

JSC Design and Procedural Standards

Engineering Directorate

Availability:

JSC & JSC contractor employees and other NASA & NASA contractor employees as required

September 2015



National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

1. PREFACE

This document contains design and procedural requirements for human spaceflight equipment based on lessons learned and best practices.

The design and procedural requirements are located in Section 5 of this manual and are identified according to the applicable discipline or category, with letter codes as follows:

G	General
E	Electrical
F	Fluids
M/P	Materials and Processes
M/S	Mechanical and Structural
P	Pyrotechnics

This document is controlled by the JSC Engineering Directorate (EA) Configuration Control Board (CCB).

Requests for information, corrections, or additions to this Standard should be submitted to [Russell Yates](#).

2. CHANGE LOG

Revision	Date	Originator	Description of Changes
Basic	January 2015	EA5 / Russell Yates / 281-483-0996	Renumbered document from JSC-STD-8080 to JSC-08080-2. Reformatted requirements. Deleted key word index, signature block, and historical changes. Added applicable documents, requirement guidelines, and reference documents. Rewrote Preface and Introduction. Improved consistency of numbering and capitalization. Corrected superscripts / subscripts. Corrected document titles. Added "None." to Remarks if none.

			Deleted superseding comments. G-5: Replaced JSC 49774 reference with NASA-STD-6016. G-11: Replaced NASA FAR Supplement text with reference. G-14: Updated FED-STD-595A reference to current revision. G-22: Reverted to 2005 revision of requirement, changed “until installed in an assembly” to “throughout their lifecycle,” added JSC references to Remarks section. G-29: Updated NPR 8705.2 reference to current revision. G-37: Deleted reference to NASA-STD-3000. G-39: Updated lightning protection standard references to current revisions. E-1: Updated NASA-STD-3000 reference to NASA-STD-3001. E-7: Updated MIL-PRF-39003/10B reference to MIL-PRF-39003/10D w/Amendment 1. E-13: Updated symbols from uA to μA. E-14: Deleted JSC 49774 reference. E-20: Removed IEEE C62.38 from list of acceptable test methods. E-24: Replaced MIL-C-17 reference with MIL-DTL-17, and MIL-W-22759 with SAE AS22759. F-5: Deleted redundant paragraph F-27: Updated requirement for de-ionized water lesson learned. MP-9: Updated JPG 1700.1 reference to JPR 1700.1. MP-11: Updated pressure vessel standard references to current revisions. MP-13: Updated pressure vessel standard references to current revisions, and updated JSC-STD-1710 reference to JPR 1710.13. MS-4: Deleted reference to NASA-STD-3000.
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			MS-5: Replaced JSC 49774 references with NASA-STD-5020, NASA-STD-6016, and MSFC-STD-557; added requirement that sole locking feature not rely on preload; changed NASA-STD-3000 reference to NASA-STD-3001. MS-7: Added reference to NASA-STD-5018. Approval Reference ECD 0209
A	Mar 2015	EA5 / Russell Yates / 281-483-0996	Preface: Added point of contact. G-10: Correction: removed extra numbering G-14: Added JSC hardware classifications to Remarks section. G-24: Added reference to G-14. G-25: Removed reference to SSP 30213. E-9: Replaced MA2-99-170 reference with SSP 51700. E-12: Correction: moved requirement from Remarks section to Statement of Standard section. E-22: Correction: removed extra header F-1: Added “and terminations” to Remarks section. F-12: Added reference to G-14. F-18: Added “with tolerances” to requirement. MS-5: Deleted requirement in favor of NASA-STD-5020, G-5, and EVA requirements. MS-11: Updated Remarks; replaced NASA SP-8042 and NASA SP-8013 references with NASA TM-2009-214785, NASA TP-2014-217370, and MEM R2. P-5: Reduced labeling requirements, replaced NSTS 08060 reference with JSC 62809. P-6: Updated Remarks; replaced NSTS 08060 reference with JSC 62809, deleted NSTS 07636 reference. Approval Reference ECD 0212

B	Sep 2015	EA5 / Russell Yates / 281-483-0996	General: Labeled retired requirements as “Reserved”. 4.6: Deleted “Cancellation” section. G-9: Replaced requirement with reference to NASA-STD-5018. G-16: Removed <i>unlikely</i> from remarks. E-7: Deleted redundant paragraphs. E-13: Removed IEC 60601-1 revision from remarks. F-30: Updated definition of maximum design pressure. MS-5: Revived requirement with references to NASA-STD-5020 and JSC 28918. MS-7: Deleted requirement in favor of G-9. P-1: Replaced requirement with reference to JSC 62809. P-2, P-5, P-6: Deleted requirements in favor of P-1. Appendix A: Updated requirement guidelines. Approval Reference ECD 0217
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4. INTRODUCTION

4.1 PURPOSE

This document contains design and procedural requirements for human spaceflight equipment based on lessons learned and best practices.

