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1.0 General

1.1 Scope This standard prescribes practices and requirements for the manufacture of cable, wire and harness assemblies. This standard does not provide criteria for cross-section or X-ray evaluation. For X-ray guidelines, see Appendix D X-Ray Guidelines.

If a conflict occurs between the English and translated versions of this document, the English version will take precedence.

The illustrations in this document portray specific points noted in the title of each section. The development committee recognizes that different parts of the industry have different definitions for some terms used herein. For the purposes of this document, the terms cable and wire harness are used interchangeably.

IPC/WHMA-A-620 can be used as a stand-alone document for purchasing products, however it does not specify frequency of in-process inspection or frequency of end product inspection. No limit is placed on the number of process indicators or the number of allowable repair/rework of defects. Such information should be developed with a statistical process control plan (see IPC-9191).

1.2 Purpose This standard describes materials, methods, tests and acceptability criteria for producing crimped, mechanically secured, or soldered interconnections and the related assembly activities associated with cable and harness assemblies.

The intent of this document is to rely on process control methodology to ensure consistent quality levels during the manufacture of products.

Any method that produces an assembly conforming to the acceptability requirements described in this standard may be used.

Standards may be updated at any time, including with the use of amendments. The use of an amendment or newer revision is not automatically required. The revision in effect **shall [D1D2D3]** be as specified by the User.

1.3 Classification Use of this standard requires agreement on the Class to which the product belongs. The User has the ultimate responsibility for identifying the Class to which the assembly is evaluated. If the User does not establish and document the acceptance Class, the Manufacturer may do so. Criteria defined in this standard reflect three Product Classes, which are as follows:

Class 1 General Electronic Products

Includes products suitable for applications where the major requirement is the function of the completed assembly.

Class 2 Dedicated Service Electronic Products

Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end-use environment would not cause failures.

Class 3 High Performance/Harsh Environment Electronic Products

Includes products where continued performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support systems and other critical systems.

1.4 Measurement Units and Applications This document uses the International System of Units (SI) in accordance with IEEE/ASTM SI 10, American National Standard for Metric Practice (Section 3). Imperial English equivalent units follow in brackets. The derived SI units used in this document are millimeters (mm) [in] for dimensions and dimensional tolerances, Celsius (°C) [°F] for temperature and temperature tolerances, grams (g) [oz] for weight, and lux (lx) [foot-candles] for illuminance.

1.4.1 Verification of Dimensions Where not specifically invoked by this standard, actual measurements, e.g., of specific solder fillet dimensions, determination of damage and wrap percentages, are not required except for referee purposes.

1.5 Definition of Requirements The words “**shall**” or “**shall not**” are used in the text of this document wherever there is a requirement for materials, process or acceptance of cable, wire and harness assemblies.

Where the words “**shall**” or “**shall not**” indicates a requirement for at least one Class, the requirements for each Class are in brackets next to the “**shall**” or “**shall not**” requirement.

N = No requirement has been established for this Class

A = Acceptable

P = Process Indicator

D = Defect

Examples:

[A1P2D3] is Acceptable Class 1, Process Indicator Class 2 and Defect Class 3

[N1D2D3] is Requirement Not Established Class 1, Defect Classes 2 and 3

1.0 General (cont.)

[A1A2D3] is Acceptable Classes 1 and 2, Defect Class 3

[D1D2D3] is Defect for all Classes.

Unless specifically stated otherwise, a defect for a Class 1 product means that the characteristic is also a defect for Class 2 and 3. A defect for a Class 2 product means that the characteristic is also a defect for a Class 3 product, but may not be a defect for a Class 1 product where less demanding criteria may apply.

The word “should” reflects recommendations and is used to reflect general industry practices and procedures for guidance only.

Many of the examples (figures) shown are grossly exaggerated to clearly depict the condition being described. Line drawings and illustrations are depicted herein to assist in the interpretation of the written requirements of this standard, many of these examples (figures) are grossly exaggerated to clearly depict the condition being described.

In the case of a discrepancy, the written description or written criteria always takes precedence over the illustrations.

1.5.1 Inspection Conditions The inspector **shall not [D1D2D3]** select the Product Class for the assembly under inspection. Documentation that specifies the applicable Class for the assembly under inspection **shall [D1D2D3]** be provided to the inspector. Criteria are given for each Product Class in three conditions: Acceptable, Defect or Process Indicator.

1.5.1.1 Acceptable This characteristic indicates a condition that, while not necessarily perfect, will maintain the integrity and reliability of the assembly in its service environment.

