

Materials and Processes Selection, Control, and Implementation Plan for JSC Flight Hardware

Engineering Directorate

Structural Engineering Division

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National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center

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PREFACE

This Materials and Processes Selection, Control, and Implementation Plan defines the implementation of the materials and processes (M&P) requirements for all new flight hardware developed by the NASA Johnson Space Center (JSC). Space Shuttle GFE, International Space Station GFE, Constellation Program GFE, and JSC-developed payload hardware are to be designed and manufactured in accordance with this plan. The plan describes the implementation of the M&P requirements in NASA-STD-6016, Standard Materials and Processes Requirements for Spacecraft; SSP 30233, Space Station Requirements for Materials and Processes; SE-R-0006, General Specification Space Shuttle System Requirements for Materials and Processes; and JPR 8080.5A, JSC Design and Procedural Standards.

This plan defines the responsibilities of the JSC Materials & Processes Branch and JSC contractors for flight hardware M&P requirements implementation and verification, and includes modifications of Space Shuttle, ISS, and Constellation Program requirements for flight hardware. The contents of this document are consistent with the tasks performed for the ISS as defined in SSP 41000, System Specification for the International Space Station.

This flight hardware Materials and Processes Selection, Control, and Implementation Plan shall be implemented on all new contracts for the procurement of JSC flight hardware, and shall be included in existing contracts through contract changes. This document is under the control of the JSC Structural Engineering Division (JSC Code ES), and any changes or revisions shall be approved by the same organization.

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MATERIALS AND PROCESSES SELECTION, CONTROL, AND IMPLEMENTATION PLAN FOR JSC FLIGHT HARDWARE

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REVISIONS		
VERSION	CHANGES	DATE
Baseline	Original version (Materials Control Plan for JSC Space station Government-Furnished Equipment)	3/96
A	Retitled and revised to address all JSC flight hardware; numerous minor technical revisions, including reference document updates	7/16/99
B	Added requirement for oxygen system hardware exposure to pressurized oxygen before flight (Section 5.1.4.1)	3/9/00
C	Added ISS alcohol usage control (VUAs); added requirements for precision-cleaned hardware; revised author; incorporated administrative changes for division reorganization; numerous minor technical revisions, including reference document updates	1/29/02
D	Clarified requirement on low earth orbit environment survivability (Section 5.3.7); added related requirement on external use of silver-plated fasteners (Section 5.6.5.2)	2/26/02
E	Revised and retitled document to make compliant with JSC 49774A, Standard Manned Spacecraft Requirements for Materials and Processes	11/05
F	Revised document to make compliant with NASA-STD-6016, Standard Materials and Processes Requirements for Spacecraft. NASA-STD-6016 replaces JSC 49774A, which is cancelled.	8/09

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1.0 INTRODUCTION

This plan documents the methods by which the NASA Johnson Space Center (JSC) will implement materials and processes control for flight hardware developed by JSC, including International Space Station GFE, Space Shuttle GFE, Constellation Program GFE (including GFE for the Orion Crew Exploration Vehicle), and payload hardware. The plan addresses the detailed requirements in NASA-STD-6016, Standard Materials and Processes Requirements for Spacecraft. The plan does not apply to program hardware developed by a program contractor as contractor-furnished equipment (CFE).

Note: Several NASA Marshall Space Flight Center (MSFC) specifications imposed by NASA-STD-6016 contain language requiring approval by MSFC M&P. In all such cases, the approval authority for flight hardware developed by JSC is JSC M&P, not MSFC.

This plan also implements for JSC flight hardware the Materials and Processes (M&P) requirements contained in SSP 30233, Space Station Requirements for Materials and Processes and SE-R-0006, General Specification Space Shuttle System Requirements for Materials and Processes. The M&P requirements for Constellation Program hardware are contained in NASA-STD-(I)-6016, which has been replaced by NASA-STD-6016; compliance with NASA-STD-6016 ensures compliance with Constellation Program M&P requirements. The plan tailors the requirements in NASA-STD-6016, SSP 30233, and SE-R-0006 for JSC in-house hardware; in the event of a conflict between these three documents and this implementation plan, this plan takes precedence.