4.2 BACKGROUND

JSC originally published its design and procedural requirements as bulletins circa 1964. In 1971, these bulletins were combined into a single document, JSCM 8080. Since then, JSC has, as needed, issued minor updates to the document, with major revisions occurring in 1991 and 2005. Through the years, the document has undergone several formatting and document number changes (e.g., JSCM 8080, JPR 8080.5, JSC-STD-8080).

4.3 APPLICABILITY

These requirements are appropriate for the acquisition, design, development, test, evaluation, operations, and sustaining engineering of any human spaceflight program, project, spacecraft, system, or end item.

The requirements may be imposed via directive, specification, or agreement.

The requirements may be imposed individually (by referring to individual requirement numbers) or wholly (by referring to the document number). If the requirements are imposed wholly, it is appropriate to assess the applicability of individual requirements (e.g., via an applicability matrix).

4.4 AUTHORITY

JPD 8080.2, JSC Design and Procedural Standards for Human Space Flight Equipment.

4.5 APPLICABLE DOCUMENTS

The latest version of these documents apply unless otherwise specified. The documents only apply when the referencing requirement applies (see Section 4.3), and only to the extent specified in the referencing requirement. The referencing

requirements for each applicable document are listed in parenthesis following the document name. Documents are grouped as follows and listed alphabetically by document number within each group: law, NASA directives, NASA standards, non-NASA government standards, and other standards.

JPR 1710.13, Design, Inspection, and Certification of Ground-Based Pressure Vessels and Pressurized Systems (MP-13)

JSC 28918, EVA Design Requirements and Considerations (MS-5)

JSC 62809, Human Rated Spacecraft Pyrotechnic Specification (P-1)

NASA-STD-5001, Structural Design and Test Factors of Safety for Spaceflight Hardware (MS-14)

NASA-STD-5018, Strength Design and Verification Criteria for Glass, Ceramics, and Windows in Human Space Flight Applications (G-9)

NASA-STD-5020, Requirements for Threaded Fastening Systems in Spaceflight Hardware (MS-5)

NASA-STD-6016, Standard Materials and Processes Requirements for Spacecraft (MP-1)

NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring (E-14)

SSP 30423, Space Station Approved Electrical, Electronic, and Electromechanical (EEE) Parts List (E-24)

DD Form 250, Material Inspection and Receiving Report (G-14)

DD Form 1149, Requisition and Invoice/Shipping Document (G-14)

FAA AC 20-136, Aircraft Electrical and Electronic System Lightning Protection (G-39)

FED-STD-595, Colors Used in Government Procurement (G-14)

MIL-DTL-17, Cables, Radio Frequency, Flexible and Semirigid (E-24)

MIL-PRF-39003/10D w/Amendment 1, Capacitors, Fixed, Electrolytic (Solid Electrolyte), Tantalum, (Polarized, Sintered Slug), Established Reliability, Styles CSS13 and CSS33 (High Reliability Applications) (E-7)

ANSI/NEMA WC 27500, Standard for Aerospace and Industrial Electrical Cable (E-24)

AIAA S-080-1998, Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components (MP-13)

AIAA S-081A-2006, Space Systems – Composite Overwrapped Pressure Vessels (COPVs) (MP-13)

ASME Boiler & Pressure Vessel Code (MP-13)

ASTM Manual 36, Safe Use of Oxygen and Oxygen Systems: Handbook for Design, Operation, and Maintenance (F-1, F-16, F-19)

NAS412, Foreign Object Damage / Foreign Object Debris (FOD) Prevention (G-5)

SAE ARP5412, Aircraft Lightning Environment and Related Test Waveforms (G-39)

SAE ARP5414, Aircraft Lightning Zoning (G-39)

SAE ARP5415, User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lighting (G-39)

SAE ARP5577, Aircraft Lightning Direct Effects Certification (G-39)

SAE AS22759, Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy (E-24)

5. DESIGN AND PROCEDURAL STANDARDS

5.1 GENERAL

G-1 Equipment Accessibility for Maintenance

STATEMENT OF STANDARD

Systems, subsystems, equipment, and components shall be designed with features that contribute to the ease and rapidity of maintenance.