1.5.1.2 Defect A defect is a condition that fails to meet the acceptance criteria of this document or negatively affects the form, fit or function of the assembly in its end use environment. The Manufacturer **shall [N1D2D3]** document and disposition each defect.

It is the responsibility of the Manufacturer to identify defects that are unique to the assembly process. It is the responsibility of the User to define unique defect categories applicable to the product.

1.5.1.2.1 Disposition Disposition is the determination of how defects should be treated. Dispositions include, but are not limited to, rework, use as is, scrap or repair.

User concurrence **shall [N1D2D3]** be required for use as is and **shall [N1N2D3]** be required for repair dispositions.

1.5.1.3 Process Indicator A process indicator is a condition that identifies a characteristic that does not affect the form, fit, function or reliability of a product. A process indicator is not a defect.

- Such condition is a result of material, design and/or operator/machine related causes that create a condition that neither fully meets the acceptance criteria nor is a defect.
- Process indicators should be monitored as part of the process control system. If the number of process indicators indicates an abnormal variation in the process, identifies an undesirable trend, or displays other conditions that indicate the process is (or is approaching) out of control, the process should be analyzed. This may result in action to reduce the variation and improve yields.
- Disposition of individual process indicators is not required and affected product should be used as is.
- Not all process indicators are specified by this standard.
- It is the responsibility of the Manufacturer to identify process indicators that are unique to the assembly process.

1.5.1.4 Conditions Not Specified Conditions that are not specified are considered acceptable unless it can be established that the condition affects end user defined form, fit, function or reliability.

1.5.1.5 Uncommon or Specialized Designs IPC/WHMA-A-620, as an industry consensus document, cannot address all of the possible product design combinations. However, the standard does provide criteria for commonly used technologies. Where uncommon or specialized technologies are used, it may be necessary to develop unique acceptance criteria. The development should include User involvement. The acceptance criteria **shall [N1N2D3]** have User agreement. Requirements for specialized processes and/or technologies not specified herein **shall [N1D2D3]** be performed in accordance with documented procedures which are available for review.

Whenever possible, new criteria or criteria on specialized products should be submitted, using the Standard Improvement Form included in this standard, to the IPC Technical Committee to be considered for inclusion in upcoming revisions of this standard.

1.0 General (cont.)

1.5.2 Material and Process Nonconformance Material and process nonconformance differs from hardware defects or hardware process indicators in that the material/process nonconformance often does not result in an obvious change in the hardware's appearance but can impact the hardware's performance, e.g., contaminated solder, incorrect solder alloy (per engineering documentation/procedure), chemical stripping of stranded wire.

Hardware found to be produced using either materials or processes that do not conform to the requirements of this standard **shall [D1D2D3]** be classified as defects and dispositioned. This disposition **shall [D1D2D3]** address the potential effect of the nonconformance on functional capability of the hardware such as reliability and design life (longevity).

1.6 Process Control The primary goal of process control is to continually reduce variation in the processes, products, or services to provide products or processes meeting or exceeding customer requirements. Process control tools such as IPC-9191, EIA-557-1 or other user-approved system may be used as guidelines for implementing process control.

Class 3 **shall [N1N2D3]** develop and implement a documented process control system. A documented process control system, if established, **shall [N1D2D3]** define process control and corrective action limits. This may or may not be a statistical process control system, see 1.6.1 Statistical Process Control. The use of statistical process control (SPC) is optional and should be based on factors such as design stability, lot size, production quantities, and the needs of the company. Manufacturers **shall [N1D2D3]** perform 100% inspection unless a sampling inspection plan is defined as part of a documented process plan.

Process control methodologies **shall [N1D2D3]** be used in the planning, implementation and evaluation of the manufacturing processes used to produce cables and wire harness assemblies. The philosophy, implementation strategies, tools and techniques may be applied in different sequences depending on the specific company, operation, or variable under consideration to relate process control and capability to end product requirements.

When a decision or requirement is to use a documented process control system, failure to implement process corrective action and/or the use of continually ineffective corrective actions **shall [N1D2D3]** be grounds for disapproval of the process and associated documentation.

