ALSEP DESIGN SUMMARY

Presentation Material

BSR-2900

17 - 20 March 1970

NASA/MSC - Bendix Aerospace Systems Division
Section 1

Alsep System Description
ALSEP SYSTEM SUMMARY

Requirements and Constraints
System Description
Array A Description
Mission Profile
Array B Description
Array C Description
Array D Description
EASEP Description

Landing Site:
Latitude: ±5°
Longitude: ±45°
APOLLO 11-13

Latitude: ±45°
Longitude: ±45°
PLUS MARIUS HILLS
APOLLO 14 & LATER

Astronaut Tasks
Simple and Safe Deployment Sequence
Maximum Deployment Time Flight 1 - 90 Minutes

MSFN/MCC Compatibility
Multiple Operation
Simultaneous Operation of Three ALSEPs

Power
SNAP-27 RTG - 63 Watts at One Year

7759-5100
SYSTEM REQUIREMENTS AND CONSTRAINTS

LIFETIME: ONE YEAR

LAUNCH VEHICLE:

INTERNAL (SEQ BAYS)
VOLUME: 15 CUBIC FEET
WEIGHT: 215 POUNDS
THERMAL: 20°F TO 160°F DURING FLIGHT

EXTERNAL (FUEL CASK)
WEIGHT: 65 POUNDS
THERMAL: < 100 BTU/HR INPUT TO LM

ENVIRONMENTAL
VIBRATION: LAUNCH, BOOST, AND LUNAR DESCENT

LUNAR SURFACE
TEMPERATURE: 300°F TO 750°F
VACUUM: < 10^-12 TORR

DUSTY MOON 7759-5101
ALSEP FLIGHT ASSIGNMENTS

APOLLO 11  EASEP
APOLLO 12  ARRAY A
APOLLO 13  ARRAY B
APOLLO 14  ARRAY C
APOLLO 15  ARRAY A-2
APOLLO 16  ARRAY D

ARRAY A

CONFIGURATION DESCRIPTION
STOWED CONFIGURATION

ALSEP IN STOWED CONFIGURATION
LSM-STOWED CONFIGURATION
ALSEP SUBPACKAGE NO. 2

7759-5116
SUBPACKAGE NO. 2
SPECIAL TOOLS

CASK DOWEL TOOL
(PART OF ELECTRICAL POWER SUBSYSTEM)

UHL 0.53 LB EACH

FLAT

MAST 1.0 LB
TOTAL (ONE HALF SHOWN)

ALL WEIGHTS ARE EARTH LB
14.6 LB CASK MOUNT & INSULATION, PART OF STRUCTURE THERMAL SUBSYSTEM, COVERED UNDER ELECTRICAL POWER SUBSYSTEM

7759-5123
FUEL CASK SUPPORT ASSEMBLY

CASK/BAND ASSY

HEAT SHIELD ASSY

SUPPORT STRUCTURE ASSY

7759-5127

CASK ROTATION DETAILS

CASK ROTATION LANYARD

GEARBOX

7759-5128

1-23
ALSEP MISSION
PROFILE

PRELAUNCH PHASE
ARRAY A

KSC ALSEP INTEGRATION
INSTALLATION IN LUNAR MODULE
RTG CASK LOADING
INSTALLATION IN LUNAR MODULE

- SLIDE IN
- LIFT AND INSERT PIP PINS
- CLOSE THERMAL DOOR

RTG CASK LOADING

7759-5131

7759-5132
ALSEP DEPLOYMENT TIMELINE

- KEY TO MISSION PLANNING

- THIS TIMELINE IS FOR REFERENCE ONLY - THE FINAL TIMELINE WILL CONFORM TO THE FLIGHT PLAN

- ALSEP I TIMELINE, 2-MAN EVA

LEGEND:

--- EVENT LINE

TEAM ACTIVITY. BOTH EVA CREWMEN REQUIRED TO ACCOMPLISH A GIVEN TASK

COUPLED ACTIVITY. BOTH CREW MEMBERS ARE WORKING ON RELATED TASKS AND ARE IN VOICE COMM WITH EACH OTHER. VISUAL CONTACT BETWEEN CREWMEN IS HIGHLY DESIRABLE BUT NOT MANDATORY

UNCOPLED ACTIVITY. CREW MEMBERS WORKING ON UNRELATED TASKS AND PROCEEDING INDEPENDENTLY

7759-5133

LUNAR SURFACE ACTIVITY

ALSEP DEPLOYMENT TASKS ASSOCIATED WITH LM

\{ \}

- REMOVE PACKAGES
- TRANSFER FUEL
- PREPARE FOR TRAVERSE

ALSEP DEPLOYMENT TASKS AT EXPERIMENT SITE

\{ \}

- DEPLOY CENTRAL STATION
- DEPLOY ANTENNA
- DEPLOY EXPERIMENTS

7759-5134
## ACTIVITY TIMELINE (CONT.)

<table>
<thead>
<tr>
<th>TIME</th>
<th>COMPONENTS IN USE</th>
<th>DESCRIPTION</th>
<th>REASON</th>
<th>CWS END</th>
<th>CWS BEGIN</th>
<th>ICON</th>
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*Please note: The table above represents a sample activity timeline. Actual timelines may vary based on specific requirements and conditions.*
# Activity Timeline (Cont.)

<table>
<thead>
<tr>
<th>MIN.</th>
<th>MEC.</th>
<th>Commander Activity</th>
<th>LM Pilot Activity</th>
<th>MEC. &amp; Remarks</th>
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<tbody>
<tr>
<td>01:24</td>
<td></td>
<td>Continue slowin...</td>
<td>Rotate PKG #2...</td>
<td></td>
</tr>
<tr>
<td>02:25</td>
<td></td>
<td>Monitor for safety</td>
<td>Rotate fuel...</td>
<td></td>
</tr>
<tr>
<td>03:52</td>
<td></td>
<td>&amp; supply tools</td>
<td>Remove fuel...</td>
<td>(Transfer fuel)</td>
</tr>
<tr>
<td>07:33</td>
<td></td>
<td>Retrieve sub...</td>
<td>Assemble barbell</td>
<td></td>
</tr>
<tr>
<td>13:48</td>
<td></td>
<td>Report: Start of traverse</td>
<td>Carry barbell</td>
<td></td>
</tr>
</tbody>
</table>

**RTG Fueling**

[Diagram of RTG fueling process]

- Cask in flight position
- Removal position (adjustable by astronaut)
- Thermal shield
- REHAE latch (lanyard operated)
- Mounting & structure
- LM interface fittings (gumman)
- Rotation mechanism (lanyard operated)

---

*7759-5140*
PREPARE FOR TRAVERSE
PREPARE FOR TRAVERSE
<table>
<thead>
<tr>
<th>MIN.: SEC</th>
<th>COMMANDER ACTIVITY</th>
<th>LM PILOT ACTIVITY</th>
<th>NDC &amp; REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:46</td>
<td>Temporarily emplace subpallet &amp; attach (14 sec)</td>
<td>Deploy mast PKG #1 (2 sec)</td>
<td></td>
</tr>
<tr>
<td>13:46</td>
<td>Rotate pkg #2 (9 sec)</td>
<td>Monitor for safety (deploy central station)</td>
<td></td>
</tr>
<tr>
<td>13:50</td>
<td>Deploy pkg #2 (10 min 3 sec)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:12</td>
<td>Report, ammeter reading</td>
<td></td>
<td>Ack &amp; log pet-zero</td>
</tr>
<tr>
<td>15:13</td>
<td>Connect pkg to cent sta (92 sec)</td>
<td>Remove, stow cable &amp; connect cable (9 sec)</td>
<td></td>
</tr>
<tr>
<td>15:13</td>
<td>Disconnect &amp; stow mast (58 sec)</td>
<td>Activate reg sw (2 sec)</td>
<td></td>
</tr>
<tr>
<td>16:11</td>
<td></td>
<td>Begin reg sw on</td>
<td></td>
</tr>
<tr>
<td>16:49</td>
<td>Rotate pkg #1 (14 sec)</td>
<td>Deploy PSF stool (9 sec)</td>
<td></td>
</tr>
<tr>
<td>16:50</td>
<td></td>
<td></td>
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### ACTIVITY TIMELINE (CONT.)

<table>
<thead>
<tr>
<th>MIN: SEC</th>
<th>COMMANDER ACTIVITY</th>
<th>LM PILOT ACTIVITY</th>
<th>MCC &amp; REMARKS</th>
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<tbody>
<tr>
<td>19:24</td>
<td>RELEASE SW5 132 SEC</td>
<td>DEPLOY SW5 131 MIN 27 SEC</td>
<td>N/A</td>
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<tr>
<td></td>
<td>RELEASE PSE 132 SEC</td>
<td>DEPLOY FSH 131 MIN 00 SEC</td>
<td>N/A</td>
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<tr>
<td></td>
<td>REMOVE LSM 154 SEC</td>
<td>DEPLOY SW5 131 MIN 02 SEC</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>RELEASE S/SHIELD BD MIN</td>
<td>DEPLOY SW5 131 MIN 02 SEC</td>
<td>N/A</td>
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<tr>
<td></td>
<td>DEPLOY S/SHIELD 191 SEC</td>
<td>DEPLOY SW5 131 MIN 02 SEC</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>ASSEMBLE ANTENNA BD MIN</td>
<td>DEPLOY SW5 131 MIN 02 SEC</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>CAPTAIN AZ/EL SETTING BD MIN 00 SEC</td>
<td>UNMOUNT AZ/EL SETTING</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>INITIATE SW 1</td>
<td>ORTAIN HERBIC PHOTOGRAPH OF DEPLOYED A/S</td>
<td>N/A</td>
</tr>
<tr>
<td>19:29</td>
<td>REMOVE RISER ON IF A/S P Does NOT RESPOND ACTIVATE SW 2 AND SW 3</td>
<td>CARRY 55 FT PLACE ON SURFACE DEPLOY GROUND SCREEN</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>REPORT SW POSITIONS</td>
<td>CARRY 55 FT PLACE ON SURFACE DEPLOY GROUND SCREEN</td>
<td>N/A</td>
</tr>
<tr>
<td>20:00</td>
<td>RETURN TO LEM</td>
<td>RETURN TO LEM</td>
<td>N/A</td>
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### DEPLOY EXPERIMENTS

<table>
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<tr>
<th>SWS</th>
<th>PSE</th>
<th>LSM</th>
<th>SIDE</th>
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<tbody>
<tr>
<td>CARRY 13 FT EXTEND LEVELING LEGS PLACE ON SURFACE (PARTIALLY SELF-LEVELING) ALIGN BY SHADOWS</td>
<td>CARRY 10 FT REMOVE GIRDLIE PLACE ON STOOL UNFOLD S/SHIELD LEVEL BY BALL INDICATOR READ ALIGNMENT BY GNOMON SHADOW</td>
<td>CARRY 50 FT DEPLOY SUPPORT LEGS PLACE ON SURFACE UNFOLD SENSOR ARMS REMOVE PRA COVERS LEVEL BY BUBBLE ALIGN BY SHADOWGRAPH READ SHADOWGRAPH ALIGNMENT</td>
<td>CARRY 55 FT PLACE ON SURFACE DEPLOY GROUND SCREEN RELEASE CC1G EMPLACE SIDE ON GROUND SCREEN EMPLACE CC1G LEVEL BY BUBBLE ALIGN BY SHADOWS</td>
</tr>
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</table>
CENTRAL STATION ERECTION
ANTENNA ALIGNMENT ON APOLLO 12
ARRAY B

CONFIGURATION DESCRIPTION

ALSEP SUBPACKAGE (ARRAY B)
ERECTED ARRAY B
CENTRAL STATION
CABLE REEL

CPLEE REMOVAL

ASTRONAUT:
- RELEASES FASTENERS
- INSERTS UHT
- LIFTS EXPERIMENT
- REMOVES UHT SOCKET PIN
- RotateS EXPERIMENT

EXPERIMENT INVERTED

CABLE REEL

MOUNTING FITTINGS

SUNSHIELD

UHT SOCKET

180° ROTATION

7759-5163
ARRAY B SUBPACKAGE 2
MISSION PROFILE
UNIQUE TO ARRAY B

PRELAUNCH PHASE
SAME AS ARRAY A PLUS ALSO INSTALLATION
(RECHARGED BATTERY) AT F-12 HOURS

LUNAR SURFACE ACTIVITY
CPLEE DEPLOYMENT
HFE DEPLOYMENT
CCGE DEPLOYMENT
DRILLING OPERATIONS

ARRAY C
CONFIGURATION DESCRIPTION
## LANDING SITES

<table>
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<th>Mission</th>
<th>Location</th>
<th>Longitude</th>
<th>Latitude</th>
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<tr>
<td>APOLLO 11</td>
<td>SEA OF TRANQUILITY</td>
<td>34 E</td>
<td>3 N</td>
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<tr>
<td>APOLLO 12</td>
<td>OCEAN OF STORMS</td>
<td>42 W</td>
<td>3 S</td>
</tr>
<tr>
<td>APOLLO 13</td>
<td>FRA MAURO</td>
<td>17 W</td>
<td>4 S</td>
</tr>
<tr>
<td>APOLLO 14</td>
<td>LITTROW</td>
<td>29 E</td>
<td>22 N</td>
</tr>
<tr>
<td>APOLLO 15</td>
<td>DAVEY RILLE</td>
<td>6 W</td>
<td>11 S</td>
</tr>
<tr>
<td>APOLLO 16</td>
<td>MARIUS HILLS</td>
<td>56.5 W</td>
<td>14.5 N</td>
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<td>APOLLO 17</td>
<td>DECARTE</td>
<td>16 E</td>
<td>10 S</td>
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<td>APOLLO 18</td>
<td>COPERNICUS</td>
<td>20 W</td>
<td>10 N</td>
</tr>
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<td>APOLLO 19</td>
<td>HADLEY APENNINES</td>
<td>2 E</td>
<td>25 N</td>
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## STOWED CONFIGURATION

![Stowed Configuration Diagram](7759-51718)

![Suprathermal Ion Detector](ALSEP 4)

- THUMPER ASSEMBLY
- CPLEE
- PASSIVE SEISMIC EXPERIMENT
- ANTENNA

**PACKAGE NO. 2**
- RTG
- ALHT CARRIER
- ANTIENNA
- AIMING MECHANISM
- MORTAR BOX

**PACKAGE NO. 1**
- SUBPACKAGES NO. 1
- SUBPACKAGES NO. 2
ALSEP SUBPACKAGE NO. 1

THERMAL MODS FOR ARRAY C

SUNSHIELD
(PART OF STRUCTURE)

CURTAIN
RERAINTS (3)

REAR CURTAIN

REFlEC1R

SIDE
CURTAINS

THERMAL PLATE

THERMAL BAG

INSULATION MASKS

PRIMARY
STRUCTURE
(REF)
ASE MORTAR BOX
ALSEP ARRAY "D"

Configuration Description

EASEP

SUBPACKAGE NO. 1

SUBPACKAGE NO. 2

7759-5180
EASEP/ALSEP HISTORY AND PLAN

JUNE 1965 - WOODS HOLE CONFERENCE ESTABLISHED SCIENTIFIC GOALS
JULY 1965 - FALMOUTH CONFERENCE Screened SCIENTIFIC PROPOSALS

APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE (ALSEP)

AUG 1965 - NASA STARTED PRELIMINARY DESIGNS (THREE CONTRACTORS)
MARCH 1966 - START OF DEVELOPMENT PROGRAM TO BUILD FOUR FLIGHT ARTICLES (BENDIX PRIME CONTRACTOR)
JULY 1968 - DELIVERY OF FIRST FLIGHT ARTICLE
OCT 1968 - DELIVERY OF SECOND FLIGHT ARTICLE

EARLY APOLLO SCIENTIFIC EXPERIMENT PAPLOAD (EASEP)

OCT 1968 - START OF EASEP DEVELOPMENT USING PARTS OF SECOND ALSEP PLUS NEW EQUIPMENT

THIS SIMPLIFIED PACKAGE WILL ALLOW THE ASTRONAUTS TO CONCENTRATE ON MAKING A SAFE LUNAR TRIP AND WILL PRODUCE IMPORTANT SCIENTIFIC DATA LONG AFTER THE FLIGHT

PLANNED MISSION ASSIGNMENTS

APOLLO 11: EASEP
APOLLO 12: ALSEP A  CONTAIN 8 DIFFERENT EXPERIMENTS
APOLLO 13: ALSEP B
APOLLO 14: ALSEP C  SETS OF 4/FLIGHT

7759-5181B

EASEP STOWED CONFIGURATION

SOLAR PANEL ARRAY
PSE
ANTENNA
PASSIVE SEISMIC EXPERIMENT
ISOTOPE HEATER
DEPLOYMENT HANDLE
LASER RANGING RETRO-REFLECTOR
TILTING HANDLE
RETO-REFLECTOR ARRAY
7759-5182
LUNAR SURFACE PHASE

- REMOVE PSEP
- TRAVERSE
- REMOVE LRRR
- DEPLOY PSEP
- DEPLOY LRRR

1-77
DEPLOYING EASEP
### ALSEP FLIGHT 1 RELIABILITY

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<th>SUBSYSTEM</th>
<th>RELIABILITY GOAL</th>
<th>CURRENT RELIABILITY PREDICTION</th>
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<tr>
<td>POWER</td>
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<tr>
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<td>0.9642</td>
<td>0.8768</td>
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<td>0.9926</td>
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<tr>
<td>PASSIVE SEISMIC</td>
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<tr>
<td>MAGNETOMETER</td>
<td>0.9900</td>
<td>0.7644*</td>
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<tr>
<td>SOLAR WIND</td>
<td>0.9900</td>
<td>0.8543*</td>
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<tr>
<td>SIDE/CCGE</td>
<td>0.9900</td>
<td>0.8803*</td>
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*GFE PREDICTIONS FURNISHED BY NASA.

### ALSEP FLIGHT 1

#### SUBSYSTEM FIGURE OF MERIT

<table>
<thead>
<tr>
<th>SUBSYSTEM</th>
<th>PROBABILITY OF SUCCESS 12 MONTH OPERATION</th>
<th>FIGURE OF MERIT 12 MONTH OPERATION</th>
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<tr>
<td>ELECTRICAL POWER SUBSYSTEM</td>
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<td>0.965811</td>
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7759-5196
ALSEP ARRAY A (FLT 1)
LUNAR PERFORMANCE INCENTIVES

TOTAL.Points.Available
- Central Mission
- Receipt of Initial Data
- Continuous Data: 3
- Final Turnoff
- Passive Seismic
- Continuous Operation
- Initial Data
- ESR Initial Data
- Park/Package Initial Data
- Park/Package Operation
Total 17

ALSEP FLIGHT 1 PROBABILITY OF SUCCESSFULLY OBTAINING SCIENTIFIC DATA ON EARTH
Section 2

Alsep Power System
## RTG/ASTRONAUT INTERFACE

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<th>Constraint</th>
<th>Resolution</th>
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</thead>
<tbody>
<tr>
<td><strong>Thermal:</strong></td>
<td>• Thermal barrier (small door) protection while at seq bay</td>
</tr>
<tr>
<td>• No suit contact with</td>
<td>• Lanyards for cask rotation &amp; dome lock</td>
</tr>
<tr>
<td>surfaces more than 250°F</td>
<td>• Tool for dome removal</td>
</tr>
<tr>
<td>• Minimize heat load on suit</td>
<td>• Tool for fuel transfer, cask to generator</td>
</tr>
<tr>
<td>Cooling equip</td>
<td>• Subpackage 2 carry places RTG away from suit</td>
</tr>
<tr>
<td><strong>Nuclear:</strong></td>
<td>• Pu 238 is α emitter</td>
</tr>
<tr>
<td>• No hazardous dose</td>
<td>• α particles are entirely absorbed in heat generation</td>
</tr>
<tr>
<td></td>
<td>• Only secondary types (γ &amp; neutrons) get out</td>
</tr>
<tr>
<td></td>
<td>• Low external field, very low dose level</td>
</tr>
<tr>
<td><strong>Electrical:</strong></td>
<td>• RTG cable has shorting switch in connector</td>
</tr>
<tr>
<td>• No exposed charged contacts</td>
<td>• Astronaut reads ammeter, removes dust covers, engages connector, &amp; activates switch</td>
</tr>
</tbody>
</table>

### Operations
- Prepare cask for transfer, 2 min; transfer fuel capsule cask to generator, 1 min; deploy subpackage 2, unree cable & make connection, 2 min (all times are approx).

---

## FUEL CASK DESIGN CONSTRAINTS

### Cask & Capsule Design

- Classical aero-dynamic shape
- Graphite material

### System Requirement

- Envelope restrictions
- Difficulty to grasp
- No metallic protrusions or attachments
- No indentations
- Low coefficient of thermal expansion ($1.0 \times 10^{-6}$)
- Weight: 42 lb
- Negligible load carrying capability.

### System Design

- Design limited by SLA withdrawal envelope
- Basket design with adjustable bands
- Adjustable bands
- Increased structural members (size and number)
- Same GAEC interface
- Allowable load paths to LM and load points of cask were accommodated by basket design, longitudinal structural members and addition of linkage in vertical plane.
ICS DEPLOYMENT REQUIREMENTS

<table>
<thead>
<tr>
<th>TASK</th>
<th>MAX FORCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUNNION RELEASE</td>
<td>20 LB</td>
</tr>
<tr>
<td>SPLINE RELEASE</td>
<td>20 LB</td>
</tr>
<tr>
<td>TILT FUNCTION</td>
<td></td>
</tr>
<tr>
<td>LOWER AND RAISE</td>
<td>20 LB</td>
</tr>
<tr>
<td>DRT ENGAGEMENT</td>
<td>20 LB</td>
</tr>
<tr>
<td>DOME REMOVAL</td>
<td>80 IN · LB</td>
</tr>
<tr>
<td>CAPSULE REMOVAL</td>
<td>20 IN · LB</td>
</tr>
</tbody>
</table>

ALSEP/CASK/LM INTERFACE SPECIFICATION REQUIREMENTS VERSUS QUALIFICATION TEST RESULTS

<table>
<thead>
<tr>
<th>INTERFACE SPECIFICATION</th>
<th>SPECIFICATION REQUIREMENT</th>
<th>TEST RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. MAXIMUM FUEL CASK SURFACE TEMPERATURE</td>
<td>BXA/GE</td>
<td>≤ 830°F</td>
</tr>
<tr>
<td>2. MAXIMUM FUEL CASK CIRCUMFERENTIAL TEMP GRADIENT</td>
<td>BXA/GE</td>
<td>≤ 150°F</td>
</tr>
<tr>
<td>3. MAXIMUM HEAT LEAK TO LM</td>
<td>BXA/GE</td>
<td>≤ 100 BTU/HR</td>
</tr>
<tr>
<td>4. MAXIMUM LM SKIN SURFACE TEMPERATURE (EXCEPT ASTRONAUT THERMAL DOOR)</td>
<td>BXA/GAEC</td>
<td>≤ 270°F</td>
</tr>
<tr>
<td>5. ASTRONAUT THERMAL DOOR TEMPERATURE</td>
<td>BXA/GAEC</td>
<td>≤ 420°F</td>
</tr>
<tr>
<td>6. MAXIMUM CASK THERMAL SHIELD TEMPERATURE</td>
<td>BXA</td>
<td>≤ 600°F</td>
</tr>
<tr>
<td>7. MINIMUM AVERAGE FUEL CASK SURFACE TEMPERATURE DURING CASK COOLING</td>
<td>BXA/GE</td>
<td>≥ 125°F</td>
</tr>
<tr>
<td>8. MAXIMUM AVERAGE FUEL CASK SURFACE TEMPERATURE DURING CASK COOLING</td>
<td>BXA/MSC</td>
<td>≤ 300°F</td>
</tr>
<tr>
<td>9. ASTRONAUT PROTECTION GUARD</td>
<td>BXA/MSC</td>
<td>≤ 250°F</td>
</tr>
</tbody>
</table>

*FOR FLOW RATE RANGE BETWEEN 15 TO 35 LB/MIN

7759-6209
FUEL CASK AND MOUNTING

REQUIREMENTS: LESS THAN 100 BTU/Hr TO LM & LM SKIN 270°F MAX

CASK IN FLIGHT POSITION SIZE, IN.
8 DIAM x 23 HIGH
25 LB

REMOVAL POSITION ADJUSTABLE BY ASTRONAUT

THERMAL SHIELD 2.8 LB
RELEASE LATCH (LANYARD OPERATED)

MOUNTING & STRUCTURE 11.92 LB
LM INTERFACE FITTINGS (GRUMMAN)

ROTATION MECHANISM (LANYARD OPERATED)

SUMMARY OF EARTH WT

<table>
<thead>
<tr>
<th>POWER SYSTEM</th>
<th>STRUCTURE THERMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE 27608</td>
<td>THERMAL SHIELD 2.8</td>
</tr>
<tr>
<td>NOT INC.</td>
<td>LB R.</td>
</tr>
<tr>
<td>25 LB FUEL</td>
<td>MOUNTING &amp; STRUCTURE 11.92 LB</td>
</tr>
<tr>
<td>CAPSULE</td>
<td>WDS &amp; STRUCTURE 52 LB</td>
</tr>
<tr>
<td></td>
<td>METAL PIPING PROJECT 5.29</td>
</tr>
<tr>
<td></td>
<td>TOTAL 20.0 LB</td>
</tr>
</tbody>
</table>

OPERATIONS

- RELEASE SUTCHES AND DOME LOCK, ROTATE CASK
- UNSCREW DOME LOCK AND CAPSULE RELEASE LATCH
- UNSCREW DOME, REMOVING DOME:
- TRANSFER FUEL CAPSULE TO FUEL TRANSFER TOOL
- APPRovan TIME 3 MIN, INC IN PRE-TRAVERSE TOTAL

7759-5820

RTG CUTAWAY

HOT FRAME
FUEL CAPSULE ASSEMBLY
OUTER CASE (COLD FRAME) ASSEMBLY
END PLATE OF FUEL CAPSULE
HERMETIC SEAL
THERMOELECTRIC COUPLE ASSEMBLY
HEAT REJECTION FINS
MOUNTING LUG

7759-5821

a-3
SUBPACKAGE 2-RTG AND RTG CABLE REEL
TRUNNION RELEASE MECHANISM

TEST SEQUENCE

1. PROTO MODEL
   VIBRATION
   THERMAL VACUUM
   TILT TEST

2. D2 MODELS (QUAL & FLIGHT)
   WEIGHT & C.G.
   VIBRATION

3. QUALIFICATION MODEL
   ACCEPTANCE TESTING
   WEIGHT & C.G.
   VIBRATION
   TILT TEST

7759-6201
TEST SEQUENCE (CONT')

3. QUALIFICATION MODEL (CONT')

QUALIFICATION TESTING

ON-PAD COOLING SIMULATION
THERMAL VAC
LAUNCH AND BOOST VIBRATION
LUNAR DECENT VIBRATION & SHOCK
FUNCTIONAL TILT TEST

4. FLIGHT MODELS

WEIGHT & C.G.
VIBRATION
TILT TEST

ACCEPTANCE TEST PROGRAM OUTLINE

<table>
<thead>
<tr>
<th>FLIGHT 1</th>
<th>COMPLETION DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RECEIVING INSPECTION</td>
<td>20 DECEMBER 1968</td>
</tr>
<tr>
<td>2. ALIGNMENT AND ASSEMBLY</td>
<td>31 JANUARY 1969</td>
</tr>
<tr>
<td>3. WEIGHT AND C.G. MEASUREMENTS</td>
<td>4 FEBRUARY 1969</td>
</tr>
<tr>
<td>4. LAUNCH VIBRATION</td>
<td>6 FEBRUARY 1969</td>
</tr>
<tr>
<td>5. FUNCTIONAL TILT TEST, NO. 1</td>
<td>6 FEBRUARY 1969</td>
</tr>
<tr>
<td>6. INSPECTION</td>
<td>10 FEBRUARY 1969</td>
</tr>
<tr>
<td>7. FUNCTIONAL TILT TEST, NO. 2</td>
<td>4 JUNE 1969</td>
</tr>
</tbody>
</table>
FLIGHT 1 BU

1. REceiving Inspection 24 February 1969
2. Alignment and Assembly 26 February 1969
3. Weight and C.G. Measurements 27 February 1969
4. Launch Vibration 5 March 1969
5. Functional Tilt Test, No. 1 5 March 1969
6. Inspection 6 March 1969
7. Functional Tilt Test, No. 2 9 June 1969

FLIGHT 2

1. REceiving Inspection 1 April 1969
2. Alignment and Assembly 4 April 1969
3. Launch Vibration 8 April 1969
4. Functional Tilt Test, No. 1 8 April 1969
5. Inspection 10 April 1969
6. Weight and C.G. Measurements 10 April 1969
7. Functional Tilt Test, No. 2 11 June 1969
## ACCEPTANCE TEST PROGRAM OUTLINE (CONT')

### FLIGHT 3

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>RECEIVING INSPECTION</td>
<td>9 APRIL 1969</td>
</tr>
<tr>
<td>2</td>
<td>ALIGNMENT AND ASSEMBLY</td>
<td>11 APRIL 1969</td>
</tr>
<tr>
<td>3</td>
<td>LAUNCH VIBRATION</td>
<td>15 APRIL 1969</td>
</tr>
<tr>
<td>4</td>
<td>FUNCTIONAL TILT TEST, NO. 1</td>
<td>15 APRIL 1969</td>
</tr>
<tr>
<td>5</td>
<td>INSPECTION</td>
<td>16 APRIL 1969</td>
</tr>
<tr>
<td>6</td>
<td>WEIGHT AND C.G. MEASUREMENTS</td>
<td>21 APRIL 1969</td>
</tr>
<tr>
<td>7</td>
<td>FUNCTIONAL TILT TEST, NO. 2</td>
<td>17 JUNE 1969</td>
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### FLIGHT 4

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<td>1</td>
<td>RECEIVING INSPECTION</td>
<td>22 APRIL 1969</td>
</tr>
<tr>
<td>2</td>
<td>ALIGNMENT AND ASSEMBLY</td>
<td>23 APRIL 1969</td>
</tr>
<tr>
<td>3</td>
<td>LAUNCH VIBRATION</td>
<td>24 APRIL 1969</td>
</tr>
<tr>
<td>4</td>
<td>FUNCTIONAL TILT TEST, NO. 1</td>
<td>25 APRIL 1969</td>
</tr>
<tr>
<td>5</td>
<td>INSPECTION</td>
<td>29 APRIL 1969</td>
</tr>
<tr>
<td>6</td>
<td>WEIGHT AND C.G. MEASUREMENTS</td>
<td>29 APRIL 1969</td>
</tr>
<tr>
<td>7</td>
<td>FUNCTIONAL TILT TEST, NO. 2</td>
<td>17 JUNE 1969</td>
</tr>
</tbody>
</table>
VIBRATION SAFETY ENCLOSURE Z AXIS

VIBRATION SAFETY ENCLOSURE X AND Y AXIS
ACA QUAL LEVEL SINE WAVE VIBRATION
LUNAR DESCENT PHASE

ACA QUAL LEVEL RANDOM VIBRATION
LUNAR DESCENT PHASE
HALF SINE SHOCK PULSE CONFIGURATION AND ITS TOLERANCE LIMITS (+X, ±Y, ±Z DIRECTION)

![Diagram of shock pulse configuration with tolerance limits](image)

(ACA) INTERFACE THERMAL SPECIFICATION REQUIREMENTS VS. QUALIFICATION TEST RESULTS

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SPECIFICATION</th>
<th>ITEM</th>
<th>MAXIMUM SPECIFICATION VALUE</th>
<th>TEST RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. FUEL CASK SURFACE TEMP</td>
<td>BXA/GE</td>
<td>CASK</td>
<td>≤350°F</td>
<td>350°F</td>
</tr>
<tr>
<td>2. FUEL CASK CIRCUMFERENTIAL TEMP GRADIENT</td>
<td>BXA/GE</td>
<td>CASK</td>
<td>≤150°F</td>
<td>150°F</td>
</tr>
<tr>
<td>3. HEAT LEAK TO LM</td>
<td>BXA/GE/GAEC</td>
<td>LM</td>
<td>&lt;100 BTU/HR</td>
<td>33 BTU/HR</td>
</tr>
<tr>
<td>4. LM SKIN SURFACE TEMP</td>
<td>BXA/GE/GAEC</td>
<td>LM</td>
<td>≤270°F</td>
<td>256°F</td>
</tr>
<tr>
<td>5. ASTRONAUT THERMAL DOOR TEMP</td>
<td>BXA/GE/GAEC</td>
<td>LM</td>
<td>≤450°F</td>
<td>432°F</td>
</tr>
<tr>
<td>6. ACA THERMAL SHIELD TEMP</td>
<td>BXA/GE/GAEC</td>
<td>LM</td>
<td>≤600°F</td>
<td>598°F</td>
</tr>
<tr>
<td>7. MINIMUM AVERAGE FUEL CASK SURFACE TEMP DURING CASK COOLING</td>
<td>BXA/GE</td>
<td>CASK COOLING</td>
<td>≥125°F</td>
<td>101°F</td>
</tr>
<tr>
<td>8. FUEL CASK SURFACE TEMP DURING CASK COOLING</td>
<td>BXA/GE/GAEC</td>
<td>LM</td>
<td>≤350°F</td>
<td>195°F</td>
</tr>
<tr>
<td>9. ASTRONAUT PROTECTION GUARD</td>
<td>BXA/GE/GAEC</td>
<td>LM</td>
<td>≤250°F</td>
<td>195°F</td>
</tr>
</tbody>
</table>
ALSEP CASK ASSEMBLY
THERMAL QUALIFICATIONS TEST PROGRAM

PRELAUNCH CASK COOLING
10 FLOW TESTS
FLOW RATES 15 TO 35 LB/MIN
PURGE TEMPERATURE 80 TO 130°F
NOZZLE PRESSURE .12 TO .64 PSI

EARTH ORBIT WITH SLA ON AND MAX SOLAR HEATING
SLA TEMP 250°F
CHAMBER PRESSURE 1 X 10\(^{-6}\) TORR
CRYOWALL -300°F
10-HOUR T/V TEST

ACV THERMAL QUALIFICATION TEST PROGRAM (CONT’)

TRANSLUNAR FLIGHT WITH SLA OFF AND MAX SOLAR HEATING
SOLAR INPUT 130 WATTS/FT\(^2\)
CHAMBER PRESSURE 1 X 10\(^{-6}\) TORR
CRYOWALL -300°F
36-HR T/V TEST

TRANSLUNAR FLIGHT WITH SLA OFF AND NO SOLAR HEATING
NO SOLAR INPUT
CHAMBER PRESSURE 1 X 10\(^{-6}\) TORR
CRYOWALL -300°F
36-HR T/V TEST

7759-6221
SLA OFF T/V TEST WITH ACA AND IR SOLAR ARRAY
CASK COOLING NOZZLE INSIDE SLA/LM THERMAL CANISTER
SUMMARY OF AIR SOAK AND THERMAL/VACUUM RESULTS

SUMMARY OF ALSEP CASK ASSEMBLY MAXIMUM TEMPERATURES DURING PRELAUNCH FLIGHT AND LUNAR DEPLOYMENT, °F

<table>
<thead>
<tr>
<th>Item</th>
<th>PreLaunch</th>
<th>Flight</th>
<th>Deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CASK SURFACE</td>
<td>200° ± 40°</td>
<td>830°</td>
<td>820°</td>
</tr>
<tr>
<td>2. CASK DOMES</td>
<td>160°</td>
<td>600°</td>
<td>590°</td>
</tr>
<tr>
<td>3. CAPSULE SURFACE</td>
<td>1250°</td>
<td>1400°</td>
<td>1400°</td>
</tr>
<tr>
<td>4. CIRCUMFERENTIAL BANDS</td>
<td>200° ± 40°</td>
<td>750°</td>
<td>730°</td>
</tr>
<tr>
<td>5. THERMAL SHIELD, FRONT</td>
<td>95°</td>
<td>600°</td>
<td>580°</td>
</tr>
<tr>
<td>6. THERMAL SHIELD, REAR</td>
<td>80°</td>
<td>230°</td>
<td>225°</td>
</tr>
<tr>
<td>7. LM THERMAL DOOR</td>
<td>80°</td>
<td>430°</td>
<td>420°</td>
</tr>
<tr>
<td>8. ACA ASTRONAUT GUARD</td>
<td>90°</td>
<td>105°</td>
<td>105°</td>
</tr>
</tbody>
</table>

*VARIATION DUE TO CASK COOLING FLOWRATE RANGE.
ACA PRELAUNCH COOLING REQUIREMENTS
COMPARED TO APOLLO 12
PERFORMANCE RESULTS

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SPECIFICATION</th>
<th>APOLLO 12 RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASK SURFACE TEMPERATURE, °F</td>
<td>&lt; 350</td>
<td>185 TO 200</td>
</tr>
<tr>
<td>ACA SENSOR TEMPERATURE, °F</td>
<td>&lt; 300</td>
<td>150 TO 165</td>
</tr>
<tr>
<td>I.U. FLOWRATE (MIN), LB/MIN</td>
<td>180</td>
<td>210</td>
</tr>
<tr>
<td>I.U. INLET TEMPERATURE, °F</td>
<td>55 TO 130</td>
<td>60 TO 120</td>
</tr>
<tr>
<td>CASK COOLING NOZZLE PRESSURE, PSI</td>
<td>0.30</td>
<td>0.42</td>
</tr>
<tr>
<td>CASK COOLING NOZZLE FLOWRATE, LB/MIN</td>
<td>18.2</td>
<td>28</td>
</tr>
</tbody>
</table>

ACA TEMPERATURES DURING PRELAUNCH CASK COOLING

<table>
<thead>
<tr>
<th>Supply Temp °F</th>
<th>Compartment Temp °F</th>
<th>CASK SURFACE</th>
<th>BAND SENOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>130</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>140</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL I.U. MANIFOLDED INLET FLOWRATE lb/min

7759-6231

2-23
ACA TEMPERATURES FOR PREDICTED CASK COOLING I.U. OPERATING RANGE

APOLLO 12 ACA CASK COOLING PERFORMANCE (CDDT)
ACA TRANSIENT TEMPERATURE RISE AFTER REMOVAL OF AIR FLOW

SUBPACKAGE 2 THERMAL INTERFACE REQUIREMENTS AND CONSTRAINTS

- PASSIVE THERMAL DESIGN AND INTEGRATION
- NONOPERATING TEMPERATURES IN LM 0 TO 160°F
- RTG THERMAL DISSIPATION 1500 WATTS
- RTG COLD FRAME TEMPERATURE 400°F TO 500°F
- HEAT LEAK FROM RTG TO PALLET 20 TO 30 WATTS
- RTG BLOCKAGE BY ALSEP EQUIPMENT <4%
- PALLET 2 LUNAR OPERATIONAL TEMPERATURES -300°F TO 450°F
- MAXIMUM CREW TOUCH TEMPERATURE 250°F
SUMMARY OF SUBPACKAGE 2 KEY THERMAL CONTROL DESIGN FEATURES

• PALLET
  - FLEXIBLE, LOW THERMAL CONDUCTANCE MOUNT
  - THIN HONEYCOMB ALUMINUM SKINS
  - HIGH TEMP., LOW W/mK = (.2/.9) Z-93 WHITE COATING
  - CLEAN PALLET UPPER SURFACE AFTER DEPLOYMENT

• SUBPALLET
  - REMOVABLE SUBPALLET WITH EQUIPMENT
  - WHITE COATING ON EXTERNAL SURFACE
  - MINIMUM CREW TASKS NEAR RTC DURING WARM UP
  - DURABLE LOW 'V4 3M 401 WHITE COATINGS ON TOOLS
  - MINIMUM CROSS SECTION AREA, MAXIMUM LENGTH ON TOOLS
  - REFLECTIVE GOLD FINISH ON FTT FACING CAPSULE END PLATE
  - HIGH TEMPERATURE IRON TITANITE COATING (.85/-.85)

• CREW TOOLS (DRT, FTT AND UHT)

• RTG

• ANTENNA, HOUSING, CARRY BAR, CABLE REEL AND MISC. EQUIPMENT

DURABLE 3M WHITE THERMAL COATING

SUMMARY OF RADIATIVE PROPERTIES OF SURFACES ON SUBPACKAGE NO. 2 THERMAL MODELS

<table>
<thead>
<tr>
<th>Surface Location</th>
<th>iΩ</th>
<th>ε</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pallet Assembly</td>
<td>.5</td>
<td>0</td>
<td>Iron Tidne</td>
</tr>
<tr>
<td>Apoll Lunar Tool</td>
<td>.5</td>
<td>0</td>
<td>3M 401 White Paint</td>
</tr>
<tr>
<td>Antenna Control</td>
<td>.5</td>
<td>0</td>
<td>3M 401 White Paint</td>
</tr>
<tr>
<td>Fuel Unit Latching Tool</td>
<td>.5</td>
<td>0</td>
<td>3M 401 White Paint</td>
</tr>
<tr>
<td>C.D.L. Latching Tool</td>
<td>.5</td>
<td>0</td>
<td>3M 401 White Paint</td>
</tr>
<tr>
<td>Carry Bars</td>
<td>.5</td>
<td>0</td>
<td>3M 401 White Paint</td>
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<tr>
<td>MTC Cable Reel</td>
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<tr>
<td>Universal Latching Tool</td>
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<td>3M 401 White Paint</td>
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<tr>
<td>TSS Surfaces</td>
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<td>Iron Tidne</td>
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<tr>
<td>Subpallet</td>
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</tr>
<tr>
<td>Photothermal Latching Equipment</td>
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<td>0</td>
<td>3M 401 White Paint</td>
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</tbody>
</table>

7759-6236

7759-6237
RTG AND PALLET 2 LUNAR OPERATING TEMPERATURES

RTG/SUBPACKAGE TEMPERATURE HISTORIES DURING DEPLOYMENT
RTG AND PALLET TEMPERATURES DURING COMPLETE LUNATION

RTG CASK LOADING
TILTING THE FUEL CASK-APOLLO 12
REMOVING THE FUEL CAPSULE
FROM THE CASK-APOLLO 12
TRANSFER FUEL

• ROTATE PKG #2 & REMOVE SUBPALLET
  USE UHT TO ROTATE PKG #2 UPRIGHT
  RELEASE BOYD BOLTS, REMOVE SUBPALLET FROM PKG #2

• ROTATE FUEL CASK FOR FUEL TRANSFER
  RETRIEVE CASK LANYARD
  ROTATE LEVERS
  PULL SPLINE
  ROTATE CASK TO DESIRED ANGLE

• REMOVE CASK DOME USING DRT

• TRANSFER FUEL CAPSULE
  ENGAGE FIT WITH CAPSULE
  LOCK TOOL TO CAPSULE TO RELEASE FROM CASK
  WITHDRAW CAPSULE
  LOWER INTO RTG
  RELEASE TOOL FROM CAPSULE TO LOCK IN RTG
Section 3

Passive Seismic Experiment
DR. GARY LATHAM WILL PRESENT THE FOLLOWING SLIDES:

- MEASUREMENTS LIST
- LPZ - SCHEMATIC DIAGRAM OF FEEDBACK-CONTROLLED SEISMOMETER
- LPZ MODEL - PHOTO
- PICTORIAL REPRESENTATION OF FINE LEVELING SYSTEM
- SPZ MODEL
- PICTORIAL REPRESENTATION OF CAGING CONCEPT
- COMPARISON SEISMOGRAMS
- EARTH TIDES
- PROBLEM AREAS
- NOMINAL RESPONSE VS. MODIFIED RESPONSE FOR LP SEISMOMETERS
- SEISMIC DISTURBANCES DURING ECLIPSE
- DOME CONCEPT FOR THERMAL SHROUD
- ASTROSEISMS - SIGNAL FROM ARMSTRONG ON LADDER
- LM ASCENT SIGNAL
- MAP SHOWING LM IMPACT AND ALSEP LOCATIONS
- SEISMOGRAMS SHOWING LM IMPACT SIGNAL AND TWO NATURAL EVENTS
- TIDES AND TEMPERATURES FROM ECLIPSE

THESE WILL BE PUBLISHED AS ADDENDUM I IN THE FINAL COMPILED EDITION OF BSR-2900.