Equipment expected to require servicing, replacement, or maintenance shall be designed to be accessible without removal of other equipment, wire bundles, and fluid lines. This should include accessibility during ground operations (horizontal and vertical) as well as on orbit.

Electrical connections and cable installations shall be designed with sufficient flexibility, length, and protection to permit disconnection and reconnection without damage to wiring or connectors.

Panel-mounted displays and controls that are inside the habitable areas shall be capable of being totally maintained from the habitable area. Each display and control installation shall be designed to permit removal and replacement without disturbing the validity and integrity of other components or subsystems.

REMARKS

The version updated in October 2004 modifies the text to align better with longer-term maintenance activities encountered on longer duration space missions such as the International Space Station (ISS) or exploration missions.

G-2 Separation of Redundant Systems**STATEMENT OF STANDARD**

Redundant systems, redundant subsystems, and redundant major elements of subsystems (such as assemblies, panels, power supplies, tanks, controls, and associated interconnecting wiring and fluid lines) shall be separated or protected to ensure that an unexpected event which damages one is not likely to prevent the other from performing the functions.

Electrical wiring of redundant systems, redundant subsystems, or redundant major elements of subsystems shall not be routed in the same wire bundle or through the same connector with wiring of the other redundant system, subsystem, or subsystem element.

This standard is not applicable to redundant components or piece parts mounted in common housings within redundant systems, subsystems, or subsystem elements.

This standard does not apply to redundant explosive charges that are located adjacent to each other in order to sever structural members at a given point or along a given line. However, the electrical wiring of redundant systems and routing shall apply.

REMARKS

For purposes of this standard, "redundancy" is defined as the ability to perform a function by more than one means.

This recommended separation for electrical wiring also applies to fluid lines.

G-3 Electrical and Fluid Systems Checkout Provisions**STATEMENT OF STANDARD**

Electrical and fluid systems and subsystems shall be designed to permit checkout tests and shall include provisions (e.g., test points) that permit these checkout tests to be conducted without disconnecting any tubing, mated flight couplings, or any other mated flight connectors.

Test points shall allow checkout of the system without loss of integrity (e.g., loss of pressure, leakage, loss of continuity, etc.).

REMARKS

None.

G-4 Protection from Debris – Electrical & Mechanical Systems**STATEMENT OF STANDARD**

Electrical and mechanical systems shall be shielded in such a way that encounters with debris or foreign material do not cause a malfunction. Acceptable methods include, but are not limited to, the following:

1. Design and fabricate electrical circuitry to prevent the establishment of unwanted current paths from such debris.
2. Provide critical electrical items with debris-proof covers, suitable containers, housings, potting, or conformal coatings.
3. Provide critical mechanical systems with debris-proof covers, shrouds, or containers that protect the entire system prior to use, or that prevent debris from entering into critical areas of the mechanism where the debris could cause binding, jamming, or seizing.
4. Incorporate filters, strainers, traps, screens, or other devices in moving-fluid components of electrical or mechanical systems to trap debris in a manner that will eliminate it as a threat to critical mechanical or electrical components. In systems where flow reversal may occur, install such devices on both sides of critical components. Make sure all such devices are able to be cleaned in-flight and/or are able to be replaced as part of the maintenance program.

REMARKS

Refer to G-5 for prevention of debris.

Crew cabin module ventilation fans are low pressure-drop devices with small clearances between blades and duct to maximize efficiency and minimize power consumption. Under microgravity conditions ventilation systems are particularly prone to blockage due to particulates. International Space Station ventilation systems suffered up to 80% reduction in flow due to the entrainment of clusters of particulate or fibrous debris in the ventilation systems. This debris penetrated through a protective screen with .02-inch diameter hole size, but then combined to block internal flow paths with .125-inch diameter. Because simple screens have been shown to be ineffective in long duration protection of ventilation systems in microgravity, depth filters should be used to protect ventilation systems from particulate fouling for long-duration missions. A similar phenomenon can occur in liquid media systems where particulates chemically combine downstream of the filter to produce larger than screen-size debris clumps. These systems should be assessed for the use of depth filters or more effective chemical filters.

