Space Station Requirements for Materials and Processes

International Space Station Alpha

Revision E Draft

January 27, 1995

NASDA

National Space Development Agency of Japan

esa european space agency

Canadian Space Agency | Agence spatiale canadienne

agenzia spaziale italiana
(Italian Space Agency)

National Aeronautics and Space Administration
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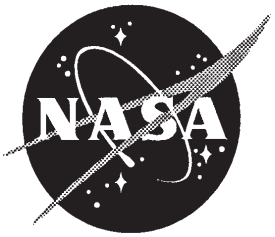

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SPACE STATION PRIME CONTRACTOR

SPACE STATION REQUIREMENTS FOR MATERIALS AND PROCESSES

~~DECEMBER 20, 1994~~JANUARY 27, 1995

PREFACE

Space Station Requirements for Materials and Processes defines the minimum requirements for Materials and Processes (M&P) and provides a general control specification for incorporation in the National Aeronautics and Space Administration (NASA) space station hardware procurements and technical programs. Space Station Requirements for Materials and Processes document contains an introduction, a list of applicable documents, subsections on general and detailed requirements along with appendices containing acronyms, definitions and Category III Material Usage Agreement codes.

The contents of this document are intended to be consistent with the tasks and products to be prepared by Space Station participants as defined in the Space Station System Specifications and applicable segment specifications where this document is required. Space Station Requirements for Materials and Processes shall be implemented on all new Space Station contractual and internal activities and shall be included in any existing contracts through contract changes. This document is under the control of the Space Station Control Board, and any changes or revisions will be approved by the Program Manager.

INTERNATIONAL SPACE STATION ALPHA PROGRAM

SPACE STATION REQUIREMENTS FOR MATERIALS AND PROCESSES

~~DECEMBER 20, 1994~~JANUARY 27, 1995

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INTERNATIONAL SPACE STATION ALPHA PROGRAM

SPACE STATION REQUIREMENTS FOR MATERIALS AND PROCESSES

LIST OF CHANGES

All changes to paragraphs, tables, and figures in this document are shown below:

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NASA/ASI

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For NASA DATE

For ESA DATE

COL–RQ–ESA–001 and COL–RQ–ESA–004 ”Meets or Exceeds” this document.

NASA/NASDA

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NASDA replaces SSP 30233 with CR–99117 as an equivalent document.

NASA/CSA

INTERNATIONAL SPACE STATION ALPHA PROGRAM

SPACE STATION REQUIREMENTS FOR MATERIALS AND PROCESSES

~~DECEMBER 20, 1994~~JANUARY 27, 1995

For NASA DATE

For CSA DATE

1.0 INTRODUCTION

1.1 SCOPE

This document is directed toward Materials and Processes (M&P) used in the fabrication and testing of flight components for all Space Station Program Elements. This document also covers Ground Support Equipment (GSE) where operations, physical interfaces, or fluid system interfaces can adversely affect the form, fit, or function of flight hardware.

1.2 PURPOSE

The purpose of this document is to define the minimum requirements for M&P and to provide a general control specification for incorporation in the National Aeronautics and Space Administration Space Station hardware procurements and technical programs.

1.3 APPLICABILITY

The controls described herein are consolidated and managed under the direction of the Prime Contractor and are applicable to all Space Station Product Group, subcontractors and International Partners. The Product Group and International Partners shall apply these controls to Space Station flight hardware. Product Group and International Partners are responsible for flowing requirements down to the lowest component–level suppliers. Product Group shall be responsible for demonstrating compliance with these requirements to the Prime contractor. International Partners shall meet or exceed the design requirements specified herein using the specification documents listed or equivalent international specifications. Controls for Ground Support Equipment shall be at the discretion of the Product Group and International Partners except as specified herein.

The following Product Group M&P Selection, Control, and Verification Plans have been reviewed for compliance, by paragraph, with the technical requirements of this document. On approval, these plans may be used for the implementation and verification of M&P requirements on International Space Station Alpha.

Product Group	Document Number
1. McDonnell–Douglas Aerospace	MDC 94H0522, Revision ~~BA~~C
2. Rocketdyne Division, Rockwell Int.	RI/RD94–605, Revision A
3. Boeing Defense & Space Group	D683–10035–1, ~~Revision A~~Issue D

2.0 DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents have been grouped into two categories: applicable documents and reference documents.

2.1 APPLICABLE DOCUMENTS

The documents in these paragraphs are applicable to the extent specified herein.

2.1.1 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DOCUMENT NO.	TITLE
NASA–NHB–8060.1B	Flammability, Odor, and Offgassing Requirements and Test Procedures For Materials In Environments That Support Combustion
References	4.2.1
NASA–NHB–8060.1C	Flammability, Odor, Offgassing and Compatibility Requirements and Test Procedures For Materials In Environments That Support Combustion
References	4.1 and 4.2.1
NASA–TM–86556	Lubrication Handbook For the Space Industry, Part A: Solid Lubricants, Part B: Liquid Lubricants
Reference	4.2.5
NHB 5300.4 (3A–1)	Requirements for Soldered Electrical Connections
Reference	4.6.6.2 and 4.6.8
NHB 5300.4 (3G)	Requirements for Interconnecting Cables, Harnesses and Wiring
Reference	4.6.3
NHB 5300.4 (3H)	Requirements for Crimping and Wire–Wrap
Reference	4.6.9 and 4.6.10
NHB 5300.4 (3I)	Requirements for Printed Wiring Board
Reference	4.6.5.1

NHB 5300.4 (3J)	Requirement for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies
Reference	4.6.6.1 and 4.6.6.2
NHB 5300.4 (3K)	Design Requirement for Rigid Printed Wiring Board and Assemblies
Reference	4.6.5.1

2.1.2 MARSHALL SPACE FLIGHT CENTER

DOCUMENT NO.	TITLE
MSFC–HDBK–527F/ JSC–09604	Materials Selection List For Space Hardware Systems
References	3.1.3, 3.1.4 and 4.1
MSFC–SPEC–250A	Protective Finishes For Space Vehicle Structures and Associated Flight Equipment, General Specification For
Reference	4.5.4 and 4.5.4.3
MSFC–SPEC–445	Adhesive Bonding, Process~~,~~ and Inspection, Requirements For
Reference	4.3.3
MSFC–SPEC–504C	Welding, Aluminum Alloys
Reference	4.3.4.3
MSFC–SPEC–522B	Design Criteria For Controlling Stress Corrosion Cracking
Reference	4.1
MSFC–SPEC–560A	The Fusion Welding of~~,~~ Steels, Corrosion and Heat Resistant Alloys
Reference	4.3.4.4
MSFC–STD–557	Threaded Fasteners, 6 Al–4V Titanium Alloy, Usage Criteria For Spacecraft Applications
Reference	4.5.5.1

