MEASURMENT SYSTEM IDENTIFICATION (English)

NASA TECHNICAL STANDARD **National Aeronautics and Space Administration**	**NASA-STD-8739.6B**
	Approved: 2021-02-04 **Superseding: NASA-STD 8739.6A with Change 1**

IMPLEMENTATION REQUIREMENTS FOR NASA APPROVED WORKMANSHIP STANDARDS

DOCUMENT HISTORY LOG

Status	Document Revision	Approval Date	Description
Baseline		2012-09-05	Initial Release
Revised	A	2016-06-30	- Move all generic requirements from 8739.1, 8739.4 and 8739.5 into this standard. Added associated documents, definitions and acronyms. - Exempt 7120.8 and "Do No Harm" missions from workmanship requirements. - Update/correct CFR referenced for toxic and hazardous substances. - Removed documents, definitions and acronyms no longer used in the text. - Corrected acronym and name for Safety Data Sheets. -Added definitions for alternate standards, manufacturing documentation, off the shelf, referee magnification levels, supplier. -Clarifying language provided for laboratory temperature and relative humidity conditions. -Project calibration control requirements are referenced rather than defining them within the workmanship standards. -Clarification added that all mission hardware workmanship shall be inspected. -Clarification of criteria to be used to approve non-standard solvents. -Prohibit use of water as a cleaning solvent for applications that use silver-plated copper wire. -Use the standard definitions in NASA-STD-8709.22 for rework and repair. -Risk mitigations may be standard practice when routinely encountering low humidity working conditions in ESD-controlled areas. - Prohibit uses of "Anti-static" containers (e.g., pink poly) for storing or transporting ESD sensitive items. - Clause 11 of J-STD-001F is not applicable for polymeric applications. - Exemption from the red-plague control plan requirements in J-STD-001FS. - Remove requirements and information related to the IPC non-modular training program for J-STD-001FS. - Remove Level B trainers from users of custom J-STD-001FS training programs. - Allow use of J-STD-001FS instead of NASA-STD-8739.3 when referenced by NASA-STD-8739.4. - Removes certification requirements for operators, inspectors and Level B trainers. - Remove grace period of three months attached to retraining requirement. - Prohibit sharing of export administrative regulations (EAR) information with foreign national students.
Revised	Change 1	2017-05-31	- Add adoption of IPC/WHMA-A-620B-S - Add interconnection types for cables and harnesses fabricated to IPC/WHMA-A-620B-S that will be treated as nonstandard.

			- Add Appendix B to describe types of NASA workmanship instructors. - Add description and definition of SMA-Sponsored Level B Training Centers. - Recommend use of ESD controls in calibration labs. - Allow wide use of NASA-generated ESD product qualification results. - Editorial corrections.
Active	B	2021-02-04	- Move training program implementation criteria to Section 5. - Removed applicability statement referring to critical hardware per NPD-8730.5. - Permit Workmanship Standards PM or delegated person to recertify SMA-Sponsored Level B Instructors. - Add ESD control baseline requirements to Section 7 to be implemented with ANSI/ESD S20.20. - ESD baseline includes minimum ESD Control Program Plan requirements and recommended equipment verification intervals. - Implemented J-STD-001GS and IPC/WHMA-A-620C-S. - Trainees may carry out retraining up to 90 days early and retain their original training expiration date. - Editorial corrections.

FOREWORD

This NASA technical standard provides uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA facilities, programs, and projects, including requirements for selecting, applying, and designing hardware for manufacturability and reliability.

This standard establishes NASA workmanship requirements, and clarifications, additions, and exceptions to requirements specified in NASA adopted industry consensus standards identified as required for use by NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects.

This standard was developed by the NASA Office of Safety and Mission Assurance (OSMA) and the NASA Workmanship Standards Program. Requests for information, corrections, or additions to this standard should be submitted to the OSMA by email to Agency-SMA-Policy-Feedback@mail.nasa.gov or via the "Email Feedback" link at https://standards.nasa.gov.

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2/4/21
Approval Date

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1. SCOPE

1.1 Purpose

1.1.1 The purpose of this standard is to provide manufacturing, quality, and training requirements for the manufacture of NASA mission hardware and electrostatic discharge (ESD) control which augment requirements found in one or more of the documents listed in Table 1, Workmanship Requirements Documents.

Table 1. Workmanship Requirements Documents

Title	Number
Workmanship Standard for Polymeric Application on Electronic Assemblies	NASA-STD 8739.1
Workmanship Standard for Crimping, Interconnecting Cables, Harnesses, and Wiring	NASA-STD 8739.4
Workmanship Standard for Fiber Optic Terminations, Cable Assemblies, and Installation	NASA-STD 8739.5
Standard for the Development of an ESD Control Program for the Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)	ANSI/ESD S20.20-2014
Requirements for Soldered Electrical and Electronic Assemblies	IPC J-STD-001G
Space and Military Applications Electronic Hardware Addendum to IPC® J-STD-001G Requirements for Soldered Electrical and Electronic Assemblies	IPC J-STD-001GS
Requirements and Acceptance for Cable and Wire Harness Assemblies	IPC/WHMA-A-620C
Space Applications Electronic Hardware Addendum to IPC/WHMA-A-620C, Requirements and Acceptance for Cable and Wire Harness Assemblies	IPC/WHMA-A-620C-S

1.2 Applicability

1.2.1 This standard applies to NASA Installations, including NASA Headquarters and NASA Centers, Component Facilities and Technical and Service Support Centers. This language applies to the Jet Propulsion Laboratory (a Federally-Funded Research and Development Center), other contractors, recipients of grants, cooperative agreements, or other agreements only to the extent specified or referenced in the applicable contracts, grants, or agreements.

1.2.2 The requirements of this standard may not apply when requirements flow down is not practical. Examples include internal research and development activities, procurement of off-the-shelf (OTS) items, or when using suppliers who work to alternate standards. Projects procuring OTS products or products made to alternate standards shall be responsible for identifying and managing risk associated with hardware that may have been built or will be built without material controls, production methods, or quality inspections defined by the workmanship standards in Table 1.

1.2.3 Questions concerning the application of this publication to specific procurements should be referred to the applicable NASA program, project, or Center.

1.2.4 In this standard, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms "may" denotes a discretionary privilege or permission, "can" denotes statements of possibility or capability, "should" denotes a good practice and is recommended, but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.

1.3 Levying Special Requirements

1.3.1 Project-specific and NASA Center-specific workmanship requirements not contained in this publication or in the standards referenced in Table 1 shall be formally documented and approved by the project's quality assurance leadership prior to implementation. See 4.1 for implementation requirements.

> *Note: Review and approval is necessary to ensure these requirements are adequate, as compared to requirements herein, and to ensure traceability of engineering and work documentation to all imposed requirements.*

1.3.2 Project-specific and NASA Center-specific requirements that conflict with requirements stated herein or in the standards in Table 1 shall be formally documented, approved, and traceable to requests for relief prior to implementation. NPR 8715.3 defines the process for requesting and granting relief from requirements within this standard.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed in this section contain provisions that constitute requirements of this standard as cited in the text. Use of more recent issues of cited documents may be authorized by the responsible SMA Technical Authority. The applicable documents are accessible via the NASA Technical Standards System at https://standards.nasa.gov or may be obtained directly from the Standards Developing Organizations or other document distributors. Additional related information is accessible via the OSMA Workmanship site at https://sma.nasa.gov/sma-disciplines/workmanship.

2.1.1 Government Documents

NPR 8715.3	NASA General Safety Program Requirements
NPR 8735.2	Hardware Quality Assurance Program Requirements for Programs and Projects
NASA-STD-8739.1	Workmanship Standard for Polymeric Application on Electronic Assemblies
NASA-STD-8739.2	Workmanship Standard for Surface Mount Technology (Note: This standard has been superseded at NASA by IPC® J-STD-001GS but is still used on pre-existing projects.)
NASA-STD-8739.3	Soldered Electrical Connections (Note: This standard has been superseded at NASA by IPC® J-STD-001GS but is still used on pre-existing projects.)
NASA-STD-8739.4	Workmanship Standard for Crimping, Interconnecting Cables, Harnesses, and Wiring
NASA-STD-8739.5	Workmanship Standard for Fiber Optic Terminations, Cable Assemblies, and Installation

2.1.2 Non-Government Documents

ANSI/ESD S20.20-2014	Standard for the Development of an ESD Control Program for the Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
SAE-GEIA-STD-0005-1A	Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder

SAE-GEIA-STD-0005-2A	Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems
IPC J-STD-001G	Requirements for Soldered Electrical and Electronic Assemblies
IPC J-STD-001GS	Space and Military Applications Electronic Hardware Addendum to J-STD-001G Requirements for Soldered Electrical and Electronic Assemblies
IPC/WHMA-A-620C	Requirements and Acceptance for Cable and Wire Harness Assemblies
IPC/WHMA-A-620C-S	Space Applications Electronic Hardware Addendum to IPC/WHMA-A-620C

2.2 Reference Documents

The documents listed in this section do not constitute requirements of this standard, but are cited in the text to provide further clarification and guidance.

