MIL-STD-1539 (USAF)
1 AUGUST 1973

MILITARY STANDARD

ELECTRICAL POWER, DIRECT CURRENT, SPACE VEHICLE DESIGN REQUIREMENTS

FSC 1810

DEPARTMENT OF THE AIR FORCE

Washington, D. C. 20301

Electrical Power, Direct Current,
Space Vehicle Design Requirements

MIL-STD-1539 (USAF)

1. This standard is approved for use by all Agencies of the Department of the Air Force.

2. Recommended corrections, additions, or deletions should be addressed to:

SAMSO/DRUE
P. O. BOX 92960
Worldway Postal Center
Los Angeles, Calif. 90009

CONTENTS

CONTENTS (CONTINUED)

ELECTRICAL POWER, DIRECT CURRENT,
SPACE VEHICLE DESIGN REQUIREMENTS

1. SCOPE

1.1 General. This standard establishes requirements for the direct current (dc) electrical power system for space vehicles.

1.2 Purpose. This standard insures compatibility between the space vehicle dc electrical power system and the space vehicle utilization equipment. This compatibility is accomplished by confining the electrical power system characteristics within definitive limits and restricting the requirements imposed on the system by the utilization equipment.

1.3 Basis for characteristics. The requirements, characteristics, and limits specified in this standard are based upon the concepts of MIL-STD-704 **as** modified for **space** vehicle applications.

2. REFERENCED DOCUMENTS

The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein:

Military Standards

MIL-STD-255 Electric Voltages, Alternating and Direct Current

MIL-STD-704 Electric Power, Aircraft, Characteristics and utilization of

(Copies of specifications, standards, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

DEFINITIONS

3.1 Electrical power system. The dc electrical power system on a space vehicle is the nominal 28-volt (V) system or the voltage system specified by the procuring activity. The electrical power system consists of the equipments which provide dc electrical power generation, energy storage, power control, and power distribution to the input power terminals of the space vehicle's utilization equipments.

3.1.1 Power generating subsystem. The power generating subsystem includes all equipments generating dc power for charging batteries or for operating directly into the power control and power distribution subsystems. Solar cell arrays or panels are commonly used on space vehicles; however, the power generating subsystem may also include thermoelectric devices, fuel cells and their reactants, reactor systems, and other sources of electrical power. Equipment and devices physically located on space vehicles, but used to supply ground test, prelaunch, or preinjection electrical power, shall be considered part of the power generating subsystem of the space vehicle. Shunts, protective diodes, instrumentation, heaters, and other controls built integral with the power generating sources are considered part of the power generating subsystem.

3.1.2 Electrical energy storage subsystem. The electrical energy storage subsystem includes all rechargeable and all nonrechargeable batteries on the space vehicle. Instrumentation, heaters, and other controls built integral with the batteries are considered part of the electrical energy storage subsystem.

3.1.3 Power distribution subsystem. The electrical power distribution subsystem on a space vehicle shall be subdivided into identifiable load groups. The power in stribution subsystem for each load group originates at a power load bus or terminal in the power control subsystem and extends to the input power terminals of the space vechicle's utilization equipments comprising that load group. The power distribution subsystem includes harnesses, cables, conductors , and connectors used in the power distribution circuits.

3.1.4 Power control subsystem. The electrical power control subsystem includes the command system interfaces, switches, relays, connectors, interconnect wiring, load buses, resetable circuit breakers, fuses, load control devices, voltage sensors, current sensors, battery chargers, battery discharge controllers, and other related devices used to interconnect and control the dc power generation subsystem, the electrical energy storage subsystem, and the power distribution subsystem of the space vehicle. Instrumentation, heaters, and other controls built integral with the power control equipments are considered part of the power control subsystem.

3.2 Utilization equipment. Utilization equipments comprise all electrical loads external to the dc power system to which the specified dc power is supplied.