SECTION 3
**SENSOR/SHRoud ARRANGEMENT**

**DEPLOYMENT TASKS**

- REMOVE LEVELING STOOL FROM SUBPACK 2
- DEPLOY STOOL AT 9 ± 1 FT E OR W OF C/S
- REMOVE SENSOR FROM SUBPACK 1
- PLACE SENSOR ON STOOL, ROUGH ALIGN (GIRDLE ARROW)
- REMOVE SHROUD GIRDLE PIN AND GIRDLE
- DEPLOY SHROUD SKIRT
- LEVEL SENSOR TO ±5° (BUBBLE LEVEL)
- READ ALIGNMENT ANGLE (GNOMON SHADOW ON COMPASS ROSE)
LEVELING STOOL
## PHYSICAL PARAMETERS

<table>
<thead>
<tr>
<th>WEIGHT</th>
<th>SENSOR</th>
<th>18.4 LB</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>SHROUD</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>CSE</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>STOOL</td>
<td>0.3</td>
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<table>
<thead>
<tr>
<th>DIMENSIONS</th>
<th>SENSOR</th>
<th>11.1 X 9.1 DIA INCHES</th>
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<tbody>
<tr>
<td></td>
<td>SHROUD</td>
<td>15 X 11 DIA</td>
</tr>
<tr>
<td></td>
<td>CSE</td>
<td>7.25 X 6.50 X 2.75</td>
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<tr>
<td></td>
<td>STOOL</td>
<td>2.3 X 11 DIA</td>
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<table>
<thead>
<tr>
<th>POWER</th>
<th>STANDBY</th>
<th>3.5 WATTS</th>
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<tbody>
<tr>
<td></td>
<td>FUNCTIONAL</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>THERM CONT</td>
<td>2.8 (MAX)</td>
</tr>
<tr>
<td></td>
<td>LEVELING</td>
<td>3.0 (PER AXIS)</td>
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</tbody>
</table>

25.8 LB

7759-5232

## VERTICAL SEISMOMETER

![Vertical Seismometer Diagram](7759-5218)
HORIZONTAL SEISMMOMETER

LONG-PERIOD SEISMMOMETERS
SHORT-PERIOD SEISMMETER
BLOCK DIAGRAM, SP SENSOR

CAGING SYSTEM SCHEMATIC
COMMAND FUNCTIONS

GAIN CHANGE LPX, LPY: 0, -10, -20, -30 DB
GAIN CHANGE LPZ: 0, -10, -20, -30 DB
GAIN CHANGE SPZ: 0, -10, -20, -30 DB
CALIBRATION LP: ON, OFF
CALIBRATION SP: ON, OFF
FEEDBACK FILTER: IN, OUT
COARSE SENSOR: IN, OUT
LEVELING MODE: AUTO, COMMAND
LEVELING SPEED: LOW, HIGH
LEVELING DIRECTION: PLUS, MINUS
LEVELING POWER, X MTR: ON, OFF
LEVELING POWER, Y MTR: ON, OFF
LEVELING POWER, Z MTR: ON, OFF
THERMAL CONTROL MODE: OFF, AUTO, ON
UNCAGE: CAGE, ARM, UNCAGE

7759-5220

BLOCK DIAGRAM, POWER CIRCUITS

7759-5223
DATA OUTPUT

SCIENCE CHANNELS: 43 WORDS PER FRAME

SP SENSOR: 29 WORDS PER FRAME
LPX SENSOR: 4 WORDS PER FRAME
LPY SENSOR: 4 WORDS PER FRAME
LPZ SENSOR: 4 WORDS PER FRAME
LPX TIDAL: 1 WORD PER 2 FRAMES
LPY TIDAL: 1 WORD PER 2 FRAMES
LPZ TIDAL: 1 WORD PER 2 FRAMES
TEMPERATURE: 1 WORD PER 2 FRAMES

ENGINEERING DATA: 8 WORDS PER 54 SEC

FRAME LENGTH: 64 WORDS

WORD LENGTH: 10 BITS

FRAME RATE: 1 FRAME/0.604 SEC

7759-5221
THERMAL ANOMALY AND POSSIBLE NOISE PROBLEM

THERMAL ANOMALY
- INSTRUMENT SPECIFICATION: 126 ± 18F, DESIGN GOAL ± 4F
- LUNAR TEMPERATURE
  - NOON TEMP
  - NIGHT TEMP
  - FIRST DAY: 134 F, 75 F*
  - SECOND DAY: 142 F, 75 F*
  - THIRD DAY: 145 F*, 126 F**
  - FOURTH DAY: 144 F, 126 F**

POSSIBLE NOISE PROBLEM
- CONSIDERABLE INSTRUMENT TILT WAS RECORDED AT SUNSET AND SUNRISE
- MAY BE CAUSED BY SHROUD PULLING

SCIENCE CONSIDERATIONS
- THE TEMP VARIATION OF LESS THAN ± 2°F IS REQUIRED TO OBTAIN Full TIDE DATA
- THE INSTRUMENT TILT RECORDED AT SUNSET AND SUNRISE MAY BE NATURAL LUNAR EVENT: THIS CAN'T BE VARIFIED UNLESS POSSIBLE SHROUD PROBLEM IS ELIMINATED
- SEISMIC DATA IS INTERRUPTED BY REPEATED LEVELING DUE TO OUT-OF-SPECIFICATION VARIATION

* ESTIMATED
** WITH LEVELING MOTOR ON

PSE AND LUNAR SUBSURFACE THERMAL MODEL
APOLLO 12 PSE THERMAL STUDY RESULTS

MAX LUNAR DAY TEMP INCREASED FOR FIRST THREE LUNAR DAYS FROM 134°F to 145°F

IMPROPER DEPLOYMENT OF PSE SKIRT ATTRIBUTED TO ELECTROSTATIC CHARGE BETWEEN LUNAR SURFACE AND MYLAR MATERIAL

SHROUD THERMAL CONDUCTIVITY IS HIGHER THAN SPECIFIED VALUE

SPECIFIED $2.5 \times 10^5$ BTU/HR·FT·F

ACTUAL $7.5 \times 10^4$ BTU/HR·FT·F

EXTERNAL SURFACE OF SKIRT DAMAGED BY LM EXHAUST OR DETERIORATED IN LUNAR ENVIRONMENT

MYLAR SHIRT $0.15/0.37$ NOM

ACT $0.37/0.37$

TEFLON SHROUD $0.2/0.73$ NOM

ACT $0.73/0.73$ (EAST SIDE 7759-5245

MODIFICATION - APOLLO 13 SHROUD

- PROVIDE ONE LAYER OF TEFLON TO IMPROVE THERMAL PERFORMANCE AND MINIMIZE TERMINATOR NOISE PROBLEM
- INCORPORATE WEIGHTS TO INSURE PROPER DEPLOYMENT
- SEW SKIRT AND ADD BUTTONS TO IMPROVE DEPLOYMENT

THERMAL MODIFICATION COMPARISON

<table>
<thead>
<tr>
<th>MODEL</th>
<th>TEMPERATURE RANGE °F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAY</td>
</tr>
<tr>
<td>APOLLO 12</td>
<td>145</td>
</tr>
<tr>
<td>APOLLO 13</td>
<td>126</td>
</tr>
</tbody>
</table>

7759-5235
BLOCK DIAGRAM, TYPICAL LP SENSOR

SINE X-AXIS
RANDOM Z-AXIS

TYPICAL CALIBRATION VOLTAGE CONTROL CIRCUIT

TYPICAL CAL VOLTS OUT XY & Z

SIG COM

7759-5237
DELTA ROD

ALCOA WELDING ROD ALLOY
0.062 DIAMETER

304 CRES

0.005 CARBON SPRING STEEL MUSIC WIRE

1.9 IN.

ALL PIECES SWAGED

7759-5230

APOLLO 12 SHORT-PERIOD NOISE PULSES

7759-5230

3-25
Section 4

Active Seismic Experiment
ACTIVE SEISMIC
NASA No. SO33

OBJECTIVE: PHYSICAL PROPERTIES TO SHALLOW DEPTHS, FORMATION PROCESSES
MEASUREMENT: ARTIFICIAL SEISMIC WAVE VELOCITY, FREQUENCY, & ATTENUATION
EQUIPMENT: ENERGY SOURCES (THUMPER & GRENADES), DETECTION EQUIPMENT (GEOPHONES & AMPLIFIERS)

ACTIVE SEISMIC EXPERIMENT SUBSYSTEM

XMIT ANTENNA AND RANGE LINE (DEPLOYED)
RECEIVING ANTENNA
MONTAGE BOX ASSEMBLY 15.25 x 8.0 x 11.5 IN (STOWED)
HI CARD

GRENADAR ASSEMBLY (4)
GRENADAR LAUNCH ASSEMBLY

GRENADAR LAUNCH ASSEMBLY
10 CENTRAL STATION
4.00 IN. HEIGHT; SPIKE 1.66 IN. DIAM

CENTRAL ELECTRONICS 6.77 x 5.18 x 2.75 IN.

7759-5636
ASE MODES OF OPERATION

THUMPER MODE: APPROX 7 MIN (PLUS SET UP) WHILE ASTRONAUT IS ON SURFACE. USES SMALL SEISMIC SOURCES RELATIVELY CLOSE TO GEOPHONES.

LISTENING (PASSIVE) MODE: 15 MINUTES, ONCE PER WEEK (AVERAGE). DETECTS TECTONIC DISTURBANCES OR METEOROID IMPACTS TO EVALUATE SYSTEM STATUS, PARTICULARLY LUNAR SURFACE NOISE LEVEL (WHICH MAY BE A FUNCTION OF AMBIENT TEMPERATURE), AND ASSIST IN SELECTING OPTIMUM TIME FOR MORTAR MODE.

MORTAR OR GRENADE MODE: APPROX 1 HR NEAR END OF ALSEP MISSION. USES RELATIVELY LARGE SEISMIC SOURCES AT RANGES UP TO 5000 FT.

NOTE: ALL MODES REQUIRE 85-FT MSFN ANTENNA BUT, WITH THE EXCEPTION OF THE THUMPER MODE, CAN BE SCHEDULED FOR MOST CONVENIENT GROUND OPERATIONS.

ASE GENERAL FEATURES

PURPOSE:
- MONITOR NATURAL LUNAR SEISMIC ACTIVITY
- GENERATE & MONITOR ARTIFICIAL SEISMIC ENERGY

MONITOR (DETECTORS):
- GEOPHONES (B) WITH LOG COMPRESSION AMPLIFIERS

IN THE RANGE FROM 3 TO 700 Hz

GENERATE SOURCES:
- EXPLOSIVE DEVICES

THUMPER
- MORTAR
- ASF's (5)
- GRENADES (4)

500
- RANGE, FT
1000
2000
5000
- CHARGE PROPORTIONAL TO RANGE
- ACTIVATED NEAR MARKED POSITIONS ON GEOPHONE CABIN

BY VARYING THE MAGNITUDE & LOCATION OF SOURCES WITH RESPECT TO DETECTORS
- OBTAIN PenETRATION OF WAVES TO ≥ 500 FT
- INVESTIGATE VELOCITY THROUGH SEVERAL LAYERS OF SUBSURFACE MATERIAL

- ACCURATE DETERMINATION OF SHOT TIME AND RANGE IS FUNDAMENTAL FOR ANALYSIS OF GEOPHONE DATA

SHOT TIME | RANGE
--- | ---
THUMPER | PRESSURE SW SIGNAL
GRENADES | XMT OFF SIGNAL

7759-5663

7759-5637

4-2
ACTIVE SEISMIC CHARACTERISTICS

KEY FEATURES

HIGH BIT RATE (10.6 KBPS) OF ASE REQUIRES 85-FT MSFN ANTENNA (ON REQUEST)
EXPLOSIVES HAVE SAFE/ARM PROTECTION FEATURES
GRENADES LAUNCHED TO 500, 1000, 3000 & 5000 FT RANGE FROM GEOPHONES
CHARGE EQUIVALENT TO 150 MILLIGRAM TNT IN THUMPER
AND UP TO 1.0 LB TNT IN GRENADE
IMPACT POINT OF GRENADES DETERMINED BY LAUNCH ANGLE,
INITIAL LAUNCH VELOCITY, & IMPACT TIME
INDIVIDUAL HEATER FOR MORTAR BOX, "THERMOSTATICALLY"
CONTROLLED ELECTRONICALLY
## Active Seismic Characteristics

### Operations

<table>
<thead>
<tr>
<th>Deployment &amp; Thumper</th>
<th>Post Deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Emplace Mortar Package</td>
<td>• Ground Operations During Deployment/Thumper Requiring Turn-On, Geophone Calibrate, &amp; Turn-Off</td>
</tr>
<tr>
<td>• Place Geophones at 10, 160 &amp; 310 ft from Central Station</td>
<td>• Later, Monitor 15 min per week</td>
</tr>
<tr>
<td>• Activate Thumper Every 15 ft</td>
<td>• Near Year-End, Turn On &amp; Calibrate Geophones, Arm &amp; Fire Grenades</td>
</tr>
<tr>
<td>• Remove Safety Release Assembly and Actuate Safe/arm Switches on Mortar Box</td>
<td>• Other Commands As Necessary</td>
</tr>
<tr>
<td>Approx Time, 20 min</td>
<td></td>
</tr>
</tbody>
</table>

### ASE Deployment Sequence

1. Verify that Central Station Astronaut Switch (S-5) Is In Open Position
2. Remove Thumper & Place in Temporary Location
3. Remove Mortar Box & Place 10 ft From Central Station In Opposite Direction To That Selected For Geophones
4. Align To Fire Away From Geophones & Erect ASE Receiving Antenna (Inc. Flag)
5. Erect Central Station Sunshield & Antenna
6. After ASEP Communications Have Been Established & Switched To ASE HBR, Place Central Station Astronaut Switch In Closed Position
7. Unfold Thumper & Walk Out In Selected Direction Placing Geophones At 10, 160, & Walk Out In Selected Direction Placing Geophones At 10, 160, & 310 ft From Central Station & In Line ± 3° Using Flag On Mortar Box (plus Flag Placed At 160-FT Geophone Location) As Reference.
ASE DEPLOYMENT SEQUENCE (CONT')

8. RETURN ALONG GEOPHONE CABLE ACTUATING THUMPER AT 15-FT INTERVALS AS INDICATED BY CABLE MARKINGS

9. PLACE CENTRAL STATION ASTRONAUT SWITCH IN OPEN POSITION

10. REMOVE GRENADE RETAINING ROD ASSY FROM MORTAR BOX

11. ACTUATE MORTAR BOX SAFETY SWITCHES (2) REMOVING SHORTS FROM GRENADE ARM/FIRE CIRCUITS

12. PLACE CENTRAL STATION ASTRONAUT SWITCH IN CLOSED POSITION

ASE EMTPLACEMENT CRITERIA

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>REQUIREMENT</th>
<th>PRIORITY</th>
<th>Indicator</th>
<th>CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE SELECTION</td>
<td>LEVEL GROUND &amp; ELEVATION</td>
<td>1</td>
<td>VB BAL</td>
<td>SITE MUST CONSIDER BOTH GROUND ELEVATION &amp; GEOPHONE ANGLES</td>
</tr>
<tr>
<td>DISTANCE FROM SUBPACKAGE 1</td>
<td>DEPRESSED OR VERTICAL</td>
<td>1</td>
<td>VB BAL</td>
<td>INTENDED ELEVATION</td>
</tr>
<tr>
<td>DIRECTION FROM SUBPACKAGE 1</td>
<td>10° ± 8° FROM ON</td>
<td>2</td>
<td>VB BAL</td>
<td>10° FOR 30 FT PLUS CONSTRAINT 10° FOR 200 FT UNIFORM</td>
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<tr>
<td>LEVEL</td>
<td>14° OF HORIZONTALITY</td>
<td>1</td>
<td>VB BAL</td>
<td>14° S AWAY FROM ON &amp; GEOPHONES</td>
</tr>
<tr>
<td>ALIGN</td>
<td>9° FROM ASSUMED GEOPHONE'S DEPLOYMENT FRONT LINE</td>
<td>1</td>
<td>VB BAL</td>
<td>9° S AWAY FROM ON &amp; GEOPHONES</td>
</tr>
<tr>
<td>DISTANCE FROM SUBPACKAGE 1</td>
<td>12° ± 2° TO 1ST 100+ 5.5°±3° TO 2ND 100+ 13.5°±3° TO 3RD 200+13.5°±3° TO 4TH</td>
<td>1</td>
<td>VB BAL</td>
<td>GEOPHONES SET LATERALLY FROM CABLE ON 15 FT PICTAILS</td>
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<tr>
<td>DIRECTION FROM SUBPACKAGE 1</td>
<td>2°</td>
<td>1</td>
<td>VB BAL</td>
<td>OPPOSITE MORTAR PACKAGE</td>
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<tr>
<td>LEVEL GEOPHONE</td>
<td>-1° OF HORIZONTAL</td>
<td>2</td>
<td>VB BAL</td>
<td>GEOPHONE RESPONSE REQUIREMENT</td>
</tr>
<tr>
<td>GRENADE CABLE</td>
<td>± 1° FROM STRAIGHT</td>
<td>1</td>
<td>VB BAL</td>
<td>VARIATION OF 2ND GEOPHONE FROM LINE BETWEEN 1ST &amp; 3RD</td>
</tr>
</tbody>
</table>

SPECIAL REQUIREMENTS

- GEOPHONES AT LEAST 10 FT FROM RTG AND SUBPACKAGE 1

7759-6661

4-5
ASE THERMAL CONTROL

MECHANICAL (MORTAR PACKAGE)
- 0.5-IN. MULTILAYER ALUMINIZED MYLAR ON SIDES & BOTTOM
- THIN ALUMINIZED MYLAR SUNSHIELD OVER TOP
- GRENADES LAUNCHED THROUGH SUNSHIELD
- ROCKET BLAST DISINTEGRATES MYLAR INSULATION REDUCING RECOIL EFFECT ON BOX STABILITY
- THERMAL PAINT TO MAINTAIN TEMP. 85°C

ELECTRICAL
- MORTAR PACKAGE
- ELECTRONIC SENSOR/CONTROL CIRCUIT OPERATES SERIES/PARALLEL HEATER ARRAY TO MAINTAIN TEMP ABOVE -60°C
- PROPORTIONAL CONTROL, DISSIPATION IS A FUNCTION OF TEMPERATURE
- CIRCUIT ACTIVATED ONLY IN STBY POWER MODE AT 0°F.
- CENTRAL ELECTRONICS IS CONTROLLED BY CENTRAL STATION ENVIRONMENT
- THUMPER HAS NO HEATER

ASE OPERATIONAL POWER PROFILE

![Operational Power Profile Graph](Image)

7759-5558
ASE SAFETY FEATURES

THUMPER

- Rotary arming switch, spring loaded to safe position, actuated ≈4 sec to charge condenser (then push to fire)
- ASI selector switch has 22 positions (inc off) and shorts all ASI's except the selected one

CENTRAL ELECTRONICS

- Central station astronaut switch (two-position) opens and closes +29 V oper power line between PDU & ASE
- In series with CMD-activated relay of PDU
- In open position, precludes accidental application of oper power to ASE

GRENADES

- Supported within launch tubes, locked in place by safety rod assy for flight & deployment (removed by astronaut)
- Arming & firing circuits of all 4 rocket motors shorted by 2 safety switches on mortar box (activated by astronaut)
- Safe slide between detonating cartridge & high explosive in each grenade, spring ejected at launch
- Thermal battery inactive (if shorted) until plate ejection trips a microswitch
- Thermal battery match is activated by a condenser which is charged via grenade arm cmd
- Thermal battery supplies power to grenade detonator through a 8-10 sec. time delay and an impact switch. If impact comes before 10 sec. or after ≈10 min., there is no battery power for detonator.

7759-5659A

ASE SAFETY FEATURES (CONT')

7759-5659B
ACTIVE SEISMIC EXPERIMENT REMOVAL

- CPLEE
- PASSIVE SEISMIC EXPERIMENT
- ANTENNA
- THUMPER ASSEMBLY
- MORTAR BOX

SUBPACKAGE NO. 1

7759-5676
ASE STOWED CONFIGURATION
ASE DATA FORMAT

- Consists of 32 - 20-bit words at 10.6 KB rate
- Uniform time sampling of geophones provided by dividing each word into 4 subwords of 5 bits each
- 1st subword used for housekeeping or engineering type data
- 2nd, 3rd and 4th subwords are geophone no. 1, geophone no. 2 and geophone no. 3 data readouts
- 10-bit frame synchronization provided in first word by storing geophone no. 1 readout during synchronization transmission and reading out in 1st subword of 2nd word

ASE FRAME DESCRIPTION (PART I)

1. Start frame
2. Control word
3. 5-bit seismic data subwords
   - E₁ (error data channel 1): 4 least significant bits + 1 spare bit
   - E₂ (error data channel 2)
   - E₃ (error data channel 3): 4 most significant bits + 1 spare bit
4. 10-bit sync word

Notes:
1. G₁, G₂, G₃: Geophone seismic data from 3 geophones
2. Each engineering data read out to 8 bits accuracy using the 1st subword of 2 words in sequence

7759-5679
### ENGINEERING WORDS

<table>
<thead>
<tr>
<th>FORMAT REF</th>
<th>WORD NO'S</th>
<th>ALSEP SYMBOL</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>E₁</td>
<td>3, 4</td>
<td>AR-4</td>
<td>RTG COLD FRAME TEMP NO. 1</td>
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<tr>
<td>E₂</td>
<td>5, 6</td>
<td>DS-7</td>
<td>PITCH ANGLE</td>
</tr>
<tr>
<td>E₃</td>
<td>7, 8</td>
<td>DS-5</td>
<td>MORTAR BOX GROD MONITOR</td>
</tr>
<tr>
<td>E₄</td>
<td>9, 10</td>
<td>DS-6</td>
<td>ROLL ANGLE</td>
</tr>
<tr>
<td>E₅</td>
<td>11, 12</td>
<td>–</td>
<td>SPARE</td>
</tr>
<tr>
<td>E₆</td>
<td>13, 14</td>
<td>AS-3</td>
<td>GLA TEMP</td>
</tr>
<tr>
<td>E₇</td>
<td>15, 16</td>
<td>DS-8</td>
<td>GEOPHONE CALIBRATION PULSE</td>
</tr>
<tr>
<td>E₈</td>
<td>17, 18</td>
<td>DS-11</td>
<td>A/D CALIBRATION 3.75 V (NOM)</td>
</tr>
<tr>
<td>E₉</td>
<td>19, 20</td>
<td>DS-10</td>
<td>A/D CALIBRATION 1.26 V (NOM)</td>
</tr>
<tr>
<td>E₁₀</td>
<td>21, 22</td>
<td>AS-1</td>
<td>CENTRAL ELECTRONICS TEMP</td>
</tr>
<tr>
<td>E₁₁</td>
<td>23, 24</td>
<td>AE-3</td>
<td>RTG OUTPUT VOLTAGE</td>
</tr>
<tr>
<td>E₁₂</td>
<td>25, 26</td>
<td>AE-4</td>
<td>RTG OUTPUT CURRENT</td>
</tr>
<tr>
<td>E₁₃</td>
<td>27, 28</td>
<td>AR-1</td>
<td>RTG HOT FRAME TEMP NO. 1</td>
</tr>
</tbody>
</table>

### ASE FRAME DESCRIPTION (PART II)

- **END OF FRAME**
- **MODE ID**
- **WORD COUNT IN EVENT FRAME**
- **MARK EVENT RELATED TO PREVIOUS FRAME**
- **NOTE:** REAL TIME EVENTS (RTE) ARE EVENTS SUCH AS THUMPER ASI SHOCK INSTANT OR GRENADE IMPACT & EXPLOSION INSTANT

7759-5682

4-16
ACTIVE SEISMIC CHARACTERISTICS

COMPONENTS

DSS

COMMANDS
TIMING
ALSEP HSK
ASE DATA
IN CENTRAL STATION

CENTRAL ELECTRONICS
INC RCVR

THUMPER

GEOPHONES (3)

MORTAR PACKAGE

MORTAR BOX
ELECTRONICS
ANTENNA
TEMP SENSOR
TEMP SENSORS (3)

GRENADE LAUNCH ASSY (GLAA)

GRENADES/XMTR (4)

INCLINOMETER

7759-5631
ASE THUMPER/GEOPHONE ASSEMBLY
ASE THUMPER FEATURES

- **INITIATOR (ASI) MOUNTING PLATE & BASE PLATE**
  - INSIDE LOWER END
- **ARM/FIRE & ASI SELECTOR SWITCHES**
  - ON UPPER END
- **FLAT, 4-CONDUCTOR CABLE TO CENTRAL ELECTRONICS**
  - ON UPPER SPLIT REEL
  - ON LOWER INTEGRAL REEL
  - UNWOUND DURING DEPLOYMENT
- **3 GEOPHONES WITH CABLES**
- **GEOPHONE FLAG STOWED ON THUMPER**
- **PRESSURE SWITCH ON ASI MOUNTING PLATE DETECTS TIME OF SEISMIC EXPLOSION**
- **GEOPHONE FLAG DEPLOYED ON LUNAR SURFACE AT 150 FT TO AID IN GEOPHONE CABLE ALIGNMENT**
- **GEOPHONES AND CABLES STOWED ON THUMPER UNTIL DEPLOYED**

THUMPER CHARACTERISTICS

- **AS1 SELECTOR SWITCH**
- **ARM/FIRE SWITCH**
- **22 POSITION SELECTOR SWITCH (INC OFF)**
- **SEPARATE ARM/FIRE SWITCH**
- **USES APOLLO STANDARD INITIATORS (AS1s)**
- **IMPACT PLATE IN LOWER END TO CONTAIN AS1 DEBRIS**
THUMPER BASE SECTION OPERATING

EXHAUST GASES

7759-5683
ASE THUMPER
FIRING POSITION
ASE THUMPER FUNCTION

ARM SWITCH

FIRE SWITCH

AS1 SEL SWITCH

AS1

THUMPER ARM EVENTS

THUMPER FIRE EVENTS

TO ASE TIMING & DATA FUNCTIONS

PRESSURE SWITCH

ASE DETECTION SYSTEM

GEOPHONE (SENSORS)

TYPE: ELECTROMAGNETIC
NATURAL FREQUENCY: 7.5 CPS
SENSITIVITY: 250 VOLT/METER/SEC
WEIGHT: 6 OZ EACH SENSOR

AMPLIFIER

3 CHANNELS EACH WITH PREAMP, FILTER AND LOG COMPRESSOR
80 DB DYNAMIC RANGE LOG COMPRESSED TO 40 DB
LOG COMPRESSOR TEMPERATURE CONTROLLED

GEOPHONE & AMPLIFIER

SENSITIVITY: 5 μm PEAK DISPLACEMENT AT 10 Hz (1 μm GOAL)
AT A SIGNAL TO NOISE RATIO OF 18 db
BANDWIDTH: 3 TO 250 Hz WITH RESPECT TO VELOCITY

BASIC DATA WORD

5-BIT WORD FOR EACH SENSOR READING AT 500 SAMPLES/SEC
(EACH CHANNEL)
ASE GEOPHONE FUNCTION

TO ASE TIMING & DATA FUNCTION
to GEO 1

GEO 1

GEO 2

GEO 3

GEOPHONE TEMP

GEOPHONE FUNCTION

AE-04 GEOPHONE

DS-01 GEOPHONE 1 DATA

DS-02 GEOPHONE 2 DATA

DS-03 GEOPHONE 3 DATA

ASE GEOPHONE FEATURES

- ELECTROMAGNETIC TRANSDUCERS (VELOCITY SENSOR)
  OUTPUT TO SEPARATE LOG COMPRESSION AMPLIFIERS
- IMPLANTED IN SURFACE BY SPIKE
- TEMPERATURE SENSOR IN ONE GEOPHONE
- 7.5 CPS NATURAL FREQUENCY
- SPRING CONSTANT DESIGNED FOR LUNAR GRAVITY

FREQUENCY RESPONSE

MEAN OF 10 TO 100 Hz RESPONSE CHARACTERISTIC

-3.5 db ABOVE 460 Hz
LESS THAN
-40 db ABOVE 500 Hz

COMBINED GEOPHONE AND AMPLIFIER FILTER RESPONSE
(BEFORE LOG COMPRESSION)

7759-5642

7759-5643

4-25
ASE MORTAR
PACKAGE ASSEMBLY
ASE GRENADE RANGING CONCEPT

CONCEPT

- BALLISTIC TRAJECTORY OF GRENADE IS CALCULATED FROM ITS INITIAL DIRECTION & TIME OF FLIGHT:
  - DIRECTION (45° ANGLE OF MORTAR CORRECTED BY INCLINOMETER ROLL & PITCH)
  - TIME-OF-FLIGHT FROM LAUNCH (FIRST RANGE LINE SIGNAL TO IMPACT (XMTR OFF))
- CONFIDENCE IS ENHANCED BY KNOWING INITIAL LAUNCH VELOCITY (BASED ON TIME BETWEEN RANGE LINE EVENTS FOR 10-IN. & 25-FT + 10-IN. TRAVEL)

7759-5649

4-28
ASE GRENADE RANGING

MECHANIZATION

• RANGE LINE: A THIN STRANDED CABLE WOUND AROUND THE OUTSIDE OF LAUNCH TUBE & CONNECTED AT ONE END TO GRENADE (30 MHz TRANSMITTING ANTENNA)

• BREAKWIRES (2): EACH A SINGLE LOOP OF FINE COPPER WIRE ARRANGED TO BE SEVERED WHEN RANGE LINE REACHES 10-IN. & 25-FT + 10-IN. POINTS

• INCLINOMETER: MEASURES DEVIATIONS AROUND TWO AXES
  • PITCH: INCREASE OR DECREASE IN THE 45° LAUNCH ANGLE
  • ROLL: ROTATION AROUND A HORIZONTAL AXIS PERPENDICULAR TO THE PITCH AXIS

ASE GRENADE RANGING

IMPLICATIONS

• INCLINOMETER DATA IS AVAILABLE IN CASE MORTAR PACKAGE SHIFTS DURING EACH FIRING

• PACKAGE STABILITY ENHANCED BY "BLOWOUT" REAR CLOSURE & THRUST TERMINATION BEFORE GRENADE LEAVES TUBE

• SEQUENTIAL FIRING ORDER (2, 4, 3, 1), ALSO USED FOR STANDARD FIRING, OPTIMIZES PACKAGE STABILITY

• NOTE THAT ARM CMD MUST BE SENT 4 TIMES (SEQUENTIAL & STANDARD CONDENSERS ARE CHARGED & DISCHARGED SIMULTANEOUSLY); ALSO, SEQUENTIAL FIRE ACTUATES ONE GRENADE EACH TIME SENT
ASE MORTAR BOX
ASE GRENADE CHARACTERISTICS

DESCRIPTION

- CASING SIZE:
  - 2.7 IN. SQUARE APPROX
  - 4 TO 6 IN. LONG

- CASING CONTAINS:
  - SOLID FUEL ROCKET MOTOR
  - SAFE SLIDE
  - HIGH EXPLOSIVE CHARGE
  - IGNITION & DETONATION DEVICES
  - THERMAL BATTERY
  - 30MHz XMTR CONNECTED TO TRAILING WIRE ANTENNA (FUNCTIONS AS RANGE LINE)

- GRENADES DIFFER ONLY IN AMOUNT OF PROPELLANT & HIGH EXPLOSIVE

OPERATION

- GRENADE ARM CMD APPLIES PULSE TO ROCKET MOTOR ARMING CIRCUIT CHARGING CONDENSER IN MORTAR BOX AND CHARGES MATCH CONDENSER IN GRENADE

- GRENADE FIRE CMD DISCHARGES CONDENSER THROUGH ASI IGNITING ROCKET MOTOR

- WHEN GRENADE LEAVES TUBE:
  - SPRING EJECTED SAFE SLIDE ENABLES DETONATOR
  - SLIDE EJECTION ACTIVATES MICROSWITCH IN GRENADE
  - MICROSWITCH DISCHARGES CONDENSER ACROSS MATCH ACTIVATING THERMAL BATTERY

7759-5646

7759-5647

4-35
**ASE GRENADE CHARACTERISTICS**

**OPERATION (CONT)**

- **BATTERY PROVIDES INTERNAL POWER FOR:**
  - 30 MHz XMTR
  - CHARGING DETONATOR CONDENSER

- **EVENT MARK FOR:**
  - BREAKWIRE (10-IN. & 25-FT + 10-IN. TRAVEL)

- **AT IMPACT, AN OMNIDIRECTIONAL IMPACT SWITCH DISCHARGES CONDENSER THROUGH DETONATOR SETTING OFF HIGH EXPLOSIVE**

- **EXPLOSION DESTROYS BATTERY AND TRANSMITTER TERMINATING RF TRANSMISSION**

- **EVENT MARK FOR XMTR OFF**

7759-5648
ASE CENTRAL ELECTRONICS FEATURES

TIMING AND DATA

• TEMP SENSING
  INTERNAL TEMPERATURE MONITORED IN BASIC ALSEP DATA AS WELL AS ASE DATA STREAM

• LOG COMPRESSION AMPLIFIERS
  LOW-NOISE, PROVIDE WIDE DYNAMIC RANGE
  PRE-EMPHASIS TO INCREASE LOW FREQUENCY RESPONSE

• GEOPHONE CALIBRATION
  • DRIVER (PULSE STRETCHER) CONVERTS COMMAND INTO 1-SEC EXCITATION PULSE APPLIED VIA AMPLIFIERS
  • ELECTRICALLY DRIVES GEOPHONES FOR MEASUREMENT OF RESONANT FREQUENCY, GENERATOR CONSTANT, & DAMPING COEFFICIENT
  • COMPARE TO PREFLIGHT DATA (RELATIVE CALIBRATION)
  • PULSING VOLTAGE SAMPLED IN ASE DATA

7759-5652

ASE CENTRAL ELECTRONICS FEATURES

TIMING AND DATA (CONT)

• ANALOG MULTIPLEXER & ADC
  • ASE COMPRESSED SEISMIC DATA CONVERTED TO 5-BIT DIGITAL
  • ASE ENG & ALSEP HK (KEY PARAMETERS) CONVERTED TO 8-BIT DIGITAL, & BOTH READ OUT AS 4 BITS IN EACH OF TWO ASE WORDS
  • ADC CAL CIRCUIT GIVES 2-POINT CHECK

• TIMING & CONTROL
  • 4, 5, & 32 SEQUENCE COUNTER OPERATES ON 10.6 KHz SQUARE WAVE FROM DSS
  • PROVIDES FOR 5-BIT SUBWORDS, 4 PER ASE WORD (20 BITS) & 32 WORDS PER FRAME (640 BITS)
  • DATA RATE, 10.6 KBPS (ALMOST ENTIRELY ASE DATA) GIVE:
    • RELATIVELY HIGH-FREQUENCY SEISMIC DATA
    • ACCURATE ENCODING & TRANSMISSION OF REAL-TIME EVENTS

7769-5653

4-39
ASE CENTRAL STATION ELECTRONICS COMPONENTS
ASE SUBSYSTEM TEST EQUIPMENT

- ETS
  - SIMULATES CENTRAL STATION ELECTRONICS
- ASSS
- SIMULATES GLA AND THUMPER DOME
- DECOMMUTATES AND DISPLAYS ASE DATA
- GLATS
- COMPLETE GLA CHECKOUT CAPABILITY
- MARPD
- GLA MOUNTING AND ANGLE CONTROL
- AIRME
- ORDNANCE ITEM CHECKOUT

7759-5678
ASE - EQUIPMENT LEVEL TESTING

SUBCONTRACT QUAL
ABCD
RECEIVER
TRANSMITTER
ANGLE DISGUISE
MULTIPLEXER
THERMAL BATTERY
REDesign & REQUAL

W3:1 FULL ASE FIELD TEST

ASU, UST
VIR SHOCK, ACCEL
1/4
1/10 (AFTE HUM 12/)
COMPLIANCE

QLA QUAL (GWz)
ENVIRONMENTAL
FULL EARTH ELEPHANTS
GRINDING VACUUM THINGS

96A
ASE QUAL C
+ CENTRAL ELECTRONICS
+ HEADPHONE
+ VPS (WET GLAS)
+ QUAL C THERMAL PLATE
VIR, SHOCK, ACCEL
1/4
1/10
MASS PROosta

EMI
MODE

EMI HUM
VIR
1/4
1/10

CRYSTAL
FILTER
FINAL

7759-5673
GLA QUALIFICATION

GLA COMPONENTS
- ROCKET MOTORS
  - VIB, TEMP CYCLING
- GRENADES
  - VIB, TEMP CYCLING
- SAFE/ARM MECHANISMS
  - HOT, COLD FIRINGS
- H.E. DETONATOR TESTS
- INITIATORS (BIAS)
- TRANSMITTER
  - T/V, VIB
- THERMAL BATTERY
  - SHOCK (2000 G'S)
- ANGLE SENSOR
  - T/V, VIB, SHOCK
  - (100 G'S)

GLA
- ENVIRONMENTAL
  - VIBRATION
  - SHOCK
  - ACCEL
  - TEMP CYCLING

GLA/GLA/MULTAR BOX
- FULL EARTH FIRINGS
  - AMBIENT (4 GLA'S)
  - LOW TEMP (4 GLA'S)
  - HIGH TEMP (GLA)
  - BATTERY EVAL TESTS (3 GLA'S)
  - CAMP PENDLETON
    - 2 FLIGHT GLA'S/BOX
    - 2 GRENADES, COLD
    - 2 GRENADES, AMBIENT
    - 4 GRENADES, HOT

ASE SYSTEM TEST-WSTF
- FULL UP EXPERIMENT (DEPLOYED) TEST
  - EXPERIMENT TEST EQUIPMENT
- 4 TEST CATEGORIES
  - EXTRA CHARGE FIRINGS (1000, 3000 FT)
  - THUMPER FIRINGS, 21 ASI'S
  - MORTAR FIRINGS, 2 GLA'S (8 GRENADES)
  - SPECIAL GEOPHONE TESTS
- THUMPER STRUCTURAL INTEGRITY AND PERFORMANCE VERIFIED
- MPA STRUCTURAL INTEGRITY AND STABILITY VERIFIED
- OVERALL GLA PERFORMANCE VERIFIED
- RF LINK (UP TO 5000 FT) VERIFIED
- CENTRAL ELECTRONICS VERIFIED
- INTRODUCTION, DETECTION AND CONDITIONING OF SEISMIC ENERGY VERIFIED.

7759-5674

7759-5675
Section 5

Laser Ranging Retro-Reflector Experiment
LASER RANGING RETRO-REFLECTOR EXPERIMENT

- STOWED

COMPONENTS

ARRAY: 100 FUSED SILICA RETROREFLECTORS
PASSIVE THERMAL CONTROL

PALLET: LM SEQ BAY INTERFACE
EXPERIMENT BASE

SUPPORT STRUCTURE: SUPPORT ARRAY/AIMING HANDLE

AIMING HANDLE: UNLOCK, TILT, LOCK ARRAY

ALIGNMENT HANDLE: HOLD EXPERIMENT DURING ARRAY TILTING
ROTATE EXPERIMENT
ALIGN AND LEVEL EXPERIMENT

BOOM ATTACHMENT: REMOVAL FROM LM
CARRY EXPERIMENT TO SITE

7759-5336

7759-5340
EASEP/LRRR EXPERIMENT
DESIGN CHARACTERISTICS (CONT’)

COMPONENTS (CONT.)

ANGLE INDICATING BRACKET: TILT INDICATION AND LOCK
SUN COMPASS PLATE
GNOMON

LIQUID BUBBLE LEVEL: LEVEL INDICATION
REAR SUPPORT: SUPPORT IN UPRIGHT POSITION

WEIGHT
51.91 LB

SIZE
26 x 27.25 x 17 IN. HIGH

PROTECTIVE COVER: PROTECT RETROREFLECTORS FROM DUST,
DIRT REMOVED IN DEPLOYMENT

7759-5337

LRRR MECHANICAL ASSEMBLY

7759-5324

5-2
LRRR FLIGHT MODEL STOWED IN SEQ BAY
-APOLLO 11
ARRAY PANEL STRUCTURE

Retro-reflector Cavity

Lightening Holes

7759-5314A
RETRO-REFLECTOR MOUNTING

A Aluminum Retainer Ring

B Upper Teflon Mounting Ring

C Fused-Silica Retro-Reflector

D Lower Teflon Mounting Ring

7759-5313
ORIGINAL MULTILAYER INSULATION BLANKET CROSS-SECTION

VELCRO HOOK (1/8" WIDE)
VELCRO HOOK (1/2" WIDE)
DACRON THREAD
COVER, DACRON

ARRAY
VELCRO (PILE) ALL AROUND ARRAY, EXCEPT AT BREAKS FOR BRACKETS, ETC.
NARMCO POLYURETHANE ADHESIVE
SPACERS (3)
DOUBLE LAYER DACRON NETTING
SHELDS (3)
DOUBLE-ALUMINIZED MYLAR

7759-5327

ASCENT HEATING THERMAL PROTECTION MOD KIT (INSTALLED AT KSC)

KAPTON 1/2 MIL ALUMINIZED BOTH SIDES
FIBERGLASS THREAD, BETA YARN, TEFLON COATED
FIBERGLASS BET CLOTH COVER
FIBERGLASS THREAD, BETA YARN TEFLON COATED
ORIGINAL BLANKET
FIBERGLASS NETTING

7759-5328

S-12
TYPICAL LASER RAY PATH IN RETRO-REFLECTOR

THERMAL MODEL
AND DEFINITION OF SUN ANGLES
HEAT INPUT TO ARRAY FROM PALLET FOR 34° ARRAY TILT ANGLE

PREDICTED CENTRAL IRRADIANCE—FINAL DESIGN CALCULATIONS
**EASEP/ASTRONAUT INTERFACE**

<table>
<thead>
<tr>
<th>CONSTRAINT</th>
<th>RESOLUTION</th>
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<tbody>
<tr>
<td>BIOMEDICAL</td>
<td>SIMPLE TASKS REQUIRING MINIMAL EFFORT AND TIME</td>
</tr>
<tr>
<td>SAFETY</td>
<td>DOSAGE RATE OF ISOTOPE HEATER NON-HAZARDOUS</td>
</tr>
<tr>
<td>THERMAL</td>
<td>NO SIGNIFICANT THERMAL EXPOSURES</td>
</tr>
<tr>
<td>SUIT PUNCTURE</td>
<td>NO SHARP EDGES; PSE UNCAGE USES APPROVED</td>
</tr>
<tr>
<td>MOBILITY</td>
<td>NO EXCESSIVE REACH - NO KNEELING</td>
</tr>
<tr>
<td>DEXTERITY</td>
<td>ALL MECHANISMS ACTUATED BY PULL PINS, HANDLES OR LANYARDS</td>
</tr>
<tr>
<td>VISUAL</td>
<td>LEVEL/ALIGN INDICATORS COMPATIBLE WITH VISOR LIMITATIONS</td>
</tr>
</tbody>
</table>

**LRRR MECHANICAL FEATURES**

**INFLUENCED BY CREW CONSIDERATIONS**

- **ALIGNMENT HANDLE**: REACH HEIGHT, SUPPORT DURING ARRAY TILT, HANDLE, TRIGGER, RELEASE MECHANISM CONFIGURATIONS
- **AIMING HANDLE**: REACH HEIGHT, HANDLE CONFIGURATION, SPRING RETURN
- **ANGLE INDICATING BRACKET**: VISIBILITY AND SIMPLICITY
- **SUN COMPASS**: VISIBILITY AND SIMPLICITY
- **BUBBLE ELVEL**: VISIBILITY AND SIMPLICITY
- **PROTECTIVE COVER**: RING/LANYARD REMOVAL, REACH HEIGHT
- **BOOM ATTACHMENT**: RING/PULL PIN REMOVAL, RING/LANYARD RELEASE FROM LM, REACH HEIGHT

REMOVE LRRR AND PSEP FROM LM, TRAVERSE TO DEPLOYMENT SITE, DEPLOY LRRR AND PSEP; TOTAL TIME APPROX 10 MIN

7769-5322

7759-5336
# LRRR Emplacement Criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>Indicator</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from LM</td>
<td>32 ft minimum</td>
<td>Paced Off</td>
<td>Crew/Payload Tracking</td>
</tr>
<tr>
<td>Direction from LM</td>
<td>In Fou of Other Astronaut</td>
<td>Eyeball</td>
<td>Monitor Deployment (Avoid LM Shadow Area)</td>
</tr>
<tr>
<td>Distance from PSEP</td>
<td>Do not directly from PSEP</td>
<td>Eyeball</td>
<td>To Avoid Shadowing Solar Panels</td>
</tr>
<tr>
<td>Site Selection</td>
<td>Level &amp; flat from Rubble</td>
<td>Eyeball</td>
<td>Constrains Leveling Capability</td>
</tr>
<tr>
<td>Tilt of array</td>
<td>Set to proper position</td>
<td>Index Marks on Sector</td>
<td>Different for Each LANDING SITE</td>
</tr>
<tr>
<td>Level, WRT Indicator</td>
<td>&gt; 5° of Indicator</td>
<td>Rubble</td>
<td>Interacts with Alignment</td>
</tr>
<tr>
<td>Align, WRT Shadow</td>
<td>&gt; 5° of Indicator Lim</td>
<td>Compass Plate Partial Rose</td>
<td>Align for Landing Site</td>
</tr>
</tbody>
</table>

Before rotating upright for final alignment LRRR must be facing away from Subearth Point (function of landing Site).

## Traverse

- **Pick up Both Packages**
- **Walk to Deployment Site**

**Site Selection**
- Approximately 30 ft from LM, in FOV of other Astronaut, in an area free of Rubble
- **Lower Packages to Lunar Surface**
DEPLOY LRRR

- Position LRRR for deployment
  - Rough align LRRR wrt sub-Earth point
  - Release deployment handle and extend to detent
  - Pull out array tilting handle to allow tilt adjustment

- Adjust LRRR tilt
  - Rotate tilting handle to set tilt indicator for landing site

- Rotate LRRR upright
  - Actuate deployment handle trigger to release detent
  - Fully extend handle
  - Use handle to rotate package

- Set final alignment
  - Align wrt shadow on partial rose
LRRR BEING CARRIED TO DEPLOYMENT SITE
-APOLLO 11
LRRR TRAINER-RELEASING ALIGNMENT HANDLE
LRRR TRAINER-EXTENDING ALIGNMENT HANDLE
LRRR TRAINER-LOWERING EXPERIMENT TO SURFACE
LRRR ARRAY TEST SUMMARY

DEVELOPMENT TESTS

MECHANICAL (VIBRATION AND SHOCK)
- SINGLE CORNER CELL
- ENGINEERING TEST MODEL (ETM)

OPTICAL ALIGNMENT
- BEFORE AND AFTER MECHANICAL TEST – ETM
- BEFORE, DURING, AFTER THERMAL CYCLING – ETM

THERMAL DISTORTION – ETM EXPOSED TO -320°F TO +250°F

THERMAL CONDUCTANCE – SINGLE CORNER CELL

MOUNT TEMPERATURE COMPENSATION – SINGLE CORNER CELL

ACCEPTANCE TESTS (QUAL AND FLIGHT MODEL ARRAYS)

MECHANICAL (VIBRATION) – ACCEPTANCE LEVEL

OPTICAL ALIGNMENT – BEFORE AND AFTER MECHANICAL TESTS

7759-5331

OPTICAL ALIGNMENT

TEST RANGE APPARATUS

7759-5339
### ARRAY OPTICAL ALIGNMENT TESTS SUMMARY

<table>
<thead>
<tr>
<th>MODEL</th>
<th>CONDITIONS</th>
<th>MAX DEVIATION FROM ARRAY POINTING DIRECTION (DEGREES)</th>
<th>DEVIATION OF ARRAY POINTING DIRECTION FROM NORMAL (DEGREES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETM</td>
<td>BEFORE VIBRATION</td>
<td>0.18</td>
<td>0.07</td>
</tr>
<tr>
<td>ETM</td>
<td>AFTER VIBRATION</td>
<td>0.29</td>
<td>0.08</td>
</tr>
<tr>
<td>ETM</td>
<td>ROOM TEMP</td>
<td>0.27</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>-32°F</td>
<td>0.19</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>ROOM TEMP</td>
<td>0.23</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>+260°F</td>
<td>0.022</td>
<td>0.02</td>
</tr>
<tr>
<td>QUAL</td>
<td>BEFORE VIBRATION</td>
<td>0.18</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>AFTER VIBRATION</td>
<td>0.18</td>
<td>0.02</td>
</tr>
<tr>
<td>FLIGHT</td>
<td>BEFORE VIBRATION</td>
<td>0.17</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>AFTER VIBRATION</td>
<td>0.16</td>
<td>0.02</td>
</tr>
<tr>
<td>SPECIFICATION</td>
<td></td>
<td>± 2.0°</td>
<td>± 0.26°</td>
</tr>
</tbody>
</table>

### LRRR EXPERIMENT TEST SUMMARY

- **CREW ENGINEERING MOCK-UP**
- CREW INTERFACES
- EARLY KSC WALK-THROUGH
- **CREW TRAINER MODEL**
- CREW TRAINING
- KC 135 TESTS
- **KSC HANDLING MODEL**
- HANDLING PROCEDURE CHECKOUT
- LM INSTALLATION TRAINING

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7759-5332

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7759-5329

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5-27
LRRR EXPERIMENT TEST SUMMARY (CONT')

- QUALIFICATION MODEL
  MASS PROPERTIES
  VIBRATION (ACCEPTANCE AND DESIGN LIMIT LEVELS)
  SHOCK
  ACCELERATION
  MECHANICAL FUNCTIONAL DEPLOYMENT
  THERMAL/VACUUM

- FLIGHT MODEL
  MASS PROPERTIES
  VIBRATION (ACCEPTANCE LEVELS)
 ALSEP TUMBLE
  MECHANICAL FUNCTIONAL DEPLOYMENT

7759-5330
Section 6

Charged Particle Lunar Environment Experiment
CHANNELTRON® ELECTRON MULTIPLIERS

HELIX TYPE

C - TYPE

INSIDE COATING FOR SECONDARY ELECTRON EMISSION

X $10^8$ sec.

PREAMP

1 mm INSIDE

UP TO $10^9$/sec.

PROTONS, ELECTRONS, X-RAYS & UV

(THEREFORE, SORT BEFORE ENTRANCE)

ELECTRON-GAIN

APPLIED KILOVOLTS

OUTPUT

CTREE PHYSICAL ANALYZER

DEFLECTION PLATES

PARTICLES IN

ELECTRON MULTIPLIERS

COLLIMATING SLITS

7759-5426

7759-5423

6-2
PHYSICAL ANALYZER

Ultraviolet Trap
Deflection Plates
Collimating Slits
Particle Stop
Helix Channeltron Holder
Channeltron

DEFLECTION VOLTAGE

3500 VOLTS

350 VOLTS

35 VOLTS

CPLEE ENERGY RANGES

<table>
<thead>
<tr>
<th>DEFLECTION VOLTAGE</th>
<th>ENERGY RANGE IN EACH DETECTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>3500 VOLTS</td>
<td>HELIX 1 2 3 4 5</td>
</tr>
<tr>
<td>350 VOLTS</td>
<td>HELIX 1 2 3 4 5</td>
</tr>
<tr>
<td>35 VOLTS</td>
<td>HELIX 1 2 3 4 5</td>
</tr>
</tbody>
</table>

PARTICLE ENERGY (KEV)

7759-5429

6-3
CPLEE TIMING SEQUENCE

ALSEP FRAME NO
0 4 8 12 16 20 24 28 32

CPLEE PHYS/AN
A | B | A | B | A | B | A | B | A | B | A | B

READOUT OF A DURING B MEAS, ETC.

