R. Miley

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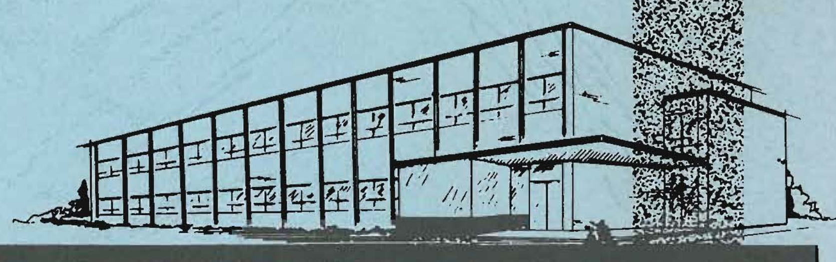
EXHIBIT B

ALSEP TECHNICAL SPECIFICATION

Contract NAS 9-5829



THE Bendix CORPORATION

BENDIX SYSTEMS DIVISION • ANN ARBOR MICHIGAN

EXHIBIT B

ALSEP TECHNICAL SPECIFICATION

Contract NAS 9-5829

March 10, 1966

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1.0 SCOPE

1.1 Scope. - This specification defines the performance interface, and design requirements for the Apollo Lunar Surface Experiment Package (ALSEP). This system will obtain long-term scientific measurements of various physical and environmental properties of the moon in keeping with the scientific objectives of the Apollo Program. This system includes a package of scientific experiments with their supporting subsystems which will be transported to the lunar surface aboard the Lunar Excursion Module (LEM). Communications and data interface will be established with the Manned Space Flight Network (MSFN), and each of the three packages will collect scientific data for a period of 1 year. The ALSEP structure will include provisions for carrying Lunar Geological Equipment (LGE) hand tools which will be used by the astronaut on the lunar surface. In addition, this specification will cover ground support equipment (GSE), test and handling equipment, and requisite training equipment associated with the ALSEP.

1.2 Associated equipment. - The ALSEP system shall be capable of operating in conjunction with the following equipment (which is not included as a part of this specification) in accordance with the interface requirements specified in paragraph 3.2.1 of this specification:

(a) Lunar Excursion Module (LEM), as defined by GAEC Specification LSD 470-1.

(b) Manned Space Flight Network (MSFN), as described by Document NASA SP-87.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents, of exact issue shown, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-E-5272C(1)	Environmental Testing, Aeronautical and Associated Equipment, General Specification for

MIL-W-6858C	Welding, Resistance, Aluminum, Magnesium, Non-hardening Steels or Alloys, Nickel Alloys, Heat-Resisting Alloys, and Titanium Alloys, Spot and Seam
MIL-I-26600 (2)	Interference Control Requirements, Aeronautical Equipment

STANDARDS

Military

MIL-STD-130B	Identification Marking of U. S. Military Property
MIL-STD-143A	Specification and Standards Order of Precedence for the Selection of
MIL-STD-810A	Environmental Test Methods for Aerospace and Ground Equipment
MS 24123A	Plate, Identification
MS 33586A	Metals, Definition of Dissimilar

DOCUMENTS

Interstate Commerce Commission

10CFR72	Shipping Regulations
49CFR71-78	Shipping Regulations

OTHER PUBLICATIONS

NASA

NPC 200-2	Quality Program Provisions for Space System Contractor

NPC 200-4	Quality Requirements for Hand Soldering of Electrical Connections
NPC 250-1	Reliability Program Provisions for Space Systems Contractors
NPC 500-1 18 May 1964	Apollo Configuration Management Manual as Amended by MSC Supplement #1, Revision B, dated 26 April 1965
MSC-ASPO-EMI-10A 17 October 1963	NASA Addendum to Specification MIL-I-26600
NASA SP-87	MSFN

Grumman Aircraft Engineering Corporation (GAEC) Documents

LED 520-1D 15 May 1965	Design Criteria and Environments for the LEM
LIS 360-22302	Environmental Conditions Induced by LEM on Scientific Equipment, Descent Stage
LSP470-1	Contract Technical Specification for Lunar Excursion Module System
LSP 360-11 11 February 1966	Scientific Equipment Performance and Interface Specifications
LIS 360-22102	Scientific Equipment Mass Properties
LID 360-22810	Scientific Equipment Containers Stowage and Removal (LEM Descent Stage)
LIS 360-22101 21 October 1965	LEM Scientific Equipment Materials Compatibility Requirements
LSP 390-8A 3 December 1965	Connectors, Miniature Circular, Electrical Power Subsystem Design Control Specifications

NASA/MSC Criteria and Standards

DS-21	Meteoroid Environment in Near-Earth, Cislunar, and Near-Lunar Space
DS-22	Flammability of Wire Bundles
DS-25	Wire Bundles - Protective Coatings
DS-1	System Accessibility for Maintenance
DS-3	Electrical Connectors - Keying
DS-4	Separation of Redundant Paths
DS-5	Transistors - Selection of Types
DS-7	Systems Checkout Provisions
DS-8	Mechanical Rigging Devices
DS-9	Protection of Spacecraft Electrical and Mechanical Systems from Debris
DS-12	Single Point Failures
DS-13	Electrical and Electronic Devices - Protection from Reverse Polarity and/or Other Improper Electrical Inputs
PS-2	Control of Time-Sensitive Components
PS-4 Rev B	Procurement Document Identification for Manned Space Flight Vehicle Items
PS-5	Protection of Electrical/Electronic Assemblies from Moisture Damage
PS-6	Ultrasonic Cleaning Electrical and Electronic Assemblies
PS-8	Application of Previous Qualification Tests

PS-9	Acceleration Recording Instruments-Shipment of Spacecraft and Related Equipment
PS-10	Protective Covers or Caps for Receptacles and Plug - Electrical
PS-11	Direct Procurement of Parts
PS-15	Explosive Devices - Shipping and Packaging Materials Restriction
PS-21	Identification Requirements - Explosive Devices

BENDIX INTERFACE SPECIFICATIONS

IC 314105	Suprethermal Ion Detector Experiment Interface
IC 314106	Passive Seismic Experiment Interface
IC 314108	Active Seismic Experiment Interface
IC 314109	Heat Flow Experiment Interface
IC 314110	GSE Interface
IC 314107	Electron/Proton Experiment Interface
IC 314103	Magnetometer Experiment Interface
IC 314104	Solar Wind Experiment Interface
IC 314114	Lunar Geological Equipment Interface

DRAWINGS

BSX 3171	RTG Fuel Cask Mounting to LEM
BSX 3125	Interface Control Drawing - Stowed Envelope - Magnetometer

3.0 REQUIREMENTS

3.1 Performance. - The following paragraphs establish the performance requirements of the ALSEP system, subsystems, and associated equipment. The ALSEP shall be designed to be compatible with the LEM vehicle requirements in accordance with GAEC Document LSP 360-11. The ALSEP Flight System shall not weigh more than 182 pounds. In this weight, there shall be provided 62 pounds allocation for experiments; 47 pounds allocation for GFE Radioisotope Thermoelectric Generator (RTG), RTG Fuel Cask, RTG Fuel Capsule and connecting cable; 3 pounds allocation for GAEC RTG Fuel Cask mounting structure. The remaining 70 pounds shall be the maximum allowable weight for all CFE ALSEP flight equipment including subsystems, experiments, interface provisions, ~~Lunar Geological Equipment (LGE) package and carrier~~, and all ALSEP mounting equipment required for ALSEP transportation in the Lunar Excursion Module (LEM).

47
62
109
73
182
28 LGE
210

3.1.1 Operational characteristics. - The ALSEP is a package of scientific instruments and supporting subsystems that will be transported to the moon aboard the LEM descent stage in two compartments of the scientific equipment (SEQ) bay. The ALSEP shall be capable of being placed on the lunar surface by the astronaut and of transmitting lunar geophysical and environmental information for a period of at least 1 year after scheduled departure of the spacecraft. In general, the ALSEP shall be self-sufficient; however, it is designed to permit the astronaut to provide optimum placement of various combinations of experiments, emplant sensors, and start operation. The ALSEP system includes the following subsystems as defined by the specified paragraphs of this specification: Electrical Power Subsystem (paragraph 3.4.1 herein); Data Subsystem (paragraph 3.4.2 herein); Structure/Thermal Subsystem (paragraph 3.4.3 herein); and LGE subsystem (paragraph 3.4.14 herein).

Specific combinations of experiment subsystems have been selected from the following:

(a) Magnetometer Experiment Subsystem* (paragraph 3.4.4. herein)

(b) Suprathermal Ion Detector Experiment Subsystem* (paragraph 3.4.5 herein)

(c) Heat Flow Experiment Subsystem* (paragraph 3.4.6 herein)

(d) Passive Seismic Experiment Subsystem* (paragraph 3.4.7 herein)

(e) Electron/Proton Experiment Subsystem (paragraph 3.4.8 herein)

(f) Active Seismic Experiment Subsystem (paragraph 3.4.9 herein)

(g) Solar Wind Experiment Subsystem* (paragraph 3.4.10 herein)

*GFE

Other equipment includes:

(a) GSE (paragraph 3.4.11 herein)

(b) Training Equipment (paragraph 3.4.12 herein)

(c) Other Equipment (paragraph 3.4.13 herein)

The ALSEP experiment complement shall consist of either of two arrays. Each experiment has been assigned to either or both arrays. Backup experiments have also been designated. These assignments (prescribed by NASA) are delineated in Table 1. The first two production flight ALSEP's shall have the Array A experiment complement. The next two production flight ALSEP's will have the Array B experiment complement. Within the weight, power, volume, and other constraints, additional experiments may be carried on any flight.

Table 1 - NASA Flight Assignments

	Array A	Array B	Array A Backup	Array B Backup
Magnetometer	x			x
Suprathermal Ion Detector	x	x		
Heat Flow		x	x	
Passive Seismometer	x	x		
Electron/Proton			x	x
Active Seismometer		x	x	
Solar Wind Detector and Proton Spectrometer	x			x

The associated ALSEP system functional block diagram is provided in Figure 1 for information only.

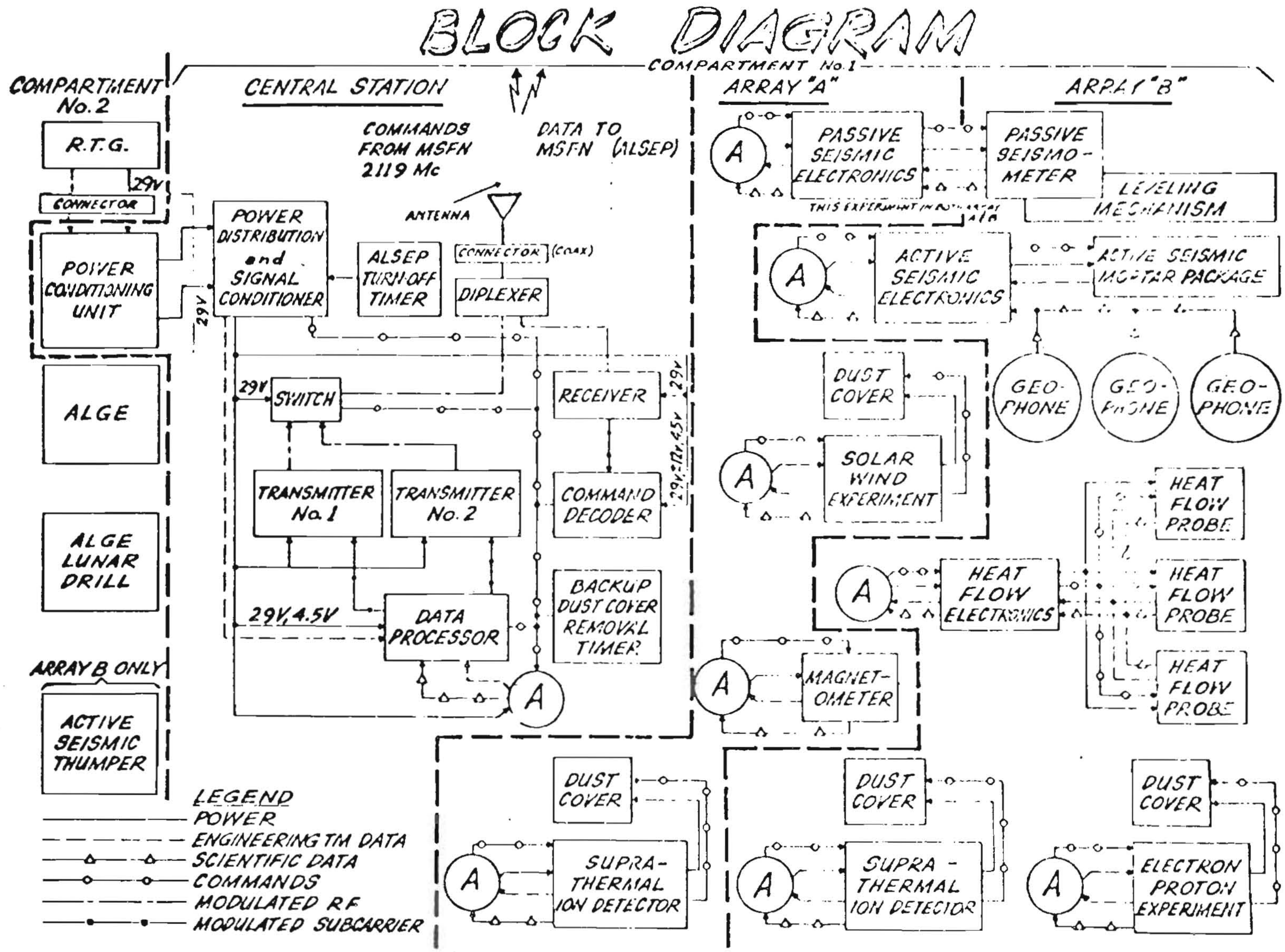

Figure 1. - System Functional Block Diagram

(FOR INFORMATION ONLY)

The ALSEP shall not interfere with the installation of the LEM descent stage SEQ bay thermal "door" prior to launch, the functional characteristics of the door during translunar flight, and the replacement of the door as part of ALSEP deployment.