MSFC–STD–655	Weld Filler Metal, Control Of
Reference	4.3.4.2

2.1.3 JOHNSON SPACE CENTER/SPACE STATION PROGRAM

DOCUMENT NO.	TITLE
JSC–SPEC–SP–R–0022A	Vacuum Stability Requirements Of Polymeric Materials For Spacecraft Applications
Reference	4.2.7
~~SSP 30240 Rev. B~~	~~Space Station Grounding Requirements~~
~~Reference~~	~~4.6.1~~
~~SSP 30245 Rev. B~~	~~Space Station Electrical Bonding Requirements~~
~~Reference~~	~~4.6.1~~
~~SSP 30312 Rev. F~~	~~Electrical, Electronic and Electromechanical Parts Management and Implementation Plan for Space Station Program~~
~~Reference~~	~~3.1.3~~
~~SSP 30426 Rev. D~~	~~Space Station External Contamination Control Requirements~~
~~Reference~~	~~4.2.7~~
~~SSP 30558 Rev. B~~	~~Fracture Control Requirement for Space Station~~
~~Reference~~	~~4.3.1~~

2.1.4 MILITARY

DOCUMENT NO.	TITLE
MIL–B–7883C	Brazing Of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum, and Aluminum Alloys
Reference	4.3.5

MIL–C–28809B	Circuit Card~~Printed–Wiring~~ Assemblies, Rigid, Flexible, and Rigid–Flex
Reference	4.6.6.2
MIL–H–6088F(1)	Heat Treatment Of Aluminum Alloys
Reference	4.1.1
MIL–H–6875G(2)	Heat Treatment Of Steel, Process For
Reference	4.1.2.1
MIL–H–81200A(1)	Heat Treatment Of Titanium and Titanium Alloys
Reference	4.1.3.1
MIL–HDBK–5E	Metallic Materials And Elements For Aerospace Vehicle Structures
Reference	3.8
MIL–HDBK–17B	Polymer Matrix Composites
References	3.8
MIL–HDBK–23A	Structural Sandwich Composites
References	4.5.2
MIL–I–6870E	Inspection Program Requirements, Nondestructive For Aircraft and Missile Materials and Parts
Reference	4.4
MIL–P–50884	Printed Wiring, Flexible and Rigid–Flex
Reference	4.6.5.2
MIL–STD–401B	Sandwich Constructions and Core Materials; General Test Methods
Reference	4.5.2
MIL–STD–454N	General Requirements for Electronic Equipment
Reference	4.2.10

MIL–STD–810D–1	Environmental Testing Methods and Engineering Guidelines
Reference	4.2.10
MIL–STD–889B	Dissimilar Metals
Reference	4.5.4
MIL–STD–1595A–1	Qualification Of Aircraft, Missile and Aerospace Fusion Welders
Reference	4.3.4
MIL–STD–2175	Castings, Classification and Inspection Of
Reference	4.3.2
MIL–T–7928	Terminals, Lug: Splices, Conductors: Crimp Style, Copper, General Specification For
Reference	4.6.9
MIL–T–9047G(2)	Titanium and Titanium Alloy Bars (Rolled or Forged) and Reforging Stock, Aircraft Quality
Reference	4.1.3

2.1.5 OTHER

DOCUMENT NO.	TITLE
ASTM–E–595–84	Total Mass Loss and Collected Volatile Condensaible Materials From Outgassing In A Vacuum Environment, Standard Test Method For
Reference	4.2.7
AWS C–3.7	Specification for Aluminum Brazing
Reference	4.3.5
AMS 2491	Surface Treatment, Polytetrafluoethylene, Preparation for Bonding
Reference	4.6.7

2.2 REFERENCE DOCUMENTS

The documents in this paragraph are provided as reference material for background information only. In case of conflict, this document shall take precedence.

DOCUMENT NO.	TITLE
SSP 41173	Space Station Quality Assurance Requirements
Rev. Basic Reference	4.3.8
NSTS 22648	Flammability Configuration Analysis for Spacecraft Applications
Reference	4.2.1

3.0 GENERAL REQUIREMENTS

Material used in the fabrication of Space Station hardware shall be selected by considering the operational requirements for the particular application and the design engineering properties of the candidate materials. The operational requirements shall include, but not be limited to, operational temperature limits, loads, contamination, life expectancy, and vehicle related induced and natural space environments. Properties to be considered in material selection include mechanical properties, fracture toughness, flammability and offgassing characteristics, corrosion, stress corrosion, thermal and mechanical fatigue properties, vacuum outgassing, fluids compatibility, fretting, galling, etc. Conditions which could contribute to deterioration of hardware in service shall receive special consideration.

3.1 MATERIALS AND PROCESSES, SELECTION, CONTROL, AND VERIFICATION PLAN

The contractor shall provide a Materials and Processes (M&P) selection, control, and verification plan when specified in the contract data requirements. This plan, upon approval by the procuring activity will become the Materials and Processes implementaion document used for verification. If the plan does not meet the contract requirements, a Contract change, deviation, or waiver shall be processed to align the plan with contract requirements. The materials and process selection and control plan shall include the following:

3.1.1 COORDINATION, APPROVAL, AND TRACKING

A method of coordinating, approving, and tracking all engineering drawings, engineering orders, and other documentation that establishes or modifies materials and/or processes usage for M&P review.

3.1.2 APPROVAL SIGNATURE

A requirement that each engineering drawing, engineering order, etc., be approved and signed by the responsible Materials and Processes organization prior to release. For designs produced by automated Computer–Aided Design/Computer–Aided Manufacturing (CAD/CAM) systems, an equivalent level of review and approval shall be defined.

3.1.3 MATERIALS AND PROCESS DOCUMENTATION

The procedures and formats for documentation of materials and processes usage will depend upon specific hardware but shall cover the final design. The system used shall be

an integral part of the engineering configuration control/release system and be integrated (or integrable) into an automated data system. A copy of the stored data shall be provided to the prime contractor in a form compatible for electronic searches for M&P purposes.

This system shall identify the following applicable information through an electronic searchable parts list or separate Materials Identification and Usage List (MIUL) with field sizes as defined by the prime contractor.

a. Associate contractor code number (assigned by the Prime Contractor)
b. Part number
c. Next assembly
d. NASA Material code
e. Material specification
f. Process specification
g. MUA number or rationale code

MSFC–HDBK–527/JSC 09604 shall be consulted to obtain material codes & ratings for materials, standard and commercial parts and components. New material codes shall be assigned by NASA Marshall Space Flight Center (MSFC), EH41.

A procedure shall be established by the contractor to ensure that all vendor designed, off–the–shelf, and vendor furnished items are covered by the M&P requirements of this document.