3.3 System ground point (SGP). The SGP is a single point on the vehicle structure to which the negative or the neutral of the electrical power system is connected. Electrically isolated power systems may have separate system ground points on the vehicle structure.

3.4 Essential loads. The utilization equipments that are necessary for the survival of the space vehicle itself are defined as essential loads.

3.5 Normal operating modes. The normal operating modes for the electrical power system on the space vehicle include all planned, expected, or commendable operating conditions. These include various load groups cycled on or off, both sunlight and eclipse conditions, high and low bus voltages, and other predictable operating conditions.

3.6 Abnormal operating modes. Abnormal operating modes for the electrical power system include those conditions resulting from short circuit failures, or open circuit failures, or other malfunctions occurring anywhere within the space vehicle including within the electrical system itself. Other abnormal operating modes include conditions resulting from temperature extremes that exceed specified or anticipated values and from excessive degradation of solar arrays or other power system equipment.

3.7 Transients. A transient is that part of the variation in a variable that ultimately disappears during transition from one steady-state operating condition to another. Transients are aperiodic and include nonrecurring current surges and voltage spikes.

3.8 Ripple. Ripple is the cyclic variation of voltage about the mean level of the voltage during steady-state dc electrical system operation. The ripple voltage may contain multiple frequencies and includes noise not generated by transients. The average value of ripple is zero.

4. GENERAL REQUIREMENTS

4.1 System. The dc power system for a space vehicle shall be so designed as to ensure that the characteristics of electrical power at the utilization equipment power input terminals conform to the requirements specified in this document. The electrical system shall be designed so that the power levels and energy requirements of each of the utilization equipments are satisfied for the specified service life of the utilization equipments. The dc power system shall be capable of meeting the functional characteristics and design requirements specified herein before and after exposure to preflight environmental conditions and during all predictable or specified flight environmental conditions.

4.2 Voltage limits. The steady state dc electrical power on the space vehicle measured at the input to the utilization equipment shall be 28.0 ± 6.0 V during normal operating conditions.

4.3 Power distribution. The dc power shall be distributed using a two wire system. The negative or ground return path for all power circuits shall be through conductors in the wiring harnesses. The vehicle structure shall not be used as an intentional current-carrying conductor.

4.3.1 System ground point (SGP). The dc power system of a space vehicle shall have the power negative buses in the power control subsystem grounded to the vehicle structure at a single point. This single point shall be referred to herein as the System Ground Point (SGP). The dc resistance as measured from the power negative bus to the vehicle structure shall not exceed 2.5 miillonms. No grounds shall be made to magnesium structure.

4.3.2 Multiple power sources. When the electrical power systems from various power sources on a vehicle are electrically isolated from each other, they shall each have a SGP connection to the vehicle structure. Either the same SGP or separate SGP's may be used for the isolated power systems. When the power systems from various power sources on a vehicle are not electrically isolated from each other, the power system negative buses shall all be connected to the same SGP. All power return leads from any one load group shall be grounded to the SGP of the power source supplying that load.

4.4 Utilization equipment. Utilization equipment shall maintain its specified performance when using power with characteristics which are specified herein. When use of power is required having other characteristics or closer tolerances than specified herein, the conversion to other characteristics or closer tolerances shall be accomplished as a part of the utilization equipment. Utilization equipment current requirements shall be determined over the input voltage range specified herein.

5. DETAILED REQUIREMENTS

5.1 Nominal time line. A nominal operational time line shall be established for the space vehicle that identifies the planned operational configurations and status of the space vehicle for all normal operating modes including acceptance testing, prelaunch checks, launch, orbit injection, attitude acquisition, on orbit, and reentry conditions as may be applicable. This time line shall include the cycling of the various loads or load groups on or off as planned, expected, or commandable for each operating mode of the space vehicle. Both sunlight and eclipse conditions, high and low bus voltages, and other predictable operating conditions shall be included. This nominal operational time line shall be at least as long as the service life of the space vechicle.