Note: Exceptions to NASA-STD-6016 are identified in Appendix F.

- a. Flight hardware under JSC control shall be designed and fabricated in accordance with this plan.
- b. This plan shall be incorporated as a general materials control specification in end-item specifications for JSC flight hardware procurements.
- c. This plan shall be implemented on all new contracts for procurement of JSC flight hardware, and shall be included in existing contracts through contract changes.
- d. Ground Support Equipment (GSE) supplied as JSC-controlled hardware shall comply with this plan where GSE hardware can adversely affect flight hardware.

Note: *This plan does not address fracture control. Fracture control for JSC flight hardware structures, including pressure vessels, is implemented in accordance with JSC 25863B, Fracture Control Plan for JSC Flight Hardware. However, the Materials and Fracture Control Certification generated to verify compliance with this plan (see Section 4.6) includes certification of compliance with fracture control requirements and any flight limitations determined by the fracture control analysis. The JSC Materials & Processes Branch monitors and reviews the fracture control program and evaluates the fracture control analysis.*

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2.0 DOCUMENTS

The following documents include specifications, standards, handbooks, and other special publications. They are applicable to the extent specified herein.

In the event of a conflict between these documents and this plan, this plan shall take precedence.

2.1 APPLICABLE DOCUMENTS

2.1.1 VOLUNTARY CONSENSUS STANDARDS

DOCUMENT NO.	TITLE
ANSI/IPC-J-STD-001C	Requirements for soldered electrical and electronic assemblies
References	5.7.6.2, 5.7.8
ASTM-E595-93	Total Mass Loss and Collected Volatile Condensable Materials From Outgassing In A Vacuum Environment
Reference	5.3.7
AWS C3.2M/C3.2:2008	Standard Method for Evaluating the Strength of Brazed Joints
Reference	5.4.5
AWS C3.3:2008	Recommended Practices for the Design, Manufacture, and Inspection of Critical Brazed Components,
Reference	5.4.5
AWS C3.4M/C3.4:2007	Specification for Torch Brazing
Reference	5.4.5
AWS C3.5M/C3.5:2007	Specification for Induction Brazing
Reference	5.4.5
AWS C3.6M/C3.6:2008	Specification for Furnace Brazing
Reference	5.4.5

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AWS C3.7M/C3.7:2005	Specification for Aluminum Brazing
Reference	5.3.5
AWS D17.1:2001	Specification for Fusion Welding for Aerospace Applications
Reference	5.4.4
EOS/ESD S20.20 (2007)	Development of an Electrostatic Discharge Control Program: Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
Reference	5.7.11
IPC-CM-770E (2004)	Component Mounting Guidelines For Printed Boards.
Reference	5.7.6.2
IPC-2221A (2003)	Generic Standard on Printed Board Design
Reference	5.7.5
IPC-2222 (1998)	Sectional Design Standard for Rigid Organic Printed Boards
Reference	5.7.5
IPC-6011 (1996)	Generic Performance Specification for Printed Boards
Reference	5.7.5
IPC-6012B (2004) (Inc. Amendment 2 (2008))	Quality and Performance Specification for Rigid Printed Boards
Reference	5.7.5
NAS 410 (2008)	NAS Certification and Qualification of Nondestructive Test Personnel
Reference	5.5.1
NAS 412 (1997)	Foreign Object Damage/Foreign Object Debris (FOD) Prevention
Reference	5.6.6

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SAE-AMS-H-6875A (1998, Reaffirmed 2006)	Heat Treatment Of Steel Raw Materials
Reference	5.2.2.1
SAE-AMS-STD-401 (1999)	Sandwich Constructions and Core Materials; General Test Methods
Reference	5.6.2
SAE-AMS 2175 (2003)	Castings, Classification and Inspection Of
Reference	5.4.2
SAE-AMS 2375D (2007)	Control of Forgings Requiring First Article Approval
Reference	5.4.1
SAE-AMS 2403L (2004)	Plating, Nickel General Purpose
Reference	5.4.8
SAE-AMS 2404E (2003)	Plating, Electroless Nickel
Reference	5.4.8
SAE-AMS 2423D (2002, Reaffirmed 2007)	Plating, Nickel Hard Deposit
Reference	5.4.8
SAE-AMS 2488D (2003, Reaffirmed 2006)	Anodic Treatment - Titanium & Titanium Alloys, Solution pH 13 or Higher
Reference	5.2.3.3
SAE-AMS 2491D (1989, Reaffirmed 2003)	Surface Treatment, Polytetrafluoroethylene, Preparation for Bonding
Reference	5.7.7
SAE-AMS 2759D (2006)	Heat Treatment of Steel Parts, General Requirements
Reference	5.2.2.1