Where batch/lot testing is required, traceability of specific test reports for batch/lot used shall be provided.

Wire, cable, and exposed surfaces of connectors ~~as defined in SSP 30312,~~ shall meet the requirements of this document ~~and SSP 30312~~ and be reported on the MIUL. All other Standard and Nonstandard Electrical, Electronic, and Electromechanical (EEE) Parts shall be exempt from the SSP 30233 requirements and reporting on the MIUL.

A periodic review by the procuring activity M&P organization shall be conducted to ensure compliance with Material and Processes requirements.

3.1.4 MATERIALS USAGE AGREEMENTS

Material Usage Agreements (MUAs) shall be submitted for all materials not rated “A” or better for the intended application in MSFC–HDBK–527/JSC 09604 or do not meet other M&P requirements of this document. A tiered MUA system with three categories shall be used.

3.1.4.1 CATEGORY I MUAS

Category I MUAs are those that involve material/processes usage that could affect the safety of the mission, crew, or vehicle or affect the mission success, but must be used for

functional reasons. Approval by the Product Group Program Manager and Prime Contract Program Manager or their designees, and NASA project office shall be required.

3.1.4.2 CATEGORY II MUAS

Category II MUAs are those that involve material/processes usage that fails a screening of Material and Processes requirements and is not considered a hazard in its use application but for which no Category III rationale code exists. Approval by the Product Group M&P Leader or designee and Prime M&P team leader or designee shall be required.

3.1.4.3 CATEGORY III MUAS

Category III MUAs are those that involve materials or processes that do not meet SSP 30233 requirements, but have a prior rationale code or are not listed in MSFC–HDBK–527, but later test data shows compliance. They are evaluated and determined by the contractor to be acceptable at the configuration/part level.

Category III MUAs shall be reported in the MIUL system or electronic data system utilizing the approved rationale codes in Appendix C. A key may be provided to correlate contractor Category III MUA database codes to the codes in Appendix C. No MUA form is submitted.

3.1.4.4 MATERIAL USAGE AGREEMENT SUBMITTAL

Category I and II MUAs shall be submitted as appropriate for each usage of a material or process that does not meet the requirements of this document. These MUAs shall be signed by a member of the contractor M&P organization and approved as indicated in the cagetories above. The information required on the MUA form shall be provided as specified in the contract data requirement for the category I and II MUAs and must include sufficient information to assess these usages. A typical MUA form is given in Appendix B page B–2.

3.2 PROCESS SPECIFICATIONS

Each Product Group (PG) or International Partner (IP) is responsible for implementing the process requirements and specifications as required herein. Each PG or IP is also responsible for flowing these requirements to their subcontractors and suppliers. Alternative specifications which meet the technical intent expressed herein may be used when identified in the PG or IP Materials & Processes Selection, Control, and Verification Plan. These alternative specifications are subject to review by the procuring

activity upon request, and will also be available to support design review activities. Other specifications that do not meet the technical intent herein shall be submitted to the procuring activity for approval through the MUA process.

3.3 MANUFACTURING PLAN

Contractor M&P organizations shall participate in manufacturing planning to ensure compliance with materials and process requirements.

3.4 CONTROLLING DOCUMENTS

All M&P shall be documented by standards and specifications to preclude unauthorized changes. Contractors shall select standards and specifications from government, industry, and company sources. NASA documents shall be considered first in the order of preference.

3.5 MATERIALS CERTIFICATION AND TRACEABILITY

All parts or materials shall be certified as to composition and properties as identified by the procuring document. Materials used in critical applications such as life limited materials, safety and fracture critical parts shall be traceable through all critical processing steps and the end–item application.

3.6 TOXIC PRODUCTS AND FORMULATIONS

Toxic products and formulations used throughout manufacture, assembly, test, and checkout shall conform to all local, state, and federal (national) safety and environmental regulations. For United States facilities, all Occupational Safety and Health Administration (OSHA) and Environmental Protection Agency (EPA) regulations apply.

3.7 DELETED

3.8 MATERIAL DESIGN ALLOWABLES

Values for allowable mechanical properties of structural materials in their design environment shall be taken from MIL–HDBK–5, Metallic Materials And Elements For Aerospace Vehicle Structures; MIL–HDBK–17B, Polymer Matrix Composites. When using MIL–HDBK–5, material ”B” allowable values may be used in redundant structure in which the failure of a component would result in a safe redistribution of applied

load–carrying members. MIL–HDBK–5, material ”S” allowables may be used for materials in lieu of ”A” and ”B” allowables where batch lot acceptance testing is a procurement requirement. Where values for mechanical properties of new or existing materials are not available, they shall be determined by analytical methods described in MIL–HDBK–5.

4.0 DETAILED REQUIREMENTS

4.1 METALS

MSFC–SPEC–522**,** Design Criteria For Controlling Stress Corrosion Cracking, criteria shall be used to select metallic materials to control stress corrosion cracking. Additional information regarding metallic materials can be found in MSFC–HDBK–527/ JSC–09604. Metallic materials shall meet the flammability requirements of NASA–NHB–8060.1, Flammability, Odor, Offgassing and Compatibility Requirements and Test Procedures For Materials In Environments That Support Combustion, as a minimum.

4.1.1 ALUMINUM

In structural applications using aluminum, maximum use shall be made of those alloys, heat treatments, and coatings which minimize susceptibility to general corrosion, pitting, intergranular and stress corrosion cracking. Aluminum alloys 2024–T6, 7079–T6, and 7178–T6 shall not be used in structural applications. The following alloys and heat treatments shall not be used in applications where the temperature exceeds 150 degrees Fahrenheit (66 degrees C): 5083–H32, 5083–H38, 5086–H34, 5086–H38, 5456–H32, and 5456–H38.

Heat treatment of aluminum alloy parts shall meet the requirements of MIL–H–6088, Heat Treatment Of Aluminum Alloys. Heat treatments not included in MIL–H–6088 may be used if sufficient test data is available to conclusively demonstrate that the specific heat treatment improves the mechanical and/or physical properties.

4.1.2 STEEL

Carbon and low alloy steels heat–treated to strength levels at or above 180 ksi UTS shall not be used. Carbon and low alloy high strength steels greater than 180 ksi UTS used in ball bearings, springs or similiar applications where primary loading is compressive, low tensile stresses or history of satisfactory performance may be used with the approval of the procuring activity by Category III MUA.

4.1.2.1 Heat Treatment of Steels–Steel parts shall be heat treated to meet the requirements of MIL–H–6875, Heat Treatment of Steel, Process for. Heat treatments not included in MIL–H–6875 may be used if sufficient test data are available to define mechanical properties of the specific steel without altering susceptibility to degradation. When acid cleaning baths or plating processes are used, the part shall be baked by an appropriate process to alleviate potential hydrogen embrittlement problems.