2.2.1 Government Documents

29 CFR 1910 Subpart Z	Toxic and Hazardous Substances
NPD 8730.5	NASA Quality Assurance Program Policy
NASA-STD-6016	Standard Materials and Processes Requirements for Spacecraft

2.2.2 Non-Government Documents

ANSI/ESD S1.1-2013	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Wrist Straps
ANSI/ESD S6.1-2014	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Grounding
ANSI/ESD S13.1-2015	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Electrical Soldering/Desoldering Hand Tools
ANSI/ESD S541-2019	Packaging Materials for ESD Sensitive Items
ANSI/ESD STM2.1-2018	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Garments – Resistive Characterization

ANSI/ESD STM3.1-2015	ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items – Ionization
ANSI/ESD STM4.1-2017	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Worksurfaces – Resistance Measurements
ANSI/ESD STM7.1-2013	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Floor Materials, Characterization of Materials
ANSI/ESD STM12.1-2013	ESD Association Standard Test Method For The Protection Of Electrostatic Discharge Susceptible Items – Seating – Resistance Measurement
ANSI/ESD STM97.1-2015	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Footwear/Flooring System – Resistance Measurement in Combination with a Person
ESD TR53-01-18	ESD Association Technical Report For The Protection Of Electrostatic Discharge Susceptible Items - Compliance Verification Of ESD Protective Equipment And Materials

2.3 Order of Precedence

2.2.1 This standard establishes requirements to provide quality requirements for the manufacturing of NASA mission hardware and for ESD control but does not supersede nor waive established Agency requirements found in other documentation. Where there are conflicts between the requirements found in this standard and the standards in Table 1, the requirements of this standard take precedence.

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms and Abbreviations

ANSI	American National Standards Institute
CDM	Charged Device Model
CFR	Code of Federal Regulations
CIS	Certified IPC® Application Specialist
CIT	Certified IPC® Trainer
CMS	Continuous Monitoring System
CPG	Common Point Ground
E-NMTTC	Eastern NASA Manufacturing Technology Transfer Center
EPA	Electrostatic Protected Area
ESD	Electrostatic Discharge
ESDA	ESD Association
ESDS	ESD Sensitive
GFCI	Ground-Fault Circuit Interruptor
GND	Ground (electrical)
GSFC	Goddard Space Flight Center
HBM	Human Body Model
iNARTE®	International Association for Radio, Telecommunications and Electromagnetics
IPC®	Registered trademark for IPC®-Association Connecting Electronic Industries; originally Institute of Printed Circuits
JPL	Jet Propulsion Laboratory
MIT	Certified IPC® Master Trainer
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements

NWSTC	NASA Workmanship Standards Technical Committee
OSHA	Occupational Safety and Health Administration
PA	Programmatic Authority
RH	Relative Humidity
SATERN	System for Administration, Training, and Educational Resources for NASA
SDS	Safety Data Sheet
SMA	Safety and Mission Assurance
STD	Standard
TA	Technical Authority
W-NMTTC	Western NASA Manufacturing Technology Transfer Center

3.2 Definitions

The definitions listed below are in addition to those listed in NASA-HDBK-8709.22, Safety and Mission Assurance Acronyms, Abbreviations, and Definitions.

Alternate Standards: Workmanship requirements baseline that is offered by the supplier as a substitute for one or more of the workmanship standards referenced in Table 1 herein. Procedures are not alternate requirements standards.

Delegated agent: NASA support contractor or alternate Federal Agency (e.g., Defense Contract Management Agency) that is formally delegated responsibility to perform Government Contract Quality Assurance functions in accordance with a written contract, task order, or Letter of Delegation.

ESD Access-controlled Area: An area (e.g., lab, cleanroom, building) containing EPA(s) where access is limited to ESD trained personnel and escorted visitors.

ESD Control Program Manager: The manager or coordinator who is the responsible party for implementation and verification of the local ESD control program plan in accordance with the requirements of this document.

ESD Control Program Plan: The top-level facility plan comprised of administrative, technical, and quality requirements, used to mitigate the risk of ESD events to ESD Sensitive (ESDS) hardware.

Level A Instructor: Instructor who teaches one or more of NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, or NASA-STD-

8739.5 courses to operators, inspectors, and Level B instructors. The local ESD Control Program Plan may choose to define and use a NASA Level A Instructor classification in its training section.

Level B Instructor: Instructor who teaches one or more of NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, or NASA-STD-8739.5 courses to operators and inspectors. The local ESD Control Program Plan may choose to define and use a Level B Instructor classification in its training section.

Manufacturing Documentation: Instructions, drawings, specifications, work orders, travelers and all other documents provided to manufacturing operators and inspectors defining the intended design, manufacturing methods, and quality controls.

Mission Hardware: Items made of a material substance that make up, or are integrated into, spacecraft, launch vehicles, or aircraft used to execute a NASA mission.

NASA Level A Training Center: The Eastern NASA Manufacturing Technology Transfer Center (E-NMTTC) at NASA Goddard Space Flight Center and the Western NASA Manufacturing Technology Transfer Center (W-NMTTC) at the Jet Propulsion Laboratory are NASA Level A training centers.

NASA Workmanship Standards Technical Committee: NASA civil service employees who are the primary points of contact for the NASA Workmanship Standards Program for each NASA Center. See https://sma.nasa.gov/sma-disciplines/workmanship for the current roster.

Off-The-Shelf: Products sold in the common marketplace, without modification, that are made and procured to a supplier-defined design, supplier-defined form, fit and function specifications, and supplier-defined quality assurance requirements.

Referee Magnification Levels: Higher levels of magnification than the maximum magnification limit defined in the applicable workmanship standard, used for closer examination of an anomaly to determine if it is a defect.

Repair: A procedure that makes a nonconforming item acceptable for use. The purpose of the repair is to reduce the effect of the nonconformance. Repair is distinguished from rework in that characteristics after repair still do not completely conform to the applicable drawings, specifications, or contract requirements.

Rework: A procedure/process (reprocessing) applied to a nonconforming item that completely eliminates the nonconformance and results in characteristics that conform completely to the drawings, specifications, or contract requirements.

SMA-Sponsored Level B Training Center: A workmanship training center identified and sponsored by the local NASA Center's SMA authority to train contractors and civil servants who work inside or outside of the Center. An SMA-Sponsored Training Center may consist of more than one location where Level B trainers provide instruction and one or more instructors.

Supplier: Any entity which manufactures hardware in accordance with the requirements herein, including NASA Centers and NASA contractors.

Wrist Strap: A personnel grounding system consisting of a wristband and a cord to connect the user to electrical ground.

Wristband: The cuff portion of an ESD wrist strap which maintains contact with the user's skin.

4. GENERAL

4.1 Implementation

4.1.1 NASA quality assurance and engineering personnel are responsible for supporting programs and projects by advising and assisting suppliers, NASA personnel, and delegated agencies in the proper and effective implementation of the provisions of this standard and the publications referenced herein.

4.1.2 Effective implementation includes establishing a system that ensures each design, process engineering, and quality control requirement is addressed in the manufacturing documentation (e.g., drawings, procedures, work orders); operators comply fully with the manufacturing documentation; each in-process control, quality inspection, and test is performed and recorded; each post-production inspection point is performed and recorded; and data records are complete.

4.1.3 Suppliers are responsible for ensuring all personnel who create, implement, and assure workmanship processes, including workmanship training, are aware of and understand how to apply the requirements of this standard.

4.1.4 Suppliers held to the requirements herein and in the standards in Table 1 shall document the processes and procedures used to incorporate the requirements therein into their design, fabrication, and inspection processes including defining the parts, materials, tooling, and equipment.

4.1.5 Suppliers shall perform work to approved manufacturing instructions (e.g., procedures, drawings, work orders, engineering documentation, specification).

4.1.6 During any phase of workmanship operations, if a condition arises that may damage the hardware, the work shall be halted at the next viable stopping point until the condition has been reviewed, documented, and resolved.

4.1.7 The standards in Table 1 are not procedures. Suppliers shall not use this standard or the standards in Table 1 as substitutes for procedures required by paragraph 4.1.4 above.

4.1.8 Suppliers who intend to work to alternate workmanship requirement standards shall establish the basis of equivalency of the alternate standard to the standard imposed by the NASA project.

4.1.9 For product acceptance, workmanship operators shall not inspect their own work.

4.2 Changes in Requirements

When changes are made to the requirements herein, NASA quality assurance and engineering personnel are responsible for assisting programs and projects that choose to flow those changes into their mission assurance plans, prime contracts, and subcontracts, and for providing this information to project personnel who will implement the requirements or who will perform

quality assurance surveillance functions, including delegated agents working in supplier manufacturing facilities.

4.3 Assembly Configurations, Processes, Materials, and Parts

4.3.1 Alternative or nonstandard configurations, processes, parts, or materials shall be reviewed and approved prior to use. See 1.3.2.

4.3.2 The supplier's request for approval for the use of configurations, processes, materials, or parts not covered by this standard shall include:

a. Details of fabrication and inspection methods, including acceptance and rejection criteria.

b. Objective evidence, in the form of test data, flight history, or analysis, that demonstrates the alternate or non-standard processes, materials, or parts satisfy mission reliability requirements.

5. TRAINING REQUIREMENTS

5.1 General Training Requirements

5.1.1 This section:

a. Establishes the workmanship training requirements for operators, inspectors, and Supplier Level B instructors.

b. Establishes the certification requirements for IPC® instructors, SMA-Sponsored Level B instructors, and NASA Level A instructors.

c. Establishes training requirements for NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, NASA-STD-8739.5, IPC J-STD-001GS, and IPC/WHMA-A-620C-S. ANSI/ESD S20.20-2014 training is controlled by the local ESD Control Program Plan. See Section 7.2.3.1.2.

Note: NASA-STD-8739.2 and NASA-STD-8739.3 are canceled. This standard applies to these canceled standards for training purposes only.

d. Establishes requirements for ensuring successful completion of the courses by operators, inspectors, and instructors results in an acceptable knowledge baseline among those personnel, and that common and predictable student processing practices are applied.