The ALSEP shall be capable of transmitting 1060 bps to earth when operating with the 30 foot MSFN earth antenna and shall be capable of transmitting 10,600 bps to earth when operating with the 85 foot MSFN earth antenna. The data processor shall have the capability to format and process data to be transmitted at 530, 1060, and 10,600 bps. The calculated uplink probability of command error shall be less than 10^{-9}. The calculated probability of bit error on the downlink shall be less than 10^{-4}.

The uplink probability of accepting and delivering a correct command shall be no less than 0.999.

The system shall incorporate a fail-safe timer for automatic termination of ALSEP operation in the event of command link failure. The timer shall have a termination value of no less than 12 and no more than 13 months.

Provisions shall be included for turning the transmitter off and on by command from earth. When both transmitters are turned off by command the system shall include provisions for surviving the lunar environment.

3.1.1.1 Mission requirements. - The ALSEP shall be capable of being transported to the moon aboard the LEM, placed on the lunar surface by one astronaut, and remaining on the moon in a functioning status after the scheduled departure of the astronaut. Each ALSEP shall be capable of operating in accordance with the specified performance requirements without interference at MSFN while up to two other ALSEPs are operating. ALSEP communication operation shall not interfere with Apollo communications.

3.1.1.2 Prelaunch operations. - Installation of the ALSEP in LEM shall take place in the MSOB (with the exception of placing the Radioisotope Thermoelectric Generator (RTG) fuel capsule into the RTG fuel cask) as further defined in paragraph 3.1.2.2.1 herein.

There will be no checkout of ALSEP after its installation into the LEM. Prelaunch operations cooling will be provided by NASA for the removal of heat generated by the RTG fuel cask while in the Spacecraft LEM Adapter (SLA).

3.1.1.3 Translunar flight. - The ALSEP system shall be inoperative during flight to the moon. The rejection of RTG fuel cask heat after launch shall be primarily by radiation, such that not more than 100 BTU/hour is transmitted directly to the LEM. There shall be no necessity for checkout or servicing of ALSEP equipment aboard the LEM during this phase of flight.

3.1.1.4 Lunar surface operation. - The ALSEP system shall be capable of being extracted from the LEM, assembled, deployed, and checked out by one member of the flight crew in accordance with the specific performance requirements of this specification and the human factors requirements of paragraph 3.1.2.6 herein. LEM thermal integrity shall be ensured following ALSEP removal by replacing the thermal shield of the SEQ bay.

3.1.1.4.1 Unloading from LEM. - Adequate means shall be provided to permit the unloading of the ALSEP to the lunar surface by the astronaut. The ALSEP shall permit removal of LGE separately or integrally with the ALSEP.

Design shall provide for independent extraction, deployment, and use of the Lunar Geological Equipment (LGE) on the lunar surface. The ALSEP shall be designed to be withdrawn from the LEM Descent Stage scientific equipment compartments in accordance with referenced Interface Control Specifications on GAEC Document LID 360-22810. All extraction and deployment of ALSEP, RTG, and experiments shall be capable of being accomplished by handcarry methods.

3.1.1.4.2 RTG fueling. - During ALSEP/LGE unloading, a thermal barrier shall be provided between the fuel cask and the astronaut. A special tool shall be provided for use after unloading the ALSEP to allow the astronaut to transfer the fuel capsule from the cask to the RTG. The ALSEP shall be designed to provide protection to the crew from the thermal hazard involved in the removal and handling of the RTG fuel cask and deployment of the hot RTG.

3.1.1.4.3 Surface transportation. - The ALSEP (either with the LGE or separately) shall be capable of being transported to the point of emplacement by the handle grips, and also by use of a bar to which the two parts of ALSEP are attached.

3.1.1.4.4 <u>ALSEP deployment.</u> - The ALSEP shall be designed in such a manner that deployment and setup time shall be less than 90 minutes as a goal. Deployment and setup is defined as extraction of the ALSEP from the LEM, transportation and setup of the experiments, and return of the crew member to the LEM (exclusive of drilling).

In the developed configuration the ALSEP shall consist of the central station, the RTG power supply in close proximity and the emplaced experiments. The central station is defined as the data subsystem including supporting structure and thermal control, the power conditioning unit including supporting structure and thermal control, all interconnecting cables between the central station and the nearest element of each emplaced experiment and the experiment tie-down structure. A volume of approximately 7" x 5" x 2" shall be allocated for experiment electronics which can be packaged more effectively in the central station. These experiment electronics are not, however, a part of the central station.

The deployment sequence and distance shall be no less than 300 feet and shall always be within the time limit as defined by Figure 2 herein. The design of ALSEP shall ensure reception of data in the case of partial deployment of experiments.

3.1.1.4.5 <u>Lunar location.</u> - The ALSEP shall be designed to operate when transmitting from a lunar location of $\pm 5^{\circ}$ from the equator and $\pm 45^{\circ}$ from the prime meridian on the earth side.

3.1.1.4.6 <u>MSFN.</u> - The MSFN will be utilized for receiving ALSEP data and for transmitting ALSEP commands. The MSFN system will maintain communications, receive and record data transmitted to earth from each ALSEP. Frequency allocations will be made within the band of 2275 to 2280 mcs for ALSEP down-link. The up-link for ALSEP command shall be established on 2119 mcs. The MSFN will be capable of simultaneous reception and handling of data from a maximum of three different ALSEPs operating from the Apollo landing area. Data transmitted from the ALSEP will be received by the MSFN 30-foot diameter parabolic antennas and recorded at the MSFN ground stations. An 85-foot antenna will be made available on special request for unique transmission requirements. This arrangement will be made compatible with Apollo operations. Existing MSFN 10 KW command transmitters will be utilized. Where applicable, the requirements of NASA SP-87 shall apply.

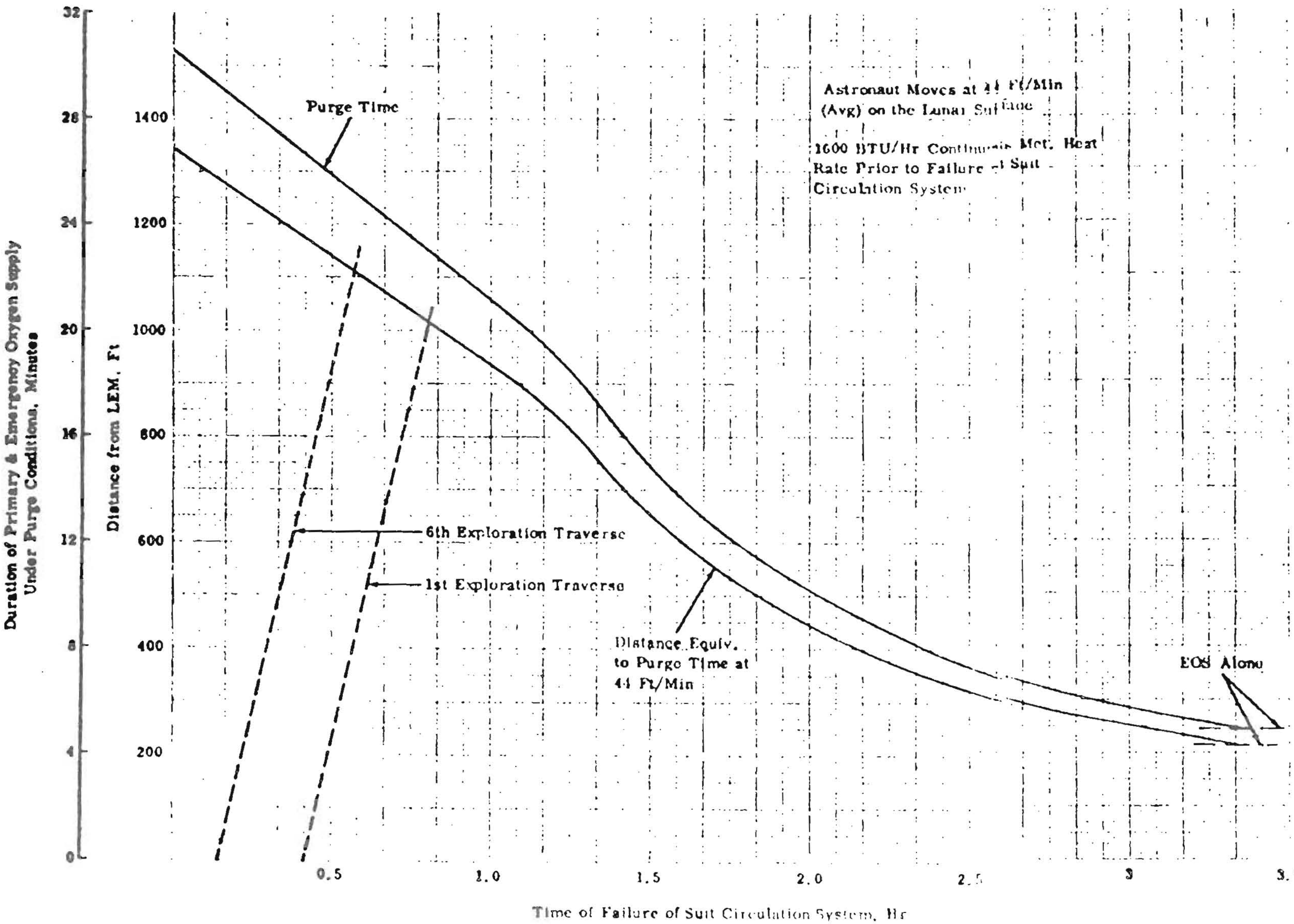

Figure 2. - EXPLORATION RADIUS CONSTRAINTS

3.1.1.5 Test level and sequence. - All functional testing shall provide identification of a failure to the replaceable component level of equipment. Unless otherwise specified, the qualification test sequences shall conform to the test sequence for aerospace and ground equipment in Standard MIL-STD-810.

3.1.1.6 Performance verification. - Each experiment's performance shall be verified with a two point (data levels) verification test during system acceptance test, system prelaunch (KSC) test, and on the lunar surface prior to lunar operation. The implementation of these three tests shall be identical. The implementation shall excite the sensor, if possible; if not possible, excitation shall be applied as close to the sensor as possible.

3.1.1.7 Engineering status data. - The ALSEP shall provide engineering data capable of being used for failure analysis and operational status evaluation.

3.1.1.8 Dust accretion. - The ALSEP shall provide a measurement of lunar dust accretion over the ALSEP as an engineering status measurement.

3.1.1.9 Thermal surface degradation. - The ALSEP shall provide the thermal control necessary for successful ALSEP performance when radiative properties of surfaces exposed to radiation are altered by a 100 percent dust cover or degraded due a one year exposure to ultraviolet radiation and vacuum.

3.1.2 Operability.

3.1.2.1 Reliability. - The ALSEP shall have as a design goal an overall reliability of 0.90 for a 1 year lunar operation. Reliability shall be a prime consideration in design, development, and fabrication (see paragraph 6.2 herein). Redundancy will be utilized in achieving both the reliability and crew safety goals. The design will provide maximum resistance to single point catastrophic failures. As a goal, the ALSEP subsystems shall have the following probability of surviving launch, translunar flight, and lunar surface operation (including deployment) in the environment specified in paragraph 3.1.2.4 herein. These subsystem probability goals are predicated on an operating life of 1 year. However, specific operating life periods for the various experiment subsystems shall be as specified in the applicable subparagraphs of paragraph 3.2.2 herein.

The requirements of DS-12, DS-4, DS-9, and DS-25 shall apply.

(a) Electrical power subsystem, 0.99

(b) Data subsystem, 0.9642

(c) Structure/thermal subsystem, 0.9997

(d) Magnetometer experiment subsystem, 0.99

(e) Suprathermal ion detector experiment subsystem, 0.99

(f) Heat flow experiment subsystem, 0.99

(g) Passive seismic experiment subsystem, 0.99

(h) Electron/proton experiment subsystem, 0.99

(i) Active seismic experiment subsystem, 0.99

(j) Solar wind experiment subsystem, 0.99

3.1.2.2 Maintainability. - Equipment arrangements, accessibility, and interchangeability features shall be incorporated into the design to allow efficient preflight servicing and maintenance. Equipment checkout, field maintenance and replacement of ALSEP experiments and other subsystems shall be performed at the component level.

3.1.2.2.1 Service and access. - The RTG fuel cask shall be accessible on the launch pad for RTG fuel capsule loading operations. The cask mounting on LEM shall permit insertion of the RTG fuel capsule at any time prior to removal of the LEM work platforms. No special platforms shall be required for ALSEP. Installation in LEM shall be accomplished by means of a mechanical GSE fixture which provides alignment and support. The requirements of Documents DS-1 and DS-8 shall apply. After installation, no prelaunch servicing shall be required. The requirements of DS-1 shall apply.

3.1.2.3 Useful life. - The ALSEP shall perform as specified herein during all phases of lunar day and night for a period of no less than 1 year. Individual useful life requirements for the various experiments shall be as specified in the appropriate subparagraphs of paragraph 3.4 herein. The requirements of PS-2 shall apply.

3.1.2.4 Environment requirements. - The ALSEP shall be capable of successfully performing the required mission during or after, as applicable, being subjected to the most severe environmental conditions shown herein or any logical combination of these environments applied simultaneously. The most severe environment values shown herein are minimum design requirements. Testing shall be in accordance with MIL-E-5272C(1) and MIL-STD-810A, as applicable.

3.1.2.4.1 Mission environment phases. - The mission is divided into seven phases for the purposes of defining the environmental conditions. These phases and the environments expected for each are shown in Table II.

3.1.2.4.2 Induced environments. - Documents LIS 360-22302 and LED 520-1D; shall apply.

3.1.2.4.3 Lunar surface environment. - The lunar surface environment shall be as defined by Document LED 520-1D; however, the meteoroid environment shall be as defined in Document DS-21.

3.1.2.4.4 Special environments. - Deployment of the suprathermal ion detector experiment on the lunar surface relative to other ALSEP equipments shall be such that at its location the contaminant static electric field is less than 0.01 gauss. The system and the collective subsystems shall not produce a magnetic field at the magnetometer deployed location greater than 0.25 gamma. The magnetometer sensors shall not be exposed to a magnetic field greater than 1.0 gauss from the time of fabrication to the time of deployment.