DEFLECTION VOLTAGE
+3500
+350
+35
BKG
CAL

-35
EVEN FRAME MARKS
-350
-35

CPLEE MAY START ANYWHERE
DATA = CNTS/SEC

19.3 SEC (NORMAL)

7759-5427

SIMPLIFIED BLOCK DIAGRAM
OF CHARGED PARTICLE EXPERIMENT

7759-5445

6-4
**DIGITAL DATA OUTPUT FORMAT**

**CHARGED PARTICLE EXPERIMENT**

<table>
<thead>
<tr>
<th>ALSEP T/M Frame</th>
<th>1st Frame</th>
<th>2nd Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CLPEE Word Number</strong></td>
<td>1 2 3 4 5 6</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>No. of Count Data Bits</td>
<td>19 19 19 19</td>
<td>20 20</td>
</tr>
<tr>
<td>No. of L.D. Bits</td>
<td>1 1 1 1</td>
<td>- -</td>
</tr>
<tr>
<td>Channeltron Detector</td>
<td>No. 1 No. 2</td>
<td>No. 3 No. 4</td>
</tr>
<tr>
<td>L.D. Bit Assignment</td>
<td>Analyzer A or B</td>
<td>Deflection Voltage Level</td>
</tr>
</tbody>
</table>

7759-5449
CPLEE DIGITAL DATA FORMAT

CPLEE PERFORMANCE CHECKS

<table>
<thead>
<tr>
<th>TECHNIQUE</th>
<th>CNT/SEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETASOURCE IN DUST COVER</td>
<td>0 TO 2000</td>
</tr>
<tr>
<td>FOR COMPLETE TEST DURING INITIAL</td>
<td>(DEPENDING ON CHANNEL)</td>
</tr>
<tr>
<td>OPERATION</td>
<td></td>
</tr>
<tr>
<td>TEST OSCILLATOR INPUT TO ALL</td>
<td>≈350,000 Hz</td>
</tr>
<tr>
<td>PREAMPS ONCE DURING EACH</td>
<td>(FILLS 19TH BIT OF REGISTER)</td>
</tr>
<tr>
<td>OPERATING CYCLE</td>
<td></td>
</tr>
</tbody>
</table>

7759-5432

7759-5430
CHARGED PARTICLE EXPERIMENT
CHARACTERISTICS

COMMUNICATIONS

<table>
<thead>
<tr>
<th>COMMANDS:</th>
<th>DATA:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• POWER OPER/STBY/OFF</td>
<td>• 6 DIGITAL WORDS PER ALSEP FRAME</td>
</tr>
<tr>
<td>• 8 SPECIAL CMDs FOR:</td>
<td>99 BPS (APPROX)</td>
</tr>
<tr>
<td>DUST COVER REMOVAL (1)</td>
<td>97% SCIENCE, 3% HK</td>
</tr>
<tr>
<td>AUTO CMD THERMAL CONTROL (2)</td>
<td>19.3 SEC NORMAL REP RATE</td>
</tr>
<tr>
<td>AUTO CMD VOLTAGE PROGRAM TO SENSOR (3)</td>
<td>6 ANALOG ENG PARAMETERS</td>
</tr>
<tr>
<td>CHANGE SENSOR GAIN (2)</td>
<td>SAMPLED ONCE PER 54-SEC ALSEP SEQUENCE</td>
</tr>
<tr>
<td>• BACKUP FROM TIMER TO REMOVE DUST COVER</td>
<td></td>
</tr>
</tbody>
</table>

DISPLAY: PRINTER/TV

7759-5420

COMMAND SIGNALS

CHARGED PARTICLE EXPERIMENT

1. Thermal Control Bypass - On
2. Thermal Control Bypass - Off
3. Dust Cover Removal
4. Automatic Deflection Voltage Level Sequence - On
5. Step Deflection Voltage Level
6. Automatic Deflection Voltage Level Sequence - Off
7. Channeltron P. S. Voltage Increase - On
8. Channeltron P. S. Voltage Increase - Off

7759-5450
CLEE COMMANDS

OCTAL COMMAND NUMBERS

- 111 CPE OPR HTR ON
  
  This command bypasses the thermostat in the CLEE and turns the operational heater on. To restore automatic thermal control, the experiment power must be commanded to STBY and back to OPER. This command has no control over survival (STBY) heaters.

- 112 CPE OPR HTR OFF
  
  This command bypasses the thermostat in the CLEE and turns the operational heater off, and is also used to turn off the operational heater after it has been turned on by command 111. See command 111 for restoration of automatic thermal control. This command has no control over survival heaters. (Operational heater on/off via 111 & 112 can be recycled indefinitely.)

CLEE COMMANDS (CONT’)

- 113 CPE CVR GO
  
  This command actuates the guillotine device for removing the CLEE dust cover.

- 114 CPE DEF SEQ ON
  
  This command starts the automatic sequence of voltages to the CLEE deflection plates whenever it has been stopped (by command 117). Initial turn-on of the experiment is in the automatic sequence mode.

- 115 CPE DEF STEP
  
  This command advances the voltage on the CLEE deflection plates one step each time it is used. In the standard sequence, when the sequence has been stopped, if automatic sequence is on, this command has no effect.

7759-5434
CPLEE COMMANDS (CONT')

- **117 CPE DEF SEQ OFF**
  
  **THIS COMMAND INTERRUPTS THE AUTOMATIC SEQUENCE OF VOLTAGES TO THE CPLEE DEFLECTION PLATES. THE VOLTAGE THEN REMAINS CONSTANT UNTIL ADVANCED BY COMMAND 115. IT IS RESTORED TO AUTOMATIC SEQUENCE BY COMMAND 114 OR BY CYCLING CPLEE TO STBY AND BACK TO OPER.**

- **120 CPE CHAN/Hi SEL**
  
  **THIS COMMAND INCREASES THE VOLTAGE ACROSS THE CHANNELTRON ELECTRON MULTIPLIERS IN BOTH PHYSICAL ANALYZERS (A & B) TO THE HIGHER VALUE, \( \approx 3200 \) VOLTS. IF IT IS AT THE LOWER SETTING, \( \approx 2800 \) VOLTS (\( \Delta \approx 400 \) VOLTS). IF THIS COMMAND IS SENT TWICE, WITHOUT COMMAND 121 BETWEEN, THE SECOND COMMAND HAS NO EFFECT.**

---

CPLEE COMMANDS (CONT')

- **121 CPE CHAN/Lo SEL**
  
  **THIS COMMAND DECREASES THE VOLTAGE ACROSS THE CHANNELTRON ELECTRON MULTIPLIERS IN BOTH PHYSICAL ANALYZERS (A & B) TO THE LOWER VALUE, \( \approx 2800 \) VOLTS, IF IT IS AT THE HIGHER SETTING, \( \approx 3200 \) VOLTS (\( \Delta \approx 400 \) VOLTS). IF THIS COMMAND IS SENT TWICE, WITHOUT COMMAND 120 BETWEEN, THE SECOND COMMAND HAS NO EFFECT.**
ANALOG VOLTAGE HOUSEKEEPING SIGNALS
CHARGED PARTICLE EXPERIMENT

1. Switchable Power Supply Voltage
2. Channeltron P.S. Voltage—Analyzer A
3. Channeltron P.S. Voltage—Analyzer B
4. Voltage P.S.
5. Temperature of Physical Analyzer A
6. Temperature of Switchable P.S.

CPL EE ANALOG DATA

SAMPLED ONCE PER 54-SEC
ALSEP SEQUENCE (ALSEP WORD 33)

AC - 01 CPE DEF P/S VOLTS
AC - 02 CPE CHAN/1 VOLTS
AC - 03 CPE CHAN/2 VOLTS
AC - 04 CPE CONV VOLTS
AC - 05 CPE PHYS/AN DEG C
AC - 06 CPE DEF P/S DEG C

NOTE: AC - 05 IS TEMPERATURE OF PHYSICAL ANALYZER A
CLEE CHANNELTRON POWER SUPPLY
CPL  LOW VOLTAGE POWER SUPPLY
CPLEE IN THERMAL VACUUM TEST
**CHARGED PARTICLE EXPERIMENT CHARACTERISTICS**

**OPERATIONS**

<table>
<thead>
<tr>
<th>DEPLOYMENT</th>
<th>POST DEPLOYMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>• LOCATE 10 FT FROM CENTRAL STATION</td>
<td>• TURN ON IOPERI PRE-ASCENT</td>
</tr>
<tr>
<td>• LEVEL +2.5</td>
<td>• READ BASELINE DATA (COVER ON)</td>
</tr>
<tr>
<td>• ALIGN ±2° WRT SHADOW (SCIENTIFIC &amp; THERMAL)</td>
<td>• AFTER ASCENT REMOVE DUST COVER</td>
</tr>
<tr>
<td>APPROX TIME, 2 MIN</td>
<td>• CONTINGENCY CORRECTIVE ACTIONS</td>
</tr>
</tbody>
</table>

7759-54 21

6-21
CPLEE TEST SET
Section 7

Heat Flow Experiment
HEAT FLOW CHARACTERISTICS

COMPONENTS

PHYSICAL PARAMETERS
(NOT INC. DRILL)

- ELECTRONICS 13 x 9 x 8
- PROBES 25.5 x 4.5 x 3.5
- (IN PACKAGE)
- EARTH WT., L.B.: 9.7 LB (TOTAL)
- POWER, W.: 3.9 TO 10.6

HEAT FLOW CHARACTERISTICS (CONT')

KEY FEATURES

- SENSOR CALIBRATION ON EARTH REQUIRES SPECIAL FACILITY
- AVOID DISTURBING LUNAR SURFACE REFLECTIVE PROPERTIES AROUND PROBES
- REQUIRES RADIATIVE THERMAL COUPLING BETWEEN PROBE & HOLE PLUS
  NO THERMAL SHORT-CIRCUIT TO SURFACE
- "THERMOSTATICALLY" CONTROLLED HEATER IN ELECTRONICS PACKAGE
# Heat Flow Characteristics

## Operations

<table>
<thead>
<tr>
<th>Deployment</th>
<th>Post Deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Locate electronics 30 ft from central station</td>
<td>• Turn on (Oper) pre-ascent</td>
</tr>
<tr>
<td>• Level +12°</td>
<td>• Read gradient data continuously except during conductivity tests</td>
</tr>
<tr>
<td>• Align +5° wrt shadow (thermal)</td>
<td>• Make conductivity tests - times for up to 48 hrs each time</td>
</tr>
<tr>
<td>• Drill holes (12) 3 meters deep &amp; place probes in bottom of holes using tool</td>
<td></td>
</tr>
<tr>
<td>• Holes 30 ft apart &amp; 16 ft from electronics</td>
<td></td>
</tr>
<tr>
<td>Approx time, 9 min, plus 30 min for drilling</td>
<td></td>
</tr>
</tbody>
</table>

## Communications (Cont’)

<table>
<thead>
<tr>
<th>Commands:</th>
<th>Data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Power Oper/Stby/Off</td>
<td>1 digital word per Alsep frame (for 10 out of every 90 frames)</td>
</tr>
<tr>
<td>• 10 special cmds for:</td>
<td>3.0 BPS (approx)</td>
</tr>
<tr>
<td>Select gradient, hi conductivity, or lo conductivity modes (3)</td>
<td>65% science, 35% HK</td>
</tr>
<tr>
<td>Select measurement sequence (6)</td>
<td>435 sec rep rate (full sequence)</td>
</tr>
<tr>
<td>Select &amp; activate conductivity HTRS (1)</td>
<td>6 analog eng parameters sampled once per 54 sec Alsep sequence</td>
</tr>
<tr>
<td>Display: X-Y plotter or print (requires data analysis)</td>
<td></td>
</tr>
</tbody>
</table>

7759-5518

7-2
HEAT FLOW SENSORS

TEMP.

NOTE: FOR ILLUSTRATION, NOT ACTUAL DATA

DAILY VARIATION
WITH SUPERIMPOSED
HI ORDER EFFECTS

ANNUAL VARIATION
DUE TO MOON'S ORBIT

- PROBLEM TO FIND THE SMALL DC COMPONENT
  IN A POSSIBLY LARGE AC WAVE

MODEL OF OPERATION: MOD/G, MOD/H, & MOD/E PLUS MANY MEASUREMENT SEQUENCES

BASIC DATA WORD: 15 BIT OUTPUT OF ADC IN 2 ALSEP WORDS (PLUS 10)

TYPICAL BRIDGE
HEADING

15 EXCITATION
13 OUTPUT
14 EXCITATION
16 OUTPUT

SENSOR TYPE: PLATINUM RESISTOR
SENSOR CIRCUITS:
- SETS OF FOUR SENSORS
- TWO COMBINATION DIFFERENCE & AMBIENT
  SELECTED BY INTERNAL LOGIC

DYNAMIC RANGE:
- TEMP DIFFERENCE BRIDGE
  HI SENSITIVITY ±0.006°C TO ±20°C
  LO SENSITIVITY ±0.008°C TO ±20°C
- AMBIENT TEMP SENSITIVITY
  ±0.006°C TO ±20°C
- CABLE THERMOCOUPLES (V/A: PROBE CABLES)
  WT: 500mA; GAIN: 225 ± 10%
- THERMOCOUPLES IN THERMISTOR BRIDGE ±0.006°C TO ±10°C
- CABLE TEMPERATURE RISE: ±0.02°C TO ±0.8°C
  CAUTION: SEE "A"

HEAT FLOW EXPERIMENT

PROBE PACKAGE
CARBON

CABLE TRAY

ELECTRONICS
PACKAGE

PROBE CARRIING PACKAGE
CONTAINS 2 PROBES & EMPLACEMENT TOOL

SUNSHIELD

HERMAL
MASK

CABLE BRACKET
REMOVED DURING
EMPLACEMENT

| ELECTRONICS |
| TABLE | |
| 10 | 9 |

| PROBE |
| TABLE | |
| 7.5 | 5 |

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7759-5521
**HFE COMMAND SUMMARY**

<table>
<thead>
<tr>
<th>CMD NUMBERS</th>
<th>OCTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>135</td>
</tr>
<tr>
<td>C2</td>
<td>136</td>
</tr>
<tr>
<td>C3</td>
<td>140</td>
</tr>
<tr>
<td>C4</td>
<td>141</td>
</tr>
<tr>
<td>C5</td>
<td>142</td>
</tr>
<tr>
<td>C6</td>
<td>143</td>
</tr>
<tr>
<td>C7</td>
<td>144</td>
</tr>
<tr>
<td>C8</td>
<td>145</td>
</tr>
<tr>
<td>C9</td>
<td>146</td>
</tr>
<tr>
<td>C10</td>
<td>152</td>
</tr>
</tbody>
</table>

INPUT BUFFER HOLDS COMMANDS FOR EXECUTION AT 90-FRAME MARK

---

**HFE DIGITAL DATA FORMAT**

- ALSEP FRAME 90, 8
- MEASUREMENT (SEQUENCE) REGISTER
- MODE REGISTER
- HFE SCIENCE DATA (TYPICAL)
- CONDUCTIVITY HEATER REGISTER
- SUBSEQUENCE REGISTER (WORD 1D)
HFE MODE REGISTER

The Mode Register is part of the HFE CMD decoder and responds to CMDs 135, 136 and 140. The state of this register is read out via TM.

<table>
<thead>
<tr>
<th>OCTAL</th>
<th>ABBR</th>
<th>MODE</th>
<th>TM (M1M2M3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>135</td>
<td>MODE/G</td>
<td>MODE 1</td>
<td>NORMAL GRADIENT 100</td>
</tr>
<tr>
<td>136</td>
<td>MODE/LK</td>
<td>MODE 2</td>
<td>LOW CONDUCTIVITY  010</td>
</tr>
<tr>
<td>140</td>
<td>MODE/HK</td>
<td>MODE 3</td>
<td>HIGH CONDUCTIVITY 001</td>
</tr>
</tbody>
</table>

The mode selected by CMD affects the data as follows:

- MODE/G and MODE/LK have identical TM (formatted by the measurement sequence programmer and subsequence programmer) but in MODE/LK the probe heater current supply is turned on and heaters respond to CMD 152.

- MODE/HK bypasses the measurement sequence programmer and produces a special TM output formatted by the subsequence programmer and heater sequence programmer.

HFE GRADIENT MEASUREMENT OPTIONS

[Diagram showing HFE gradient measurement options]

7759-5529
HFE MEASUREMENT SEQUENCE PROGRAMMER

THE MEASUREMENT SEQUENCE PROGRAMMER (MSP) IS A 16-STATE BINARY COUNTER USING 4 FLIP-FLOPS. ITS OPERATION CAN BE MODIFIED BY CMD TO PERFORM 8-STATE, 4-STATE, AND 2-STATE PROGRAMS. THE FLIP-FLOPS HAVE DUAL FUNCTIONS:

- FORMAT HFE DATA BY CONTROLLING GATES TO THE OUTPUT REGISTER
- SUPPLY MSP STATUS DATA FOR TM (P-BITS)

NOTE THAT EXECUTION OF A MEASUREMENT CMD (141 THROUGH 146) DOES NOT RESET MSP. OPERATION CONTINUES FROM PREVIOUS STATE.

IN DIAGRAM, THE SET (5) AND CLEAR (C) POSITIONS OF THE FLIP-FLOPS CORRESPOND TO ONE AND ZERO IN THE TM.
HFE SUBSEQUENCE PROGRAMMER

THE SUBSEQUENCE PROGRAMMER IS A 4-STATE COUNTER HAVING DUAL FUNCTIONS:

- CONTROL GATING OF DATA, WITHIN A SUBSET, TO THE OUTPUT REGISTER:
  (WHERE THE TYPE OF SUBSET IS CONTROLLED BY THE MSP)
- SUPPLY SUBSEQUENCE REGISTER STATUS DATA FOR TM (R-BITS)

THE STATE OF R₂R₁ CHANGES EVERY OTHER ALSEP FRAME (ONE 10-BIT WORD OF HFE DATA IN EACH ALSEP FRAME) STARTING WITH A RESET AT THE 90-FRAME MARK.

THE TRANSITION FROM 11 TO 00 BETWEEN 7 AND 8 MARKS THE 90 + 8 FRAME, THIS ADVANCES P₁ FROM ZERO TO ONE.

FROM ALSEP FRAME 16 TO 89 THERE IS NO HFE DATA AND REGISTER CHANGES ARE INHIBITED.

<table>
<thead>
<tr>
<th>R₂</th>
<th>R₁</th>
<th>ALSEP FRAME NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>90, 1</td>
<td>8, 9</td>
</tr>
<tr>
<td>01</td>
<td>2, 3</td>
<td>10, 11</td>
</tr>
<tr>
<td>10</td>
<td>4, 5</td>
<td>12, 13</td>
</tr>
<tr>
<td>11</td>
<td>6, 7</td>
<td>14, 15</td>
</tr>
</tbody>
</table>

7759-5532

HFE TIMING FUNCTIONS

7759-5533

7-9
### HFE GRADIENT MEASUREMENT INDEX

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>ABBR</th>
<th>P-H.1%</th>
<th>DATA SOURCE</th>
<th>PROBE/ EXCITATION</th>
<th>(H2,P2) SUBSET DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH-01</td>
<td>GDT 1HN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE EXCITATION</td>
</tr>
<tr>
<td>DH-07</td>
<td>GDT 1HN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE OUTPUT</td>
</tr>
<tr>
<td>DH-01</td>
<td>GDT 2HN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE EXCITATION</td>
</tr>
<tr>
<td>DH-04</td>
<td>GDT 2HN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE OUTPUT</td>
</tr>
<tr>
<td>DH-09</td>
<td>GDT 1LN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE EXCITATION</td>
</tr>
<tr>
<td>DH-06</td>
<td>GDT 1LN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE OUTPUT</td>
</tr>
<tr>
<td>DH-07</td>
<td>GDT 1LN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE EXCITATION</td>
</tr>
<tr>
<td>DH-06</td>
<td>GDT 1LN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE OUTPUT</td>
</tr>
<tr>
<td>DH-09</td>
<td>GDT 1LN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE EXCITATION</td>
</tr>
<tr>
<td>DH-06</td>
<td>GDT 1LN</td>
<td>0000</td>
<td>ZENER</td>
<td>VOLTAGE</td>
<td>000+BRIIDGE OUTPUT</td>
</tr>
</tbody>
</table>

### HFE HEATER SEQUENCE PROGRAMMER

**CMD C10 HFI HTR STEPS**

- H4 ADV  H3 ADV  H2 ADV  H1

- **16 STATE BINARY COUNTER USING 4 FLIP FLOPS**
- **STATUS TRANSMITTED IN 1M AS 16 BITS (ALL 3 MODES)**
- **EFFECT ON OPERATION AND DATA:**
  - **MODE/6** - NO EFFECT CAN BE ADVANCED VIA CMD 152 BUT PROBE HEATER CURRENT SUPPLY IS OFF
  - **MODE/LK** - CONTROLS ON/OFF STATUS OF 8 HEATERS (PROBE) IN LOW MODE OF PROBE HEATER CURRENT SUPPLY
  - **MODE/HK** - CONTROLS DATA OUTPUT AND ON/OFF STATUS OF 8 HEATERS IN HIGH MODE OF PROBE HEATER CURRENT SUPPLY
  - **PROBE HEATER ON/OFF STATUS IN ANALOG IM (ALSEP WORD 39) CLUSP 59**
HFE HEATER SELECT CODE

H4 {0 = PROBE 1
     1 = PROBE 2

H3 {0 = LOWER HEATER
     1 = UPPER HEATER

H2 {0 = UPPER SECTION
     1 = LOWER SECTION

H1 {0 = HEATER OFF
     1 = HEATER ON

EXAMPLE: WHEN H-BITS - 1011,
          HEATER H24 IS ON
          WHERE
          H24 INDICATES FOURTH
          HEATER IN PROBE 21

NOTE: THIS CODE APPLIES TO HEATER CONTROL
       IN BOTH MODE/LK AND MODE/HK

HFE MEASUREMENTS IN MODE/HK
HFE COMMAND DETAILS

OCTAL CMD NUMBER
135 HFE MODE/G SEL

This CMD (C1) 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 and cable thermocouples under the control of the MSP. CMD 135 also turns off the probe heater current supply. Different measurement sequences in MODE/G may be selected by transmitting subsequent CMDs. At power turn-on, the HFE initializes in MODE/G. If the HFE is in MODE/G, 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.

HFE COMMAND DETAILS (CONT’)

136 HFE MODE/LK SEL

This CMD (C2) 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/G. 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/LK, transmission of CMD 136 has no effect.

140 HFE MODE/HK SEL

This CMD (C3) 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 140 (C3) must also be transmitted before valid data will be obtained in MODE/HK. 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/HK, transmission of CMD 140 has no effect.

7759-5538
HFE COMMAND DETAILS (CONT')

141  HFE SEQ/FUL SEL

THIS CMD (C4) IS A 1-STATE CMD. IT CANCELS THE EFFECT OF CMDs 142 THROUGH 146 CAUSING THE MSP TO PERFORM ITS FULL 16-STATE CYCLE OF OPERATION IN MODE/G OR MODE/LK. IF TRANSMITTED DURING MODE/HK OPERATION, THIS CMD WILL CAUSE INVALID OPERATION UNTIL CMD 144 IS EXECUTED. AT POWER TURN-ON, THE HFE INITIALIZES IN SEQ/FUL. IF THE HFE IS IN MODE/G OR MODE/LK AND IN SEQ/FUL, TRANSMISSION OF CMD 141 HAS NO EFFECT.

142  HFE SEQ/P1 SEL

THIS CMD (C5) IS A 1-STATE CMD AND ALTERNATES WITH CMD 143 TO SELECT ONLY ONE PROBE FOR MEASUREMENT. IN MODE/HK THIS CMD IS MEANINGLESS. IN MODE/G AND MODE/LK IT CAUSES THE MSP TO LOCK FLIP-FLOP P2 IN THE CLEAR STATE AND BYPASS P2. THE MSP ACTS AS AN 8-STATE COUNTER IF CMD 141 WAS PREVIOUSLY EXECUTED, OR AS A 2-STATE COUNTER IF CMD 144, 145 OR 146 WAS PREVIOUSLY EXECUTED. SEQ/P1 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141.

143  HFE SEQ/P2 SEL

THIS CMD (C6) IS A 1-STATE CMD AND ALTERNATES WITH CMD 142 TO SELECT ONLY ONE PROBE FOR MEASUREMENT. IT HAS THE SAME CHARACTERS AS CMD 142 EXCEPT THAT FLIP-FLOP P2 IS LOCKED IN THE SET STATE.

144  HFE LOAD 1

THIS CMD (C7) IS A 1-STATE CMD AND IS USED ALONE OR IN COMBINATION WITH CMD 145 OR 146 TO POSITION AND LOCK TWO FLIP-FLOPS (P4 P3) OF THE MSP. CMD 144 PLACES P4P3 IN THE CLEAR POSITION (00) AND BYPASSES THOSE STEPS. THE MSP THEN ACTS AS A 4-STATE COUNTER IF CMD 141 WAS PREVIOUSLY EXECUTED AND AS A 2-STATE COUNTER IF CMD 142 OR 143 WAS PREVIOUSLY EXECUTED. THIS APPLIES TO MODE/G AND MODE/LK. IN MODE/HK CMD 144 MUST BE EXECUTED TO OBTAIN VALID DATA. CMDs 145 OR 146 MAY BE USED IN MODE/G OR MODE/LK FOLLOWING CMD 144, TO LOCK P4 P3 IN THE 10 OR 01 STATE RESPECTIVELY.

THE EFFECT OF CMD 144 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141.

NOTE: WHEN IN MODE/G OR MODE/LK 00 STATE PROVIDES HIGH EXCITATION DIFFERENTIAL TEMPERATURE DATA ONLY.
**HFE COMMAND DETAILS (CONT')**

145  
**HFE LOAD 2**

This CMD (CMD 145) is a 1-state CMD and is used in combination with either CMD 144 (preceding CMD 145) or CMD 146 (preceding or following CMD 145) to position and lock P2 P3 (see CMD 144). CMD 145 positions flip-flop P3 in the set state. Therefore, 144-145 yields 01 (low excitation differential temperature data only) while 145-146 yields 11 (cable thermocouple data only). Execution of this CMD in mode/hk 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 (CMD 146) is a 1-state CMD operating essentially the same as CMD 145 except that it positions flip-flop P4 in the set state, when preceded by CMD 144 it yields 10 for P4 P3 (ambient temperature data only). Execution of this CMD in mode/hk causes invalid data until CMD 144 is executed.

---

**HFE COMMAND DETAILS (CONT')**

152  
**HFE HTS STEPS**

This CMD (CMD 152) is a 16-state CMD which advances the heater excitation programmer (H2 H3 H2 H1) each time the CMD is executed. In mode/c the programmer advances but there is no other effect since the probe heater current supply is off. In mode/lk 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/hk the heater excitation programmer (advanced by CMD 152) also selects the data to be sampled.
HFE ANALOG DATA

AH-01  HFE +5V SUPPLY
AH-02  HFE -5V SUPPLY
AH-03  HFE +15V SUPPLY
AH-04  HFE -15V SUPPLY
AH-05  (DELETED)
AH-06  HFE HTR/LK ON/OFF
AH-07  HFE HTR/HK ON/OFF

EACH SAMPLED ONCE
EVERY 54 SEC ALSEP SEQUENCE

HFE THERMAL CONTROL

NOTE: ADDITIONAL THERMOSTAT TURNS A PORTION OF INSTRUMENT ELECTRONICS ON/OFF BETWEEN MEASUREMENTS IF TEMP IS LOW/HIGH

7759-6544

7-15
HFE POWER PROFILE

HFE TIE-DOWN
### HFE ALIGNMENT MARKINGS

- TAPE CABLE TO CENTRAL STATION (PROBABLY NW OF HFE)
- SOCKET FOR UHT
- DEPTH INDICATION ON PROBE
- EMPLACEMENT TOOL
- TO PROBE

### HFE ENSAMBLAGE CRITERIA

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>REQUIREMENT</th>
<th>PRIORITY</th>
<th>INDICATOR</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Subpackage 1</td>
<td>&gt; 1 ft (0.3 m)</td>
<td>2</td>
<td>Painted</td>
<td>To obtain from separation from HFC.</td>
</tr>
<tr>
<td>90° of vertical</td>
<td>2</td>
<td>Etched</td>
<td></td>
<td>To obtain from separation with probe's requirement.</td>
</tr>
<tr>
<td>Wet Shadow</td>
<td>&gt; 1 ft (0.3 m)</td>
<td>2</td>
<td>Painted</td>
<td>To obtain from separation with probe's requirement.</td>
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<tr>
<td>Distance from Electronics</td>
<td>270° of 1 ft (0.3 m)</td>
<td>1</td>
<td>Painted</td>
<td>To obtain from separation with probe's requirement.</td>
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<tr>
<td>Direction from Electronics</td>
<td>At least 14°</td>
<td>1</td>
<td>Painted</td>
<td>To obtain from separation with probe's requirement.</td>
</tr>
<tr>
<td>Vertical Alignment</td>
<td>Within +15°</td>
<td>2</td>
<td>Etched</td>
<td>Directives for recording</td>
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<tr>
<td>Experiment/Intervention</td>
<td>Separation distance from HFC.</td>
<td>1</td>
<td>Painted</td>
<td>To obtain from separation with probe's requirement.</td>
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**Special Requirements:** Arrow orientation points last batch.
### DESIGN GOALS AND HEAT FLOW EXPERIMENT MEASUREMENTS

<table>
<thead>
<tr>
<th>Probe Temperature (Lower Meter)</th>
<th>Lunar Subsurface Temperature (Upper 2 Meters)</th>
<th>Temperature Difference in Lower Meter for 50-cm Length</th>
<th>Thermal Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range 200-250°K</td>
<td>90-350°K</td>
<td>± 20°C</td>
<td>5 x 10⁻⁵ to 1 x 10⁻³ cal/cm-sec°C</td>
</tr>
<tr>
<td>Resolution 0.1°C</td>
<td>0.5°C</td>
<td>0.001°C</td>
<td>± 20%</td>
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<tr>
<td>Accuracy ± 0.1°C</td>
<td>± 0.5°C</td>
<td>± 0.003°C</td>
<td>± 20%</td>
</tr>
<tr>
<td>Stability 0.1°C/year</td>
<td>0.5°C/year</td>
<td>0.003°C/year</td>
<td>-</td>
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</table>

**TYPICAL PROBE EMPLOYMENT**

[Diagram of Typical Probe Emplacement]
CALIBRATION APPARATUS-SCHMATIC BLOCK
DIAGRAM

CALIBRATION APPARATUS DETAILS
TYPICAL CALIBRATION DATA FOR RING AND GRADIENT SENSORS

TEMPERATURE GRADIENT TEST APPARATUS AND INSTRUMENTATION SCHEMATIC BLOCK DIAGRAM
GRADIENT TUBE ASSEMBLY ALTERATION OF T & ΔT

TYPICAL RING BRIDGE SHORTING RATIOS
TEMPERATURE GRADIENT APPARATUS TESTS

Legend

- Data taken by temporary arrangement
- Data taken at lower gradient by different source
- Temperature gradient apparatus tests
- Temperature gradient apparatus tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Temperature (°C)</th>
<th>Gradient Temperature (°C)</th>
<th>Complete</th>
<th>Normal</th>
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<tr>
<td>1</td>
<td>20.5</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>3</td>
<td>21.5</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>4</td>
<td>22.0</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>5</td>
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<td>6</td>
<td>23.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
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Note: All tests were conducted under controlled conditions.

7759-5565
THERMAL CONDUCTIVITY APPARATUS AND TEST INSTRUMENTATION PRINCIPAL ELEMENTS

TYPICAL THERMAL CONDUCTIVITY MEASUREMENTS-MODE 2

7-25
TYPICAL THERMAL CONDUCTIVITY MEASUREMENTS-MODE 3
HFE ELECTRONICS, PROBES, AND EMLACEMENT TOOL
DVT HFE IN THERMAL VACUUM TEST
HFE DEPLOYMENT-REMOVING PROBE FROM PROBE BOX
HFE DEPLOYMENT-MEASURING DEPTH
OF BOREHOLE WITH EMPLACEMENT TOOL
PROBE PACKAGE ASSEMBLY-OPEN

- Lower Container Assembly
- Spacer Tube
- Upper Container Assembly
- Probe Bag Assembly
- Probe Cable Stowage Trough
- Packing Piece Assembly
- Strap
- Teflon Pull Ring
- Carrying Strap
- Nylon Bulkhead
- Pull Ring
- Aluminum K Strip
- Storage Tube
- Aluminum Corner Post
- Velcro Closure Straps

7759-5553
Section 8

Alsep System Design Constraints and Design Selection
DESIGN CONSTRAINTS AND SELECTION

DESIGN CONSTRAINTS
ALSEP POWER HISTORY
POWER MANAGEMENT
POWER REDUCTION
OVERLOAD PROTECTION
EXPERIMENT POWER SWITCHING
UPLINK
ANTENNA POINTING
MISSION TERMINATION
CENTRAL STATION THERMAL CONTROL
ADDITIONAL DESIGN APPROACHES

LIFETIME: CONTINUOUS OPERATION FOR ONE YEAR
RELIABILITY: GOAL OF 0.9 FOR SYSTEM OPERATION
TOTAL SYSTEM WEIGHT: 185 LBS
VEHICLE CONSTRAINTS: SEQ BAYS
VOLUME: 19 ft³
WEIGHT: 210 LBS TOTAL
TEMPERATURE: 0 to 180°F
EXTERNAL FUEL CASK
VOLUME: CONSTRAINED BY SLA WITHDRAWAL LINE
WEIGHT: 25 LBS
THERMAL: 100 BTU'S PER HOUR INPUT TO LM
LAUNCH, BOOST, LUNAR DESCENT VIBRATION
LUNAR SURFACE:
TEMPERATURE: -300°F TO +250°F
VACUUM: LESS THAN 10⁻¹² TORR
SURFACES: ASSUME ALL SURFACES EXPOSED TO RADIATION ARE DUST COVERED AND UV DEGRADED
DESIGN CONSTRAINTS
(ORIGINAL EXHIBIT B) CONT'

POWER:
SNAP-27 RTG - 56 WATTS AT ONE YEAR

OPERATION:
OPERATE 3 TO 4 ALSEP'S SIMULTANEOUSLY

BIT ERROR RATES:
UPLINK: $10^{-9}$
DOWNLINK: $10^{-4}$

MSFN/MCC

ANTENNAS: 30 FOOT DISH WITH INFREQUENT USE OF 85 FOOT DISHES PERMISSIBLE

OPERATION: REAL TIME SUPPORT 
- CONTINUOUSLY FIRST 45 DAYS
- 2 HOURS PER DAY THEREAFTER

REAL TIME SUPPORT OF TWO SYSTEMS SIMULTANEOUSLY

ALL RECEIVED DATA IS RECORDED 7759-5707

DESIGN CONSTRAINTS
(ORIGINAL EXHIBIT B) CONT'

DEPLOYMENT SITE:
LATITUDE: ±15°
LONGITUDE: ±45° ±45°

SOLAR ELEVATION ANGLE 7° TO 30° (45° GOAL)

ASTRONAUT ACTIVITIES AND INTERFACES
SIMPLE AND SAFE

DEPLOYMENT TIME: 90 MINUTE MAXIMUM (F-1)

DEPLOYMENT DISTANCE: 300 TO 1000 FEET

CAPABILITIES:
REACH: WORKING 28° TO 66°
MAXIMUM 22° TO 72°

VISUAL: HIGH-CONTRAST INDICATORS 7759-5708
ASTRONAUT INTERFACES

SAFETY

BIOMED: WITHIN EXERTION AND LIFE SUPPORT LIMITATIONS
TEMPERATURES: NO CONTACT WITH EXTREMELY HOT SURFACES
PUNCTURES: NO SHARP EDGES, ETC.; NO HAZARDOUS PYROTECHNICS
NO EXPOSED HIGH VOLTAGE POINTS

CAPABILITY

MOBILITY: LIMITATIONS ON REACH (UP AND DOWN) KNEELING, TWISTING, ETC.
DEXTERITY: HANDLE SIZE COMPATIBLE WITH GLOVES, NO ADJUSTMENTS REQUIRING EXTREME PRECISION
VISUAL: HIGH-CONTRAST INDICATORS FOR LEVELING AND ALIGNMENT

CHANGES IN CONSTRAINTS

WEIGHT:

SEQ BAYS: 220 LBS
EXTERNAL: 65 LBS

\[ 285 \text{ LBS} \]

POWER RTG OUTPUT:

63 WATTS MINIMUM, 70 WATTS TYPICAL, 80 WATTS MAXIMUM

SITE:

LATITUDE: \( \pm 45^\circ \)

PLUS MARIUS HILLS FLIGHT 4 AND SUBSEQUENT

TURN OFF:

TWO YEARS OR LONGER

7759-5709

8-3
SCIENTIFIC MERIT AS FUNCTION OF TIME

MOST OF THE SCIENCE OBJECTIVES ARE OBTAINED AT COMPLETION OF SUCCESSFUL OPERATION FOR ONE LUNAR DAY. FURTHER OPERATION PROVIDES CONFIRMING DATA.

A SIGNIFICANT NUMBER OF IMPACTS OR TECTONIC EVENTS MUST BE OBSERVED. DATA IS GREATLY ENHANCED BY SIMULTANEOUS OPERATION OF TWO OR MORE SEISMOGRAMS.

ESTIMATED FULFILLMENT OF SCIENCE OBJECTIVES

<table>
<thead>
<tr>
<th>Time</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>30 days</td>
<td>50%</td>
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<tr>
<td>90 days</td>
<td>75%</td>
</tr>
<tr>
<td>180 days</td>
<td>85%</td>
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<tr>
<td>1 year</td>
<td>100%</td>
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</tbody>
</table>

PERFORMANCE INCENTIVES

<table>
<thead>
<tr>
<th>Time</th>
<th>Incentive</th>
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<tbody>
<tr>
<td>1 minute</td>
<td>12.5%</td>
</tr>
<tr>
<td>10 days</td>
<td>27.5%</td>
</tr>
<tr>
<td>30 days</td>
<td>42.5%</td>
</tr>
<tr>
<td>90 days</td>
<td>67.5%</td>
</tr>
<tr>
<td>180 days</td>
<td>80.5%</td>
</tr>
<tr>
<td>360 days</td>
<td>87.5%</td>
</tr>
<tr>
<td>Turn off</td>
<td>100%</td>
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</tbody>
</table>

ALSEP SYSTEM

POWER VS TIME

ARRAY A

OPERATIONAL POWER

MAXIMUM

MINIMUM

EXHIBIT B 56.0 W

POWER WATTS

1966

F M A M J J A S O N D J F M A M J

1967

55.1 58.5 61.3 61.5 62.7 57.1 59.3 55.9 54.0 52.7 58.9 55.1 54.3 52.7 57.9 59.3 55.5

53.5

1967

F M A M J J A S O N D J F M A M J

1968

53.5 59.3 58.9 58.1 57.4 60.9 63.0 58.0 59.3 55.6

53.5

7759-5705

8-4
ESTIMATED SYSTEM OPERATIONAL POWER

POWER MANAGEMENT

POWER REDUCTION PROGRAM

POWER OVERLOAD PROTECTION

EXPERIMENT POWER SWITCHING

POWER/ THERMAL CONTROL CONSIDERATIONS
DESIGN APPROACHES TO REDUCE POWER

POWER CONDITIONING UNIT

AUTOTRANSFORMER FOR HIGHER EFFICIENCY

DATA PROCESSOR

CHANGE LOGIC FOR REDUCED POWER 25 to 14.5 WATTS

COMMAND DECODER

LOGIC CHANGE

PARTIAL REDUNDANCY VERSUS FULL REDUNDANCY

RTG CABLE

LARGE CONDUCTOR SIZE TO REDUCE LOSSES

7759-5718

POWER OVERLOAD PROTECTION

REQUIREMENT:
- PROTECT CENTRAL STATION FROM CATASTROPHIC FAULTS
- AUTOMATIC OPERATION WITHOUT GROUND CONTROL
- ALLOW FOR REASONABLE TURN-ON AND SWITCHING TRANSIENTS
- MAINTAIN LOGIC STATUS DURING FAULT

ADDITIONAL CONSTRAINT:
- TIMING CONSISTENT WITH POWER SOURCE DYNAMIC RESPONSE

APPROACH:
- RESETTABLE CIRCUIT BREAKERS - FAULT PROTECTION AT 500 MA
- TIME CONSTANTS - ALLows REASONABLE TRANSIENTS, PROTECTS AGAINST SERIOUS OUT-OF-REGULATION CONDITION
- RIPPLE OFF - SLOW DEGRADATION PROTECTION

7759-5714

8-6
**EXPERIMENT POWER SWITCHING/EXPERIMENT SURVIVAL**

**REQUIREMENT:**
PROVIDE SCHEME TO PERMIT EXPERIMENTS TO SURVIVE FOR PERIODS WITHOUT OPERATING POWER-ON

**ADDITIONAL CONSTRAINT:**
TWO HOURS PER DAY REAL TIME COVERAGE AFTER 45 DAYS

**APPROACH:**
OPERATE
STANDBY (SURVIVAL)
STANDBY - OFF

---

**POWER MODES**

---

**500 MA CB OPERATIONAL POWER**

**EXPERIMENT ELECTRONICS**

**500 MA STANDBY POWER**

**HEATERS**

**POWER RETURN**

---

**7759-5716**

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**POWER SUBSYSTEM/CENTRAL STATION THERMAL CONTROL**

**REQUIREMENT:**
OBTAIN THE BEST USE OF AVAILABLE POWER AND POWER SWITCHING MODES FOR IMPROVED THERMAL CONTROL

**APPROACH:**
DAYTIME IMPROVEMENTS - COMMANDABLE 7 AND 14 WATT DUMP LOADS
NIGHTTIME IMPROVEMENTS - COMMANDABLE 5 AND 10 WATT HEATERS

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**7759-5725**

---

8-7
POWER CONVERTER CONSIDERATIONS

REQUIREMENTS:

HIGH EFFICIENCY

DESIRABLE TO PRESENT CONSTANT LOAD TO RTG

REDUCE OUTPUT RIPPLE

PROVIDE SURGE AND TRANSIENT CAPABILITY

ALTERNATE APPROACHES TO PCU DESIGN:

<table>
<thead>
<tr>
<th>REGULATOR</th>
<th>CONVERTER</th>
<th>FILTERING</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHORTING SHUNT</td>
<td>AUTOTRANSFORMER</td>
<td>MODEST OUTPUT CAPACITANCE AND TRANIENT CONTROL</td>
</tr>
<tr>
<td>SHUNT</td>
<td>ISOLATED TRANSFORMER</td>
<td>LARGE FILTERS</td>
</tr>
</tbody>
</table>

DESIGN SELECTION: SHUNT REGULATOR/AUTOTRANSFORMER/MODEST FILTERING

HIGH EFFICIENCY

BETTER EMI CHARACTERISTICS

SIZE AND WEIGHT
ANTENNA POINTING REQUIREMENTS

LUNAR LIBRATION: AN APPARENT WOBBLING MOTION AS VIEWED FROM THE EARTH; CAUSES EQUIVALENT EARTH MOTION IN LUNAR COORDINATES

PRINCIPAL EFFECTS:
± 7.5° LUNAR LONGITUDE DUE TO:
- CONSTANT ANGULAR RATE OF MOON ABOUT ITS AXIS
- VARIABLE ANGULAR RATE IN ELLIPTICAL ORBIT AROUND EARTH
± 6.5° LUNAR LATITUDE DUE TO:
- INCLINATION OF MOON'S ROTATION AXIS TO ITS ORBITAL PLANE

SECONDARY EFFECTS:
- NON-SPHERICAL EARTH & MOON
- SOLAR PETURBATIONS
- GYROSCOPE & PENDULUM COUPLING

COMBINED EFFECTS: PATTERN CHANGES MONTHLY & YEARLY

ANTENNA POINTING REQUIREMENT

MEAN SUBEARTH POINT

RANGE OF LANDING LONGITUDE

RANGE OF INSTANTANEOUS SUBEARTH POINTS (LIBRATION)

COORDINATES REQUIRED

SHADED ANGLES = 16°
ANTENNA AND ANTENNA POINTING

REQUIREMENT:
POINT AT THE NOMINAL CENTER OF EARTH'S MOVEMENT PATTERN
TOTAL ALLOWABLE LEVELING, ALIGNMENT, AND MECHANISM ERROR -5°
ACCEPTABLE GAIN UP TO 17° OFF AXIS

ALTERNATIVE:

BRINGSIGHT AT EARTH AND OFFSET
LOCAL VERTICAL, E-W REFERENCE

MECHANISM
BALL AND SOCKET
GEARS AND GIMBAL

SELECTION:
ANTENNA - AXIAL HELIX - ACCEPTABLE GAIN TO 22°
LOCAL VERTICAL, E-W REFERENCE
AIMING MECHANISM, TWO GIMBAL - GEARED SYSTEM
ASTRONAUT CAPABILITY
HIGHER CONFIDENCE

UPLINK APPROACH

REQUIREMENTS
TURN ON, INITIALIZE EXPERIMENTS
INITIATE EXPERIMENT MODE CHANGES
OPERATE THREE SYSTEMS SIMULTANEOUSLY
PROVIDE MODULATION SCHEME WITH ADEQUATE SECURITY
MCC COMPATIBILITY

APPROACHES:
REDUNDANCY
FULLY REDUNDANT WITHOUT TIMER
PARTIALLY REDUNDANT WITH TIMER

MODULATION
SIMPLE MODULATION/ADDRESS SCHEMES
SPREAD SPECTRUM MODULATOR

APPROACH SELECTED:
1. PARTIALLY REDUNDANT WITH ON BOARD TIMER
POWER SAVINGS
2. 21 BIT COMMAND WITH ONE AND TWO KHZ MODULATION
SIMPLICITY AND RELIABILITY
AMPLE ADDRESS CAPABILITY
SUFFICIENT ADDRESS AND MESSAGE SECURITY

7759-5712
DATA LINK ANALYSIS

REQUIREMENT: BIT ERROR RATES

UPLINK: $10^{-9}$
DOWNLINK: $10^{-4}$

BORESIGHT ANTENNA GAIN: 15.2 DB

UPLINK: 2119 MHz

10 KW TRANSMITTER POWER

IF S/N MARGIN

30 FT $+ 9.3$ DB
85 FT $+ 18.1$ DB

DOWNLINK: 2276.5 TO 2279.5 MHz

1 WATT OUTPUT POWER

LINK MARGIN

NORMAL BIT RATE $- 1.06$ K BPS

30 FT DISH $- + 7.2$ DB
ASE BIT RATE $- 10.6$ K BPS
85 FT DISH $+ 6.5$ DB

7759-5703

ISOLATION AND GROUNDING

EXPERIMENT INTERFACES
DC ISOLATION OF SIGNAL GROUND, CHASSIS RETURN, AND POWER RETURN
SURGE AND TRANSIENT SUPPRESSION

HEATERS, DRIVE MOTORS, SOLENOID

CENTRAL STATION SINGLE POINT GROUND

SURGE PROTECTION

PWR RETURN

HEATERS, DRIVE MOTORS, SOLENOID

SIGNAL RETURN

SHIELD

SCIENCE SIGNALS

CHASSIS

7759-5721

8-11
MISSION TERMINATION

REQUIREMENT:
TURN OFF DOWNLINK AT END OF ONE YEAR

APPROACHES:
HIGHLY REDUNDANT UPLINK/NO TIMER
MECHANICAL TIMER - BATTERY AND PRIME POWER SOURCE DRIVER
SOLID STATE ELECTRONIC TIMER
CHEMICAL TIMERS

ADDITION CONSTRAINT:
(DIRECTED INTERPRETATION OF EXECUTIVE ORDER)
ON BOARD MISSION TERMINATION DEVICE INDEPENDENT OF UPLINK

SELECTION:
BATTERY OPERATED MECHANICAL TIMER
LOW POWER, WEIGHT, VOLUME

USER DATA
7759-5704

CENTRAL STATION THERMAL CONTROL

REQUIRED: 0 TO 100°F ON THERMAL PLATE
ALL HORIZONTAL SURFACES ARE DUST COVERED

ALTERNATIVES:
SURVEYOR TYPE
SECOND SURFACE MIRRORS
LOUVERS AND SIDE RADIATOR

SELECTION:
SUNSHADE AND SPECULAR REFLECTOR
SIMPLE, PRECISE, COMPLETELY PASSIVE
COMPATIBLE WITH DUST COVER

7759-5719

8-12
ADDITIONAL DESIGN APPROACHES OR CONSIDERATIONS NOT DISCUSSED

POWER:
- REGULATOR RANGE
- RTG TEMPERATURE WINDOW VERSUS ACCURACY
- PCU HOLD OFF CIRCUIT/RTG WARM UP
- TURN ON USING ASTROSWITCHES

DATA SUBSYSTEM:
- PULSE RISE AND FALL TIMES AND REPETITION RATE VERSUS CROSSTALK
- LOGIC NOISE IMMUNITY

THERMAL:
- REDUCTION OF HEAT LEAK USING MANGANIN WIRE

EXPERIMENT INTERFACES:
- SELECTION OF FLAT CONDUCTOR CABLE OVER CONVENTIONAL CABLING
- POWER DISTRIBUTION OVER LONG LINES (SIDE AND LSM)
- PULSE RISE AND FALL TIME CONTROL IN FLAT CONDUCTOR CABLING
- VARIABLE EXPERIMENT INTERFACES
- ISOLATION AND GROUNDING PHILOSOPHY

ALSEP FLIGHT 1 RELIABILITY

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Reliability Goal</th>
<th>Current Reliability Prediction</th>
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<tbody>
<tr>
<td>Power</td>
<td>0.9900</td>
<td>0.9819</td>
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<tr>
<td>Data</td>
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<td>0.8766</td>
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<td>Structural/Thermal</td>
<td>0.9997</td>
<td>0.9926</td>
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<td>Passive Seismic</td>
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<td>0.9322</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>0.9900</td>
<td>0.7644</td>
</tr>
<tr>
<td>Solar Wind</td>
<td>0.9900</td>
<td>0.8543</td>
</tr>
<tr>
<td>SIDE/CCGE</td>
<td>0.9900</td>
<td>0.6803</td>
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*GFE Predictions Furnished by NASA.