4.1.2.2 Drilling and Grinding of High Strength Steel — The drilling of holes, including beveling and spot facing, in martensitic steel hardened to 180 ksi UTS or above, shall be

avoided. When such drilling, machining, reaming, or grinding is unavoidable, carbide–tipped tooling and other techniques necessary to avoid formation of untempered martensite shall be used. Micro–hardness and metallurgical examination of test specimens typical of the part shall be used to determine if martensite areas are formed as a result of drilling or grinding operations, or temper etch actual hardware in lieu of destructive test. The surface roughness of finished holes shall not be greater than 63 roughness–height–ratio, and the edges of the holes shall be deburred by a method which has been demonstrated not to cause untempered martensite.

4.1.2.3 Corrosion Resistant Steel — Unstabilized, austenitic steels shall not be used above 700 degrees Fahrenheit (371 degrees C). Welded assemblies shall be solution heat–treated and quenched after welding except for the stabilized or low carbon grades such as 321, 347, 316L, 304L.

4.1.2.4 Deleted

4.1.3 TITANIUM

Most titanium alloys have limited hardenability with section size and should not be used in sections which exceed their specified limits. The variation of mechanical properties with section size as heat–treated is indicated in Table II of MIL–T–9047, Titanium and Titanium Alloy Bars (Rolled or Forged) and Reforging Stock, Aircraft Quality. For candidate titanium alloys other than those listed in MIL–T–9047, similar information shall be obtained by the contractor and approved by the procuring activity. The surfaces of titanium parts shall be machined or chemically milled to eliminate all contaminated zones formed during processing.

Titanium shall not be used with Liquid Oxygen (LOX) or Gaseous Oxygen (GOX) at any pressure or with air at oxygen partial pressures above 5 psia (34.5 kPa).

4.1.3.1 Heat Treatment — Heat treatment of titanium and titanium alloy parts shall meet the requirements of MIL–H–81200, Heat Treatment of Titanium and Titanium Alloys.

4.1.3.2 Titanium Contamination — Care shall be exercised to ensure that cleaning fluids and other chemicals used on titanium are not detrimental to performance. Surface contaminants which can induce stress corrosion, hydrogen embrittlement, or reduce fracture toughness include the following: hydrochloric acid, cadmium, silver, chlorinated cutting oils and solvents, methyl alcohol, fluorinated hydrocarbons, and components containing mercury.

4.1.3.3 Fretting of Titanium — Titanium alloys are susceptible to the reduction of fatigue life by fretting at interfaces between titanium alloys or titanium and other metal parts; therefore, structural applications of titanium shall be designed to avoid fretting.

4.1.3.4 Titanium Welding — Alloyed titanium shall be welded using alloy weld wire to avoid potential hydrogen embrittlement associated with the use of Commercially Pure

(CP) wire in alloy welds. Use of CP wire in alloy–to–alloy welds or CP–to–alloy welds may be used with the approval of the procuring activity by Category III MUA. CP wire may be used in CP–to–CP alloy welds.

4.1.4 MAGNESIUM

Magnesium alloys shall not be used except in areas where minimal exposure to corrosive environments can be expected and protection systems can be maintained with ease and high reliability. Magnesium alloys shall not be used in the primary structure, or in other areas subject to wear, abuse, foreign object damage, abrasion, erosion, or at any location where fluid or moisture entrapment is possible.

4.1.5 BERYLLIUM

Beryllium shall not be used for primary structural applications without approval of the procuring activity. Beryllium is allowed as an alloying constituent up to a maximum of 4% (percent) by weight.

4.1.6 CADMIUM

Cadmium shall not be used in crew environments at temperatures above 100 degrees Centigrade or in vacuum environments where the temperature/pressure environment could cause contamination of optical surfaces or electrical devices.

4.1.7 MERCURY

Equipment containing mercury shall not be used where the mercury could come in contact with the spacecraft or spaceflight equipment during manufacturing, assembly, test, checkout, and flight. Well protected lamps containing mercury, including those used in the fluorescent penetrant inspection of flight parts are exempt from this requirement.

4.1.8 REFRACTORY METALS

Since engineering data on refractory alloys are limited, especially under extreme environmental usage of spacecraft, appropriate tests shall be performed to characterize such materials for the intended application. Results of such tests and related engineering data shall be compiled and made available to the procuring activity upon request.

4.1.9 SUPERALLOYS (NICKEL–BASED AND COBALT–BASED)

High nickel content alloys are susceptible to sulfur embrittlement; therefore, any foreign material which could contain sulfur, such as oils, grease, and cutting lubricants, shall be

removed by suitable means prior to heat treatment or high temperature service. Some of the precipitation hardening superalloys are susceptible to alloying element depletion at the surface in a high temperature, oxidizing environment. This effect shall be carefully evaluated when a thin sheet is used, since a slight amount of depletion could involve a considerable proportion of the effective cross section of the material.

4.2 NONMETALLIC MATERIALS

4.2.1 GENERAL REQUIREMENTS

As a general requirement for all nonmetallic materials, the contractor shall obtain data or analyses as necessary to meet the requirements of NHB 8060.1C. The Toxic Hazard Index (T) for materials/assemblies shall be calculated using the methods defined in Test 7. SMAC values shall be selected from NHB 8060.1B, Appendix D. For compounds for which no SMAC values are found in NHB 8060.1B, the values in MAPTIS may be used. Test 2 (Heat and Visible Smoke Release Rates) of NHB 8060.1C will not be required. Test 18 (Arc Tracking Test) of NHB 8060.1C will not be required for polytetrafluoroethylene (PTFE), PTFE laminate, ethylene tetrafluoroethlyene (ETFE), or silicone insulated wires. Guidelines for hardware flammability assessment are located in NSTS 22648.

4.2.2 ELASTOMERIC MATERIALS

Elastomeric components shall have long–term resistance to aging, low temperature, ozone, heat aging, polymer reversion, working fluids, lubricants, and operating media. Elastomeric materials shall be cure dated for tracking purposes. RTV elastomeric materials which liberate acetic acid during cure shall not be used.

4.2.3 POLYVINYLCHLORIDE

Use of polyvinylchloride on flight hardware shall be limited to applications in pressurized areas where temperatures do not exceed 120 degrees Fahrenheit (49 degrees C). Polyvinylchloride shall not be used in vacuum.

4.2.4 FIBER REINFORCED PLASTICS

Defects resulting from the manufacturing process shall be assessed through the proper application of Nondestructive Inspection (NDI) techniques. Design allowables shall be obtained on material samples using materials and processes representative of flight hardware.