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SAE-AMS 2759/9C (2007)	Hydrogen Embrittlement Relief (Baking) of Steel Parts
Reference	5.2.2.1
SAE-AMS 2770H (2006)	Heat Treatment of Wrought Aluminum Alloy Parts
Reference	5.2.1
SAE-AMS 2771C (2004)	Heat Treatment of Aluminum Alloy Castings
Reference	5.2.1
SAE-AMS 2772E (2008)	Heat Treatment of Aluminum Alloy Raw Materials
Reference	5.2.1
SAE-AMS 2774B (2008)	Heat Treatment, Wrought Nickel Alloy and Cobalt Alloy Parts
Reference	5.2.9.1
SAE-AMS-H-81200A (2003)	Heat Treatment of Titanium and Titanium Alloys.
Reference	5.2.3.1
SAE-AS7928A (2008)	Terminals, Lug: Splices, Conductors: Crimp Style, Copper, General Specification For
Reference	5.7.9

2.1.2 GOVERNMENT AND MILITARY STANDARDS

DOCUMENT NO.	TITLE
DOT/FAA/AR-MMPDS-04	Metallic Materials Properties Development and Standardization (MMPDS)
Reference	4.5, 5.3.4
MIL-HDBK-17-1F (2002)	Volume 1. Polymer Matrix Composites Guidelines for Characterization of Structural Materials
Reference	4.5
MIL-HDBK-17-2F (2002)	Composite Materials Handbook Volume 2. Polymer Matrix Composites Materials Properties
Reference	4.5

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MIL-HDBK-17-3F (2002)	Volume 3. Polymer Matrix Composites Materials Usage, Design, and Analysis
Reference	4.5
MIL-HDBK-17-4A (2002)	Composite Materials Handbook Volume 4. Metal Matrix Composites
Reference	4.5
MIL-HDBK-17-5 (2002)	Volume 5. Ceramic Matrix Composites
Reference	4.5
MIL-HDBK-6870A (2001)	Inspection Program Requirements, Nondestructive for Aircraft and Missile Materials and Parts
Reference	5.5.1
MIL-PRF-31032A (2006) (Inc. Supplement 1 (2008))	Printed Circuit Board/Printed Wiring Board, General Specification for
Reference	5.6.5
MIL-HDBK-454B (2007)	General Guidelines for Electronic Equipment
Reference	5.3.9
MIL-STD-810F (2000) Change Notice 3 (2003)	Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
Reference	5.3.9
MIL-STD-889B (1976) (Change Notice 3 (1993))	Dissimilar Metals
Reference	5.6.4

2.1.3 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DOCUMENT NO.	TITLE
CxP 70145 (Baseline Change 001 (2008))	Constellation Program Contamination Control Requirements
Reference	5.4.9

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NASA-STD-5006	General Fusion Welding Requirements for Aerospace Materials Used in Flight Hardware
Reference	5.4.4
NASA-STD-5009	Nondestructive Evaluation Requirements for Fracture-Critical Metallic Components
Reference	5.5.1
NASA-STD-(I)-6001A	Flammability, Offgassing, and Compatibility Requirements and Test Procedures
References	5.1, 5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.1.5
NASA-STD-6016	Standard Materials and Processes Requirements for Spacecraft
References	1.0, 3.1.1, 3.5, Appendix F
NASA-STD-6008	NASA Fastener Procurement, Receiving Inspection, and Storage Practices for Spaceflight Hardware
Reference	5.6.6
NSTS 1700.7B (including ISS Addendum)	Safety Policy and Requirements for Payloads Using the Space Transportation System
References	3.4, 5.1.3
NASA-TM-86556	Lubrication Handbook For the Space Industry, Part A: Solid Lubricants, Part B: Liquid Lubricants
Reference	5.3.5
NASA-STD-8739.4	Crimping, Interconnecting Cables, Harnesses, and Wiring
References	5.7.3, 5.7.9, 5.7.10
NASA-STD-8739.5	Fiber Optic Terminations, Cable Assemblies, and Installation
References	5.7.4
NASA-STD-8739.1	Workmanship Standard for Surface Mount Technology
References	5.7.6.1

