbm)	30.5	31.2	-	29 (T) 27 (M)	32 (T) 32 (M)
AE-16[1,3]	66	Transmitter B RF Power (dbm)	30.0	31.1	-	29 (T) 27 (M)	32 (T) 32 (M)
AE-17[3]	81	Transmitter A Input Current (milliamps)	360	400	-	350 (T) 0 (M)	410 (T) 500 (M)
AE-18[1,3]	22	Transmitter B Input Current (milliamps)	375	420	-	350 (T) 0 (M)	420 (T) 500 (M)

NOTES:

(1) Redundant functions, not normally active

(2) Stated values assume carrier present

(3) These measurements are temperature dependent. See Table 3.2-6.

(4) Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit. See Section 4.3

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TABLE 3.2-3(d)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits[4]	
			Low	High		Low	High
CS-1	-	AE-3 x AE-4	61.5	76.0	-	-	-
CS-2	-	AE-3 x AE-5	4.8	44.0	-	1.0 (T)	50 (T)
CS-3	-	CS-2 - 4.2 $(AE-5)^2$	4.4	14.6	-	-	-
CS-4[1]	-	AE-3 x AE-6	4.8	44.0	-	1.0 (T)	50 (T)
CS-5[1]	-	CS-4 - 4.2 $(AE-6)^2$	4.4	14.6	-	-	-

NOTE 1: Redundant functions, not normally active
NOTE 4: Red-Line Limit Legend - (T) Test Limit. See Section 4.3.