Table II. - ALSEP System Environments

Environment Considered	Storage Unpackaged	Storage Packaged	Movement to the Pad	Factory & Assembly Bldg. Checkout	Launch Pad Environment	Flight	Lunar Operations
Humidity	15 to 50% relative	N/A (applied to Pkg.)	15 to 100% relative	Max. 50%	Max. 50%	N/A	N/A
Rain	N/A	N/A " " "	N/A	N/A	N/A	N/A	N/A
Salt-Spray	N/A	N/A " " "	N/A	N/A	N/A	N/A	N/A
Sand and Dust	N/A	N/A " " "	N/A	N/A	N/A	N/A	*
Fungus	N/A	N/A " " "	N/A	N/A	N/A	N/A	N/A
Ozone	N/A	N/A " " "	N/A	N/A	N/A	N/A	N/A
Hazardous Gases	N/A	N/A " " "	N/A	N/A	N/A	N/A	N/A
E. M. I.	N/A	N/A " " "	N/A	LEM Std.	LEM Std.	N/A	3. 3. 9 herein
Acceleration	1.0 g thru axis	2.67 g Vert. with 1 g lateral	1.0 g Vert.	N/A	N/A	5 g's	N/A
Vibration	N/A	*	*	N/A	N/A	GAEC LIS-360-23302	N/A
Shock	*	*	*	N/A	N/A	*	12 inch free fall onto a hard surface under * lunar gravity
Temperature	-20° to $+110^{\circ}F$	$-65^{\circ}F$ to $160^{\circ}F$	-20° to $+110^{\circ}F$	$+50^{\circ}F$ to $+100^{\circ}F$	$+50^{\circ}F$ to $100^{\circ}F$	$0^{\circ}F$ to $160^{\circ}F$	
Radiation	N/A	N/A	N/A	Negligible	Negligible	Less than lunar opn's.	*
Solar Radiation	360 BTU/ft^2hr. 6 hr/day	N/A	N/A	N/A	N/A	N/A	*
Meteoroids	N/A	N/A	N/A	N/A	N/A	N/A	**
Pressure	Ambient	Sea level to 50,000 ft.	Ambient	Ambient	Ambient	$<1 \times 10^{-8}$ m.m. H. g	*
Acoustics	N/A	N/A	N/A	N/A	N/A	*	N/A

* Document LED 520-1D

**The ALSEP contractor shall be responsible for incorporating micro-meteoroid protection into the ALSEP design in accordance with DS-2

3.1.2.5 Ground handling and transportability. - Full design recognition shall be given to the durability requirements of ALSEP equipment and subsystems during preflight preparation. However, special packaging and transportation methods shall be used including special containers and the monitoring of transportation environment. Real time recording of critical environments shall be provided. Design requirements for the containers shall be as defined by LED 520-1D. The requirements of PS-9 shall apply.

3.1.2.6 Human factors. - The human factors requirements for the ALSEP system shall include selection of a suitable location for placement of the ALSEP on the lunar surface. The crew will also perform requisite tasks such as assembly, deployment of sensors, unloading, RTG fueling, erection and pointing of the antenna, activation and checkout of the ALSEP and manual adjustments. These tasks shall be time phased with other crew tasks and shall recognize the limitations in mobility and dexterity imposed by the current extra-vehicular mobility unit (EMU). ALSEP mechanisms and connectors for attachments and deployment shall be designed for maximum compatibility with crew and EMU capabilities.

3.1.2.6.1 Deployment of experiments. - Human factors requirements for deployment of experiments will be defined in the applicable interface documents.

3.1.2.6.2 System deployment and activation. - The ALSEP design shall allow the following tasks to be performed:

(a) Electrical connection of RTG and central station

(b) Emplacement and orientation of data subsystem and erection of sunshade.

(c) Electrical connection, erection, and pointing of the antenna.

(d) Turn-on the command receiver and command decoder. In the normal operating mode the astronaut will (1) turn on the command receiver and decoder, (2) initialize all logic circuitry and (3) set the experiments to a ready condition. Further activation of the system will be commanded from the earth. Three easily accessible switches shall be provided to accomplish these functions. There shall be a visual indication of the power-on condition.

An additional switch shall be provided which will permit astronaut activation of the entire ALSEP system, including initiation of the transmitter and experiments, in the event of command link failure.

3.1.2.7 Safety. - Safety requirements shall comply with the limitations of the suited astronaut and the following:

3.1.2.7.1 Personnel safety. - The safety of the crew while unloading, transporting, and deploying the equipment on the lunar surface and of personnel while handling the equipment on earth shall be a prime consideration in ALSEP design. This shall include avoidance in equipment design of sharp edges, corners, and protuberances. Inherent protection of personnel from inadvertent contact with high temperature surfaces and hazardous electrical points shall be provided.

3.1.2.7.2 Equipment safety. - Where practicable, the various components shall be hermetically sealed or of explosion-proof construction. The Apollo Standard Initiator (ASI) shall be the only type of pyrotechnic electrical initiator used in the ALSEP design.

3.1.2.7.3 Hazard proofing. - The design of the ALSEP shall minimize the hazard of fire, explosion and toxicity to the crew, launch area personnel and facilities. The hazards to be avoided include accumulation or leakage of combustible gases, the hazard of spark or ignition sources including static electricity discharge, and toxicity due to inhalation or spillage of volatile or poisonous expendables. The requirements of DS-22 shall apply.

3.1.2.7.4 Nuclear safety criteria. - The primary nuclear safety criteria shall be:

Procedures which will be used in the manufacture, storage, transportation, and ground handling of the fuel capsule shall conform to the applicable AEC, state, and local regulations covering such operations, in particular, Regulations 10CFR72 and 49CFE71-78.

3.1.2.7.5 Fail safe. - Part, component, or subsystem failures shall not propagate sequentially. The requirements of DS-12 shall apply. With occurrence of failure, operation will be maintained in a preferred mode.

3.2 Interface requirements. -

3.2.1 System interface requirements. -

3.2.1.1 LEM spacecraft/ALSEP interface. - The ALSEP will be transported to the moon aboard the LEM vehicle in two specially provided compartments in the SEQ Bay of the LEM descent stage. The description of these compartments shall be as defined by Document LID-360-22810. They provide a volume of approximately 15 cubic feet. Depending on the manner in which the LEM lands on the moon, the lower edges of these compartments can be 18 inches to 60 inches above the lunar surface.

3.2.1.2 Other interfaces. - The ALSEP shall also interface with KSC for prelaunch checkout and installation as defined in paragraph 3.1.1.2 herein. The characteristics of the MSFN interface shall be as defined in paragraph 3.1.1.4.6 herein. The astronaut interface shall be as defined in paragraph 3.1.2.6 herein.

3.2.2 Subsystem interface requirements. -

3.2.2.1 Electrical power subsystem interface definition. - In transit and when deployed on the lunar surface the RTG shall be mounted on a multipurpose pallet. The PCU shall be located within the central station electronics compartment and will be electrically interconnected to the RTG at the deployment site. Thermal control of the PCP shall be provided by the central station.

3.2.2.1.1 Mechanical interface. - The fuel cask shall be located outside the ALSEP envelope, between LEM and the SLA. It shall be vertically oriented with the top and bottom of the cask barrel attached to a special mounting frame which in turn is fastened to LEM. Means shall be provided for rotation of the cask thermal insulation to protect the astronaut during ALSEP unloading from the hot cask. Means shall also be provided for rotating the cask to permit direct access to the fuel capsule for transfer to the RTG. The RTG fuel cask shall be mounted to the LEM Descent Stage in conformance with Drawing BSX 3171, Figure 3, herein.

3.2.2.1.2 Thermal interface. - The RTG fuel cask induced thermal conditions on LEM shall be in accordance with the requirements defined in paragraph 3.1.1.3 herein.

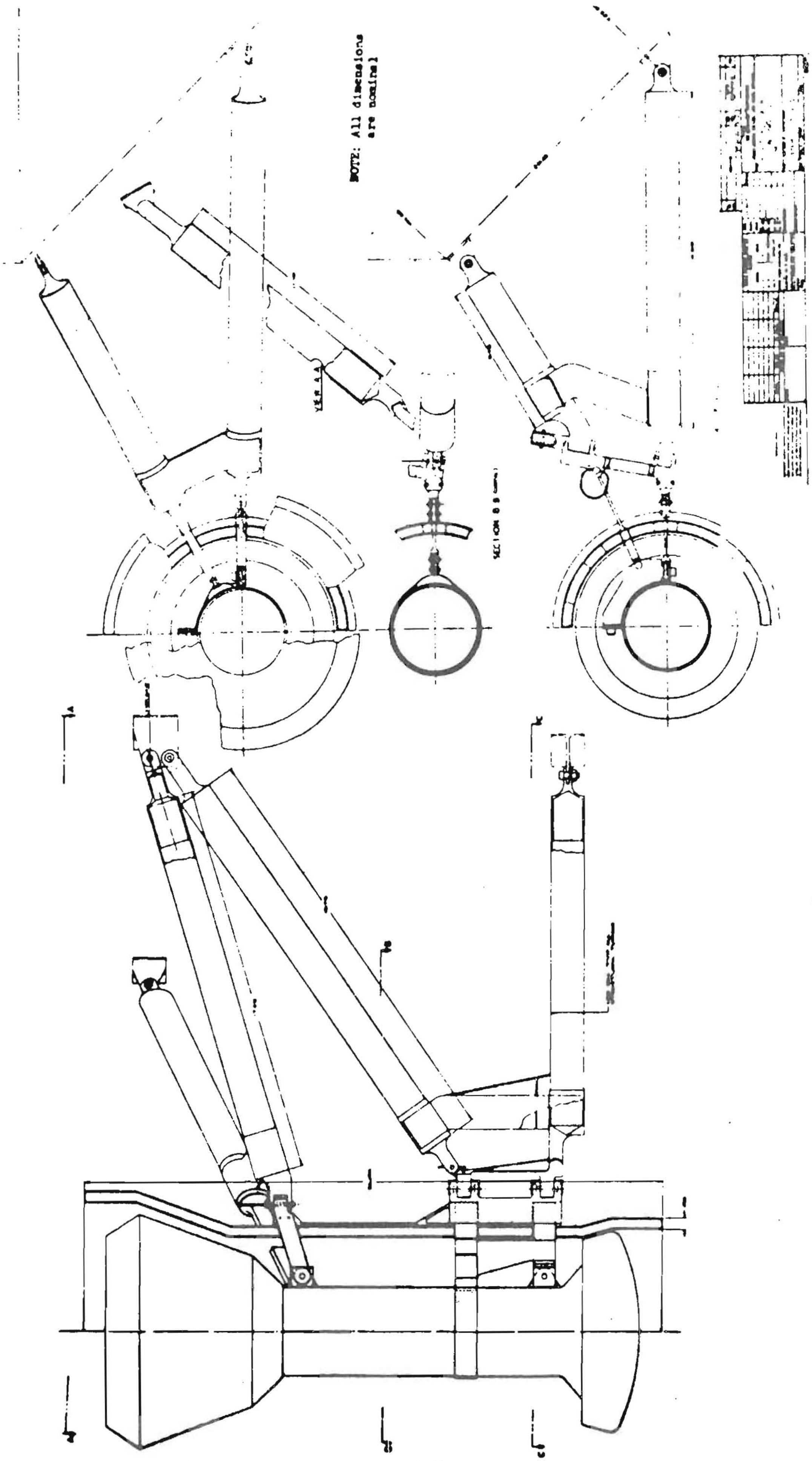

Figure 3 - RTG Cask Mounting

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3.2.2.1.3 Electrical interface. - At the interface between the electrical power subsystem and the data subsystem, the ALSEP shall provide:

(a) A capability of 12 items of engineering status information for which the signal conditioning is performed in the data subsystem.

(b) A capability of five sources of power and a ground return, as follows:

+29V unregulated
+29V ± 1 percent
+12V ± 1 percent
-12V ± 1 percent
+4.5V ± 1 percent

3.2.2.1.4 RTG/PCU interface. - The interface between the RTG and PCU shall be at the connector between the RTG cable and the central station. The RTG output power to the PCU shall be no less than 56 watts at 14 vdc nominal.

3.2.2.2 Data Subsystem interface definition. -

3.2.2.2.1 Mechanical interface. - The data subsystem electronics shall mechanically interface only with the thermal plate, which in turn interfaces with the structure subsystem.

3.2.2.2.2 Electrical interface. -

3.2.2.2.2.1 Data subsystem/experiment(s) interface. - The data subsystem/experiment electrical interface shall be as shown in the applicable subparagraphs of paragraphs 3.2.2 herein.

The command decoder and circuitry control devices shall be set to initial safe conditions before experiment activation.

3.2.2.2.2.1.1 Digital data. - Digital data shall be taken from the experiment in 10-bit words at the time specified by the telemetry format. Control and timing signals in the form of a demand line and shift pulse line shall be supplied by the data subsystem to synchronize the data to the data subsystem timing.

3.2.2.2.2.1.2 Engineering status measurements. - The data subsystem shall accept analog status information in the range of 0.0 to 5.0 volts and shall provide 8 bit analog to digital conversion of these signals.

3.2.2.2.2.1.3 Control timing lines. - The control and timing lines shall be supplied to the experiments for internal control and data synchronization.

3.2.2.2.2.1.4 Power sources. - Experiment prime power sources available at the central station shall be controlled by the data subsystem and shall be:

(a) Experiment prime power source: +29V ± 1 percent

(b) Thermal control power source: +29V

(c) Ground: for +29V return

3.2.2.2.2.1.5 Commands. - Each experiment shall be supplied with the appropriate commands indicated in the applicable subparagraphs of paragraph 3.4 herein.

3.2.2.2.3 Data subsystem/structure/thermal subsystem interface. - The data subsystem shall provide for monitoring up to 26 temperature status measurements from the central station exclusive of PCU. The data subsystem shall provide five power lines for central station heater control, each line capable of being switched by earth command. Each line shall provide +29V at 3.0 watts maximum.