1.6.1 Statistical Process Control When a statistical process control system is used, it **shall [D1D2D3]** include the following elements as a minimum:

- Training is provided to personnel with assigned responsibilities in the development, implementation, and utilization of process control and statistical methods that are commensurate with their responsibilities.
- Quantitative methodologies and evidence is maintained to demonstrate that the process is capable and in control. Improvement strategies define initial process control limits and methodologies leading to a reduction in the occurrence of process indicators in order to achieve continuous process improvement.
- Criteria for switching to sample based inspection is defined. When processes exceed control limits, or demonstrate an adverse trend or run, the criteria for reversion to higher levels of inspection (up to 100%) is also defined.
- When defect(s) are identified in the lot sample, and the number exceeds the limit allowed by the sampling plan, the entire lot is 100% inspected for the occurrence(s) to the defect(s).
- A system is in place to initiate corrective action for the occurrence of process indicators, out-of-control process(es), and/or discrepant assemblies.
- A documented audit plan is defined to monitor process characteristics and/or output at a prescribed frequency.
- Objective evidence of process control may be in the form of control charts or other tools and techniques of statistical process control derived from application of process parameter and/or product parameter data.

1.7 Order of Precedence In the event of conflict, the following order of precedence applies:

- 1) Procurement as agreed between User and Manufacturer.
- 2) Engineering documentation reflecting the User's detailed requirements.
- 3) When invoked by the User or per contractual agreement, IPC/WHMA-A-620.

The developing committee recognizes that some requirements in IPC/WHMA-A-620 differ from those in other industry standards such as IPC-A-610 and J-STD-001. When IPC/WHMA-A-620 is cited or required by contract as a stand-alone document for inspection and/or acceptance, the requirements of J-STD-001 or IPC-A-610 do not apply unless separately and specifically

1.0 General (cont.)

required. When IPC/WHMA-A-620, J-STD-001, IPC-A-610 and/or other related documents are cited, the order of precedence should be defined in the procurement documents. If not defined in the procurement documents, the manufacturer should negotiate order of precedence with the User.

The User has the opportunity to specify alternate acceptance criteria.

1.7.1 Clause References When a clause in this standard is referenced, its subordinate clauses also apply.

When sections of this standard are referenced in other parts of the document, then the criteria of that referenced section apply.

1.7.2 Appendices Appendix A applies, see also 1.8 Terms and Definitions. Other appendices to this standard are not binding requirements unless separately and specifically required by the applicable contracts, engineering documentation, or purchase orders.

1.8 Terms and Definitions Terms are consistent with the definitions provided by IPC-T-50. For the understanding of this document, selected definitions pertaining specifically to cable and wire harness manufacturing are listed below and in Appendix A.

1.8.1 FOD (Foreign Object Debris) A generic term for a substance, debris, particulate matter or article alien to the assembly or system.

1.8.2 Inspection An evaluation of quality characteristics relating to a standard or engineering documentation.

1.8.3 Manufacturer (Assembler) The individual, organization, or company responsible for the assembly process and verification operations necessary to ensure full compliance of assemblies to this standard.

1.8.4 Objective Evidence Documentation in the form of hard copy, computer data, video, or other media.

1.8.5 Process Control A system or method to continually steer an operation in reducing variation in the processes or products to meet or exceed the goal in quality and performance.

1.8.6 Supplier The individual, organization or company which provides to the Manufacturer (assembler) components (cables, wire harnesses, electronic, electromechanical, mechanical, printed boards, etc.) and/or materials (solder, flux, cleaning agents, etc.).

1.8.7 User The individual, organization, company, contractually designated authority or agency responsible for the procurement of electrical/electronic hardware, cables and wire harnesses, etc., and having the authority to define the Product Class and any variation or restrictions to the requirements of this standard, i.e., the originator/custodian of the contract detailing these requirements.

1.8.8 Diameter

1.8.8.1 Conductor Diameter The conductor diameter is the outside diameter of wire, either stranded or solid, without the insulation.

1.8.8.2 Wire Diameter Wire diameter is the outside diameter of wire, either stranded or solid, including insulation if present.

1.8.8.3 Strand Diameter The strand diameter is the outside diameter of the individual metal filament used within a stranded wire.

1.8.9 Engineering Documentation Drawings, specifications, technical illustrations, and other documents, prepared and released by the design activity in any form of media, that establish the design and design requirements.

1.9 Requirements Flowdown When this standard is contractually required, the applicable requirements of this standard (including Product Class – see 1.3 Classification) **shall [D1D2D3]** be imposed on all applicable subcontracts, engineering documentation, and purchase orders. Unless otherwise specified the requirements of this standard are not imposed on the procurement of commercial-off-the-shelf (COTS) assemblies or subassemblies.

When a part is adequately defined by a specification, the requirements of this standard should be imposed on the manufacture of that part only when necessary to meet end-item requirements. When it is unclear where flowdown should stop, the flowdown requirements **shall [D1D2D3]** be established between the Manufacturer and the User. When an assembly is procured, that assembly should meet the requirements of this standard. If the assembly is manufactured by the same Manufacturer, the requirements are as stated in the contract for the entire assembly.

