



NASA TECHNICAL STANDARD

**NASA-STD 8739.6A,
Change 1**

**National Aeronautics and Space Administration
Washington, DC 20546-0001**

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Superseding: NASA-STD
8739.6A**

**IMPLEMENTATION REQUIREMENTS FOR NASA
WORKMANSHIP STANDARDS**

**MEASUREMENT SYSTEM IDENTIFICATION:
NOT MEASUREMENT SENSITIVE**

DOCUMENT HISTORY LOG

Status	Document Revision	Approval Date	Description
Baseline		2012-09-05	Initial Release
	A	2016-06-30	<ul style="list-style-type: none"> - 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. <p>Clause 11 of J-STD-001F is not applicable for polymeric applications.</p>

NASA-STD-8739.6A Change 1 – 2017-05-31

			<ul style="list-style-type: none"> - 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.
	Change 1	2017-05-31	<ul style="list-style-type: none"> -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.

NASA-STD-8739.6A Change 1 – 2017-05-31

FOREWORD

This standard is published by the National Aeronautics and Space Administration (NASA) to provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects, including requirements for selection, application, and design criteria of an item.

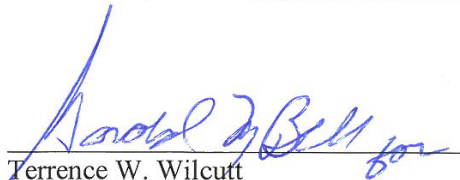
This standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities, and Technical and Service Support Centers and is intended to be applied on NASA contracts.

This standard establishes NASA workmanship requirements, and clarifications, additions, and exceptions to requirements specified in industry consensus standards related to workmanship and referenced in NPD 8730.5, NASA Quality Assurance Program Policy.

For the purpose of this document, the term "supplier" includes in-house NASA production operations, NASA prime contractors, and NASA subcontractors who are manufacturing or otherwise processing mission hardware.

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

This NASA-STD was developed by NASA Headquarters Office of Safety and Mission Assurance and the NASA Workmanship Standards Program. Requests for information, corrections, or additions to this Standard should be submitted to the National Aeronautics and Space Administration, Director, Safety and Assurance Requirements Division, Office of Safety and Mission Assurance, Washington, DC 20546 or via "Feedback" in the NASA Technical Standards System at <http://standards.nasa.gov>.


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Approval Date

TABLE OF CONTENTS

DOCUMENT HISTORY LOG 2
TABLE OF CONTENTS 5
LIST OF APPENDICES 7
LIST OF TABLES 7

1. SCOPE 8
1.1 Purpose..... 8
1.2 Applicability 9
1.3 Levying Special Requirements 9

2. APPLICABLE DOCUMENTS..... 9
2.1 General..... 9
2.2 Government Documents 10
2.3 Non-Government Documents 11
2.4 Order of Precedence..... 11

3. ACRONYMS AND DEFINITIONS..... 11
3.1 Acronyms and Abbreviations 11
3.2 Definitions..... 13

4. GENERAL..... 14
4.1 Implementation 14
4.2 Changes in Requirements 15
4.3 Assembly Configurations, Processes, Materials, and Parts 15

5. TRAINING REQUIREMENTS 15
5.1 Personnel Training 15
5.2 Program Implementation 15

6. GENERAL TECHNICAL REQUIREMENTS..... 15
6.1 Temperature and Relative Humidity..... 16
6.2 Occupational Health Requirements 16
6.3 Materials Selection..... 17
6.4 Tool Selection and Control 17
6.5 Protection of Materials, Parts and Assemblies During Handling, Processing and Storage
17
6.6 Inspection and Inspection Optics 17
6.7 Solvents and Cleaning..... 18
6.8 Rework and Repair 18

**7. ELECTROSTATIC DISCHARGE CONTROL STANDARD
IMPLEMENTATION 19**
7.1 Applicable ESD Standard 19
7.2 ESD Requirements Addendum to ANSI/ESD S20.20-2014 19

NASA-STD-8739.6A Change 1 – 2017-05-31

8.	POLYMERIC APPLICATIONS STANDARD IMPLEMENTATION	20
8.1	Applicable Polymeric Applications Standard	20
8.2	Exclusions of IPC [®] J-STD 001FS Requirements for Polymeric Applications.....	20
9.	SOLDERING STANDARD IMPLEMENTATION	20
9.1	Applicable Soldering Standard	20
9.2	Exceptions to IPC [®] J-STD-001FS Requirements	20
9.3	Use of Cancelled NASA Workmanship Soldering Standards	20
10.	CABLE HARNESS ASSEMBLY STANDARD IMPLEMENTATION	21
10.1	Applicable Cable Harness Standard.....	21
10.2	Exceptions to IPC [®] IPC/WHMA-A-620B-S Requirements	21
10.3	Inspectors trained to IPC [®] IPC/WHMA-A-620B-S inspecting hardware built to the NASA-STD-8739.4 standard.....	22
10.4	Use of IPC [®] J-STD-001FS for Soldering	22
11.	FIBER OPTIC CABLE ASSEMBLY STANDARD IMPLEMENTATION	22
11.1	Applicable Fiber Optic Cable Standard	22
12.	IPC[®] TRAINING PROGRAMS.....	22
12.1	IPC [®] Training	22
12.2	Custom IPC [®] Training.....	23