4.2.5 LUBRICANTS

NASA–TM–86556, Lubrication Handbook For the Space Industry, Part A: Solid Lubricants, Part B: Liquid Lubricants, shall be used in the evaluation and selection of lubricants for space flight systems and components. Long life performance shall be considered in lubricant selection. Lubricants containing chloro–fluoro components shall not be used with aluminum or magnesium if shear stresses can be imposed.

4.2.6 LIMITED–LIFE ITEMS

Materials shall be selected to ensure maximum life and minimum maintenance. As a goal, all materials shall be selected to provide the full operational service life with no maintenance. Materials which are not expected to meet the design life requirements but must be used for functional reasons shall be identified as limited–life items requiring maintainability.

4.2.7 VACUUM OUTGASSING

Non–metal materials which are exposed to space vacuum shall meet the requirements of JSC–SPEC–SP–R–0022, Vacuum Stability Requirements Of Polymeric Materials For Spacecraft Applications, or be tested using the technique of ASTM–E595, Total Mass Loss and Collected Volatile Condensible Materials From Outgassing In A Vacuum Environment, Test Method for, with acceptance criteria of <0.1 percent Collected Volatile Condensable Materials (CVCM) and <1.0 percent Total Mass Loss (TML). ~~Other requirements are contained in SSP 30426, Space Station External Contamination Control Requirements.~~

4.2.8 LOW EARTH ORBIT ENVIRONMENT SURVIVABILITY

Materials exposed in the low Earth orbit (LEO) environments shall be selected to perform in that environment for their intended life cycle exposure. The critical properties of the material shall survive exposure to the LEO environments of atomic oxygen, solar ultraviolet radiation, ionizing radiation, plasma, vacuum, thermal cycling and contamination. Meteoroids and orbital debris shall also be considered in the analysis of long term degradation.

4.2.9 DELETED

4.2.10 MOISTURE AND FUNGUS RESISTANCE

All non–metal materials in the pressurized habitable environment shall be evaluated for fungus resistance prior to selection and qualification. Materials which are non–nutrient to

fungi shall be used, as defined by MIL–STD–810, Environmental Testing Methods and Engineering Guidelines, Method 508, or MIL–STD–454, General Requirements for Electronic Equipment, Requirement 4, Fungus–Inert Materials, Table 4–I, Group I. When fungus–nutrient materials must be used, they shall be treated to prevent fungus growth. Materials not meeting this requirement shall be identified including any action required such as inspection, maintenance, or replacement periods. Fungus treatment shall not adversely affect unit performance or service life or constitute a health hazard to higher order life. Materials so treated shall be protected from environments that would be sufficient to leach out the protective agent.

4.2.11 DELETED

4.3 PROCESSES

4.3.1 FORGING

Because mechanical properties are optimum in the direction of material flow during forging, forging techniques shall be used that produce an internal grain– flow pattern such that the direction of flow is essentially parallel to the principal stresses. The forging pattern shall be essentially free from re–entrant and sharply folded flow lines. After the forging technique, including degree of working, is established, the first production forging shall be sectioned to show the grain–flow patterns and to determine mechanical properties at control areas. The procedure shall be repeated after any change in the forging technique. The information gained from this effort shall be utilized to redesign the forging as necessary. These data and results of tests on the redesign shall be retained by the contractor and be made available for review by the procuring activity. Where forgings are used in critical applications, trim ring or protrusion specimens shall be obtained for each forging and shall be tested for required minimum mechanical properties. ~~Control of fracture critical forgings and manufacturing planning shall meet the requirements of SSP 30558.~~

4.3.2 CASTINGS

Castings shall meet the requirements of MIL–STD–2175, Castings, Classification And Inspection Of.

4.3.3 ADHESIVE BONDING

Structural adhesive bonding shall meet MSFC–SPEC–445, Adhesive Bonding, Process, and Inspection, Requirements For, with the exception of paragraph 3.1.1.1. Adhesives

used for production parts will not be retested if within shelf life. Bonded primary structural joints shall demonstrate cohesive failure modes in shear.

4.3.4 WELDING

The design selection of parent materials and weld methods shall be based on consideration of the weldments, including adjacent heat affected zones, as they affect operational capability of the parts concerned. Welding procedures shall be selected to provide the required weld quality, minimum weld energy input, and protection of the heated metal from contamination. The suitability of the equipment, processes, welding supplies, and supplementary treatments selected shall be demonstrated through qualification testing of welded specimens representing the materials and joint configuration of production parts. As a minimum requirement, welding operators shall be qualified in accordance with MIL–STD–1595, Qualification Of Aircraft, Missile and Aerospace Fusion Welders. In addition, the contractor shall provide the necessary training and qualification requirements to certify each operator and the applicable welding equipment for specific welding tasks.

4.3.4.1 Weld Repair – At the discretion of the cognizant engineer, two additional welding operations may be performed on any one location, within a two inch length, to repair defects determined by inspection without the procuring activity's Material Review Board (MRB) approval. Weld repair does not include the correction of dimensional deficiencies by weld buildup or "buttering" of parts in areas where the design did not provide a welded joint. All weld repairs shall be fully documented to facilitate procuring activity review. The weld repair process and inspection shall be qualified to the same level of assurance as the primary process specification drawing requirement using the same inspection technique that found the original defect and by all other methods of examination that were originally required for the affected area. The results are subject to review by the Prime Contractor upon request.

4.3.4.2 Weld Filler Metal – Weld wire filler materials shall meet the requirements of MSFC–STD–655, Weld Filler Metal, Control Of. In addition, qualitative analysis or nondestructive testing shall be conducted on each nickel base filler rod or immediately before and after each segment of rolled nickel base weld wire used to assure that the correct filler metal is used on each specific critical part.

4.3.4.3 Aluminum Welding – The welding of aluminum alloys shall meet the requirements of MSFC–SPEC–504, Welding, Aluminum Alloys.

4.3.4.4 Welding of Steel Alloys – Welding of steel alloys shall meet the requirements of MSFC–SPEC–560, Welding, Steels, Corrosion and Heat Resistant Alloys.

4.3.4.5 Low Stress Welds and Structures – Weldments meeting all conditions below are suitable for reduced qualification and inspection before flight:

1) Not listed as criticality 1 on the Critical Items List as determined by Failure Modes and Effect Analysis;
2) Having no site on the weld above 4,000 psi uniaxial stress;
3) Made from materials with KQ/FTY > 0.5 in ^.5 at the design thickness;
4) By a process specification and procedure specified in the contractor M&P Selection, Control, and Verification Plan.

The equipment, welder performance qualification, WPS qualification, equipment operational check and general workmanship requirements of MSFC–SPEC–504 apply to all parent metals. Pressure testing is an acceptable alternate to penetrant and radiographic tests for these low stress welds. Incomplete penetration butt and corner welds are acceptable for design. Low stress welds shall be identified on drawings.