7759-5702
Section 9

Alsep Structural Design
SYSTEM REQUIREMENTS AND CONSTRAINTS

- LM INSTALLATION
- MASS PROPERTIES
- PRELAUNCH OPERATIONS
- LAUNCH, FLIGHT AND LANDING
- REMOVAL FROM LM
- ASTRONAUT INTERFACE
- LUNAR ENVIRONMENT
- DATA TRANSMISSION AND RECEPTION
- GENERAL DESIGN CRITERIA

MECHANICAL CRITERIA

- STRUCTURAL ELEMENTS
  - WITHSTAND LOADS OF LAUNCH, FLIGHT, & LUNAR LANDING
  - WITHSTAND LOADS ASSOCIATED WITH DEPLOYMENT
  - SUPPORT THE EQUIPMENT ON THE LUNAR SURFACE

- JOINTS, FITTINGS & FASTENERS
  - HOLD SECURELY IN LOCKED POSITIONS
  - RELEASE & FUNCTION DURING DEPLOYMENT

SPECIAL JIGS & SHIPPING CONTAINERS PROVIDE PROTECTION FOR PRELAUNCH HANDLING, TRANSPORTATION, & STORAGE
ASTRONAUT INTERFACE

SAFETY
BIOMED: WITHIN EXERTION AND LIFE SUPPORT LIMITATIONS
TEMPERATURES: NO CONTACT WITH EXTREMELY HOT SURFACES
PUNCTURES: NO SHARP EDGES, ETC.; NO HAZARDOUS PYROTECHNICS

CAPABILITY
MOBILITY: LIMITATIONS ON REACH (UP & DOWN), KNEELING, TWISTING, ETC.
DEXTERITY: KNOBS & HANDLES SIZED TO FIT GLOVES, MINIMUM USE OF FINE
ADJUSTMENTS, FEW ELECTRICAL CONNECTORS MATED ON MOON

VISUAL: INDICATORS (LEVELING & ALIGNMENT) PROVIDE HIGH CONTRAST;
STRIPES ON PACKAGE EDGES WHERE THERMAL DESIGN PERMITS

ASTRONAUT CONSTRAINTS

REACH PARAMETERS
MAXIMUM
- 60 INCHES
ABOVE LUNAR SURFACE
- 28 INCHES FOR WORKING AND MANIPULATING
  22 INCHES FOR GRASPING OBJECTS

FORCE PARAMETERS
KNOBS
0.75" DIA  -  3.8 LB MAX
1.00" DIA  -  5.0 LB MAX
1.25" DIA  -  7.6 LB MAX
1.50" DIA  -  9.6 LB MAX
PUSH/PULL, RIGHT/LEFT, UP/DOWN
-  20 LB MAX
DYNAMETRIC FORCE
-  10 LB MAX
STATIC LOAD
-  60 LB MAX

7759-5880
ASTRONAUT CONSTRAINTS (CONT')

VIEWING ANGLES

OPTIMUM — 30° CONE CIRCUMSCRIBED BY 15° RIGHT AND LEFT, 0° UP AND 30° DOWN FROM THE HORIZONTAL LINE-OF-SIGHT.

MAXIMUM — 90° RIGHT AND LEFT, 70° UP AND 60° DOWN FROM HORIZONTAL LINE-OF-SIGHT.

CONTRAST — BLACK CHARACTERS ON WHITE BACKGROUND — PREFERRED.
— BLACK CHARACTERS ON YELLOW OR GOLD BACKGROUND — ACCEPTABLE.
— ORANGE CHARACTERS ON WHITE BACKGROUND — ACCEPTABLE.

SAFETY

THERMAL — 200°F MAXIMUM — SUIT CAPABILITY

MECHANICAL — 0.030" RADII ON ALL EXPOSED EDGES AND CORNERS — TEFLOHN TAPE OR SUBSTITUTE ACCEPTABLE WHERE MATERIAL THICKNESS PRECLUDES REQUIRED RADII.

ELECTRICAL — NO ASTRONAUT INTERCONNECTION OF ELECTRICALLY HOT CABLES.

ORDINANCE — REDUNDANCE REQUIRED TO ACTUATE ORDINANCE.

7759-6881

INSTALLATION IN LUNAR MODULE

• SLIDE IN
• LIFT AND INSERT PILOT PINS
• CLOSE THERMAL DOOR

INSTALLATION FIXTURE

7759-5849
**LM HARD POINTS**

- Bullet pins (4) on LM in rear of SEQ bay
- Tabs (4) on sides of ALSEP (engage by raising ALSEP)
- Pip pins (4)

**REMOVAL FROM LUNAR MODULE**

- Bottom of SEQ bay 18 in. to 60 in. from surface & ± 15° tilt (any direction)
- Close LM door for thermal integrity
- Landing location within ± 5° from equator & ± 45° E - W
- LM probably lands facing NW or SW
- Sun angle 7° to 20° (possible 45°) above horizon and rising
- ALHT removal separately or attached to ALSEP
**Lunar Surface Phase**

- ALSEP Deployment Tasks Associated with LM

- ALSEP Deployment Tasks at Experiment Site

- Remove Packages
  - Release & Remove Lanyard & Lower Door
  - Remove & Deploy Tools
  - Release & Remove ALHT

- Transfer Fuel

- Deploy Central Station

- Traverse

- Deploy Experiments

- Prepare for Traverse

- Retrieve Boom Lanyard, Pull PKG Out & Lower with Boom

- Release PKG & Place in Temporary Location

- Repeat for PKG #2

- Repeat for PKG #2

- Remove Packages

- 7759-5835

- 7759-5834

*Remove Packages*

- 9-5
PREPARE FOR TRAVERSE

- ROTATE & RE-ORIENT PKG #2
- JOIN MAST TO PKG #2
  (ALREADY MATED TO PKG #1)

7759-5836
BARBELL CARRY

- Allows all equipment to be carried by one man in one traverse
- Suitcase handles for two-man or backup carry mode
- Gives good balance & view of feet
- Equivalent earth weight = 35 lb
- May be set down to rest
- Carry bar later used as antenna mast

TRAVERSE

- Commander carries subpallet & ALHT leads & picks route
- LM pilot carries ALSEP barbell
- Rest, as necessary
- Commander picks deployment site
DEPLOY EXPERIMENTS

<table>
<thead>
<tr>
<th>SWS</th>
<th>PSE</th>
<th>LSM</th>
<th>SIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARRY 13 FT</td>
<td>CARRY 10 FT</td>
<td>CARRY 50 FT</td>
<td>CARRY 55 FT</td>
</tr>
<tr>
<td>EXTEND LEVELING LEGS</td>
<td>REMOVE GIRDLE</td>
<td>DEPLOY SUPPORT LEGS</td>
<td>PLACE ON SURFACE</td>
</tr>
<tr>
<td>PLACE ON SURFACE (PARTIALLY SELF-LEVELING)</td>
<td>PLACE ON STOOL</td>
<td>PLACE ON SURFACE</td>
<td>PLACE ON SURFACE</td>
</tr>
<tr>
<td>ALIGN BY SHADOWS</td>
<td>UNFOLD SHROUD</td>
<td>UNFOLD SENSOR ARMS</td>
<td>DEPLOY GROUND SCREEN</td>
</tr>
<tr>
<td></td>
<td>LEVEL BY BALL</td>
<td>REMOVI PRA COVERS</td>
<td>RELEASE CC1G</td>
</tr>
<tr>
<td></td>
<td>INDICATOR</td>
<td>LEVEL BY BUBBLE</td>
<td>ENSPLACE CC1G</td>
</tr>
<tr>
<td></td>
<td>READ ALIGNMENT</td>
<td>ALIGN BY SHADOW</td>
<td>LEVEL BY BUBBLE</td>
</tr>
<tr>
<td></td>
<td>BY CANDONOM SHADOW</td>
<td>SHADOWGRAPH</td>
<td>ALIGN BY</td>
</tr>
<tr>
<td></td>
<td>SHADOW</td>
<td>READ SHADOWGRAPH</td>
<td>SHADOWS</td>
</tr>
</tbody>
</table>

DEPLOYMENT FOR ALSEP 1

- 500 FT BASED ON LM ASCENT BLAST WITH 100% SAFETY FACTOR
- DATA POWER 10 FT
- PASSIVE SEISMIC 10 FT
- MAGNETOMETER 50 FT
- 13 FT Solar Wind Spectrometer
- Suprathermal Ion Detector
- Cold Cathode Ion Gage

7759-5842

9-12
DEPLOY ANTENNA

- ASSEMBLE ANTENNA
  - INSTALL MAST ON CENTRAL STATION
  - INSTALL AIMING MECHANISM ON MAST
  - INSTALL ANTENNA ON AIMING MECHANISM

- ORIENT ANTENNA
  - ENTER COARSE & FINE ADJUSTMENTS IN AZIMUTH
  - ENTER COARSE & FINE ADJUSTMENTS IN ELEVATION
  - LEVEL AIMING MECHANISM BASE
  - ALIGN E-W WRT SHADOW
  - RECHECK LEVEL

STOWED CONFIGURATION

SUPERRATHERMAL ION DETECTOR
LUNAR SURFACE MAGNETOMETER
ANTENNA
SOLAR WIND SPECTROMETER
PASSIVE SEISMIC EXPERIMENT

ALSEP 1

RTG
SUBPACKAGE NO. 2

ALHT CARRIER

ANTENNA AIMING MECHANISM
SUBPACKAGE NO. 1

7759-5841

7769-5833

9-13
ELECTRONICS COMPARTMENT

- Thermal plate temp sensors (TMT)
- DSS heater thermostats
- DSS & backup HTR elements

Commands 17:
- DSS HTR ON/OFF

Part of electrical power subsystem

7759-5815
CENTRAL STATION THERMAL CONTROL

MECHANICAL

N-S DIRECTION

SUNSHIELD
REFLECTORS
CURTAINS (E-W)
HEATERS
INSULATION
THERMAL PLATE (RADIATOR)

RADIATION
FROM PLATE
FROM SURFACE

SOLAR RADIATION

LUNAR SURFACE

FASTENERS

BOYD BOLT

USED FOR TENSION & SAFETY CONNECTIONS

INTERSTHIELD
SUNSHIELD/PRIMARY STRUCTURE

PIP PINS

SPRING LOADED HEX HEAD
USED FOR SAFETY CONNECTIONS

SHIMMERUPPALETT ALUM PRETT TOWN SHIMPALETT

7759-5814

7759-5828

9-19
SUNSHIELD TIE-DOWN

RELEASE THIS FASTENER LAST

FASTENER LOCATIONS

LUNAR SURFACE

SUNSHIELD TIE-DOWN

EXPERIMENT MOUNTING PROVISIONS

ATTACHMENT BY 75° ROTATION
BOYD BOLT
FASTENERS

SUBPALLET

7759-5813
CABLES, REELS AND CONNECTORS

CONDUCTORS (COPPER):
- WIDTH: 0.025 IN.
- EQUIV 132 AWG
- THICKNESS: 0.002 IN.
- SPACING: 0.050 IN. CENTER TO CENTER
- RESISTANCE:
  - 15°: 4.8
  - 45°: 16.8
  - 90°: 26.8
- MUTUAL CAPACITANCE: 9 PF/FT
- INSULATION: TRAPEZOIDAL, KEVLAR 29, PA66, NYLON SANDWICHED
- ABOUT 0.002 IN. THICKNESS OUTER, 0.002 IN. THICKNESS INNER
- RESISTANCE: 3 x 10^7 MEG OHM/FT

SPECIAL CABLE FOR RTG SPECIAL CONNECTORS FOR RTG & SIDE TO BE MATED ON THE MOON

LEVEL AND ALIGN INDICATORS

- BUBBLE:
  - RING ON FACE INDICATES REQUIRED SETTING
  - USED ON:
    - ANTENNA
    - LSM
    - SIDE
    - CPLEE
    - PSE HAS BALL

- COMPASS:
  - SUN
  - PSE
  - CPLEE

- PAINT:
  - EAST
  - N & S

USED ON:
- PSE, SWS, CPLEE
STRUCTURE/ THERMAL ALIGNMENT MARKINGS

AFTER LEVELING, ROTATE THIS KNOB TO BRING SHADOW OF POST UP TO PAINT

7759-5823

MAST/AIMING MECHANISM

7759-5843

9-22
EXTENDERS

TUBULAR EXTENDERS (4) (HUNTER SPRING)

7759-5826
ALSEP SUBPACKAGE 2 (FLIGHTS 1 & 4)
APOLLO LUNAR HAND TOOLS

GEOLOGIC SAMPLING TOOLS
- ASEPTIC SAMPLER
- SPRING SCALE
- HAMMER
- SCOOP
- TONGS
- BRUSH/SCRIBER
- HAND LENS
- CARRIER

SURVEYING & PHOTOGRAPHIC INSTRUMENTS
- Gnomon
- Surveying Instrument
- Instrument Staff 1
- Surveying Instrument 2
- Instrument Staff 3

EARTH MT. 12-5 lb
Geological tools will
be inserted to 0.5 lb
ALSEP deployment tools
(not included inALSEP time line)

7759-5818
SPECIAL TOOLS

DOME REMOVAL TOOL
(PART OF ELECTRICAL
POWER SUBSYSTEM)

UHT 0.53 LB
EACH

FIT

MAST 1.30 LB,
TOTAL
(ONE HALF
SHOWN)

ALL WEIGHTS ARE EARTH LB
14.6 LB FUEL CASK MOUNT & INSULATION, PART OF STRUCTURE/ THERMAL
SUBSYSTEM, COVERED UNDER ELECTRICAL POWER SUBSYSTEM

ALSEP FLIGHT 3 SUBPACKAGE 1

7769-6816

7769-6803

9-36
ALSEP STEADY-STATE ACCELERATION LEVEL (DESIGN-LIMIT)

LEVEL: 14 g

DURATION: 60 SEC. (MINIMUM)

AXIS: + X (ONLY)

TOLERANCES: PER MIL. STD. 810 B

ORIGINAL ALSEP DYNAMIC ENVIRONMENTAL SPECIFICATIONS (GAEC ICD NO. LIS-360-22302)

ACCELERATION: 4.5 g (MAX., +X AXIS)

SHOCK: 0 to 20 MSEC. INCREASING RAMP
20 TO 220 MSEC.: 10.8 g DWELL
220 TO 300 MSEC. DECREASING RAMP

VIBRATION:

LAUNCH & BOOST
DIAGONAL: 1 SHEET/AXIS @ OCT/MIN
5-15.9 Hz: 0.164 IN. DIA.
16.5 - 100.0 IN. G - PEAK

RANDOM: 5 MIN/AXIS
10 - 25 Hz: +12 DB/OCT
25 - 80: 0.0148 g^2/Hz
90 - 125: +12 DB/OCT
150 - 550: 0.0044 g^2/Hz
950 - 1250: -12 DB/OCT
1250 - 2000: 0.0148 g^2/Hz

7759-5883
ORIGINAL DYNAMIC ENVIRONMENTAL SPECIFICATIONS (CONT')

LUNAR DESCENT

SINUSOIDAL: 1 SWEEP/AXIS @ OCT/MIN

| 5-19.4 Hz | 0.01 IN. DIA. |
| 19.4-100 | 1.92 g*PEAK |

RANDOM: 12.5 MIN./AXIS

| 15-100 Hz | 0.013 g²/Hz |
| 100-176 | -6 DB/OCT |
| 176-2000 | 0.010 g²/Hz |

NOTE: ABOVE LEVELS ARE INDUCED (ACCEPTANCE) - DESIGN LIMIT LEVELS ARE DEFINED TO BE INDUCED ACCELERATION LEVELS TIMES 1.3.

ALSEP ENGINEERING TESTS

<table>
<thead>
<tr>
<th>TEST ITEM</th>
<th>DATE</th>
<th>TEST*</th>
<th>LEVEL</th>
<th>AXES</th>
<th>OBJECTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proto-1 (SP-1)</td>
<td>June 1967</td>
<td>Vibration (Sine &amp; Random)</td>
<td>Design Limit</td>
<td>x, y, z</td>
<td>Dynamic Response of ALSEP Structure</td>
</tr>
<tr>
<td>Proto-1 (SP-2)</td>
<td>Sept. 1967</td>
<td>Vibration (Sine &amp; Random)</td>
<td>Design Limit</td>
<td>x, y, z</td>
<td>Dependence of Dynamic Response upon Number of Fasteners &amp; Pre-Load</td>
</tr>
<tr>
<td>LAM Proto-1 (SP-1)</td>
<td>Oct. 1967</td>
<td>Vibration (Sine &amp; Random)</td>
<td>Design Limit</td>
<td>x, y, z</td>
<td>Dynamic Response of LAM and SWS</td>
</tr>
<tr>
<td>Proto-A (SP-1 &amp; 2)</td>
<td>Oct. 1967</td>
<td>Vibration (Sine &amp; Random)</td>
<td>Design Limit</td>
<td>x, y, z</td>
<td>Demonstration of ALSEP Structural Integrity</td>
</tr>
<tr>
<td>Proto-2 (SP-1)</td>
<td>Apr. 1968</td>
<td>Vibration (Sine &amp; Random)</td>
<td>Design Limit</td>
<td>x, y, z</td>
<td>Variation of Dynamic Response with Reduction of Fastener -- with Off-Loaded Experiments</td>
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<tr>
<td>Proto-2 (SP-2)</td>
<td>July 1968</td>
<td>Vibration (Sine &amp; Random)</td>
<td>Design Limit</td>
<td>x, y, z</td>
<td>Variation of Dynamic Response with Off-Loaded Experiments</td>
</tr>
</tbody>
</table>

* Prior to the LAM Proto-1 Tests the original ALSEP Test Levels were revised per LTA-3 tests results.

7759-5884

7759-5885
## ALSEP QUALIFICATION TESTS

<table>
<thead>
<tr>
<th>TEST ITEM</th>
<th>SUBPACKAGE</th>
<th>DATE</th>
<th>TEST</th>
<th>LEVEL</th>
<th>AXES</th>
</tr>
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<tbody>
<tr>
<td>QUAL SA</td>
<td>1 &amp; 2</td>
<td>APR. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>ACCEPTANCE</td>
<td>X, Y, Z</td>
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<tr>
<td></td>
<td></td>
<td>JUNE 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>DESIGN LIMIT</td>
<td>X, Y, Z</td>
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<tr>
<td></td>
<td></td>
<td>JUNE 1968</td>
<td>SHOCK</td>
<td>DESIGN LIMIT</td>
<td>X, Y, Z</td>
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<tr>
<td></td>
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<td>JULY 1968</td>
<td>STEADY STATE ACCELERATION</td>
<td>DESIGN LIMIT</td>
<td>X</td>
</tr>
<tr>
<td>D-2 FLT. SPARE</td>
<td>1</td>
<td>AUG. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>ACCEPT &amp; DES LIMIT</td>
<td>X, Y, Z</td>
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<tr>
<td></td>
<td>2</td>
<td>SEPT. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>ACCEPT &amp; DES LIMIT</td>
<td>X, Y, Z</td>
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<tr>
<td>QUAL SB</td>
<td>1 &amp; 2</td>
<td>DEC. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>DESIGN LIMIT</td>
<td>X, Y, Z</td>
</tr>
<tr>
<td></td>
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<td>JAN. 1969</td>
<td>SHOCK</td>
<td>DESIGN LIMIT</td>
<td>X, Y, Z</td>
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<td></td>
<td></td>
<td>JAN. 1969</td>
<td>STEADY STATE ACCELERATION</td>
<td>DESIGN LIMIT</td>
<td>X</td>
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<tr>
<td>QUAL C</td>
<td>1</td>
<td>MARCH 1969</td>
<td>SHOCK</td>
<td>DESIGN LIMIT</td>
<td>X, Y, Z</td>
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<tr>
<td></td>
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<td>MAY 1969</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>DESIGN LIMIT</td>
<td>X, Y, Z</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAY 1969</td>
<td>STEADY STATE ACCELERATION</td>
<td>DESIGN LIMIT</td>
<td>X</td>
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## ALSEP FLIGHT ACCEPTANCE TESTS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DATE</th>
<th>TEST</th>
<th>LEVEL</th>
<th>AXES</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-2 FLIGHT (SP-1 &amp; 2)</td>
<td>AUG. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>ACCEPTANCE</td>
<td>X, Y, Z</td>
</tr>
<tr>
<td>FLIGHT 1 (SP-1 &amp; 2) ARRAY A</td>
<td>SEPT. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>ACCEPTANCE</td>
<td>X, Y, Z</td>
</tr>
<tr>
<td>FLIGHT 2 (SP-1 &amp; 2) ARRAY A</td>
<td>SEPT. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>ACCEPTANCE</td>
<td>X, Y, Z</td>
</tr>
<tr>
<td>FLIGHT 3 (SP-1 &amp; 2) ARRAY B</td>
<td>DEC. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>ACCEPTANCE</td>
<td>X, Y, Z</td>
</tr>
<tr>
<td>FLIGHT 4 (SP-1) ARRAY C</td>
<td>NOV. 1968</td>
<td>VIBRATION (SINE &amp; RANDOM)</td>
<td>ACCEPTANCE</td>
<td>X, Y, Z</td>
</tr>
</tbody>
</table>
ALSEP LIMIT LEVEL SHOCK SPECIFICATION
(REF. MIL. STD. 810B)

NOMINAL DESIGN LIMIT* VIBRATION LEVELS

*COMBINED L, R, AND LUN. ITEMS.

7759-5889

9-43
NOMINAL DESIGN LIMIT
RANDOM VIBRATION SPECTRUM

TEST: L & R
TEST ITEM: ALSEP SUBPACKAGE NO. 1
DURATION: 2.5 MIN

NOMINAL DESIGN LIMIT RANDOM VIBRATION SPECTRUM

TEST: L & R
TEST ITEM: ALSEP SUBPACKAGE NO. 2
DURATION: 3 MIN
NOMINAL DESIGN LIMIT
RANDOM VIBRATION SPECTRUM

TEST: L & B
TEST ITEM: ALSEP SUBPACKAGE 1 & 2
AXIS: Y
DURATION: 2.5 MIN

G_RMS = 4.2

NOMINAL DESIGN LIMIT
RANDOM VIBRATION SPECTRUM

TEST: L & B
TEST ITEM: ALSEP SUBPACKAGE 1 & 2
AXIS: Z
DURATION: 2.5 MIN

G_RMS = 5.3
NOMINAL DESIGN LIMIT RANDOM VIBRATION SPECTRUM

TEST: LUN. DES.
TEST ITEM: ALSEP SUBPACKAGE 1 & 2
ALSEP-ACA AXIS: X, Y, Z
DURATION: 12.5 MIN
Section 10

Alsep Thermal Design
SUMMARY OF SYSTEMS REQUIRING THERMAL CONTROL ON ALSEP AND EASEP

1. CENTRAL STATION (CS)

2. EXPERIMENTS
   A. PASSIVE SEISMIC (PSE)
   B. ACTIVE SEISMIC (ASE)
   C. MAGNETOMETER (MB)
   D. SOLAR WIND (SW)
   E. SUPRATHERMAL ION DETECTOR (SIDE)
   F. HEAT FLOW (HF)
   G. CHARGED PARTICLE (CP)
   H. COLD CATHODE GAUGE (CCG)

3. RADIOISOTOPE THERMOELECTRIC GENERATOR (RTG)

4. GRAPHITE LM FUEL CASK (GLFC)

5. CREW
   A. CASK DOME TOOL (CDT)
   B. FUEL TRANSFER TOOL (FTT)
   C. UNIVERSAL HANDLING TOOL (UHT)

6. LUNAR HAND TOOLS (LHT)

7. ANTENNA

8. SUBPACKAGE 2

9. PASSIVE SEISMIC EXPERIMENT PACKAGE (PSEP)

10. LASER RANGING RETRO-REFLECTOR (LRRR)
CENTRAL STATION THERMAL CONTROL
REQUIREMENTS AND CONSTRAINTS

THERMAL

- Passive Thermal Control
- Temperature Limits
  - Operating: 22°F to 158°F
  - Non-Operating: 0°F to 180°F
- Dust (x = 1) on all horizontal surfaces exposed to solar radiation
- LM ascent stage plume heating (2 BTU/ft²)

DEPLOYMENT

- Minimum crew deployment tasks
- Deployment distance > 300 feet
- East-West alignment: ±0.5 degrees
- Vertical alignment: ±0.5 degrees
- Local slopes: ≤ 1.5 degrees
- Latitude: ≤ 1.46 degrees

LUNAR ENVIRONMENTS

- Lunar surface temperature: -300°F to +250°F
- Space temperature: -460°F
- Incident solar energy: 130 watts/ft²
- Lunar albedo (average): 0.07
- Lunar surface emittance (average): 0.93
- Lunar surface thermophysical properties:
  - Thermal conductivity (Cal/sec-cm-c): Dust: 1 x 10⁵, Rock: 2.2 x 10³
  - Specific heat (Cal/gm°C): Dust: 0.2, Rock: 2
  - Density (gm/cm³): Dust: 0.9, Rock: 2.5
  - Thermal inertia (kge⁻¹/²): Dust: 750, Rock: 30

7769-5902

7769-5903

10-2
VARIATION OF LUNAR SURFACE TEMPERATURE AT LUNAR EQUATOR DURING A COMPLETE LUNATION

INITIAL ALSEP CENTRAL STATION THERMAL CONTROL CONCEPTS

<table>
<thead>
<tr>
<th>Concept</th>
<th>Design Schematic</th>
<th>Thermal-Rule Temp Range (^{\circ}F)</th>
<th>Solar Absorbance (a_s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Horizontal Radiator</td>
<td></td>
<td>0 to 120</td>
<td>0 to 295</td>
<td>Excellent design if no dust, but strongly affected by dust. Straightforward design. No alignment requirements.</td>
</tr>
<tr>
<td>Direct Vertical Radiator (Radiator Faces Lunar Pole)</td>
<td></td>
<td>0 to 195</td>
<td>6 to 195</td>
<td>Possibly unaffected by dust. Can be seriously degraded by misalignment. Lunar day temperatures excessive.</td>
</tr>
</tbody>
</table>

7759-5904
### INITIAL ALSEP CENTRAL STATION THERMAL CONTROL CONCEPTS (CONT')

<table>
<thead>
<tr>
<th>CONCEPT</th>
<th>DESIGN SCHEMATIC</th>
<th>THERMAL PLATE TEMP RANGE °F</th>
<th>SOLAR ABSORPTANCE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Horizontal Radiator with Louvers</td>
<td><img src="image" alt="Diagram of Direct Horizontal Radiator with Louvers" /></td>
<td>Solar Absorptance: 0 to 115</td>
<td>Insulators: 50 to 115, 50 to 125</td>
<td>Gives best temperature range. No alignment requirements. Adversely affected by dust. Active thermal control.</td>
</tr>
<tr>
<td>Horizontal Radiator with A Frame Sunshield</td>
<td><img src="image" alt="Diagram of Horizontal Radiator with A Frame Sunshield" /></td>
<td>Solar Absorptance: 0 to 160</td>
<td>Insulators: 0 to 160, 0 to 190</td>
<td>Unaffected by dust. Requires alignment. Lunar day temperatures excessive.</td>
</tr>
<tr>
<td>Vertical Radiator with A Frame Sunshield</td>
<td><img src="image" alt="Diagram of Vertical Radiator with A Frame Sunshield" /></td>
<td>Solar Absorptance: 0 to 120</td>
<td>Insulators: 0 to 120, 0 to 126</td>
<td>Unaffected by dust. Requires alignment. Lunar day temperatures excessive.</td>
</tr>
<tr>
<td>Horizontal Radiator with Sunshield and Reflector</td>
<td><img src="image" alt="Diagram of Horizontal Radiator with Sunshield and Reflector" /></td>
<td>Solar Absorptance: 0 to 120</td>
<td>Insulators: 0 to 120, 0 to 126</td>
<td>Selected concept. Unaffected by dust. Requires alignment. Uses specular reflector.</td>
</tr>
</tbody>
</table>
PRIMARY COMPONENTS OF DATA SUBSYSTEM THERMAL CONTROL SYSTEM

THERMAL PLATE TEMPERATURE AS A FUNCTION OF INSULATION MASK WIDTH AND INTERNAL ELECTRONICS POWER DISSIPATION

10-5
EFFECT OF SUNSHIELD HEIGHT
ON THERMAL PLATE TEMPERATURE

KEY DESIGN FEATURES OF ALSEP
CENTRAL STATION

SYSTEM FEATURE

1. THERMAL PLATE – RADIATES ALL INTERNAL ELECTRONICS DISIPATION TO SPACE
2. MULTILAYER INSULATION BAG – PROVIDES MAJOR RADIATIVE AND CONDUCTIVE ISOLATION FROM LUNAR THERMAL ENVIRONMENTS
3. SUNSHIELD – PREVENTS DIRECT SOLAR HEATING AND DUST DEGRADATION OF THERMAL PLATE
4. SPECULAR REFLECTOR – MINIMIZES THERMAL RADIATIVE ENERGY INTERCHANGE BETWEEN THERMAL PLATE AND MOON VIA THE SUNSHIELD
5. THERMAL PLATE ISOLATORS – PROVIDE THERMAL PLATE ISOLATION FROM LUNAR SURFACE THROUGH PRIMARY STRUCTURE AFTER DEPLOYMENT
6. MANGANIN CABLE INSERTS – REDUCE CONDUCTION HEAT LEAK VIA ELECTRICAL CABLES TO CENTRAL STATION
KEY DESIGN FEATURES OF ALSEP
CENTRAL STATION (CONT’)

SYSTEM FEATURE

7. PRIMARY STRUCTURE — SUPPORT STRUCTURE FOR SUBPACKAGE 1. PROVIDES INITIAL ISOLATION FROM LUNAR SURFACE

8. THERMAL PLATE INSULATION MASK — CENTERS THERMAL PLATE TEMPERATURE SWING BETWEEN 0 AND 120°F AND MINIMIZES SOLAR HEATING ON THERMAL PLATE

9. SUNSHIELD EXTENDERS — PROVIDE 28" SEPARATION DISTANCE BETWEEN SUNSHIELD AND THERMAL PLATE

10. POWER DISSIPATION MODULE (PDM) — DISSIPATES EXCESS RTG ELECTRICAL POWER NOT UTILIZED BY ALSEP

11. MULTILAYER SIDE CURTAINS — PREVENT DIRECT SOLAR ENERGY ON THERMAL PLATE

7750-5901
PSEP QUAL MODEL IN SOLAR SIMULATION TEST
ALSEP CENTRAL STATION DEPLOYED
## COMPARISON OF EASEP AND ALSEP THERMAL CONTROL SYSTEMS

<table>
<thead>
<tr>
<th></th>
<th>EASEP</th>
<th>ALSEP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEMP SPECIFICATION</strong></td>
<td>-65° TO 180°F</td>
<td>0° TO 125°F</td>
</tr>
<tr>
<td><strong>TYPE DESIGN</strong></td>
<td>DIRECT</td>
<td>INDIRECT</td>
</tr>
<tr>
<td><strong>PASSIVE</strong></td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td><strong>SUNSHIELD</strong></td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td><strong>SPECULAR REFLECTOR &amp; SIDE CURTAINS</strong></td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td><strong>ISOTOPE HEATERS</strong></td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td><strong>THERMAL COATINGS</strong></td>
<td>MIRRORS</td>
<td>S-135 WHITE PAINT</td>
</tr>
<tr>
<td><strong>THERMAL DISSIPATION</strong></td>
<td>63W</td>
<td>38W</td>
</tr>
<tr>
<td><strong>DAY</strong></td>
<td>35W</td>
<td>38W</td>
</tr>
<tr>
<td><strong>NIGHT</strong></td>
<td>2.2 FT²</td>
<td>2.1 FT²</td>
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<tr>
<td><strong>RADIATOR AREA</strong></td>
<td>CLEVIS</td>
<td>ACTUATION SPRINGS</td>
</tr>
<tr>
<td><strong>STRUCTURE ISOLATION</strong></td>
<td>BOLTS</td>
<td></td>
</tr>
<tr>
<td><strong>ROD CLAMP COMMANDS</strong></td>
<td>5, 10 &amp; 15W</td>
<td>7, 14 &amp; 21W</td>
</tr>
<tr>
<td><strong>HEATERS</strong></td>
<td>ISOTOPE HEATERS</td>
<td></td>
</tr>
<tr>
<td><strong>THERMAL COATINGS</strong></td>
<td>COMMANDABLE</td>
<td></td>
</tr>
<tr>
<td><strong>ALIGNMENT</strong></td>
<td>1.5°</td>
<td>1.5°</td>
</tr>
<tr>
<td><strong>HORIZONTAL</strong></td>
<td>±.5°</td>
<td>±.5°</td>
</tr>
<tr>
<td><strong>EAST - WEST</strong></td>
<td>±5°</td>
<td>±5°</td>
</tr>
<tr>
<td><strong>DEBRIS, DUST, ENGINE CONTAMINATION PROTECTION</strong></td>
<td>NO</td>
<td>PARTIAL</td>
</tr>
<tr>
<td><strong>PLUME PROTECTOR</strong></td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td><strong>DEPLOYMENT DISTANCE</strong></td>
<td>70 TO 100 FT</td>
<td>&gt;300 FT</td>
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</table>

## SUMMARY OF ALSEP AND EASEP THERMAL COATINGS

<table>
<thead>
<tr>
<th>COATING DESCRIPTION</th>
<th>PROPERTIES</th>
<th>CONTRAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dowel® 1-0240 White Paint</td>
<td>2.9</td>
<td>STABLE, ORGANICALLY VAPORIZED</td>
</tr>
<tr>
<td>2. Xtralite® 3-015R White Paint</td>
<td>16.9</td>
<td>STABLE, ORGANICALLY VAPORIZED</td>
</tr>
<tr>
<td>3. Gewebe Kasten</td>
<td>11.1</td>
<td>ADJUSTABLE ERROR</td>
</tr>
<tr>
<td>4. Silvered Reflective Kapton film</td>
<td>15.5</td>
<td>LOW AND HIGH TEMPERATURE SUPERINSULATION MATERIAL</td>
</tr>
<tr>
<td>5. Zylon 22000 Black菊</td>
<td>36.5</td>
<td>DURABLE, LIGHT</td>
</tr>
<tr>
<td>6. Gold Plating</td>
<td>23.9</td>
<td>LOW DENSITY</td>
</tr>
<tr>
<td>7. Aluminized Teflon</td>
<td>16.5-64</td>
<td>OUTER SUPERINSULATION</td>
</tr>
<tr>
<td>8. Polished Aluminum</td>
<td>21.08</td>
<td>LIGHT REFLECTANT</td>
</tr>
<tr>
<td>9. Zylon 22000 Black菊</td>
<td>36.5</td>
<td>DURABLE, LIGHT</td>
</tr>
<tr>
<td>10. Zylon 22000 Black菊</td>
<td>36.5</td>
<td>DURABLE, LIGHT</td>
</tr>
<tr>
<td>11. Gore® Aluminized Mylar and Kapton Film</td>
<td>1.21-74</td>
<td>\7759-5918</td>
</tr>
</tbody>
</table>
DESCRIPTION OF ALSEP QUAL AND FLIGHT T/V TESTS

<table>
<thead>
<tr>
<th>Qualification (Mission Sim)</th>
<th>Lunar Day</th>
<th>Lunar Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lunar Surface Temp.</td>
<td>+250°F</td>
<td>-300°F</td>
</tr>
<tr>
<td>Solar Simulation</td>
<td>130 WATTS/FT²</td>
<td></td>
</tr>
<tr>
<td>Cryowall Temp.</td>
<td>-300°F</td>
<td></td>
</tr>
<tr>
<td>Chamber Pressure</td>
<td>&gt;10⁶ TORR</td>
<td>&gt;10⁶ TORR</td>
</tr>
<tr>
<td>Chamber Test Duration</td>
<td>15 DAYS</td>
<td>15 DAYS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acceptance</th>
<th>Lunar Day</th>
<th>Lunar Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lunar Surface Temp.</td>
<td>+250°F</td>
<td>-300°F</td>
</tr>
<tr>
<td>Solar Simulation</td>
<td>130 WATTS/FT²</td>
<td></td>
</tr>
<tr>
<td>Cryowall Temp.</td>
<td>-300°F</td>
<td></td>
</tr>
<tr>
<td>Chamber Pressure</td>
<td>&gt;10⁶ TORR</td>
<td>&gt;x10⁶ TORR</td>
</tr>
<tr>
<td>Chamber Test Duration</td>
<td>2.5 DAYS</td>
<td>2.5 DAYS</td>
</tr>
</tbody>
</table>

7759-5919

THERMAL PLATE TEMPERATURES FOR SIMULATED LUNAR OPERATION

[Graph showing thermal plate temperatures for simulated lunar operation]
PRIMARY COMPONENTS OF CENTRAL STATION THERMAL CONTROL SYSTEM
THERMAL BALANCE ON RADIATOR PLATE OF QUAL SA MISSION SIMULATION MODEL IN REAL LUNAR ENVIRONMENT

Radiation To Other Surfaces
\[ -1.741 \]
(-12.566)

Reflected
\[ +0.076 \]
(-1.728)

Radiator Support
\[ +0.050 \]
(-0.117)

Space
\[ +0.491 \]
(-1.195)
Through Masks
\[ -0.069 \]
(-0.117)

Cables
\[ +0.015 \]
(-2.318)

Through Thermal Bag
\[ +0.646 \]
(-0.654)

* Into Radiator
* From Radiator

All values are in watts

xxx Noon
xxx Night

7759-5914

10-13
ALSEP CENTRAL STATION DEPLOYED ON LUNAR SURFACE-APOLLO 12
### ALSEP FLIGHT 1

#### THERMAL PERFORMANCE SUMMARY

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Station</td>
<td>97°F</td>
<td>22°F</td>
<td>75°F</td>
<td>FOR HEATER OFF NIGHT TEMP WAS 0°F.</td>
</tr>
<tr>
<td>PSE</td>
<td>134°F</td>
<td>75°F</td>
<td>59°F</td>
<td>DESIGN CHANGE FOR APOLLO 13 (F 3) PSE</td>
</tr>
<tr>
<td>LSM</td>
<td>175°F</td>
<td>22°F</td>
<td>187°F</td>
<td>DESIGN CHANGE FOR APOLLO 15 (A 2) LSM</td>
</tr>
<tr>
<td>SWE</td>
<td>145°F</td>
<td>1°F</td>
<td>144°F</td>
<td>DUST ON RADIATOR PLATE MIRRORS DURING CREW DEPLOYMENT</td>
</tr>
<tr>
<td>SDE</td>
<td>170°F</td>
<td>12°F</td>
<td>158°F</td>
<td></td>
</tr>
</tbody>
</table>

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**7759-5923**

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**10-15**
Section 11

Alsep Central Station
Electrical Design
DATA SUBSYSTEM BLOCK DIAGRAM
**ALSEP COMMAND LINK**

* ANTENNA  
* DIPLEXER  
* COMMAND RECEIVER  
* COMMAND DECODER

**COMMAND LINK CHARACTERISTICS**

<table>
<thead>
<tr>
<th>FUNCTION/PARAMETER</th>
<th>ALSEP</th>
<th>MSFN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. FREQUENCY</td>
<td>2119 ± 0.001 % MHz</td>
<td>2119 MHz</td>
</tr>
<tr>
<td>2. MODULATION</td>
<td>–</td>
<td>PM, ± 3 RADIANS</td>
</tr>
<tr>
<td>3. MODULATING SIGNAL</td>
<td>–</td>
<td>1 KHz SINE WAVE SYNC SIGNAL LINEARLY ADDED TO A 2 KHz SUBCARRIER</td>
</tr>
<tr>
<td>4. DATA RATE</td>
<td>275 ± 25 KHz</td>
<td>1000 bps</td>
</tr>
<tr>
<td>5. IF BANDWIDTH (3 db)</td>
<td>-101 TO -61 dbm</td>
<td>–</td>
</tr>
<tr>
<td>6. RECEIVER DYNAMIC RANGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. PERMISSIBLE Pe (PROBABILITY OF BIT ERROR)</td>
<td>10^-9</td>
<td></td>
</tr>
<tr>
<td>8. REQUIRED PREDETECTION S/N FOR 10^-9 BER</td>
<td>12 db</td>
<td></td>
</tr>
<tr>
<td>9. S/N MARGIN FOR Pe of 10^-9 (30° ANTENNA)</td>
<td>NOMINAL +9.3 db</td>
<td>WORST CASE +3.7 db</td>
</tr>
</tbody>
</table>

7759-6010A 7759-6010B
COMMAND RECEIVER TELEMETRY SUMMARY

CHANNEL 36  AE-14  
RCVR LOCAL OSC LEVEL
* DETECTOR CIRCUIT SAMPLES OSCILLATOR SIGNAL. DETECTED SIGNAL IS THEN AMPLIFIED TO PROPER TM LEVEL

CHANNEL 16  AT-21  
LOCAL OSC CRYSTAL A TEMP
* USES THERMISTOR/RESISTOR NETWORK POWERED BY 12 VDC.
* THERMISTOR IS CEMENTED (EPOXY) TO CRYSTAL CAN.

CHANNEL 17  AT-22  
LOCAL OSC CRYSTAL B TEMP
* USES THERMISTOR/RESISTOR NETWORK POWERED BY 12 VDC.
* THERMISTOR IS CEMENTED (EPOXY) TO CRYSTAL CAN.

CHANNEL 9  AB-01  
CMD DEMOD 1KHz PRESENT
* SIGNAL IS OBTAINED FROM RECEIVER'S AUDIO OUTPUT.
* USES 1KHz BANDPASS AMPLIFIER AND DIODE DETECTOR.

CHANNEL 21  AE - 13  
RCVR PRE-LIMITING LEVEL
* DIODES IN FINAL STAGE OF IF PROVIDE HARD LIMITING.
* TM SIGNAL PROVIDED BY THE LIMITING DIODE CURRENT.

7758-6013A

7758-6013B
COMMAND RECEIVER SPECIFICATIONS

• INPUT FREQUENCY  2119 MHz ± 0.001%
• INPUT SIGNAL LEVEL -101dbm to -61dbm
• NOISE FIGURE 10db MAXIMUM
• LOCAL OSC FREQUENCY 2059 MHz ± 0.0025%/YR
• INTERMEDIATE FREQUENCY 60 MHz
• IF 3db BANDWIDTH 250 to 350KHz WITH AN INPUT SIGNAL LEVEL OF -100dbm
• IF REJECTION 60db MINIMUM AT 3.4 MHz
• AUDIO OUTPUT SIGNAL
  (a) LEVEL - 0.8 VOLT/RADIAN (UP TO ± 3.0 RADIANS)
  (b) FREQ - 100 Hz TO 5 KHz

7759-6014A

COMMAND RECEIVER SPECIFICATIONS (CONT)

• POWER
  + 12 VDC AT 55 MILLIAMPERES (NOMINAL) - SUPPLIED THROUGH A CIRCUIT BREAKER RATED AT 150 MILLIAMPERES (NOMINAL). CIRCUIT IS AUTOMATICALLY GIVEN A RESET COMMAND EVERY 12 HOURS.
  - 6VDC AT 55 MILLIAMPERES (NOMINAL) - SYSTEM PROTECTION PROVIDED BY SERIES RESISTOR.
• CONNECTORS - RF - COAXIAL OSM 210-2
  - OTHER - HUGHES WST0014M20BNH00

7759-6014B
COMMAND DECODER SIMPLIFIED BLOCK DIAGRAM

COMMAND DECODER

* CONTAINS A DEMODULATOR
  - TO GENERATE AN NRZ-C BIT STREAM FROM THE PHASE MODULATED COMPOSITE 1 & 2 KHz AUDIO INPUT.
  - WHICH DETECTS "THRESHOLD" TO START DECODER "SEARCH MODE".
  - TO GENERATE 1, 2 AND 4KHz TIMING CLOCKS WHICH ARE SYNCHRONIZED WITH THE 1kHz SYNC SUBCARRIER RECEIVED FROM THE MSFN.
* ACCEPTS COMMAND SIGNALS FROM THE MSFN NETWORK AND PROVIDES UP TO 100 UNIQUE COMMANDS TO USERS.
COMMAND DECODER (CONT)

- A COMMAND FROM THE MSFN CONSISTS OF A 2kHz SUBCARRIER PHASE MODULATED WITH A 1kHz SUBCARRIER TO PRODUCE 61 SERIAL BITS WITH THE FOLLOWING FORMAT.