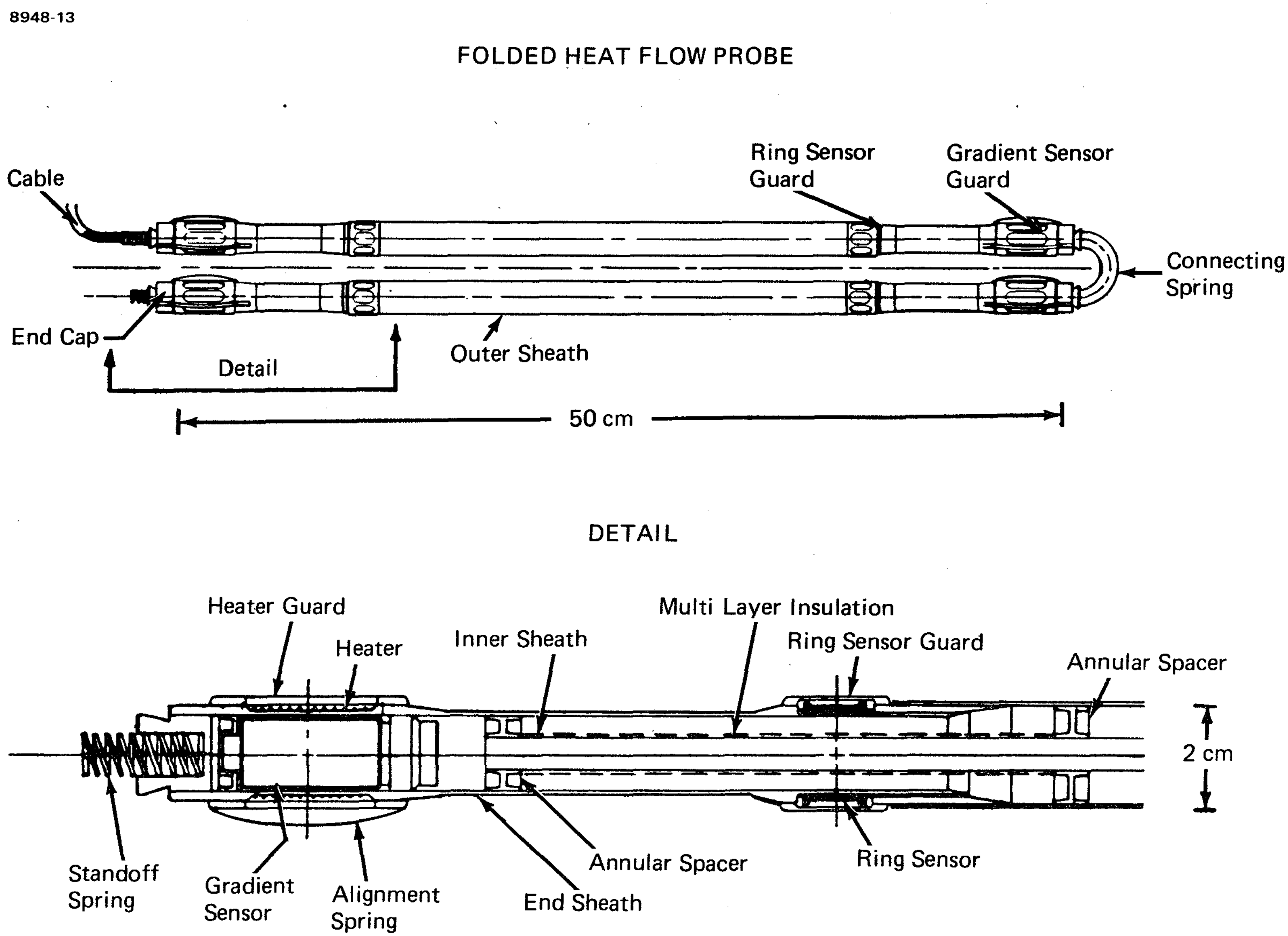

Figure 3.8-1 HFE Sensor Configuration

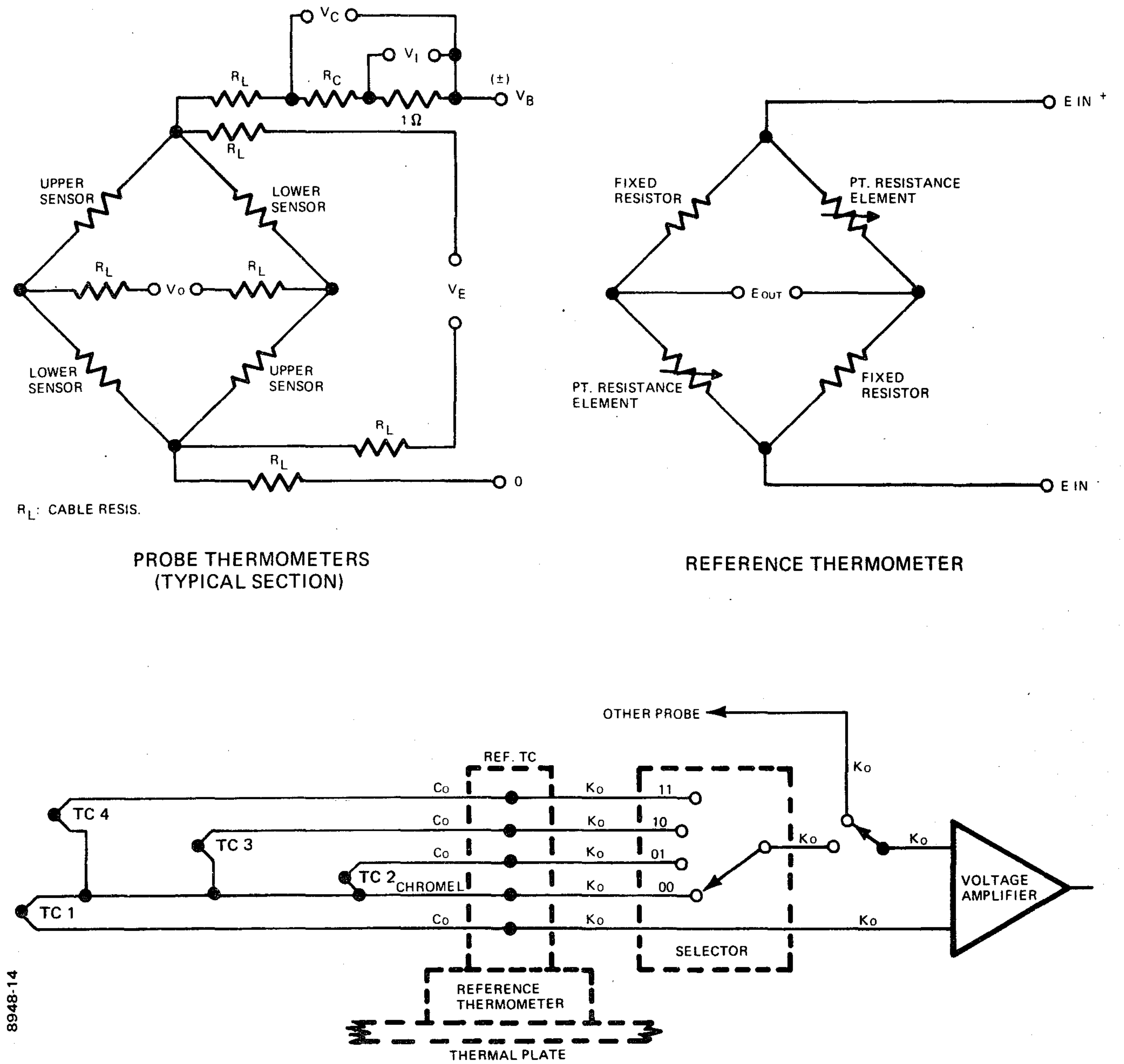

Figure 3.8-2 HFE Sensor Circuit Configuration

TABLE 3.8-3 (a)

IDENTIFICATION OF HFE MEASUREMENT CONFIGURATIONS

PROBE 1 MEASUREMENTS									HEATER
Sci. Mode	Meas. No.	Sensor & Section	Circuit (Fig. 3.8-2)	V_B	Meas. in HFE Word 0	1	2	3	
1 and 2	DTH 11	Grad/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	DTH 12	Grad/Lo	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	DTL 11	Grad/Up	Bridge	$\pm 0.4^V$	$+V_C$	$+V_O$	$-V_C$	$-V_O$	
	DTL 12	Grad/Lo	Bridge	$\pm 0.4^V$	$+V_C$	$+V_O$	$-V_C$	$-V_O$	
	T 11	Grad/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	T 12	Grad/Lo	Bridge	$\pm 4^V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	TCR 1	- -	Ref. Bridge	± 0.5	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	TC 1	- -	Thermcpl.	-	1	2	3	4	
3	DT 111	Ring/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	1
	DT 112	Ring/Up	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	2
	DT 123	Ring/Lo	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	3
	DT 124	Ring/Lo	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	4
	T 111	Ring/Up	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	1
	T 112	Ring/Up	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	2
	T 123	Ring/Lo	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	3
	T 124	Ring/Lo	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	4

TABLE 3.8-3 (b)

IDENTIFICATION OF HFE MEASUREMENT CONFIGURATIONS (CONT.)

PROBE 2 MEASUREMENTS									HEATER
Sci. Mode	Meas. No.	Sensor & Section	Circuit (Fig. 3.8-2)	V_B	Meas. in HFE Word 0	1	2	3	
1 and 2	DTH 21	Grad/Up	Bridge	$\pm 4V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	DTH 22	Grad/Lo	Bridge	$\pm 4V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	DTL 21	Grad/Up	Bridge	$\pm 0.4V$	$+V_C$	$+V_O$	$-V_C$	$-V_O$	
	DTL 22	Grad/Lo	Bridge	$\pm 0.4V$	$+V_C$	$+V_O$	$-V_C$	$-V_O$	
	T 21	Grad/Up	Bridge	$\pm 4V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	T 22	Grad/Lo	Bridge	$\pm 4V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	TCR 2	- -	Ref. Bridge	$\pm 0.5V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	TC 2	- -	Thermcpl.	-	1	2	3	4	
3	DT 211	Ring/Up	Bridge	$\pm 4V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	1
	DT 212	Ring/Up	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	2
	DT 223	Ring/Lo	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	3
	DT 224	Ring/Lo	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	4
	T 211	Ring/Up	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	1
	T 212	Ring/Up	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	2
	T 223	Ring/Lo	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	3
	T 224	Ring/Lo	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	4