LIST OF APPENDICES

APPENDIX A. REQUIREMENTS FOR WORKMANSHIP STANDARDS TRAINING PROGRAMS 24
APPENDIX B. TYPES OF NASA WORKMANSHIP INSTRUCTORS 39

LIST OF TABLES

Table 1. Workmanship Requirements Documents 8
Table 2. Nonstandard Interconnects in IPC[®] IPC/WHMA-A-620B-S 21
Table A-1. Recommended Course Lengths 36

IMPLEMENTATION REQUIREMENTS FOR NASA WORKMANSHIP STANDARDS

1. SCOPE

1.1 Purpose

The purpose of this standard is to provide quality requirements for the manufacture of electronic assemblies and for 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-001F
Space Applications Electronic Hardware Addendum to IPC® J-STD-001F Requirements for Soldered Electrical and Electronic Assemblies	IPC® J-STD-001FS
Requirements and Acceptance for Cable and Wire Harness Assemblies	IPC® IPC/WHMA-A-620B
Space Applications Electronic Hardware Addendum to IPC/WHMA-A-620B	IPC® IPC/WHMA-A-620B-S

1.1.1 Baseline quality management system requirements are specified in NPD 8730.5. Where there are conflicts between the requirements found in this document and NPD 8730.5, the requirements of NPD 8730.5 take precedence.

1.1.2 Where there are conflicts between the requirements found in this document and the industry voluntary consensus standards in Table 1, the requirements of this document take precedence.

NASA-STD-8739.6A Change 1 – 2017-05-31

1.2 Applicability

1.2.1 This standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers and may be cited in contract, program, and other Agency documents as a technical requirement. This Standard may also apply to the Jet Propulsion Laboratory (JPL) and to other contractors, grant recipients, or parties to agreements to the extent specified or referenced in their contracts, grants, or agreements.

1.2.2 This standard applies to critical work, as defined by NPD 8730.5. Critical work is any task that if performed incorrectly or in violation of prescribed requirements poses a risk of loss of human life; serious injury; loss of a Class A, B, or C payload (see NPR 8705.4); loss of a Category 1 or Category 2 mission (see NPR 7120.5); or loss of a mission resource valued at greater than \$2M (e.g., NASA space flight hardware, Government test or launch facility).

1.2.3 The workmanship requirements of this document do not apply to programs and projects executed under NPR 7120.8 though these programs or projects may choose to impose them in their mission assurance plan.

1.2.4 The requirements of this document do not apply when requirements flow down is not practical such as when procuring off-the-shelf (OTS) items and when using suppliers who work to alternate standards. Projects procuring OTS products or products made to alternate standards for applications described in 1.2.2 above are 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.

1.2.5 Use of the term “supplier” applies to any entity that is manufacturing hardware in accordance with the requirements herein including NASA Centers and NASA contractors.

1.3 Levying Special Requirements

1.3.1 Projects-specific and Center-specific workmanship requirements not contained in this publication or the standards referenced in Table 1 shall be formally documented prior to implementation. Also see 4.1.1.

1.3.2 Project-specific and Center-specific requirements that conflict with requirements stated herein or in the standards in Table 1 shall be formally approved and traceable to approved requests for relief prior to implementation.

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 Technical Authority. The applicable documents are accessible via the NASA

NASA-STD-8739.6A Change 1 – 2017-05-31

Standards and Technical Assistance Resource Tool at <http://standards.nasa.gov> or may be obtained directly from the Standards Developing Organizations or other document distributors.

2.2 Government Documents

2.2.1 Code of Federal Regulations

29 CFR 1910 Subpart Z Toxic and Hazardous Substances

2.2.2 National Aeronautics and Space Administration

NPD 8730.2 NASA Parts Policy

NPD 8730.5 NASA Quality Assurance Program Policy

NPR 1800.1 NASA Occupational Health Program Procedures

NPR 7120.5 NASA Space Flight Program and Project Management Requirements

NPR 7120.8 NASA Research and Technology Program and Project Management Requirements

NPR 8705.4 Risk Classification for NASA Payloads

NASA-STD-6016 Standard Materials and Process Requirements for Spacecraft

NASA-STD 8709.22 Safety and Mission Assurance Acronyms, Abbreviations, and Definitions

NASA-STD-8739.1 Workmanship Standard for Polymeric Applications 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-001FS 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-001FS but is still used on pre-existing projects.)