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NASA-STD-8739.2 Requirement for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies

References 5.7.6.1, 5.7.6.2

2.1.4 JOHNSON SPACE CENTER / SPACE STATION PROGRAM

The latest revision of all JSC documents shall be used unless a specific release is identified in this section.

DOCUMENT NO.	TITLE
JSC 20584	Spacecraft Maximum Allowable Concentrations for Airborne Contaminants
Reference	5.1.2
JSC 25863	Fracture Control Plan for JSC Flight Hardware
Reference	1.0
JPR 8080.5	JSC Design and Procedural Standards Manual
References	1.0 and 6.0
JPR 8500.4	Engineering Drawing System Manual: Drawing Format, Requirements, and Procedures
References	3.0, 4.2
SE-R-0006D	Space Shuttle Program Requirements for Materials and Processes
References	3.1.1, 3.4
SSP 30233G	Space Station Requirements for Materials and Processes
Reference	3.1.1
SSP 30234F	Instructions for Preparation of Failure Modes and Effects Analysis and Critical Items List for Space Station
References	3.2.1, 3.2.2
SSP 30426D	Space Station External Contamination Control Requirements
Reference	5.3.7

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SSP 50431A Space Station Program Requirements for Payloads

Reference 3.2.1

2.1.5 MARSHALL SPACE FLIGHT CENTER

DOCUMENT NO. TITLE

MSFC-SPEC-250A (1977) Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specification for

Reference 5.6.4

MSFC-SPEC-445A (1990) Adhesive Bonding, Process and Inspection, Requirements for

Reference 5.4.3

MSFC-SPEC-504C (1990) Welding, Aluminum Alloys

References 5.4.4.3, 5.4.4.5

MSFC-STD-3029A (2005) Guidelines for Selection of Metallic Materials for Stress-Corrosion-Cracking Resistance in Sodium Chloride Environments
(formerly
MSFC-SPEC-522B)

Reference 5.6.3

MSFC-SPEC-560A (1988) The Fusion Welding of Steels, Corrosion and Heat Resistant Alloys

Reference 5.4.4.4

MSFC-STD-557A (2005) Threaded Fasteners, 6 Al-4V Titanium Alloy, Usage Criteria for Spacecraft Applications

Reference 5.6.5

MSFC-SPEC-766 (1982) Specification: Fusion Welding Titanium and Titanium Alloys

Reference 5.4.4.5

MSFC-PROC-404A (1989) Procedure: Gases Drying and Preservation, Cleanliness Level and Inspection Methods

Reference 5.1.4.1

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2.1.6 JOHNSON SPACE CENTER MATERIALS AND PROCESSES BRANCH

The latest revision of all JSC Materials and processes Branch documents shall be used.

PRC-0001	Manual Arc Welding of Aluminum Alloy Flight Hardware
Reference	5.4.4.3
PRC-0002	Manual Arc Welding of Titanium Alloy Flight Hardware, Process Specification for
Reference	5.4.4.5
PRC-0005	Manual Arc Welding of Steel and Nickel Alloy Flight Hardware
Reference	5.4.4.4
PRC-0008	Qualification of Manual Arc Welders, Process Specification for
Reference	5.4.4.5
PRC-0010	Automatic and Machine Arc Welding of Steel and Nickel Alloy Hardware
Reference	5.4.4.4
PRC-1001	Adhesive Bonding
Reference	5.4.3
PRC-2003	Heat Treatment of Nickel Alloys
Reference	5.2.9.1
PRC-5001	Process Specification for Cleaning of Hardware
References	5.4.9, 5.4.9.3
PRC-5002	Passivation and Pickling of Metallic Materials
Reference	5.6.4.1
PRC-6001	Composite Laminate Prepreg. Parts, Process Specification for the Manufacture of
Reference	5.3.4