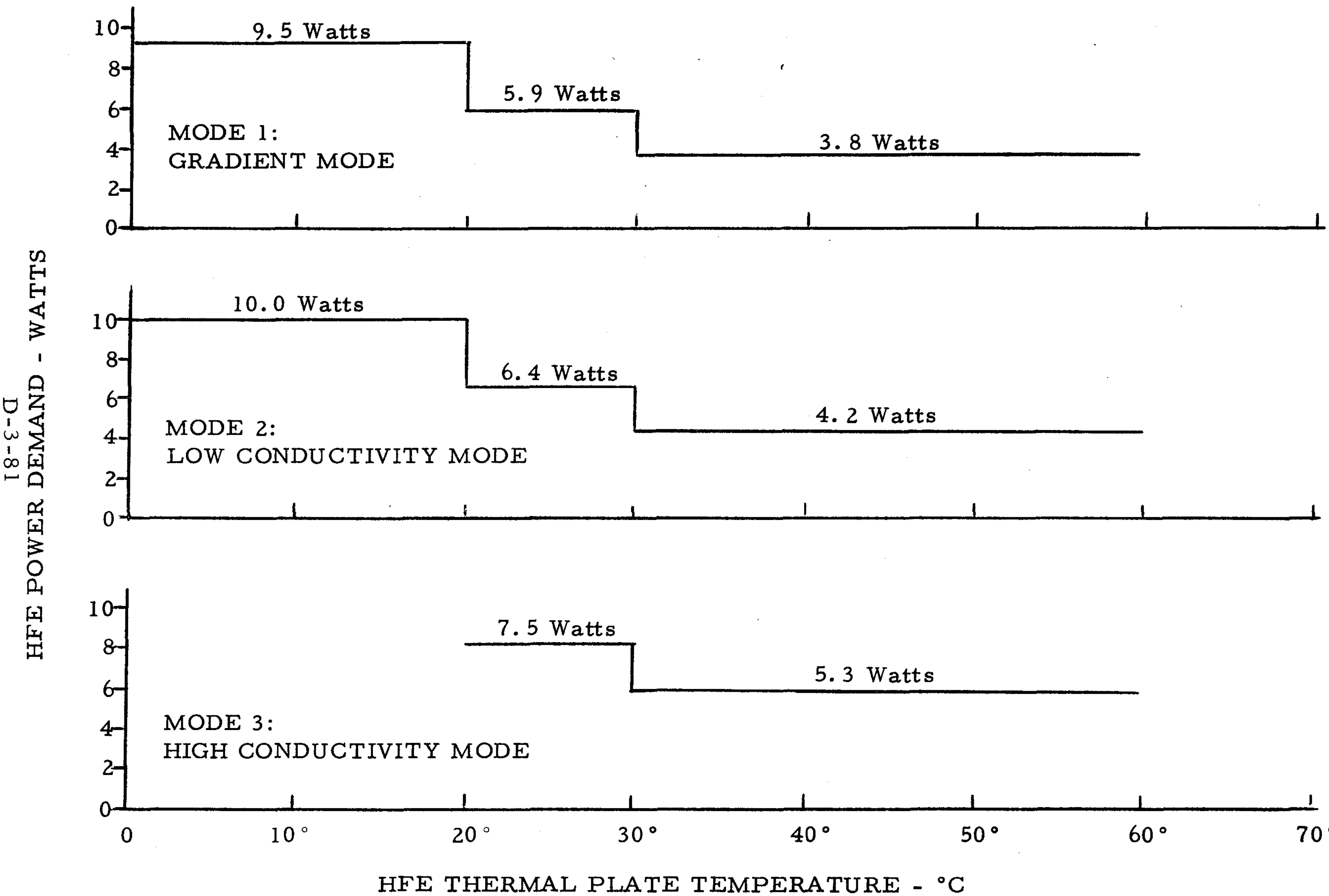

Figure 3.8-3 HFE Power Profile

Table 3.8-4

HFE Science Data Display

Display Heading	Data Interpretation
MEAS.	For interpretation see Table 3.8-3
RATIO	The result of combining the measurement words from a particular bridge configuration in the ratio $\frac{\text{Word 1 - Word 3}}{\text{Word 0 - Word 2}}$
RB	The value of bridge resistance (ohms) derived from the application of a calibration curve to the associated value of RATIO
VALUE (°K)	The temperature derived for each probe/section from a. bridge resistance value of the absolute temperature measurement (T) b. ratio value of the differential temperature measurement c. polynominals containing configuration and calibration factors.
GAIN	Measurement system gain for reference temperature and thermocouple measurements
OFFSET	Measurement system offset for reference temperature and thermocouple measurements referred to the amplifier input.

TABLE 3.8-5

HFE COMPUTED SCIENTIFIC DATA

Meas.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits	
			Low	High		Low	High
DTH	--	Temp. Difference @ HI Sensitivity					
		. Ratio	-.0058	+.0058	----	----	----
		. Bridge Resistance (ohms)	350	450	----	----	----
		. Value (°K)	- 2	+ 2	----	----	----
DTL	--	Temp. Difference @ LO Sensitivity					
		. Ratio	-.058	+.058	----	----	----
		. Bridge Resistance (ohms)	350	450	----	----	----
		. Value (°K)	- 20	+ 20	----	----	----
T	--	Absolute Temperature					
		. Ratio	+.0046	+.0058	----	----	----
		. Bridge Resistance (ohms)	352	452	----	----	----
		. Value (°K)	200	250	----	----	----
TCR	--	Reference Temperature (°K)	278	328	----	273 (T)	333 (T)
TC	--	Thermocouples (°K)	90	350	----	----	----
GAIN	--	Amplifier Gain	994	1001	----	950	1050
OFFSET	--	Amplifier Offset	-.000100	-.000015	----	-.000250	+.000250

3.8.6 Apollo Lunar Surface Drill (ALSD)

The Apollo Lunar Surface Drill (ALSD) is part of the equipment complement for the Apollo J1 Mission and serves two purposes. First, as a necessary item of ancillary equipment for the Heat Flow Experiment, it provides the means by which the astronaut will drill two 1.125-inch-diameter holes approximately 10 feet deep into which the two HFE probes will be placed. Second, as part of the Lunar Geology Experiment, the ALSD will be used to drill a third hole, one inch in diameter, about 8 feet deep and obtain a core sample of the lunar subsurface for return to the LRL and subsequent geological investigation. The drill which will be employed to produce the lunar subsurface holes is a hand-held, battery powered, rotary-percussion drill. Drill specifications are shown in Table 3.8-6.