NASA-STD-8739.4 Crimping, Interconnecting Cables, Harnesses, and Wiring

NASA-STD-8739.5 Fiber Optic Terminations, Cable Assemblies, and Installation

NASA-HDBK-8739.21 Workmanship Manual for Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)

NASA-STD-8739.6A Change 1 – 2017-05-31

2.3 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)
IPC® J-STD-001F	Requirements for Soldered Electrical and Electronic Assemblies
IPC® J-STD-001FS	Space Applications Electronic Hardware Addendum to J-STD-001F Requirements for Soldered Electrical and Electronic Assemblies
IPC® IPC/WHMA-A-620B	Requirements and Acceptance for Cable and Wire Harness Assemblies
IPC® IPC/WHMA-A-620B-S	Space Applications Electronic Hardware Addendum to IPC/WHMA-A-620B

2.4 Order of Precedence

This Standard establishes requirements to provide quality requirements for the manufacture of electronic assemblies and for ESD control but does not supersede nor waive established Agency requirements found in other documentation. Conflicts between this Standard and other requirements documents shall be resolved by the responsible Technical Authority.

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms and Abbreviations

ANSI	American National Standards Institute
AO-HRR	American Optical Hardy-Rand-Rittler
CD	Compact Disc
CFR	Code of Federal Regulations
CIS	Certified IPC® Application Specialist
CIT	Certified IPC® Trainer
CVCM	Collected Volatile Condensable Material
E-NMTTC	Eastern NASA Manufacturing Technology Transfer Center

NASA-STD-8739.6A Change 1 – 2017-05-31

ESD	Electrostatic Discharge
EPA	Electrostatic Protected Area
GSFC	Goddard Space Flight Center
HBM	Human Body Model
FOD	Foreign Object Debris
IDC	Insulation Displacement Connection
IPC [®]	Registered trademark for IPC [®] -Association Connecting Electronic Industries
JPL	Jet Propulsion Laboratory
JSC	NASA Johnson Space Center
NPD	NASA Policy Directive
MIT	Certified IPC [®] Master Trainer
MSFC	NASA Marshall Space Flight Center
NPR	NASA Procedural Requirements
OSHA	Occupational Safety and Health Administration
RH	Relative Humidity
SATERN	System for Administration, Training, and Educational Resources for NASA
SDS	Safety Data Sheet
SMA	Safety and Mission Assurance
STD	Standard
TAA	Technical Assistance Agreement
TML	Total Mass Loss
W-NMTTC	Western NASA Manufacturing Technology Transfer Center
WSTC	Workmanship Standards Technical Committee

3.2 Definitions

The definitions listed below are in addition to those listed in NASA-STD-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.

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 (See A.2.1.g). The local ESD Control 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 (see A.2.1.d.). The local ESD Control 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: Hardware used in Category 1 and Category 2 projects and/or Class A, B, or C payloads, including critical support hardware.

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 <http://nepp.nasa.gov/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.

NASA-STD-8739.6A Change 1 – 2017-05-31

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.

SMA-Sponsored Level B Training Center: A workmanship training center that has been 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. See A.2.2.

Supplier: Any entity who is manufacturing hardware in accordance with the requirements herein, including NASA Centers and NASA contractors.

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. 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 identified and performed; and data records are complete.

4.1.2 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.

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

4.1.4 Suppliers shall provide operators the approved manufacturing instructions (e.g., procedures, drawings, work orders, engineering documentation, specification).

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

4.1.6 The standards in Table 1 are not procedures. Suppliers shall not use this document or the standards in Table 1 as substitutes for procedures required by paragraph 4.1.3 above.

NASA-STD-8739.6A Change 1 – 2017-05-31

4.1.7 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.

4.2 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 delegated agents serving as inspectors in supplier manufacturing facilities.

4.3 Assembly Configurations, Processes, Materials, and Parts

4.3.1 NASA review and approval is required prior to a supplier's use of alternate or nonstandard configurations, processes, or materials.

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 or theoretical analysis, that demonstrates the alternate or non-standard processes, materials, or parts satisfy mission reliability requirements.

5. TRAINING REQUIREMENTS

This section supersedes the Section 5 requirements of NASA Standards 8739.1, 8739.4, and 8739.5.

5.1 Personnel Training

Personnel performing manufacturing processes and inspections prescribed in workmanship standards listed in Table 1 shall be trained in accordance with Appendix A of this standard.

5.2 Program Implementation

Workmanship training programs shall be implemented in accordance with Appendix A of this standard.