4.3.5 BRAZING

Brazing shall meet the requirements of MIL–B–7883, Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum, and Aluminum Alloys. Brazing of aluminum alloys may as an alternate meet the requirements of AWS C–3.7, Specification for Aluminum Brazing. Subsequent fusion–welding operations in the vicinity of brazed joints or other operations involving high temperatures which might affect the brazed joint are prohibited. Brazed joints shall be designed for shear loading and shall not be relied upon for strength in tension for structural parts.

4.3.6 STRUCTURAL SOLDERING

Soldering shall not be used for structural applications.

4.3.7 ELECTRICAL DISCHARGE MACHINING

Parts manufactured using Electrical Discharge Machining (EDM) shall be processed to control or eliminate the recast layer and heat affected zone. The manufacturer of EDM processed parts shall document the steps taken to determine the depth of, and the steps taken to control, the recast layer and the heat affected zone. A metallographic examination shall be conducted to determine the extent and hardness of the EDM cast and heat affected zone on a pre–production specimen.

4.3.8 PERSONNEL QUALIFICATION/TRAINING

Requirements for personnel qualification and training are found in SSP 41173.

4.4 MATERIAL NONDESTRUCTIVE INSPECTION

4.4.1 NDE PLAN

The Nondestructive Evaluation (NDE) activities associated with aerospace hardware shall meet the intent of MIL–I–6870, Inspection Program Requirements, Nondestructive for Aircraft and Missile Materials and Parts. A NDI plan, when required by the contract data requirement, shall be prepared by the contractor and submitted for review by the procuring activity. This plan shall present the scheme for establishing the NDI/Nondestructive Test (NDT) requirements and implementation procedures to meet these requirements.

4.4.2 NDE ETCHING

All fracture critical parts shall be NDE etched prior to dye penetrant inspection unless otherwise specified by the procuring activity. (NOTE – All machined or otherwise mechanically disturbed surfaces which are to be penetrant inspected must be adequately etched to assure removal of smeared, masking material prior to penetrant application on fracture critical parts.)

4.4.3 DELETED

4.4.4 DELETED

4.4.5 DELETED

4.4.6 DELETED

4.4.7 DELETED

4.4.8 DELETED

4.5 SPECIAL MATERIALS REQUIREMENTS

4.5.1 RESIDUAL STRESSES

Residual tensile stresses are induced into manufactured parts as a result of forging, machining, heat treating, welding, or special metal–removal processes. Residual stresses

shall be controlled or minimized during the fabrication sequence by special treatments such as annealing and stress relieving. These stresses may be harmful in structural applications when the part is subjected to fatigue loading, operation stresses, or corrosive environments. Therefore, every available effort shall be made to eliminate or minimize residual tensile stresses from finished structural parts.

4.5.2 SANDWICH ASSEMBLIES

Sandwich assemblies shall be designed to prevent the entrance and entrapment of water vapor or other contaminants into the core structure. Honeycomb sandwich assemblies that will be subjected to heating shall use a metallic or glass reinforced core to minimize the absorption of moisture. Sandwich assemblies can utilize perforated and moisture–absorbing cores provided they are protected during assembly and prelaunch activities. Sandwich assemblies shall satisfy the requirements of MIL–HDBK–23, and test methods for sandwich constructions and core materials shall meet the requirements of MIL–STD–401, Sandwich Constructions and Core Materials; General Test Methods.

4.5.3 DELETED

4.5.4 CORROSION PREVENTION AND CONTROL

All parts, assemblies, and equipment, including spares, shall be finished to provide protection from corrosion in accordance with the requirements of MSFC–SPEC–250, Protective Finishes For Space Vehicle Structures and Associated Flight Equipment, General Specification For. Corrosion evaluation shall show the possible effects of fluid release resulting from the failure or permeation of barriers. Corrosion control of galvanic couples shall be in accordance with MIL–STD–889, Dissimilar Metals. Specific corrosion prevention and control techniques shall be defined in the Materials and Processes Selection, Control, and Verification Plan.

4.5.4.1 Steel– Where exposed to atmosphere or corrosive environments, all parts, including fasteners made from low alloy, high strength steels, shall be suitably protected. Where plating is used, it shall be applied by a process which has been proven to be nonembrittling to the high strength steel and shall be compatible with the space environment.

4.5.4.2 Sealing– All mechanical joints and seams located in exterior or internal corrosive environments, including structures under fairings, shall be faying–surface sealed. Sealants used shall be covered by a published specification and shall have acceptable ratings. Sealants not covered by a published specification or without acceptable ratings shall be subject to review and approval by the procuring activity. Removable panels and

access doors in exterior or interior corrosive environments shall be sealed either by mechanical seals or by separable, faying–surface sealing.

4.5.4.3 Deleted

4.5.5 FASTENERS

4.5.5.1 Fastener Installation – Self locking fastener reuse shall be allowed when the running torque prior to clamp up remains between the maximum self locking torque and the minimum breakaway torque. Wet installation of fasteners is not required except in applications where condensation or aqueous corrosive environments exist. The installation of titanium fasteners and associated parts shall meet the requirements of MSFC–STD–557, Threaded Fasteners, 6Al–4V Titanium Alloy, Usage Criterial For Spacecraft Applications.

4.6 MATERIALS AND PROCESSES FOR ELECTRICAL COMPONENTS

4.6.1 ELECTRICAL BONDING AND GROUNDING

Parts and materials used in e~~E~~lectrical bonding and grounding shall ~~be accomplished in accordance with SSP 30240 and SSP 30245, however, parts and materials shall~~ meet the requirements of this document.

4.6.2 USE OF SILVER

Silver is prohibited as a plating on printed wiring boards, terminal boards and bus bars.

4.6.3 WIRE/CABLE ASSEMBLIES

The following shall be assembled or installed to meet the requirements of NHB 5300.4 (3G).

1. Electrical connectors,
2. Interconnecting cables, harness, and wiring
3. Solders Sleeves.

4.6.4 FIBER OPTICS

Fabrication controls and processes shall be established for joining of fiber optic cable assemblies.

4.6.5 PRINTED WIRING BOARDS

4.6.5.1 Rigid PWB – Fabrication controls and processes used in rigid printed wiring boards shall meet the requirements of NHB 5300.4 (3K) and NHB 5300.4 (3I).

4.6.5.2 Flexible PWB – Fabrication controls and processes flexible and rigid/flex printed wiring boards shall meet the requirements of MIL–P–50884.

4.6.6 PRINTED WIRING ASSEMBLIES

4.6.6.1 Staking/Conformal Coating – Fabrication controls and processes used in staking and conformal coating of printed wiring boards and electronic assemblies shall meet the requirements of NHB 5300.4 (3J).