5.1.2 NASA Level A training centers have been designated at NASA Goddard Space Flight Center (GSFC) and NASA's Jet Propulsion Laboratory (JPL) for the purposes of providing master training sites to conduct training for all levels of NASA workmanship students, including Level B instructors. Terms and requirements included in this standard for NASA Level A training centers do not apply to courses designed for NASA GSFC or JPL internal use. See https://sma.nasa.gov/sma-disciplines/workmanship for NASA Level A training center contact information.

5.1.3 NASA Center Safety and Mission Assurance (SMA) organizations may sponsor and manage local Level B instructors for the purpose of providing greater access to training with lower travel costs for operators and inspectors. Terms and requirements included in this standard for SMA-Sponsored Level B training centers do not apply to courses based on local requirements documents and not central to NASA Workmanship Standards training.

5.2 Workmanship Personnel

5.2.1 The following personnel shall be trained to apply workmanship standards requirements:

a. Operator: Builds and inspects PCB assemblies, electrical cables/harnesses, fiber optic cables, and/or polymerics. The terminology for an IPC®-trained operator is Certified IPC® Specialist (CIS).

b. Inspector: Inspects PCB assemblies, electrical cables/harnesses, fiber optic cables, and/or polymerics for defects.

c. ESD operator and ESD program monitor: Handles ESDS hardware or performs special duties relative to ESD controlled area certification. The local ESD control implementation plan may define alternative names for these roles.

d. Level B Instructor: Trains operators and inspectors to one or more of the following NASA workmanship standards: NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5. Within the scope of ESD control, suppliers may choose to use a Level B instructor designation for ESD training (see Table 2 Note). See 5.2.2 and 5.2.3 for the distinctions between SMA Sponsored Level B Instructors and Supplier Level B Instructors.

e. ESD Instructor: Instructs ESD personnel the controls, practices, and handling techniques as defined in the local ESD Control Program Plan. The local ESD Control Program defines the minimum qualifications required for ESD instructors and any hierarchies that apply to instructors and students they teach.

f. Certified IPC® Trainer (CIT): Trains CIS operators and inspectors inside or outside of their own company.

g. NASA Level A Instructor (on behalf of a NASA Level A training center): Trains operators, inspectors, and Level B instructors inside and outside of their own organization to one or more of the following workmanship standards: NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5. Suppliers and NASA Centers are permitted to use a NASA Level A instructor designation for ESD training (see Table 2 Note).

5.2.2 SMA-Sponsored Level B instructors may train operators and inspectors inside and outside of their own organization as well as U.S. government civil service personnel (NASA and non-NASA).

5.2.3 Supplier Level B instructors:

a. May train operators and inspectors who are employed by the instructor's organization or operators and inspectors who work for companies contracted to their organization (e.g., subcontract to NASA).

b. Shall not train students from organizations to which the instructors' organization delivers mission hardware or that have contractual oversight authority.

5.2.4 Training of personnel to NASA workmanship standards and IPC® standards is specific to the student type (e.g., operator, inspector, instructor, CIS, CIS-inspector only). Individuals who desire to perform the duties of both an operator and an inspector for a NASA workmanship standard shall meet the grading criteria for both operator and inspector. See 4.1.9.

5.2.5 Personnel who are trained to the instructor level (NASA Standard, or IPC® standards) meet the training requirement for operators and inspectors. Upon request suppliers shall provide evidence that all work is performed by a person trained to the appropriate role.

5.2.6 Students shall not inspect their own work when being graded for inspection training.

5.2.7 Where training is performed using primarily computer-based material without the presence of an instructor (e.g., on-line, SATERN, Compact Disc (CD)-based), the requirements described herein relative to the responsibilities of trainers do not apply. See paragraphs 5.8.22 through 5.8.25, 5.10.2.3, and 5.10.2.4 for limitations on the use of computer-based training.

5.3 Personnel Competency

5.3.1 Suppliers who are required to comply with one or more of the workmanship standards in Table 1 are responsible for ensuring that all operators and inspectors in their organization who manufacture NASA mission hardware are capable of performing their tasks in a way that results in compliant product. Suppliers who employ Level B instructors are responsible for ensuring that the Level B instructors have a sufficient mastery of the course content they teach; have the appropriate teaching skills to properly instruct students; and are able to effectively assess their students' mastery of the subject matter.

5.3.2 A personnel certification process may be applied by the supplier using criteria in addition to that specified in this standard at the supplier's discretion.

5.3.3 Suppliers who are required to comply with one or more of the workmanship standards in Table 1 shall ensure operators, inspectors and instructors within their organization meet the visual acuity and training requirements herein as a prerequisite for processing NASA mission hardware. See 5.7.

5.3.4 Level B instructors who teach on behalf of a NASA Center organization shall be certified by the Center's representative on the NASA Workmanship Standards Technical Committee (NWSTC). The Center's representative on the NWSTC may delegate this responsibility. See https://sma.nasa.gov/sma-disciplines/workmanship for the current roster.

5.3.5 SMA-Sponsored Level B instructor certification shall consist of a written record (e.g., a card, certificate, memo on file) indicating the NWSTC member recognizes the individual as a valid source of workmanship training for individuals assigned to work at that NASA Center. This certification may be one-time or may be refreshed following Level B Instructor retraining as determined by the applicable NASA Center.

5.3.6 SMA-Sponsored Level B instructor certification shall be revoked when the individual is no longer assigned to perform this service for the NASA Center or fails to meet the minimum training and certification requirements of 5.6.

5.3.7 Suppliers who are required to comply with the IPC® standards in Table 1 are responsible for ensuring all CITs used by their organization to train CISs carry valid IPC® certifications. Additional certification criteria may be imposed by the supplier at the supplier's discretion.

5.3.8 The NASA Workmanship Standards Program Manager is the responsible authority for certifying NASA Level A Instructors who teach operator, inspector, and Level B instructor courses for NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4,

and NASA- STD-8739.5. Responsibility for the certification of NASA Level A instructors may be delegated by the NASA Workmanship Standards Program Manager to the local NASA Center's NWSTC representative.

5.3.9 Portability of Workmanship Training

5.3.9.1 NASA workmanship standards training obtained from a NASA Level A or Level B trainer is transferable and valid for work performed at all NASA supplier facilities; however, suppliers may elect to require additional training to address facility, process, or hardware design considerations.

5.3.9.2 Supplier custom-developed IPC® training shall not be treated as portable between suppliers.

5.3.9.3 Early retraining after change of employment may be required if the prior training did not include the full requirements set (i.e., partial training, see 5.8.9).

5.4 Evidence of Training

5.4.1 Training records shall be retained by the supplier for a minimum of five years.

5.4.2 Evidence of training within the prior twenty-four (24) months shall be available for review by project personnel and during audits.

5.5 Minimum Workmanship Training Requirements for Operators and Inspectors

5.5.1 Operators and inspectors shall meet the following training requirements as a minimum:

a. Complete initial training or complete retraining within twenty-four (24) months of the prior training from:

(1) A NASA Level A or Level B instructor (per Table 5) for one or more of the NASA workmanship standards: NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5.

(2) A CIT for the IPC® standards in Table 1.

b. Compliance with the vision requirements of paragraph 5.7.

5.6 Minimum Training and Certification Requirements for Instructors

5.6.1 The minimum training requirements for Level B instructors shall be as follows:

a. Complete initial training or complete retraining within twenty-four (24) months of the prior training at the instructor level from a NASA Level A instructor for one or more of the NASA workmanship standards: NASA- STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5.

b. Compliance with the vision requirements of paragraph 5.7.

5.6.2 Additional certification requirements for Level B instructors who work on behalf of a NASA Center shall be as follows:

a. Review and comment on, or concur with, all updates to NASA-STD-8739.1, NASA-STD-8739.4, NASA-STD-8739.5, and NASA-STD-8739.6.

b. As an alternative to retraining every two years as stated in 5.6.1, an audit performed by the Workmanship Standards Program Manager or their delegate may be used to establish that the Level B instructor is providing consistent training and policy interpretation to their students, where:

(1) Retraining or audits shall be accomplished a minimum of every two years.

(2) Audits shall be performed in accordance with a formally documented process.

5.6.3 Minimum certification requirements for NASA Level A instructors shall be as follows:

a. Review and comment on, or concur with, all updates to NASA-STD-8739.1, NASA-STD-8739.4, NASA-STD-8739.5, and NASA-STD-8739.6.

b. Compliance with the vision requirements of paragraph 5.7.

c. Participate in and successfully complete biennial continuing education and NASA Level A training center information-sharing programs developed and provided by the NASA Workmanship Standards Program.

5.6.4 Proficiency based on hands-on experience is expected for all NASA Level A and Level B Instructors.

5.7 Vision Requirements

5.7.1 Vision testing is a prerequisite for initial training and retraining. Vision testing is not required for ESD training or ESD certification unless required by the local ESD Control Program.

5.7.2 Vision screening shall be performed within twenty-three (23) months of the training or retraining start date as a prerequisite for NASA workmanship standards training.

5.7.3 Visual acuity levels in 5.7.6 may be met using corrected vision (eyeglasses or contact lenses).

5.7.4 Vision tests shall be administered a minimum of once every two years by a qualified examiner using standard instruments and techniques.

5.7.5 Documentation indicating minimum visual requirements have been met shall be made available to training centers or instructors when students register for workmanship training.

5.7.6 Vision testing shall verify the following:

a. Near Vision. Jaeger 1 at 14 inches (355.0 mm), reduced Snellen 20/20, or equivalent approved testing methods.

b. Color Vision. Ability to distinguish red, green, blue, and yellow colors as prescribed in Dvorine Charts, Ishihara Plates, American Optical Hardy-Rand-Rittler (AO-HRR) Tests, or equivalent approved testing methods. A practical test, using color coded wires or electrical parts, is acceptable for color vision testing.