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-001F and its space addendum IPC[®] J-STD-001FS, IPC[®]

NASA-STD-8739.6A Change 1 – 2017-05-31

IPC/WHMA-A-620B and its space addendum IPC[®] IPC/WHMA-A-620B-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. 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 For areas where ESD-sensitive hardware, rated Human Body Model (HBM) Class 1A and less sensitive are processed, the relative humidity shall be no less than 30 percent.

6.1.4 For areas where ESD-sensitive hardware rated HBM Class 0 and more sensitive are processed, the relative humidity shall be no less than 40 percent.

6.1.5 In field operations where the required controlled conditions cannot be effectively achieved, special precautions shall be documented and implemented to minimize the effects of the uncontrolled environment on the operation being performed 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. OSHA, 29 CFR Part 1910, Subpart Z provides requirements for personal protective equipment such as eye protection, gloves, respirator protection, etc. and engineering controls such as exhaust ventilation and fume extractors. 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. Also see NPD 8730.2B, Attachment B, paragraph B.4, Note.

6.2.2 Supplier personnel shall read and understand the relevant Safety Data Sheets (SDSs) before beginning work with any solvents, fluxes, solders, uncured polymers, or polymer subcomponents (e.g., catalysts, staking filler powders).

6.2.3 SDS's 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 Uses of Pb-free tin solder and surface finishes in mission hardware shall comply with the requirements of NPD 8730.2, Attachment B: Criteria to Mitigate Risks Associated with Lead-Free Solder and Surface Finishes.

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 During Handling, Processing and Storage

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, 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.

6.5.3 Workmanship areas (e.g., materials processing, storage, assembly, soldering, testing, and inspection), are to be controlled to prevent the introduction of routine maintenance or fugitive lubricants, silicones, and other materials that have the potential for product contamination and impact on workmanship quality.

6.6 Inspection and Inspection Optics

6.6.1 All printed wiring assemblies, cables, cable harnesses, and fiber optic cables used in mission hardware shall be visually inspected 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 Visual inspections shall be performed using the magnification defined in the relevant workmanship standard in Table 1. Inspection magnification systems that permit simultaneous viewing with both eyes are preferred; however, single eye viewing devices are acceptable.

NASA-STD-8739.6A Change 1 – 2017-05-31

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

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

6.6.5 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 and isopropyl alcohol are considered standard solvents and do not require approval prior to use for cleaning printed circuit boards, printed wiring assemblies, or soldered contacts, terminals, or splices. All other solvents require prior approval from the applicable NASA Technical Authority.

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 Safety Data Sheets (SDS) for proper handling of solvents.

6.7.5 When using silver-coated copper wire, aqueous solvents shall not be used for cleaning.

6.8 Rework and Repair

6.8.1 Rework that results in product conformity, as defined in NASA-STD 8709.22, is permissible. Each occurrence of rework and the non-conformance it corrects shall be recorded.

6.8.2 Repair that will not result in full product conformity, as defined in NASA-STD 8709.22, requires NASA review and approval for each type of proposed repair prior to use.

NASA-STD-8739.6A Change 1 – 2017-05-31

6.8.3 Each repair and the nonconformance it corrects shall be documented before it is accomplished.

6.8.4 Requests for approval for a repair shall include a description of the defect the repair will correct, the method to be used, an explanation of why the repair method and final configuration will present a low risk to mission success, a description of how the incidence and results of the repair will be recorded, and a description of how the defect will be avoided in future operations on Project hardware.

6.8.5 Assemblies shall be cleaned following repairs in accordance with the methods and criteria defined in the appropriate standard in Table 1.

7. ELECTROSTATIC DISCHARGE CONTROL STANDARD IMPLEMENTATION

7.1 Applicable ESD Standard

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

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

7.2.1 See section 6.1 of this standard for relative humidity requirements. For instances where maintaining the RH level shown in 6.1.3 or 6.1.4 above is 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.

7.2.2 ANSI/ESD S20.20-2014 requires the development and implementation of an ESD Control Program which provides detailed requirements and acceptance levels applicable to local production facilities. A recommended ESD Control Program plan template is provided in NASA-HDBK-8739.21.

7.2.3 ESD wrist straps and heel strap systems shall be verified to be functional each time they are put on prior to entry into an Electrostatic Protected Area (EPA) or prior to coming within one meter of an ESD sensitive (ESDS) item.

7.2.4 Antistatic material shall not be used in direct contact with ESDS items for storage or transport (e.g., Pink Poly).

7.2.5 ESD Product Qualification test data generated on behalf of a NASA Center, when performed in accordance with ESDA product qualification criteria and test methods, may be used by all NASA Centers as a part of their ESD Product Qualification Programs. NASA Centers have the option to flow this allowance to their suppliers.

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 001FS Requirements for Polymeric Applications

8.2.1 The requirements in the following sections of IPC[®] J-STD-001FS are not applicable: Clause 10, Clause 11.

9. SOLDERING STANDARD IMPLEMENTATION

9.1 Applicable Soldering Standard

IPC[®] J-STD-001FS contains baseline soldering requirements for mission hardware.