5.2 Power requirements of loads

5.2.1 Load groups. The utilization equipments are to be grouped into identified load groups. One or more of these identified load groups shall be used for essential loads only. The load groups shall be identified with power hoses or terminals in the electrical power control subsystem.

5.2.2 Redundant loads. Redundant utilization equipments shall be placed in different load groups so that electrical power will be supplied by seperate wires and so that damage to one load group will not affect the others.

5.2.3 Nominal power profile. The nominal power profile shall be determined for each load group and for the total electrical load, as a function of operational time based upon the vehicle configuration and status used for the nominal time line.

5.2.4 Consumed energy. The energy consumed by the utilization equipments on the space vehicle shall be determined as a function of time based upon the nominal power profile.

5.3 Energy management

5.3.1 Energy requirements. During every time period of operation, the sum of the electrical energy consumed by the utilization equipments plus the electrical power system losses, can be no greater than the sum of the electrical energy generated during the same time period plus the electrical energy stored at the beginning of that time period. By the use of the consumed energy time line, and the nominal time line to identify the space vehicle operating conditions, the power generating capabilities and energy storage capabilities shall be shown to satisfy this requirement for each operating mode and for the entire service life of the space vehicle.

5.3.2 Energy margins. Energy generating and storage capabilities in excess of the nominal load requirements shall be identified as energy margins. Energy generating and storage margins shall be provided to accommodate the following:

(a) Inaccuracies in predicting utilization load requirements.

(b) The predictable degradation of the electrical system that will occur during the service life of the space vehicle.

(c) Variations in component and end item electrical characteristics from unit to unit.

(d) Variations in electrical characteristics due to off nominal space vehicle orbits , stabilization, or thermal environments.

(e) Current limiting operations, the trip bands of the protection equipment, and other abnormal conditions during which full space vehicle operations are required.

(f) Predictable variations in the nominal time line and the nominal power profile.

The power generating and energy storage margins provided shall be identified as “reserve” unless they are otherwise specifically identified. For each battery, the maximum depth of discharge and the number of discharge-charge cycles used shall be determined as a function of operating time. Redundant power generatng and energy storage components shall be provided as necessary to meet the reliability requirements and service life of the space vehicle.

5.3.3 Analysis. The energy analysis of the electrical power system operation shall be coupled with the thermal analysis so that any effects of temperature on component electrical characteristics will be considered during all normal operating modes as well as during possible abnormal operating conditions. The thermal analysis shall include the effect of internally generated heat within the electrical power system during all normal operating modes as well as during possible abnormal operating conditions.

5.3.4 Power control. The power control subsystem shall be designed to regulate and control the electrical power generation, energy storage, and power distribution subsystems to satisfy the dc power requirements of the space vehicle.

5.3.5 Charge control. When battery charge discharge controls are used, separate controls shall be provided for each rechargeable battery or system of rechargeable batteries connected in series to provide the required bus voltage.

5.4 Failure protection

5.4.1 Fault isolation. The electrical power system shall include fault isolation that protects against short circuits in the utilization equipment or in the electrical distribution subsystem which could adversely affect the electrical system operation. The fault isolation shall either open the circuit to remove the load and short circuit from the load bus or shall limit the current so that electrical power characteristics to other loads remain within the specified limits. Provisions shall not be included for fault. isolation of nonredundant essential loads.

5.4.2 Power control. The power control. subsystems shall be designed, installed, and protected so that the failure of any power source will not result in subsequent impaired performance of the remaining power sources.

5.4.3 Battery failure. The installation of the batteries shall include provisions that minimize damage to the space vehicle and to the electrical system in the event of a major failure of the battery. The major failures to be considered include, but are not limited to, an explosion of any of the batteries due to the internal generation of excessive gas or a massive short circuit involving multiple cells.