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PRC-6002	Sandwich Structures, Process Specification for the Assembly of
Reference	5.3.4
PRC-6003	Trimming and Drilling of Composites, Process Specification for
Reference	5.3.4
PRC-6501	Ultrasonic Inspection of Composites, Process Specification for the
Reference	5.3.4, 5.5.1
PRC-6503	Radiographic Inspection
Reference	5.5.1
PRC-6504	Ultrasonic Inspection of Wrought Metals
Reference	5.5.1
PRC-6505	Magnetic Particle Inspection
Reference	5.5.1
PRC-6506	Liquid Penetrant Inspection
Reference	5.5.1
PRC-6509	Eddy Current Inspection
Reference	5.5.1
PRC-6510	Process Specification for Ultrasonic Inspection of Welds
Reference	5.5.1
PRC-7001	Soldering of Electrical Components
Reference	5.7.8
PRC-7002	Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies
References	5.7.6.1 and 5.7.6.2
PRC-7003	Electrical Cables, Wiring, and Harnesses

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Reference	5.7.3
PRC-7005	Printed Circuit Boards and Assemblies
Reference	5.7.5
ES SOP-004.5	Control of Weld and Braze Filler Materials, Electrodes, and Fluxing Materials
Reference	5.4.4.2, 5.4.5
ES SOP-007.5	Materials and Processes Drawing Approval
Reference	4.1.2, 4.6.1
ES SOP-007.6	Materials and Fracture Control Certification
Reference	4.6
ES SOP 0009.86	Written Practice for Certification and Qualification of Nondestructive Evaluation Personnel
Reference	5.5.1

2.2 REFERENCE DOCUMENTS

DOCUMENT NO.	TITLE
ASTM G63-99	Standard Guide for Evaluating Nonmetallic Materials for Oxygen Service
Reference	5.1.4
ASTM G88-90	Standard Guide for Designing Systems for Oxygen Service
Reference	5.1.4
ASTM G94-92	Standard Guide for Evaluating Metals for Oxygen Service
Reference	5.1.4
CxP 70165 (2008)	Constellation Program Requirements for the Manufacture and Inspection of Electrical/Electronic Assemblies for Aerospace and High Performance (AHP) Applications

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Reference	5.7
JSC 29353A	Flammability Configuration Analysis for Spacecraft Applications
Reference	5.1.1
GSFC Supplement S-312-P003	Process Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses,
Reference	5.7.5

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3.0 REQUIREMENTS IMPLEMENTATION RESPONSIBILITIES

Primary responsibilities for implementing the requirements in this plan are divided between the JSC Materials & Processes Branch and JSC contractors as outlined in this section. These and other responsibilities are discussed in further detail in other sections of this document. JSC contractors are divided into in-house contractors that design and fabricate flight hardware at JSC, using the JSC engineering drawing release system per JPR 8500.4, and outside contractors that design and fabricate flight hardware for JSC in accordance with a contractor drawing release system

3.1 "PLAN" AND "NON-PLAN" CONTRACTORS

The terms "plan" and "non-plan" JSC contractors are used only for the purposes of this plan, as follows:

3.1.1 "PLAN" CONTRACTOR

A "plan" flight hardware contractor is defined as a contractor that has a Materials and Processes Selection, Control, and Implementation Plan approved by the JSC Materials & Processes Branch as meeting the requirements of either this control plan or the applicable program materials and processes requirements document (such as JSC SE-R-0006 for Space Shuttle, SSP 30233 for ISS, and NASA-STD-6016 for Constellation and future programs). Only a few major contractors are required by contract by the JSC Materials & Processes Branch to provide a Materials and Processes Selection, Control, and Implementation Plan. (Refer to Section 4.1 of this plan for information on Materials and Processes Selection, Control, and Implementation Plans.) Plan contractors (and not the JSC Materials & Processes Branch) are responsible for certifying their flight hardware for materials and processes to JSC requirements, unless otherwise specified in the Materials and Processes Selection, Control, and Implementation Plan and/or the contract.