3.2.2.3 Magnetometer experiment interface definition. - The magnetometer experiment subsystem consists of a 3 axis flux gate magnetometer which shall measure the gradient of the lunar magnetic field at one point and the temporal variations in the three components of the lunar magnetic field. It shall process this information and provide it in the form of digital data to the data subsystem.

3.2.2.3.1 Telemetry. - Telemetry rate for the magnetometer experiment subsystem shall be a nominal 90 bps (average). The magnetometer shall, upon receipt of a demand pulse, shift out one 10-bit word of digital data from each of the three sensors, at a rate of 1060 bits per second. The magnetometer shall store the data until demand pulses are received from the data processor. The intervals between demand pulses shall be such that three data words from one scientific measurement are cleared before the next measurement. Additional provisions shall be made for shifting out seven 10-bit data words for engineering status data. The magnetometer shift register shall produce a 4.5V ± 0.5 signal for a logic "1" and a 0.2V ± 0.1V signal for a logic "0". This register shall have an output impedance of less than 1000 ohms.

3.2.2.3.1.1 Synchronizing pulses. - The magnetometer shall be provided with the following synchronizing pulses.

(a) Data frame synchronizing pulses. A pulse shall be transmitted to the magnetometer at the beginning of each telemetry frame (53/32 pulses per second). This pulse shall have an amplitude of 4.5V ± 0.5V and a width of 120 milliseconds. These pulses shall be applied to an impedance no less than 10 K ohms.

(b) Data clock pulses. A continuous square wave having a frequency of 1060 pulses per second shall be provided to the magnetometer. These pulses shall have an amplitude of 4.5 ± 0.5V and shall be applied to an impedance no less than 10 K ohms.

(c) Demand pulses. A data demand pulse shall be provided for each 10-bit word. These pulses shall be provided on two lines, one to demand scientific data and the other to demand engineering status data. These pulses shall have an amplitude of 4.5V ± 0.5V and width equal to one telemetry word (approximately 0.01 second). The input impedance shall be no less than 10 K ohms to these pulses.

3.2.2.3.1.2 Earth commands. - ALSEP shall provide a capability for 8 separate commands from earth to the magnetometer. Each of these commands shall be of a pulse type. The command pulse shall have an amplitude of 4.5V ± 0.5V and a width of 20 milliseconds. The input impedance of the magnetometer for each of these commands shall be no less than 10 K ohms.

3.2.2.3.2 Interconnecting cable. - The magnetometer shall be electrically connected to the central station by a cable capable of being deployed to no more than 50 feet. This cable shall be stowed within the envelope specified in paragraph 3.2.2.3.4 herein.

3.2.2.3.3 Thermal control. - The magnetometer subsystem shall provide its own thermal control.

3.2.2.3.4 Size and form factor. - The magnetometer experiment subsystem shall have a space requirement not to exceed that defined in Drawing BSX 3125, Figure 4, herein.

3.2.2.3.5 Weight. - The magnetometer experiment shall weigh no more than 14.5 pounds exclusive of the interconnecting cable which shall weigh no more than 0.5 pound.

3.2.2.3.6 Power. - Power requirements shall be no more than 2.9 watts operating during lunar day plus no more than 0.6 watts for thermal control during lunar night; an additional 3.5 watts shall be required for "flipping" every 12 hours (time share basis). The peak power shall be no more than 7.0 watts.

3.2.2.3.7 Experiment useful life. -

3.2.2.3.7.1 Mission operating time. - The mission operating time for the magnetometer experiment shall be 1 year.

3.2.2.4 Suprathermal ion detector experiment interface. - The experiment consists of the basic experiment, leveling structures, mounting structure, thermal control surfaces, thermal insulation, cabling, cable storage areas, dust cover, and groundplane. The basic experiment shall be capable of detecting positive ions in the cold lunar ionosphere as well as those introduced by the raw and thermalized solar wind. The experiment shall provide for analysis of the flux, energy, and velocity of these positive ions. The experiment data shall also enable conclusions to be drawn regarding the composition of the low energy portion of the ion spectrum and ambient electric field effects.

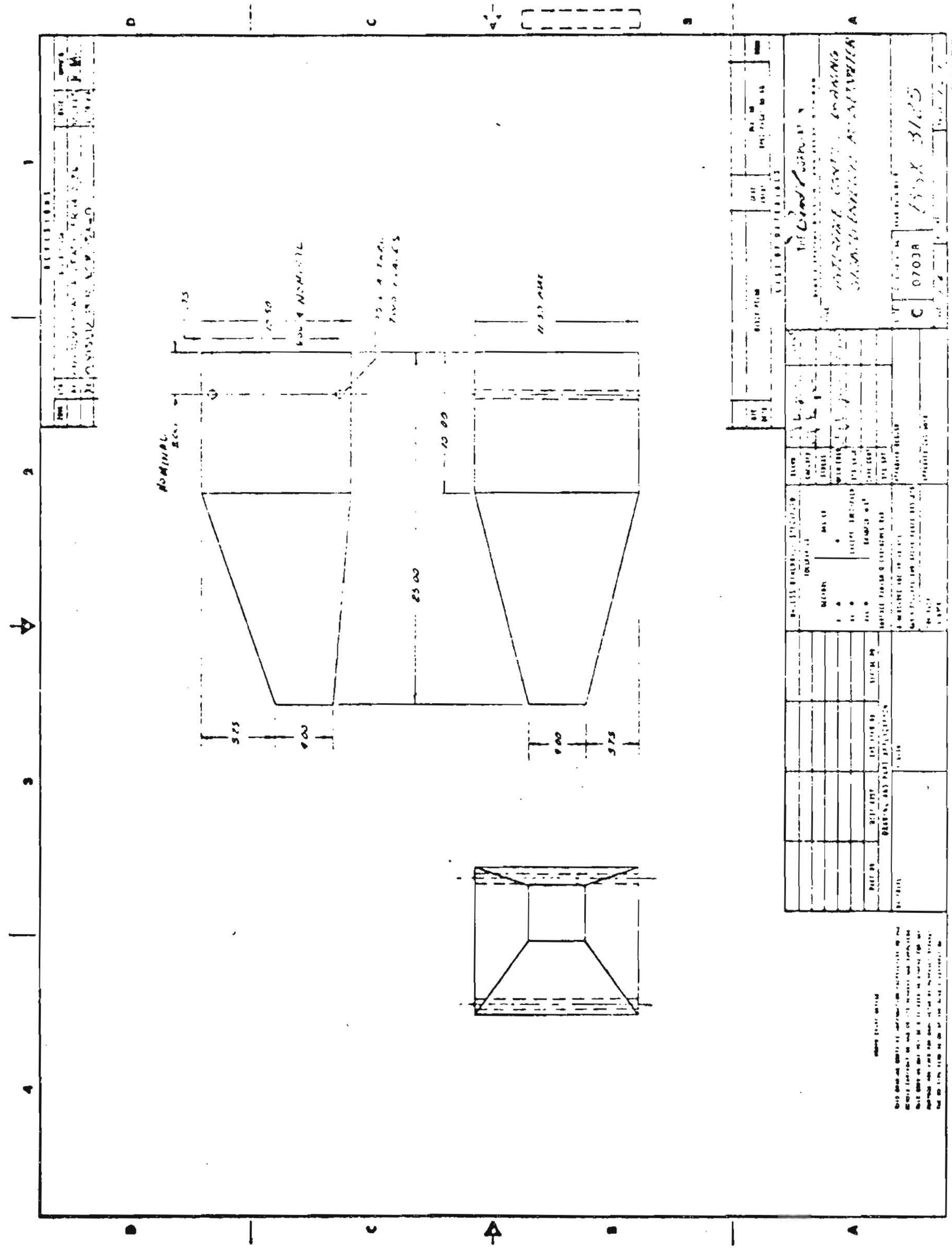

Figure 4.-Magnetometer Mechanical Interface

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The experiment shall also measure the pressure of the lunar atmosphere including any temporal variations and the rate loss of contaminants left in the area of ALSEP by the astronauts and LEM.

3.2.2.4.1 Telemetry. - Telemetry rate for the ion detector experiment subsystem shall be a nominal 50 bps (average) of scientific and engineering data. The ion detector shall, upon receipt of a demand pulse, shift out one 10-bit word of digital data at a rate of 1060 bits per second. The ion detector shall code three 10-bit words per telemetry frame and shall store these words until cleared by demand pulses. The intervals between demand pulses shall be such that three data words are cleared before the next measurement. The ion detector shift register shall produce a 4.5V ±0.5V signal for a logic "1" and a 0.2V ±0.1V signal for a logic "0". This register shall have an output impedance of less than 1000 ohms.

3.2.2.4.1.1 Synchronizing pulses. - The ion detector shall be provided with the following:

(a) Data frame synchronizing pulses. A pulse shall be sent to the ion detector at the beginning of each telemetry frame (53/32 pulses per frame). This pulse shall have an amplitude of 4.5V ± 0.5V and a width of 120 milliseconds. These pulses shall be applied to an impedance no less than 10 K ohms.

(b) Data clock pulses. A continuous square wave having a frequency of 1060 pulses per second shall be provided to the ion detector. These pulses shall have an amplitude of 4.5 ± 0.5V and shall be applied to an impedance no less than 10 K ohms.

(c) Demand pulses. A data demand pulse will be provided for each 10-bit word. These pulses shall have an amplitude of 4.5V ±0.5V and width equal to one telemetry word (approximately 0.01 sec). The ion detector input impedance shall be no less than 10 K ohms.

3.2.2.4.1.2 Earth commands. - ALSEP shall provide a capability for 16 separate pulse commands from earth to the ion detector. The command pulse shall have an amplitude of 4.5 volts ±0.5 volts and a width of 20 milliseconds. The input impedance of the ion detector for each of these commands shall be no less than 10 K ohms.

3.2.2.4.2 Dust cover removal. - In normal operation, the dust cover shall be removed by earth command subsequent to ascent stage departure. However, a backup timer shall be provided in the data subsystem to activate dust cover removal after a suitable time delay in case of command link failure.

3.2.2.4.3 Interconnecting cable. - The suprathermal ion detector shall be electrically connected to the central station by a cable capable of being deployed to a length of 60.0 feet. This cable shall be stowed within the envelope specified in paragraph 3.2.2.4.5 herein.

3.2.2.4.4 Thermal control. - The experiment subsystem shall provide its own thermal control.

3.2.2.4.5 Size and form factor. - The experiment dimensions shall be no more than 15.5 inches by 9.0 inches by 4.5 inches where the 15.5-inch dimension is vertical.

3.2.2.4.6 Weight. - The weight of the experiment subsystem shall be no more than 12.5 pounds exclusive of the interconnecting cable which shall weigh no more than 0.5 pound.

3.2.2.4.7 Power requirement. - The power required by the ion detector shall be no more than 3.5 watts for lunar day and the power required for the pressure gauge shall be no more than 1.5 watts for lunar day. An additional 1.5 watts shall be required for thermal control during lunar night. The peak power shall be no more than 6.5 watts.

3.2.2.4.8 Experiment useful life. -

3.2.2.4.8.1 Mission operating time. - The mission operating time for the suprathermal ion detector experiment shall be 1 year.

3.2.2.5 Heat flow experiment interface. - The heat flow experiment subsystem shall be composed of three probes, three identical probe electronics packages and a common electronics package. The three probes are emplaced by the astronaut in the lunar surface.

3.2.2.5.1 Telemetry. - The ALSEP shall provide for the heat flow experiment 20.0 bps of scientific and engineering status. Analog measurements shall also be provided for engineering data. The analog output impedance shall be no more than 1000 ohms and have a range of 0.0 to 5.0 volts. The heat flow experiment shall, upon receipt of a demand pulse, shift out one 10-bit word of digital data at a rate of 1060 bits per second. The heat flow shift register shall produce a 4.5V ±0.5V signal for a logic "1" and a 0.2V ±0.1V signal for a logic "0". This register shall have an output impedance of no more than 1000 ohms.

3.2.2.5.1.1 Synchronizing pulses. - The heat flow experiment shall be provided with the following:

(a) Data frame synchronizing pulses. A pulse shall be sent to the heat flow experiment at the beginning of each telemetry frame (every 32/53 second). This pulse shall have an amplitude of 4.5V ±0.5V and a width of 120 milliseconds. These pulses shall be applied to an impedance of no less than 10 K ohms.

(b) Data clock pulses. A continuous square wave having a frequency of 1060 pulses per second shall be provided to the heat flow experiment. These pulses shall have an amplitude of 4.5V to ±0.5V, and shall be applied to an impedance of no less than 10 K ohms.

(c) Demand pulses. A data demand pulse shall be provided for each 10-bit word. These pulses shall have an amplitude of 4.5V ±0.5V and width equal to one telemetry word (approximately 0.01 sec). The heat flow experiment shall appear as an impedance of no less than 10K ohms.

3.2.2.5.1.2 Earth commands. - ALSEP shall provide a capability for 16 separate commands from earth to the heat flow experiment. Each of these commands shall be of a pulse type. The command pulse shall have an amplitude of 4.5V ±0.5V and width of 20 milliseconds. The input impedance of the heat flow experiment for each of these commands shall be no less than 10 K ohms.

3.2.2.5.2 Interconnecting cable. - The central electronics of the heat flow experiment shall be connected to the central station by a cable capable of being deployed to a distance of 5 feet. This cable shall be stowed in the envelope specified in paragraph 3.2.2.5.4 herein.

3.2.2.5.3 Thermal control. - The heat flow experiment shall provide its own thermal control.

3.2.2.5.4 Size and form factor. - Size and form factor shall be defined by the following:

(a) Probe package dimensions shall be no more than 2 inches by 3 inches by 22 inches.

(b) Probe electronics and cable package volume and the central heat flow electronics package volume when combined shall be no more than 600 cubic inches.

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3.2.2.5.5 Weight. - The total weight of the heat flow experiment shall be no more than ~~7.0~~ pounds exclusive of the interconnecting cable which shall weigh no more then ~~0.1~~ pound.