5.4.4 Overvoltage and undervoltage. Failures in the electrical power system that can result in voltages higher or lower than specified herein being applied to utilization equipments shall be identified as critical failure modes.

5.5 Power quality

5.5.1 Ripple voltage. The ripple voltage shall be less than 0.8 V peak-to-peak as measured over the bandwidth from dc to 10 megahertz (MHz) when the power system is delivering the maximum rated current into resistive loads.

5.5.2 Transients. Generation of voltage transients an the dc electrical power by load or source switching shall be limited to ±28-V peak measured from the steady state value. In addition, the integrated area under the transient voltage-time function shall not exceed 0.003 volt-seconds.

5.5.3 Bus impedance. The impedance of the power sources measured at each of the load buses shall be determined analytically to be sufficiently low over a frequency range from dc to 50 MHz SO that conducted interference voltages produced by utilization loads will not be excessive.

5.5.4 Power transfer. Switching of power sources shall not result in power loss to any utilization equipment that exceeds 50 milliseconds. The current surges resulting from switching power sources or utilization equipments on or off shall not cause the voltage limits, transients, or power quality to exceed the values specified herein.

6. NOTES

6.1 Deviations. Variations to the voltage characteristics specified in 4.2 and 5.5 of this standard must be approved by the procuring activity. Variations that are cost effective and that enhance the total space vehicle design may be proposed by contractors. The advantages of proposed variations should be clearly identified with substantiating, quantitative analysis. The advantages should clearly overbalance the advantages accrued to all space vehicle programs by the consistent use of this standard. If a higher nominal voltage is required for a particular space vehicle, the preferred value, based upon MIL-STD-255 and other considerations, is 115 ± 20 V.

6.2 Instrumentation. The minimum recommended monitoring instrumentation for the space vehicle electrical power system is that which reports the values of the voltage and current at or through load buses, voltage and current from each power generating source, voltage and current to or from each battery, the temperatures of major electrical system components, and the configuration status of the power control subsystem including switch and relay positions and circuit breaker status.

6.3 Fault isolation. The use of fuses, command resetable circuit breakers, current limiting resistors, or the use of other current limiting devices is acceptable when the devices are properly designed and applied. The use of current or voltage monitoring devices which, when sensed on the ground, allow the monitored equipment to be commanded open or off is also acceptable when compatible with operational capabilities. The selection of fuse size or trip band on fault isolation devices should provide adequate margins for worst case component tolerances, for thermal environments, for the in rush transient resulting from initial application of power to the space vehicle, for the in rush transients resulting from turning individual or group loads on or off, as well as for steady state operations. The fault isolation devices should be capable of interrupting at least twice the worst case short circuit currents.

Custodian:
Air Force - 19

Review Activity:
Air Force - 11

Preparing activity:
Air Force - 19
(Project No. 1810-F003)

☆ U. S. GOVERNMENT PRINTING OFFICE. 1973 -713-146/1170

INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge *(DO NOT STAPLE)*, and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

(Fold along this line)

(Fold along this line)

DEFENSE LOGISTICS AGENCY

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO 4966 WASHINGTON, D. C.

POSTAGE WILL BE PAID BY THE DEFENSE LOGISTICS AGENCY

SAMSO/DRUE
PO Box 92960
Worldway Postal Center
Los Angeles CA 9009

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION (Mark one)
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER (Specify): ______
b. ADDRESS (Street, City, State, ZIP Code)	

5. PROBLEM AREAS

a. Paragraph Number and Wording

b. Recommended Wording

c. Reason/Rationale for Recommendation

6. REMARKS

7a. NAME OF SUBMITTER (Last, First, MI) – Optional	b. WORK TELEPHONE NUMBER (Include Area Code) – Optional
c. MAILING ADDRESS (Street, City, State, ZIP Code) – Optional	8. DATE OF SUBMISSION (YYMMDD)

DD FORM 1426 82 MAR

PREVIOUS EDITION IS OBSOLETE