Note: IPC[®] J-STD-001F, Class 3 is not an authorized substitute for IPC[®] J-STD-001FS.

9.2 Exceptions to IPC[®] J-STD-001FS Requirements

9.2.1 The red plague (cuprous oxide corrosion) requirements in IPC[®] J-STD-001FS sections 0.1.7 through 0.1.7.1 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 for exceptions to the IPC[®] J-STD-001FS 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 documents as of October, 2011. Use of these standards without waiver is allowed for programs and projects having assurance baseline documents published prior to their cancellation. Programs and projects with assurance baseline document published after NASA-STD-8739.2 and NASA-STD-8739.3 cancellation shall obtain waiver approval prior to using cancelled standards in their baseline requirements.

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-001FS for soldering new mission hardware without waiver approval. Inspectors trained to IPC[®] J-STD-001FS may inspect hardware built to cancelled NASA soldering standards in accordance with the accept/reject criteria of the cancelled standard, however, when an identified artifact is considered a defect in accordance with IPC[®] J-STD-001FS criteria, authorized technical experts and contract authorities shall disposition the defect (e.g., use or repair) based on mission risk. Programs and projects building, replacing, modifying, or repairing equipment defined by

NASA-STD-8739.6A Change 1 – 2017-05-31

drawings which invoke the cancelled NASA soldering standards may work to the requirements and training certifications of IPC[®] J-STD-001FS without waiver.

10. CABLE HARNESS ASSEMBLY STANDARD IMPLEMENTATION

10.1 Applicable Cable Harness Standard

10.1.1 NASA-STD-8739.4 and IPC[®] IPC/WHMA-A-620B-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[®] IPC/WHMA-A-620B, Class 3 is not a substitute for IPC[®] IPC/WHMA-A-620B-S.

10.2 Exceptions to IPC[®] IPC/WHMA-A-620B-S Requirements

The interconnect types in Table 2 have not been established as widely qualified for NASA mission applications and thus are not considered 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 2. Nonstandard Interconnects in IPC[®] IPC/WHMA-A-620B-S

Section	Title
5.1	Stamped and formed open barrel
5.4	Ferrule Crimp
6.0	IDC Section
7.0	Ultrasonic Welding
8.1.1	Mesh splice
8.3	Ultrasonic Weld splice
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
17.2.3	Threaded Fasteners-Wires
17.2.4	Threaded Fasteners- High Voltage Applications
18.0	Solderless Wrap

10.3 Inspectors trained to IPC® IPC/WHMA-A-620B-S inspecting hardware built to the NASA-STD-8739.4 standard

Inspectors trained to IPC® IPC/WHMA-A-620B-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® IPC/WHMA-A-620B-S criteria, authorized technical experts and contract authorities shall disposition the defect (e.g., use or repair) based on mission risk. Programs and projects building, replacing, modifying, or repairing equipment defined by drawings which invoke the NASA-STD-8739.4 standard may work to the requirements and training certifications of IPC® IPC/WHMA-A-620B-S without waiver.

10.4 Use of IPC® J-STD-001FS for Soldering

Where NASA-STD-8739.4 invokes NASA-STD-8739.3 for soldering processes and inspections, IPC® J-STD-001FS shall be used in lieu of NASA-STD-8739.3. Also see 9.3.2.

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.

12. IPC® TRAINING PROGRAMS

Two training program approaches, as described below, are available and recognized as valid for students seeking operator or inspector training to IPC® J-STD-001FS and IPC® IPC/WHMA-A-620B-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. The IPC® may be contacted to obtain information concerning authorized suppliers of this training and for registration instructions. See Appendix A herein, sections A.2 through A.6, for NASA workmanship training requirements.

12.1 IPC® Training

12.1.1 IPC® J-STD-001FS Training: The IPC® offers a six-module IPC® J-STD-001FS course which is recognized as valid for meeting the NASA workmanship training requirement for IPC® J-STD-001FS. 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-001FS training requirement. Students who take the modular course are instructed in all quality class levels including the space class.

NASA-STD-8739.6A Change 1 – 2017-05-31

12.1.2 IPC® IPC/WHMA-A-620B-S Training: The IPC® offers an eight-module, IPC® IPC/WHMA-A-620B three-day lecture-only course which is complemented by a five-day hands-on course. Completing both courses is recognized as valid for meeting the NASA workmanship training requirement for IPC/WHMA-A-620B-S.

12.2 Custom IPC® Training

The supplier has the option to create a training program for IPC® J-STD-001FS and IPC® IPC/WHMA-A-620B-S which meet the requirements of Appendix A herein, with the condition that only IPC® certified trainers (IPC® CIT or IPC® MIT) act as the instructor.