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3.2.2.5.6 Power. - The experiment subsystem shall require no more than 3.5 watts continuous for experiment operation plus no more than an additional 2.0 watts intermittent (time share) during lunar day and lunar night. Additional power required for thermal control during lunar night shall be no more than 4.0 watts. The peak power shall be no more than 9.5 watts.

3.2.2.5.7 Experiment useful life. -

3.2.2.5.7.1 Mission operating time. - The mission operating time for the heat flow experiment shall be 1 year.

3.2.2.6 Passive seismic experiment interface. - The passive seismic experiment shall be composed of three long-period instruments (two horizontal and one vertical) and one short period vertical instrument. The seismometer electronics shall accept the signals furnished by the seismic masses, amplify and filter these signals, and furnish them in digital form to the data subsystem.

3.2.2.6.1 Telemetry. - The ALSEP shall provide the capability for a data rate for the passive seismic experiment of 600 bps plus 8 engineering status measurements. The passive seismic experiment shall, upon receipt of a demand pulse, shift out one 10-bit word of digital data at a rate of 1060 bits per second. The passive seismic experiment shall store data until demand pulses are sent to read out 23 data words per frame. The interval between demand pulses shall be such that one data word is cleared before the next measurement. Additional provisions shall be made be made for shifting out eight 10-bit data words for engineering status data. The passive seismic experiment shift register shall produce a 4.5V ±0.5V signal for a logic "1" and a 0.2V ±0.1V signal for a logic "0". This register shall have an output impedance of less than 1000 ohms.

3.2.2.6.1.1 Synchronizing pulses. - The passive seismic experiment shall be provided with the following:

(a) Data frame synchronizing pulses. A pulse shall be sent to the passive seismic experiment at the beginning of each telemetry frame. This pulse shall have an amplitude of 4.5V ±0.5V and a width of 120 milliseconds. These pulses shall be applied to an impedance of no less than 10 K ohms.

(b) Data clock pulses. A continuous square wave having a frequency of 1060 pulses per second shall be provided to the passive seismic experiment. These pulses shall have an amplitude of 4.5 V ±0.5V and shall be applied to an impedance of no less than 10 K ohms.

(c) Demand pulses. A data demand pulse shall be provided for each 10 bit word. These pulses will be provided on two separate lines, one to demand scientific data and the other to demand engineering status data. These pulses shall have an amplitude of 4.5V ±0.5V and width equal to one telemetry word (approximately 0.01 sec). The passive seismic experiment impedance shall be no less than 10 K ohms.

3.2.2.6.1.2 Earth commands. - ALSEP shall provide a capability for 11 separate pulse commands from earth to the passive seismic experiment. The command pulse shall have an amplitude of 4.5V ±0.5V and a width of 20 milliseconds. The input impedance of the passive seismic experiment for each of these commands shall be no less than 10 K ohms.

3.2.2.6.2 Interconnecting cable. - The passive seismic experiment shall be electrically connected to ALSEP by a cable capable of being deployed to a length of no more than 10 feet. This cable shall be stowed within the volume specified in paragraph 3.2.2.6.4 herein.

3.2.2.6.3 Thermal control. - The passive seismic experiment shall provide its own thermal control.

3.2.2.6.4 Size and form factor. - The size and form factor of the passive seismic experiment shall be defined by the following:

(a) Instrument dimensions shall be no more than 11 inches diameter by 17 inches high.

(b) Electronics dimensions shall be no more than 7 inches by 5 inches by 2.8 inches.

3.2.2.6.5 Weight. - The weight of the passive seismic experiment shall be no more than 25.0 pounds exclusive of the interconnecting cable to the ALSEP central station which shall weigh no more than 0.2 pounds.

3.2.2.6.6 Power. - The normal operating power requirements of the passive seismic experiment shall be no more than 7.5 watts during lunar day and no more than 8.0 watts during lunar night. In addition, no more than 3.0 watts shall be required for leveling and this shall be used only during lunar day on an intermittent (time share) basis. The peak power shall be no more than 10.5 watts.

3.2.2.6.7 Experiment useful life. -

3.2.2.6.7.1 Mission operating time. - The mission operating time for the passive seismic experiment shall be 1 year.

3.2.2.7 Electron/proton experiment interface. - The electron/proton experiment consists of two separate sensor assemblies, common power conditioning and common output electronics, housed in a single package. A dust cover, leveling mechanism, cabling, and associated structure/thermal packaging is also included. The electron/proton experiment shall be capable of detecting particles (both electrons and protons) with energies ranging from 50 ev to 150 kev. The experiment shall automatically switch across the energy spectrum for both types of particles.

3.2.2.7.1 Telemetry. - ALSEP shall provide a capability for a telemetry rate for the electron/proton experiment of 100 bits per second. The electron/proton experiment shall, upon receipt of a demand pulse, shift out one 10-bit word of digital data at a rate of 1060 bits per second. The electron/proton experiment shall code five 10-bit words and shall store these words until cleared by the demand pulses. The electron/proton experiment shift register shall produce a 4.5 volt ±0.5 volt signal for a logic "0". This register shall have an output impedance of no more than 1000 ohms. Analog signals in the 0 to 5 volt range shall be provided for six items of engineering status data.

3.2.2.7.1.1 Synchronization pulses. - The data subsystem shall provide the following synchronizing pulses to the electron/proton experiment:

(a) Data frame synchronization pulses. A pulse shall be sent to the electron/proton experiment at the beginning of each telemetry frame (every 32/53 second). This pulse shall have an amplitude of 4.5V ±0.5V and a width of 120 milliseconds. These pulses shall be applied to an impedance no less than 10 K ohms.

(b) Data clock pulses. A square wave having a frequency of 1060 pulses per second shall be provided to the electron/proton experiment. These pulses shall have an amplitude of 4.5V ±0.5V and shall be applied to an impedance no less than 10 K ohms.

(c) Demand pulses. A data demand pulse shall be provided for each 10-bit word. These pulses shall have an amplitude of 4.5V ±0.5V and width equal to one telemetry word (approximately 0.01 sec). The electron/proton experiment shall appear as an impedance of no less than 10 K ohms.

3.2.2.7.1.2 Earth commands. - ALSEP shall provide a capability for 8 separate commands from earth to the electron/proton experiment. Each of these commands shall be pulses having an amplitude of 4.5V ±0.5V and a width of 20 milliseconds. The input impedance of the electron/proton experiment for each of these commands shall be no less than 10 K ohms.

3.2.2.7.2 Dust cover and release mechanism. - A dust cover shall be provided for the experiment apertures and the thermal plate area. The cover shall be removed after departure of the LEM ascent stage by earth command or a backup timer in the data subsystem.

3.2.2.7.3 Interconnecting cable. - The electron/proton experiment shall be electrically connected to ALSEP by a cable having a capability of being deployed to a length of no more than 10 feet. This cable shall be stowed within the volume specified in paragraph 3.2.2.7.5 herein.

3.2.2.7.4 Thermal control. - The electron/proton experiment subsystem shall provide its own thermal control.

3.2.2.7.5 Size and form factor. - The size and form factor of the electron/proton experiment shall be no more than 4.5 inches by 10 inches by 12.5 inches.

3.2.2.7.6 Weight. - The weight of the electron/proton experiment shall be no more than 4.5 pounds exclusive of the interconnecting cable which shall weigh no more than 0.1 pound.

3.2.2.7.7 Power. - The electron/proton experiment shall require no more than 5.0 watts of continuous power.

3.2.2.7.8 Experiment useful life. -

3.2.2.7.8.1 Mission operating time. - The mission operating time for the electron/proton experiment shall be 1 year.

3.2.2.8 Active seismic experiment interface. - The active seismic experiment shall consist of two seismic energy sources and detection equipment. The two seismic energy sources shall be a mortar package and a thumper device. The experiment shall allow the sources to be used either separately in alternate ALSEPs or together in one ALSEP. The detection equipment shall consist of geophones, cable, amplifiers, and detection electronics. The electronics shall accept signals from the geophones, amplify and filter these signals, and furnish them in digital form to the data subsystem.

3.2.2.8.1 Telemetry. - The ALSEP shall provide a capability for a data rate from the active seismic experiment of 10,200 bits per second. The active seismic experiment shall provide fully formatted digital data in serial form to the data subsystem. The active seismic experiment shall code 7-bit digital words sampled no less than 486 times per second from each of three geophones. Timing and sampling of data are controlled by a programmer in the experiment electronics and fed to the data subsystem. The active seismic experiment shall produce a 4.5V ±0.5V signal for a logic "1" and a 0.2V ±0.1V signal for a logic "0". The active seismic experiment shall have an output impedance of no more than 1000 ohms. Analog signals in the 0 to 5 volt range shall be provided for four items of engineering data.

3.2.2.8.1.1 Synchronization pulses. - The data subsystem shall provide data clock synchronization to the active seismic experiment. A square wave having a frequency of at least 10,200 pulses per second shall be provided to the active seismic experiment. These pulses shall have an amplitude of 4.5V ±0.5V and shall be applied to an impedance of no less than 10 K ohms.

3.2.2.8.1.2 Earth commands - ALSEP shall provide a capability for 10 separate commands from earth to the active seismic experiment. Each of these commands shall be of a pulse type. The command pulse shall have an amplitude of 4.5V ±0.5V and width of 20 milliseconds. The input impedance of the active seismic experiment for each of these commands shall be no less than 10 K ohms.

3.2.2.8.2 Interconnecting cable. - The active seismic experiment shall be connected by a cable having the capability of being deployed no more than 10 feet. This cable shall be stowed within the volume specified in paragraph 3.2.2.8.4 herein.

3.2.2.8.3 Thermal control. - The thermal control for the active seismic experiment subsystem shall be provided in the design of the subsystem.

3.2.2.8.4 Size and form factor. - Size and form factor shall be defined by the following:

(a) Electronics package dimensions shall be no more than 4 by 4 by 4 inches.

(b) Mortar package dimensions shall be no more than 14 by 6 by 7 inches.

(c) Geophone package dimensions shall be no more than 10 by 8 by 2 inches.

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3.2.2.8.5 Weight. - The active seismic experiment subsystem shall weigh no more than 16.4 pounds, exclusive of the interconnecting cable from the electronics to ALSEP which shall weigh no more than 0.1 pound.

3.2.2.8.6 Power. - The power requirement of the active seismic experiment shall be no more than 7.0 watts during thumper operation, during lunar day (time share), no more than 6.0 watts during mortar operation, during lunar day (time share), and no more than 1.75 watts for thermal control when the experiment is inactive during lunar night.

3.2.2.8.7 Useful life. -

3.2.2.8.7.1 Mission operating time. - The active seismic experiment shall be capable of lunar operation for 30 minutes during the astronaut operation of the thumper. It shall then remain inactive for no more than 1 year after which the mortar package shall be capable of activation and experiment operation for a period of 30 minutes.

3.2.2.9 Solar wind experiment interface. - This subsystem consists of a plasma probe, associated structure/thermal packaging, leveling structure, dust cover, and interconnecting cable. The solar wind experiment subsystem shall determine the temporal and directional characteristics of the flux-energy spectra of the solar wind as it exists at the lunar surface.

3.2.2.9.1 Telemetry. ALSEP shall provide a capability for a telemetry rate for the solar wind experiment for scientific and engineering status data of 100 bits per second. The solar wind experiment shall, upon receipt of a demand pulse, shift out one 10-bit word of digital data at a rate of 1060 bits per second. The solar wind shift register shall produce a 4.5V ±0.5V signal for a logic "1" and a 0.2V ±0.1V signal for a logic "0". This register shall have an output impedance no less than 1000 ohms.

3.2.2.9.1.1 Synchronizing pulses. - The solar wind experiment shall be provided with the following synchronizing pulses from the data subsystem:

(a) Data from synchronizing pulses. A pulse shall be sent to the solar wind experiment at the beginning of each telemetry frame (every 32/53 second). This pulse shall have an amplitude of 4.5V ±0.5V and a width of 120 milliseconds. These pulses shall be applied to an impedance of no less than 10 K ohms.

(b) Data clock pulses. A continuous square wave having a frequency of 1060 pulses per second shall be provided to the solar wind experiment. These pulses shall have an amplitude of 4.5V ±0.5V and shall be applied to an impedance of no less than 10 K ohms.

(c) Demand pulse. A data demand pulse shall be provided for each 10-bit word. These pulses shall have an amplitude of 4.5V ±0.5V and width equal to one telemetry word (approximately 0.01 second). The solar wind experiment shall appear as an impedance of no less than 10 K ohms.

3.2.2.9.1.2 Earth commands. - ALSEP shall provide a capability for 8 separate pulse commands from earth to the solar wind experiment. The command pulses shall have an amplitude of 4.5V ±0.5V and a width of 20 milliseconds. The input impedance of the solar wind experiment for each of these pulses shall be no less than 10 K ohms.

3.2.2.9.2 Dust cover. A dust cover with a release mechanism shall be provided for the solar wind experiment grid structure. The release mechanism shall be activated by earth command after scheduled departure of the LEM ascent stage. A backup timer in the data subsystem shall also be provided to activate dust cover removal.

3.2.2.9.3 Interconnecting cable. - The solar wind experiment shall be electrically connected to ALSEP by a cable having the capability of being deployed to a length of no more than 10 feet. This cable shall be stowed within the envelope specified in paragraph 3.2.2.9.5 herein.

3.2.2.9.4 Thermal control. -Thermal control for the solar wind experiment subsystem shall be provided in the design of the subsystem.

3.2.2.9.5 Size and form factor. - Size and form factor of the solar wind experiment subsystem shall be no more than 11 by 9 by 14 inches.

3.2.2.9.6 Weight. - The solar wind experiment subsystem shall weight no more than 10.0 pounds, exclusive of the interconnecting cable which shall weigh no more than 0.1 pound.

3.2.2.9.7 Power. - The power requirement for the solar wind experiment shall be no more than 5.0 watts during lunar day and an additional power of no more than 1.5 watts for thermal control during lunar night. The peak power shall be no more than 6.5 watts.