G-5 Prevention of Debris – Electrical & Mechanical Systems

STATEMENT OF STANDARD

A Foreign Object Debris (FOD) prevention program shall be established for all ground operations of mechanical and electrical systems of flight hardware including the design, development, manufacturing, assembly, repair, processing, testing, maintenance, operation, and check out of the equipment to ensure the highest practical level of cleanliness.

The FOD prevention program shall conform to NAS412, Foreign Object Damage / Foreign Object Debris (FOD) Prevention.

REMARKS

Refer to G-4 for protection from FOD.

NAS412 is available through NASA Technical Standards Program at Marshall Space Flight Center.

Refer to NASA-STD-6016, Standard Materials and Processes Requirements for Spacecraft, for selection of materials to prevent growth of biological contaminants.

G-6 [Reserved]

G-7 [Reserved]

G-8 Design for Redundancy Verification

STATEMENT OF STANDARD

Spacecraft systems, subsystems, and equipment shall be designed to permit verification of redundant functions or operational modes any time the system, subsystem, or equipment requires testing prior to launch or during the mission.

REMARKS

This standard is not to be interpreted to require verification of redundancy every time the system, subsystem, or equipment is tested but merely to require that the systems/subsystems/equipment be designed in a manner to allow redundancy verification if it is deemed necessary. Verification of redundancy may occur at any time from acceptance testing through launch processing, mission operations, and post flight.

G-9 Shatterable Material**STATEMENT OF STANDARD**

Uncontained shatterable materials shall meet the requirements of NASA-STD-5018, Strength Design and Verification Criteria for Glass, Ceramics, and Windows in Human Space Flight Applications.

REMARKS

Uncontained shatterable materials include any piece of glass and other glass-like materials, such as germanium and sapphire, which, if broken, will endanger the crew or the mission success.

Examples of items that are considered contained are camera lenses that are covered by lens caps while not in use and shatterable materials that are permanently and completely covered by clear plastic, tape, or screen protectors.

G-10 Time/Cycle Critical Part Control**STATEMENT OF STANDARD**

Spacecraft components which are time-critical and/or cycle-critical or which have limited storage life shall be subject to the following controls:

1. Each time-critical or limited-life assembly, subassembly, component, and spare shall be clearly and indelibly marked with a serial number.
2. Appropriate documentation shall accompany all time-critical and limited-life items and shall include the date of manufacture of the item and of its most time-critical component. Realistic life limits shall be assigned and documented for each item and shall be suitably altered as new data and new evidence are obtained.
3. Status records shall be maintained on all such items after installation in the spacecraft. Operating-time logs shall be maintained for all items having limited operating lives. Components shall have sufficient life remaining to adequately support mission requirements.
4. Special storage requirements shall be carefully defined and strictly observed.

A time-age-life cycle database shall be maintained for verification (and notification) of time-age-life component status.

REMARKS

This requirement may be satisfied by the inventory management subsystem of the onboard data management system.

G-11 Procurement Document Identification for Human Spaceflight Items

STATEMENT OF STANDARD

Purchase requests (PRs), requests for proposal (RFPs), purchase orders (POs), credit card purchases, contracts, and subcontracts for items procured for use in human spaceflight shall be submitted with the statement shown below.

The information shall be printed, stamped, or added in boldface type.

FOR USE IN HUMAN SPACEFLIGHT, MATERIALS, MANUFACTURING, AND WORKMANSHIP OF HIGHEST QUALITY STANDARDS ARE ESSENTIAL TO ASTRONAUT SAFETY.

IF YOU ARE ABLE TO SUPPLY THE DESIRED ITEMS WITH A QUALITY WHICH IS HIGHER THAN THAT OF THE ITEMS SPECIFIED OR PROPOSED, YOU ARE REQUESTED TO BRING THIS FACT TO THE IMMEDIATE ATTENTION OF THE PURCHASER.

Procedures shall assure that new PRs, RFPs, POs, contracts, and subcontracts issued by prime contractors and their subcontractors down to the lowest tier include this information. Present contracts and subcontracts involving such hardware shall be amended at the earliest possible date to require the prime contractor or subcontractor to establish such procedures in all actions covering new procurement.

REMARKS

See 48 C.F.R. § 1852.246-73, NASA Federal Acquisition Regulations Supplement, Human Space Flight Item (1997).

G-12 Application of Previous Qualification Test Data

STATEMENT OF STANDARD

When certifying an item for a new application, use of qualification test data obtained during a previous certification shall meet the following conditions prior to use:

1. There is no change in design and specifications from the original item certified including operating limits, weight, dimensions, materials, performance and tolerance, reliability, and quality.
2. The configuration (part number and dash number) previously tested is identical to the configuration proposed for the new application.
3. Manufacturing/Fabrication methods and process have not changed and are certified
4. Previous environmental test conditions are greater than or equal to the environmental extremities and exposure durations required for the new application.