4.6.6.2 Other Processes – Processes used for printed wiring assemblies shall meet the requirements of MIL–C–28809 except as modified by requirements in NHB 5300.4 (3A–1) and NHB 5300.4 (3J).

4.6.7 ETCHING FLUOROCARBONS

The etching of fluorocarbons shall meet the requirements of AMS 2491.

4.6.8 ELECTRICAL SOLDERING

Fabrication controls and processes used in soldering of electrical connections shall meet the requirements of NHB 5300.4 (3A–1).

4.6.9 ELECTRICAL CRIMPING

Crimping of electrical terminations shall meet the requirements of NHB 5300.4 (3H). However, terminal lugs, splices, and two–piece shield termination rings shall meet the tensile strength and electrical requirements of MIL–T–7928.

4.6.10 ELECTRICAL WIRE WRAPPED CONNECTIONS

Wire wrapping shall meet the requirements of NHB 5300.4 (3H). Wire wrapping shall not be used, except for in Ground Support Equipment.

APPENDIX A ABBREVIATIONS AND ACRONYMS

ASTM	American Society for Testing and Materials
CAD	Computer–Aided Design
CAM	Computer–Aided Manufacturing
CDR	Critical Design Review
CIL	Critical Items List
CP	Commercially Pure
CVCM	Collected Volatile Condensable Materials
DR	Data Requirement
EDM	Electrical Discharge Machining
EPA	Environmental Protection Agency
ETFE	Ethylene Tetrafluoroethylene
GOX	Gaseous Oxygen
GSE	Ground Support Equipment
HDBK	Handbook
IP	International Partner
JSC	Johnson Space Center
kPa	Kilopascals
ksi	Kilopounds per Square Inch
LOX	Liquid Oxygen
M&P	Materials and Processes
MCP	Materials Control Plan
MCR	Materials Control Requirement
MIL	Military
MIUL	Material Identification Usage List
mm	Millimeter
MRB	Materials Review Board
MSFC	Marshall Space Flight Center
MUA	Material Usage Agreement
NASA	National Aeronautics and Space Administration
NDE	Nondestructive Evaluation
NDI	Nondestructive Inspection

NDT	Nondestructive Test
NHB	NASA Handbook
NSTS	National Space Transportation System
OSF	Office of Space Flight
OSHA	Occupational Safety and Health Administration
PDR	Preliminary Design Review
PG	Product Group
psia	Pounds per Square Inch Absolute
PTFE	Polytetrafluoroethylene
RTV	Room Temperature Vulcanizing (rubber)
SE	Support Equipment
SMAC	Spacecraft Maximum Allowable Concentration
SPEC	Specification
SSQ	Space Station Quality
STD	Standard
TBS	To Be Specified
TML	Total Mass Loss
UTS	Ultimate Tensile Strength
UV	Ultraviolet

APPENDIX B DEFINITIONS

Corrosive Environment – Solid, liquid, or gaseous environment that deteriorates the materials by reaction with the environment. Cleanrooms and vacuum are normally considered noncorrosive.

Primary structure – Principle or main structure which sustains the significant applied loads or provides main load paths for distributing reactions to applied loads and which if it fails creates a catastrophic hazard.

Prime Contractor – The Space Station integration contractor, ie Boeing – Houston

Procuring Activity – The contractual customer. The procuring activity for a subcontractor is the Product Group. The procuring activity for the Product Group is the Prime contractor. The procuring activity for the Prime contractor is NASA.

Safety critical hardware – Hardware that, if it fails, creates a catastrophic hazard.

Structural – Primary load bearing structure.

Structural adhesive bond – Structural joint using adhesive bonds for the purpose of transferring structural load between structures.

Structure – All components and assemblies designed to sustain loads or pressures, provide stiffness and stability, or support or containment.

Subcontractor – a hardware contractor that reports to a Product Group.

Product Group – A contractor that reports directly to the Prime Contractor. In this case, Boeing HAB/LAB (Huntsville, Al), McDonnell Douglas Aerospace, and Rocketdyne

MATERIAL USAGE AGREEMENT	C	USAGE AGREEMENT NO.	REV	PAGE OF

PROJECT:	SYSTEM:	CATEGORY:	ORIGINATOR:	ORGANIZATION/CONTRACTOR:

PART NUMBER(S):	USING ASSEMBLY(S):	ITEM DESCRIPTION:	ISSUE:

MATERIAL DESIGNATION:	MANUFACTURER:	SPECIFICATION:	PROPOSED EFFECTIVITY:

MATERIAL CODE:			LOCATION:	ENVIRONMENT:		
THICKNESS:	WEIGHT:	EXPOSED AREA	HABITABLE ☐	PRESSURE PSIA:	TEMP.F:	MEDIA:
			NONHABITABLE ☐			

APPLICATION:

RATIONALE: (use second page if required.)

MATERIAL USAGE AGREEMENT DISPOSITION

CONTRACTOR TIER 1	CONTRACTOR PRIME	NASA PROJECT MGR.	NASA M & P

	DATE	APPROVE	REJECT	DEFER	MEMO NO.:
					EFFECTIVITY:

ORIGINATING CONTRACTOR

APPENDIX C CATEGORY III MUA RATIONALE CODES

FLAMMABILITY RATIONALE CODES

CODE	RATIONALE
101	APPROVED MATERIALS USAGE AGREEMENT (MUA) CATEGORY I.
102	APPROVED MATERIALS USAGE AGREEMENT (MUA) CATEGORY II.
103	MATERIALS PASSED REQUIREMENTS WHEN TESTED IN CONFIGURATION.
104	UNEXPOSED, OVERCOATED OR SANDWICHED BETWEEN NON–FLAMMABLE MATERIAL AND NO IGNITION SOURCE OR PROPAGATION PATH.
105	MINOR USAGE (LESS THAN 0.1 LB. AND 2 SQ–IN SURFACE AREA); NO PROPAGATION PATH OR IGNITION SOURCE.
106	MATERIAL IS USED IN HERMETICALLY SEALED CONTAINER.
107	PASSES TEST NO. 8 OF NHB 8060.1, FLAMMABILITY TEST FOR MATERIALS IN VENTED CONTAINERS, BY TEST OR ANALYSIS.
108	OFF THE SHELF EQUIPMENT HAVING MATERIAL ACCEPTABLE IN CONFIGURATION; NO IGNITION SOURCE OR PROPAGATION PATH.
109	MATERIAL NOT EXPOSED; TOTALLY IMMERSED IN FLUID; EVALUATED FOR FLUID COMPATIBILITY ONLY.
110	MATERIAL IS ACCEPTABLE WHEN USED ON A METAL SUBSTRATE THAT PROVIDES A GOOD HEAT SINK. MATERIAL CONSIDERED NONCOMBUSTIBLE IN THIS CONFIGURATION BY TEST OR ANALYSIS.
111	MATERIAL NOT A–RATED FOR FLAM IS SANDWICHED BETWEEN NON–FLAMMABLE MATERIALS WITH EDGES ONLY EXPOSED AND IS MORE THAN 2 IN. FROM AN IGNITION SOURCE OR MORE THAN 12IN. FROM OTHER MATERIALS NOT A–RATED.
112	MATERIAL NOT A–RATED FOR FLAM IS UNEXPOSED OR IS OVERCOATED WITH A NON–FLAMMABLE MATERIAL.
113	MATERIAL(NOT MORE THAN 0.010 IN. THICKNESS) NOT A–RATED FOR FLAM IS SPRAYED OR BONDED TO A METALLIC SURFACE >0.062 IN. THICK
114	MATERIAL NOT A–RATED FOR FLAM IS USED IN ”SMALL AMOUNTS” AND IS MORE THAN 2 IN. FROM AN IGNITION SOURCE OR MORE THAN 12 IN. FROM OTHER MATERIALS NOT A–RATED FOR FLAM. ”SMALL AMOUNTS” FOR FLAM MAY BE QUANTIFIED AS FOLLOWS: TOTAL WEIGHT <0.1 LB. AND <2.0 SQ. IN. SURFACE AREA.