5.8 General Training Program Requirements for NASA Workmanship Standards

5.8.1 NASA workmanship training for NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5 is intended for U.S.-domestic manufacturing personnel, particularly those producing high reliability items. This training is not intended for foreign nationals who are not sponsored by the U.S. Government or who are not currently in a contractual relationship with NASA (either directly or via subcontract). See 5.9.6 and 5.9.7.

5.8.2 Personnel who have never taken a NASA workmanship standards training course shall first take the initial training course.

5.8.3 Personnel who take and pass the initial training course or the retraining course shall be awarded evidence of successful completion of training (e.g., certificate, wallet-sized card, electronic record).

5.8.4 Personnel who are repeating training within twenty-four months of taking the initial training course may take a shortened retraining class.

5.8.5 Operators, inspectors, and Level B instructors shall complete retraining within twenty-four (24) months of prior training completion.

5.8.6 Operators, inspectors, and Level B instructors who complete shortened retraining within a 90-day window prior to the expiration of the existing training period shall be granted a new expiration date that is exactly two years following the existing expiration date.

5.8.7 The NASA Level A training center or Level B instructor may reinstate the option to students, whose prior training occurred more than twenty-four (24) months in the past, to take the shortened retraining class. The criteria used to determine which students qualify for this option shall be documented in written procedures.

5.8.8 The curriculum of the initial training course or the retraining course may be expanded to meet local needs. The training completion record shall clearly indicate that the student successfully completed training for the applicable standard. Indications on the training record which are applicable to the added material may be added at the instructor’s or supplier’s discretion.

5.8.9 The curriculum of the initial training course or the retraining course may be tailored in circumstances where the students do not perform work in certain areas. The training record and evidence of training completion shall detail the limits of the training by identifying the training as partial and by either specifying the included material or by specifying the excluded material.

5.8.10 The curriculum for operators and inspectors for the NASA standards training shall be identical. Operators and inspectors may be tested differently for hands-on proficiency so as not to penalize inspectors for not possessing hands-on skills which apply only to operators.

5.8.11 All students shall participate in ungraded hands-on demonstrations and exercises.

5.8.12 All students training to be instructors shall be trained and tested to the level of operator, inspector, and instructor.

5.8.13 The evidence of successful training completion shall contain the following information as a minimum:

a. Student’s name.

b. Course name, with exclusions or additions as applicable.

c. Training level: operator, inspector, instructor.

d. Completion date.

e. Instructor’s name.

f. Instructor’s organization such as the training center name, sponsoring SMA organization, or the supplier name.

5.8.14 The instructor or the instructor’s organization shall maintain training records for all students they have trained for a minimum of five years.

5.8.15 Training equipment does not require regular calibration, however, it shall be maintained and checked in a manner ensuring students are able to obtain normal results using the recommended techniques and are not prevented from successful course completion due to underperforming classroom equipment or supplies.

5.8.16 Expired calibration stickers shall not be left on equipment not requiring calibration. When expired calibration stickers are used as teaching aids, they shall be identified in advance to auditors performing institutional-level quality audits.

5.8.17 A training package developed by NASA including the instructional presentations and all paper tests and quizzes will be made available to all Level B instructors following successful completion of training. Level B instructors may use these training materials with or without modification or augmentation.

5.8.18 Training program curriculum and materials which are developed solely by the supplier and used by Level B instructors and CITs at supplier facilities which are not NASA Training centers shall be made available to NASA programs and projects for review and approval upon request.

5.8.19 Workmanship training programs for NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, NASA-STD-8739.5, and supplier-created IPC® training programs shall:

a. Document the methods and procedures proposed to fulfill the requirements of this standard.

b. Utilize visual standards consisting of satisfactory work samples or visual aids that clearly illustrate the quality characteristics relevant to the applicable workmanship standard. Examples of unacceptable conditions may also be used for clarification or comparison.

c. Make applicable standards readily available.

5.8.20 Workmanship training program documentation shall include, as a minimum:

a. Procedures for training and retraining, including who will be trained and for what purpose (e.g., operator, inspector).

b. Procedures for recording training and retraining, and the method of identifying trained personnel.

c. Lesson plan(s) and student workbook.

d. Hours of instruction.

5.8.21 Personnel assignments shall be reviewed for impact when a supplier training program fails to meet requirements set forth herein. Retraining from an alternate source may be required to meet the training requirements of 5.11 and 5.12 herein.

5.8.22 Initial training courses, except for ESD control, shall not be primarily computer-based courses without the use of an instructor.

5.8.23 Retraining courses may use computer-based content; however, they shall also include practical, hands-on content evaluated by a certified instructor.

5.8.24 Long-distance-learning retraining programs that deliver tests and practical exams to remotely located students and then evaluate the exams using certified instructors in another location (completed tests and boards shipped to instructor) are allowed.

5.8.25 The supplier is responsible for the effectiveness of computer-based or long-distance-learning arrangements (also see 5.2.7).

5.9 Training Program Requirements, NASA Training Centers

5.9.1 The NASA Workmanship Standards Program Manager is responsible for ensuring compliance by the Eastern NASA Manufacturing Technology Transfer Center (E-NMTTC) with the requirements herein.

5.9.2 JPL's representative on the NWSTC is responsible for ensuring compliance by the W-NMTTC with the requirements herein.

5.9.3 The NASA Center's representative on the NWSTC is responsible for ensuring compliance by Level B instructors working on behalf of their NASA Center with the requirements herein.

5.9.4 The responsible parties described in 5.9.1 through 5.9.3 shall:

a. Provide NASA Level A and NASA Level B instructors current information disseminated by the NASA Workmanship Standards Program Manager that impacts workmanship policy, training, and curriculum.

b. Certify the NASA Level A and/or Level B instructors who work on behalf of their NASA Center.

c. Deliver a yearly activity report to the NASA Workmanship Standards Program Manager which describes the number of students trained and the number and types of NASA workmanship standards courses taught for the report year. These yearly reports shall include all of the following as a minimum:

(1) The name of each workmanship course given.

(2) The number of students who attended each course.

(3) Breakdown for students between NASA civil service and non-NASA.

(4) The number of students who have passed and the number of students who have failed the classes in the reporting period.

5.9.5 Procedures used by NASA Level A and Level B trainers who work on behalf of a NASA Center shall specify methods for ensuring students enrolled in workmanship standards courses are only those individuals who comply with the visual acuity requirements herein (see 5.7).

5.9.6 Foreign nationals shall not be enrolled in a NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, or NASA-STD-8739.5 course taught by a NASA Level A instructor or a Level B instructor working on behalf of a NASA Center unless a Technical Assistance Agreement (TAA) is drawn up between that training center, the foreign company or governmental organization, and the U.S. State Department. Export Administration Regulations (EAR) information and data cannot be disclosed or shared during classroom discussion.

5.9.7 If a foreign national is to receive workmanship training under an approved TAA, NASA Headquarters approval shall be required for training which lasts longer than 14 days or if the enrollee is from a designated country (as determined by the U.S. State Department).

5.9.8 All NASA workmanship training centers offering NASA workmanship standards courses to the general public shall provide ready access to:

a. Course offerings.

b. Schedules, including start and stop times.

c. Course descriptions.

d. Enrollment information including:

(1) Course fees, payment requirements (timing, methods).

(2) Rules and amounts applicable to financial penalties for cancelled reservations.

(3) Registrar point of contact.

(4) How to submit evidence of successful visual acuity testing prior to completion of the registration process.

(5) Limitations on enrollment in retraining classes based on date of last training (maximum time elapsed is twenty-four (24) months, see 5.8.8).

e. Rules on course attendance (e.g., lateness, missed time).

5.9.9 Advertising content shall include a description of the target audience and practical experience level of the typical passing student to make clear to interested parties what experience is needed for this training. Schedule information should include encouragements to the students to sign up for courses three months in advance of their need.

5.10 IPC® Training

The IPC® training programs are designed and controlled by IPC®. IPC® training materials may be augmented to provide training for more specific workmanship activities, at the trainer's discretion. Two training program approaches, as described below, are available and recognized as valid for students seeking operator or inspector training to IPC J-STD-001GS and IPC IPC/WHMA-A-620C-S. Suppliers are responsible for determining how they will meet the training requirement for operators and inspectors, whether through IPC® course offerings or through a custom training program in accordance with 5.10.2. The IPC® may be contacted to obtain information concerning authorized suppliers of this training and for registration instructions. See sections 5.2 through 5.6 for NASA workmanship training requirements related to these IPC standards.

5.10.1 IPC® Training Programs

5.10.1.1 IPC® J-STD-001GS Training: The IPC® offers a six-module IPC® J-STD-001GS course which is recognized as valid for meeting the NASA workmanship training requirement for IPC J-STD-001GS. IPC® soldering training may be taken in whole or in parts. The IPC® certificate of completion notes which modules were completed. As a minimum, Module 1, Module 6, and one other Module (either 2, 3, 4, or 5) shall be taken to meet the minimum IPC® J-STD-001GS training requirement. Students who take the modular course are instructed in all quality class levels including the space class.

5.10.1.2 IPC® IPC/WHMA-A-620C-S Training: The IPC® offers an eight-module, IPC/WHMA-A-620C three-day lecture-only course which is complemented by a five-day hands-on course. Both courses must be completed to meet the NASA workmanship training requirement for IPC/WHMA-A-620C-S.