5. Previous functional/performance test results are greater than or equal to the accuracy, input-output, sensitivity, and other performance/operational characteristics required for the new application.
6. The previous test configuration is documented and is considered an adequate methodology/technology to provide test results for the new application.
7. Previous test equipment tolerances and data resolution are documented.
8. Inspection methods, inspection points, and acceptance test procedures are greater than or equal to the rigor of previous methodologies.
9. Previous operating environments, exposure duration, cycling, and usage are greater than or equal to the operations concept required for the new application.
10. Previous failures have been evaluated for impact to the validity of test and analysis data

REMARKS

Flight Certification of any item involves evaluation of verification data to determine if customer requirements have been met. When some of that data is already available from a prior flight certification program, and the appropriate technical evaluation determines that the data can be used to support a new certification program, it is cost effective to use existing data instead of performing additional testing. Previous failures and waivers must be reconsidered or resubmitted for approval by the authorizing organization. Environmental testing typically refers to vibration, thermal, thermal vacuum, radiation, loads, and electromagnetics.

G-13 [Reserved]

G-14 Classification of Flight and Non-Flight Equipment

STATEMENT OF STANDARD

The status of flight equipment and nonflight equipment (equipment which is not suitable for use in flight but which could be accidentally substituted for flight articles) shall be identified and classified as follows:

CLASS I	Equipment acceptable for flight use. Identification shall be in accordance with drawings and specifications.
CLASS II	Equipment acceptable for use in ground tests or training in a hazardous environment. The nameplate or a label adjacent to the nameplate shall be conspicuously marked "CLASS II, CONTROLLED EQUIPMENT" with flight compatible material.

CLASS III Equipment acceptable for nonhazardous training or display purposes. This equipment shall be conspicuously identified by red (or orange) stripes alternating with a contrasting base color or painted solid red. Red paint no. 28913 as specified by FED-STD-595, Colors Used in Government Procurement, is the preferred color. An alternative to the paint method of identification is a red (or orange) striped nameplate or label marked "CLASS III, NOT FOR FLIGHT" applied to the equipment. The identification shall be visible when the equipment is installed.

In addition, equipment not readily identifiable as nonflight equipment, as well as nonflight equipment hidden from view in a major module, shall have a red (or orange) serialized streamer attached to, or in the immediate vicinity of the installation. The streamer shall be of a size and material compatible with the environment under which it will be used. Streamers are to be traceable to the major module which identifies and controls the item. A record of nonflight equipment and, if appropriate, associated streamer serial numbers shall accompany each major module upon formal transfer (i.e., DD250/1149) from one organization to another.

Appropriate instructions shall be printed on each streamer. Streamers shall be numbered and accounted for prior to launch.

The color coding requirements of this standard do not apply to explosive devices.

REMARKS

Nonflight equipment or hardware must be identified to preclude possible use during a flight mission.

Hazardous environment is defined as a chamber environment (such as vacuum, high temperature, low temperature, and oxygen-rich atmosphere) or any other environmental condition that could subject the user of the equipment to a hazard of any kind.

In practice, JSC uses additional hardware classifications. Class IE is for experimental hardware and some commercial off-the-shelf hardware. Class IIIW equipment is acceptable for use in water immersion training in a hazardous environment. Ground Support Equipment (GSE) is non-flight equipment designed to interface with flight hardware. And Special Test Equipment (STE) are similar to GSE, but not controlled until time of use. See JPR 1281.10, Inspection and Testing, for more complete definitions of JSC hardware classifications.

Additionally, some JSC programs classify hardware as Flight Support Equipment, which includes government-furnished equipment.

Though not an official JSC classification, the term Airborne Support Equipment (ASE) refers to flight equipment installed to support operations. See MIL-HDBK-340A, Test

Requirements for Launch, Upper-Stage, and Space Vehicles, Vol I, Baselines, for a more complete definition of ASE.