The drill and two sets of fiberglass bore stems are stowed in the MESA. The set of six sterilized titanium core stems are stowed in Sample Return Container No. 1 on both the outbound and inbound flights. When the MESA is opened the Sample Return Container No. 1 is unloaded, the set of core stems will be placed in the Apollo Lunar Hand Tool Carrier for the traverse to the HFE/core sample location.

Emplacement of the two HFE probes makes it necessary for the two sets of bore stems to remain in the bore holes, functioning as casing to facilitate insertion of the heat probes without danger of cave-ins. The HFE probe emplacement tool is a telescoping tube with an open clip at the end to engage the Heat Flow probe cable. This tool is packaged with HFE probe 1. It is marked every two centimeters with alphanumeric characters to indicate the depth to which the HFE probe has been emplaced in the bore stem casing as well as the depth to which the bore stem assembly has been drilled into the subsurface. Reading from the bottom to the top of the probe emplacement tool, the coding is consecutively A1 through A9, B1 through B9, C1 through C8, F1 through F9, J1 through J9, K1 through K8, L1 through L9, N1 through N9, P1 through P9, T1 through T9, V1 through V9 and Y1 through Y9. See Table 3.8-6 for interpretation of the markings. An orange mark is painted on the emplacement tool covering V3 and V4 to designate nominal hole depth.

In the stowed configuration for the outboard flight, the bore stem adapter is mounted on the ALSD spindle. During the drilling operations for the two sets of HFE bore holes, the astronaut will release the adapter from the fiberglass bore stems by first rotating the drill powerhead 90 degrees counter-clockwise and then "blipping" or momentarily activating the drill motor. If the cohesion of the lunar soil to the bore stems provides

TABLE 3.8-6

HEAT FLOW EMPLACEMENT TOOL INDICATIONS

Tool Marking	Centimeters from Top of Probe	Tool Marking	Centimeters from Top of Probe	Tool Marking	Centimeters from Top of Probe
	-3 (TC1)		74		146
A1		J1		P1	
	4		76		148
A2		J2		P2	
	6		78		150
A3		J3		P3	
	8		80		152
A4		J4		P4	
	10		82		154
A5		J5		P5	
	12		84		156
A6		J6		P6	
	14		86		158
A7		J7		P7	
	16		88		160
A8		J8		P8	
	18		90		162 TC2
A9		J9		P9	
	20		92		
	20		92		166
B1		K1		T1	
	22		92		168
B2		K2		T2	
	24		96		170
B3		K3		T3	
	26		98		172
B4		K4		T4	
	28		100		174
B5		K5		T5	
	30		102		176
B6		K6		T6	
	32		104		178
B7		K7		T7	
	34		106		180
B8		K8		T8	
	36				182
B9				T9	
	38				184
	38		110		184
C1		L1		V1	
	40		112 TC3		186
C2		L2		V2	
	42		114		188
C3		L3		V3	
	44		116		190
C4		L4		V4	
	46		118		192
C5		L5		V5	
	48		120		194
C6		L6		V6	
	50		122		196
C7		L7		V7	
	52		124		198
C8		L8		V8	
			126		200
		L9		V9	
			128		202
	56		128		202
F1		N1		Y1	
	58		130		204
F2		N2		Y2	
	60		132		206
F3		N3		Y3	
	62 TC4		134		208
F4		N4		Y4	
	64		136		210
F5		N5		Y5	
	66		138		212
F6		N6		Y6	
	68		140		214
F7		N7		Y7	
	70		142		216
F8		N8		Y8	
	72		144		218
F9		N9		Y9	
	74		146		220