<table>
<thead>
<tr>
<th>20 BITS</th>
<th>7 BITS</th>
<th>7 BITS</th>
<th>7 BITS</th>
<th>20 BITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

1. - PREAMBLE - ALL ONES OR ALL ZEROS
2. - ADDRESS INDIVIDUAL ALSEP (A or B DECODER)
3. - COMMAND COMPLEMENT
4. - COMMAND
5. - TIMING (EXECUTION) - ALL ONES OR ALL ZEROS

7759-60168

COMMAND DECODER ADDRESSING

- THE SEVEN ADDRESS BITs ARE USED TO UNIQUELY COMMAND FOUR SEPARATE ALSEPs Deployed on the lunar surface.
- EACH COMMAND DECODER HAS AN "A" SECTION AND A REDUNDANT "B" SECTION. EITHER MAY BE SELECTED TO PROCESS A COMMAND BY TRANSMITTING THE PROPER ADDRESS CODE.
- CODES

<table>
<thead>
<tr>
<th>ALSEP</th>
<th>ADDRESS NO. (OCTAL)</th>
<th>CODE PATTERN</th>
<th>COMMAND DECODER NUMBER</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>130</td>
<td>1011000</td>
<td>1A</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0011000</td>
<td>1B</td>
</tr>
<tr>
<td>2</td>
<td>116</td>
<td>1011110</td>
<td>2A</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>0011110</td>
<td>2B</td>
</tr>
<tr>
<td>3</td>
<td>151</td>
<td>11101001</td>
<td>3A</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>01101001</td>
<td>3B</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>0010101</td>
<td>4A</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>0110101</td>
<td>4B</td>
</tr>
</tbody>
</table>

7759-6017
COMMAND DEMODULATOR

SIGNAL INPUT FROM CMD RCVR

INPUT AMPLIFIER -> DATA DETECTOR -> INTEGRATE AND DUMP -> DATA FLIP-FLOP

DATA FLIP-FLOP -> NRZ-C DATA

THRESHOLD DETECTOR -> INTEGRATOR 

SCHMIDT TRIGGER -> FLIP-FLOP

SYNC DETECTOR -> LOOP FILTER -> VCO <-> 8 KHZ

FLIP-FLOP -> FLIP-FLOP

4 KHZ CLOCK

7759-6018

COMMAND DECODER SECTION

BLOCK DIAGRAM-DIGITAL

7759-6019

11-12
FUNCTIONAL FLOW CHART COMMAND DECODER

COMMAND DECODER DELAYED COMMAND SEQUENCER

- PROVIDES A BACKUP FEATURE FOR LOCAL GENERATION OF COMMANDS IN CASE THE COMMAND LINK CANNOT BE ESTABLISHED

- GENERATES 7 ONE-TIME COMMANDS AFTER A DELAY OF 96 (PLUS) HOURS FROM START OF "PET" (WHERE "PET" STARTS AT THE TIME THE ASTRONAUT MATES THE RTG WITH THE CENTRAL STATION BY INSERTING P22 INTO J22)

- COMMANDS ARE IDENTICAL TO THOSE GENERATED IN RESPONSE TO SIGNALS FROM THE MSFN AND ARE OR'ED IN THE COMMAND LINE DRIVER.
**COMMAND DECODER DELAYED COMMAND SEQUENCER (CONT)**

- DELAYED (ONE-TIME) COMMANDS ARE IDENTIFIED AS FOLLOWS:

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>TIME OF EXECUTION</th>
<th>COMMAND NUMBER (OCTAL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REMOVE CPL EE DUST COVER</td>
<td>96 HRS &amp; 2 MIN</td>
<td>113</td>
</tr>
<tr>
<td>SET C CIC SEAL BREAK</td>
<td>96 HRS &amp; 2 MIN</td>
<td>105</td>
</tr>
<tr>
<td>UNCAKE PSE</td>
<td>96 HRS &amp; 2 MIN</td>
<td>073</td>
</tr>
<tr>
<td>EXECUTE C C I S SEAL BREAK</td>
<td>96 HRS &amp; 3 MIN</td>
<td>110</td>
</tr>
<tr>
<td>SWS DUST COVER REMOVAL</td>
<td>96 HRS &amp; 4 MIN</td>
<td>122</td>
</tr>
<tr>
<td>SET SIDE DUST COVER</td>
<td>96 HRS &amp; 4 MIN</td>
<td>107</td>
</tr>
<tr>
<td>EXECUTE SIDE DUST COVER REMOVAL</td>
<td>96 HRS &amp; 5 MIN</td>
<td>110</td>
</tr>
</tbody>
</table>

**DELAYED COMMAND SEQUENCER FUNCTIONAL FLOW CHART**

![Flow Chart Diagram]

7769-6021B

7769-6022

11-14
FEATURES

DETECTS INITIAL POWER TURN-ON OR
MOMENTARY POWER INTERRUPTION TO -

1. SET COMMAND DECODER IN SEARCH MODE
2. SET COMMAND DECODER IN "TIMER ACCEPT" MODE
3. START DELAYED COMMAND SEQUENCER

COMMAND DECODER-OTHER LOCAL COMMANDS

THE FOLLOWING REPETITIVE COMMANDS ARE GENERATED WITHIN THE
COMMAND DECODER:

1 - PSE CALIBRATE - COMMAND #065
   * OCCURS 12 HOURS AFTER T_0 AND EVERY 12 HOURS THEREAFTER

2 - RECEIVER CIRCUIT BREAKER RESET
   * OCCURS 12 HOURS AFTER T_0 AND EVERY 12 HOURS THEREAFTER

3 - MAGNETOMETER FLIP-CALIBRATE - COMMAND #131
   * FIRST OCCURRENCE IS 108 HOURS PLUS 1 MIN
     AFTER T_0 - REPEATS EVERY 12 HOURS THEREAFTER

4 - RESTORE POWER TO LOW PRIORITY EXPERIMENT - CMD #052
   * FIRST OCCURRENCE IS 108 HOURS AND 7 MINUTES AFTER T_0
     AND EVERY 12 HOURS THEREAFTER

* ALL ABOVE COMMANDS MAY BE INHIBITED BY TRANSMITTING COMMAND #033

COMMAND #031 IS CONSIDERED CRITICAL! SHOULD THE COMMAND
LINK BE LOST FOLLOWING TRANSMISSION OF CMD #033, THEN ALL
LOCALY GENERATED COMMANDS WOULD BE LOST.
COMMAND DECODER INTERFACE CIRCUIT
(ONE EACH FOR 100 COMMANDS)

```
4.5 - 5.5 VDC

Vee

40KΩ
21KΩ
1KΩ
5.2
330Ω

0.0022 µfd

LINE DRIVER
FAIRCHILD LPDT µL 9042

INTERFACE

SOURCE CURRENT

USER

SINK CURRENT

COMMAND PULSE

20 ± 2 M SEC

4.0 ± 1.5

0.2 ± 2

1 ± 10 µ SEC (MAX)

INACTIVE STATE

ACTIVE STATE

DRIVER SPECIFICATION

SOURCE I ≤ 45 µ AMP
(NINACTIVE STATE)

SINK I ≤ 750 µ AMP
(ACTIVE STATE)

7759-6025
```

COMMAND DECODER TELEMETRY SUMMARY

* COMMAND VERIFICATION (CV) WORD
  - LOCATED IN WORD 46 OF TELEMTRY FORMAT FOR FLIGHT SYSTEMS 1 & 2 AND IN WORD 5 FOR FLIGHT SYSTEMS 3 & 4
  - CONSISTS OF 2 ZEROS, THE RECEIVED COMMAND AND A PARITY BIT
  - EXAMPLE OF CV WORD RECEIVED AT THE MSFN

```
0 0 0 0 1 1 1 1 1 0 1
FILLER COMMAND PARITY
BITS (OCTAL 36)
```

ONCE FOR EACH CMD TRANSMITTED

- PARITY "ONE" VERIFIES BIT BY BIT CHECK OF COMMAND WITH COMPLEMENT.
- THE SEVEN COMMAND BITS IDENTIFY THE BINARY CODE DETECTED BY THE COMMAND DECODER.

7759-6026

11-16
COMMAND DECODER TELEMETRY SUMMARY

CHANNEL 48 AT-31 COMMAND DECODER BASE TEMP
  * SIGNAL OBTAINED FROM THERMISTOR LOCATED NEAR CENTER OF BASE PLATE

CHANNEL 49 AT-32 COMMAND DECODER INTERNAL TEMP
  * THERMISTOR LOCATED ON "PULSE SHAPER" PRINTED CIRCUIT BOARD

CHANNEL 61 AT-33 COMMAND DEMODULATOR, VCO TEMP
  * THERMISTOR LOCATED ON DEMODULATOR PRINTED CIRCUIT BOARD

CIRCUITS - TEMPERATURE SENSING CIRCUITS ARE ARRANGED AS FOLLOWS:

+12VDC 3010uRT-1 3010u
TO MULTIPLEXER
RETURN

RT-1 "FENWAL" ISO-CURVE 15K ohm THERMISTOR.

TELEMETRY READOUT VS. TEMPERATURE

USED IN THE FOLLOWING MEASUREMENTS:
AT-27 AT-08
AT-26 AT-07
AT-25 AT-06
AT-24 AT-05
AT-23 AT-04
AT-22 AT-03
AT-21 AT-02
AT-20 AT-01
AT-19 AT-31
AT-18 AT-30
AT-17 AT-29
AT-16 AT-28
AT-15 AT-27
AT-14 AT-26
AT-13 AT-25
AT-12 AT-24
AT-11 AT-23
AT-10 AT-22
AT-09 AT-21
AT-08 AT-20

TEMP IN DEGREES FAHRENHEIT

DECIMAL

OCTAL

7759-6027

11-17
CMD DECODER/TIMER INTERFACE

DELAYED CMD TIME SEQUENCE

RECEIVER CIRCUIT BREAKER RESET COMMANDS

PSE CAL. CMD. (OR ED WITH 065 & 073 WITHIN THE PSE ELECTRONICS PACKAGE)
COMMANDS 73, 105 AND 113 (96 HOURS + 2 MIN.)
COMMAND 110 (96 HOURS + 3 MIN.)
COMMANDS 107 AND 122 (96 HOURS + 4 MIN.)
COMMAND 110 (96 HOURS + 5 MIN.)
COMMAND 131 (108 HOURS + 1 MIN.) REPETITIVE
COMMAND 062 (108 HOURS + 7 MIN.) REPETITIVE

NOTES:
(1) "96 HOUR POINT" IS 84 TO 96 HOURS AFTER SYSTEM ACTIVATION
(2) "SYSTEM ACTIVATION" ON FLIGHT SYSTEM 3 AND FLIGHT SYSTEM 4
(3) ALL DELAYED COMMANDS WILL BE REPEATED IN 96 HOURS FOLLOWING EACH ACTIVATION OF THE POWER RESET CIRCUIT

7759-6030
## COMMAND DECODER

### OPERATING MODE SEQUENCE

<table>
<thead>
<tr>
<th>MODE</th>
<th>STARTED BY:</th>
<th>TERMINATED BY:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ADDRESS SEARCH</td>
<td>DECODER RESET (THRESHOLD TRUE)</td>
<td>ADDRESS RECOGNITION; STARTS THE COUNTER FROM COUNT OF 29</td>
</tr>
<tr>
<td>2. COMMAND WORD ENTRY</td>
<td>ADDRESS RECOGNITION</td>
<td>COUNT OF 43; CLEARS PARITY SAMPLE, TERMINATING THE UPLINK SHIFTING</td>
</tr>
<tr>
<td>3. COMMAND EXECUTION</td>
<td>COUNT OF 43</td>
<td>COUNT OF 63; SETS COMMAND VERIFICATION ENABLE FLIP-FLOP</td>
</tr>
<tr>
<td>4. CV WORD READOUT</td>
<td>COUNT OF 63</td>
<td>1. DATA END RESET, OR 2. COUNT OF 2047, DEMAND OVERRIDE</td>
</tr>
</tbody>
</table>

### MAIN CONTROL FUNCTIONS
- **SHIFT REGISTER CLOCK WAVEFORM CONTROL**
- **DECODER RESET**
- **NOTE THAT THE PROGRAMMER COUNTER IS STARTED BY ADDRESS RECOGNITION**

---

### DECODER CONTROLLER SIMPLIFIED BLOCK DIAGRAM

[Diagram showing the decoder controller's simplified block diagram, including various blocks like CVR READOUT, 1.06 KH-CLOCK, DATA DEMAND, 1 KH ENABLE, TIMING CONTROL, and other related components.]

---

7759-6077
"CV 177 ANOMALY" MECHANISM

- IS DUE TO DATA END RESET BEING PREVENTED FROM resetting THE RESET CONTROL FLIP-FLOP

1. DATA END RESET IS A SHORT PULSE

2. RESET CONTROL FLIP-FLOP IS AN R-S FLIP FLOP TRIGGERED BY "LOWS"

3. RESET CONTROL FLIP-FLOP SET INPUT IS THE SHIFT TIMING SIGNAL WITH THE FOLLOWING WAVEFORM:

```
HIGH   LOW
1 MILLISEC   1/8 MILLISEC
```

4. WHEN THE SET INPUT IS LOW, THE RESET OUTPUT OF THE FLIP-FLOP CANNOT BE DRIVEN LOW, I.E., TO ITS "ACTIVE" LEVEL.

5. DUE TO THE ASYNCHRONISM BETWEEN THE UPLINK AND DOWNLINK, THE SHORT DATA END RESET PULSE WILL COINCIDE WITH A SET PULSE 1 IN 8 TIMES (AVERAGE).

6. COINCIDENCE RESULTS IN A SECOND CV WORD CONTAINING THE UPLINK TRAILER AS DATA, I.E., ALL "1'S".

7. FINALLY, THE DECODER IS RESET BY THE NEXT DATA END RESET OR BY DEMAND OVERRIDE.

"CV 177 ANOMALY" MECHANISM (CONT')

4. WHEN THE SET INPUT IS LOW, THE RESET OUTPUT OF THE FLIP-FLOP CANNOT BE DRIVEN LOW, I.E., TO ITS "ACTIVE" LEVEL.

5. DUE TO THE ASYNCHRONISM BETWEEN THE UPLINK AND DOWNLINK, THE SHORT DATA END RESET PULSE WILL COINCIDE WITH A SET PULSE 1 IN 8 TIMES (AVERAGE).

6. COINCIDENCE RESULTS IN A SECOND CV WORD CONTAINING THE UPLINK TRAILER AS DATA, I.E., ALL "1'S".

7. FINALLY, THE DECODER IS RESET BY THE NEXT DATA END RESET OR BY DEMAND OVERRIDE.
CENTRAL STATION TIMER

- THE CST IS AN ACCUTRON MECHANISM OBTAINED FROM THE BULOVA WATCH CO.
- A TUNING FORK IS USED TO ACCURATELY CONTROL SWITCH CLOSURE TIME
- SIZE: 1.32 x 1.32 x 2.63 INCHES
- WEIGHT: 0.265 POUNDS
- POWER IS PROVIDED BY A SEPARATE BATTERY
- TWO MODES OF OPERATION ARE PROVIDED:
  - "STOP MODE" - POWER IS APPLIED AND FORK IS OSCILLATING AT LOW LEVEL - ROTARY MOTION IS NOT PRODUCED. MAXIMUM CURRENT IS 7 MICROAMPERES. THIS MODE IS USED FROM FINAL TEST UNTIL DEPLOYMENT ON THE LUNAR SURFACE
  - "START MODE" - ADDITIONAL POWER IS APPLIED FOR INCREASED AMPLITUDE OF FORK OSCILLATION. ROTARY MOTION IS PRODUCED TO DRIVE THE SWITCH MECHANISM. MAXIMUM CURRENT IS 12 MICROAMPERES

CENTRAL STA TIMER MECHANISM

OUTSIDE CENTRAL STATION

1 MIN SW ACTION PRODUCED BY SINGLE SEGMENT COMMUTATOR

METAL EQUIV SW CLOSED FOR 500 ± 200 MS

WIRE BRUSH INSULATION

17 HR SWITCH IS PRODUCED SNAP ACTION MECHANISM

720 ± 30 DAY SWITCH

ACCUTRON MOVEMENT

1 MIN SW ACTION PRODUCED BY SINGLE SEGMENT COMMUTATOR

WIRE BRUSH INSULATION

17 HR SWITCH IS PRODUCED SNAP ACTION MECHANISM

720 ± 30 DAY SWITCH

* JUMPER IS REMOVED AND 360 Hz SIGNAL APPLIED TO START FORK.
CENT STA TIMER BATTERY

- CONSISTS OF A P.R. MALLORY ZINC-MERCURIC-OXIDE, TYPE RMCC1W CELL, IN A SPECIAL PACKAGE FOR ALSEP. BASIC CELL IS CALLED "PACER"
- INITIAL TERMINAL VOLTAGE IS 1.5 VOLTS MAXIMUM
- MINIMUM CELL CAPACITY IS 750 MILLIAMPERE HOURS
- CELL CAPACITY IS DERATED TO 375 MILLIAMPERE HOURS FOR ALSEP
- CELL CAPACITY IS GUARANTEED AFTER STORAGE (OPEN CIRCUIT) FOR UP TO 2 YEARS
- OPERATING TEMPERATURE IS -27 to +162°F

TIMER PROBLEM/TEST SUMMARY

BASED ON A DETAILED ANALYSIS OF TEST DATA AND CONFERENCES BETWEEN BENDIX/BULOVA – ENGINEERING/RELIABILITY/MATERIALS GROUPS, NASA/MSC PERSONNEL, CHEMISTS AT GSFC, CHEMISTS AND METALLURGISTS AT MAL/KSC, BALL BROS. HARD VACUUM LUBRICATION SPECIALISTS, APPLICATIONS ENGINEERS AT DOW CORNING, DR. F. J. CLAUS AT LMSC, MR. ROBERT TROMBLEY AT THE NEY CO., AND DR. P. WALDRON AT LINCOLN LABS, IT WAS DECIDED TO MODIFY THE ALSEP TIMERS AS FOLLOWS:
TIMER PROBLEM/TEST SUMMARY MODIFICATIONS (CONT)

- REPLACE BERYLLIUM/COPPER WHEELS WITH PALINEY 7 WHEELS TO IMPROVE WEAR CHARACTERISTICS
- LUBRICATE ALL JEWELS WITH KRYTOX; ELIMINATE LUBRICATION ON WHEEL SPOKES TO PREVENT WHEEL TACKINESS
- REPLACE NEOPRENE SEALS WITH VITON SEALS TO ELIMINATE SULPHUR
- USE ELECTRON MICROSCOPE TO PERFORM PRE-ASSEMBLY INSPECTION OF EACH WHEEL TO ASSURE THAT ALL TEETH ARE ACCURATELY FORMED DURING MFG/CUTTING OPERATION
- PERFORM POST-ASSEMBLY INSPECTION OF JEWEL ALIGNMENT ON WHEEL TEETH TO PREVENT MISALIGNMENT AND POSSIBLE WEAR ACCELERATION DUE TO CHISELING. USE 216X MICROSCOPE

TIMER PROBLEM/TEST SUMMARY RESULTS (CONT)

TWO TIMERS, MODIFIED AS ABOVE, WERE SUBJECTED TO T/V TESTS. THE TEST CONSISTED OF 36 TEMPERATURE CYCLES FROM -10 TO +150°F AT 10⁻⁵ TORR OR BETTER. FOLLOWING THE TEST EXAMINATION AT KSC WITH A SEM, THERE WAS NO DEGRADATION OF TEETH AND NO EVIDENCE OF DEBRIS. BASED ON THIS ANALYSIS, THE TIMERS WERE JUDGED TO BE SATISFACTORY FOR FLIGHT.
### Timer Problem/Test Summary

<table>
<thead>
<tr>
<th>Date/SN</th>
<th>Test</th>
<th>Lub</th>
<th>Symptom/Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/87</td>
<td>VAC AMT 1</td>
<td>MOEBIUS</td>
<td>SEIZURE OF MINUTE SWITCH COMMUTATOR AND BRUSH</td>
</tr>
</tbody>
</table>

**Problem/Corrective Action**

COMMUTATOR COATED WITH EPON82J - SMALL SEGMENT LEFT BARE TO PROVIDE SWITCH FUNCTION. ADDED SINTERED NYLON CHIP IMPREGNATED WITH DCF18 FLUOROCARBON OIL ADJACENT TO BRUSH CONTACT FOR VAPOR LUBRICATION.

---

<table>
<thead>
<tr>
<th>Date/SN</th>
<th>Test</th>
<th>Lub</th>
<th>Symptom/Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/87</td>
<td>VAC AMT 1</td>
<td>MOEBIUS</td>
<td>AFTER 3622 HOURS IN VACUUM, COULD NOT REPEATEDLY SWITCH OPERATING MODES</td>
</tr>
</tbody>
</table>

**Problem/Corrective Action**

MOEBIUS, WHICH HAD VAPORIZED LEAVING GUMMY SUBSTANCE IN JEWELS, WAS REPLACED WITH DCF18 FLUOROCARBON OIL. FS1281 GREASE ADDED TO SPOKE OF INDEX WHEEL.

---

<table>
<thead>
<tr>
<th>Date/SN</th>
<th>Test</th>
<th>Lub</th>
<th>Symptom/Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/88</td>
<td>T/V</td>
<td>FS1285</td>
<td>TACKY WHEEL AND JEWELS, DEBRIS ON PANEL JEWEL AND TEETH AFTER 36 T/V CYCLES. SLOW OPERATION AT -20°F.</td>
</tr>
</tbody>
</table>

**Problem/Corrective Action**

FS1281, WHICH HAD MIGRATED ONTO TEETH, WAS REMOVED FROM WHEEL SPOKE.

---

<table>
<thead>
<tr>
<th>Date/SN</th>
<th>Test</th>
<th>Lub</th>
<th>Symptom/Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/68</td>
<td>T/V</td>
<td>FS1285</td>
<td>SLOW ON 1st DAY (-10°F). STOPPED ON 32nd DAY (-10°F).</td>
</tr>
</tbody>
</table>

**Problem/Corrective Action**

ACUMULATION OF DARK SUBSTANCE ON TEETH IMPAIRED INDEXING. FS1285 OIL REPLACED WITH FS1281 GREASE WITH DCF18 BARRIER COATING TO PREVENT MIGRATION OF LUBRICANT. WHEEL MATERIAL CHANGED FROM B4C TO PALMIY 7 WITHOUT LUB.
### TIMER PROBLEM/TEST SUMMARY

<table>
<thead>
<tr>
<th>DATE/IN</th>
<th>TEST</th>
<th>LUB</th>
<th>SYMPTOM/PROBLEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/88</td>
<td>120 DAYS</td>
<td>FS1286 IN JEWEL</td>
<td>STOPPED THREE TIMES DURING TEST - ALL AT LOW TEMP. LIMIT.</td>
</tr>
<tr>
<td></td>
<td>10 to 110°F</td>
<td>FS1281 on SPOKE</td>
<td></td>
</tr>
</tbody>
</table>

#### PROBLEM

Corrosion at MAL/KSC revealed teeth coated with debris. Electron microprobe revealed that debris consisted primarily of silicone and sulphur with base materials.

#### CORRECTIVE ACTION

12/88

T/V SIMULATED HERMETIC SEAL

Convelex-10 FS1281 Krytox Spe Gruva Grease

Various failures: combination of foundry 7 wheel with Krytox lub operate well under all conditions with only slight wheel wear which resulted from misalignment of jewels on wheel teeth.

---

7759-6076

11-26
ALSEP TELEMETRY LINK

* DIGITAL DATA PROCESSOR (DDP)
* MULTIPLEXER/CONVERTER
* TRANSMITTERS (TWO)
* DIPLEXER/SWITCH
* ANTENNA

7759-6035
THE DIGITAL DATA PROCESSOR -

- Is the focal point for the collection, formatting and control of all telemetered data
- Contains command selectable "X" and "Y" sections. Except for the frame counter and interface circuits, the DDP is fully redundant
- Has 3 modes of operation defined as "Normal" (1060b/s), "Slow" (530b/s) and active seismic (10,600b/s)
- Uses a crystal oscillator to derive all timing and control signals
- Collects data into a 64 word frame repeating each 604 milliseconds. Each word consists of 10 bits or about 9.43 milliseconds (normal mode)
- Processes collected data into the required telemetry format is serial form. Each data source is sampled at least once per frame

DATA PROCESSOR
SIMPLIFIED BLOCK DIAGRAM

7758-6037
**GENERATION OF BASIC CLOCKS**

**COMMANDS**

106.6 KHz (0.005%)

- 2

84.8 KHz

- MODE

SELECT

42.4 Kbps

÷ 2

÷ 10

÷ 8

→ 1060 BPS OR 530 BPS

÷ 8

→ 10600 BPS

**"X" SECTION**

- REDUNDANT **"Y" SECTION**

A - NORMAL MODE

B - SLOW MODE

**DIGITAL DATA PROCESSOR**

* CONTROL WORD GENERATOR
  - Generates the 22-bit synchronization code
  - Provides mode, frame and ALESEP ID in the last 8 bits of the 30-bit sync word

* SPLIT PHASE MODULATOR
  - Encodes data into a "split phase" signal
  - PCM "0" is represented by "01" and causes a positive phase transition
  - PCM "1" is represented by "10" and causes negative phase transition

* FRAME COUNTER
  - Is not redundant
  - Contains a counter which is advanced one step per 64 word frame
  - Is reset by a 90th frame "end of frame" signal from the multiplexer/ converter

7759-6039

7759-6040
DIGITAL DATA PROCESSOR

• MULTIFORMAT COMMUTATOR
  - USES 2 DIVIDE BY 8 COUNTERS WITH GATING FOR ANY ONE OF 64 CONSECUTIVE PERIODS (WORDS).
  - PRODUCES SIGNALS OF ONE WORD LENGTH AND MULTIPLES OF ONE WORD LENGTH TO SELECT AND GATE DATA INTO A MODULATOR
  - CONTAINS A "PATCH PLANE" FOR FLEXIBLE WORD ASSIGNMENTS

• DEMAND REGISTER
  - ACTS AS A BUFFER BETWEEN THE DEMAND DECODER ASSEMBLY AND THE DEMAND LINES TO ELIMINATE GATING TRANSIENTS
  - ACTS AS A MASTER SWITCH TO INHIBIT ALL DEMANDS DURING ASE MODE

7759-6041-A

DIGITAL DATA PROCESSOR (CONT')

• DIGITAL MULTIPLEXER
  - CONTAINS A 10-BIT SHIFT REGISTER TO ACCEPT 8 PARALLEL BITS FROM THE A/D CONVERTER OR 8 SERIAL BITS FROM THE COMMAND DECODER.
  - SHIFTS OUT 10-BIT WORDS WITH "ZEROS" IN THE TWO MOST SIGNIFICANT FIGURES. BITS ARE SHIFTED HIGH ORDER FIRST.
## FORMAT FLIGHT SYSTEM

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<thead>
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<th>PER FRAME</th>
<th>LEGEND</th>
<th>ASSIGNMENTS</th>
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**TELEMETRY FORMAT**

**FLEXIBLE WORD ASSIGNMENTS**

**WORDS MARKED WITH X ARE ASSIGNED BY DRAWING DURING FABRICATION OF THE DIGITAL DATA PROCESSOR'S MULTI-FORMAT COMMUTATOR.**

7759-6042

7759-6043
### FORMAT FLIGHT SYSTEM #3

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<th>PER FRAME</th>
<th>LEGEND</th>
<th>ASSIGNMENTS</th>
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<td>3</td>
<td>x</td>
<td>CONTROL</td>
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<td>PASSIVE SEISMIC (SHORT PERIOD)</td>
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<td>SUPRA-THERMAL ION DETECTOR/CCGE</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>CHARGED PARTICLE</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>COMMAND VERIFICATION (ALL ZEROS IF NO COMMAND)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>H</td>
<td>HOUSEKEEPING</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>NA</td>
<td>NOT ASSIGNED (ALL ZEROS TRANSMITTED)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>EG</td>
<td>COLD CATHODE CATHODE EXPERIMENT (MISE)</td>
<td></td>
</tr>
</tbody>
</table>

Each box contains one 10 bit word. Total represents one frame of 640 bits.

7759-6044

### FORMAT FLIGHT SYSTEM #4

<table>
<thead>
<tr>
<th># of Words</th>
<th>PER FRAME</th>
<th>LEGEND</th>
<th>ASSIGNMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>CONTROL</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>X</td>
<td>PASSIVE SEISMIC (SHORT PERIOD)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>*</td>
<td>PASSIVE SEISMIC (LONG PERIOD SEISMIC)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>*</td>
<td>PASSIVE SEISMIC (LONG PERIOD TIDAL + TEMP)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>MAGNETOMETER</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>S</td>
<td>SOLAR WIND</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>SUPRA-THERMAL ION DETECTOR/CCGE</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>CHARGED PARTICLE</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>COMMAND VERIFICATION (ALL ZEROS IF NO COMMAND)</td>
<td></td>
</tr>
<tr>
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<tr>
<td>3</td>
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<td>NOT ASSIGNED (ALL ZEROS TRANSMITTED)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>EG</td>
<td>COLD CATHODE CATHODE EXPERIMENT (MISE)</td>
<td></td>
</tr>
</tbody>
</table>

Each box contains one 10 bit word. Total represents one frame of 640 bits.

7759-6045

11-35
ALSEP DATA FORMAT

54.34 sec = 1 cycle

1 2 3 4 5 6 7 8 9

30.53 sec = 1 frame

1 2 3 4 5 6 7 8 9

CONTROL GROUP

1/106 sec = 1 word

1 2 3 4 5 6 7 8 9

1/1060 sec = 1 bit

NORMAL BIT RATE SHOWN
SLOW RATE = 0.5 x 1060
= 530 BPS

FOR CONTINGENCY
HIGH BIT RATE = 10,600 BPS
FORMATTED BY ASE

CONTROL WORDS AND CMD VERIFICATION

DA-01 ALSEP FRAME SYNC

BARREKER CODE

COMPLEMENT OF
BARREKER CODE

DA-02 ALSEP FRAME CMD

WORD 46 ON ALSEP I

FILLER BITS (ZEROS)

DA-05 ALSEP CMD AS RCVD

DA-06 ALSEP CMD MAP

ONE WORD SAMPLE AS EACH
COMMAND IS RECEIVED AT
ALSEP, AT OTHER TIMES THE
SAMPLE IS ALL ZEROS

MODE BIT, DEFINED AS FOLLOWS:

FRAME MODE BIT MEANING
1 1 NORMAL BIT RATE
2 1 LOW BIT RATE
3 X MSB
4 X DATA PROC
5 X ID NO.
6 NONE NONE
* " "
* " "
* " "
W " "
0 NONE NONE

7759-6047

11-36
DATA PROCESSOR TIMING/CONTROL SIGNALS

DATA PROCESSOR TIMING/CONTROL SIGNALS

- DATA PROCESSOR TIMING/CONTROL SIGNALS
- DATA PROCESSOR TIMING/CONTROL SIGNAL INTERFACE

TIMING/COREL SIGNAL INTERFACE
EXPERIMENT/DATA PROCESSOR INTERFACE

DIGITAL DATA

DIGITAL DATA PROCESSOR
TELEMETRY SUMMARY

CHANNEL 2  AE-01  0.25 VDC CALIBRATION OF ADC
A ZENER DIODE AND RESISTIVE DIVIDER IS USED TO PROVIDE AN ACCURATE REFERENCE VOLTAGE FOR TM CHANNEL CALIBRATION

CHANNEL 3  AE-02  4.75 VDC CALIBRATION OF ADC
THIS VOLTAGE IS OBTAINED FROM THE SAME NETWORK AS THE 0.25 VDC AND PROVIDES A SECOND CALIBRATION POINT

CHANNEL 46  AT-29  DIGITAL DP, BASE TEMPERATURE
USES A THERMISTOR LOCATED ON THE BASE PLATE

CHANNEL 47  AT-30  DIGITAL DP, INTERNAL TEMPERATURE
USES A THERMISTOR LOCATED ON ONE OF THE PRINTED CIRCUIT BOARDS

7759-6050

7759-6051
ANALOG MULTIPLEXER/CONVERTER

PHYSICAL DESCRIPTION

| SIZE       | 2.62 x 4.23 x 5.92 inches |
| WEIGHT     | 2.2 pounds                |
| POWER      | Requires a total of 1435 milliwatts (nominal at room ambient) at the following voltage levels: |
|            | 65 milliwatts at +15 vdc |
|            | 150 milliwatts at +12 vdc |
|            | 1100 milliwatts at +5 vdc |
|            | 1200 milliwatts at -12 vdc |
| PARTS COUNT| INTEGRATED CIRCUITS: 76 |
|            | FIELD EFFECT TRANSISTORS: 156 |
|            | TRANSISTORS: 185 |
|            | DIODES: 307 |
|            | ZENER DIODES: 9 |
|            | CAPACITORS: 158 |
|            | RESISTORS: 102 |
|            | CRYSTALS: 2 |
| PACKAGING  | All parts are mounted on 15 two layer PCBs |
| CONNECTOR  | HUGHES 244 PIN |

ANALOG MULTIPLEXER/CONVERTER

THE COMPONENT -

• CONSISTS OF A 90 CHANNEL ANALOG MULTIPLEXER, A SEQUENCER, BUFFER AMPLIFIERS AND TWO EIGHT-BIT A/D CONVERTERS WITH BUFFERED OUTPUTS

• USES REDUNDANT GATES, DRIVERS AND A/D CONVERTERS FOR RELIABLE OPERATION

• MONITORS UP TO 90 DATA SOURCES ON A SEQUENTIAL SAMPLE BASIS. REQUIRES ABOUT 54 SECONDS FOR ONE COMPLETE SEQUENCE OF SAMPLES

• CONVERTS EACH INPUT INTO AN 8-BIT BINARY WORD

• PROVIDES THE 8-BIT BINARY WORD IN PARALLEL TO THE DIGITAL MULTIPLEXER OF THE DDP
MULTIPLEXER TIMING DIAGRAM

C1
C2
C3
C4
C5
R1
R2
MUX OUTPUT

5 OF 15 'C' RATE PULSES
2 OF 6 'R' RATE PULSES

MUX
ADVANCE
PULSES
ADC
ENCODER
COMMAND
DATA
AVAILABLE

MUX CHANNEL 1
MUX CHANNEL 2
MUX CHANNEL 3
MUX CHANNEL 4

R1
R2
R3
R4
R5
R6

DATA FORMAT AND CHANNEL SEQUENCE

CHANNEL #1
CHANNEL #2
CHANNEL #3
CHANNEL #4

A/D CONVERTER FUNCTIONAL BLOCK DIAGRAM

ANALOG INPUT FROM BUFFER AMPLIFIER

RAMP GENERATOR
SYNC LOGIC

ADC ENCODE COMMAND

OFFSET ADJ
COMPARATOR
A/D ENCODER
CONTROL

2 MHz OSC
GATE

ACCUMULATOR BINARY COUNTER

7759-6057
7759-6058

11-42
INPUT REQUIREMENTS

ANALOG INPUTS

RANGE  0 TO +5 volts
INPUT Z  ≥ 1 megohm (ON state)
           ≤50 megohms (OFF state)
SOURCE Z  ≤ 10 k ohms
*PROPER OPERATION WITH AN OVERVOLTAGE OF
    +8 to -6.5 volts for channels 21, 36, 45, & 80
    +8 to -9 volts for channels 6, 7, 26, 52, 67, & 70
    +8 to -5 volts for all other channels
IS NOT DAMAGED BY AN OVERVOLTAGE OF ±12 VOLTS ON ANY CHANNEL.

ADVANCE PULSE
REQUIRED FOR ADVANCING MULTIPLEXER THROUGH ITS 90 CHANNELS.
SUPPLIED BY DDP
ADC START (ENCODE) PULSE
DRIVESSYNC LOGIC TO START A/D CONVERSION, SUPPLIED BY DDP
*PROPER OPERATION IS NOT GUARANTEED BEYOND
PLUS AND MINUS OPERATIONAL LIMITS

7759-6059

ANALOG MULTIPLEXER/CONVERTER OUTPUTS

BINARY OUTPUT
0000000  FOR A NEGATIVE INPUT
0000001  FOR ZERO INPUT
1111110  FOR +5 VOLTS INPUT
1111111  FOR GREATER THAN +5 VOLTS INPUT
LOGICAL "0" IS  +4.0 ± 1.5 VOLTS
LOGICAL "1" IS  +0.2 ± 0.2 VOLTS

TEMPERATURE TELEMETRY
CHANNEL 33  AT-27  BASE TEMP
            (SIGNAL OBTAINED BY A THERMISTOR/RESISTOR NETWORK POWERED BY +12 VDC
            THERMISTOR LOCATED ON BASE PLATE)
CHANNEL 34  AT-28  INTERNAL TEMP
            (SAME AS ABOVE EXCEPT THERMISTOR MOUNTED ON PCB)

7759-6060

11-43
TRANSMITTER

PHYSICAL DESCRIPTION

- **SIZE**: 1.5 x 2 x 7.5 inches
- **WEIGHT**: 1.17 pounds (each)
- **POWER**: 8 watts at 29 VDC
  0.5 watts at 12 VDC
- **EMPLOY MODULAR CONSTRUCTION WITH 11 SEPARATE CIRCUIT MODULES**
- **MODULES ARE MOUNTED ON A MILLED MAGNESIUM BASE PLATE WITH INTER-MODULE WIRING THROUGH MILLED PASSAGEWAYS**

TRANSMITTER

- **PROVIDES A MINIMUM OF 1 WATT INTO A 50 OHM LOAD WITH A MAXIMUM VSWR OF 1.3:1**
- **PROPER CRYSTAL IS INSTALLED DURING MANUFACTURE FOR OPERATION ON EITHER 2276.5 MHz (CHANNEL #1), 2278.5 MHz (CHANNEL #2) OR 2275.5 MHz (CHANNEL #3), 2279.5 MHz (CHANNEL #4) IS ASSIGNED BUT NOT IMPLEMENTED**
- **FREQUENCY STABILITY IS 0.0025% YEAR**
- **TWO IDENTICAL COMPONENTS, TRANS A AND TRANS B, ARE PROVIDED WITH ONE IN STANDBY**
- **EITHER A OR B MAY BE SELECTED BY COMMAND FROM THE MSFN**
- **IF ONE IS SWITCHED "OFF" DUE TO AN OVERCURRENT CONDITION, THE OTHER IS AUTOMATICALLY SWITCHED "ON"**
- **IF COMMANDED "OFF" A RESISTOR (HEATER) IS AUTOMATICALLY SWITCHED ON FOR CENT STA THERMAL STABILITY**
TRANSMITTER, BLOCK DIAGRAM

TRANSMITTER TELEMETRY SUMMARY

<table>
<thead>
<tr>
<th>TRANSMITTER A CHANNEL</th>
<th>TRANSMITTER CRYSTAL TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 AT-23</td>
<td>USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL</td>
</tr>
<tr>
<td>19 AT-24</td>
<td>USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL</td>
</tr>
<tr>
<td>51 AE-51</td>
<td>TRANS AGC VOLTAGE</td>
</tr>
<tr>
<td>81 AE-17</td>
<td>TRANS PWR DOUBLER DC CURRENT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TRANSMITTER B CHANNEL</th>
<th>TRANSMITTER CRYSTAL TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 AT-25</td>
<td>USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL</td>
</tr>
<tr>
<td>32 AT-26</td>
<td>USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL</td>
</tr>
<tr>
<td>66 AE-16</td>
<td>TRANS AGC VOLTAGE</td>
</tr>
<tr>
<td>22 AE-18</td>
<td>TRANS PWR DOUBLER DC CURRENT</td>
</tr>
</tbody>
</table>

7759-6064

11-46
ASTRONAUT SWITCHES—FLT 4

11-48
WIRE HARNESS

• All components are interconnected with a pre-formed wire harness which provides the proper mating plugs.

• Within the thermally controlled area, AWG# 24 single conductor, stranded, copper wire is used.

• Two printed circuit terminal boards are used to permit transition from copper to manganin for wires which must go outside the thermally controlled area.

• To reduce thermal conduction, manganin wire, which has a thermal conductivity about 1/17 that of copper, is used between the PC terminal boards and external interfaces (connectors). Because of the high current, + and - wires to the RTG connector are copper.

• Connectors used are made by Hughes, Schjeldahl, Deutsch and Microdot.

HARNESS TO EXTERNAL CONNECTORS

CONNECTORS USED ARE MADE BY HUGHES, SCHJELDAHL, DEUSTCH AND MICRODOT

7759-6068

EXPOSED TO LUNAR ENVIRONMENT

7759-6069
POWER DISTRIBUTION UNIT

THE PDU -

- PROVIDES FOR THE DISTRIBUTION AND CONTROL OF POWER TO EXPERIMENTS AND CENT STA COMPONENTS
- CONTAINS CIRCUITRY TO PROTECT THE SYSTEM AGAINST OVERLOADS OCCURING FROM COMPONENT FAILURES
- PROVIDES SIGNAL CONDITIONING FOR CENT STA AND POWER SUBSYSTEM TELEMETRY SIGNALS
- WILL, BY SEQUENTIAL TURN-OFF OF 3 EXPERIMENTS, ADJUST THE TOTAL POWER DEMAND TO A VALUE WITHIN THE AVAILABLE POWER LIMIT
- UPON SENSING A POWER OVERLOAD CONDITION, WAITS ABOUT 135 MILLISECONDS BEFORE SWITCHING AN EXPERIMENT TO STANDBY
- PROVIDES MOUNTING SPACE FOR THE "DUST DETECTOR" ELECTRONICS

PHYSICAL DESCRIPTION OF THE PDU

* SIZE 2.8 x 4 x 7.25 inches
* WEIGHT 2.29 pounds
* POWER
  375 milliwatts at 129 VDC
  75 milliwatts at 15 VDC
  735 milliwatts at 12 VDC
  85 milliwatts at 5 VDC
  8 milliwatts at 6 VDC
  475 milliwatts at -12 VDC
* PARTS COUNT
  17 FLATPACKS
  37 TRANSISTORS
  11 AMPLIFIERS
  98 DIODES
  27 RELAYS
  238 RESISTORS
  44 CAPACITORS
  7 FUSES
  2 THERMISTORS
* PACKAGING - ALL PARTS ARE MOUNTED ON 5 PCBs
* CONNECTOR - HUGHES - 244 PIN

7759-6083

11-54
SIMPLIFIED BLOCK DIAGRAM PDU

EXPERIMENT POWER CONTROL (1 OF 4)

*NOTE: RIPPLE-OFF SEQ USED ON 1, 3 & 4 ONLY

7759-6085

11-55
SWITCHING FOR POWER DUMP RESISTORS

- CMD ON (017)
  +29VDC

- CMD OFF (021)

- CMD ON (022)
  +29VDC

- CMD OFF (023)

  - EACH RESISTOR IS 340 ohms
  - RESISTORS ARE LOCATED ON EXTERIOR OF CENTRAL STATION

SWITCHING FOR CENTRAL STA HEATERS

- CMD ON (024)
  +29 VDC

- CMD OFF (025)

- CMD ON (026)
  +29 VDC

- CMD OFF (027)

  - EACH RESISTOR IS 340 ohms
  - RESISTORS ARE MOUNTED ON THERMAL PLATE

7759-6090
**EXPERIMENT RIPPLE-OFF SEQUENCE**

- If overload condition exists for 135±15ms, then from count 1 to count 9, a "STBY SEL" CMD is issued to EXP #4.
- After 9ms, if overload still exists, a "STBY SEL" CMD is issued to EXP #3 from count 9 to count 17.
- If overload still exists, a "STBY SEL" CMD is issued to EXP #1 from count 17 to count 25.
- When overload is cleared, the counter is reset and further experiment switching is inhibited.

---

**PDU TELEMETRY CIRCUITS**

- TM CKT for RTG HOT & COLD FRAME
- TM CKT "INTERNAL" TEMPERATURES
- TM CKT for Structural Temperatures

---

7759-6091
**EXP PWR MODE TM**

FROM EXP PWR CONTROL:
- +29 VDC WHEN EXP NO 1 IS IN STBY
- +29 VDC WHEN EXP NO 2 IS IN STBY
- +29 VDC WHEN EXP NO 3 IS IN STBY
- +29 VDC WHEN EXP NO 4 IS IN STBY
- +29 VDC WHEN HTR NO 2 IS ON

**CENTRAL STATION TEMPERATURE MEASUREMENTS**

<table>
<thead>
<tr>
<th>TEMPERATURE MEASUREMENT</th>
<th>NUMBER OF POINTS</th>
<th>RANGE</th>
<th>ACCURACY</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTG HOT FRAME</td>
<td>3</td>
<td>950°F TO 1150°F</td>
<td>±5°F</td>
</tr>
<tr>
<td>RTG COLD FRAME</td>
<td>3</td>
<td>400°F TO 600°F</td>
<td>±5°F</td>
</tr>
<tr>
<td>EXTERNAL STRUCTURE TEMP.</td>
<td>7</td>
<td>-300°F TO +200°F</td>
<td>±15°F</td>
</tr>
<tr>
<td>INTERNAL STRUCTURE TEMP.</td>
<td>6</td>
<td>-60°F TO +200°F</td>
<td>±10°F</td>
</tr>
<tr>
<td>C/S COMPONENT TEMP.</td>
<td>19</td>
<td>-50°F TO +200°F</td>
<td>±10°F</td>
</tr>
</tbody>
</table>
DIPLEXER SWITCH
DATA SUBSYSTEM DIPLEXER SWITCH LEADING PARTICULARS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion loss</td>
<td>0.5 db</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.14:1</td>
</tr>
<tr>
<td>Center frequency</td>
<td></td>
</tr>
<tr>
<td>Isolation for 3 db bandwidth (4 MHz)</td>
<td>30-40 db</td>
</tr>
<tr>
<td>Switching voltage</td>
<td></td>
</tr>
<tr>
<td>DC power (position B)</td>
<td>12 vdc</td>
</tr>
<tr>
<td>DC power (position A)</td>
<td>150 MW</td>
</tr>
<tr>
<td>Switching time</td>
<td>0</td>
</tr>
<tr>
<td>RF power capability</td>
<td>120 milliseconds</td>
</tr>
<tr>
<td>Weight</td>
<td>1.5 watts</td>
</tr>
<tr>
<td>Stray magnetic field (steady-state)</td>
<td>1.28 pounds</td>
</tr>
<tr>
<td>Form factor</td>
<td>10 gamma at 3 feet</td>
</tr>
<tr>
<td></td>
<td>4 x 4.5 x 1.3 inches</td>
</tr>
</tbody>
</table>
DIPLEXER FILTER
**DIPLEXER**

- Provides transmitter/receiver isolation with a common antenna.
- Uses tunable cavity bandpass filters - 5 in transmit and 5 in receive path.

**Characteristics**

<table>
<thead>
<tr>
<th>Path</th>
<th>Insertion Loss</th>
<th>Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver</td>
<td>1.30 db</td>
<td>2.5 db</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.30:1</td>
<td>1.90:1</td>
</tr>
<tr>
<td>Center Frequency</td>
<td>2159 MHz</td>
<td>2139-2120 MHz</td>
</tr>
<tr>
<td>Max 3 db Bandwidth</td>
<td>11.0 MHz</td>
<td>24 MHz</td>
</tr>
<tr>
<td>Min 3 db Bandwidth</td>
<td>11.0 MHz</td>
<td>2.18 MHz</td>
</tr>
</tbody>
</table>

**Transmitter Path**

- Insertion Loss: 0.70 db
- VSWR: 1.30:1
- Center Frequency: 2275-2280 MHz
- Max 3 db Bandwidth: 45 MHz
- Min 3 db Bandwidth: 45 MHz
- Power Handling Capability: 20.0 Watts

**Miscellaneous**

- Dimensions: 2.5 x 2.5 x 6.88 inches
- Weight: 0.9 pounds

---

**Diplexer Filter**

**Minimum Rejection Requirements**

[Graph showing rejection requirements for transmitter and receiver channels.]