G-15 Resolution of Flight Equipment Failures/Anomalies Prior to Launch

STATEMENT OF STANDARD

Where flight or flight-like equipment has failed or otherwise exhibited anomalous performance or intermittent operation, launch-to-orbit of identical or like equipment, either as part of the flight vehicle or as a replacement, shall not be permitted unless one of the following occurs:

1. It is verified that the basic deficiency which caused the failure or anomalous performance is not present in the flight equipment or its replacement.
2. The basic deficiency has been counteracted by changes in operational procedures to a degree that eliminates it as an unacceptable risk to the success of the mission or the safety of the crew.
3. The basic deficiency does not present an unacceptable risk to the success of the mission and safety of the crew.

Do not use equipment that exhibits or has exhibited intermittent malfunctions, failures, or anomalies for flight until the malfunction, failure, or anomaly has been corrected or resolved to the satisfaction of the Flight Readiness Review Board.

REMARKS

This standard supports the current philosophy that all failures or anomalous performance must be resolved before launch.

Where the cause of an inconsistency remains unresolved, equipment is unreliable.

G-16 Operational Limits on Temperature-Controlled Equipment

STATEMENT OF STANDARD

For spacecraft equipment where the operating temperature is normally controlled by heating or cooling equipment and the temperature is monitored in ground test and flight, the test program and/or appropriate analyses shall define the following:

1. The maximum and minimum temperatures expected in normal operations
2. The maximum and minimum temperatures (including duration and temperature rate of change, as appropriate) at which equipment may be expected to:
 - a. Fail to meet specified performance until temperature is restored to normal range.
 - b. Be permanently rendered inoperative.

For critical components, automatic safing with manual override only shall be used.

Information used to satisfy requirements 1 and 2 above shall be provided in operational constraints documentation.

REMARKS

Knowing the maximum and minimum operating limits of spacecraft equipment is essential for flight and mission management. This information needs to be readily available for real time decision-making.

Item #1:

This information is needed for equipment characterization and could be used for recognizing a thermal malfunction within the spacecraft equipment.

Item #2

This information provides guidance to NASA in an off-nominal mission scenario where normal operating temperatures may need to be exceeded due to malfunction(s) either external or internal to the equipment. In such a scenario it may become necessary to operate equipment beyond the qualification limits and mission manager's need to know how far the equipment can be pushed and reasonably expect that the equipment can be turned off and subsequently reactivated to support the safe return of the crew. The ultimate purpose of this information is to enable flight and mission management to make the best decisions possible in an off-nominal situation to maximize the probability of safely returning the crew.

Relevant information used to form the guidelines may include data or analysis from other program or manufacturer development (from Department of Defense (DoD) to Commercial of the Shelf (COTS)), data from operational programs due to unplanned thermal conditions, similar hardware data (document similarities and contrasts, e.g. non-screened parts data), sub-part data, bench testing that was not previously documented in reports, inadvertent test conditions, etc.

The desired outcome is a set of useful temperature and duration guidelines for the deliverable units at the lowest cost. Therefore, deriving the guidelines from the best available information is preferred and supplemental high-cost testing must be approved by the Program. Engineering judgment should also be applied and documented as appropriate in meeting this requirement.

G-17 Separate Stock for Spaceflight Parts and Materials

STATEMENT OF STANDARD

Assemblies, parts, and materials procured or designated specifically for use in space shall be:

- positively identified
- stored in controlled access areas
- physically separated from nonflight parts and materials to avoid mixing.

REMARKS

This standard is to prevent nonstandard, nonspaceflight, nonsegregated stock from being unintentionally used in space or in the fabrication of spaceflight equipment.

For purposes of this standard, the term "controlled access area" is defined as: stock areas or areas of rooms which are separated from nonflight stock areas or rooms by fences, walls, or other physical separations and which have access control to ensure the following:

1. Access by authorized personnel only
2. Proper parts and materials storage, maintenance, and withdrawal
3. Compliance with applicable quality assurance directives

G-18 Safety Precautions – Test and Operating Procedures

STATEMENT OF STANDARD

Procedures developed for testing and operating spaceflight equipment or ground support equipment shall clearly indicate any step which, if not correctly followed, would result in injury to personnel, damage to a system or equipment, or an environmental impact.

The cover sheet of the procedure shall indicate if the test or operation is hazardous.

REMARKS

A warning statement, preceded by the word WARNING in upper case letters, is commonly used to emphasize any instructions which, if not correctly followed, would result in injury to personnel, damage to a system or equipment, or an environmental impact. The statement usually indicates the reason for the warning.

G-19 Special Processes – Identification of Drawings

STATEMENT OF STANDARD

Manufacturing, assembly, or installation drawings for spacecraft, space flight equipment, experiments, and ground support equipment shall identify all special processes required to manufacture, assemble, and install the equipment.