TOXICITY (OFFGASSING) RATIONALE CODES

201	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY I.
202	MEETS TOX REQUIREMENTS WITH PERFORMED CURE.

203	T VALUE FOR MATERIAL/COMPONENT IN USAGE WEIGHT IS LESS THAN 0.5 IN EACH 118 CUBIC METER VOLUME.
204	MATERIALS USAGE IN HERMETICALLY SEALED CONTAINER

FLUID SYSTEM COMPATIBILITY RATIONALE CODES

CODE	RATIONALE
301	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY I.
302	PASSES REQUIREMENTS IN CONFIGURATION.
303	”B” RATED MATERIAL PASSED BATCH LOT TEST.
304	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY II.

THERMAL VACUUM STABILITY RATIONALE CODES

CODE	RATIONALE
401	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY I.
402	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY II.
403	”C” RATED MATERIAL; EXPOSED AREA IS NOT MORE THAN 2 SQ–IN. AND NOT NEAR A CRITICAL SURFACE.
404	”X” RATED MATERIAL; EXPOSED AREA IS LESS THAN 1/4 SQ–IN.
405	UNEXPOSED, OVERCOATED OR ENCAPSULATED WITH APPROVED MATERIAL.
406	”B” RATED MATERIAL CURED TO MEET THE REQUIREMENTS OF AN ”A” RATING.
407	MEETS TVS REQUIREMENTS IN CONFIGURATION.
408	MATERIALS USAGE IN HERMETICALLY SEALED CONTAINER
409	MATERIAL NOT A–RATED FOR TVS IS ENCLOSED IN A SEALED CONTAINER (I.E., DESIGNED WITH A LEAKAGE RATE OF <0.0001 STANDARD CC/SEC. WITH ATMOSPHERE PRESSURE DIFFERENTIAL – REF. MSFC–PROC–1301, SECTION 1.3)

STRESS CORROSION CRACKING RATIONALE CODES

CODE	RATIONALE
501	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY I.
502	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY II.
503	MAXIMUM TENSILE STRESS LESS THAN 50% OF YEILD STRENGTH FOR PART ON ELECTRICAL/ELECTRONIC ASSEMBLIES.
504	MARTENSITIC OR PH STAINLESS STEELS USED IN BALL BEARING, RACE OR SIMILAR APPLICATIONS WHERE THE PRIMARY LOADING IS COMPRESSIVE.

505	METAL NOT A–RATED FOR SCC IS NOT EXPOSED TO A CORROSIVE ENVIRONMENT AFTER FINAL ASSEMBLY THROUGH TO END ITEM USE.
506	CARBON & LOW ALLOY HIGH STRENGTH STEELS GREATER THAN 180 KSI USED IN BALL BEARINGS, SPRINGS, OR SIMILAR APPLICATIONS WHERE PRIMARY LOADING IS COMPRESSIVE, LOW TENSILE STRESSES, OR HISTORY OF SATISFACTORY PERFORMANCE.

CORROSION RATIONALE CODES

CODE	RATIONALE
601	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY I.
602	APPROVED MATERIAL USAGE AGREEMENT(MUA) CATEGORY II.
603	ADEQUATELY FINISHED FOR CORROSION PROTECTION.
604	ACCEPTABLE IN USE ENVIRONMENT
606	ELECTRICAL GROUNDING REQUIRED, CLADDING PLUS CONVERSION COATING ADEQUATE.
607	THERMAL CONDUCTANCE AND ELECTRICAL BONDING REQUIREMENTS PRECLUDE PAINTING. CONVERSION COATING IS ADEQUATE (FOR ALUMINUM ONLY).
608	FINISHED ON A HIGHER ASSEMBLY.
609	LAMINATED SHIM–MINIMUM EXPOSURE OF CORROSION RESISTANT MATERIAL.
610	SURFACE OF A METAL NOT A–RATED FOR CORR IS TREATED OR COATED IN A MANNER WHICH MEETS OR EXCEEDS THE REQUIREMENTS OF MSFC–SPEC–250A. ACTUAL SURFACE TREATMENT SHALL BE LISTED.
611	METAL NOT A–RATED FOR CORR IS NOT EXPOSED TO A CORROSIVE ENVIRONMENT AFTER FINAL ASSEMBLY THROUGH TO END ITEM USE.
612	WELDING OF TITANIUM ALLOY–TO–ALLOY OR CP–TO–ALLOY USING CP FILLER METAL IN MIXED ALLOY WELDS WHERE HYDROGEN EMBRITTLEMENT IS NOT PREDICTED IN SERVICE.

GENERAL CODES

CODE	RATIONALE
701	MATERIAL RATINGS IN MAPTIS ARE USED FOR ACCEPTANCE IN PLACE OF MSFC–HDBK–527/JSC 09604. (DATE OF MAPTIS RATING USAGE TO BE DOCUMENTED).
702	GENERIC MATERIALS CONTROLLED BY MIL–SPEC OR INDUSTRY SPECIFICATION USING MAPTIS AVERAGES FOR RATINGS OR TEST RESULTS. MATERIAL CODES FOR GENERIC MATERIAL SHALL BE USED.
703	MIL–SPEC OR INDUSTRY SPEC ALLOWING SEVERAL MATERIAL OPTIONS WHERE ALL OPTIONS HAVE ACCEPTABLE RATINGS
704	MATERIALS CONTROLLED BY SSQ SPECIFICATION