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7759-6120

7759-6121

11-61
ANTENNA DESCRIPTION

- FLAT "RIBBON-LIKE" COPPER CONDUCTOR WRAPPED AROUND FIBERGLASS-EPOXY TUBE
- 1 1/2 INCHES IN DIAMETER AND 23 INCHES LONG
- USES 5" GROUND PLANE WITH A 2" CYLINDRICAL SKIRT
- IMPEDANCE MATCHING TRANSFORMER AT ANTENNA FEED POINT MATCHES THE ANTENNA IMPEDANCE TO A 50 OHM COAXIAL LINE
- DESIGNED FOR EASY ATTACHMENT TO THE POINTING MECHANISM WITH "QUICK-CONNECT" SPRING LOADED DETENTS
- COATED WITH WHITE REFLECTING THERMAL PAINT
- WEIGHT - 1.28 POUNDS INCLUDING CONNECTOR AND CABLE

ANTENNA CHARACTERISTICS

<table>
<thead>
<tr>
<th></th>
<th>TRANSMIT</th>
<th>RECEIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SPEC</td>
<td>MEAS</td>
</tr>
<tr>
<td>GAIN ON BORESIGHT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEAMWIDTH AT 11.0 db GAIN</td>
<td>15.2 db</td>
<td>16.0 db</td>
</tr>
<tr>
<td>BEAMWIDTH AT 11.5 db GAIN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AXIAL RATIO</td>
<td>3 db</td>
<td>1.3 db</td>
</tr>
<tr>
<td>INPUT VSWR</td>
<td>1.25 : 1</td>
<td>1.20 : 1</td>
</tr>
<tr>
<td>SIDELOBE LEVEL</td>
<td>-10 db</td>
<td>-11 db</td>
</tr>
<tr>
<td>WEIGHT (ACTUAL)</td>
<td>1.28 lbs (including cable)</td>
<td></td>
</tr>
</tbody>
</table>
ANTENNA TEST

1. ANTENNA PATTERN THRU ANT CENTERLINE AND FEED TUBE (NOT SHOWN)
2. ANTENNA PATTERN THRU ANT CENTERLINE AND FEED TUBE (NOT SHOWN)

NOTE: COMPLETE INTERIOR COVERED WITH ABSORBER

ANTENNA PATTERN
(DOWNLINK)

FREQUENCY 2277.5 MHz
S/N 4
POSITION OF CONNECTOR

RELATIVE POWER ONE WAY (dB)

ANGLE

11-64
ANTENNA PATTERN
(UPLINK)

FREQUENCY 2119 MHz
S/N 4
POSITION OF CONNECTOR

RELATIVE POWER ONE WAY (dB)

ANGLER

7759-6118
POWER AMPLIFIER MODULE
BLOCK DIAGRAM

INPUT
10 mW
+ 28 V

PRE-AMPLIFIER
100 mW
190 MHz

DOUBLER STAGE
300 mW
380 MHz

DRIVER STAGE
1 W
380 MHz

FINAL POWER STAGE
3 W
380 MHz

OUTPUT

7759-6125
FREQUENCY MULTIPLIER MODULE
BLOCK DIAGRAM

INPUT 380 MHz

MATCHING NETWORK ➔ X3 FREQUENCY MULTIPLIER ➔ X2 FREQUENCY MULTIPLIER ➔ OUTPUT FILTER ➔ OUTPUT 2280 MHz
ALSEP REDUNDANT

90 CHANNEL MULTIPLEXER & A/D CONVERTER

SEQUENCER BOARD ASSEMBLY
ANALOG MULTIPLEXER/CONVERTER

THE COMPONENT —

• CONSISTS OF DUAL 90 CHANNEL ANALOG MULTIPLEXERS, SEQUENCERS, BUFFER AMPLIFIERS AND 8-BIT A/D CONVERTERS WITH BUFFERED OUTPUTS

• USES REDUNDANT GATES, SEQUENCERS AND A/D CONVERTERS FOR RELIABLE OPERATION

• MONITORS UP TO 90 DATA SOURCES ON A SEQUENTIAL SAMPLE BASIS. REQUIRES ABOUT 54 SECONDS FOR ONE COMPLETE SEQUENCE OF SAMPLES

• CONVERTS EACH INPUT INTO AN 8-BIT BINARY WORD

• PROVIDES THE 8-BIT BINARY WORD IN PARALLEL TO THE DIGITAL MULTIPLEXER OF THE DDP

7759-6105

ANALOG MULTIPLEXER/CONVERTER

PHYSICAL DESCRIPTION

SIZE 2.62 X 4.23 X 5.92 INCHES
WEIGHT 1.83 POUNDS
POWER REQUIRES A TOTAL OF 1435 MILLIWATTS (NOMINAL AT ROOM AMBIENT) AT THE FOLLOWING VOLTAGE LEVELS—
100 MILLIWATTS AT + 15 VDC
650 MILLIWATTS AT + 12 VDC
750 MILLIWATTS AT + 5 VDC
650 MILLIWATTS AT – 12 VDC
PACKAGING ALL PARTS ARE MOUNTED ON 11 TWO LAYER PCBs
CONNECTOR HUGHES - 244 PIN

7759-6106

11-77
SIMPLIFIED BLOCK DIAGRAM

A/D CONVERTER FUNCTIONAL BLOCK DIAGRAM
INPUT REQUIREMENTS

ANALOG INPUTS

<table>
<thead>
<tr>
<th>RANGE</th>
<th>0 TO +5 VOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT Z MEGOHM (ON STATE)</td>
<td>1 MEGOHM</td>
</tr>
<tr>
<td>SOURCE Z MEGOHMS (OFF STATE)</td>
<td>50 MEGOHMS</td>
</tr>
</tbody>
</table>

PROPER OPERATION WITH AN OVERVOLTAGE OF ±12 VOLTS ON ANY CHANNEL

ADVANCE PULSE

REQUIRED FOR ADVANCING MULTIPLEXER THROUGH ITS 90 CHANNELS
SUPPLIED BY DDP

ADC START (ENCODE) PULSE

DRIVES SYNC LOGIC TO START A/D CONVERSION. SUPPLIED BY DDP

7759-6111

ANALOG MULTIPLEXER/CONVERTER OUTPUTS

BINARY OUTPUT -

<table>
<thead>
<tr>
<th>BINARY OUTPUT</th>
<th>DESCRIPTION</th>
</tr>
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<tbody>
<tr>
<td>00000000</td>
<td>FOR A NEGATIVE INPUT</td>
</tr>
<tr>
<td>00000001</td>
<td>FOR ZERO INPUT</td>
</tr>
<tr>
<td>11111110</td>
<td>FOR +5 VOLTS INPUT</td>
</tr>
<tr>
<td>11111111</td>
<td>FOR GREATER THAN +5 VOLTS INPUT</td>
</tr>
</tbody>
</table>

LOGICAL "0" IS +4.0 ±1.5 VOLTS
LOGICAL "1" IS +0.2 ± 0.2 VOLTS

TEMPERATURE TELEMETRY

CHANNEL 33 AT-27 BASE TEMP
(SIGNAL OBTAINED BY A THERMISTOR)
RESISTOR NETWORK POWERED BY +12 VDC
THERMISTOR LOCATED ON BASE PLATE

CHANNEL 34 AT-28 INTERNAL TEMP
(SAME AS ABOVE EXCEPT THERMISTOR MOUNTED ON PCB)

7759-6112

11-79
ANALOG MULTIPLEXER CHANNEL ASSIGNMENTS

APPEARS IN WORD 33 ON ALSEP 1
ALSEP RESETTABLE SOLID STATE TIMER
ALSEP RESETTABLE SOLID STATE TIMER

Gulton Industries Inc.
DATA SYSTEMS DIVISION
ALBUQUERQUE, NEW MEXICO

RSS TIMER
MODEL
DST 230
DATE
6946

SERIAL
8204-001

FED. CODE IDENT. NO.
12574

CONTRACT NO.
SC-620

BENDIX PART NO.
2388511

NASA CONTRACT NO.
NAS 9-5829

SPECIMEN DATE

11-83

7758-6129
MAJOR DESIGN PARAMETERS–ALSEP
RESETTABLE SOLID STATE TIMER (RSST)

TIME-OUT PERIOD: 
3 MONTHS + 6 DAYS (NOMINAL) & IS COMMAND RESETTABLE TO EXTEND TIME-OUT BY ADDITIONAL 3 MONTH PERIODS

TIMING ACCURACY: 
± 5 PERCENT (± 5 DAYS)

OPERATING VOLTAGE: 
+ 10 TO + 14 VOLTS DC

CURRENT DRAIN: 
LESS THAN 20 MILLIAMPS STEADY STATE (100 MILLIAMPS PEAK)

SIZE AND WEIGHT: 
2.00” X 1.38” X 2.80” HEIGHT. LESS THAN 7 OUNCES

CONSTRUCTION: 
ALL SOLID STATE (EXCEPT RELAY) COUNTERS (REGISTERS) ARE RCA COS-MOS ALL OTHER ELECTRONIC PARTS ARE DISCRETE THREE 2” X 2.8” PRINTED CIRCUIT BOARDS USED UNIT IS REPAIRABLE

MAJOR RSST DESIGN PARAMETERS (CONT’)

ENVIRONMENTAL: 
OPERATES FROM -22°F TO +158°F @ SEA LEVEL TO 10^{12} mmHg. 20 G-PEAK SHOCK, 14 G ACCELERATION, 5.7 G-RMS RANDOM VIBRATION. COMPATIBLE WITH MIL-I-26600 AND MSC-ASPO-EMI-10A EMI REQUIREMENTS AND ALSEP POWER LINE RIPPLE AND TRANSIENT REQUIREMENTS.

RELIABILITY: 
PREDICTED PROBABILITY OF SUCCESS IS GREATER THAN .996 PER TWO YEAR OPERATION (ASSUMING RESET AT 3 MONTH INTERVALS). THE PROBABILITY OF AVOIDING AN EARLY TIME-OUT IS PREDICTED AT BETTER THAN .999 FOR TWO YEARS OF OPERATION.
KEY FUNCTIONS-ALSEP
RESETTABLE SOLID STATE TIMER (RSST)

- PROVIDES SPDT LATCHING RELAY CLOSURE AT 3 MONTH TIME-OUT TO DISABLE THE DATA TRANSMITTER (VIA PDU TRANSMITTER CONTROL). (COMMAND LINK BACKUP FUNCTION)

- PROVIDES 18 HOUR AND 1 MINUTE CALIBRATION AND UNCAGING PULSES FOR COMMAND LINK BACKUP.

- PROVIDES SHORT CIRCUIT FAILURE PROTECTION. (250 MILLIAMP AT WORST CASE FAILURE MODE)

KEY RSST FUNCTIONS (CONT')

- PROVIDES 30 SECOND POWER DROP OUT COUNTER PERIOD RETENTION

- PROVIDES LOW VOLTAGE AND SLOW POWER TURN-ON PROFILE FAIL-SAFE OPERATION (TIMER RESET WILL OCCUR PRIOR TO SPURIOUS TIME-OUT)

- HOUSEKEEPING TELEMETRY:
  A) 1.5 MONTH +3 DAYS ELAPSED TIME TELEMETRY (EACH COUNTER)
  B) 18 HOUR ELAPSED TIME TELEMETRY (TOGGLE)

- TEST: CAN BE OPERATED IN “SPEED-UP” MODE WITH AN EXTERNAL TEST SIGNAL TO BE TIMED-OUT IN 3 MINUTES IN ORDER TO FULLY TEST ALL FUNCTIONS. THE RELAY IS RESETTABLE FOR TEST PURPOSES
FUNCTIONAL BLOCK DIAGRAM-RSST
PCU POWER TRANSFORMER ASSEMBLY
POWER CONDITIONING UNIT

PHYSICAL DESCRIPTION

SIZE - 8.36 X 4.14 X 2.94 IN.
WEIGHT - 4.5 POUNDS


PARTS COUNT - TRANSISTORS 27 RELAY 1
          - DIODES 44 THERMISTORS 4
          - ZENER DIODES 4 INDUCTORS 11
          - CAPACITORS 71 TRANSFORMERS 8
          - RESISTORS 87

PACKAGING - SEVEN CORDWOOD MODULES ARE MOUNTED ON A 'MOTHER BOARD'. THERMAL REQUIREMENTS ARE MET BY USING MACHINED, GOLD-PLATED, MAGNESIUM CASES FOR THE MODULES.

CONNECTOR - HUGHES - 88 PIN 7759-6301
PCU FEATURES

* CONSISTS OF REDUNDANT POWER CONDITIONERS WITH BOTH AUTOMATIC AND COMMANDABLE SELECTION OF THE STANDBY SECTION. OVER/UNDER VOLTAGES ARE SENSED FOR AUTOMATIC SWITCHING FROM PCU#1 TO PCU#2.
* PROVIDES 6 REGULATED DC OUTPUT VOLTAGES WITH NOMINAL VALUES OF +29, +15, +12, +5, -6, AND -12 VOLTS.
* CONTAINS FILTERS TO LIMIT OUTPUT RIPPLE VOLTAGE TO BE APPROXIMATELY 150 MILLIVOLTS PEAK-TO-PEAK.
* OPERATES AT AN EFFICIENCY OF ABOUT 85% WITH A 48 WATT LOAD.

PCU FEATURES (CONT)

* HAS "HOLD-OFF" CIRCUIT ON PCU1 TO PREVENT STARTING UNTIL RTG POWER IS SUFFICIENT TO PERMIT PCU OPERATION WITH REGULATION.
* TO MAINTAIN THE RTG TEMPERATURE WITHIN SAFE LIMITS, THE PCU HOLDS THE RTG LOAD AT A (RELATIVELY) CONSTANT VALUE.
* PROVIDES TM SIGNALS FOR MONITORING RTG CURRENT, RTG VOLTAGE, SHUNT REGULATOR CURRENT AND TEMPERATURES.
* PROVIDES RESERVE POWER REFERENCE AND RESERVE POWER LEVEL SIGNALS TO RIPPLE-OFF CIRCUITS IN THE PDU.
TYPICAL RTG/PCU INTERFACE CHARACTERISTICS

SIMPLIFIED BLOCK DIAGRAM - PCU
**PCU 1 DIAGRAM**

1. REGULATOR RESISTOR - LOCATED ON EXTERIOR OF CENTRAL STATION
2. HOLD-OFF CIRCUIT ON PCU #1 ONLY. SWITCH IS ASTRONAUT SWITCH S-1
3. TYPICAL OF 6 Rectifier/Filter Circuit. Filter is common to both PCU #1 & PCU #2.

---

**PCU POWER/ THERMAL RELATIONSHIP**

- **Operating Range**
- **55 Watt Regulator**
- **Approximate**

---

7759-6311

11-95
### EPS DATA

<table>
<thead>
<tr>
<th>FROM RTG</th>
<th>FROM PCU</th>
<th>FROM PDU</th>
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</thead>
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<tr>
<td>AR-01 HOT FRAME 1 DEG F</td>
<td>AT-36 PCU 1 OSC DEG F</td>
<td>AE-07 PCU + 29V OUT</td>
</tr>
<tr>
<td>AR-02 HOT FRAME 2 DEG F</td>
<td>AT-37 PCU 2 OSC DEG F</td>
<td>AE-08 PCU + 15V OUT</td>
</tr>
<tr>
<td>AR-03 HOT FRAME 3 DEG F</td>
<td>AT-38 PCU 1 REG DEG F</td>
<td>AE-09 PCU + 12V OUT</td>
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<tr>
<td>AR-04 CLD FRAME 1 DEG F</td>
<td>AT-39 PCU 2 REG DEG F</td>
<td>AE-10 PCU + 5V OUT</td>
</tr>
<tr>
<td>AR-05 CLD FRAME 2 DEG F</td>
<td>AE-03 PCU IN VOLTS</td>
<td>AE-11 PCU - 12V OUT</td>
</tr>
<tr>
<td>AR-06 CLD FRAME 3 DEG F</td>
<td>AE-04 PCU IN AMPS</td>
<td>AE-12 PCU - 6V OUT</td>
</tr>
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</table>

### EPS COMMANDS

**OCTAL CMD NUMBERS**

**017 DISSIP R1 ON**

This cmd actuates relay K-16, in the PDU, to the position that applies +29 VDC to a 7-watt power dissipation resistor, and is used to optimize the load on the PCU.

**021 DISSIP R1 OFF**

This cmd actuates relay K-16, in the PDU, to the position that removes +29 VDC from the 7-watt power dissipation resistor.

**022 DISSIP R2 ON**

This cmd actuates relay K-17, in the PDU, to the position that applies +29 VDC to a 14-watt power dissipation resistor, and is used to optimize the load on the PCU.
EPS COMMANDS (CONT)

023 DISSIP R2 OFF

THIS CMD ACTUATES RELAY K-17, IN THE PDU, TO THE POSITION THAT REMOVES
+29 VDC FROM THE 14-WATT POWER DISSIPATION RESISTOR.

060 PCU 1 SEL

THIS CMD ACTUATES RELAY K-01, IN THE PCU, WHICH APPLIES +16 VDC FROM THE
RTG TO PCU 1 AND SIMULTANEOUSLY DEENERGIZES PCU 2. PCU 1 IS PRESET TO BE
ENERGIZED AT INITIAL LUNAR ACTIVATION. NOTE THAT THERE IS AN AUTOMATIC
SWITCH-OVER FEATURE TO PCU 2 IN THE EVENT THE +12 VDC BUS VARIES MORE
THAN + 1 VDC. ADDING OR REMOVING ELECTRICAL LOADS (VIA GROUND COMMANDS)
ON PCU 1 CAN PREVENT THE +12 VDC BUS FROM VARYING OUT OF LIMITS. IN THE
EVENT AUTOMATIC SWITCH-OVER TO PCU 2 HAS OCCURRED, THIS COMMAND MUST BE
FLAGGED AS HIGHLY CRITICAL, THE CAUSE OF THE SWITCH-OVER MUST BE DETERMINED
BEFORE THIS COMMAND IS EXECUTED.

7759-63078

EPS COMMANDS (CONT)

062 PCU 2 SEL

THIS CMD ACTUATES RELAY K-01, IN THE PCU, WHICH APPLIES +16 VDC FROM
THE RTG TO PCU 2 AND SIMULTANEOUSLY DEENERGIZES PCU 1. NOTE THAT
AT THE TIME OF LUNAR ACTIVATION, PCU 2 IS DEENERGIZED, WITH NO MEANS
TO DETERMINE ITS CONDITION. FURTHER NOTE THAT THERE IS NO AUTOMATIC
SWITCH-OVER FROM PCU 2 TO PCU 1. THIS SITUATION, THEREFORE, MAKES THIS
COMMAND HIGHLY CRITICAL. THIS COMMAND SHOULD BE EXECUTED ONLY AFTER
DETERMINING THAT PCU 1 IS ON THE VERGE OF FAILING.

7759-6307C

11-98
PCU DESIGN FEATURES

1. SHUNT REGULATOR
   - PROVIDES LOAD FOR RTG
   - ALL POWER IN THE REGULATOR IS AVAILABLE ON DEMAND

2. STORAGE TIME COMPENSATION
   - REDUCES LOSSES
   - REDUCES RIPPLE
   - REDUCES FILTER SIZE

3. HIGH FREQUENCY OSCILLATION
   - REDUCES SIZE AND WEIGHT

PCU DESIGN FEATURES
(CONT’)

4. AUTOTRANSFORMER FOR +29 VOLT LINE
   - IMPROVES EFFICIENCY AND REDUCES SIZE AND WEIGHT
   - COMPARED TO CONVENTIONAL ISOLATION TRANSFORMER DESIGN (NET IMPROVEMENT; 1.0 LBS AND 2.5 WATTS FOR ALSEP PCU)
   - IMPOSES CONSTRAINTS TO THE DESIGN
     a. ISOLATION IMPOSSIBLE
     b. POSITIVE VOLTAGE MUST BE GREATER THAN THE INPUT VOLTAGE, ASSUMING A BALANCED OUTPUT
     c. NEGATIVE VOLTAGE RESULTS IN A DISADVANTAGE
     d. MAX ADVANTAGE AT INPUT VOLTAGE · DIMinishes AS OUTPUT VOLTAGE INCREASES

7759-6326

11-99
PCU—COMPARISON OF AUTOTRANSFORMER AND ISOLATION TRANSFORMER DESIGN
{OUTPUT POWER IDENTICAL}

- AUTOTRANSFORMER DESIGN
  - INPUT POWER: 64.0 WATTS
  - WATT LOSS: 7.7 WATTS
  - EFFICIENCY: 88%
  - WEIGHT: 0.25 LBS
  - EQUIVALENT TO ALL OTHER OUTPUT CIRCUITS

- ISOLATION TRANSFORMER DESIGN
  - INPUT POWER: 66.5 WATTS
  - WATT LOSS: 10.2 WATTS
  - EFFICIENCY: 85%
  - WEIGHT: 6.05 LBS

SHORTING PLUG SCHEMATIC – FLIGHT 1

11-100
RTG SHORTING PLUG INSTALLED IN CENTRAL STATION
PDM - SCHEMATIC

MANGANIN WIRE

47, 48
4.37Ω
.3Ω
1, 2

51, 52
4.37Ω
.3Ω
5, 6

49, 90
.3Ω
7, 8

SHUNT REGULATOR NO. 1
RESISTORS

7759-6319

PDJ
PCU CONNECTOR

123Ω
.3Ω
9

132Ω
10, 12

PDJ
PDU CONNECTOR

125Ω
.3Ω
11

143Ω
4Ω

PDR NO. 1
(7 WATTS)

PDR NO. 2
(14 WATTS)
Section 12

Alsep Test Program
ALSEP TEST PROGRAM

ALSEP TEST PROGRAM - THREE PHASES

1. ENGINEERING EVALUATION - ENGINEERING, PROTOTYPE TESTS
2. FORMAL SYSTEM PERFORMANCE VERIFICATION TESTS - QUALIFICATION TESTS
3. FORMAL SYSTEM ACCEPTANCE TESTING - FLIGHT ACCEPTANCE TESTS

TEST SCHEDULE

<table>
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</tbody>
</table>

7759-6400

12-1
ALSEP TEST PROGRAM

ENGINEERING EVALUATION TESTS
1) PART - DEVICE TESTS
2) CENTRAL STATION COMPONENT - PCU, PDU, DP, CD, ETC.
   • BREADBOARD
   • BRASSBOARD
   • ENGINEERING MODEL
   • PROTOTYPE
3) EXPERIMENT
   • DEVELOPMENT - BREADBOARD, STRUCTURAL/ THERMAL
   • ENGINEERING MODEL - DVT
   • PROTOTYPE
4) SYSTEM LEVEL TESTS
   • ENGINEERING STRUCTURAL/THERMAL MODELS
   • ENGINEERING MODEL
   • PROTOTYPE MODEL
     - PROTO G
     - PROTO A
     - PROTO B
     - PROTO C

ALSEP TEST PROGRAM

SYSTEM PERFORMANCE VERIFICATION TESTS - QUALIFICATION
1) CENTRAL STATION COMPONENT
   • PRE-INTEGRATION ACCEPTANCE (PIA) TESTS
2) EXPERIMENTS
   • PRE-INTEGRATION ACCEPTANCE (PIA) TESTS
3) CENTRAL STATION
   • CENTRAL STATION INTEGRATION
   • CENTRAL STATION VERIFICATION
4) SYSTEM
   • EXPERIMENT INTEGRATION TESTS (EIT)
   • ACCEPTANCE TESTS
   • DESIGN LIMIT TESTS
   • MISSION SIMULATION TESTS
5) QUALIFICATION MODELS
   • QUAL SA
   • QUAL B
   • QUAL C
   • EASEP - LRRR AND PSEP

7759-6402
7756-6403
ALSEP TEST PROGRAM

SYSTEM ACCEPTANCE TESTS - FLIGHT ACCEPTANCE TESTS
1) CENTRAL STATION COMPONENTS
   • COMPONENT PIA
2) EXPERIMENTS
   • EXPERIMENT PIA
3) CENTRAL STATION
   • CENTRAL STATION INTEGRATION
   • CENTRAL STATION VERIFICATION
4) SYSTEM
   • EXPERIMENT INTEGRATION TESTS (EIT)
   • FLIGHT ACCEPTANCE TESTS
5) FLIGHT MODELS
   • FLIGHTS 1, 2, 3, AND 4
   • FLIGHT A-2
   • EASEP · LRRR AND PSEP

ALSEP TEST PROGRAM

COMPONENT QUALIFICATION TESTS · NEW A-2, D COMPONENTS
• TIMER, RSST
• MULTIPLEXER
• TRANSMITTERS
• RECEIVER
COMPONENT LEVEL TESTING
• BREADBOARD · BRASSBOARD
• ENGINEERING MODEL · DVT
• PROTOTYPE
• QUALIFICATION
• FLIGHT
COMPONENT FLIGHT SPARE TESTING
• ACCEPTANCE
  • FUNCTIONAL
  • VIBRATION
  • -22°F TO 158°F FUNCTIONAL

7759-6405
## ALSEP Test Program

### Typical Acceptance Test Schedule

<table>
<thead>
<tr>
<th>MONTHS</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
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<tr>
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</table>

- Ant. VSWR
- C/S Power Diss.
- RTG Leak
- EMI
- Mass Properties
- Vibration SP 1 & 2
- Modified 1st
- Magnetic Properties
- Tumble Test SP 1 & 2
- Boyd Bolt Verification
- Antenna Aiming Mechanism Functional
- Thermal-Vacuum
- RTG Beam
- Ant VSWR
- Ant Radiated Pwr
- Modified 1st

### ALSEP Test Program

### Typical Qualification (Design Limit) Test Schedule

<table>
<thead>
<tr>
<th>MONTHS</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
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- D.L. Vibration SP 1 & 2
- Modified 1st
- Shock SP 1 & 2
- Modified 1st
- Acceleration SP 1 & 2
- RTG LEAR
- Modified 1st
- Boyd Bolt Verification
- Mission Simulation T/V
- RTG LEAR
- Antenna VSWR
- Antenna Aiming Mech. Funct

7759-6407.
### ASLEP TEST PROGRAM

**TEST PROGRAM DOCUMENTATION**

1. **TEST PROCEDURES**
   - All dual and flight procedures are Type I documents
   - All engineering and prototype procedures are Type II documents

2. **Pre and Post Test Meetings**
   - Each test

3. **O Orr and OAR for Qualification**

4. **FTTR and CARR for Each Flight Model**

5. **Discrepancy Reports, Failure Reports, Failure Analysis Reports**

6. **Test Reports**
   - **FLIGHT**
     - Pre and Post Test Meeting Minutes, AS Run Test Procedures, Discrepancy Reports
   - **QUAL**
     - Same as Flight plus Engineering Analysis

---

### ASLEP CASK ASSEMBLY TEST PROGRAM MATRIX

<table>
<thead>
<tr>
<th>Acceptance</th>
<th>Flight Qualification</th>
<th>Flight 1</th>
<th>Flight 2</th>
<th>Flight 3</th>
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**QUALIFICATION**

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<td>SLA Off Solar Sim</td>
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7759-6408

7759-6432

12-5
ALSEP TEST PROGRAM

CENTRAL STATION POWER DISSIPATION

- OBJECTIVE
  - OBTAIN CENTRAL STATION POWER CHARACTERIZATION

- TEST ITEM
  - CENTRAL STATION

- TEST METHOD
  - CENTRAL STATION POWER CONSUMPTION UNDER VARIABLE LOADS
  - CALIBRATE HK-1 AGAINST ACTUAL INPUT VOLTAGE
  - CALIBRATE HK-5 AGAINST ACTUAL INPUT CURRENT
  - DETERMINE RANGE OF SHUNT REGULATORS IN PCU'S
  - CALIBRATE HK-8 AND HK-13 AGAINST ACTUAL SHUNT REGULATOR CURRENTS
  - MEASURE COMMANDABLE HEATER POWER AND PDM POWER
  - VERIFY RIPPLE OFF CIRCUITRY

ALSEP TEST PROGRAM

AMBIENT 1ST

- OBJECTIVES
  ASSURE CORRECT FUNCTIONAL PERFORMANCE OF ALSEP AS A SYSTEM:
  CENTRAL STATION, ALL EXPERIMENTS AND RTG
  OBTAIN A BASELINE SYSTEM TEST PRIOR TO SUBSEQUENT
  ENVIRONMENTAL TESTS

- TEST ITEM
  ALSEP CENTRAL STATION, ALL EXPERIMENTS, RTG

- TEST METHOD
  DRIVE RTG WITH EFC; VERIFY POWER OUTPUT CHARACTERISTICS
  TURN ON CENTRAL STATION, VERIFY PROPER OPERATION AND STATUS
  TURN ON EXPERIMENTS, VERIFY RESPONSE TO COMMANDS AND
  CORRECT FUNCTION OF EACH EXPERIMENT PRIOR TO TURN ON
  OF ADDITIONAL EXPERIMENTS
  WITH EXPERIMENTS ON, SEND ALL COMMANDS, VERIFY CORRECT
  CENTRAL STATION AND EXPERIMENT OPERATION

12-6
ALSEP TEST PROGRAM

SYSTEM EMI

- OBJECTIVE
  - ASSURE ALSEP COMPLIANCE WITH RADIATED AND CONDUCTED SUSCEPTIBILITY AND INTERFERENCE

- TEST ITEM
  - DEPLOYED ALSEP SYSTEM WITH EXPERIMENTS

- TEST METHOD
  - CONDUCTED INTERFERENCE, 15 KHz TO 25 MHz
  - CONDUCTED SUSCEPTIBILITY, 50 Hz TO 250 MHz
  - RADIATED INTERFERENCE, 150 KHz TO 10 GC
  - RADIATED SUSCEPTIBILITY, 15 KHz TO 10 GC
  - TRANSIENT CONDUCTED 7.5 V, 10μSEC, PULSES
  - RECEIVER REJECTION, 150 KHz TO 10 GHz

ALSEP TEST PROGRAM

SYSTEM STRAY FIELD MAGNETIC PROPERTIES

- OBJECTIVE
  - ESTABLISH THAT MAGNETIC FIELDS PRODUCED BY ALSEP WILL BE < 0.25 GAMMA AT THE LOCATION OF LSM

- TEST ITEM
  - DEPLOYED ALSEP SYSTEM

- REQUIREMENT
  - < 0.25 GAMMA AT LSM, NORMALLY DEPLOYED (50 FEET)
  - < 10 GAMMA AT 10 FEET, AS TESTED

- TEST METHOD
  - CENTRAL STATION, SWG, SIDE, PSE SETUP IN CHAMBER PER EMI TEST LAYOUT, TEST MAGNETOMETER PROBE AT LSM POSITION (10 FEET FROM CENTRAL STATION)
  - X, Y, Z STRAY FIELDS MEASURED WITH CENTRAL STATION ON, EXPERIMENTS IN STANDBY, EXPERIMENTS TURNED ON IN SEQUENCE
  - CHAMBER FACILITY CALIBRATED (EMPTY) WITH TEST MAGNETOMETER PROBE TO ADJUST FOR DISTORTION PRODUCED BY CHAMBER
ALSEP TEST PROGRAM

STOWED MAGNETIC PROPERTIES

- OBJECTIVE
  - DETERMINE THE PERMANENT AND REMANENT MAGNETIC FIELDS OF ALSEP

- TEST ITEM
  - SUBPACKAGES 1 AND 2 STOWED

- TEST REQUIREMENTS
  - PERMANENT FIELD AT 10 FEET < 10 GAMMA
  - REMANENT FIELD AT 10 FEET < 50 GAMMA

- TEST METHOD
  - SUBPACKAGE IN HELMHOLTZ COIL
  - DEGAUSS
  - MEASURE PERMANENT FIELD AT 10 FEET, S/P ROTATED IN EACH AXIS
  - STANDARDIZE: APPLY 20 GAUSS D.C. FIELD, EACH AXIS IN TURN
  - MEASURE REMANENT FIELD AT 10 FEET, S/P ROTATED IN EACH AXIS
  - DEGAUSS
  - RE-MEASURE PERMANENT FIELD AT 10 FEET

VIBRATION TEST

- OBJECTIVE
  - VERIFY ABILITY OF SUBPACKAGES TO WITHSTAND ACCEPTANCE LEVEL VIBRATIONS

- TEST ITEM
  - SUBPACKAGES 1 AND 2

- TEST METHOD
  - ONE SINE AND TWO RANDOM VIBRATIONS IN EACH OF THE THREE PRINCIPAL ALSEP AXES
  - VISUAL MONITORING DURING TEST AND INSPECTION AT TEST COMPLETION
  - EACH SUBPACKAGE VIBRATED SEPARATELY WHILE NON-OPERATING
  - ACCEPTANCE LEVELS ARE AT ANTICIPATED FLIGHT INDUCED, QUAL LEVELS ARE 1.3 TIMES HIGHER THAN ACCEPTANCE FOR SINE AND (1.3)^2 TIMES HIGHER FOR RANDOM

7759-6413

7759-6414
ALSEP TEST PROGRAM
(ALSEP SUBPACKAGES)

PEAK ACCELERATION (g)

FREQUENCY (CPS)

ALSEP TEST PROGRAM
(ALSEP SUBPACKAGES)

L & B X-AXIS (SP-1&2)

FREQUENCY (CPS)

L & B Y-AXIS (SP-1&2)

FREQUENCY (CPS)

L & B Z-AXIS (SP-1&2)

FREQUENCY (CPS)

LUNAR DESCENT X, Y, Z AXES (SP-1&2)

FREQUENCY (CPS)

7759-6415

7759-6416
ALSEP TEST PROGRAM

SHOCK TEST (QUAL ONLY)

● OBJECTIVE
  - VERIFY ABILITY OF SUBPACKAGES TO WITHSTAND QUAL LEVEL SHOCK

● TEST ITEM
  - SUBPACKAGES 1 AND 2

● TEST METHOD
  - 3 SAWTOOTH SHOCK PULSES IN EACH OF THE +X, +Y, +Z ALSEP AXES
  - SHOCK PULSES ARE 15 G, 11 MILLISECONDS, SAWTOOTH PULSES
    PER MIL-STD-810B
  - EACH SUBPACKAGE TESTED SEPARATELY WHILE NON-OPERATING

7759-6417

ALSEP TEST PROGRAM

ACCELERATION TEST (QUAL ONLY)

● OBJECTIVE
  - VERIFY ABILITY OF SUBPACKAGES TO WITHSTAND QUAL LEVEL ACCELERATION

● TEST ITEM
  - SUBPACKAGES 1 AND 2

● TEST METHOD
  - 14 G ACCELERATION FOR ONE MINUTE IN +X ALSEP AXIS
  - EACH SUBPACKAGE TESTED SEPARATELY WHILE NON-OPERATING

7759-6418

12-10
ALSEP TEST PROGRAM

THERMAL VACUUM TEST

- OBJECTIVE
  - TO VERIFY SYSTEM START UP AND OPERATION UNDER SIMULATED LUNAR VACUUM AND TEMPERATURE CONDITIONS

- TEST ITEM
  - DEPLOYED ALSEP SYSTEM WITH RTG

TEST SEQUENCE

- OPEN DOOR 1ST
- LUNAR MORNING 1ST*
- LUNAR NOON 1ST*
- CROSSTALK TEST*
- LUNAR NIGHT 1ST*
- OPEN DOOR 1ST

*10^{-5} TORR

7759-6419
ALSEP FLIGHT 4 DEPLOYED IN THERMAL VACUUM CHAMBER
Section 13

Alsep Test Equipment
ALSEP TEST EQUIPMENT REQUIREMENTS

1. CENTRAL STATION
   MODULES
   COMPONENTS
   DATA SUBSYSTEM

2. EXPERIMENTS

3. SYSTEM

ACCEPTANCE TEST FLOW SUMMARY

COMPONENT TEST → CENTRAL STATION INTEGRATION → SYSTEM INTEGRATION TESTING → SYSTEM PERFORMANCE TESTS

SUBSYSTEM ENVIRONMENTAL TESTS → SUBSYSTEM PERFORMANCE TESTS → VENDOR ACCEPTANCE TESTS → PREINTEGRATION TESTS (PIA)

AT VENDOR'S FACILITY → AT BENDIX

7759-6501
TYPICAL IN-HOUSE COMPONENT
FLOW DIAGRAM

INDIVIDUAL BOARD CHECKOUT → CHECKOUT OF ALL BOARDS WITH MOTHERBOARD → HOT (+150°F) COLD (-22°F) TEST

COMPLETE ASSEMBLY OF COMPONENT → PREINSTALLATION ACCEPTANCE (P/A) TEST HOT-COLD-AMBIENT → TO DSS INTEGRATION

7769-6502
SYSTEM TEST SET CAPABILITIES

1. UPLINK SIGNAL GENERATION
2. DOWNLINK SIGNAL RECEPTION
3. DOWNLINK SIGNAL RECORDING
4. DOWNLINK SIGNAL PROCESSING
   DECOMMUTATION
   LIMIT CHECKING
   D/A CONVERSION
5. DISPLAYS
   POWER/FREQUENCY
   PRINTER
6. C/S INTERFACE DIGITAL & ANALOG SIMULATION
   LOADS
   VOLTAGE/CURRENT
   PULSE CHARACTERISTICS
   SIGNAL CONDITIONING
   EXPERIMENT DATA SIMULATION

7759-6515

SYSTEM TEST SET BLOCK DIAGRAM
ALSEP SYSTEM TEST
SET-PROGRAMMER PROCESSOR
STS PROGRAMMER PROCESSOR BLOCK DIAGRAM

PAPER TAPE READER

A-D CONVERTER

STRIP CHART RECORDER

TELETYPE

COMPUTER

4K X36 BIT WORD 2µS

PRINT COMMAND TRANSMISSION AND VERIFICATION

PRINT STATION IDENT, MODE, TIME & PROCESSOR STATUS

STS PROGRAMMER PROCESSOR MAIN SOFTWARE

PROGRAMS:

EXECUTIVE
DECOMMUTATION
LIMIT TABLE OVERLAY (CMALT)

FUNCTIONS:

MACHINE CONTROL
DECOMMUTATION OF MAIN FRAME & HOUSEKEEPING INCLUDING PSE DATA
LIMIT CHECKING
CONVERTS SEISMIC DATA FOR ANALOG RECORDING
PRINT HK DATA ON OT OR CHANGE FLAG CONDITIONS
CONTINUOUS PRINT AVAILABLE ON DEMAND

PRINT STATION IDENT, MODE, TIME & PROCESSOR STATUS
STS PROGRAMMER PROCESSOR
EXPERIMENT SOFTWARE

PROGRAMS:
- FIXED BASIC ROUTINE
- VARIABLE LIMIT TABLE OVERLAY
- TEMPERATURE MONITORS
- SPECIAL ROUTINES
- ASE PROGRAM

FUNCTIONS:
- SUBFRAME DECOMMUTATION
- COMMAND TRACKING
- AUTOMATIC COMMAND SEQUENCING - SWS
- PRINT EXPERIMENT DATA FORMAT ON CHANGE OR OT FLAG
  CONTINUOUS PRINT AVAILABLE ON DEMAND
- DATA ANALYSIS - SWE DATA AVERAGING
  HFE - GAIN, OFFSET & DIFFERENCE RATIO
  CALCULATIONS
- LOG DECOMPRESSION FOR ASE SEISMIC DATA

7759-0522
RTG SIMULATOR BLOCK DIAGRAM

POWER SUPPLY → SOURCE IMPEDANCE SIMULATION → OUTPUT

→ METERING CIRCUITS

RTD SIMULATOR

→ PDM SIMULATOR

7759-6524
Section 14

Alsep Reliability
ALSEP RELIABILITY REQUIREMENTS

- CAPABLE OF OPERATING FOR AN EXTENDED PERIOD OF TIME IN A HOSTILE LUNAR ENVIRONMENT
- EACH EXPERIMENT & MAJOR SUBSYSTEM HAS A RELIABILITY GOAL OF (.99), FOR 1 YEAR OF OPERATION
- ALSEP SYSTEM MUST HAVE MAXIMUM RESISTANCE TO SINGLE POINT FAILURE SOURCES
- FAILURE SHALL NOT PROPAGATE THROUGHOUT THE SYSTEM

RELIABILITY PROGRAM

- DEVELOP A RELIABILITY PROGRAM PLAN BASED ON NPC 250-1
- DEVELOP RELIABILITY GUIDELINES FOR SUB-CONTRACTORS
KEY RELIABILITY FUNCTIONS

- RELIABILITY PROGRAM MANAGEMENT
- SUBCONTRACTOR & SUPPLIER CONTROL
- RELIABILITY PREDICTIONS
- FAILURE MODES EFFECTS & CRITICALITY ANALYSES
- DESIGN REVIEW & CHANGE REVIEW
- PARTS & MATERIALS
- FAILURE REPORTING, FAILURE ANALYSIS & CORRECTION ACTION
- TEST EVALUATION
- SPECIFICATION, DRAWING, AND PROCEDURE REVIEW & APPROVAL
- DOCUMENTATION

SYSTEM RELIABILITY APPROACH

- ANALYZE SYSTEM DESIGN CONSTRAINTS
- ANALYZE ARRAY CONFIGURATION
- IDENTIFY INCOMPATIBILITIES BETWEEN SYSTEM RELIABILITY & PROPOSED ARRAYS EMPLOYING MATH MODELING & PREDICTION TECHNIQUES
- PERFORM TRADEOFF ANALYSES FOR DESIGN RELIABILITY OPTIMIZATION WITHIN PROGRAM CONSTRAINTS
CENTRAL STATION UPLINK ELECTRONICS SIMPLIFIED RELIABILITY BLOCK DIAGRAM

COMMAND RECEIVER

DIPLEXER FILTER

I.O. OSC

I.F. STAGES

DEMODULATOR

COMMAND RECVER

LEGEND

ELEMENT IN STANDBY

ARRAY IN CONFIGURATION

COMMAND DECODER

DIGITAL DECODER

DIGITAL DECODER

COMMAND DECODE GATES

COMMAND RECEIVER

AUTOMATIC BACKUP SEQUENCER

7759-6604

DOWNLINK ELECTRONICS RELIABILITY FEATURES

- FULL REDUNDANCY FOR EXPERIMENT SCIENCE DATA HANDLING
- TRANSMITTER IS STANDBY REDUNDANT W/AUTOMATIC AND COMMANDABLE SWITCHOVER CAPABILITY
- DATA PROCESSOR, STANDBY REDUNDANT
- MULTIPLEXER PARTIALLY REDUNDANT FOR CRITICAL HOUSEKEEPING STATUS DATA
- REDUNDANT A/D CONVERTERS
- COMPLETE MULTIPLEXER REDUNDANCY FOR ARRAY A 2 & D

7759-6605
POWER SUBSYSTEM

- POWER CONDITIONING UNIT, STANDBY REDUNDANT WITH AUTOMATIC AND COMMANDABLE SWITCHOVER CAPABILITY
- POWER DISTRIBUTION UNIT, SELECTED PIECE-PART REDUNDANCY TO PRECLUDE SINGLE POINT FAILURE SOURCES
- RTG HAS LATTICE NETWORK REDUNDANCY
FAILURE MODES, EFFECT, AND CRITICALITY ANALYSES

- IDENTIFY ALL SINGLE POINT FAILURES
- ELIMINATE OR REDUCE SINGLE POINT FAILURES
- DESIGN TO MINIMIZE THE RISK OF SINGLE POINT FAILURES (I.E., LOW PROBABILITY OF OCCURRENCE)
- EVALUATE CRITICALITY OF ALL FAILURE MODES TO ESTABLISH PRIORITY FOR RELIABILITY ENHANCEMENT (I.E., REDUNDANCY SIMPLIFICATION, STRESS DERATING, ADDITIONAL PROCESS CONTROL)

SUBCONTRACTOR CONTROL

- REVIEW & APPROVE SUBCONTRACTOR RELIABILITY PROGRAM PLAN
- MAINTAIN SUBCONTRACTOR RELIABILITY LIAISON
- PROVIDE TECHNICAL DIRECTION ON ALL RELIABILITY ACTIVITIES
- REVIEW & APPROVE ALL PARTS & MATERIALS SELECTED
- CONDUCT PERIODIC RELIABILITY PROGRAM REVIEWS
- REVIEW & APPROVE FAILURE ANALYSIS REPORTS
ALSEP FAILURE REPORTING & CORRECTIVE ACTION SYSTEM

RELIABILITY REVIEW OF ALL DR's
→ INVESTIGATE ALL POTENTIAL FAILURES
→ IDENTIFY FR REQUIREMENTS ON DR's
→ TWX FAILURE NOTIFICATION TO MSC

PREPARE FAILURE REPORT
→ PARTICIPATE IN TEST ARTICLES TROUBLESHOOTING
→ LABORATORY DIAGNOSIS OF FAILED PART(S)
→ INITIATE CORRECTIVE ACTION(S)

COMPLETE FAILURE ANALYSIS REPORT
→ SUBMIT FARS TO MSC FOR CLOSEOUT
→ CLOSEOUT FARS VIA MSC LETTER
→ MAINTAIN & DISTRIBUTE FR MONTHLY STATUS

PARTS AND MATERIALS PROGRAM

- DEVELOP AND PUBLISH AN APPROVED PARTS AND MATERIALS LIST FOR ALSEP USAGE
- ESTABLISH PART SELECTION PREFERENCE AND HI-REL REQUIREMENTS
- SELECT PARTS

7759-6610

7759-6611

14-6
PARTS AND MATERIALS PROGRAM (CONT')

- PREPARE SPECIFICATION CONTROL DRAWINGS
- PARTICIPATE IN FAILURE ANALYSIS ACTIVITIES
- CONDUCT PART EVALUATION TESTS
- APPROVE SUBCONTRACTOR PARTS AND MATERIALS SELECTIONS
- CONDUCT SCREENING AND BURN-IN

HOW HIGH IS "HI-REL"

- NASA/APOLLO AND MINUTEMAN
- NASA/MSFC, JPL
- MIL-ER AND MIL-TX SERIES
- INDUSTRY HI-REL (MEG-A-LIFE, SURE, ETC)
- MIL SPEC AND BURN IN
- NON-MIL SPEC AND BURN IN AND LOT ACCEPTANCE.