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

12.2.2 Custom computer-based courses shall not be used for IPC® J-STD-001FS or IPC® IPC/WHMA-A-620B-S initial training.

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

APPENDIX A. REQUIREMENTS FOR WORKMANSHIP STANDARDS TRAINING PROGRAMS

A.1 General

A.1.1 This section:

- a. Establishes the training requirements for workmanship operators, inspectors, and instructors.
- b. Establishes the certification requirements for IPC[®] instructors, Level B instructors who teach on behalf of a NASA Center's SMA organization, 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-001FS, IPC[®] IPC/WHMA-A-620B-S and ANSI/ESD S20.20-2014.
- d. Establishes requirements for ensuring that successful completion of the courses by workmanship operators, inspectors, and instructors results in an acceptable knowledge baseline among those personnel, and that common and predictable student processing practices are applied.

A.1.2 NASA Level A training centers have been designated at NASA Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory (JPL) for the purposes of providing master training sites for the conduct of training for all levels of NASA workmanship students, including Level B instructors. Terms and requirements included in this document for NASA Level A training centers do not apply to courses designed for GSFC or JPL internal use. See <http://nepp.nasa.gov/workmanship> for NASA Level A training center contact information.

A.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.

A.2 Workmanship Personnel

A.2.1 The following personnel shall be trained to workmanship standards:

- a. Operator: Builds and inspects printed wiring assemblies, cables, cable harnesses (electrical), and fiber optic cables. The terminology for an IPC[®]-trained operator is Certified IPC[®] Specialist (CIS).
- b. Inspector: Inspects printed wiring assemblies, cables, and cable harnesses for defects in accordance with workmanship standard requirements. The terminology for an IPC[®]-trained inspector is CIS-inspector.

NASA-STD-8739.6A Change 1 – 2017-05-31

- c. ESD operator and ESD program monitor: Handles ESD sensitive 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. Suppliers may choose to use a Level B instructor designation for ESD training (see Table A-1 Note).
- e. ESD Instructor: Instructs ESD operators, ESD program monitors, and local instructors to the local ESD control implementation plan traceable to ANSI/ESD S20.20-2014 and as defined in the local ESD control 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 A-1 Note).

A.2.2 Level B instructors sponsored by, or working on behalf of, a NASA Center 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).

A.2.3 Level B instructors employed in a Level B Supplier Training Program:

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

A.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 make special arrangements with their instructor to take a specialized training course that combines the two curricula.

A.2.5 Personnel who are trained to the instructor level (NASA Standard, or IPC[®] standards) meet the training requirement for operators and inspectors. Suppliers are responsible for

NASA-STD-8739.6A Change 1 – 2017-05-31

ensuring personnel who perform more than one role (e.g., instructor and inspector) are competent to perform all work assignments.

A.2.6 Workmanship operators shall not inspect their own work.

A.2.7 Where training is performed using primarily computer-based material without the presence of an instructor (e.g., on-line, SATERN, CD-based), the requirements described herein relative to the responsibilities of trainers do not apply. See paragraphs 9.4.2 and A.8.23 through A.8.25 for limitations on the use of computer-based training.

A.3 Personnel Competency

A.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. Hands-on demonstration of proficiency shall not be treated as a substitute for ongoing oversight of personnel competency.

A.3.2 A personnel certification process may be applied by the supplier using criteria in addition to that specified in this document at the supplier's discretion.

A.3.3 Suppliers who are required to comply with one or more of the workmanship standards in Table 1 are responsible for ensuring operators, inspectors and instructors within their organization meet the visual acuity and training requirements herein as a prerequisite for processing NASA mission hardware (see A.7).

A.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 (WSTC). The Center's representative on the NASA WSTC may delegate this responsibility. See <http://nepp.nasa.gov/workmanship> for the current roster. As a minimum, certification shall consist of a written record (e.g., a card, certificate, memo on file) indicating the NASA WSTC 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. This certification shall be revoked when the individual is no longer assigned to perform this service for the Center or fails to meet the requirements of A.6.

A.3.5 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 CISOs carry valid IPC[®] certifications. Additional certification criteria may be imposed by the supplier at the supplier's discretion.

NASA-STD-8739.6A Change 1 – 2017-05-31

A.3.6 The NASA Workmanship Standards Program Manager is responsible 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 W-NMTTC NASA Level A instructors may be delegated by the NASA Workmanship Standards Program Manager to JPL's representative on the NASA WSTC. The JPL representative on the NASA WSTC may delegate this responsibility.

A.3.7 Portability of Workmanship Training

A.3.7.1 NASA workmanship standards training, except ESD 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.

A.3.7.2 Supplier custom-developed IPC[®] training shall not be treated as portable between suppliers.

A.3.7.3 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 A.8.10).