3.1.2 "NON-PLAN" CONTRACTOR

A "non-plan" flight hardware contractor is defined as a contractor that neither has, nor is required by contract to develop, a Materials and Processes Selection, Control, and Implementation Plan approved by the JSC Materials & Processes Branch. Consequently, a non-plan contractor cannot provide final materials certification for JSC flight hardware.

The JSC Materials & Processes Branch shall provide Materials and Fracture Control Certification for JSC flight hardware provided by non-plan contractors.

3.2 NEW FLIGHT HARDWARE

Basic M&P responsibilities for new flight hardware are summarized in this section. Recertification of existing Shuttle and payload flight hardware provided to support ISS and

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recertification of existing Shuttle and ISS hardware for the Constellation program are addressed in section 3.4 of this plan. Further details on these and other M&P responsibilities are discussed in other sections of the plan.

3.2.1 JSC PLAN CONTRACTOR FLIGHT HARDWARE

JSC plan contractor flight hardware refers to flight hardware developed for JSC by a contractor with an approved Materials and Processes Selection, Control, and Implementation Plan (per Section 3.1.1).

The plan contractor shall perform the following basic M&P functions:

- a. The plan contractor shall provide drawing review and approval for M&P
- b. The plan contractor shall provide a Materials Identification and Usage List (MIUL) (or an electronic searchable parts list) for all Criticality category 1 Space Shuttle and ISS flight hardware. (Criticality categories are defined in SSP 30234.) Criticality categories 1R, 1S, 1SR and 1P are not included.
- c. The plan contractor shall provide a Materials Identification and Usage List (MIUL) (or an electronic searchable parts list) for all Constellation Program flight hardware except noncritical (Criticality 3) flight crew equipment.

Notes:

1. *The MIUL is required for payload criticality 1 hardware only if the payload is Class A or Class B per SSP 50431, Space Station Program Requirements for Payloads (or equivalent classes for other program payloads)*
2. *For selected plan contractors, additional MIUL requirements may be specified in the contract.*

d. The plan contractor shall generate and approve Materials Usage Agreements (MUAs) and water-soluble Volatile Organic Compound Usage Agreements (VUAs).

Final MUA/VUA approval will be by the JSC Materials and Processes Branch.

e. The plan contractor shall provide materials certification as specified in the Materials and Processes Selection, Control, and Implementation Plan and/or the contract.

3.2.2 JSC NON-PLAN CONTRACTOR FLIGHT HARDWARE (& FLIGHT HARDWARE DESIGNED BY JSC EMPLOYEES)

The above two types of flight hardware in the title are grouped together in this section because both types of flight hardware have M&P functions that are performed by the JSC Materials & Processes Branch, as shown below:

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a. The JSC Materials & Processes Branch shall provide drawing review and approval for M&P.

This requirement applies to drawings generated by JSC employees, and to most of the non-plan contractors who generate drawings in the "JSC engineering drawing system", with the following two exceptions:

(a) A few non-plan contractors who generate flight hardware drawings in the JSC engineering drawing system have been selected by the JSC Materials & Processes Branch to sign their own JSC drawings for M&P (and also generate their own MIULs and MUAs).

(b) The JSC Materials & Processes Branch does not approve contractor drawings generated per a contractor's own engineering drawing system, but does review such drawings to the extent necessary to insure compliance with M&P requirements.

Note: JSC Materials & Processes Branch drawing review and approval may be conducted by civil servants or by in-house contractors.

b. The JSC Materials & Processes Branch shall provide a Materials Identification and Usage List (MIUL) (or an electronic searchable parts list) for Criticality category 1 flight hardware and all Constellation flight hardware except Criticality 3 flight crew equipment (see 3.2.1).