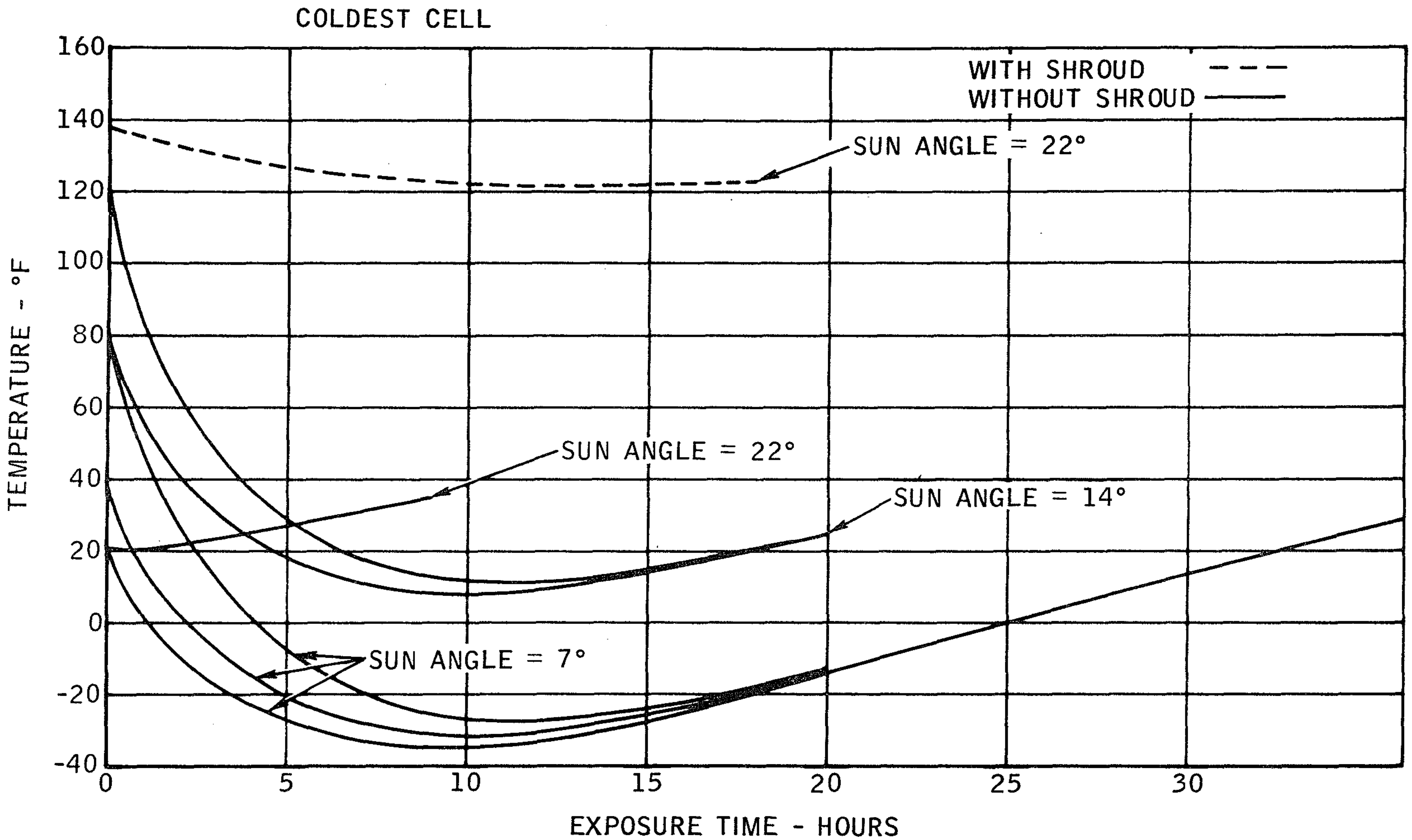

FIGURE 3.8-4 ALSD BATTERY TEMPERATURE HISTORY

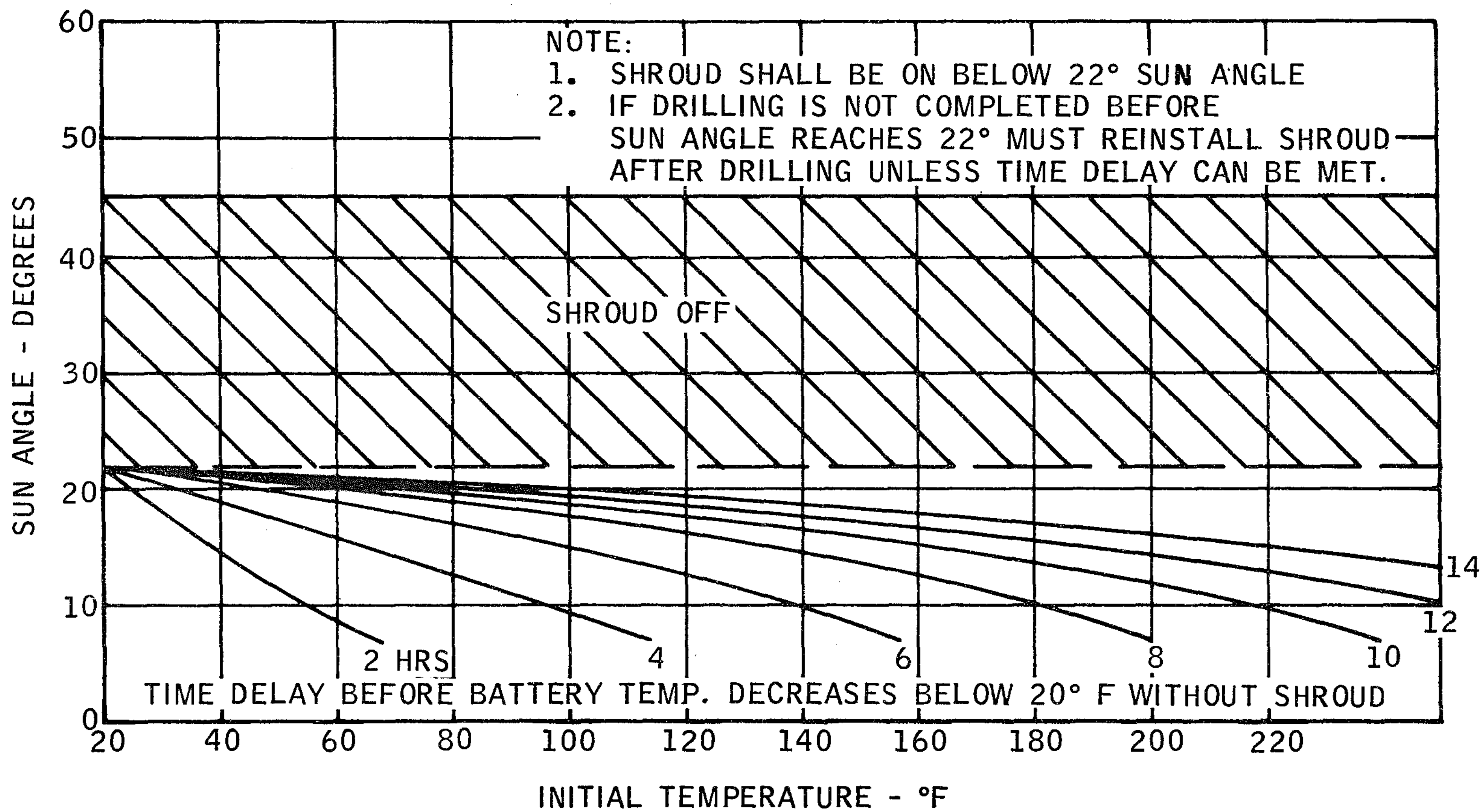

FIGURE 3.8-5 SUN ANGLE VERSUS INITIAL TEMPERATURE

SECTION 4

OPERATIONAL CONSTRAINTS AND LIMITATIONS

Under normal circumstances ALSEP Array A-2 when properly deployed will perform as outlined in Section 3. As described in that Section, certain functions can be altered by ground command. This section contains information on certain deployment alternatives, the operational constraints on the use of the command link to modify equipment performance and the limitations in telemetered data.

4.1 DEPLOYMENT CONSTRAINTS

4.1.1 Thermal Effects

The performance of ALSEP Array A-2 is dependent on the location of the landing site as well as on its terrain characteristics. As presently constituted each unit of the system is configured for operation at approximately 26° north latitude in anticipation of deployment at Hadley Rille. This significant offset from the equator requires special leveling and alignment indicators as described in Section 3.1 to reduce errors in the sun compasses and maintain instrument alignment with the ecliptic. Thermal control configurations are also not symmetrical because of greater solar heating on the south side of the equipment at lunar noon. Hence a significant change in landing site could alter the performance stated in Section 3 for the system as presently configured.

The slope of the surface in the immediate vicinity of the Central Station has an effect on the temperature control of that unit. If the local surface slopes up, particularly in the north-south direction, it tends to reduce the efficiency of the thermal radiating surfaces and to cause higher thermal plate temperatures. Figure 4.1 illustrates the effect of local terrain slope on the temperatures of the electronic units in the Central Station. The surface slopes could result from deployment of the equipment at the bottom of a crater. The best location for the Central Station is on top of a knoll with the local surface sloping away from the equipment.