7759-6613
PARTS SELECTION FLOW

- PART FUNCTIONAL REQUIREMENT
- APPROVED PARTS LIST
- PARTS LIST
- IDEP APMML BILL OF MAT'L
- NON-MIL-SPEC PART + SCREENING + LOT ACC TESTS
- RESPECIFY REQUIREMENT
- YES
- NO

PARTS APPLICATION ANALYSES

- COMPUTERIZED (ECAP) CIRCUIT ANALYSES
- PART DERATING
  - CAPACITORS-ELECTROLYTIC 60% VOLT
  - RESISTORS 50% POWER
  - SEMICONDUCTORS 50% VOLTAGE 50% CURRENT
  - TJ = 140°C MAX
  - TRANSFORMERS, & COILS 15°C RISE
TYPES OF PARTS TESTS

1. QUALIFICATION
   2. LOT ACCEPTANCE
      GROUP "A"
      100% - FUNCTIONAL
      & ENVIRONMENTAL
      (NON-DESTRUCTIVE)
      GROUP "B"
      SAMPLE
      MECHANICAL
      ENVIRONMENTAL
      GROUP "C"
      SAMPLE
      LIFE
      GROUP "B"

7759-6616

TYPES OF PARTS TESTS (CONT')

1. SCREENING & BURN IN
   100%
   EXERCISE RATED STRESSES
   TIME COMPATIBLE WITH INFANT MORTALITY
   DELTA LIMITS
   LOT REJECTION CRITERIA

7759-6617

14-9
% "HI-REL" PARTS IN CENTRAL STATION

<table>
<thead>
<tr>
<th>CAT</th>
<th>QTY</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>270</td>
<td>8.9</td>
</tr>
<tr>
<td>2</td>
<td>147</td>
<td>4.8</td>
</tr>
<tr>
<td>3</td>
<td>1071</td>
<td>35.2</td>
</tr>
<tr>
<td>4</td>
<td>1153</td>
<td>37.9</td>
</tr>
<tr>
<td>5</td>
<td>244</td>
<td>8.0</td>
</tr>
<tr>
<td>6</td>
<td>159</td>
<td>6.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3044</td>
<td>100.0</td>
</tr>
</tbody>
</table>

7759-6618

SIGNIFICANT DESIGN IMPROVEMENTS

1. MULTIPLEXER
   REPLACED EPOXY SEMICONDUCTORS WITH HERMETIC-SEALED DEVICES.
   REDESIGNED MULTIPLEXER WITH MOS FETS, COMPLETELY REDUNDANT (A2 ALSEP)
   REDESIGNED A/D CONVERTER.
   INTEGRATED SYSTEM (ARRAY D)

2. RECEIVER, COMPLETELY REDUNDANT (ARRAY D)

3. SOLID STATE TIMER (A2 & ARRAY D)  

7759-6619

14-10
SOLID STATE TIMER

- RELIABILITY - 99% FOR 2-YEAR OPERATION
- DESIGNED TO PREVENT PREMATURE SYSTEM SHUTDOWN
- REDUNDANT THREE-MONTH COUNTERS
- POWER INTERRUPT CAPABILITY FOR 2 MINUTES WITHOUT resetting COUNTERS

A-2 MULTIPLEXER PART COUNT

<table>
<thead>
<tr>
<th>PART TYPE</th>
<th>OLD DESIGN</th>
<th>A-2 DESIGN</th>
<th>PERCENT PART REDUCTION CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-FET</td>
<td>160</td>
<td>...</td>
<td>-NA-</td>
</tr>
<tr>
<td>MOS-FET</td>
<td>...</td>
<td>17</td>
<td>-NA-</td>
</tr>
<tr>
<td>MOS INTEGRATED CIRCUIT</td>
<td>...</td>
<td>8</td>
<td>-NA-</td>
</tr>
<tr>
<td>BIPOLAR INTEG CCT</td>
<td>22</td>
<td>...</td>
<td>-NA-</td>
</tr>
<tr>
<td>TRANSISTORS</td>
<td>191</td>
<td>4</td>
<td>98%</td>
</tr>
<tr>
<td>DIODES</td>
<td>326</td>
<td>4</td>
<td>99%</td>
</tr>
<tr>
<td>CAPACITORS</td>
<td>163</td>
<td>2</td>
<td>99%</td>
</tr>
<tr>
<td>RESISTORS</td>
<td>33</td>
<td>33</td>
<td>0%</td>
</tr>
<tr>
<td>THERMISTOR</td>
<td>1</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>896</strong></td>
<td><strong>69</strong></td>
<td><strong>&gt;92%</strong></td>
</tr>
</tbody>
</table>
## Parts Reliability Improvements

### Items

<table>
<thead>
<tr>
<th>TYPE 2N4012 TRANSISTORS, TRANSMITTER POWER AMPLIFIER</th>
<th>Problems and Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential internal wiring defects</td>
<td></td>
</tr>
<tr>
<td>Eliminated by alternate source equivalent type, qualified for ALSEP application</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dual Transistor Flatpacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential internal wiring defects</td>
</tr>
<tr>
<td>Per NASA alert. ALSEP parts returned to vendor for X-ray screening prior to flight use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Magnetic Latching Relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose getter particles cited per NASA alert. Bendix &quot;new technology&quot; techniques developed to remove suspect units</td>
</tr>
</tbody>
</table>

### Items

<table>
<thead>
<tr>
<th>Circuit Breaker Relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscillating modes during slow rise loading corrected by adding backup overload relay to eliminate &quot;cut-throat&quot; design</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>FET Semiconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature turn off problem at low temperature in MUX gate circuits corrected by selection of FET for pinch off voltages unique to ALSEP application</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operational Amplifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degradation of A702A OP AMP in CPLEE traced to high level transients. Eliminated by current limiting resistors</td>
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### Parts Reliability Improvements (cont')

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</tr>
</tbody>
</table>

---

7759-6622

---

7759-6623

---

14-12
<table>
<thead>
<tr>
<th>ITEMS</th>
<th>PROBLEMS AND SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINTED CIRCUIT BOARDS</td>
<td>MOUNTING OF LOGIC BOARDS IN CPLEE MODIFIED TO ELIMINATE BOWING AND STRESS ON SOLDERED CONNECTIONS</td>
</tr>
<tr>
<td>M1000-10172 THERMOSTATS</td>
<td>BXA EVALUATION TESTS TO VERIFY CONTACT RESISTANCE DEGRADATION CITED BY NASA ALERTS. GOLD CONTACTS AND STABILITY SCREENING TESTS IMPLEMENTED ON PARTS PRIOR TO FLIGHT USE</td>
</tr>
<tr>
<td>2N2222/ML 3C TRANSISTORS</td>
<td>MARGINAL INTERNAL WIRING CONDITIONS CITED BY NASA ALERT. ALSEP PROCUREMENT CHANGED TO ELIMINATE USE OF PARTS FROM SUSPECT SUPPLIER</td>
</tr>
<tr>
<td>OPERATIONAL</td>
<td>MOISTURE SUSCEPTIBILITY OF $\mu$709 TYPES CITED BY NASA ALERT. ALSEP PROCUREMENT CHANGED TO $\mu$741 TYPE RECOMMENDED BY ALERT.</td>
</tr>
</tbody>
</table>
RELIABILITY OF ALSEP UPLINK & DOWNLINK ARRAY A, B, & C

PROBABILITY OF SUCCESSFULLY RECEIVING CFE EXPERIMENT DATA
Section 15

Dust Detector Experiment
DUST DETECTOR EXPERIMENT HISTORY

SEP 65  DR. B.J. O'BRIEN PROPOSAL
         (ACCEPTED AS ALSEP HOUSEKEEPING)
         3 RADIATION-RESISTANT SOLAR CELLS
         AND 3 THERMISTORS, 0.3 LB 0.5 WATT,
         10 BITS/SECOND

SEP 68  PROPOSAL WITHDRAWN
         DTREM I PROPOSED

DEC 68  DTREM I ASSIGNED TO EASEP
         DTREM II ASSIGNED TO APOLLO 12 AND UP.
         RETROFIT TO APOLLO 14 ONLY.

JULY 69  DTREM I DATA, O'BRIEN REPRESSAL

NOV 69  MSFEB APPROVES M515-LUNAR DUST EXPERIMENT

DUST DETECTOR FLIGHT ASSIGNMENT

<table>
<thead>
<tr>
<th>APOLLO</th>
<th>DTREM</th>
<th>P.I.</th>
<th>CO-P.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>DTREM I</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>DDE</td>
<td>O'BRIEN</td>
<td>FREDEN</td>
</tr>
<tr>
<td>13</td>
<td>DDE</td>
<td>FREDEN</td>
<td>O'BRIEN</td>
</tr>
<tr>
<td>14</td>
<td>DTREM II</td>
<td>FREDEN</td>
<td>O'BRIEN</td>
</tr>
<tr>
<td>15</td>
<td>DTREM II</td>
<td>FREDEN</td>
<td>O'BRIEN</td>
</tr>
<tr>
<td>16</td>
<td>NONE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7759-6701
**DUST DETECTOR EXPERIMENT**

**OBJECTIVE:** MEASURE EAST, WEST, HORIZONTAL DUST TO ± FEW PER CENT

**METHOD:** CELL ENERGY BALANCE

\[ \epsilon \sigma \uparrow^* - \alpha S \cos \phi + \text{SMALL ERRORS} \]

CELL

MEASURE CELL CURRENT AND TEMPERATURE TO GET \( \alpha/\epsilon \) FOR DUSTY CELL.

CELLS ARE UV AND PROTON RADIATION RESISTANT.

---

**DTREM II OBJECTIVES**

**FREDEN**

PROTON DOSE (DAMAGE) TO SOLAR CELL IN THREE ENERGY INTERVALS.

<table>
<thead>
<tr>
<th>Energy Interval</th>
<th>Protons</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ( \rightarrow \infty ) MEV</td>
<td></td>
</tr>
<tr>
<td>6 MIL CELL</td>
<td>4.5</td>
</tr>
<tr>
<td>20 MIL CELL</td>
<td>9 MEV</td>
</tr>
</tbody>
</table>

**O'BRIEN**

MEASURE HORIZONTAL DUST TO ± FEW %.

**HICKSON**

1. MEASURE LUNAR SURFACE BRIGHTNESS TEMPERATURE (TO ± 1 KELVIN AT NIGHT) = FOURTH ROOT OF ENERGY FROM SURFACE

2. GET RANGE OF LUNAR SURFACE THERMAL INERTIA PARAMETER, \( \gamma = 1/\sqrt{\text{kpc}} \)

3. MEASURE ANGULAR DEPENDENCE OF LUNAR SURFACE IR EMISSION. (NON-LAMBERTIAN EMISSION)

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7759-6703

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15-2
DUST DETECTOR

- To assess dust accretion on PSEP & infer degradation of thermal surfaces
- Uses three 2 cm x 2 cm photocells, each having:
  - Blue filter to cut off UV below 0.4 microns
  - 0.060-in. fused silica radiation protection
  - Thermistor on rear to monitor temp

Note: at PSEP turn-on, flip-flop can be either on or off

Amplifiers (3)

Temp

DATA SUBSYSTEM

THERMISTORS (3)

PHOTOCELLS (3)

DETECTOR PACKAGE

7759-6705
PULL-PIN FASTENERS

- SPRING-LOADED DETENT BALLS
- USED FOR SHEAR CONNECTIONS ON:
  - PSEP/LM INTERFACE
  - BOOM & HANDLE ASSEMBLY
  - SOLAR PANEL RESTRAINTS
  - ANTENNA TIE-DOWN

DTREM PACKAGE—APOLLO 11

7759-6706

7759-6707
PSEP—GEOMETRY OF DTREM I

DUST-DETECTOR SOLAR-CELL OUTPUT
ALSEP DESIGN SUMMARY
ADDENDA I-V

Presentation Material
BSR-2900
17 - 20 March 1970

NASA/MSC - Bendix
Aerospace Systems Division
Addendum I

PASSIVE SEISMIC EXPERIMENT

Presented by Dr. Gary Latham
Lamont Geological Observatory
### PSE Scientific Measurements

<table>
<thead>
<tr>
<th>Data Channel</th>
<th>Parameter Measured</th>
<th>Minimum Detectable Signal</th>
<th>At Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPZ</td>
<td>Vertical Ground Motion</td>
<td>0.3 µm, p-p</td>
<td>Shorter than 15 sec.</td>
</tr>
<tr>
<td>LPX</td>
<td>Horizontal Ground Motion</td>
<td>0.3 µm, p-p</td>
<td>Shorter than 15 sec.</td>
</tr>
<tr>
<td>LPY</td>
<td>Horizontal Ground Motion</td>
<td>0.3 µm, p-p</td>
<td>Shorter than 15 sec.</td>
</tr>
<tr>
<td>SPZ</td>
<td>Vertical Ground Motion</td>
<td>0.1 µm, p-p</td>
<td>0.1 sec.</td>
</tr>
<tr>
<td>Z - FB</td>
<td>Vertical Component of Gravity</td>
<td>8 µgal</td>
<td>DC</td>
</tr>
<tr>
<td>X-FB</td>
<td>Surface Tilt</td>
<td>0.01 sec. arc</td>
<td>DC</td>
</tr>
<tr>
<td>Y-FB</td>
<td>Surface Tilt</td>
<td>0.01 sec. arc</td>
<td>DC</td>
</tr>
<tr>
<td>TEMP.</td>
<td>Instrument Temperature</td>
<td>0.2 deg C</td>
<td>DC</td>
</tr>
</tbody>
</table>

![Diagram](image_url)
PSE PROBLEM AREAS

- **Long Period Vertical Seismometer**
  Natural period lengthened (60 sec instead of 15 sec).
  Acceptable operation achieved by removal of feedback filters.

- **Short Period Vertical Seismometer**
  1. Reduced calibration pulse amplitude.
     Calibration coil shorted - problem not electronic
  2. Lack of sensitivity to small signals.
     Mass rubbing frame. Delta rods broken.
  3. Noise pulses at output.
     Basic power variation (0.6 mv)

- **Thermal Control**
  Excessive temperature variation.
  Degraded thermal shroud. Have added motor heating at night.

- **Seismic and Tidal Variations at Terminator Crossing**
  Expansion and contraction of shroud couples mechanically to sensor.
Figure 4: Seismic signals recorded in the experiment performed.

The tidal and temperature outputs are plotted against time. The x, y, and z axes represent the different parameters measured.

Time, days - Jan 1969

P.S.E. - DVT
LONG TERM TEST
TIDAL AND TEMP OUTPUTS

X, Y = 0.2 ARC SEC
Z = 1 MGAL
T = 0.4°C

Output signal volts vs. time, days - Jan 1969
Addendum II

POWER SUBSYSTEM

Presented by A. Pitrolo

General Electric Company
<table>
<thead>
<tr>
<th>TITLE</th>
<th>PHOTO</th>
<th>PERTINENT FEATURES</th>
<th>USE</th>
<th>QUANTITY FABRICATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENERATOR ASSEMBLY</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Beryllium structure with high emissive coating, includes elements conversion, welded vacuum seal, supports use of fuel capsule.</td>
<td>On Lunar Surface</td>
<td>10</td>
</tr>
<tr>
<td>FUEL CAPSULE ASSEMBLY</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Graphite structure; pyro-carb coated beryllium heat soak coated with vacuum and sealant.</td>
<td>Supports heat source during Earth to Lunar mission re-entry heat shields</td>
<td>13</td>
</tr>
<tr>
<td>FUEL CAPSULE ASSEMBLY (PDCU)</td>
<td><img src="image3.png" alt="Image" /></td>
<td>Pu-238 microsphere core; 20 watt super alloy structure coated with high emissive coating, helium vent provided.</td>
<td>Heat source to generator—Lunar surface</td>
<td>6</td>
</tr>
<tr>
<td>PLANT HANDLING TOOL</td>
<td><img src="image4.png" alt="Image" /></td>
<td>Light weight design, dual-lip torquing &amp; plated surface to reflect capsule</td>
<td>Mounts onto the ABB fuel transfer assembly tool, used by astronaut to remove capsule from PLCS for insertion into OA</td>
<td>12</td>
</tr>
<tr>
<td>GENERATOR ASSEMBLY SHIPPING CONTAINER</td>
<td><img src="image5.png" alt="Image" /></td>
<td>Provide gas storage environment check for damage, mounting, operation</td>
<td>Earth storage container for generator assembly</td>
<td>1</td>
</tr>
<tr>
<td>FUEL CAPSULE GROUND SHIPPING CASK</td>
<td><img src="image6.png" alt="Image" /></td>
<td>Stainless steel construction, cavity temp. 150°F, capsule temp. 200°F, compliance to ACS and JSC regulations.</td>
<td>Stores heat source on Earth</td>
<td>6</td>
</tr>
<tr>
<td>TEST CONSOLE</td>
<td><img src="image7.png" alt="Image" /></td>
<td>Electric heater power supply: 1-100 watts generator, load resistance, 6-16 voltage, current, power readings.</td>
<td>Operates and checks out generator resistance with nuclear heat source or electric heat source</td>
<td>12</td>
</tr>
<tr>
<td>ELECTRIC FUEL CAPSULE SIMULATOR</td>
<td><img src="image8.png" alt="Image" /></td>
<td>Simulates heat source (100 watt capacity), dynamic capability, generator 5 environment, high vacuum operation, weight, stiffness simulation.</td>
<td>Permits testing of generators and PLCS</td>
<td>17</td>
</tr>
<tr>
<td>GROUND HANDLING TOOL</td>
<td><img src="image9.png" alt="Image" /></td>
<td>Titanium–molybdenum construction, load device to secure capsule, max slip temp. 112°F</td>
<td>Handles heat source on Earth</td>
<td>10</td>
</tr>
<tr>
<td><strong>CAPSULE BACK PLATE LOCK CLEAT TOOL</strong></td>
<td><strong>STEEL</strong></td>
<td><strong>TISSUE</strong></td>
<td><strong>inox 111351</strong></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------</td>
<td>------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td><strong>SILK HANDLING TOOL</strong></td>
<td><strong>STEEL</strong></td>
<td><strong>TITANIUM</strong></td>
<td><strong>STEEL</strong></td>
<td></td>
</tr>
<tr>
<td><strong>PORT ENTRY TOOL</strong></td>
<td><strong>ALUMINUM</strong></td>
<td><strong>STAINLESS STEEL</strong></td>
<td><strong>ALUMINUM</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SILK TRANSFER CASK</strong></td>
<td><strong>STAINLESS STEEL</strong></td>
<td><strong>SILK</strong></td>
<td><strong>STAINLESS STEEL</strong></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2

II-3
SNAP-27 PROGRAM BACKGROUND

INITIAL STUDY

- FEASIBILITY STUDY FOR RTG IN LUNAR ROVING VEHICLE
- CONTRACT TO AEC (SLRV) 40 WATT GENERATOR
- STUDY RECOMMENDED BERYLLIUM FOR STRUCTURE

SNAP-27 (AEC) SURFACE EXPERIMENT PACKAGE STUDY (SEP)

PHASE IIIA - TECHNOLOGY PROGRAM

PLAN TO START - SPRING 1965
ACTUAL START - AUGUST 1965
EIGHT MONTH PROGRAM

CONCEPTUAL DESIGN (50 WATT)
THERMOELECTRIC DEVELOPMENT PROGRAM (3M)

10-COUPLE MODULES
MAT'L COMPATIBILITY
MAT'L SELECTION
BERYLLIUM FABRICATION

PROCESS DEVELOPMENT
Y-12, SOLAR PROOF GENERATOR
(W/O T/E)

DEVELOPMENT PLAN

SNAP-27 PROGRAM

INITIATED IN SEPTEMBER 1965
STRUCTURED AS COMPONENT DEVELOPMENT EFFORT
PARALLEL DESIGN AND TECHNOLOGY DEVELOPMENT
SNAP-27 DESIGN AND PERFORMANCE CHARACTERISTICS

MISSION APPLICATION
POWER APOLLO LUNAR SURFACE EXPERIMENT PACKAGE (ALSEP)

CONVERSION CONCEPT
Pu-238 FUELED THERMOELECTRIC SYSTEM USING LEAD-TELLURIDE ALLOY THERMOCOUPLES IN TWO SERIES PARALLEL STRINGS.

DESIGN LIFE
ONE YEAR LUNAR OPERATION PRECEDED BY TWO YEARS EARTH STORAGE.

GENERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Output Power</th>
<th>Specified (Watts)</th>
<th>Measured (Watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>65 (BOM)*</td>
<td>73.3 (BOM)</td>
</tr>
</tbody>
</table>

| Output Voltage (Nominal) | 16 VOLS DC |
| Current (Nominal)        | 4 AMPS     |
| Over-All Efficiency (Nominal) | 4.75 %  |
| Average Hot Junction Temperature | 1075°F (580°C) |
| Average Cold Junction Temperature | 525°F (275°C) |
| Fuel Capsule Thermal Output (Nominal) | 1450 WATTS |

MECHANICAL CHARACTERISTICS

| Over-All Diameter Over Fins | 15.7 INCHES |
| Over-All Length              | 10.1 INCHES |
| Number of Fins               | 8           |
| Fin Radial Length            | 5.0 INCHES  |
| Fin Axial Length             | 10.0 INCHES |

WEIGHT

| Generator Assembly (Includes Cable, Connector, and Instrumentation) | 28.2 POUNDS |
| Radiosotope Fuel Capsule Assembly | 14.5 POUNDS |
| Fueled Generator          | 42.7 POUNDS |

* Beginning (or End) of Mission
** 1485 WATT THERMAL INPUT, 12, 13 HOURS
SNAP-27 TTC DESIGN CONSTRAINTS

- GENERATOR STORES IN LM INERT
- SYSTEM FUELED ON LUNAR SURFACE
- COMPATIBLE WITH SATURN V/ALSEP ENVIRONMENTS

VIBRATION:  
- SINE  
  FREQUENCY (CPS)  QUAL VALUES  
  5-20  0.39" DA  
  20-35  7.8 ± 1 G 0 TO PEAK  
  35-100  10.4 ± 1 G 0 TO PEAK

  3 OCTAVE/MINUTE SINE

- RANDOM  
  FREQUENCY (CPS)  QUAL VALUES G²/CPSE  
  23.8-50  0.224  
  80-120  12 DB/OCTAVE ± 1 DB  
  120-950  0.0444  
  950-1250  12 DB/OCTAVE ± 1 DB  
  1250-2000  0.0148

SHOCK - SAUTOOTH 11 MSEC USE 15G 3 SHOCK/AXIS

- FLANGE MOUNT  
  6.500 INCH DIA BOLT CIRCLE  
  8 HOLES .256 - .263 DIA .0012 TRUE POSITION

- VOLTAGE CONTROL - 16 VOLTS ± .2 VOLTS
- START UP TEMPERATURE ≤ 1075°F
- COMPATIBLE WITH MENDIX CABLE
- MENDIX SUPPLIED CONNECTOR
- 6 TEMPERATURE SENSORS FOR DIAGNOSTICS
- FLOATING GROUND
- WEIGHT AND CG 1" DIA SPHERE ON GEOMETRIC CENTER 8.91  
  INCHES ABOVE MOUNTING FLANGE
- TWO YEAR INERT STORAGE
SNAP-27 IPU DESIGN AND DEVELOPMENT PROGRAM
SYSTEM ANALYSIS AND DESIGN

DEVELOPMENT TEST PROGRAM

MAGNETIC ANALYSIS → INTERNAL LOSSES

THERMO-ELECTRIC MATERIALS

COUPLE DESIGN

DEGRADATION ALLOWANCE

RELIABILITY ANALYSIS

GENERATOR ASSEMBLY

MATERIALS:
- COMPATIBILITY
- T/E INSULATION
- OUTER CASE & HOT FRAME COATINGS
- BN FRICTION TESTS

MACHINING TESTS:
- SHRINK FIT
- FIN ATTACHMENT
- T/C ATTACHMENT

THERMOELECTRIC:
- 10 COUPLE MODULES
- 104 COUPLE MODULES

DEVELOPMENT TEST PROGRAM

FUEL LOADING

FINAL INTERNAL & EXTERNAL GEOMETRY

PERFORMANCE MAPPING

CONTINGENCY ANALYSIS & PLANNING

QUALIFICATION TESTING

CAPSULE DESIGN

G ASSEMBLY

MAGNETIC:
- MOCK-UP, GA ASSEMBLY TEST

THERMAL/MECH:
- MOCK-UP
- PROOF MODEL NO. 1
- FOLLOWER PERFORMANCE
- FOLLOWER SPRING RELAX.

ENG. MODEL SERIES:
- MOD 5 SHOCK, VIBRATION
- MOD 6 LIFE
- MOD 7 PERFORMANCE
- MOD 8 SIMULATED MISSION

FUEL CAPSULE

MATERIALS:
- COATINGS AND LIFE TEST
- COMPATIBILITY
- IMPACT
- CREEP RUPTURE
- WELD TESTS
- BURST TESTS

COMPONENT:
- LINER RUPTURE
- FILTER DEVELOP.
- SERIES I IMPACT
- SERIES II IMPACT
- VENTED DESIGN IMPACT
GENERATOR ASSEMBLY TEST PROGRAM

- Electric Insulator Friction Coefficient Measurements
- Follower Performance Tests
- Hermetic Seal Deflection Tests
- Hermetic Closure Transition Rings
- Shrink Fit Performance
- 10-Couple Module Tests
- 104-Couple Module Tests
- Structural Proof Tests
- Radiator Thermal Performance Tests
- Magnetic Field Tests
- Free Convection Air Operation Tests
- Outer Case Fin and Transition Braze Development
- Hot Frame Joining Development
- Hot Frame Emissive Coating
- Outer Case and Fin Emissive Coating
- Thermal Insulation Stability Tests
- Isothermal Compatibility Tests
- Insulation and Thermoelectric Thermal Conductivity Tests
- Thermoelectric Product Specification Development
- Beryllium Material Properties Tests
- Electric Lead thru Development
- Life Test of Full Size Generators
- Transient Start-up Characteristics of RTG
CAPSULE AND FUEL TEST PROGRAM

- DEVELOPMENT TESTS
  IMPACT TESTS (22)
  DROP TEST
  BURST PRESSURE TESTS
  FATIGUE TESTS
  CREEP RUPTURE TESTS
  CRACK PROPAGATION TESTS
  PENDULUM IMPACT TESTS
  VIBRATION TEST (PART OF GLFC TEST)
  RUPTURE DISC TESTS
  PED TESTS
  CAPSULE/LM HARDWARE IGNITION TESTS
  WELDED JOINT TESTS
  COMPATIBILITY
  COATING AND EMISSIVITY TESTS

- SAFETY TESTS
  RADIANT HEAT TESTS
  SOIL CONDUCTIVITY AND BURIAL TESTS
  RADIATION LEVELS

- FUEL TESTS
  COMPATIBILITY
  SOLUBILITY
  IMPACT
<table>
<thead>
<tr>
<th>Component Type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outer Case Assembly</strong></td>
<td>- HOT PRESS Be CYLINDER</td>
</tr>
<tr>
<td></td>
<td>- CROSS ROLLED SHEET Be FINS</td>
</tr>
<tr>
<td></td>
<td>- SILVER BRAZE ALLOY</td>
</tr>
<tr>
<td></td>
<td>- 19 - DL TRANSITION RINGS</td>
</tr>
<tr>
<td></td>
<td>- SPRAY RADIFRAX COATING</td>
</tr>
<tr>
<td><strong>Cold Frame</strong></td>
<td>- HOT Pressed Be</td>
</tr>
<tr>
<td><strong>Thermoelectrics</strong></td>
<td>- PbTe and Pb SeTe, COPPER</td>
</tr>
<tr>
<td><strong>Thermopile Insulation</strong></td>
<td>- POWDERED MIN-K 1301</td>
</tr>
<tr>
<td></td>
<td>- PRESSED MIN-K (AFT SEAL)</td>
</tr>
<tr>
<td><strong>Forward Seal</strong></td>
<td>- COLD FOIL REFLECTING SURFACE</td>
</tr>
<tr>
<td></td>
<td>(SPOT WELDED)</td>
</tr>
<tr>
<td><strong>Aft Seal</strong></td>
<td>- IN 102</td>
</tr>
<tr>
<td><strong>Hot Frame</strong></td>
<td>- IN 102</td>
</tr>
<tr>
<td></td>
<td>- INTERIOR COATED WITH RADIFRAX</td>
</tr>
<tr>
<td><strong>Springs</strong></td>
<td>- INCONEL X</td>
</tr>
<tr>
<td><strong>Shims</strong></td>
<td>- ISOMICA</td>
</tr>
<tr>
<td><strong>Spring Lock</strong></td>
<td>- BERYLLIUM</td>
</tr>
<tr>
<td><strong>Hot Buttons</strong></td>
<td>- 1010 STEEL</td>
</tr>
<tr>
<td></td>
<td>- 0.003&quot; ARMCO IRON COATING</td>
</tr>
<tr>
<td><strong>Hot Side Insulator</strong></td>
<td>- BORON NITRIDE</td>
</tr>
<tr>
<td><strong>Insulator Support Structure</strong></td>
<td>- MOLY</td>
</tr>
<tr>
<td><strong>Cover Gas</strong></td>
<td>- ARGON</td>
</tr>
<tr>
<td><strong>Followers</strong></td>
<td>- BERYLLIUM OXIDE</td>
</tr>
</tbody>
</table>
THREOELECTRIC PROGRAM

1. SELECT BEST THERMOELECTRIC (T/E) MATERIALS

   | 3N TYPE CANDIDATES | 2P TYPE CANDIDATES |
   | TPM 10 (PbTe)      | TPM 15 (PbSrTe)    |
   | 3N-                | 3P-                 |

2. SELECT T/E OPERATING TEMPERATURES

   \( T_H = 1100^\circ\text{F} \)
   \( T_C = 525^\circ\text{F} \)

3. DETERMINE CUPPLE EXTRANEOUS RESISTANCE FOR ELEMENT SIZE

   DESIGN N-LEG \( 1.70 \text{ \Omega} \)
   F-LEG \( 3.0 \text{ \Omega} \)

4. SIZE ELEMENT

   N LEG \( 0.207'' \text{ DIA X 0.400 LONG} \)
   P LEG \( 0.247'' \text{ DIA X 0.400 LONG} \)

5. VERIFY T/E MATERIAL PERFORMANCE - TEST PROGRAM

   A. COMPATIBILITY OF T/E'S WITH ELEMENTS OF SNAP-27
   B. T/E PROPERTY DATA - INDEPENDENT MEASUREMENTS BY EMI
   C. SHORT AND LONG LIFE TEST PROGRAM WITH 19 FLAT PLATE MODULES
   D. LONG LIFE TEST PROC. WITH 13 QUARTER SIZE SNAP-27 GEN.
<table>
<thead>
<tr>
<th>COUPLE</th>
<th>TEST DESCRIPTION</th>
<th>HOT JUNG TIME-TO-(°C)</th>
<th>COLD JUNG TIME-TO-(°C)</th>
<th>CAS PRESS. Pc (PSI)</th>
<th>SPRING PRESS. Pp (PSI)</th>
<th>TOTAL TIME OF TEST AT 9/5/69</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Short Term Stability</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>Terminated at 2106 hr.</td>
</tr>
<tr>
<td>B2</td>
<td>Short Term Stability</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>Terminated at 1832 hr.</td>
</tr>
<tr>
<td>C3</td>
<td>Short Term Stability</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>28,146 hr.</td>
</tr>
<tr>
<td>C4</td>
<td>Short Term Stability</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>26,535 hr.</td>
</tr>
<tr>
<td>C5</td>
<td>Off Design Hot Junction</td>
<td>1130</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>25,011 hr.</td>
</tr>
<tr>
<td>C6</td>
<td>Off Design Hot Junction</td>
<td>1130</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>25,464 hr.</td>
</tr>
<tr>
<td>C7</td>
<td>Off Design Hot Junction</td>
<td>1050</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>26,363 hr.</td>
</tr>
<tr>
<td>C8</td>
<td>Off Design Hot Junction</td>
<td>1050</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>Terminated at 23,997 hr.</td>
</tr>
<tr>
<td>C9</td>
<td>Off Design Hot Junction</td>
<td>1120</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>(7/19/69)</td>
</tr>
<tr>
<td>C10</td>
<td>Off Design Hot Junction</td>
<td>1120</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>26,397 hr.</td>
</tr>
<tr>
<td>C11</td>
<td>Lower Gas Pressure</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>Terminated at 6,000 hr.</td>
</tr>
<tr>
<td>C12</td>
<td>Lower Gas Pressure</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>150</td>
<td>16,767 hr - terminated</td>
</tr>
<tr>
<td>C13</td>
<td>Lunar Cycle</td>
<td>1100/1050</td>
<td>525/460</td>
<td>25</td>
<td>150</td>
<td>9/12/69 after 36 cycles</td>
</tr>
<tr>
<td>C14</td>
<td>Increased Spring Pressure</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>250</td>
<td>22,613 hr.</td>
</tr>
<tr>
<td>C15</td>
<td>Increased Spring Pressure</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>250</td>
<td>23,099 hr.</td>
</tr>
<tr>
<td>C16</td>
<td>Increased Spring Pressure</td>
<td>1100</td>
<td>525</td>
<td>25</td>
<td>750</td>
<td>17,785 hr.</td>
</tr>
<tr>
<td>C17</td>
<td>Lunar Cycle</td>
<td>1100/1050</td>
<td>525/460</td>
<td>25</td>
<td>150</td>
<td>23,197 hr-cycling terminated</td>
</tr>
<tr>
<td>C18</td>
<td>Off Design Cold Junction</td>
<td>1100</td>
<td>575</td>
<td>25</td>
<td>150</td>
<td>23,353 hr.</td>
</tr>
<tr>
<td>C19</td>
<td>Off Design Cold Junction</td>
<td>1100</td>
<td>625</td>
<td>25</td>
<td>150</td>
<td>22,868 hr.</td>
</tr>
</tbody>
</table>

Total Number Module Hours @ 9/5/69 = 393,388

Module was originally set at 0.5 pascal; outgassing of the insulation increased pressure to 2.5 pascal
Module was originally set at 3.0 pascal; outgassing of the insulation increased pressure to 7.0 pascal
### 104-Coupled Test Matrix

<table>
<thead>
<tr>
<th>MODULE</th>
<th>TEST DESCRIPTION</th>
<th>HOT JUNC TEMPERATURE (°F)</th>
<th>COLD JUNC TEMPERATURE (°F)</th>
<th>TOTAL TIME ON TEST AT 371/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>104-81</td>
<td>OFF DESIGN HOT JUNCTION</td>
<td>1030</td>
<td>525</td>
<td>12,056 HOURS</td>
</tr>
<tr>
<td>104-82</td>
<td>EFFICIENCY TESTING WITH 4-ZONE HEATER</td>
<td>1070</td>
<td>525</td>
<td>22,475 HOURS</td>
</tr>
<tr>
<td>104-83</td>
<td>IN STORAGE - TEST START POSTPONED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>104-84</td>
<td>IN STORAGE - TEST START POSTPONED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>104-85</td>
<td>IN STORAGE - TEST START POSTPONED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>104-86</td>
<td>SHOCK AND VIBRATION</td>
<td>1100</td>
<td>525</td>
<td>TERMINATED 8/4/67 AT 2,413 HOURS</td>
</tr>
<tr>
<td>104-87</td>
<td>ON-OFF CYCLE PERFORMANCE - CYCLING TERMINATED AFTER 17 CYCLES</td>
<td>1100</td>
<td>525</td>
<td>TERMINATED 10/10/67 AT 5,839 HOURS</td>
</tr>
<tr>
<td>104-88</td>
<td>LUNAR CYCLE PERFORMANCE - CYCLING TERMINATED AFTER 20 CYCLES</td>
<td>1100/525/</td>
<td>1045/460</td>
<td>TERMINATED 5/8/68 AT 9,451 HOURS</td>
</tr>
<tr>
<td>104-89</td>
<td>LONG TERM STABILITY WITH ZENON GAS</td>
<td>1100</td>
<td>525</td>
<td>26,138 HOURS</td>
</tr>
<tr>
<td>104-90</td>
<td>EFFICIENCY</td>
<td>1100</td>
<td>525</td>
<td>26,477 HOURS</td>
</tr>
<tr>
<td>104-91</td>
<td>OFF DESIGN HOT JUNCTION</td>
<td>1130</td>
<td>525</td>
<td>TERMINATED 11/22/70 AT 24,090 HOURS</td>
</tr>
<tr>
<td>104-92</td>
<td>LONG TERM STABILITY</td>
<td>1100</td>
<td>525</td>
<td>25,766 HOURS</td>
</tr>
<tr>
<td>104-93</td>
<td>ON-OFF CYCLE PERFORMANCE - CYCLING TERMINATED AFTER 20 CYCLES, THERMAL REDUCED TO 1000°F</td>
<td>1100</td>
<td>525</td>
<td>25,833 HOURS</td>
</tr>
<tr>
<td>104-94</td>
<td>REDUCED HOT JUNCTION</td>
<td>1050</td>
<td>525</td>
<td>25,566 HOURS</td>
</tr>
<tr>
<td>104-95</td>
<td>REDUCED HOT JUNCTION, PUMP PRESSURE 250 PSI</td>
<td>1050</td>
<td>525</td>
<td>23,107 HOURS</td>
</tr>
</tbody>
</table>

---

**Diagram:**
- **Data Shown:**
  - B2 & C1 at 150 PSI
  - C1 & C15 at 20 PSI
  - Note: On module C15, two terminal couples were omitted which were defective from start of test.

**Graph:**
- **Axes:**
  - Y-axis: Power Ratio (P/Pm)
  - X-axis: Test Time (HR)
- **Data Points:**
  - 20 PSI
  - 150 PSI

---

**Page:**

---

**II. 17**
Influence of Gas Pressure

Data shown are averages of two independent P-couple strings.
- Data at 1050°F
- Data at 1100°F
- Data at 1200°F
- Data at 1250°F

Note: The given pressures are starting pressures. Due to insulation outgassing effects, actual operating pressures (shown in parentheses) are higher.

10-Couple Module Data Influence of Hot Junction Temperature
Compatibility Test Fixture Assemblies Nos. 11, 13, 15 and 17
SNAP-27 Isothermal Test Material

<table>
<thead>
<tr>
<th>Description</th>
<th>Material</th>
<th>Size</th>
<th>Source</th>
<th>Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Block</td>
<td>Inconel 102</td>
<td>0.275 L</td>
<td>Allegheny</td>
<td>Will be cleaned and stored in bonded stock.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.70 D</td>
<td>Ladum</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Carborundum</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Boron Nitride</td>
<td>0.075 L</td>
<td></td>
<td>Will be cleaned, baked, and stored in bonded stock.</td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td>0.70 D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Shoe</td>
<td>110 Cu</td>
<td>0.075 L</td>
<td></td>
<td>Will be cleaned and stored in bonded stock.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.70 D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Junction</td>
<td>C1020 Steel</td>
<td>0.075 L</td>
<td></td>
<td>Will be cleaned and stored in bonded stock.</td>
</tr>
<tr>
<td>Button</td>
<td></td>
<td>0.70 D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold Electrode</td>
<td>110 Cu</td>
<td>0.075 L</td>
<td></td>
<td>Cleaned and bonded to thermoelectric legs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.70 D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold Block</td>
<td>Beryllium</td>
<td>0.070 L</td>
<td>G.E.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.070 D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filler Pad</td>
<td>Quartz Wool</td>
<td></td>
<td>Engelhard</td>
<td>Will be baked and stored in bonded stock.</td>
</tr>
<tr>
<td>Spacers</td>
<td>Quartz Plate</td>
<td>0.0725 L</td>
<td>Engelhard</td>
<td>Will be cleaned and stored in bonded stock.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.71 D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>MIN-K 1301</td>
<td>Powdered</td>
<td>Johns-Manville</td>
<td>Baked to remove all binder and moisture, stored in closed container, and</td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td>Form</td>
<td></td>
<td>placed in bonded stock until used.</td>
</tr>
<tr>
<td>Quartz Tubes</td>
<td>Quartz</td>
<td>0.75 × 0.03 ID</td>
<td>Engelhard</td>
<td>Will be assembled by the glass-blowing shop of Central Research, 3M</td>
</tr>
<tr>
<td>Xenon Gas</td>
<td>Xenon</td>
<td></td>
<td>Matheson</td>
<td>Company.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Back filled to 0.3 lb/in.² at room temperature.</td>
</tr>
</tbody>
</table>
SYSTEM DESIGN AND PERFORMANCE EVALUATION

DESIGN

NUMBER OF COUPLES 442

- END OF LIFE POWER 56.6 WATTS (CHANGED TO 63.5)
- ALLOWANCE FOR UP TO ONE STRING FAILURE (9.5°C/COUPLE)
- ALL COUPLES LADDENED FOR INCREASED RELIABILITY
- HEAT FLOW TO THERMOELECTRICS SELECTED FOR MAXIMUM EFFICIENCY AND OUTPUT OF 16 VOLTS
- SYSTEM CHARACTERISTICS DETERMINED FOR ON AND OFF DESIGN PERFORMANCES AND MANUFACTURING TOLERANCE RANGES.

HARDWARE BUILT

- THREE ENGINEERING PROTOTYPES (2 GE, 1 BENDIX)
- TWO QUALIFICATION UNITS (1 GE, 1 BENDIX)
- FIVE FLIGHT UNITS

TEST PROGRAM

- LIFE TEST UNDER LUNAR CONDITIONS 28,000 HOURS
- PERFORMANCE AFTER QUAL DYNAMIC TESTS
- PERFORMANCE CHARACTERISTICS OF ALL SYSTEMS/Thermal Vacuum
- MAGNETIC MEASUREMENTS
- TRANSIENT START-UP CHARACTERISTICS
SNAP-27 IPU THERMAL PROGRAM

TEST

• THERMAL MOCK-UP GENERATOR
  ALUMINUM-12 AND 6 FIN
  AIR AND THERMAL VACUUM
  FIN TEMPERATURE MAPPING
  AXIAL AND CIRCUMFERENTIAL
  GRADIENTS
  VERIFICATION OF ANALYTICAL TOOLS
  INTERFACE BOUNDARIES

• FOLLOWER-COLD JUNCTION ΔT
  BeO, Be FOLLOWERS

• ENGINEERING PROOF MODEL #1
  TEMP DISTRIBUTIONS
  ΔT THRU SHRINK FIT

• SHRINK FIT THERMAL TEST
  ΔT THRU SHRINK FIT

• FUEL AND FUEL CAPSULE ΔT
  FUEL PROPERTIES
  LINER TEMPERATURES

• THERMOPILE INSULATION THERMAL
  CONDUCTIVITY

• COATING DEVELOPMENT
  HI AND LOW EMISSIVE COATINGS

ANALYSIS

FINS
  OPTIMIZATION TAKE-OFF OF FIN
  DESIGN

IPU
  (TWO-PROBLEM SOLUTION)
  TEMPERATURE DISTRIBUTION
  LOCATION OF KEY PARTS
  FUEL LOADING
  SYSTEM PERFORMANCE

IPU
  (3DIMENSIONAL-22° THERMAL MODEL)
  CHECK ON ORIGINAL ANALYSIS
  VARIABLE MATERIAL PROPERTIES
  VARIABLE SINK AND FUEL LOADING
  SUPPORT COMING TEST PROGRAM

FUEL CAPSULE
  TEMPERATURE DISTRIBUTION
COMPONENTS OF THERMAL SYSTEM

- RADIATOR
- OUTER CASE
- FINS
- COLD FRAME
- B&O FOLLOWERS
- THERMOELECTRICS
- THERMOPILE INSULATION MIN-K
- THERMOPILE COVER GAS
- END ENCLOSURE INSULATION MIN-K
- END SEALS
- ALSEP BASEPLATE
- HOT FRAME
- ELECTRICAL INSULATORS
- HEAT SOURCE
- HEAT SOURCE BACKPLATE

Lunar Night Sink Temperature, Q = 1200 watts
RADIATOR

OUTER CASE/FIN ASSEMBLY

- Define Constraints
- Determine Range of Heat Rejection
- Perform Optimization Studies
  - Thermal Surfaces
  - Number of Fins
  - Fin Size
  - Lunar Sink
  - Effects of ALSEP Baseplate
- Test Program
  - Verify Analytical Techniques
    - Aluminum Structure with 12 and 6 Fins
  - Measure Performance of Coated Outer Frame/Cold Frame Unit - MOD 1
  - Develop Outer Surface Coatings
    - RADIFRAZ
    - Assess Long Term Performance
      - Coating Samples
        - MOD 3 Generator 12,163 Hours
        - MOD 8B Generator 8,340 Hours
        - MOD 10 Generator 10,000 Hours
HEAT LOAD IMPOSED ON A DEPLOYED SNAP-27 BY THE LUNAR ENVIRONMENT

HEAT INPUT FROM ENVIRONMENT ~ WATTS

SUN RAY

TOTAL

MOON

SOLAR

ALBEDO

SUN ANGLE ~ DEGREES

SOLAR ABSORPTIVITY = 0.9
INFRARED EMITTANCE = 0.85
LUNAR SINK TEMPERATURE FOR A DEPLOYED SNAP-27

TOTAL EFFECTIVE SINK TEMP. °F

SUN ANGLE ~ DEGREES
EMISSIVITY 0.85
T_MNK 170°F
T_BASE 510°F
18 IN. AXIAL LENGTH
5.674 IN. CYLINDER IDA,
ONE END BLOCKED

NO. OF FINS

0.1
0.2
0.3
0.4
FIN BASE THICKNESS (INCHES)

0

RADIAl FIN LENGTH (INCHES)

TOTAL FIN WEIGHT (POUNDS)

3
4
5
6

0

6

10

12

4

6

12

10

6

10

5

10

6

110

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Minimum Fin Weight and Thickness Variation with Number of Fins and Fin Emmissivity

- $Q_{REJ} = 1400$ WATTS
- $T_{SINK} = 170^\circ F$
- $T_{FIN BASE} = 510^\circ F$
- Axial Fin Length = 18 in.
- Cylinder Dia. = 5.67 in.
- One End Blocked

MINIMUM WEIGHT LOCUS

Minimum Fin Weight and Thickness Variation with Number of Fins and Fin Emmissivity
NOTES:
1. TRAPEZIODAL FINS
2. CYLINDER OA = 3.674 IN.
3. RADIAL FIN LENGTH = 0.8 IN.
4. FIN BASE THICKNESS = 0.005 IN.
5. AXIAL LENGTH = 18 IN.
6. ONE END BLOCKED
7. EMITTIVITY = 0.45

SNAP-27 Operational Fin Base Temperature for Reference Design
B-0 FOLLOWERS

- MINIMIZE TEMPERATURE DROP FROM COUPLER TO OUTER CASE
- DEVELOP ANALYTICAL MODEL CONSIDERING:
  
  - SPHERICITY
  - GAP (CLEARANCE)
  - PRESSURE
  - CAS

- VERIFY BY TESTS
  - COMPONENT TESTS
  - QUALITY CONTROL (DIMENSIONS) ESTABLISHED
  - SYSTEM ΔT 20-25° FROM COPPER CAP TO PIN BASE
  - B-0 FOLLOWERS SUPERIOR
Figure 3.1 - Follower Thermal Conductance Test Unit Schematic
Table 1-1 Summary of Test Results

<table>
<thead>
<tr>
<th>Follower and Test Fixture</th>
<th>Radial Tolerance</th>
<th>Gap Spherical Deviation</th>
<th>Gap Follower</th>
<th>Cap Follower</th>
<th>Temperature Difference Across Spherical Interface*</th>
<th>Radial Tolerance Between Follower and Cold Frame</th>
<th>Temperature Difference Between Follower and Cold Frame Within 300°F</th>
<th>Total Temperature Difference Between Cold Gap and Cold Frame*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be-00</td>
<td>0</td>
<td>300</td>
<td>1000</td>
<td>27.0</td>
<td>6.5</td>
<td>33.5</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Be-22</td>
<td>0</td>
<td>300</td>
<td>1500</td>
<td>8</td>
<td>4.2</td>
<td>7.1</td>
<td>52.6</td>
<td></td>
</tr>
<tr>
<td>Be-15</td>
<td>0</td>
<td>500</td>
<td>600</td>
<td>141</td>
<td>21.4</td>
<td>7.1</td>
<td>28.5</td>
<td></td>
</tr>
<tr>
<td>Bu-22</td>
<td>0</td>
<td>300</td>
<td>1500</td>
<td>7</td>
<td>8.0</td>
<td>6.5</td>
<td>27.5</td>
<td></td>
</tr>
<tr>
<td>Be-33</td>
<td>0</td>
<td>500</td>
<td>600</td>
<td>14</td>
<td>15.0</td>
<td>8.0</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Be-0-00</td>
<td>4.3</td>
<td>700</td>
<td>80</td>
<td>14</td>
<td>9.0</td>
<td>11.5</td>
<td>20.5</td>
<td></td>
</tr>
<tr>
<td>1                   Be-0-12**</td>
<td>1.0</td>
<td>950</td>
<td>40</td>
<td>12</td>
<td>8.5</td>
<td>8.9</td>
<td>17.4</td>
<td></td>
</tr>
<tr>
<td>2                   Be-0-33</td>
<td>0</td>
<td>150</td>
<td>450</td>
<td>8</td>
<td>5.7</td>
<td>10.5</td>
<td>16.2</td>
<td></td>
</tr>
</tbody>
</table>

Remarks

* At nominal heat flow of 1.41kw and 6 lb. vertical load, normalized to 500°F gap temperature.