Notes:

1. *The MIUL is required for payload criticality 1 hardware only if the payload is Class A or Class B per SSP 50431, Space Station Program Requirements for Payloads (or equivalent classes for other program payloads)*
2. *For selected plan contractors, additional MIUL requirements may be specified in the contract.*
3. *JSC Materials and Processes Branch functions may be performed by civil servants or in-house support contractors.*

c. The JSC Materials & Processes Branch shall provide assistance to flight hardware managers in the generation of Materials Usage Agreements (MUA)

d. The JSC Materials & Processes Branch shall approve MUAs

e. The JSC Materials & Processes Branch shall provide Materials and Fracture Control Certification

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3.3 MATERIALS AND PROCESSES RECIPROCAL AGREEMENTS

NASA Centers (or other space agencies) with reciprocal agreements for Materials and Processes with JSC shall generate MUAs and materials certifications on payload hardware that they manage or manufacture.

The reciprocal or intercenter agreements with other NASA Centers and other space agencies involve acceptance of each other's materials certifications and MUAs.

Currently, NASA Centers that have reciprocal agreements with JSC include Glenn Research Center, Marshall Space Flight Center, Jet Propulsion Laboratory, and Goddard Space Flight Center. NASA also has M&P reciprocal agreements with the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), and the Russian space companies, Energia and Khrunichev; these agreements cover stowed cargo as well as payloads.

Copies of these agreements can be obtained from the JSC Materials & Processes Branch.

3.4 PREVIOUSLY CERTIFIED GFE FOR ISS AND CONSTELLATION

JSC Shuttle GFE for ISS include JSC GFE provided by the Space Shuttle Vehicle Engineering Office and the EVA Project Office to support the ISS, and JSC Shuttle Payload GFE provided by the responsible JSC payload organizations for the ISS.

JSC Shuttle GFE hardware certified prior to the baseline release of JSC 27301 is certified by the JSC Materials & Processes Branch as meeting the requirements of SE-R-0006, Space Shuttle Program Requirements for Materials and Processes, and NSTS 1700.7, Safety Policy and Requirements for Payloads Using the Space Transportation System.

a. For previously approved hardware built to SE-R-0006 and NSTS 1700.7 and supplied as GFE to the ISS Program, Materials Usage Agreements (including Materials Stowage Codes) shall be reviewed by the JSC Materials & Processes Branch, or plan contractor, as applicable, to verify compliance with this plan.

All JSC Shuttle GFE certified since the baseline release of JSC 27301 is certified by the JSC Materials & Processes Branch as meeting the requirements of SSP 30233, Space Station Requirements for Materials and Processes as well as SE-R-0006 and NSTS 1700.7.

b. For previously approved hardware built to SE-R-0006, NSTS 1700.7, SSP 30233, or previous releases of JSC 27301 and subsequently supplied as GFE to the Constellation Program for use in modules smaller than 50 m³ (such as the Orion Crew Exploration Vehicle, which has an internal free volume of 15 m³), toxic offgassing data shall be reevaluated by the JSC Materials & Processes Branch, or plan contractor, as applicable, to verify that they still meet requirements in the smaller volume.

This requirement does not apply to ISS hardware shipped to ISS as cargo on Orion.

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3.5 ISS GFE AS ORION CARGO

Recertification of GFE delivered to ISS as cargo by the Orion Crew Exploration Vehicle is not required. MIULs are required only for Criticality category 1 hardware.

Except when specifically noted otherwise, all JSC GFE certified since this release of JSC 27301 (Rev. F) is certified by the JSC Materials & Processes Branch as meeting the requirements of NASA-STD-6016 as well as SSP 30233, SE-R-0006 and NSTS 1700.7.

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4.0 GENERAL REQUIREMENTS

Requirements for materials used in the fabrication and processing of flight hardware are as follows:

- a. Selection shall be by consideration of the worst-case operational requirements for the particular application and the design engineering properties of the candidate materials.
- b. The operational requirements shall include, but are not limited to, the following:
 - (1) Operational temperature limits.
 - (2) Loads.
 - (3) Contamination.
 - (4) Life expectancy.
 - (5) Moisture or other fluid media exposure.
 - (6) Vehicle-related induced and natural space environments.
- c. Properties that shall be considered in material selection include, but are not limited to, the following:
 - (1) Mechanical properties.
 - (2) Fracture toughness.
 - (3) Flammability and offgassing characteristics.
 - (4) Corrosion.
 - (5) Stress corrosion.
 - (6) Thermal and mechanical fatigue properties.
 - (7) Glass-transition temperature.
 - (8) Coefficient of thermal expansion mismatch.
 - (9) Vacuum outgassing.
 - (10) Fluids compatibility.
 - (11) Microbial resistance.
 - (12) Moisture resistance.
 - (13) Fretting.
 - (14) Galling.
 - (15) Susceptibility to electrostatic discharge (ESD).
 - (16) Susceptibility to contamination.
- d. Conditions that could contribute to deterioration of hardware in service shall receive special consideration.
- e. Nonflight materials used in processing and testing of flight hardware shall not cause degradation of the flight hardware.