4.1.2 Deployment Sequence Hold Points

In the event of an inability to complete the deployment tasks within the nominal timeline, the sequence of ALSEP deployment tasks may be temporarily stopped after the completion of any one of the task groups identified in Table 4-1. In case the ALSEP deployment cannot be completed during EVA 1 and part of the deployment must be deferred to EVA 2, three EVA hold points (following the completion of Tasks #3, 6 and 13) have been identified. The deployment may be resumed at a later point in time by continuing with the next series of tasks.

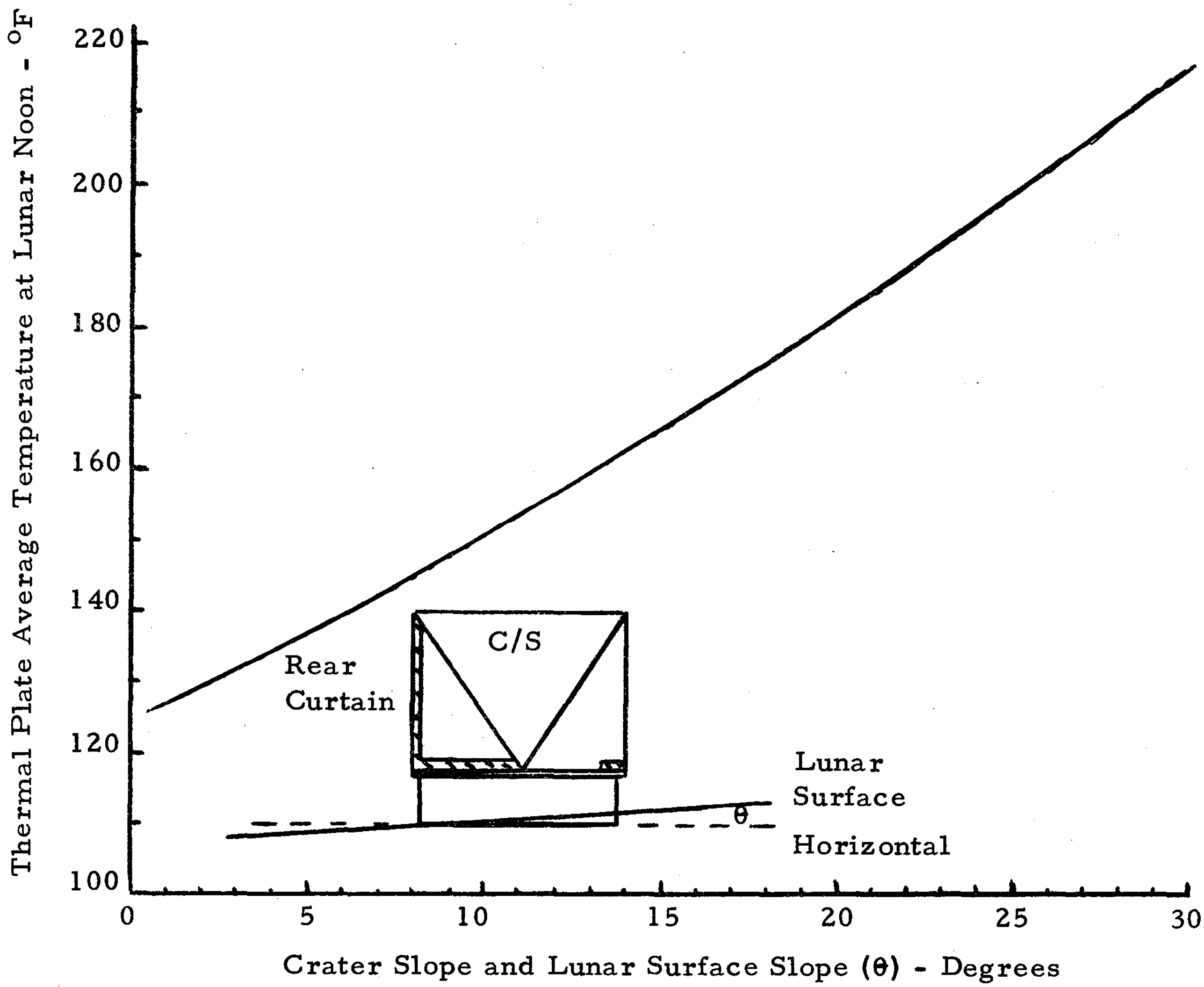

Figure 4.1 Effect of Surface Slope on Thermal Control

TABLE 4.1

DEPLOYMENT HOLD POINTS

Task Group	Deployment Tasks
1.	Open SEQ Bay Doors, offload ALSEP Subpackages #1 and #2, emplace them in the sun, and close SEQ Bay Doors.
2.	Remove UHT's and Carry Bar.
3.	Rotate Fuel Cask. (EVA HOLD POINT)
4.	Remove Fuel Cask Dome.
5.	Unstow ALSD, place on LRV.
6.	Remove fuel element from Cask and insert into RTG, offload LRRR and place on LRV, close SEQ Bay Doors, carry ALSEP and drive LRV to ALSEP deployment site, offload LRRR from LRV and emplace LRRR in and facing the sun, offload HFE subpallet, connect RTG and HFE cables to central station, offload SIDE/CCIG subpallet, deploy HFE subpallet (*), offload SIDE/CCIG, offload HFE Probe Box (*), and rotate central station, (Pull shorting switch lanyard before a hold). (EVA HOLD POINT).
7.	Offload and deploy PSE.
8.	Offload and deploy HFE Electronics Box (*).
9.	Offload and deploy ALSD (*).
10.	Offload and deploy SWS.
11.	Offload and deploy LSM. (Partially deploy, including legs, if a hold is imminent).
12.	Drill first bore hole and insert first probe into bore stem (*).

TABLE 4.1 (CONT.)

DEPLOYMENT HOLD POINTS

Task Group	Deployment Tasks
13.	Release sunshield Boyd bolts, raise sunshield, install antenna mast, offload gimbal and install on mast, install antenna on gimbal, and aim antenna (**). (EVA HOLD POINT)
14.	Drill second bore hole.
15.	Deploy SIDE/CCIG.
16.	Insert second probe into bore stem and level and align HFE Electronics Box.
17.	Depress shorting switch and turn on Astro Switch #1.
18.	Deploy LRRR.
19.	Photograph LRRR and ALSEP.