3.2.2.9.8 Experiment useful life. -

3.2.2.9.8.1 Mission operating time. - The mission operating time for the solar wind experiment shall be 1 year.

3.2.2.10 LGE interface. -

3.2.2.10.1 Mechanical interface. - The LGE drill box and tool carrier box shall mechanically interface only with the structural/thermal subsystem. The interface between the LGE tools and their containers shall be defined by the following:

3.2.2.10.2 Weight. - The weight LGE drill and hand tools (GFE) shall be no more than 28.0 pounds. The weight of the CFE drill box and tool carrier shall be as defined by paragraph 3.4.14.2.2 herein.

3.2.2.10.3 Power. - The lunar drill shall have a self-contained power supply. The LGE subsystem shall have zero power requirement on ALSEP.

3.2.2.10.4 Useful life. -

3.2.2.10.4.1 Mission operating time. - The LGE subsystem shall be capable of lunar operation for the time required for drilling and geological traverse by the astronaut.

3.3 Design and construction. -

3.3.1 General constraints. -

3.3.1.1 Volume. - The mounting provisions and envelope dimensions for the equipment to be stowed in the LEM descent stage are shown in GAEC Interface Control Drawing LID 360-22810. The volume of the ALSEP shall be a nominal 15.0 cubic feet within the LEM SEQ bay.

3.3.1.2 Weight. - Mass Properties of the ALSEP shall be as specified in GAEC Document LIS 360-22102.

The ALSEP shall weigh no more than 210 pounds including the LGE subsystem. The packaging of ALSEP shall be designed so that the weight in each of the LEM descent stage scientific equipment compartments shall be between 75 and 115 pounds.

3.3.1.3 Center of gravity. - The center of gravity of the ALSEP equipment stowed in each compartment shall be within a sphere whose origin is the geometrical center of the compartment; a five-inch radius sphere when the weight within the compartment is 105.0 pounds or less, decreasing uniformly to 3.75 inches radius as the weight in the compartment is increased to 115.0 pounds.

3.3.1.4 Form factor. - GAEC ICD LIS 360-22810 defines the form factor of the compartments in the SEQ bay.

3.3.1.5 Document identification. - The requirements of PS-4 Revision B shall apply.

3.3.1.6 Power circuit protection. - Power circuit protection shall be provided to ensure operation of the ALSEP data subsystem and all remaining experiment subsystems if a failure occurs within any experiment subsystem. This protection shall allow experiment power overloads up to the point just below where system damage would occur. In addition, circuit protection shall be provided to prevent subsystem damage during periods of severe power overloads which reduce the operating voltages.

3.3.1.7 Voltage polarity reversal. - The equipment design shall eliminate the possibilities of subsystems being damaged by a reversal of primary voltage polarity. The requirements of DS-13 shall apply.

3.3.1.8 Power distribution. - ALSEP power distribution voltage below the nominal operating voltage shall not damage any ALSEP equipment.

3.3.1.9 Test equipment. - Test equipment shall be designed so that failure within the equipment or interruption of power will not cause failure or damage to the equipment being tested, and failure of the equipment being tested will not cause failure or damage to the test equipment. Test equipment utilized in tests performed within test procedures which are subject to NASA approval shall have an accuracy of 10 times that of the equipment being tested where feasible. The ALSEP system shall be designed with sufficient test points to permit testing to be performed without interrupting the system circuitry. The requirements of DS-7 shall apply.

3.3.1.10 Mechanical locks. - All handling devices utilized for ALSEP flight equipment shall have positive mechanical locking provisions to prevent accidental release of the equipment.

3.3.1.11 Mechanical rigging devices. - The requirements of DS-8 shall apply.

3.3.1.12 Moisture damage. - The requirements of PS-5 shall apply.

3.3.2 (Deleted)

3.3.3 Materials, parts, and processes. - As a guide, materials, parts, and processes shall be in general accordance with Document GAEC ICD LIS-360-22101, shall be compatible with the intended use, and shall be compatible with the environment requirements specified in 3.1.2.4 herein.

3.3.3.1 Materials. - Materials used in the fabrication of all components shall be of the highest quality compatible with design requirements specified herein. In general, the following types of material shall not be used without prior written approval of NASA:

(a) Flammable materials

(b) Toxic materials

(c) Unstable materials

(d) Plastic - (only epoxy resin-based compounds, teflon, and mylar shall be used).

(e) Dissimilar metals in direct contact which tend toward active electrolytic or galvanic corrosion.

3.3.3.2 Standard processes. - Standard processes used during equipment fabrication shall conform or be equivalent to applicable Government standards. The order of precedence for selection of specifications and standards shall conform to Standard MIL-STD-143; however, the contractor may submit in-house fabrication specifications for NASA approval. Contractor submitted in-house fabrication controls or specifications should be as encompassing as the following most commonly used Government specifications and/or standards.

3.3.3.2.1 Protective treatment. - All materials used which are not inherently corrosive-resistant shall be treated to resist any corrosive effects resulting from environmental conditions specified herein. Protective coatings shall not crack, chip, peel, or scale with age when subjected to the environmental extremes specified. Finishing, coating, and marking materials shall conform to Document GAEC ICD LIS-360-22101.

3.3.3.2.2 Soldering. - NASA Publication NPC 200-4 shall apply for hand soldering of all electrical connections.

3.3.3.2.3 Welding. - Resistance welding (spot and seam) shall conform to Specification MIL-W-6858.

3.3.3.2.4 Ultrasonic cleaning. - The requirements of PS-6 shall apply.

3.3.4 Standard parts. - NASA Standard parts, Air Force-Navy (AN) or Military Standards (MS) or joint Air Force-Navy (JAN) shall be used where applicable.

3.3.4.1 Standardization. - Maximum economic standardization of parts and components shall be provided. Where identical or similar functions are performed in more than one application within the system, effort shall be made to use only one item design for all system applications.

3.3.4.2 Electrical connectors. - Where applicable, electrical connectors shall conform to Document LSP 390-8A. Documents DS-3 and PS-10 shall apply.

3.3.4.3 Parts procurement. - The requirements of PS-8 and PS-11 shall apply.

3.3.4.4 Transistors. - The requirements of DS-5 shall apply.

3.3.5 Moisture and fungus resistance. - Materials which are not nutrients for fungus shall be used whenever possible. The use of materials which are nutrients for fungus shall not be prohibited in hermetically sealed assemblies and in other accepted and qualified uses such as paper capacitors and treated transformers. If it is necessary to use fungus nutrient materials in other than such qualified application, these materials shall be treated with a process which will render the resulting exposed surface fungus resistant.

3.3.6 Corrosion of metal parts. - Metals shall be corrosion-resistant type or suitable treated to resist corrosive conditions likely to be met in storage or normal service. Unless suitably protected against electrolytic corrosion, dissimilar metals, as defined in Standard MS 33586, shall not be used in direct physical contact.

3.3.7 Interchangeability and replaceability. - Interchangeability and replaceability shall be compatible with the requirements of paragraph 3.1.2.2 herein. Items of equipment with the same part numbers shall be physically and functionally interchangeable.

3.3.8 Workmanship. - The ALSEP shall be constructed, finished, and assembled in accordance with highest standards.

3.3.9 Electromagnetic interference (EMI). -

3.3.9.1 Operation. - Electrical and electronic equipment shall perform as specified herein when operating either independently or in conjunction with other equipment with which there are electrical connections, or which may be installed nearby. This requires that the operation of such equipment shall not be adversely affected by interference voltages and fields reaching it from external sources and also requires that such equipment shall not, in itself, be a source of interference which might adversely affect the operation of other equipments. These general criteria ensure that the system will meet the requirements of the overall system acceptance criteria, and electromagnetic compatibility as specified in the performance specifications. In addition to these general requirements, the system shall satisfy the requirements of paragraph 3.1.2.4 and Specification MIL-I-26600, and NASA Addendum MSC-ASPO-EMI-10A.

3.3.9.2 Transient interference. - Transient or short duration interference resulting from the operation of electrical or electromechanical devices shall not compromise the performance requirements as specified herein.

3.3.9.3 Interference-free design. - Interference control shall be considered in the basic design of all subsystem electronic and electrical equipment and specialized equipment such as simulation sources and GSE. The design shall be such that, before interference control components are applied, the amount of interference internally generated and propagated shall be the minimum achievable. The application of interference control components (e.g., filtering, shielding, bonding) shall conform to good engineering practice and, wherever practical, shall be an integral part of the subsystem or component.

3.3.9.4 Power and signal grounding. All DC power returns, i.e., primary power (RTG) and secondary power, and all signal returns shall be isolated from component or subsystem chassis. In addition, the signal returns, power returns and chassis grounds shall each be furnished separately and shall be isolated from each other by no less than one megohm. These return paths shall be interconnected only at one common point located in the data subsystem.

3.3.9.5 Filtering. - Filters shall be provided at each component or subsystem, as required, to prevent internally generated electrical interference signals being conducted out of the component or subsystem.

3.3.9.6 Conductor shielding. - Shielding, as necessary, shall be grounded to the basic structure or chassis at one or both ends as required for each continuous length of shielded wire except for coaxial cables. A coaxial cable being employed as an r.f. transmission line shall use the outer conductor for signal return and shall have both ends of the outer conductor connector-grounded.

3.3.10 Identification and marking. - The ALSEP shall be marked for identification in accordance with Standard MIL-STD-130. The nameplate shall conform to Standard MS 24123. Explosive devices shall be marked in accordance with the requirements of Document PS-21.

3.3.10.1 Nameplate data. - The nameplate shall include but not be limited to the following data:

(a) Item nomenclature

(b) Item part number

(c) Item serial number

3.3.11 Storage. - The ALSEP shall have a shelf life of 2 years. Shelf life is defined as a storage period in a controlled environment of 50°F to 80°F and a relative humidity of no more than 50 percent following acceptance and prior to installation in the LEM for flight.

3.3.12 Factors of safety. - The following guidelines shall be used for factors of safety:

(a) Tie-down bracketry, safety factor of 3.0

(b) Tie-down pins and bolts, safety factor of 3.0

(c) Structure and parts, safety factor of 1.5 (ultimate)
1.1 (yield)

(The basic values for material allowable design stresses are as defined by Handbook MIL-HDBK-5.)

3.4 Requirements of subareas. - Deployable dust covers shall be included in the design of all particle experiments. Designs of all CFE experiments shall permit them to be leveled on the lunar surface within $\pm 5^{o}$ of true horizontal, except for the active seismic experiment which shall be within $\pm 10^{o}$.

Test connections shall be provided as necessary for each experiment to permit functional testing of the experiment independent of the flight system cable connectors. Performance requirements for both GFE and CFE experiments shall be specified in their respective Interface Control Specifications (listed below for reference) which will be the governing document for the design of each experiment.

IC 314105	Suprathermal Ion Detector Experiment Interface
IC 314106	Passive Seismic Experiment Interface
IC 314108	Active Seismic Experiment Interface
IC 314109	Heat Flow Experiment Interface
IC 314110	GSE Interface
IC 314107	Electron/Proton Experiment Interface
IC 314103	Magnetometer Experiment Interface
IC 314104	Solar Wind Experiment Interface
IC 314114	Lunar Geological Equipment Interface

3.4.1 Electrical power subsystem. -

(a) GFE components

(1) Unfueled generator - a SNAP 27 type RTG

(2) RTG fuel capsule - an encapsulated radioisotopic heat source or fuel.

(3) RTG fuel cask - a container for the fuel capsule during trans-lunar flight.

(4) Cable - from RTG to PCU

(b) CFE components

(1) PCU

(2) RTG fuel cask mounting ~~and rotation device~~

(3) RTG fuel cask (thermal) insulation

(4) Handling tool - to transfer the RTG fuel capsule from the fuel cask to the RTG on the moon.

(5) Cable storage container

(6) Cable connector

3.4.1.1 Operational characteristics. -

3.4.1.1.1 Electrical design criteria. - The PCU design shall incorporate RTG protection circuitry and shall be subject to NASA/AEC review and approval with particular emphasis on its effect on RTG life and performance. The PCU design shall incorporate protection against damage by short circuiting which may occur on any output terminals. Excitation and associated conditioning hardware for the RTG temperature transducers will be provided by the ALSEP system. RTG temperature transducers will be GFE.

3.4.1.1.1.1 RTG/PCU. - The RTG/PCU shall provide the conditioned DC power specified in paragraph 3.2.2.1.3 herein at its output connector with the following characteristics:

Ripple:	Less than 100 millivolts, peak to peak, on all output voltages.
Transient response:	The 29.0 ±1 percent volt output shall be maintained with a rate of change of load current of 0.25 ampere/millisecond. For a change greater than 0.25 ampere/millisecond, the output voltage shall remain between 28.0 and 30.0 volts and recover to 29.0 volts ±1 percent within 50 milliseconds.

3.4.1.2 Electrical power subsystem design and construction. -

3.4.1.2.1 Weight. - The weight of the subsystem shall be no more than ~~56.46~~ 56.70 pounds apportioned as follows:

GFE:	47.00 pounds
Bendix: CFE	9.70 pounds

3.4.2 Data subsystem. - The data subsystem consists of the following components: antenna, diplexer and switch, command receiver, command decoder, data processor, transmitters, and power distribution and signal conditioning unit. The data subsystem shall receive, decode, and distribute commands from the MSFN to the deployed units of the ALSEP. It shall also accept and process experimental data and status information from the ALSEP experiments and system status information from the thermal, data, and power subsystems. This information shall be processed into a digital telemetry format and transmitted back to the earth as an S-band signal.

3.4.2.1 Operational characteristics. - The data subsystem shall be capable of simultaneous reception of commands and the transmission of data.

The data subsystem shall accept experiment data and engineering status data from the subsystems. These data shall be conditioned, processed, formatted, and stored as necessary and transmitted to earth using pulse code modulation. The carrier shall be phase modulated in a manner that requires minimum modification to the MSFN. The data subsystem shall also receive commands from earth. These shall be processed and distributed to the proper ALSEP subsystem and/or components.

The acceptance of a false command shall not create a crew safety hazard.

The antenna design shall be such that the astronaut can sight the antenna in the correct direction from a standing position. The antenna shall provide earth coverage for one year after sighting without automatic or command tracking of the earth.