Process specifications shall be referenced, or the processes shall be specified in detail on the respective drawings.

All referenced specifications not normally available shall be submitted upon request.

REMARKS

The requirements of this standard are in addition to other requirements of the drawing system used. The preferred method of documenting the special processes is to release separate process specifications and to make reference to the specifications on the drawings.

Examples of special processes are cleaning, potting, etching, wire splicing, soldering, welding, brazing, and bonding.

G-20 Spacecraft Equipment – Protection from Liquids During Ground Operations

STATEMENT OF STANDARD

Equipment sensitive to moisture and located where it is subject to liquid leaks during ground operations shall be identified in the design documentation. This documentation shall also include:

- The rationale for positioning the equipment in that location.
- A plan for implementing protection of this equipment.

REMARKS

Major damage to spacecraft and serious delay of programs can result from small, easily correctable leaks that would be of minor significance except for the effect of the leakage on exposed equipment. Experience has shown that fluid system leaks are particularly prevalent during initial ground testing of new spacecraft.

Sources of moisture and liquid leaks may include systems fluids, water condensation, fluid from GSE or facilities, and natural phenomena.

Protection from damage by leakage may include one or more of these methods:

1. Designing the equipment to be insensitive to the liquid leakage
2. Designing the plumbing or equipment containing the liquid to locate couplings, vents, service points, and other items where leakage from them could not reach the sensitive equipment
3. Providing ground support equipment or devices to protect the sensitive equipment from leakage during ground operation

4. Providing proper insulation to prevent condensate from forming and subsequently falling on the equipment

G-21 Spacecraft Equipment – Moisture Protection

STATEMENT OF STANDARD

Spacecraft equipment within a pressurized compartment shall be designed so that performance of the equipment will not be degraded by humidity or moisture droplets in the spacecraft atmosphere or by condensation of moisture from the spacecraft atmosphere.

REMARKS

None.

G-22 Product Identification

STATEMENT OF STANDARD

Parts used in flight hardware shall be identified by physical part marking or container marking per requirements defined on the applicable drawing.

Hardware drawings shall include identification processes necessary to control parts throughout their lifecycle.

REMARKS

Identification requirements, such as user control number, nomenclature, serialization, lot number, date code, values, tolerances, sizes, and polarization may also be necessary for specific parts. Marking systems may include human readable and/ or machine readable codes. Physical marking with alphanumeric characters, direct part marking, bar coding, and combinations of the three methods are example solutions.

For purposes of this standard, a part is defined as one piece or two or more pieces of material joined together that are not normally subject to disassembly without destruction of design use.

The detailed methods for numbering and marking parts should be provided in documentation, such as specifications and drawing system manuals.

This standard applies to all parts including electronic, electrical, electromechanical, mechanical, and machined parts.

JSC parts management and traceability requirements and processes are defined in the following documents:

- JPD 8500.3, Serial and Lot Numbers for Certain Items of Government-Furnished Equipment
- JPR 1281.8, Product Identification and Traceability
- JPR 8500.4, Engineering Drawing System Manual.

G-23 Pressure Garment Wiring – Ignition of Materials by Electrical Current

STATEMENT OF STANDARD

Electrical current entering a crew member's pressure garment shall be limited to a level that will not ignite or damage materials that would contact damaged wiring within the garment under the worst combination of short-circuit current and environment.

Energy storage or conversion devices capable of producing short-circuit current of a magnitude and discharge rate sufficient to ignite materials shall not be located inside pressure garments, unless:

1. adequate current limiting is provided, or
2. there is no contact between potentially damaged wires and the material in question

REMARKS

In this standard, "no contact" is defined as no electrically conductive path.

The fire hazard associated with inclusion of communications and bioinstrumentation wiring in the oxygen-rich environment of pressure garments necessitates the analysis and selection of suitable materials to minimize the potential flammability hazard. It is necessary to confirm the compatibility of the materials and electrical currents under failure conditions in the planned oxygen environment.

Current limiting may be required to assure values below the threshold level for ignition of materials caused by arcing or heating from high-resistance heat sources. An alternative to current limiting is strategic materials placement to ensure that flammable materials, that are demonstrated to ignite at the use conditions, are prevented from contacting potentially damaged electrical wiring or componentry.

Selection of materials with suitable flammability characteristics is constrained by other requirements, such as flexibility, bulk, weight, and comfort of the crew.