5.10.2 Custom IPC® Training Programs

5.10.2.1 The supplier has the option to create a training program for IPC J-STD-001GS and IPC/WHMA-A-620C-S which meets the requirements of this section, with the condition that only IPC® certified trainers (CIT or MIT) act as the instructor.

5.10.2.2 Custom training program curricula and materials which are developed solely by the supplier and used by CITs and MITs at supplier facilities, shall be made available to NASA programs and projects for review and approval upon request.

5.10.2.3 Courses that are fully virtual shall not be used for IPC J-STD-001GS or IPC/WHMA-A-620C-S initial training.

5.10.2.4 For custom IPC J-STD-001GS and IPC/WHMA-A-620C-S retraining courses, computer-based training is allowed, but shall be combined with practical exercises and exams which are administered and evaluated by a CIT or MIT.

5.11 Courses

5.11.1 Course material shall accurately and completely represent the requirements statements in the applicable standards.

5.11.2 For courses in which each requirement cannot be directly covered due to time constraints, the course content shall combine overviews of less critical areas, more detailed coverage of the critical topics, and instructions related to finding all applicable requirements in the standard.

5.11.3 Workmanship courses may omit topic areas not used by the local organization. If whole topic areas are absent from the training, it shall be made clear to the students and shall be represented in the training completion certificate, preferably by paragraph number.

Using NASA-STD-8739.1 as an example, if bonding is not covered, the training certificate says "except Bonding per Section 11."

5.11.4 Requirements above and beyond those included in the NASA standards may be taught, but shall be identified as auxiliary to the NASA standards baseline. Incorrect answers to test questions, and failure of students to demonstrate practical skills which are not directly related to requirements found in the relevant NASA workmanship standard, shall not be considered when assessing the student's successful completion of the NASA workmanship standards courses for NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5.

5.11.5 Course content shall consist of lectures, practical exercises, quizzes, and exams which accomplish the following:

a. Describe and interpret the technical requirements in the standard.

b. Reference the location of each of the technical requirements.

c. Demonstrate the method for achieving compliant assembly features (e.g., solder joints, contact crimps, polymer coating layers).

d. Demonstrate the student's ability to achieve compliant features and/or recognize defects.

e. Assess the student's retention and understanding of the requirements.

f. Assess Level B instructor candidates' abilities to teach the material.

5.11.6 When the course is intended for training or retraining Level B instructors, course material shall include special topics relative to instructor competencies (e.g., time management, assistance to students, processing foreign national students).

5.11.7 Class time shall be provided to the Level B instructor students to allow them to demonstrate adequate instructor skills.

5.11.8 Course content shall be available for review and approval by the NASA Workmanship Standards Program Manager and/or the local responsible NWSTC member (See 5.9.3).

5.11.9 Course content deemed inappropriate or insufficient by the Workmanship Standards Program Manager and/or the local responsible NWSTC member (See 5.9.3) shall not be used.

5.11.10 Courses shall be limited to teaching only one NASA-STD. Overview classes which introduce the content of several or all of the NASA workmanship standards are not within the scope of this NASA-STD.

5.11.11 NASA Level A training centers shall be capable of providing training courses for NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5. Level B instructors have the option to provide only those courses which are applicable to their organization.

5.11.12 The recommended course lengths for the NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5 courses (slide package, practical exercises and exams, written exams, and quizzes) are shown in Table 2.

Table 2. Recommended Course Lengths

Course	Initial Training (Operators & Inspectors)	Instructors	Retraining Class Duration
Polymeric Applications (Operators) per NASA-STD-8739.1	32 hours	40 hours	16 hours
Polymeric Applications (Inspectors) per NASA-STD-8739.1	8 hours	N/A	8 hours
Surface Mount per NASA-STD-8739.2	32 hours	40 hours	16 hours
Hand Solder per NASA-STD-8739.3	36 hours	56 hours	16 hours
Crimp, Cable & Harness per NASA-STD-8739.4	36 hours	56 hours	16 hours
Fiber Optics per NASA-STD-8739.5	32 hours	56 hours	16 hours

Note: There is no NASA-wide training program for ESD control because all students are trained in accordance with the local implementation plan used in the facility in which they work (see ANSI/ESD S20.20-2014 and Section 0 herein).

5.12 Student Requirements

5.12.1 The NASA workmanship standards training classes are primarily intended for personnel who will process mission hardware in accordance with one or more of the standards in Table 1. This training is not intended or designed to teach basic electronic assembly and manufacturing skills such as basic soldering.

5.12.2 Students training to be Level B instructors shall demonstrate the skills necessary to demonstrate the practical exercises as instructors.

5.12.3 Students shall provide evidence to their NASA Level A or Level B instructor or training center’s registrar of a visual acuity assessment completed within the preceding 23 months which meets the requirements of Section 5.7 prior to training or retraining.

5.12.4 For NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, and NASA-STD-8739.5 courses, students shall be evaluated on the basis of written and practical tests.

5.12.4.1 A passing grade for written exams shall be 80% and above.

5.12.4.2 A passing grade for practical exams shall be 85% and above.

5.12.4.3 Written and practical scores shall not be averaged.

5.12.4.4 To pass the class, the student shall pass both the written and the practical exams.

5.12.4.5 IPC® establishes the testing and scoring requirements for the IPC® courses. For the local ESD courses, the NASA Center or supplier establishes the testing and scoring requirements.

5.12.5 A student shall not be allowed to pass a class if they are absent for more than 10% of the overall class time, or if the time missed is detrimental to the required level of training, as deemed by the instructor.

5.12.6 If the student's lateness or absence has been deemed detrimental, the student shall be dismissed from class and will have to re-enroll. A dismissed student forfeits all course costs.

5.13 Enrollment

5.13.1 Students shall be able to enroll in workmanship standards courses online and by phone.

5.13.2 See Section 5.8.5 and 5.8.7 above for timing restrictions associated with registering for retraining courses and 5.7.2 for expiration limits on vision test results. Current vision test results are a prerequisite for workmanship training.

5.13.3 Students who have taken their prior class (full class or retraining) at a different facility or from a different instructor than the facility or instructor from which they are seeking retraining shall produce evidence of successful completion of the prior class and the name of the instructor.

5.13.4 Prior to enrollment, the evidence provided shall be analyzed to ensure the prior training was not a limited training course per 5.8.1 and was obtained from a valid source.

5.14 Applicability of Training

5.14.1 Students who pass classes given by a NASA Level A or Level B instructor meet the training requirements of the applicable NASA workmanship standards for the duration of twenty-four (24) months following course completion and may be assigned by the supplier to process NASA mission hardware.

5.14.2 Students who take and pass a workmanship standards training course where portions of the requirements are not taught, and those portions are noted on the training completion certificate or card, are not permitted to perform those functions (as an operator or inspector) on NASA mission hardware. This policy applies regardless of the source of training (NASA training center, a supplier's Level B instructor, or an IPC® training center).

6. GENERAL TECHNICAL REQUIREMENTS

This section establishes general technical requirements for workmanship processes applied to NASA mission hardware. This section also establishes requirements which augment or modify the requirements of IPC J-STD-001GS, IPC/WHMA-A-620C-S and ANSI/ESD S20.20-2014.

6.1 Temperature and Relative Humidity

6.1.1 Workmanship operations should be limited when workplace temperature is less than 18 °C (65 °F) or greater than 30 °C (85 °F) to reduce the risk of human error due to uncomfortable work conditions. Continuous temperature monitoring is not required except for processes that specify temperature control limits (e.g., polymer cure).

6.1.2 The range (lower and upper) of relative humidity (RH) in the assembly area shall be controlled to the extent necessary to prevent condensation or corrosion on sensitive surfaces and to prevent promoting defects in moisture sensitive devices and assemblies. For operator comfort and to reduce the risk of human error, the workplace RH should be maintained below 70 percent. Relative humidity monitoring and record-keeping is not required except for processes that specify relative humidity control limits (e.g., ESD control).

6.1.3 In field operations where the above conditions cannot be effectively achieved, process-unique controls should be documented and implemented to minimize the effects of the uncontrolled environment on the operation being performed on the hardware. Process-unique controls are tools and methods such as usage of localized dehumidifiers, heaters, air ionizers, or other similar means to control the environment's effect on the hardware.

6.2 Occupational Health Requirements

6.2.1 Handling and storage of some of the as-received and processed materials used to meet the requirements of this standard may be classified as hazardous processes. Occupational Safety and Health Administration (OSHA), 29 CFR Part 1910, Subparts I and Z provide requirements for engineering controls such as exhaust ventilation and fume extractors, and personal protective equipment such as eye protection, gloves, and respirator protection. State and local regulations may also be applicable. OSHA requires personal protective equipment be provided by the employer and used as appropriate to the work being performed.

6.2.2 Safety Data Sheets (SDS) shall be available for reference in the work area.

6.3 Materials Selection

6.3.1 All materials used shall meet project contamination, outgassing and offgassing requirements. The requirements of NASA-STD-6016 are typically applied to invoke these requirements and manage project material usage approvals.

6.3.2 Suppliers of PCB assemblies shall conform with the criteria of SAE-GEIA-STD-0005-1A and SAE-GEIA-STD-0005-2A using control level "2C" for control of Lead(PB)-free materials.

6.4 Tool Selection and Control

6.4.1 Suppliers shall comply with project metrology and calibration control requirements. It is recommended that ESD Controls be applied in calibration laboratories where ESD-sensitive items are processed (Class 1A or more sensitive).

6.4.2 The selection of tools, instruments, and other devices used for fabrication, testing, verification, and inspection activities shall be appropriate for the task, clean and maintained, and shall not impart damage to the parts or assemblies.