The data subsystem shall accommodate a maximum bit rate of 10, 600 bits per second when an 85 foot diameter receiving antenna is used. This shall not require special positioning of the ALSEP antenna. Engineering status data shall be transmitted as part of the high bit rate data.

The data subsystem shall generate a bit stream which uniquely identifies a particular ALSEP system. Timing information accurate to one hour shall be provided in the bit stream.

The data subsystem shall provide means to verify via the bit stream that a command has been properly processed and distributed.

3.4.2.1.1 Reception. - The data subsystem shall recieve transmission from earth MSFN sites on a frequency of 2119± .001 percent using a 10 KW transmitter, a 30 foot diameter antenna, and a deviation of ±3 radians. The received signal shall be a PCM sub bit encoded phase modulated 2 Kc/s subcarrier and a 1 Kc/s sync tone. The command formatting shall minimize required modifications to existing command facilities of the MSFN. The data subsystem shall provide a capability to decode and distribute no less than 100 discrete logic commands to the proper subsystems.

3.4.2.1.2 Transmission. - The data subsystem shall accept from the experiments digital NRZ data signals. The transmitted data shall be split-phase modulated. The carrier frequency shall be pre-set to any one of three frequencies in the range of 2275 Mc/s to 2280 Mc/s. Absence of data from any experiment, for any reason, shall not compromise the ability of the subsystem to transmit remaining data. The signal shall be received at MSFN using a 30 foot diameter antenna.

3.4.2.1.3 Modes of operation. - The data subsystem shall be capable of operating in four separate modes as defined by Table III.

3.4.2.1.4 Synchronization. - The telemetry format shall contain 30 bits for synchornization and identification purposes.

Mode	Frame Time	Experimental Data and Status Information	Mode Activation/ Deactivation
Normal	32/53 Sec	1060 bpsec (no active seismic)	Command/ command
Slow	64/53 Sec	530 bpsec (same experiments as above)	Command/ command
Active Seismic			
(a) Thumper	TM framing done by the active seismic experiment	10,600 bpsec (active seismic experiment and engineering status data only)	Command/ command
(b) Mortar	TM framing done by the active seismic experiment	10,600 bpsec (active seismic experiment and engineering status data only)	Command/ command

TABLE III
DATA SUBSYSTEM MODES OF OPERATION

3.4.2.1.5 Power distribution. - The data subsystem shall accept power of +29V $\pm$1 percent, +12V $\pm$1 percent, -12V $\pm$1 percent, and +4.5V $\pm$0.5 volt from the electrical power subsystem and switch it ON and OFF to the users by command from the earth.

3.4.2.1.5.1 Overload protection. - Overload protection shall be provided in the 29-volt power lead to each experiment as specified in paragraph 3.3.1.6 herein. This protection shall be automatically activated when an experiment failure causes a power drain of sufficient magnitude to render the RTG/PCU (and hence the command link) inoperative.

3.4.2.1.6 Redundancy. - Redundancy shall be employed within the data subsystem to ensure its operation for the required useful life. The techniques employed shall range from duplication of a component to providing back-up of critical signal paths within a component.

3.4.2.2 Data subsystem design and construction. -

3.4.2.2.1 Weight. - The weight of the data subsystem including cabling and thermal container shall be no more than 30.00 pounds.

3.4.2.2.2 Power. - The data subsystem shall require no more than 25.0 watts.

3.4.3 Structure/thermal subsystem. - The structure thermal subsystem shall consist of the following:

(a) Pallet supporting the RTG and LGE

(b) Removable overturn fence to protect the RTG during lunar transportation.

(c) Supporting framework around and under the data subsystem electronics.

(d) Upper structure which serves as a thermal control sunshade for the central station when deployed, and as a support for the experiments when stowed; experiment tie down fittings are included.

(e) Dust detector installed in the upper structure.

(f) Magnetometer box, including foam packaging, which also provides stowage for antenna components.

(g) LEM mounting structure to support RTG fuel cask.

The structure/thermal subsystem shall provide support and shock and vibration isolation, as necessary, for the supported equipment. Each individual deployed subsystem within the ALSEP shall provide its own thermal control and where electrical power is required to effect thermal control, that power shall be included within the power allocation for the subsystem.

3.4.3.1 Operational characteristics. - The data subsystem, PCU and all of the experiments shall be mounted on one of the two mounting structures, fitted and secured as a single package in one compartment. The RTG and the LGE shall be similarly mounted, fitted, and secured in the other compartment. The inner surface of the sunshade shall have an emissivity of no more than 0.05. The outer surface shall have an α/ϵ ratio of no more than 0.22 at the time of lunar deployment.

3.4.3.2 Design and construction.

3.4.3.2 1 Weight. - The weight of the structure/thermal subsystem shall be no more than 23.50 pounds, of which the LEM mounting structure for the RTG fuel cask is allocated 3.00 pounds. 20.50#

3.4.4 Magnetometer experiment. - The GFE magnetometer experiment subsystem is defined in paragraph 3.2.2.3 herein.

3.4.5 Suprathermal ion detector experiment. - The GFE suprathermal ion detector experiment subsystem is defined in paragraph 3.2.2.4 herein.

3.4.6 Heat flow experiment. - The GFE heat flow experiment subsystem is defined in paragraph 3.2.2.5 herein.

3.4.7 Passive seismic experiment. - The GFE passive seismic experiment subsystem is defined in paragraph 3.2.2.6 herein.

3.4.8 Electron/proton experiment. -

3.4.8.1 Detector. - The basic detector shall be the Bendix Channeltron Multiplier ® (hereinafter referred to as "the detector"), which is positioned to detect particles passing through a pair of deflection plates. Particles passing through the plates are deflected by the applied voltage on the plates into five detectors. The five detectors accommodate five energy ranges for a single voltage on the deflection plates. Three positive voltages, three negative voltages, and zero volts are applied sequentially to the deflection plates to analyze the electron and proton energy ranges and the background.

The maximum count rate capability of each detector shall be no less than 4×10^5 particles/second. The pulses from each detector shall be counted in a 19 stage counter over a time period of approximately 1.2 seconds.

Two of these sensor assemblies (with five detectors in each assembly) shall be incorporated into this experiment, with their acceptance angles at 60° with respect to each other, to provide directional data.

3.4.8.2 Cable storage and deployment. - The electron/proton experiment shall include provisions for storing at least 10 feet of cable to enable deployment of the experiment up to 10 feet from ALSEP. The cable storage assembly shall be located on top of the dust cover with the cable mounted in an open frame, secured with a breakaway tie-down that can be eaxily released by the astronaut.

3.4.8.3 Leveling monitor. - A leveling monitor shall be included as part of the experiment to enable the astronaut to determine that the deployed experiment is adequately leveled. This shall be accomplished by means of a circular ball level mounted as part of the dust cover.

3.4.9 Active seismic experiment. - The active seismic experiment shall consist of two seismic energy sources and a detection system. The active seismic experiment shall be capable of artificially producing seismic energy in near-surface lunar materials and detecting these seismic signals to ascertain the physical properties of the materials. The instrument shall be capable of providing data for study of the velocity of compressional waves, the frequency spectra, and the attenuation of seismic energy. These data shall be interpreted to yield the elastic coefficients of the lunar surface. The active seismic experiment shall also provide data on the degree of induration and bearing strength of lunar surface materials. The active seismic experiment shall also investigate the thickness and fine structure of the shallow depth materials on the moon.

3.4.9.1 Seismic energy sources. - The two seismic energy sources shall be a mortar package and a thumper device. The experiment shall allow the sources to be used either separately in alternate packages or together in one package.

3.4.9.1.1 Mortar package. - The active seismic mortar package shall contain four explosive grenades and launching tubes. Each grenade shall have an explosive device, a range indicator, and a launching device. The maximum explosive charge shall be no more than the equivalent of 16 ounces of TNT. A contact fuse shall be employed for detonation. The explosive shall be armed ohly upon launch from the mortar package. The grenades shall be positioned in the package at predetermined angles to yield calculated trajectories and ranges upon launch; the ranges (nominal) shall be 0.25, 0.5, 0.75 and 1.0 mile.

3.4.9.1.2 Thumper. - The active seismic thumper shall be a cylindrical device packaged in two sections for transit to the moon. The upper section shall contain necessary electronics for the squib firing circuit, a safety switch, a firing switch, and a barrel with no less than 20 ignition squibs. Each ignition squib shall have a useful charge weight of no less than 150 milligrams of explosive. The squibs shall be activated separately by a 21-position commutator for firing safety. The upper section shall be bayonet-connected to the lower portion of the squib barrel. The lower section shall provide for contact of the device to the lunar surface materials by means of a flange at its base.

3.4.9.2 Detection system. -

3.4.9.2.1 Geophones. - Three geophone detection devices shall be employed to detect the induced seismic energy. The geophones shall have a natural frequency of 7.5 cycles per second, with damping to 0.6 of critical. The geophones shall have a sensitivity better than 5 milimicrons of ground motion at 10 cps, as a design goal.

3.4.9.2.2 Cable. - Three hundred feet of no less than nine conductor H-film tape cable shall be employed in the geophone array. The geophones shall be attached to the main cable at 150-foot intervals by means of a short pigtail lead wire. Three hundred feet of five-conductor H-film cable shall be employed to operate the thumper device. Five feet of 15-conductor H-film cable shall be employed to operate the mortar package and fire the grenades.

3.4.9.2.3 Amplifiers and detection electronics. - The amplifiers and detection electronics shall have a dynamic range of no less than 80 db, with logarithmic compression to 40 db over a pass band of 0.5 to 100 cycles per second, as a design goal. The system shall have an input noise no greater than 0.1 microvolt. A miniature receiver for the signals from the grenade transmitters shall be included.

3.4.10 Solar wind experiment. - The GFE solar wind experiment subsystem is defined in paragraph 3.2.2.9 herein.

3.4.11 ALSEP GSE. - ALSEP GSE shall consist of electrical and mechanical equipment built to commercial quality. Off-the-shelf electronic test equipment shall be used where available. The GSE electrical equipment shall support the ALSEP test program to perform tests on experiment subsystems, power subsystem, data subsystem and on the ALSEP system. Running time indicators shall also be furnished.

The GSE mechanical equipment shall consist of devices to permit assembly, transportation and handling of ALSEP end items in the factory and at KSC.

3.4.11.1 System test set. - The system test set shall perform dynamic functional tests on a partial or complete ALSEP system. The system test set shall be capable of being used for central station integration tests, integration of the experiments with the central station and testing on the completely-assembled ALSEP. The system test set shall be capable of measuring the performance of each experiment and the data, power, and electrical distribution subsystems. These tests shall consist of functional tests and two-point calibration verification tests on each experiment. The system test set shall be capable of fault isolation to the component level on the data subsystem and the subsystem level for the experiments and other subsystems.

3.4.11.1.1 Data unit. - The data unit shall consist of r.f. and digital electronic equipment for interface between the program processor and the ALSEP. The downlink (telemetry) shall be capable of being received from ALSEP and demodulated for processing by the program processor. Uplink (command) data shall be capable of being taken from the program processor and modulated on a subcarrier and transmitted to the ALSEP.

3.4.11.1.2 Program processor. - The program processor shall consist of a stored program PCM telemetry decommutator with data processing calabilities; peripheral logic for output control to all input stimuli for the ALSEP system; and manual command control for uplink operation. Digital-to-analog converters shall be provided for monitoring data on strip chart recorders.

The telemetry section shall synchronize the system, normalize the input PCM bit stream, and control the decommutation and routing of the data. The processing section shall control the operation of the telemetry section by supplying acquisition criteria, decommutation, and routing instructions.

3.4.11.1.3 Description. - The system test set shall consist of not more than six racks of equipment. These racks shall be suitable for installation of standard 19-inch electronic test equipments. The overall height of the test set shall be no more than 7 feet. The system test set shall operate on 110-120 volt, 60 cycle per second electrical power. The power required shall be no more than 10 kilowatts. The system test set shall be designed to operate in an interior air conditioned environment. Gross weight shall be no more than 2,500 pounds.

3.4.11.2 Subsystem test sets. - Test sets, consisting primarily of standard laboratory equipment, shall be provided to apply tests to each subsystem.

(a) Electrical power subsystem
(b) Cable distribution and signal conditioning unit
(c) Ordnance
(d) Data subsystem
(e) Experiments

Each test set shall be capable of generating output functions and be capable of receiving, converting, storing (if necessary), and displaying output functions of the subsystem. Test sets shall not generate experiment sensor signals. Test sets shall be used as a check to verify proper operation of the subsystem.

3.4.11.2.1 Experiments simulator. - The experiments simulator shall be capable of generating simulated experiment subsystem output functions to the data subsystem.

3.4.11.2.2 Experiment sensor simulators. - The experiment subsystems shall have internal provisions for checkout as specified in 3.1.1.4.16. Sensor simulators shall be included in the GSE system test set to supply an external simulation. The experiment sensor simulators shall consist primarily of standard laboratory components and be capable of generating a signal to stimulate the experiment over the operating range of the experiment. They shall inject a calibration signal to the basic experiment sensing elements or into the experiment electronics as close to the basic experiment sensing element as practicable. Each experiment sensor simulator shall be capable of operation in a manual mode with individual experiment test sets. They shall also be used in an automatic mode for overall system tests. In the automatic mode the operation of the sensor simulator shall be capable of remote control by the system test set.

3.4.11.3 Mechanical equipment. -

3.4.11.3.1 Devices for assembly. - Mechanical devices to permit transportation and assembly of flight end items in the factory and in the field shall be as follows:

(a) Transportation dollies

(b) Hoisting slings

(c) LEM-ALSEP installation fixture

(d) GSE special tools

(e) Antenna alignment gauge

3.4.11.3.2 Devices of transportation. - Shipping containers to permit transport of ALSEP end items to the field from the contractor's facility shall be as follows:

(a) Compartment Numbers 1 and 2 containers

(b) Experiment subsystem containers

(c) Spare electronic component containers and experiment subsystem containers.

3.4.11.4 Electrical interface requirements. - The various items of GSE will interface with all inputs and outputs of the ALSEP units and subsystems as defined in their respective specifications.