G-24 Protecting Flight Equipment from Support Equipment

STATEMENT OF STANDARD

Ground support equipment (GSE), airborne support equipment (ASE), facility equipment, or test equipment used in ground or flight operations shall be equipped with protective devices to preserve safe operation margins of the flight equipment.

REMARKS

GSE or ASE, as a result of misuse or malfunction, has the potential for causing irreparable damage to spacecraft flight systems if the GSE or ASE does not incorporate design features for protecting against such eventualities.

All GSE and ASE designs should be evaluated from the standpoints of inadvertent operator error and hardware (component) malfunction to ensure that protective features are adequate to safeguard spacecraft subsystems. Consideration should be given to the need for not only static overload protection (such as pressure relief, electrical fuses, etc.) but also protection from such elements as dynamic or transient conditions (e.g., electronic filters, accumulators) or contaminants (e.g., contaminant filters).

See the G-14 Remarks section for definitions of GSE and ASE.

G-25 Thermal Design and Analysis

STATEMENT OF STANDARD

Hardware shall be designed to function in the full range of the thermal environment to which it will be exposed.

Thermal analyses shall be performed for nominal and worst-case conditions for all temperature-sensitive components and structures.

Worst hot and cold cases shall be analyzed using realistic combinations of thermal parameters which produce the worst-case conditions.

REMARKS

Example: A solar constant with 3 percent seasonal variation will be used. Other heat flux impacts, solar absorptances, emittances, conductances, etc. will be varied to include measurement uncertainties, variations in application of coatings, and degradation. Boundary temperatures and heater voltages will be varied over the ranges expected.

Thermal analysis includes both transient and steady state.

G-26 Internally-Generated Radiation

STATEMENT OF STANDARD

Laser sources sufficiently powerful to be a hazard shall be positioned to preclude the possibility of looking directly at the source.

Sources emitting electromagnetic wavelengths between x-ray and visible light, sufficiently strong to pose a hazard, shall be positioned to preclude crew exposure or touch.

Hazard distance shall be marked.

REMARKS

None.

G-27 Fire Control

STATEMENT OF STANDARD

The primary means of fire control shall be the selection of materials that are nonflammable or nonpropagating in their use configuration. Materials flammability control is addressed in MP-1, Materials and Processes Control.

The capability for fire detection and suppression shall be provided.

The material used to extinguish fires shall be nontoxic to humans and shall be capable of being easily cleaned up after it is used.

REMARKS

Fire, particularly in a space vehicle, can be catastrophic. Special precautions are necessary, more so than on earth, because countermeasures must be self-contained within the space vehicle.

In microgravity conditions, fires that are not actively fed with oxygen will self-extinguish. One fire control strategy is to eliminate ventilation, remove electrical power, evacuate personnel, and allow the fire to self-extinguish.

Fire-resistant storage should be provided for hardware that is controlled for flammability by stowage when not in use.

G-28 Sealing – Solid Propellant Rocket Motors

STATEMENT OF STANDARD

On completion of final inspection following manufacture, each solid propellant rocket motor shall be sealed and pressurized to prevent damage due to entry of moisture or foreign material.

The pressurant shall be dry N₂ gas.

The pressure applied shall be sufficient to ensure against entry of contaminants under any anticipated storage conditions.

The seal shall be designed to withstand internal pressure corresponding to the maximum anticipated storage temperature with an adequate safety factor or shall include a relief device.

The seal shall be installed such that it can be expelled during normal rocket ignition without damage to the nozzle. If no other provisions can be made to inspect the grain, access shall be provided through the seal.

REMARKS

The seal may contain provisions for relief of pressure, pressurizing, and pressure gauge installation as necessary.

G-29 Reentry Propulsion Subsystem In-Flight Test

STATEMENT OF STANDARD

Crewed spacecraft which use a separate propulsion subsystem for reentry attitude control shall include means for testing this subsystem before jettisoning the last of any other attitude control systems which could be used to position the spacecraft in a reentry attitude.

REMARKS

Control circuitry and attitude cues should be developed to enable the crew to test the reentry propulsion subsystem of the reentry module before abandoning an operating attitude control subsystem.

This standard is not applicable for spacecraft without a separate propulsion subsystem for reentry attitude control. For such cases, refer to NPR 8705.2, Human-Rating Requirements and Guidelines for Space Flight Systems, Section 3.2, System Safety Requirements.

This standard does not preclude the need for redundant reentry attitude control systems.