6.5 Protection of Materials, Parts and Assemblies

6.5.1 Handling, processing, and storing materials, piece parts, and assemblies involved in workmanship operations shall be performed under controlled conditions to prevent damage and degradation (e.g., access to work area, foreign object debris (FOD) control, contamination, excess paperwork, personal items, refuse items, unmixed and mixed batches of polymers).

6.5.2 Smoking, eating, and drinking shall be prohibited in areas where workmanship processes are applied.

6.6 Inspection and Inspection Optics

6.6.1 All PCB assemblies, cables, cable harnesses, and fiber optic cables shall be visually inspected to evaluate quality conformance in accordance with the methods and defect criteria specified in the applicable standard in Table 1 and the applicable requirements herein. Product inspection using a sampling plan is not compliant with this standard.

6.6.2 Inspection magnification systems shall be capable of rendering true colors, proportional dimensions, and adequate resolution at the chosen magnification to perform the specified inspection.

6.6.3 The light source shall provide shadowless illumination of the area being viewed except when oblique lighting is required.

6.6.4 The use of referee magnification levels not defined in the workmanship standards in Table 1 is considered out of scope of the workmanship standards and shall be defined in project requirements when applicable.

6.7 Solvents and Cleaning

6.7.1 Deionized water, ethyl alcohol, and isopropyl alcohol are considered standard solvents and do not require approval prior to use for cleaning PCBs, PCB assemblies, soldered contacts, terminals, cable harness assemblies, or splices. Use of other cleaning materials shall follow the relief process provided by NPR 8715.3.

6.7.2 Requests for approval for the use of non-standard solvents shall include sufficient engineering documentation to qualify the process. Examples of qualification may include:

a. Evidence of prior successful use (e.g., heritage in relevant applications, process qualification test data).

b. Description of typical ionic residues associated with unremoved solvent.

c. Corrosiveness of solvent when applied to materials present in mission hardware (e.g., part leads, part packages, printed circuit boards, wire insulation, staking).

d. Techniques to be used for addressing special use considerations or manufacturer instructions including operator hazard avoidance.

6.7.3 Solvents shall be properly labeled and maintained in a clean and uncontaminated condition, and controlled to ensure non-expired shelf life.

6.7.4 Solvents and cleaners shall not leave a residue or contaminate parts or materials. Refer to the SDS for guidance in the proper handling of solvents.

6.7.5 Aqueous solvents shall not be used to clean silver (Ag) plated copper.

6.8 Rework and Repair

6.8.1 Rework that results in product conformity is permissible. Each occurrence of rework and the nonconformance it corrects shall be recorded.

6.8.2 Repair that will not result in full product conformity shall be reviewed and approved prior to implementation per the material review board (MRB) process.

6.8.3 Assemblies shall be cleaned following repairs in accordance with the cleanliness criteria defined in the appropriate standard in Table 1.

7. ELECTROSTATIC DISCHARGE CONTROL STANDARD IMPLEMENTATION

7.1 Applicable ESD Standard

7.1.1 ANSI/ESD S20.20-2014 contains the baseline ESD control requirements for mission hardware.

7.1.2 ANSI/ESD S20.20-2014 requires the development and implementation of an ESD Control Program Plan that serves as the principle document for implementing and verifying the Program.

7.1.3 ESD Product Qualification test data generated on behalf of a NASA Center, when performed in accordance with ESD Association (ESDA) product qualification criteria and test methods, may be used by all NASA Centers as a part of their ESD Product Qualification Programs.

7.2 ESD Requirements Supplement to ANSI/ESD S20.20-2014

7.2.1 This section provides the supplemental requirements and guidance applicable to use of ANSI/ESD S20.20-2014 for processing NASA mission hardware.

7.2.2 General ESD Control Program Plan Requirements

7.2.2.1 The ESD Control Program Plan shall be in accordance with ANSI/ESD S20.20-2014 and the requirements herein.

7.2.2.2 Tailoring of ESD controls outside of the limits of 7.2.4 and 7.2.5 herein shall be documented in the local ESD Control Program Plan and include documented technical justification (e.g., risk assessments, rationale, evaluation).

7.2.2.3 NASA Centers shall create, approve, and implement a Center-level ESD Control Program Plan in accordance with 7.2.2.1, and with concurrence by the NASA Center's ESD Control Program Manager.

Note: The approval/reapproval process for the Center-level ESD Control Program Plan follows the Center-level document approval process.

7.2.2.4 NASA Program, Project, or Supplier ESD Control Plans used for operations within a NASA facility that are subject to the Center's quality management system, shall be compliant to the local Center-level ESD Control Program Plan.

Note: The Center's ESD Control Program Manager is expected to be the Center's primary SME for the technical theory, practical implementation, and policies of ESD Control. It is recommended that programs and projects consult with the Center's ESD Control Program Manager for the development of quality assurance requirements tailoring; contract or task Statements of Work (SOW); deviations and waivers; and when evaluating requests for tailoring, deviations, or waivers from suppliers. Programs and

projects are recommended to consult with the Center ESD Control Program Manager or their delegate when planning supplier quality audits or assessments and production quality surveillance activities.

7.2.3 Administrative Requirements

7.2.3.1 Personnel Training and Certification

7.2.3.1.1 The ESD Control Program Manager shall have formal training in:

(a) The technical requirements in Chapter 8 of ANSI/ESD S20.20-2014,

(b) Static charge reduction and discharge risk mitigation methods for operators and Electrostatic Protected Areas (EPAs), and

(c) Processes for certification and verification of ESD control materials and EPAs.

Note: ESDA, International Association for Radio, Telecommunications and Electromagnetics (iNARTE®), or other third-party ANSI/ESD S20.20 training courses are recommended to meet this requirement. This may also be accomplished via documented on-the-job training.

7.2.3.1.2 The ESD Control Program Plan shall define the type of training, level of training, and certification required for each participant in the program. This includes visiting technicians trained to other ESD Control Program Plans.

7.2.3.1.3 The local ESD Control Program defines qualifications required for ESD instructors and any hierarchies applicable to instructors and the students they are permitted to teach. The training requirements in those plans shall meet the requirements of ANSI/ESD S20.20-2014, paragraph 7.2, Training Plan.

7.2.3.1.4 ESD training is specific to the local ESD Control Program Plan, and therefore is non-transferable.

7.2.3.1.5 Non-trained personnel shall be escorted by trained or certified personnel when in or near an EPA.

7.2.3.1.6 Non-trained personnel shall not be permitted within 39.4 inches (1 meter) of ESDS items.

7.2.4 Baseline ESD Control Program Plan Requirements

7.2.4.1 The Certification, Recertification, and Compliance Verification Plan requirements of ANSI/ESD S20.20-2014 apply with the following additions and modifications:

7.2.4.1.1 The ESD Control Program Plan shall define the baseline sensitivity level addressed by the EPA requirements (e.g., Human Body Model (HBM) Class 1A) as well

as any other EPA sensitivity levels considered to be within the scope of the plan (e.g., HBM 1B, HBM 0, CDM C1).

7.2.4.1.2 The ESD Control Program Plan shall define the criteria for when ESDS hardware is to be handled within a certified EPA (e.g., mission risk class, R&D status, commercial off-the-shelf ground support equipment).

7.2.4.1.3 All EPA certifications shall be performed by the ESD Control Program Manager, or their representative.

7.2.4.1.4 EPAs not verified within 6 months shall be considered expired and require recertification for use as an EPA.

7.2.4.1.5 The date of EPA removal from service shall be included on the verification record.

Note: Abandoned or expired EPAs pose an ESD risk because technicians assume that the EPA is in a safe working condition, although it has not been verified as such. This creates significant programmatic risk for Project due to the lack of documentation to properly retire risk of an ESD event.

7.2.4.1.6 EPAs shall be recertified prior to use when any of the following conditions apply:

(a) Any changes are made to the EPA location or grounding configuration without prior approval by the ESD Control Program Manager.

(b) New worksurfaces have been added.

(c) ESD failure traceable to the EPA.

(d) The EPA will be used for processing items more sensitive than the current EPA certification level.

(e) The EPA owner or ESD Control Program Manager has decommissioned the EPA.

Note: For certified EPAs that are used occasionally for non-ESDS work, a minimal set of compliance verification tests as defined by the governing ESD Control Program Plan should be performed prior to performing ESDS work.

7.2.4.2 General ESD Requirements for ESD Control Program Plan

7.2.4.2.1 The ESD Control Program Plan shall define the handling and documentation requirements for each ESD sensitivity level used in the program.

7.2.4.2.2 The ESD Control Program plan shall require a charge mitigation process if essential insulators or isolated conductors must be used within 12 inches of ESDS item(s).

Note: While a PC monitor may be considered essential, keyboards and mice are not.

Note: Carbon dioxide (CO_2) snow cleaning or other compressed air nozzles may be considered essential insulators and are a source of charged ions that may pose significant risk to ESDS items.

7.2.4.2.3 Vacuum cleaning equipment, hoses, and associated tools, used for cleaning ESDS articles that cannot be grounded at the nozzle shall be treated as essential insulators.

7.2.4.2.4 ESDS hardware shall be either grounded or protected from charge accumulation during transport.

7.2.4.2.5 A subassembly (e.g., electrical box) shall have conductive or dissipative connector caps or plugs in place except when being mated to system cabling, or during environmental bake or test operations.

7.2.4.2.6 Requirements for reducing the static charge on connectors, cables and harnesses prior to mating system interface connectors to system test sets shall be defined in the ESD Control Program Plan.