3.4.12 Training equipment. - The following deliverable training equipment shall be provided by the ALSEP contractor:

The MSC training model (designated as E-2) shall be built to the basic configuration in terms of mechanical design, handling, and astronaut manipulative features. It shall not contain electrical or electronic features. To the extent possible it shall be ballastable to 1G and 1/6G, both in total and in each deployable element. The simulator will be designed for considerable handling during astronaut training. Further, in a number of cases, the earth weights of deployable elements are such that 1/6 weight will ballastable features cannot be achieved. In these cases the particular elements will be made as light as possible consistent with the end utilization of the training simulator.

3.4.13 Other equipment. - In addition to deliverable flight models, spares, and training equipment, the following mockups and models will be fabricated.

3.4.13.1 Non-deliverable. - Non-deliverable in accordance with the delivery schedule in Article IV of this contract. These items will be removed, delivered or disposed of in accordance with subclauses (h) and (i) of the General Provisions of this contract entitled "Government Property".

3.4.13.1.1 Qualification models. - The qualification model (designated as B-1, B-2) will be manufactured with the same tooling, processes, quality control procedures and design as the flight hardware. There will be one system qualification model, an Array A which will later be refurbished to an Array B. This model will first undergo design limit tests in the Array A configuration continuing with a mission simulation test while still installed in the space chamber. This cycle will be repeated for Array B. Refurbishment will require a new sunshield, Array B experiments and possible cabling changes, plus re-inspection. No additional hardware will be required for system qualification. No qualification hardware will be required for "in-house" test other than this system equipment.

3.4.13.1.2 Simulator, thermal mechanical. - This model (designated as D-12) is built to the same drawings as Model D-1 and is used by Bendix for thermal model test. This model requires heaters to simulate operational heat dissipation.

3.4.13.1.3 Prototype. - The prototype (designated as G) will be manufactured to preliminary flight model drawings, and flight production processes. Production documentation must be used. This model will be assembled into a system for system level design verification testing.

3.4.13.1.4 Engineering model. - The engineering model (designated as H) will duplicate the mechanical and electrical flight hardware in form, fit and function. Flight qualified components and materials will be used to the greatest extent possible. Production dies, tooling, and manufacturing processes need not be used. These models will be used for design verification testing up to the subsystem level. The test will verify both mechanical and electrical operating modes. Tests will be performed at both component and subsystem levels as required.

3.4.13.1.5 Mechanical mockup. - This is an ALSEP mechanical engineering model (designated as I) including structure, all fittings, and mechanically operative parts to be used for static structural tests, vibration surveys, and mechanical functional tests. Mass, C.G., and the mounting attachments of "black boxes" will be simulated.

3.4.13.2 Deliverable. -

3.4.13.2.1 Thermal/mechanical simulators. - This model (designated as D-1 and D-2) is a complete simulation of the ALSEP system packaged configuration in physical characteristics. Use as a thermal model required that this simulator duplicates the flight hardware with respect to system characteristics such as heat dissipation, capacity, conductivity, and radiation properties. The use of this model is for thermal vacuum tests of LTA-8. In this case it is an inert model serving only as a heat sink. Model D-2 is used for orbital flight of LEM-3. Both models shall have components of flight mass properties, heat capacities, and external finishes.

3.4.13.2.2 Simulator (mechanical). - This model (designated as E-1) is a complete mechanical simulation of the ALSEP system packaged configuration including weight, center of gravity, structural simulation, etc. Model E-1 will be vibration tested in LTA-3.

3.4.13.2.3 Structure simulator. - This model (designated as F) is a simulation of the ALSEP system packaged configuration to be used by GAEC for "fit checks". This must be a rugged rigid simulator capable of repeated handling by GAEC personnel. It must accurately locate hard attach points and duplicate the final Array A or B outside envelope. This is a "boiler plate" model.

3.4.14 LGE subsystem. - The LGE subsystem consists of the following:

(a) GFE components

(1) Lunar drill

(2) Hand tools

(b) CFE components

(1) Drill box

(2) Tool carrier

3.4.14.1 Operational characteristics. -

3.4.14.1.1 Drill box. - The drill box shall be removable from LEM in two modes: as a separate unit and as an integral part of ALSEP. The drill box shall allow easy removal of the drill by the astronaut subsequent to removal from LEM.

3.4.14.1.2 Tool carrier. - The tool carrier shall be removable from LEM in two modes: as a separate unit and as an integral part of ALSEP. The tool carrier shall be capable of maintaining the integrity and cleanliness of the tools, and sample containers, and shall facilitate use by the astronaut in performing the geological traverse subsequent to removal from LEM.

3.4.14.2 Design and construction. - The LGE experiment subsystem shall be designed for efficient stowage in ALSEP. This subsystem shall be constructed in such a manner that one astronaut can remove it from ALSEP, before or after extraction of ALSEP from LEM, perform the requisite operations and reinstall it in ALSEP if necessary.

3.4.14.2.1 Size and form factor. - The LGE subsystem shall consist of a drill box having dimensions of no more than 9 inches by 19 inches by 22 ineches and a tool box having dimensions of no more than 6 inches by 17 inches by 19 inches with a supporting leg at right angles at one end having dimensions of no more than 1 inch by 19 inches by 12 inches.

3.4.14.2.2 Weight. - The weight of the CFE components (drill box and tool carrier) of the LGE subsystem shall be no more than 8.5 pounds. The weight of the GFE components shall be as defined by paragraph 3.2.2.10 herein.

4.0 QUALITY ASSURANCE PROVISIONS

The following paragraphs specify the technique by which compliance with the requirements of Section 3.0 shall be verified. See paragraph 6.3 herein for basis of the quality program.

4.1 Inspection. - The following requirements of Section 3.0 shall be verified by inspection:

Requirement	Paragraph of Section 3.0 of this Specification
Prelaunch operations	3.1.1.2
Maintainability	3.1.2.2
Ground handling and transportability	3.1.2.5
Personnel safety	3.1.2.7.1
Equipment safety	3.1.2.7.2
Hazard proofing	3.1.2.7.3
System interface requirements	3.2.1
Subsystem interface requirements	3.2.2
Volume	3.2.2, 3.3.1.1, and 3.4
Weight	3.2.2, 3.3.1.2, and 3.4

Requirement	Paragraph of Section 3.0 of this Specification
Center of gravity	3.2.2, 3.3.1.3, and 3.4
Form factor	3.2.2, 3.3.1.4, and 3.4
Selection of specification and standards	3.3.2
Materials, parts, and processes	3.3.3
Standard parts	3.3.4
Moisture and fungus resistance	3.3.5
Corrosion of metal parts	3.3.6
Interchangeability and replaceability	3.3.7
Workmanship	3.3.8
Electromagnetic interference	3.3.9
Identification and marking	3.3.10

4.2 Analysis. - The following requirements of Section 3.0 of this specification shall be verified in whole or in part by review of analytical data.

Requirement	Paragraph of Section 3.0 of this Specification
Operational characteristics	3.1.1
Reliability	3.1.2.1
Useful life	3.1.2.3
Storage	3.3.11

4.3 Demonstration. - The following requirements of Section 3.0 shall be verified by demonstration.

Requirement	Paragraph of Section 3.0 of this Specification
Lunar surface operations	3.1.1.4
Human factors	3.1.2.6

4.4 Test. - The following requirements of Section 3.0 shall be verified by test.

Requirement	Paragraph of Section 3.0 of this Specification
Translunar flight	3.1.1.3
Environment	3.1.2.4
Electromagnetic interference	3.3.9
Performance	3.2.2 and 3.4; applicable subparagraphs

5.0 PREPARATION FOR DELIVERY

5.1 Packaging and shipping. - Packaging and shipping of equipment shall be in accordance with the contract. Materials or containers used for packaging and shipping shall be restricted as specified in Document PS-15.

6.0 NOTES

6.1 Specification preparation. - This specification was prepared in accordance with the format and content requirements of Exhibit I of Document NPC 500-1 and Appendix A of MSC Supplement No. 1, as applicable.

6.2 Basis for reliability program. - The ALSEP reliability program is based on the intent and requirements of NASA Document NPC 250-1, as interpreted specifically to best suit the requirements of the ALSEP program. No demonstration of reliability is required. Section 4.3.4 of NPC 250-1 is deleted.

6.3 Basis for quality program. - The ALSEP quality program is based on the intent and requirements of NASA Documents NPC 200-2, and NPC 200-4, as interpreted specifically to best suit the requirements of the ALSEP project, as modified by ALSEP instruction modification to NPC 200-2.

6.4 CEI specification list. - The CEI specification for the ALSEP project are:

(a) ALSEP System Specification SS 100000

(b) System Test Set Specification CP 412100

Deliverable ALSEP models other than the flight articles will be covered by issuance of addendum to Specification SS 100000.

7.0 QUALIFICATION TESTS

7.1 General. - The ALSEP contractor shall perform a Qualification Test of each ALSEP flight end item configuration to provide proper assurance that the ALSEP design, development, and production programs have resulted in the desired product. The Qualification Test will be performed in four phases:

(a) ALSEP Acceptance Test
(b) ALSEP Performance and Compatibility, Electrical
(c) ALSEP Electromagnetic Interference
(d) ALSEP Performance, Environmental

The intent of these required test phases is to prove the ALSEP operational capability and to demonstrate the contractor design margins as reflected in the Qualification Test Procedures delivered in accordance with Exhibit C. These design margins shall meet the criteria in paragraph 7.6 of this specification.

7.2 Specific requirements, NASA required proof of design. -

7.2.1 Qualification model. - The ALSEP qualification model for each flight end item shall consist of production parts, components, and subsystem fabricated and assembled with production processes and tooling by ALSEP production personnel. The qualification model shall conform in all respects to the ALSEP production flight equipment. No ALSEP development equipment shall be used in any way with the qualification model during the Qualification Test Program. No ALSEP equipment used during the ALSEP Qualification Tests will be acceptable to NASA for later use in ALSEP missions for either primary or spare purposes.

7.2.2 Testing equipment. - Testing equipment used for the purpose of ALSEP qualification shall be described in detail in the Qualification Test Procedures. Equipment shall be approved by NASA prior to use in the qualification program.

7.3 Test personnel. - Personnel performing the qualification testing shall have received the 16 hour ALSEP training course and shall be thoroughly familiar with all ALSEP assembly, acceptance test, and qualification test procedures. A single individual will be assigned as the ALSEP qualification test conductor. The test conductor shall control all qualification test operations, maintain a complete test operations log, assure that all tests are run properly and thoroughly as required in the applicable Qualification Test Procedure and control the ALSEP qualification test areas.

7.4 Test conduction. - Qualification tests shall be conducted in controlled test areas by personnel described in 7.3. There will be a NASA designated test representative present for each qualification test. Each step of the test phase shall be performed in a predescribed sequence shown in the Qualification Test procedure. Should any test step result in data in disagreement with the limits established in the test procedure for that step, the test shall be immediately stopped, the discrepancy brought to the attention of the NASA test representative and a disposition of the discrepancy mutually made between the NASA representative and the contractor test conductor prior to resumption of testing. In case the above representatives are unable to agreee on disposition, the Contracting Officer shall make a written determination of the appropriate disposition which shall be implemented.

7.5 Test details. -

(a) ALSEP Qualification Test, Acceptance Test Phase

Prior to subjection of the ALSEP qualification model to subsequent qualification test phases, the model shall be successfully tested in accordance with the ALSEP production flight equipment acceptance test procedure.

(b) Electrical Performance and Compatibility Test Phase

Testing shall be performed to determine electrical performance of the components, subsystems, and the system with adverse electrical power, communications and environmental conditions applied. The performance shall be demonstrated with forcing levels and conditions at the maximum design tolerance for each appropriate operational condition. Compatibility tests shall be performed and shall prove the following principles:

(1) All components and subsystems do operate successfully in conjunction with each other.

(2) Intrasystem transfer of power, data, and commands in performed in all operating modes such that no components or subsystem acts to degrade the operation of an interfacing component or subsystem.

(3) The resultant total interface to the communications receiving station and associated testing equipment does reflect the harmonious intersystem operation.

(c) Electromagnetic Interference (EMI)

A sequence of electromagnetic interference tests shall be performed to assure the proper system operational interfaces. These tests shall prove the following principles:

(1) The ALSEP will be able to operate successfully in all operational and testing electromagnetic environments.

(2) The ALSEP will introduce no detrimental electromagnetic effect on other systems operating during the total ALSEP operational mission or during the sequence of launch area tests.

To accomplish these proofs, demonstrations of ALSEP susceptibility to externally imposed electromagnetic siganls shall be performed. Introduction of these signals shall be via injection into the system power inputs and the system antenna. Also, specific demonstrations of the ALSEP radiated electromagnetic environment for all operational modes shall be provided.

(d) ALSEP Environmental Performance

Testing shall be performed to prove the ALSEP capability to meet in appropriate parts and in total all environments to which the ALSEP Flight Equipment will be subjected. In addition tests will be performed to environmental levels used for limits in the ALSEP design. Electrical performance of ALSEP shall be monitored during environmental tests of conditions present during ALSEP active mission phases (lunar operation). Also, electrical performance of ALSEP shall be verified in total after subjection of ALSEP to environmental tests in passive configurations.

7.6 Reference documentation. - The ALSEP design shall conform with criteria designated in this specification. Qualification testing shall as a minimum prove the ability of ALSEP to operate successfully with subjection to environments and electrical criteria contained in the following documents to the extent specified in this specification:

(a) MIL-I-26600, EMI-10A
(b) LIS 360-22302
(c) LED 520-1D
(d) LSP 360-11
(e) DS-3
(f) DS-7
(g) DS-13
(h) PS-5

In addition, tests and test procedures shall be compatible with Specification MIL-E-5272 and MIL-STD-810.

7.7 Qualification test limitations. - Tests planned by the contractor in addition to those tests previously identified and the qualification test model shall conform with the following limitations:

(a) Off Limit Tests

Tests shall be made in discrete environmental and operational steps limited to 200 percent of the equipment design level.

(b) Mission Simulation

Tests shall be limited to two complete accelerated mission sequences. Total simulation test time shall be less than 2 months.

(c) Life Tests

Life testing of the ALSEP qualification model shall be limited to 4 months.