(*) May be deferred if a hold is imminent. HFE and ALSD tasks may be interrupted in order to permit completion of other, less time-consuming ALSEP tasks.

(**) Depress shorting switch and turn on Astro Switch #1 if a hold is imminent. Experiments can be commanded to standby power OFF so no hazard would exist for astronauts.

4.2 COMMAND CONSTRAINTS

4.2.1 Critical Commands

Certain functions of ALSEP Array A-2 are purposely controllable in MCC but because of the impact they have on system performance the associated commands should be considered as CRITICAL. The commands listed in Table 4.2 should be considered critical for the reasons stated.

4.2.2 Modification of Normal Operation by Commands

Only a limited number of measured engineering parameters can have their normal value, as stated in Section 3, modified deliberately by ground command, if conditions require it. The majority of these are measurements from temperature sensors located near commandable heaters. Most commands which have a significant power change associated with their implementation will cause some change in the temperature and reserve current measurements of the Power Conditioning Unit, and in the temperature of the Power Dissipation Module.

4.8 HEAT FLOW EXPERIMENT (HFE)

4.8.1 HFE Deployment Constraints

Constraints on the deployment of the HFE are shown in Table 3.1-11.

4.8.2 HFE Turn-on Constraints

Power should be applied to the HFE within 90 minutes after removal of the ALSEP from the LM. If operational power cannot be provided, the Standby, survival mode should be initiated. Operating power must be provided to the HFE no later than 5 days after removal of the ALSEP from the LM.

4.8.3 HFE Operational Constraints

The temperature of the electronics package displayed as TCR 1 and TCR 2 should be monitored to ensure the temperature is within the range 273°K to 333°K.

When operating in Mode 1, the HTR status should read "OFF". See Table 5.3-8 for heater sequence.

The operational power to the HFE should not be de-activated during lunar night unless the standby heater is energized.

Whenever the high conductivity mode, Mode 3, is desired, Command 140, 144 and 142 must be sent.

The red-line limits for the analog engineering measurements are listed in Table 3.8-1.

4.8.4 ALSD Constraints

After removal of the ALSD subsystem from the LM descent stage MESA, but prior to HFE/ALSD deployment, it may be necessary to temporarily leave the ALSD on the lunar surface. If the ALSD is to be left on the lunar surface for 30 minutes or longer, the ALSD must be placed on the surface with the battery end down and the back of the battery oriented toward the sun. The battery must not be shaded by the bore stems or treadle. The ALSD must not be left in the shadow of the LM.

If, after the battery thermal shroud has been removed, drill operations are delayed for 30 minutes or longer, and if the sun angle is less than 22°, then the shroud must be replaced onto the battery until drilling operations are resumed. The orientation of the shrouded drill during this period should be battery end down on the lunar surface with the back of the battery facing the sun. The output of the ALSD battery is generally proportional to battery temperature. Within the limits of the expected lunar surface and ALSD temperature excursions, a higher battery output will result from a higher battery temperature.

The ALSD battery should not be rested between hole drilling operations in expectation that the battery will recover or rejuvenate itself. The amount of battery recovery per unit of time is near zero.

If it becomes necessary to use the wrench designed for titanium core stems to release a fiberglass bore stem from the stem adapter, caution must be used in positioning the wrench halfway between bore stem joints. If the wrench is applied at a taper joint, the taper joint may be weakened or damaged.

TABLE 5.2 (e)

NOTES

1 Preset turn-on operating mode.

2 Lunar surface initial conditions programmed in during final system checkout.

3 Changes bit rate at end of ALSEP frame during which command executed.

4 Changes bit rate upon command execution.

5 Experiment numbers are as follows:

Experiment No.	Experiment
1	PSE
2	LSM
3	SWS
4	SIDE/CCIG
5	HFE

6 Short period calibration and uncage commands are initiated automatically at 18 hour intervals by the timer unless this feature has been inhibited by execution of CD-37.

7 Uncage command is executed automatically by the delayed command sequencer at 144 hours + 2 minutes, although uncaging may have been previously accomplished by ground command or as outlined in Note 6 above.

8 Manual leveling sequence is as follows: Send CL-15 to change from auto to manual leveling mode, change direction, and speed by CL-10 and CL-11 as necessary, and then execute leveling operation by sending appropriate leveling motor commands, CL-6, CL-7, or CL-8. Leveling operation is terminated by retransmission of CL-6, CL-7, or CL-8.

9 Sequence of command is auto on[1]/auto off/manual on/manual off.

10 For 0° flip position; reverse sign for 180° flip position.

11 Also activated every 18 hours after and including hour 162 + 1 min. by delayed command sequence.

12 Field offset sequence is as follows: select proper axis with CM-3, then execute CM-2 the proper number of times to step from present value to desired value.

13 Also executed at hour 144 + 4 minutes by delayed command sequence. Repetition of CW-1 three times within ten seconds results in High Voltage Gain Change.

14 First execution of CM-7 performs X-axis survey, second execution Y-axis survey and third execution Z-axis survey.

TABLE 5.2 (f)

NOTES (CONTINUED)

Note 15

HFE Command Sequencing

a. The command sequence for transfer from Modes 1 or 2 to Mode 3 is:

CMD 140, preceded or followed by
CMD 144 and CMD 142

These commands will be implemented if sent at the normal rate for ALSEP sequential commands.

b. The command sequence for transfer out of Mode 3

- to Mode 1 is: CMD 135, followed by CMD 141
- to Mode 2 is: CMD 136, followed by CMD 141

(CMD 141 selects full measurement cycle)

c. The command sequences for selecting subsets of the full HFE measurement cycle during Modes 1 and 2 are:

Command 144 selects a subset consisting of the four high sensitivity gradient measurements only.

Command 144, followed at least 54 seconds later by command 145, selects a subset consisting of the four low sensitivity gradient measurements only.

Command 144, followed at least 54 seconds later by command 146, selects a subset consisting of probe ambient temperature measurements only.

Command 145 preceded or followed by command 146 selects a subset consisting of thermocouple measurements only.