7.2.4.3 Packaging

7.2.4.3.1 Electrostatic protective packaging shall prevent the generation of static charge and provide protection from electrostatic fields.

7.2.4.3.2 ESD protective packaging used shall satisfy the material properties per ANSI/ESD S541-2019.

7.2.4.3.3 Static dissipative materials in contact with ESDS items shall be compliant to ANSI/ESD S541-2019.

7.2.4.3.4 Topical antistatic packaging materials (e.g., pink poly) not verified and documented to be free of tertiary amines shall not be permitted for use as the primary packaging method for ESDS hardware.

Note 1: There is no requirement for secondary packaging for ESD protection. Secondary packaging is used for physical protection only.

Note 2: Topical antistatic packaging materials verified and documented to be free of tertiary amines, and are in full compliance with the static dissipative surface resistance requirements of this section, are allowed for use as anti-static protection only if the article is stored within an EPA.

Note 3: Topical antistatic packaging materials that satisfy Note 2 may be used as secondary packaging for physical protection either inside or outside the confines of an EPA.

7.2.4.4 EPA Perimeter, Marking and Signage

7.2.4.4.1 The ESD Control Program Plan shall include requirements for signage and perimeter indicators.

Note: EPA perimeter indicators such as floor tape, partitions, and rope guards are used to prevent unauthorized and untrained personnel as defined in 7.2.3.1.5 from entering the EPA and to prevent the EPA from being used for unauthorized purposes.

7.2.4.4.2 ESD access-controlled areas shall be limited to ESD trained personnel and escorted visitors.

7.2.4.4.3 EPAs within access-controlled areas shall have a minimum 12 inch traffic buffer beyond the applicable sides of the perimeter, including those sides that share a boundary with a non-EPA work bench or work area.

7.2.4.4.4 EPAs outside of access-controlled areas shall have a minimum one-meter traffic buffer beyond the applicable sides of the perimeter, including those sides that share a boundary with a non-EPA work bench or work area.

Note 1: When an EPA is outside of an ESD Access-controlled area, the one-meter traffic buffer requirement may be tailored to 12 inches when technically justified by the use of alternate controls that limit the presence of static charge sources and conductive grounding between 1 meter and 12 inches of the ESD item being processed. The use of cotton or cotton-blend garments is one such method.

Note 2: ESD shielding material should be used when limited space is available, and non-ESD work is carried out in proximity to active EPAs.

7.2.5 Baseline ESD Control Technical Requirements

The following ESD Control components can be verified using the test methods provided in Section 7 herein, the methods in ESD TR53-01-18, or the alternative methods provided in Table 3.

7.2.5.1 Work Surfaces

7.2.5.1.1 The resistance of the work surfaces where ESDS items are handled shall be in the dissipative range, from 10^6 to $<10^9\Omega$. See Table 3, #1.

7.2.5.1.2 The resistance from the center of the work surface to the common point ground (CPG) shall be 10^6 to $<10^9\Omega$. See Table 3, #2.

7.2.5.1.3 When conductive surfaces must be used as an ESD work surface, control methods to prevent an ESD event shall be documented by the ESD Control Program Plan.

Note: Conductive surfaces, grounded or ungrounded, can enable ESD events to occur.

7.2.5.2 ESD-Protective Floor Surfaces

7.2.5.2.1 A dissipative floor or floor mat shall be used for EPAs certified for processing HBM Class 0A (<125 volts) ESDS hardware.

7.2.5.2.2 The surface resistance for dissipative floors and floor mats shall measure from 10^6 to $<10^9\Omega$. See Table 3, #3.

7.2.5.2.3 The surface resistance for conductive floors and floor mats shall measure less than $10^6\Omega$. See Table 3, #3.

7.2.5.2.4 Protective floor grounding for dissipative floors shall measure from 10^6 to $<10^9\Omega$. See Table 3, #4.

7.2.5.2.5 Protective floor grounding for conductive floors shall use GFCI and measure less than $1x10^6\Omega$. See Table 3, #4.

7.2.5.3 Personnel Grounding Systems.

7.2.5.3.1 Local ESD Control Program Plans shall address how personnel will connect ESD wrist straps within the 1 meter buffer region to protect exposed ESDS hardware.

7.2.5.3.2 ESD wrist straps systems or heel strap systems shall be verified to be functional each time before use. See Table 3, #5.

7.2.5.3.3 The wristband resistance shall be 800kΩ to 1.2MΩ as measured between wristband connection point and skin contact surface. See Table 3, #6.

7.2.5.3.4 The wrist strap ground terminal resistance shall be < 1Ω as measured from the wrist strap ground terminal to the CPG. Follow manufacturer's recommendation for continuous monitoring systems. See Table 3, #7.

7.2.5.3.5 Elastic conductive fabric wristbands shall not be used where shedding of conductive fibers is a concern. Metal expansion bracelet or conductive thermoplastic wristbands ensuring continuous conductive contact with the wearer's skin are preferred.

7.2.5.3.6 Foot grounding devices, when used, shall be worn on both feet and measure $< 3.5x10^7\Omega$. See Table 3, #8.

7.2.5.3.7 The method and frequency of calibration for Continuous Monitored System (CMS) ESD wrist strap systems shall be documented in the local ESD Control Program Plan. See Table 3, #9.

7.2.5.4 Stools, Chairs, and Mobile Equipment/Carts

7.2.5.4.1 Groundable, static dissipative seating is required in EPAs rated for processing HBM Class 0 items.

7.2.5.4.2 Where static dissipative seating is used, each chair's resistance shall be verified to be 10^6 to < $10^9\Omega$ between the chair's Groundable Point and CPG on a frequency documented by the ESD Control Program Plan. See Table 3, #10.

7.2.5.4.3 Conductive furniture and other similar conductive items that may present a charge within 12 inches of the ESDS items, or may come in direct contact with grounded operators, shall be grounded and verified to have a resistance from CPG to Groundable Point of less than 1 ohm per ANSI/ESD S6.1-2014.

7.2.5.4.4 Mobile equipment or carts within the traffic buffer region of the EPA shall be equipotentially bonded to CPG or shall be grounded through the conductive or dissipative floor.

7.2.5.4.4.1 Equipment or carts tied directly to CPG shall measure < 1Ω when measured from the equipment ground to CPG. See Table 3, #11.

7.2.5.4.4.2 Equipment or carts grounded through conductive or dissipative flooring shall measure 10^6 to < $10^9\Omega$ when measured from the equipment ground to CPG. See Table 3, #11.

7.2.5.5 Relative Humidity

7.2.5.5.1 Relative humidity within an EPA processing HBM Class 1A, or less sensitive, hardware shall be 30% to 70%. See Table 3, #12.

7.2.5.5.2 Relative humidity within an EPA processing HBM Class 0A or Class 0, or more sensitive, hardware shall be 40% to 70%. See Table 3, #12.

7.2.5.5.3 The ESD control program plan shall address the frequency at which the humidity is checked by personnel, or equipment set points, as well as how often the value is recorded, how the data is recorded, and how the data is stored.

7.2.5.5.4 Stop-work conditions and mitigation methods for relative humidity outside of the prescribed range shall be defined in the ESD Control Program Plan.

7.2.5.5.5 For instances where maintaining the RH levels shown in 7.2.5.5 are not practical, special methods, procedures, equipment, and assurance requirements designed to overcome the risks of relative humidity levels below or above the required limits shall be used and documented in the applicable ESD Control Program Plan.

7.2.5.6 Air Ionizers

7.2.5.6.1 Air ionizers are the preferred mitigation method when processing ESDS mission hardware whenever essential insulators are within twelve inches of an ESDS item in any rated ESD sensitivity class to comply with ANSI/ESD S20.20-2014, section 8.3.1.B (re: charge removal from insulators).

Note: The presence of ionized air may create an increased risk for corona discharge in the presence of energized power or radio frequency equipment, therefore, the use of ionizers should be assessed before use in those environments.

7.2.5.6.2 Charge dissipation time from +1000 V to +100 V and -1000 V to -100 V shall be ≤ 20 seconds when measured in the center of the working area. See Table 3, #13.

7.2.5.6.3 The offset voltage of ionizers shall be ≤ ± 35V. Table 3, #14.

Note: Cleaning ionizer charge tips may be used to return ionizers to within specifications and is recommended when performance testing indicates a trend towards an out-of-specification condition.

7.2.5.7 Grounding Configurations

7.2.5.7.1 EPA grounding connections shall not be daisy-chained.

7.2.5.7.2 Where the Auxiliary ground enters the EPA, the resistance between the Auxiliary ground and the equipment ground shall be ≤ 1Ω. See Table 3, #15.

7.2.5.7.3 The resistance of the Auxiliary ground from end to end, shall be ≤ 25Ω. See Table 3, #16.

7.2.5.7.4 Where used, the GFCI's self-check shall be verified for proper shock protection and reset.

7.2.5.8 ESD Garments

7.2.5.8.1 The ESD Control Program Plan shall document when ESD garments are used.

7.2.5.8.2 ESD garments shall be worn fully zipped or buttoned when in use.

7.2.5.8.3 All components of the ESD garments (i.e., coveralls, smock, boots, hood, booties) shall meet the requirements of ANSI/ESD STM2.1-2018.

7.2.5.8.4 Garment performance shall be verified upon receipt from the manufacturer and following laundering service.

7.2.5.8.5 The ESD garment resistance from point to point shall be < 10^{11}Ω. See Table 3, #17.

7.2.5.9 Electrical Equipment and Tools

7.2.5.9.1 Soldering iron tip to equipment ground resistance shall be < 5Ω. See Table 3, #18.

7.2.5.9.2 Battery powered portable tools without conductive or static dissipative handle grips shall be treated as essential insulators. AC powered hand tools should

employ a three-wire grounded power cord or have conductive or static dissipative handle grips. DC powered portable tools should have conductive or static dissipative handle grips.