A.4 Evidence of Training

A.4.1 Training records shall be retained by the supplier for a minimum of five years.

A.4.2 Evidence of training within the prior twenty-four (24) months shall be available for review by project personnel and during audits.

A.5 Minimum Training Requirements for Operators, Inspectors, and Personnel Associated with Local ESD Control Programs

A.5.1 Personnel under a local ESD Control Program shall meet the training requirements defined in the Program's ESD Control plan. The training requirements in local plans shall meet the requirements of ANSI/ESD S20.20-2014, paragraph 7.2, Training Plan.

A.5.2 Workmanship 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 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.

NASA-STD-8739.6A Change 1 – 2017-05-31

- b. Achievement of vision requirements per paragraph A.7.

A.6 Minimum Training and Certification Requirements for Instructors

A.6.1 The local ESD Control Program defines the minimum qualifications required for ESD instructors and any hierarchies that might apply 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.

A.6.2 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. Achievement of vision requirements per paragraph A.7.

A.6.3 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, and NASA-STD-8739.5.
- b. As an alternative to retraining every two years as stated in A.6.2.a above, an audit by a Level B instructor who is a civil service representative of a NASA Center may be used to establish that the Level B instructor is providing consistent training and policy interpretation to their students. Retraining or audits shall be accomplished a minimum of every two years. Audits shall be performed in accordance with a formally documented process.

A.6.4 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, and NASA-STD-8739.5.
- b. Achievement of vision requirements per paragraph A.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.

A.6.5 Proficiency based on hands-on experience is expected for all NASA Level A and Level B Instructors.

NASA-STD-8739.6A Change 1 – 2017-05-31

A.7 Vision Requirements

A.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.

A.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.

A.7.3 Vision requirements may be met with corrected vision (eyeglasses or contact lenses).

A.7.4 Vision tests shall be administered a minimum of once every two years by a qualified examiner using standard instruments and techniques.

A.7.5 Documentation indicating that minimum visual requirements have been met shall be made available to training centers or instructors when students register for workmanship training.

A.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, AO-HRR Tests, or equivalent approved testing methods. A practical test, using color coded wires or electrical parts, is acceptable for color vision testing.

A.8 General Training Program Requirements for NASA Workmanship Standards

A.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 US-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).

A.8.2 Personnel who have never taken a NASA workmanship standards training course shall first take the initial training course. See Table A-1 for the recommended duration and minimum content requirements for the initial course.

A.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).

A.8.4 Personnel who are repeating training within twenty-four months of taking the initial training course may take a shortened retraining class. See Table A-1 for the recommended duration for retraining courses.

NASA-STD-8739.6A Change 1 – 2017-05-31

A.8.5 Operators, inspectors, and Level B instructors who fail to enroll and complete the retraining course within twenty-four (24) months of taking the initial training course forfeit the option to take the shortened class for retraining.

A.8.6 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.

A.8.7 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.

A.8.8 The curriculum of the initial training course or the retraining course may be reduced 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.

A.8.9 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. All students shall participate in ungraded hands-on demonstrations and exercises.

A.8.10 All instructor students shall be trained and tested to the level of operator, inspector, and instructor.

A.8.11 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.

A.8.12 The instructor or the instructor's organization shall maintain training records for all students they have trained for a minimum of five years.

NASA-STD-8739.6A Change 1 – 2017-05-31

A.8.13 Training equipment does not require regular calibration, however, it shall be maintained and checked in a manner that ensures that 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.

A.8.14 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.

A.8.15 A training package 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.

A.8.16 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.

A.8.17 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.
- d. Not duplicate IPC[®] copyrighted material.

A.8.18 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.

NASA-STD-8739.6A Change 1 – 2017-05-31

A.8.19 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 A.11 and A.12 herein.

A.8.20 Initial training courses, except for ESD control, shall not be primarily computer-based courses without the use of an instructor.

A.8.21 Retraining courses may use computer-based content; however, they shall also include practical, hands-on content that has been evaluated by a certified instructor.

A.8.22 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.

A.8.23 The supplier is responsible for the effectiveness of computer-based or distance-learning arrangements (also see A.8.18).

A.9 Training Program Requirements, NASA Training Centers

A.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.

A.9.2 JPL's representative on the NASA WSTC is responsible for ensuring compliance by the W-NMTTC with the requirements herein.

A.9.3 The NASA Center's representative on the NASA WSTC is responsible for ensuring compliance by Level B instructors working on behalf of their Center with the requirements herein.

A.9.4 The responsible parties described in A.9.1 through A.9.3 shall:

- a. Ensure that their NASA Level A and NASA Level B instructors are provided 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 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 as a minimum:
 - (1) The name of each workmanship course given.
 - (2) The number of students who attended each course.

NASA-STD-8739.6A Change 1 – 2017-05-31

(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.