** These data are not very conclusive, since taken at too high heat fluxes and temperature differences.

OTHER KEY DEVELOPMENT THERMAL SYSTEM TESTS

1. BORON NITRIDE COEFFICIENT OF FRICTION

2. HOT FRAME THERMAL COATINGS

3. FORWARD END SEAL THERMAL SURFACE (LOW ε)

4. THERMAL CONDUCTIVITY OF MIN-K

5. OUTER CASE THERMAL COATINGS

III-35
MOD 10 - THEORETICAL VERSUS ACTUAL PERFORMANCE

THEORETICAL MATERIAL PERFORMANCE
TPM 10/TPM 15
CAPSULE INPUT - 1505 W

NOTE: POINTS SHOWN ARE ACTUAL TEST DATA SUPERIMPOSED UPON ANALYTICAL CURVES

PERFORMANCE PREDICTION FOR 10,000 HRS, OPERATION INCLUDING FUEL DECAY

TEST DATA

O EQUALS 300 HOURS
\( \triangle \) EQUALS 6,000 HOURS
1505 W

CURRENT (AMPS)

VOLTAGE (VOLTS)

POWER (WATTS)
<table>
<thead>
<tr>
<th>FLIGHT</th>
<th>THERMAL LOAD (WATTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1487</td>
</tr>
<tr>
<td>2</td>
<td>1485</td>
</tr>
<tr>
<td>3</td>
<td>1479</td>
</tr>
<tr>
<td>4</td>
<td>1483</td>
</tr>
<tr>
<td>BACK UP</td>
<td>1485</td>
</tr>
<tr>
<td>QUAL UNIT</td>
<td>1484</td>
</tr>
<tr>
<td>Parameter</td>
<td>Value</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Thermal loading, watts</td>
<td>1480 ± 30</td>
</tr>
<tr>
<td>Fuel form</td>
<td>Pu$_{238}$ microspheres</td>
</tr>
<tr>
<td>Fuel geometry</td>
<td>$^{238}$Pu</td>
</tr>
<tr>
<td>Fuel specific power, w/g</td>
<td>30 - 250 µ dia</td>
</tr>
<tr>
<td>Physical density range of fuel particles, g/cm³</td>
<td>Cylindrical annulus</td>
</tr>
<tr>
<td>Effective fuel power density, w/cm³</td>
<td>0.400 ± 0.01</td>
</tr>
<tr>
<td>Fuel conductivity (effective)</td>
<td>9.1 - 10.3</td>
</tr>
<tr>
<td>Fuel conductivity (in helium)</td>
<td>2.6 ± 0.2</td>
</tr>
<tr>
<td>Fueled length, in.</td>
<td>0.62 @ 1400°F clad temp</td>
</tr>
<tr>
<td>Capsule OD (nominal, uncoated), in.</td>
<td>13.76</td>
</tr>
<tr>
<td>Capsule material</td>
<td>2.509</td>
</tr>
<tr>
<td>Liner material</td>
<td>Haynes-25</td>
</tr>
<tr>
<td>Emissive coating</td>
<td>Haynes-25</td>
</tr>
<tr>
<td>Emissivity (minimum)</td>
<td>RC-356</td>
</tr>
<tr>
<td>Mission time, years</td>
<td>0.85</td>
</tr>
<tr>
<td>Storage time, years</td>
<td>1</td>
</tr>
<tr>
<td>* Fuel volume, in.³</td>
<td>2</td>
</tr>
<tr>
<td>* Fuel annulus width, in.</td>
<td>33.9 - 38.14</td>
</tr>
<tr>
<td>* Liner assembly void volume, in.³</td>
<td>0.407 - 0.475</td>
</tr>
<tr>
<td>Total void volume, in.³</td>
<td>17.65</td>
</tr>
<tr>
<td>Total capsule weight (w/backplate)lb.</td>
<td>40.3</td>
</tr>
<tr>
<td>* Range due to fuel power density variance</td>
<td>15.46 max.</td>
</tr>
</tbody>
</table>

* Range due to fuel power density variance
FUEL CAPSULE ASSEMBLY DESIGN FEATURES
### SUMMARY OF SNAP-27 FLIGHT GENERATOR TEST RESULTS

<table>
<thead>
<tr>
<th>OPERATING CONDITIONS</th>
<th>GENERATOR POWER OUTPUT (Watts)</th>
<th>POWER INPUT (Watts)</th>
<th>EQUI. LOAD</th>
<th>SINK TEMP. (°F)</th>
<th>MOD 13 GA S/N 6320006</th>
<th>MOD 19 GA S/N 6320009</th>
<th>MOD 21 GA S/N 6320011</th>
<th>MOD 22 GA S/N 6320012</th>
<th>MOD 23 GA S/N 6320013</th>
</tr>
</thead>
<tbody>
<tr>
<td>1505</td>
<td>16 VOLS</td>
<td>+170</td>
<td>69.8</td>
<td>69.1</td>
<td>68.2</td>
<td>68.3</td>
<td>70.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1455</td>
<td>16 VOLS</td>
<td>+170</td>
<td>67.1</td>
<td>67.5</td>
<td>66.0</td>
<td>66.2</td>
<td>67.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1415</td>
<td>16 VOLS</td>
<td>+170</td>
<td>64.3</td>
<td>64.7</td>
<td>63.2</td>
<td>63.2</td>
<td>65.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1505</td>
<td>16 VOLS</td>
<td>-280</td>
<td>72.5</td>
<td>72.9</td>
<td>71.3</td>
<td>71.3</td>
<td>72.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1455</td>
<td>16 VOLS</td>
<td>-280</td>
<td>68.8</td>
<td>68.8</td>
<td>66.7</td>
<td>67.3</td>
<td>68.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1415</td>
<td>16 VOLS</td>
<td>-280</td>
<td>65.3</td>
<td>65.3</td>
<td>64.0</td>
<td>64.1</td>
<td>65.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1450</td>
<td>+4.7 OHMS</td>
<td>AMBIENT</td>
<td>69.6</td>
<td>69.7</td>
<td>67.9</td>
<td>69.1</td>
<td>70.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Total Accumulated Operational Time (Air and Vacuum) (Hours):**
  - MOD 13: 550
  - MOD 19: 593
  - MOD 21: 581
  - MOD 22: 640
  - MOD 23: 571

- **Operational Time in Vacuum (Hrs):**
  - MOD 13: 240
  - MOD 19: 264
  - MOD 21: 236
  - MOD 22: 303
  - MOD 23: 233

- **Final GA Leak Rate in std cc/sec of Argon while Operating in a 417°F Sink at 4.7 ohm load:**
  - MOD 13: $2.50 \times 10^{-6}$
  - MOD 19: $4.36 \times 10^{-7}$
  - MOD 21: $1.09 \times 10^{-6}$
  - MOD 22: $3.7 \times 10^{-7}$
  - MOD 23: Less Than $3.92 \times 10^{-7}$

- **Storage Container Serial No.:**
  - MOD 13: 6287007
  - MOD 19: 6287008
  - MOD 21: 6287009
  - MOD 22: 6287010
  - MOD 23: 6287003

- **Total Weight (Pounds) (Less Protective Cable Sleewing):**
  - MOD 13: 27.83
  - MOD 19: 27.77
  - MOD 21: 27.96
  - MOD 22: 27.86
  - MOD 23: 27.80

### GENERATOR TEST PERFORMANCE SUMMARY

<table>
<thead>
<tr>
<th>GENERATOR</th>
<th>TOTAL ACCUM TEST TIME (HRS)</th>
<th>POWER OUTPUT WATTS HOL LUNAR DAY</th>
<th>HEAT INPUT WATTS</th>
<th>POWER OUTPUT WATTS HOL LUNAR DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOD 5(1)</td>
<td>12,165</td>
<td>70.8</td>
<td>73.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1500 AFTER 10000 HRS REDUCED TO 1485 WATTS</td>
<td>66.6</td>
</tr>
<tr>
<td>MOD 8B(1)</td>
<td>8,341</td>
<td>65.0</td>
<td>66.0</td>
<td>1415</td>
</tr>
<tr>
<td>MOD 10(2)</td>
<td>7,697</td>
<td>71.2</td>
<td>73.3</td>
<td>1505</td>
</tr>
<tr>
<td></td>
<td>10,244</td>
<td></td>
<td>1505</td>
<td>71.52 @ 49°F = sink</td>
</tr>
<tr>
<td></td>
<td>30,750</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) ENGINEERING DEVELOPMENT GENERATORS

(2) PRIME FLIGHT QUALITY - IDENTICAL TO FIVE DELIVERED FLIGHT UNITS
MAGNETIC FIELD MEASUREMENTS ON SNAP-27 GENERATOR

ALSEP SPEC CALLS FOR FIELD TO BE LESS THAN 0.1 GAMMA AT A DISTANCE OF FIFTY FEET FROM THE RTG CENTER LINE.

MOD 10 SNAP 27 GENERATOR AFTER EXPOSURE TO 15 OERSTED FIELD.

MOD 10 SNAP 27 GENERATOR DEPERMED AFTER EXPOSURE (STRAY OR CURRENT FIELD)

DISTANCE ALONG SPECIFIED AXIS - METERS

TOTAL FIELD - GAMMAS
### Structural Design

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MARGIN</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting Lugs</td>
<td>0.30</td>
<td>45 G Static</td>
</tr>
<tr>
<td>Cold Frame</td>
<td>6.17</td>
<td>Shrink Fit</td>
</tr>
<tr>
<td></td>
<td>&gt; . LARGE</td>
<td>Follower Shear</td>
</tr>
<tr>
<td>Fins</td>
<td>&gt;&gt; LARGE</td>
<td>45 G Static</td>
</tr>
<tr>
<td>Follower Springs</td>
<td>NOT CRITICAL</td>
<td>DESIGN FOR 16.4% RELAXATION AFTER TWO YEARS OPERATION</td>
</tr>
<tr>
<td>Hot Frame</td>
<td>0.15</td>
<td>BASED ON SPRING PRESSURE AND INTERNAL GAS PRESSURE LOAD OF 60 PSI</td>
</tr>
<tr>
<td>Hermetic Seal - Aft</td>
<td>3.00</td>
<td>DESIGNED FOR MINIMUM THERMAL LEAK - SUBJECTED TO COMPONENT TEST</td>
</tr>
<tr>
<td></td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Transition Ring</td>
<td>LARGE</td>
<td></td>
</tr>
<tr>
<td>Braze in Case</td>
<td>LARGE</td>
<td></td>
</tr>
<tr>
<td>Ring</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Seal Weld</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer Case</td>
<td>AMple</td>
<td>ANALYSIS COMPLEX - SYSTEM PROVEN BY RIGOROUS TESTS</td>
</tr>
</tbody>
</table>

---

II-70
## GENERATOR ASSEMBLY STRUCTURAL ANALYSIS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>LOAD</th>
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</thead>
<tbody>
<tr>
<td>MOUNTING LUGS</td>
<td>G-LOADS, 3 AXIS</td>
</tr>
<tr>
<td>COLD FRAME</td>
<td>SHRINK FIT STRESSES</td>
</tr>
<tr>
<td></td>
<td>FOLLOWER SPRING SHEAR</td>
</tr>
<tr>
<td>OUTER CASE</td>
<td>LATERAL AND AXIAL LOADS</td>
</tr>
<tr>
<td></td>
<td>SHRINK FIT</td>
</tr>
<tr>
<td></td>
<td>THERMAL STRESS</td>
</tr>
<tr>
<td>FINS</td>
<td>LATERAL LOAD</td>
</tr>
<tr>
<td></td>
<td>THERMAL STRESS</td>
</tr>
<tr>
<td>FOLLOWER SPRING</td>
<td>SPRING</td>
</tr>
<tr>
<td></td>
<td>RELAXATION</td>
</tr>
<tr>
<td>HOT FRAME</td>
<td>PRESSURE (GAS)</td>
</tr>
<tr>
<td></td>
<td>COMPRESSION LOAD OF T/E ELEMENTS</td>
</tr>
<tr>
<td>HERMETIC SEALS</td>
<td>PRESSURE</td>
</tr>
<tr>
<td></td>
<td>DEFLECTION</td>
</tr>
<tr>
<td>TRANSITION RING BRAZED AND WELD</td>
<td>PRESSURE LOAD</td>
</tr>
</tbody>
</table>
GRAPHITE LM FUEL CASK

GLPC
CLFC REQUIREMENTS

OPERATIONAL:
- SUPPORT FUEL CAPSULE FROM LAUNCH TO LUNAR SURFACE
- REJECT CAPSULE HEAT OF 1500 WATTS TO MAINTAIN CLAD TEMPERATURE OF $\leq 1450^\circ F$
- ALLOW FOR CAPSULE INSERTION ON THE PAD AND REMOVAL ON THE LUNAR SURFACE

SAFETY:
- CONTAIN FUEL TO GROUND IMPACT (RE-ENTRY ABORT) i.e., MAINTAIN FUEL CAPSULE INTEGRITY
- MINIMIZE RELEASE OF HAZARDOUS FUEL FOR ANY OTHER SYSTEM ABORT, e.g., LAUNCH VEHICLE EXPLOSION, FIREBALL, BURIAL, ETC.
GLPC DESIGN RESTRAINTS

- CYLINDRICAL SHAPE 8" OD x 23" LONG
- WEIGHT \leq 40 POUNDS WITH FUEL CAPSULE
- PAD COOLING TO \leq 350°F
- THERMAL OUTPUT \leq 1530 WATTS
- ATTACHMENT BAND LOADS TO 900 POUNDS
- DEPLOYMENT LOAD LIMITS
  - LOCKING SPLINE PULL 20 POUNDS
  - DOME ROTATION 80 IN.LBS.
GLPC ENVIRONMENTS

NORMAL OPERATION

- **SURFACE TEMPERATURE:**
  - AIR - 125°F TO 700°F
  - VACUUM - LESS THAN 835°F

- **CAPSULE TEMPERATURE:** 1450°F

- **DYNAMIC ENVIRONMENT:**
  - VIBRATION SINE 3G TO 100 HZ
  - RANDOM 0.15G²/M TO 2000 Hz
  - SHOCK 15 G
  - QUASISTATIC LOAD 60 G

PAD ABORT

- **BLEST:** 20% YIELD SIVB
  - STATIC OVERPRESSURE 525 PSI
  - STATIC IMPULSE 2.1 PSI SECONDS

- **FRAGMENTATION:**
  - SHEETS 1 IN² TO 200 FT² 300 FPS TO 3500 FPS
  - COMPONENTS 1 LB TO 200 LBS 100 FPS TO 300 FPS

- **FIREBALL:**
  - 5000°F MAX. TO 12 SECONDS
  - 1875°F AFTERFIRE FOR 1 HOUR

RE-ENTRY

- **EARTH ORBITAL:**
  - INITIAL VELOCITY 25,700 FPS
  - MAX. HEATING RATE 110 BTU/FT²-SEC
  - DURATION 6600 SECONDS

- **SUPERORBITAL:**
  - INITIAL VELOCITY 36,333 FPS
  - INITIAL 6-1/4° TO 36°
  - MAX. HEATING RATES
    - 6-1/4°-10° 480 BTU/FT²-SEC
    - 4-1/4°-10° 1900 BTU/FT²-SEC
  - DURATION
    - 6-1/4° - 170 SECONDS
    - 38° - 35 SECONDS

IMPACT

- **GLPC:** TERMINAL VELOCITY 300 FPS, TEMPERATURE OF PCA 1850°F
## GLPC MATERIALS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MATERIAL</th>
<th>COATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMARY HEAT SHIELD</td>
<td>PYROCARB 406</td>
<td>NONE</td>
</tr>
<tr>
<td>SECONDARY HEAT SHIELD</td>
<td>Be</td>
<td>Ag, Rh, RC-165</td>
</tr>
<tr>
<td>SHS ATTACHMENT RINGS</td>
<td>INCO X</td>
<td>Al₂O₃</td>
</tr>
<tr>
<td>SHS ATTACHMENT BOLTS</td>
<td>L 605</td>
<td>OXIDIZED</td>
</tr>
<tr>
<td>INSULATION</td>
<td>FIBERFRAX</td>
<td>NONE</td>
</tr>
<tr>
<td>LATCH FITTING</td>
<td>Ti</td>
<td>CARBONATE BATH</td>
</tr>
<tr>
<td>FORWARD CAPSULE SUPPORT</td>
<td>Ag, Ti, L-605, CKS 302</td>
<td>LITHOID</td>
</tr>
<tr>
<td>DOME COVER</td>
<td>Ti</td>
<td>NONE</td>
</tr>
<tr>
<td>CAPSULE/BACKPLATE</td>
<td>L-605</td>
<td>OXIDIZED</td>
</tr>
<tr>
<td>SPINE LOCK</td>
<td>Ti, Te, Al₂O₃</td>
<td>NONE</td>
</tr>
<tr>
<td>CAPSULE</td>
<td>L-605</td>
<td>RC-356</td>
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## GLPC WEIGHTS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MATERIAL</th>
<th>CALCULATED NOMINAL WEIGHT</th>
</tr>
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<tbody>
<tr>
<td>GRAPHITE PRIMARY SHIELD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CYLINDER</td>
<td>PYROCARB</td>
<td>7.90</td>
</tr>
<tr>
<td>END CAPS</td>
<td>PYROCARB</td>
<td>6.16</td>
</tr>
<tr>
<td>RETAINER</td>
<td>PYROCARB</td>
<td>.43</td>
</tr>
<tr>
<td>TOTAL GRAPHITE</td>
<td></td>
<td>14.49</td>
</tr>
<tr>
<td>SECONDARY SHIELD</td>
<td></td>
<td></td>
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<tr>
<td>CYLINDER</td>
<td>BERYLLIUM</td>
<td>5.62</td>
</tr>
<tr>
<td>COATINGS</td>
<td>Rh, Ag, Al61</td>
<td>.30</td>
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<tr>
<td>ATTACHMENTS</td>
<td>INOX, Ti L605</td>
<td>1.57</td>
</tr>
<tr>
<td>TOTAL SECONDARY SHIELD</td>
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<td>7.49</td>
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<tr>
<td>INSULATION</td>
<td></td>
<td></td>
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<tr>
<td>INSIDE END CAPS</td>
<td>FIBER-FRAX</td>
<td>.87</td>
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<tr>
<td>OTHER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LATCH FITTING</td>
<td>Ti</td>
<td>.98</td>
</tr>
<tr>
<td>FORWARD CAPSULE SUPPORT</td>
<td>Ti, L-605</td>
<td>1.27</td>
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<tr>
<td>DOME COVER</td>
<td>Ti</td>
<td>.43</td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td></td>
<td>25.54</td>
</tr>
<tr>
<td>CAPSULE/BACKPLATE</td>
<td>L-605</td>
<td>14.80</td>
</tr>
<tr>
<td>TOTAL WEIGHT RANGE</td>
<td></td>
<td>40.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38.89 TO 41.04</td>
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</table>

II-78
### SUMMARY OF ACTUAL CLPC WEIGHTS

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>PCA (LBS)</th>
<th>CLPC HARDWARE (LBS)</th>
<th>CLPC TOTAL W/PCA (LBS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUAL</td>
<td>14.8</td>
<td>25.55</td>
<td>40.35</td>
</tr>
<tr>
<td>FLIGHT 1</td>
<td>14.8</td>
<td>25.60</td>
<td>40.40</td>
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<tr>
<td>FLIGHT B/U</td>
<td>14.6</td>
<td>25.40</td>
<td>40.00</td>
</tr>
<tr>
<td>FLIGHT 2</td>
<td>14.7</td>
<td>24.85</td>
<td>39.55</td>
</tr>
<tr>
<td>FLIGHT 3</td>
<td>14.1</td>
<td>25.44</td>
<td>39.54</td>
</tr>
<tr>
<td>FLIGHT 4</td>
<td>14.4</td>
<td>25.00</td>
<td>39.40</td>
</tr>
</tbody>
</table>
PLY ORIENTATION - END CAP
CLPC/FCA RE-ENTRY PROGRAM

SAFETY CRITERIA
CONTAINMENT OF FUEL TO POINT OF GROUND IMPACT

ABORT REGIME
EARTH ORBITAL DECAY
ABORT IN TRANSLUNAR TRAJECTORY

6.25° - 38° DPH (MOST PROBABLE)
38° - 90° DPH (POSSIBLE)

ATTACHED TO LM TO POINT OF RELEASE
CASK EITHER SPINNING OR ORIENTED

PROGRAM
CHARACTERIZE MATERIALS/MATERIAL BEHAVIOR BY TEST
INCORPORATE MAXIMUM DESIGN CAPABILITY

FUEL CAPSULE TEMPERATURE < MELT
NO STRUCTURAL FAILURE OF GRAPHITE

ASSESS CLPC/FCA IN WORST (LIMIT) CASES
DETERMINE MOST REASONABLE RE-ENTRY CONDITIONS

LM CONFIGURATION
LM BREAK-UP
CLPC/SUPPORT STRUCTURE INTERACTIONS

GRAPHITE MATERIAL CHARACTERIZATION PROGRAM
ROOM TEMPERATURE - TO 4500°F
AS PLANE AND C DIRECTION

PROPERTIES
- TENSILE $\sigma$, $\varepsilon$
- SHEAR $\tau$
- FLEXURE $\tau$
- COMPRESSION $\sigma$, $\varepsilon$
- EXPANSION
- CONDUCTIVITY
- SPECIFIC HEAT
- ARC JET TESTS
- TUNNEL TESTS

- REFLECTOMETER TEST
- TOTAL HEMISPHERICAL TEST
- TOTAL CONDUCTIONS DEVELOPMENT
- WEIGHT LOSS TESTS
- OXIDIZED FLEXURE TESTS
- AIR, VACUUM STEADY STATE
- AND NON-STEADY STATE TESTS
- OF MATERIALS IN CONTACT
- REPRESENTATIVE SAMPLE
- DEVELOPMENT
- DENSITY GRADIENT TECHNIQUES
- PROCESS DEVELOPMENT FOR
- QC CONTROL

. STRENGTH FOR DESIGN ALLOWABLES
. THERMAL DATA FOR THERMAL
. STRESS CALCULATIONS
. ABLATION RECESSIOn CHARACTERISTICS
. FOR RE-ENTRY PERFORMANCE
. EMISSANCE PROPERTIES FOR THERMAL
. CONTROL
. OXIDATION PROPERTIES FOR ON-PAD
. AIR EXPOSURE
. COMPATIBILITY INFORMATION FOR
. DESIGN AND SAFETY INTEGRITY
. SPECIFICATIONS

II-82
RE-ENTRY SEQUENCE

PHASE I
LM Laterally Spinning or Oriented

PHASE II
LM/SS Separation
Oriented GLFC and Support Structure

PHASE III
SS/GLFC Separation
Laterally Oriented GLFC

EARTH
RE-ENTRY CASES EVALUATED

REFERENCE CASES
- FREE AND UNENCUMBERED GLFC

LIMIT CASES
- ULTRA-CONSERVATIVE
- GLFC FOLLOWS IN TRAJECTORY AFTER SEPARATION
- AUGMENTED HEATING (FACTOR OF 5)
- TWO CONDITIONS
  - MAXIMUM HEATING (GLFC IN ITS OWN FLOW)
  - THERMAL SHOCK (GLFC HEATING IS 0 TO POINT OF MAXIMUM LM HEATING)

MISSION ABORT CASES
- GLFC AND SS HEATING WHILE ON LM IN THE LM FLOW
- GLFC AND SS FOLLOW ITS OWN TRAJECTORY AFTER SEPARATION FROM LM
- GLFC FOLLOWS ITS OWN TRAJECTORY AFTER SS MELTS

GLFC WITHOUT HEAT SHIELD

RE-ENTRY MODES FOR ALL CASES
- SIDE-ON STAGNATED
- PLANAR TUMBLE
- SPIN
## TABLE P4-3. OLFC MISSION ABORT THERMAL RESULTS

<table>
<thead>
<tr>
<th>Summary Time</th>
<th>Graphite C-1</th>
<th>Graphite C-2</th>
<th>Bar/Heater M1</th>
<th>Therm.</th>
<th>Chord</th>
<th>Graphite Shield</th>
<th>Incident Power</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(°F)</td>
<td>(°F)</td>
<td>(°F)</td>
<td>(°F)</td>
<td></td>
<td>(°F)</td>
<td>(°F)</td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
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<td>150</td>
<td>1630</td>
<td>3000</td>
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<td>1630</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>687</td>
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<td>1630</td>
<td>3000</td>
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<td>1630</td>
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</tr>
<tr>
<td>3.0</td>
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<td>1630</td>
<td>3000</td>
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<td>3.5</td>
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<td>1630</td>
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<td>4.0</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
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</tr>
<tr>
<td>4.5</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>687</td>
<td>150</td>
<td>1630</td>
<td>3000</td>
<td></td>
<td>1630</td>
<td>3000</td>
<td></td>
</tr>
</tbody>
</table>

### Notes:
1. The two lower Alurom cases are similar to temperature because of the very short times for the GLFC/85 flight.
2. Barometric reference at lower portion of GLFC/85 flight.
3. Review all references and check for material from previous analysis.

## SNAP-27 SHIELD RECESSION HISTORY

- **1. Orbital Decay Reference Case**
- **2. Side-Stagnated**

![Graphite Temperature vs. Time](image)

**TIME FROM 400KFT - SEC**
MAXIMUM HEAT SHIELD ABLATION

- FREE GLFC (REFERENCE CASE)
  EARTH ORBITAL
  SIDE-ON STAGNATED
  ABLATION (INCHES)
  0.098

- LM TRAJECTORY (LIMIT CASE)
  EARTH ORBITAL
  SIDE-ON STAGNATED
  0.238
  (.141 AT MAXIMUM HEATING)

- MISSION ABORT CASE
  EARTH ORBITAL
  SIDE-ON STAGNATED
  < 0.098
CAPSULE/GLFC REMOVAL TEST
REWORKED EPSG - QUALIFICATION GLFC

LATCH FITTING I.D. VS. LATCH FITTING TEMP
BACKPLATE O.D. VS. BACKPLATE TEMP.
WITHDRAWAL FORCE VS. BACKPLATE TEMP.

A - BACKPLATE TEMP. FOR 30 POUND WITHDRAWAL FORCE
B - LATCH FITTING TEMP. FOR 30 POUND WITHDRAWAL FORCE
A' - BACKPLATE TEMP. FOR 19.5 POUND WITHDRAWAL FORCE
B' - LATCH FITTING TEMP. FOR 19.5 POUND WITHDRAWAL FORCE

DIAMETRAL CLEARANCE AT REAR SUPPORT

MAXIMUM DRAWING TOLERANCE
MINIMUM DRAWING TOLERANCE

TEMPERATURE - °F

WITHDRAWAL FORCE - POUNDS

TEMPERATURE - °F

BACKPLATE TEMPERATURE - °F
### Temperature Profiles

<table>
<thead>
<tr>
<th>ITEM</th>
<th>2 SUN OF</th>
<th>MAXIMUM POSSIBLE TEMPERATURE</th>
<th>DOME OFF -10 MIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Control Point</td>
<td>710</td>
<td>675</td>
<td>648</td>
</tr>
<tr>
<td>1. Latch Ring</td>
<td>734</td>
<td>705</td>
<td>683</td>
</tr>
<tr>
<td>2. Backplate</td>
<td>828</td>
<td>823</td>
<td>690</td>
</tr>
<tr>
<td>3. Capsule Dome</td>
<td>1420</td>
<td>1415</td>
<td>1392</td>
</tr>
<tr>
<td>4. Impact Ring</td>
<td>1136</td>
<td>1124</td>
<td>1083</td>
</tr>
</tbody>
</table>

### SNAP-27 GNC Anomaly Temperatures

<table>
<thead>
<tr>
<th>Row</th>
<th>2 SUNS LUNAR SURFACE</th>
<th>MAX. POSSIBLE TEMPERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row C</td>
<td>710 °F</td>
<td>675 °F</td>
</tr>
<tr>
<td>Row C'</td>
<td>797 °F</td>
<td>774 °F</td>
</tr>
<tr>
<td>Row D</td>
<td>807 °F</td>
<td>790 °F</td>
</tr>
<tr>
<td>Row E</td>
<td>712 °F</td>
<td>690 °F</td>
</tr>
<tr>
<td>Total Cylinder</td>
<td>756 °F</td>
<td>735 °F</td>
</tr>
</tbody>
</table>
SOLAR FLUX

SHIELD ORIGINAL SIZE, HAS BEEN REOULCED, HOWEVER CURRENT PROGRAM WILL ASSUME 2 DIAMETER SIZE AND USE 2 SUN HEAT FLUX INPUT.

FIGURE 2-4. WORST CASE CLFC LUNAR ENVIRONMENT
POTENTIAL PROBLEM AREAS OF CAPSULE REMOVAL

- Flight handling tool hangup
- Interference between backplate and latch fitting
- Movement of impact ring
- Interference between capsule and impact ring
<table>
<thead>
<tr>
<th>CAPSULE NO.</th>
<th>&quot;A&quot; DIA.</th>
<th>MIN A (DIA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUAL FCA #4</td>
<td>4.8501-4.8512</td>
<td>4.8554-4.8555</td>
</tr>
<tr>
<td>FL.T 2 FCA #2</td>
<td>4.8558-4.8570</td>
<td>4.8520-4.8525</td>
</tr>
<tr>
<td>BACKUP FCA #6</td>
<td>4.8838-4.88514</td>
<td>4.8500-4.8519</td>
</tr>
<tr>
<td>FL.T 3 FCA #7</td>
<td>4.8523-4.8536</td>
<td>4.8532</td>
</tr>
<tr>
<td>FL.T 4 FCA #8</td>
<td>4.8535-4.8540</td>
<td>4.8538</td>
</tr>
</tbody>
</table>
GLFC IMPACT TEST

IMPACT RESPONSE OF GLFC/CAPSULE

TEST CONDITIONS

Capsule temperature: equivalent re-entry
11,000 ft. altitude above terrain
Concrete target

DATA OBTAINED

Random tumbling mode
Terminal velocity = 295 fps
Maximum velocity = 304 fps
Capsule temperature at release = 1890°F
Caliche soil impact
GLFC BLAST TEST

PURPOSE

Realistic evaluation of blast capability
Comparison with analysis

TEST CONDITIONS

600 psi static overpressure
2.2 psi-sec impulse

TEST SPECIMEN

Actual GLFC
Actual Capsula heated
Simulated fuel
Fully instrumented
Bandix mount

TEST SET-UP

Shock tunnel
2 ft diameter
Pressurized to sea-level
C-4 plastic explosive

RESULTS

157 fps velocity
GLFC cylinder completely destroyed
SHS found 750 ft from tunnel
GLFC end caps essentially intact
FIG 7 GLFC OPERATIONAL TESTS ASTRONAUT SPACE SUIT TEMPERATURES
GLFC TEST PROGRAM - DEVELOPMENT TESTS

PYROCARB 406 CHARACTERIZATION
6 SERIES OF VIBRATION TEST (1 HOT) (MOST WITH BENDIX HARDWARE)
3 TEST SERIES AT BENDIX

T/V TESTS 4 DAYS
BENDIX T/V TESTS

GRAPHITE EMISSIVITY AND COATING

LITTON CHAMBER FUNCTIONAL TESTS

ASTRONAUT LIVE DEPLOYMENT TESTS

SPLINE LOCK/GRAFITE OXIDATION TESTS

SPLINE LOCK PULL TESTS

MATERIALS COMPATIBILITY TESTS

BERYLLIUM SHS COATING EMISSIVITY TESTS

GLFC SAFETY TESTS

• PAD ABORT TESTS
  SIVB BLAST TEST
  SIVB FRAGMENTATION TESTS

• RE-ENTRY
  DROP TEST (TO TERMINAL VELOCITY)
  Ames Ablation and Ti Band Tests

GLFC QUALIFICATION TESTS

• JOINT QUAL WITH BENDIX HARDWARE
  OA TEST
  AIR SOAK
  THERMAL VACUUM
  LAUNCH VIBRATION
  LUNAR DESCENT VIBRATION
  SHOCK
  TILT AND DEPLOYMENT

II-106
Addendum III
LASER RANGING RETRO-REFLECTOR EXPERIMENT

Presented by Dr. J. Faller
Wesleyan University
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Present Accuracy</th>
<th>1.5 H. Range Uncertainty</th>
<th>6.15 H. Range Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon Distance</td>
<td>500 M</td>
<td>230 M</td>
<td>35 M</td>
</tr>
<tr>
<td>Accuracy</td>
<td>1 x 10^{-7}</td>
<td>4 x 10^{-7}</td>
<td>6 x 10^{-7}</td>
</tr>
<tr>
<td>Angular Position of Moon with respect to Pergone</td>
<td>1 x 10^{-7}</td>
<td>4 x 10^{-7}</td>
<td>6 x 10^{-7}</td>
</tr>
<tr>
<td></td>
<td>5 x 10^{-7}</td>
<td>4 x 10^{-7}</td>
<td>6 x 10^{-7}</td>
</tr>
<tr>
<td>Time Necessary for close predictions of change of the Moon's position</td>
<td>25 years</td>
<td>4 year</td>
<td></td>
</tr>
</tbody>
</table>

4) Observing stations are assumed for periods longer than 1/2 year.

<table>
<thead>
<tr>
<th>Device</th>
<th>Present Accuracy</th>
<th>1.5 H. Range Uncertainty</th>
<th>6.15 H. Range Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidereal Parallaxes</td>
<td>1 x 10^{-9}</td>
<td>3 x 10^{-9}</td>
<td>5 x 10^{-9}</td>
</tr>
<tr>
<td></td>
<td>3 x 10^{-9}</td>
<td>4 x 10^{-9}</td>
<td>6 x 10^{-9}</td>
</tr>
<tr>
<td>Coordination of Retroreflectors with respect to Center of Moon</td>
<td>500 M</td>
<td>250 M</td>
<td>35 M</td>
</tr>
<tr>
<td></td>
<td>160 M</td>
<td>70 M</td>
<td>10 M</td>
</tr>
<tr>
<td></td>
<td>100 M</td>
<td>50 M</td>
<td>5 M</td>
</tr>
<tr>
<td>Quantity</td>
<td>Present Accuracy (ft)</td>
<td>1.5 M. Range Uncertainty</td>
<td>10 M. Range Uncertainty</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------</td>
<td>--------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Rotation Period of Earth</td>
<td>$5 \times 10^{-4}$ sec</td>
<td>$10 \times 10^{-4}$ sec</td>
<td>$1 \times 10^{-3}$ sec</td>
</tr>
<tr>
<td>Distance of Station from Axis of Rotation</td>
<td>10 M</td>
<td>3 M</td>
<td>0.3 M</td>
</tr>
<tr>
<td>Distance of Station from Equatorial Plane</td>
<td>30 M</td>
<td>3 M</td>
<td>0.3 M</td>
</tr>
<tr>
<td>Motion of the Pole</td>
<td>1 to 3 M</td>
<td>1.5 M</td>
<td>0.15 M</td>
</tr>
<tr>
<td>East-west Continental Drift Rate Observable in 3 years</td>
<td>30 to 60 m/yr</td>
<td>30 m/yr</td>
<td>3 m/yr</td>
</tr>
<tr>
<td>Time for Observing</td>
<td>Precise 10 m/yr</td>
<td>15 m/yr</td>
<td>1.5 m/yr</td>
</tr>
<tr>
<td>Drift of Hawaii, toward Japan</td>
<td>15 to 30 yr</td>
<td>15 yr</td>
<td>1.5 yr</td>
</tr>
</tbody>
</table>

* 2 or more observing stations are required
* Depending on latitude of station

---

![Graph showing intensity relative to initial intensity due to velocity variation in latitude.](image)

*Graph showing efficiency for fixed corner array for current reflection.**

*Graph showing efficiency for fixed laser corner reflector array.*

Corner Diameter (in) Inches
FIGURE 3 RELATIVE CEILAL TRAIFICATION AS A FUNCTION OF TEMPERATURE GRADEANCE LINEAR GRADIENT
Addendum IV
APOLLO LUNAR SURFACE DRILL

Presented by W. Britton
Martin - Marietta Company
OBJECTIVE -

(1) DRILL TWO (2) 1-1/8 INCH DIAMETER HOLES EACH TO A DEPTH OF 30 FEET IN SUPPORT OF HEAT FLOW EXPERIMENT (HFE)

(2) DRILL ONE 1-INCH DIAMETER HOLE TO A DEPTH OF EIGHT FEET TO OBTAIN SUB-SURFACE CORE SAMPLES.

PERFORMANCE REQUIREMENTS -

(1) STANDED ON ALBEE IN SIRC BAY IN TRANSIT
(2) DRILL TWO HOLES FOR HFE IN THIRTY MINUTES
(3) DRILL ONE HOLE FOR CORE SAMPLES IN TWENTY-FIVE MINUTES
(4) ALSO SHALL NOT EXCEED 31.0 POUNDS
(5) OPERABLE BY ONE ASTRONAUT UNDER 1/6-G ENVIRONMENT
(6) EXPOSED SURFACES OF ALSO SHALL NOT EXCEED 250°F

DESIGN REQUIREMENTS -

ELECTRICAL - PROVIDE SUFFICIENT ENERGY TO DRILL THREE SUB-SURFACE HOLES IN A LUNAR ENVIRONMENT.

ESTIMATED POWER REQUIREMENT = 150 WATT-HOURS
AVAILABLE POWER = 300 WATT-HOURS

THERMAL - WITHSTAND TRANS-LUNAR SIRC-RAY TEMPERATURES OF 20-160°F
OPERATE AT LUNAR SUN ANGLES OF 7 TO 45 DEGREES ABOVE THE HORIZON.
LOW TEMPERATURE DESIGN MARGIN (BATTERY) Δ = 30°F
HIGH TEMPERATURE DESIGN MARGIN (BATTERY) Δ = 35°F

MECHANICAL - WITHSTAND LAUNCH AND BOOST, AND LUNAR DESCENT MECHANICAL ENVIRONMENTS OF VIBRATION, SHOCK, AND ACCELERATION, QUAL. UNIT RECEIVED DOUBLE EXPOSURE TO QUAL-LEVEL ENVIRONMENTS INCLUDING SINE-SODAL VIBRATION,
DRILL THREE SUB-SURFACE HOLES IN A LUNAR ENVIRONMENT
QUAL. UNIT EXPOSED TO A COMPLETE DRILLING MISSIONS.
DEVELOPMENT (INITIAL CONTRACT)
- Faster head percussive energy
- Core bit optimization
- Core stem optimization
- HOLE CASING OPTIMIZATION
- Battery cells
- High & low temperature operation
- Vacuum operation
- Human engineering
- Final simulated lunar surface drilling (system level)
- Field tests (Death Valley & Bakersfield)

QUALIFICATION (INITIAL CONTRACT)
- Vibration (sineoidal & random)
- Shock
- Acceleration
- Electromagnetic interference
- Thermal-vacuum
- Simulated lunar surface operation (1/6-g & spacesuit)

DEVELOPMENT (MODIFICATION CONTRACT)
- Robo-filament/fiberglass bore stem test
- Bore bit tests
- Quick release adapter
- Simulated lunar surface drilling (system level)

QUALIFICATION (MODIFICATION CONTRACT)
- Vibration (sineoidal & random)
- Shock
- Operation in simulated lunar surface

ACCI (VAC.)
**APOLLO LUNAR SURFACE DRILL FLIGHT READINESS**

<table>
<thead>
<tr>
<th>DEMONSTRATED DESIGN MARINS</th>
<th>MISSION REQUIREMENTS</th>
<th>OVER-TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ENVIROMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIBRATION</td>
<td>1 EXPOSURE TO FLIGHT LEVEL</td>
<td>2 EXPOSURES TO QUALIFICATION LEVEL, 1 EXPOSURE TO FLIGHT LEVEL, PLUS LOW FREQUENCY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OVER-TESTS</td>
</tr>
<tr>
<td>THERMAL - VACUUM</td>
<td>1 EXPOSURE TO NOMINAL MISSION CYCLE</td>
<td>1 EXPOSURE TO HIGH THERMAL EXTREMES, 1 EXPOSURE TO LOW THERMAL EXTREMES, NON-PRESSURIZED POWER HEAD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OPERATION IN VACUUM.</td>
</tr>
</tbody>
</table>

| 2. DRILLING OPERATIONS     |                      |            |
| SYSTEM DEPLOYMENT          | 1 CYCLE              | 8-10 CYCLES |
| POWER HEAD                 | 20 MINUTES POWER-ON TIME | 120 MINUTES POWER-ON TIME |
| BATTERY                    | 150 WATT-HOURS       | 300 WATT-HOURS (AVAILABLE) |
| ROCK STEMS                 | 1 HOLE TO A 3-METER DEPTH | 4-6 HOLES TO A 3-METER DEPTH |
| CORE STEMS                 | 1 HOLE TO A 2-METER DEPTH | 4 HOLES TO A 24-METER DEPTH |
| DRILL BITS                 | 10-INCHES OF HARD ROCK DRILLING | 50-60 INCHES OF HARD ROCK DRILLING |
| ADAPTER                    | 10 CYCLES OF OPERATION | 50 CYCLES OF OPERATION |
Addendum V

HEAT FLOW EXPERIMENT

Presented by Dr. M. Langseth
Lamont Geological Observatory
<table>
<thead>
<tr>
<th>INITIAL TEMPERATURE</th>
<th>RADIOACTIVE ISOTOPE ABUND.</th>
<th>DEPTH TO FUSION</th>
<th>SURFACE HEAT FLOW (CAL x 10^9/cm^2/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLD 0°C</td>
<td>CHROMOSIC (88%) DIFFERENTIATED</td>
<td>560 km</td>
<td>2.75</td>
</tr>
<tr>
<td>COLD 0°C</td>
<td>TERTIARIAL (88%) DIFFERENTIATED</td>
<td>620 km</td>
<td>2.54</td>
</tr>
<tr>
<td>WARM 500°C</td>
<td>CHROMOSIC (88%) DIFFERENTIATED</td>
<td>480 km</td>
<td>3.71</td>
</tr>
<tr>
<td>WARM 500°C</td>
<td>CHROMOSIC UNDIFFERENTIATED</td>
<td>300 km</td>
<td>3.60</td>
</tr>
<tr>
<td>WARM 500°C</td>
<td>CHROMOSIC (98%) DIFFERENTIATED</td>
<td>NO FUSION</td>
<td>3.64</td>
</tr>
<tr>
<td>YOUNG 2 x 10^9</td>
<td>CHROMOSIC (88%) DIFFERENTIATED</td>
<td>280 km</td>
<td>5.21</td>
</tr>
</tbody>
</table>

**Abundances of radioactive isotopes in gram x 10^9/gram**

<table>
<thead>
<tr>
<th>Isotope</th>
<th>CHROMOSIC*</th>
<th>TERRESTRIAL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>1.062</td>
<td>3.067</td>
</tr>
<tr>
<td>39.6</td>
<td>0.079</td>
<td>0.022</td>
</tr>
<tr>
<td>38.7</td>
<td>4.4</td>
<td>11.43</td>
</tr>
<tr>
<td>44.6</td>
<td>9.42</td>
<td>3.48</td>
</tr>
</tbody>
</table>

* NAGNLOAD (1959)  
* ABDINANG (1964)

\[
HF_{DC} = -K \frac{dT}{dx}
\]
APOLLO LUNAR HEAT-FLOW EXPERIMENT
### Specifications for Resolution, Accuracy, and Stability of Measurements of the Heat Flow Experiment

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Temperature of Probe in Lower 1 Meter of Bore Hole</th>
<th>$\Delta T$ in Lower 1 Meter of Bore Hole</th>
<th>Temperature of Thermocouples in Upper 2 Meters of Bore Hole</th>
<th>Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>100 to 250 K</td>
<td>$\pm 30$ K</td>
<td>90 to 350 K</td>
<td>$5 \times 10^{-2}$ to $1 \times 10^{-4}$ cal/cm°-sec</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.1 K</td>
<td>$0.001$ K</td>
<td>$0.5$ K</td>
<td>$0.2$°</td>
</tr>
<tr>
<td>Accuracy</td>
<td>$0.1$ K</td>
<td>$0.003$ K</td>
<td>$0.5$ K</td>
<td></td>
</tr>
<tr>
<td>Stability</td>
<td>$0.1$ K/year</td>
<td>$0.003$ K/year</td>
<td>$0.5$ K/year</td>
<td></td>
</tr>
</tbody>
</table>
FIGURE 1  SCHEMATIC DIAGRAM OF PLATINUM RESISTANCE TEMPERATURE SENSOR

LEGEND:

- Minimum Required Signal
- Absolute Temperature Change, Element 2A
- Bridge Change at 233°F
- Bridge Change at 200°F

Changes are referred to measurements made on 7/5

Temperature Change - Millivolts

<table>
<thead>
<tr>
<th>Date</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/24</td>
<td>Fraility Test</td>
</tr>
<tr>
<td>7/5</td>
<td>Fluidity Test</td>
</tr>
<tr>
<td>7/6</td>
<td>Reference</td>
</tr>
<tr>
<td>7/8</td>
<td>Random Variation</td>
</tr>
<tr>
<td>7/10</td>
<td>Me-Jam of Drops</td>
</tr>
<tr>
<td>7/12</td>
<td>Acceleration</td>
</tr>
<tr>
<td>7/14</td>
<td>Thermal Shock</td>
</tr>
<tr>
<td>7/15</td>
<td>Random Variation</td>
</tr>
<tr>
<td>7/18</td>
<td>2g Sin</td>
</tr>
<tr>
<td>7/30</td>
<td>40g Sin</td>
</tr>
</tbody>
</table>

FIGURE 1  PLATINUM SENSOR 2A, 2B, 1A, & 1B PERFORMANCE - RESPONSE DATA
REFERENCE THERMOMETER

FIG. 2
LEGEN\D
T-14A, T-14C Without Electronics
T-27 are 2°C Gradient Tests
Others are 2°C Gradient Tests

PROTOTYPE MODEL ACCEPTANCE TEST SHORING RATIOS
HEAT FLOW BRIDGE CIRCUIT

Symbol    Loc
○ 1 Beads + N₂  (1.2 X 10⁻³ Cal/cm sec Cl
△ And. 1 Beads + He  (5 X 10⁻⁴ Cal/cm sec Cl

Time (Min)
0 50 100 150 200 250
BRIDGE PULSE EXCITATION

1 msec

Excitation

\[ V_0 = \frac{V^+ - V^-}{2} \]

\[ V_E = \frac{V^+_E - V^-_E}{2} \]

D.C. Offset is Cancelled
Each Sensor Sampled Every 7.2 Minutes

BLOCK DIAGRAM OF HEAT FLOW ELECTRONICS