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4.1 MATERIALS AND PROCESSES, SELECTION, CONTROL, AND IMPLEMENTATION PLAN

- a. The contractor shall provide a Materials and Processes Selection, Control, and Implementation Plan when specified in the contract data requirements.
 - b. The contractor Materials and Processes Selection, Control, and Implementation Plan shall document the degree of conformance and method of implementation for each requirement in this plan, identifying applicable in-house specifications used to comply with the requirement.
 - c. The contractor Materials and Processes Selection, Control, and Implementation Plan shall also describe the methods used to control compliance with these requirements by subcontractors and vendors.
 - d. The contractor Materials and Processes Selection, Control, and Implementation Plan, upon approval by the procuring activity, shall become the M&P implementation document used for verification.
 - e. All JSC flight hardware contractors not required by their contract to provide a Materials and Processes Selection, Control, and Implementation Plan shall use this document as their Materials and Processes Selection, Control, and Implementation Plan instead of developing a separate contractor plan.
- Only a few major contractors are required by contract to provide a Materials and Processes Selection, Control, and Implementation Plan.*
- f. The contractor Materials and Processes Selection, Control, and Implementation Plan shall address the content of sections 4 through 6 of this plan.

4.1.1 COORDINATION, APPROVAL, AND TRACKING

The contractor Materials and Processes Selection, Control, and Implementation Plan shall identify the method of coordinating, approving, and tracking all engineering drawings, engineering orders, and other documentation that establishes or modifies materials and/or processes usage.

4.1.2 APPROVAL SIGNATURE

- a. The contractor Materials and Processes Selection, Control, and Implementation Plan shall include a requirement that all design drawings and revisions contain an M&P approval block, or equivalent, to ensure that the design has been reviewed and complies with the intent of this document.
- b. Design drawings and revisions shall be signed by the responsible M&P authority prior to release.

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c. The M&P drawing approval process shall comply with ES SOP-007.5, Materials and Processes Drawing Approval.

d. For non-plan contractors, the JSC Materials & Processes Branch shall review drawings to the extent necessary to insure compliance to M&P requirements.

4.1.3 MATERIALS AND PROCESSES CONTROLS

a. All materials and processes shall be defined by standards and specifications.

b. Materials and processes shall be identified directly on the appropriate engineering drawing.

c. Contractor Materials and Processes Selection, Control, and Implementation Plans shall identify those M&P standards and specifications used to implement specific requirements in this document.

JSC M&P standards and specifications used to implement the requirements of NASA-STD-6016 are identified throughout this document.

d. Standards and specifications shall be selected from government, industry, and company specifications and standards.

e. Rationale for the selection of company specifications over government and industry voluntary consensus standards and specifications shall be documented in the contractor Materials and Processes Selection, Control, and Implementation Plan.

f. The rationale for selection of company specifications over government and industry voluntary consensus standards and specifications shall include an identification of government or industry specifications or standards examined and an explanation of why each was unacceptable.

g. Company M&P specifications shall be identified by document number and revision letter in the contractor Materials and Processes Selection, Control, and Implementation Plan.

h. All contractor M&P specifications used to produce flight hardware shall be made available to the responsible NASA Program or Project Office and M&P organization.

i. Changes to M&P standards and specifications identified in the contractor Materials and Processes Selection, Control, and Implementation Plan shall require NASA M&P organization-approved Materials Usage Agreements (MUAs) in accordance with section 4.3 of this plan.

j. Process specifications shall define process steps at a level of detail that ensures a repeatable/controlled process that produces a consistent and reliable product.

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