A.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 A.7).

A.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.

A.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).

A.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. Course prerequisites including:
 - (1) Required visual acuity testing prior to course attendance.
 - (2) Limitations on enrollment in retraining classes based on date of last training (maximum time elapsed is twenty-four (24) months, see paragraph A.8.7).
- e. 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.
- f. Rules on course attendance (e.g., lateness, missed time).

NASA-STD-8739.6A Change 1 – 2017-05-31

A.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.

A.10 IPC[®] Training

The IPC[®] training programs are designed and controlled by the IPC[®]. IPC[®] training materials may be augmented but not modified due to copyright limitations.

A.11 Courses

A.11.1 Course material shall accurately and completely represent the requirements statements in the applicable standards.

A.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.

A.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.

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

A.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.

A.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, etc.).
- d. Demonstrate the student's ability to achieve compliant features and/or recognize defects.

NASA-STD-8739.6A Change 1 – 2017-05-31

- e. Assess the student's retention and understanding of the requirements.
- f. Assess Level B instructor candidates' abilities to teach the material.

A.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).

A.11.7 Class time shall be provided to the Level B instructor students to allow them to demonstrate adequate instructor skills.

A.11.8 Course content shall be available for review and approval by the NASA Workmanship Standards Program Manager and/or the local responsible WSTC member (See A.9.3).

A.11.9 Course content deemed inappropriate or insufficient by the Workmanship Standards Program Manager and/or the local responsible WSTC member (See A.9.3) shall not be used.

A.11.10 Courses shall be limited to teaching only one NASA-STD document. Overview classes which introduce the content of several or all of the NASA workmanship standards are not within the scope of this NASA-STD.

A.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.

NASA-STD-8739.6A Change 1 – 2017-05-31

A.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 A-1.

Table A-1. Recommended Course Lengths

Course	Initial Training Class Duration Operators & Inspectors	Instructors	Re-training Class Duration
Polymeric Operations (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).

A.12 Student Requirements

A.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.

A.12.2 Level B instructor students shall successfully demonstrate the requisite skill needed to demonstrate the practical exercises.

A.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 paragraph A.7 prior to training or retraining.

NASA-STD-8739.6A Change 1 – 2017-05-31

A.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.

A.12.4.1 A passing grade for written exams shall be 80% and above.

A.12.4.2 A passing grade for the practical exams shall be 85% and above.

A.12.4.3 Written and practical scores shall not be averaged.

A.12.4.4 To pass the class, the student shall pass both the written and the practical exams.

A.12.4.5 The 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.

A.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 considered detrimental to the required level of training by the instructor.

A.12.5.1 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.12.5.2 A dismissed student forfeits all course costs.

A.13 Enrollment

A.13.1 Students shall be able to enroll in workmanship standards courses by mail, email, and phone.

A.13.2 See Section A.8.5 and A.8.6 above for timing restrictions associated with registering for retraining courses and A.7.2 for expiration limits on vision test results. Current vision test results are a prerequisite for workmanship training.

A.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. Prior to enrollment, the evidence provided shall be analyzed to ensure the prior training was not a limited training course per A.8.10 and was obtained from a valid source. Level B instructors shall have been trained by a NASA Level A instructor or certified by a NASA WSTC member.

A.14 Applicability of Training

A.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.

NASA-STD-8739.6A Change 1 – 2017-05-31

A.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 or from a supplier's Level B instructor).

APPENDIX B. TYPES OF NASA WORKMANSHIP INSTRUCTORS

B.1 NASA Workmanship Instructors

B.1.1 Instructors may have working conditions which dictate their training audience. Table B-1 below clarifies the permitted functions of various workmanship instructors, and their associated certification requirements.

Table B-1. Types of NASA Workmanship Instructors

Designation →	Level A	Level B	Level B
Practices where?	NMTTC-E or NMTTC-W (A.1.2)	SMA-Sponsored Training Center	In contractor or NASA facility
Trains whom?	All types of students ^{1/} (3.2, A.2.1.g)	All operators and inspectors ^{1/} (3.2, A.2.1.d, A.2.2)	Operators and inspectors who work for the instructor’s employer or work for a subcontractor of the instructor’s employer (3.2, A.2.1.d)
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 Program Technical Committee (WSTC) member for that Center or their delegate (A.3.4)	The employer of the instructor (A.3.1)
Certification required?	Yes, at least once	Yes, at least once (A.3.4)	No
Retraining required?	Yes, biennially (A.6.4)	Yes, every 24 months or via an audit (A.6.2 and A.6.3)	Yes, every 24 months (A.6.2)
Review and concurrence required for final drafts of updates to standards?	Yes (A.6.4)	Yes (A.6.3)	No

^{1/} special conditions apply for training students who are foreign nationals (A.9.6, A.9.7)