TABLE 5.3-7 (a)

HFE COMMAND DETAILS

Octal Command Number	Command Title	Command Description
135	HFE MODE 1 SEL	This CMD is a 1-state CMD. It places the HFE in the gradient, or normal, mode of operation in which measurements are obtained from the gradient sensors, reference sensors and cable thermocouples. CMD 135 also turns off the probe heater current supply. Different measurement sequences in mode 1 may be selected by use of CMD 141 through 146. At power turn-on, the HFE initializes in Mode 1. If the HFE is in Mode 1 transmission of CMD 135 has no effect. Note that the HFE input buffer holds CMDs for execution at the 90-frame mark; thus, sequential CMDs must be transmitted at least 54 sec. apart.
136	HFE MODE 2 SEL	This CMD is a 1-state CMD. It places the HFE in the low conductivity, or ring source, mode of operation in which measurements, and sequences, are identical to Mode 1. It also turns on the probe heater current supply in the low (ring source) mode allowing heaters to be activated by CMD 152. If the HFE is in Mode 2, transmission of CMD 136 has no effect.
140	HFE MODE 3 SEL	This CMD is a 1-state CMD. It places the HFE in the high conductivity, or heat pulse, mode of operation in which measurements are obtained from the ring (or remote) sensors under the control of the heater sequence programmer. Note that CMD 144 must also be transmitted before valid data will be obtained in mode 3. Either CMD may be transmitted first. CMD 140 also turns on the probe heater current supply in the high, or heat pulse, mode allowing heaters to be activated by CMD 152. If the HFE is in Mode 3, transmission of CMD 140 has no effect.
141	HFE SEQ/FUL SEL	This CMD is a 1-state CMD. It cancels the effect of CMDs 142 through 146 causing the measurement sequence programmer (MSP) to perform its full 16-state cycle of operation in Mode 1 or Mode 2. If transmitted during Mode 3 operation, this CMD will cause invalid operation until CMD 144 is executed. At power turn-on, the HFE initializes the SEQ/FUL. If the HFE is in Mode 1 or Mode 2 and in SEQ/FUL, transmission of CMD 141 has no effect.

TABLE 5.3-7 (b)

HFE COMMAND DETAILS (CONT.)

Octal Command Number	Command Title	Command Description
142	HFE SEQ/P1 SEL	This CMD is a 1-state CMD and alternates with CMD 143 to select only one probe for measurement. In Mode 3 this CMD doubles the recognized data rate. In Mode 1 and Mode 2 it causes the MSP to select probe 1 measurements only. SEQ/P1 is cleared by subsequent execution of CMD 141.
143	HFE SEQ/P2 SEL	This CMD is a 1-state CMD and alternates with CMD 142 to select only one probe for measurement. It has the same characteristics as CMD 142 except that probe 2 measurements only are selected.
144	HFE LOAD 1	This CMD is a 1-state CMD and is used alone or in combination with CMD 145 or 146 to program the MSP. Used alone in Modes 1 and 2, it causes the selection of only the high sensitivity bridge measurement data. In Mode 3 CMD 144 must be executed to obtain valid data. CMDs 145 and 146 may be used in Mode 1 following CMD 144 to select low sensitivity bridge or absolute temperature measurements respectively. The effect of CMD 144 is cleared by subsequent use of CMD 141.
145	HFE LOAD 2	This CMD is a 1-state CMD and is used in combination with either CMD 144 (Preceding 145) or CMD 146 (preceding or following 145) to program the MSP. As stated above, 144-145 yields low sensitivity differential temperature data only. CMDs 145-146 yield cable thermocouple data only. Execution of this latter CMD in Mode 3 causes invalid data until CMD 144 is executed. The effect of CMD 145 is cleared by subsequent execution of CMD 141.
146	HFE LOAD 3	This CMD is a 1-state CMD used with CMDs 144 & 145 to program the MSP. When preceded by CMD 144 it yields ambient temperature data only. When preceded or followed by CMD 145 it yields only thermocouple data. Execution of this CMD in Mode 3 causes invalid data until CMD 144 is executed.

TABLE 5.3-7 (c)

HFE COMMAND DETAILS (CONT.)

Octal Command Number	Command Title	Command Description
152	HFE HTR STEPS	This CMD is a 16-state CMD which programs each time the CMD is executed the selection of the 4 heater elements in each probe as listed in Table 5.3-8. In Mode 1 the sequence advances but there is no other effect since the probe heater current supply is off. In Mode 2 the execution of CMD 152 alternates the heater status between on and off, simultaneously stepping through the 8 heaters (current supply is on full time and heater elements are switched in and out of circuit). In Mode 3 the heater excitation programmer (advanced by CMD 152) also selects the data to be sampled.

TABLE 5.3-8

DETAILED DESCRIPTION OF COMMAND 152 HFE HEATER SEQUENCE

(1) Sequence No.	MODE 3 PRINTOUT DISPLAY(2)		Ring Bridge Selected
	Measurements(3)	HTR. State	
1	DT111 & T111	H12 OFF	K11
2	DT112 & T112	H12 ON	
3	DT121 & T121	H14 OFF	K12
4	DT122 & T122	H14 ON	
5	DT113 & T113	H11 OFF	K11
6	DT114 & T114	H11 ON	
7	DT123 & T123	H13 OFF	K12
8	DT124 & T124	H13 ON	
9	DT211 & T211	H22 OFF	K21
10	DT212 & T212	H22 ON	
11	DT221 & T221	H24 OFF	K22
12	DT222 & T222	H24 ON	
13	DT213 & T213	H21 OFF	K21
14	DT214 & T214	H21 ON	
15	DT223 & T223	H23 OFF	K22
16	DT224 & T224	H23 ON	

Configuration		
Probe 1	Upper Section	H11 (K11) H12
	Lower Section	H13 (K12) H14
Probe 2	Upper Section	H21 (K21) H22
	Lower Section	H23 (K22) H24

Notes:

1. Each CMD 152 is executed only at the time of the ALSEP 90th frame mark.

2. When HFE is in Mode 2, the selected heater is energized in low current mode. The measurement sequence is independently selected.

3. When HFE is in Mode 3, the selected heater is energized in high current mode and the ring bridge measurement sequence is: high sensitivity differential temperature (DT), followed by high sensitivity ambient temperature (T); on the selected bridge only.