7.2.6 ESD Control Summary

7.2.6.1 The values provided in Table 3 are a summary of ESD control technical requirements. Verification intervals and test methods used shall be defined within the ESD Control Program Plan.

Note: EPAs not verified within 6 months of certification or verification must be re-certified per 7.2.4.1.4 or removed from service.

Table 3. Summary of ESD Control Verification Values

#	ESD Control	Verification Values (Alternate Test Methods)	Recommended Verification Intervals				
			Continual	Daily	Monthly	Biannual	Annual
1	Work Surface Resistance	10^6 to < $10^9\Omega$ (ANSI/ESD STM4.1-2017)			×		
2	Work Surface Grounding	10^6 to < $10^9\Omega$ (ANSI/ESD STM4.1-2017)			×		
3	Protective Floor Resistance	If Dissipative: 10^6 to < $10^9\Omega$ (ANSI/ESD STM7.1-2013) If Conductive: < $10^6\Omega$ (ANSI/ESD STM7.1-2013)			×		
4	Protective Floor Grounding	If Dissipative: 10^6 to < $10^9\Omega$ (ANSI/ESD STM7.1-2013) If Conductive: < $1x10^6\Omega$ (ANSI/ESD STM7.1-2013)			×		
5	Wrist Strap Check	Go/No Go functional check before use	×				
6	Wristband Resistance Range	From 800kΩ to 1.2MΩ *per ANSI/ESD S20.20-2014* (ANSI/ESD S1.1-2013)			×		
7	Personnel Ground System Resistance	< 1Ω (if no CMS)			×		
8	Foot Grounding Device Integrity	< $3.5x10^7\Omega$ (ANSI/ESD STM97.1-2015)		×			
9	ESD CMS	Calibration is required					×
10	Stool / Chair Grounding	10^6 to < $10^9\Omega$ (ANSI/ESD STM12.1-2013)				×	
11	Mobile Equipment/ Carts	• < 1Ω if tied directly to CPG *per ANSI/ESD S20.20-2014* • $10^6\Omega$ to < $10^9\Omega$ if tied thru flooring (ANSI/ESD S6.1-2014)				×	

12	Relative Humidity (RH)	• 30-70% RH for handling of HBM Class 1A EPAs or higher • 40-70% RH for handling of HBM Class 0A EPAs or lower	×				
13	Ionizers Charge Dissipation Time	≤ 20 seconds (ANSI/ESD STM3.1-2015)			×		
14	Ionizers Offset Voltage	≤ ± 35V *per ANSI/ESD S20.20-2014* (ANSI/ESD STM3.1-2015)			×		
15	Equipment GND to Auxiliary GND	≤ 1Ω			×		
16	Auxiliary GND	≤ 25Ω *per ANSI/ESD S20.20-2014* (ANSI/ESD S6.1-2014)			×		
17	Garments	$< 10^{11}\Omega$ *per ANSI/ESD S20.20-2014* (ANSI/ESD STM2.1-2018)			×		
18	Soldering Iron Tip to Ground	< 5Ω (ANSI/ESD S13.1)		×			

8. POLYMERIC APPLICATIONS STANDARD IMPLEMENTATION

8.1 Applicable Polymeric Applications Standard

NASA-STD-8739.1 contains baseline staking, bonding, conformal coating, and encapsulation requirements for mission hardware.

8.2 Exclusions of IPC® J-STD 001GS Requirements for Polymeric Applications

The requirements in the following sections of IPC J-STD-001GS are not applicable: Section 10, Section 11, and Section 5.6.3.

9. SOLDERING STANDARD IMPLEMENTATION

9.1 Applicable Soldering Standard

IPC J-STD-001GS contains baseline soldering requirements for mission hardware.

Note: IPC J-STD-001, Class 3 is not an authorized substitute for IPC J-STD-001GS.

9.2 Exceptions to IPC® Requirements

9.2.1 The lead(Pb)-free and red plague (cuprous oxide corrosion) requirements in IPC J-STD-001GS and IPC/WHMA-A-620C-S sections 0.1.5 through 0.1.6 do not apply for the minimum baseline requirements although they may be documented and imposed at the discretion of the NASA project.

9.2.2 See Section 8.2 herein for exceptions to the IPC J-STD-001GS for polymeric applications.

9.3 Use of Cancelled NASA Workmanship Soldering Standards

9.3.1 NASA-STD-8739.2 and NASA-STD-8739.3 are cancelled standards as of October, 2011. Use of these standards without waiver is only allowed for programs and projects having assurance baseline documents published prior to their cancellation.

9.3.2 Programs and projects that have invoked NASA-STD-8739.2 and NASA-STD-8739.3 in their baseline requirements prior to October, 2011 may use IPC J-STD-001GS for fabricating and inspecting new mission hardware without waiver approval. Programs and projects building, replacing, modifying, or repairing equipment defined by drawings which invoke the cancelled NASA soldering standards may work to the requirements and training certifications of IPC J-STD-001GS without waiver.

10. CABLE HARNESS ASSEMBLY STANDARD IMPLEMENTATION

10.1 Applicable Cable Harness Standard

10.1.1 NASA-STD-8739.4 and IPC/WHMA-A-620C-S contain baseline requirements for electrical cable and cable harness assembly for mission hardware. The supplier shall use either one of these standards.

10.1.2 Only one standard shall be used to build an individual piece of mission hardware.

Note: IPC/WHMA-A-620C, Class 3 is not a substitute for IPC/WHMA-A-620C-S.

10.2 Exceptions to IPC/WHMA-A-620C-S Requirements

The interconnect types in Table 4 have not been established as widely qualified for NASA mission applications and thus shall not be used as standard interconnections for NASA cables and harnesses. See 4.1, 4.2 and 4.3.1- herein for requirements that apply for uses of non-standard interconnect types.

Table 4. Nonstandard Interconnects in IPC/WHMA-A-620C-S

Section	Title
5.1	Stamped and Formed – Open Barrel
5.4	Termination Ferrule Crimp
6	Insulation Displacement Connection (IDC)
7	Ultrasonic Welding
8.1.1	Splices - Mesh
8.3	Ultrasonic Weld Splices
13.11	Swage-Type Connector
15.2.1.2	Shield Termination – Shield Jumper Wire – Shield Braid
15.2.1.3	Shield Termination – Shield Jumper Wire – Daisy Chain
15.7	Shrink Tubing – Conductive Lined
16.3	Spiral Plastic Wrap (Spiray Wrap Sleeving)
17.2.2	Hardware Installation – Threaded Fasteners – Wires
18.0	Solderless Wrap

10.3 Inspection of Hardware Fabricated to NASA-STD-8739.4

10.3.1 Inspectors trained to IPC/WHMA-A-620C-S may inspect hardware built to the NASA-STD-8739.4 standard in accordance with the accept/reject criteria of the NASA-STD-8739.4 standard, however, when an identified artifact is considered a defect in accordance with IPC/WHMA-A-620C-S criteria, authorized technical experts and contract authorities shall disposition the defect (e.g., use or repair) based on mission risk.

10.3.2 Programs and projects building, replacing, modifying, or repairing equipment defined by drawings which invoke NASA-STD-8739.4 may work to the requirements and training certifications of IPC/WHMA-A-620C-S without waiver.

10.4 Use of IPC J-STD-001GS for Soldering

Where versions of NASA-STD-8739.4 prior to Revision A invoke NASA-STD-8739.3 for soldering processes and inspections, IPC J-STD-001GS may be used in lieu of NASA-STD-8739.3. Also see 9.3.2 herein.

11. FIBER OPTIC CABLE ASSEMBLY STANDARD IMPLEMENTATION

11.1 Applicable Fiber Optic Cable Standard

NASA-STD-8739.5 contains baseline requirements for fiber optic cable assembly for mission hardware. This standard does not contain any changes to the baseline requirements of NASA-STD-8739.5.

APPENDIX A. TYPES OF NASA WORKMANSHIP INSTRUCTORS

A.1 NASA Workmanship Instructors

A.1.1 Instructors may have working conditions which dictate their training audience. Table 5 below clarifies the permitted functions of various workmanship instructors, and their associated certification requirements.

Table 5. Types of NASA Workmanship Instructors

Designation →	**Level A**	**Level B**	**Level B**
Practices where?	NMTTC-E or NMTTC-W (5.1.2)	SMA-Sponsored Training Center	In contractor or NASA facility
Trains whom?	All types of students[1/] (3.2, 5.2.1)	All operators and inspectors[1/] (3.2, 5.2.1, 5.2.2)	Operators and inspectors who work for the instructor's employer or work for a subcontractor of the instructor's employer (3.2, 5.2.1)
Civil servant or contractor?	Either	Either	Contractor
Accountable party for competency of the instructor and compliance to 8739.6	The certifying authority: the NASA Workmanship Program Manager or their delegate	The NASA Workmanship Standards Technical Committee (NWSTC) member for that NASA Center or their delegate (5.3.4)	The employer of the instructor (5.3.1)
Certification required?	Yes, at least once	Yes, at least once (5.3.4)	No
Retraining required?	Yes, every 24 months (5.6.3)	Yes, every 24 months or via an audit (5.6.2)	Yes, every 24 months (5.6.1)
Review and concurrence required for final drafts of updates to standards?	Yes (5.6.3)	Yes (5.6.2)	No

1/ special conditions apply for training students who are foreign nationals (5.9.6, 5.9.7)