1.0 General (cont.)

1.10 Personnel Proficiency All instructors, operators, and inspection personnel **shall [D1D2D3]** be proficient in the tasks to be performed. Objective evidence of that proficiency **shall [D1D2D3]** be maintained and available for review. Objective evidence should include records of training to the applicable job functions being performed, work experience, testing to the requirements of this standard, and/or results of periodic reviews of proficiency. Supervised on-the-job training is acceptable until proficiency is demonstrated.

1.11 Acceptance Requirements All products **shall [D1D2D3]** meet the requirements of the contracts, engineering documentation, applicable standards, and the requirements for the applicable Product Class specified herein.

1.12 Inspection Methodology

1.12.1 Process Verification Inspection Process verification inspection **shall [N1N2D3]** consist of the following:

- Surveillance of the operation to determine that practices, methods, procedures and a written inspection plan are being properly applied.
- Inspection to assess conformance to the standard.

1.12.2 Visual Inspection The assembly **shall [N1D2D3]** be evaluated in accordance with the established process control system, see 1.6 Process Control, or by 100% visual inspection, see 1.6.1.c. Statistical Process Control and 1.11 Acceptance Requirements.

1.12.2.1 Lighting Illumination at the surface of workstations should be at least 1000 lux [approximately 93 foot-candles]. Supplemental lighting may be necessary to assist in visual inspection. Light sources should be selected to prevent shadows on the item being inspected except those caused by the item being inspected.

Note: In selecting a light source, the color temperature of the light is an important consideration. Light ranges from 3000-5000 K enable Users to distinguish various metal and plating features and contaminants with increased clarity.

1.12.2.2 Magnification Aids Magnification power for assembly inspection **shall [A1P2D3]** be at least the minimum inspection power specified in Table 1-1 and Table 1-2. Other magnification powers within the inspection range may be used. The magnification power requirement is based on the gauge of the wire being inspected. For assemblies with mixed wire sizes, the greater magnification may be used for the entire assembly. If the presence of a defect cannot be determined at the inspection power, the item is acceptable. The referee magnification power is intended for use only after a defect has been determined but is not completely identifiable at the inspection power.

The tolerance for magnification aids is $\pm 15\%$ of the selected magnification power. Magnification aids should be maintained and calibrated as appropriate (see IPC-OI-645).

Table 1-1 Magnification Aid Applications – Wire and Wire Connections¹

Wire Size AWG Diameter mm [inch]	Magnification Power	
	Inspection Range	Maximum Referee
Larger than 14 AWG >1.63 mm [0.064 in]	N/A	1.75X
14 to 22 AWG 1.63 — 0.64 mm [0.064 to 0.025 in]	1.5X — 3X	4X
<22 to 28 AWG <0.64 mm — 0.32 mm [<0.025 — 0.013 in]	3 — 7.5X	10X
Smaller than 28 AWG <0.32 mm [<0.013 in]	10X	20X

Note 1: Referee magnification power is intended to be used only to verify a product rejected at the inspection magnification. For assemblies with mixed wire size, the greater magnification may be (but is not required to be) used for the entire assembly.

1.0 General (cont.)

Table 1-2 Magnification Aid Applications – Other

Cleanliness (cleaning or no-clean processes)	Magnification not required, Note 1
Encapsulation, Staking	Magnification not required, Notes 1, 2
Component	Magnification not required, Notes 1, 2
Marking	Magnification not required, Note 2

Note 1: Visual inspection may require the use of magnification, e.g., for very small features, to determine if the contamination or anomaly affects form, fit or function.

Note 2: If magnification is used it is limited to 4X maximum.

1.13 Facilities Work areas **shall [D1D2D3]** be maintained at levels that prevent contamination or deterioration of tools, materials, and work surfaces. Eating, drinking, smoking, including use of e-cigarettes, and/or use of tobacco products **shall [D1D2D3]** be prohibited in the work area.

For operator comfort and solderability maintenance, the temperature should be maintained between 18 °C [64.4 °F] and 30 °C [86 °F] and the relative humidity should not exceed 70%. For process control, more restrictive temperature and humidity limits may be required.

1.13.1 Field Assembly Operations In field assembly operations where the controlled environmental conditions required by this standard cannot be effectively achieved, precautions **shall [N1D2D3]** be taken to minimize the effects of the uncontrolled environment on the operation being performed on the hardware.

1.13.2 Health and Safety The use of some materials and processes used to meet the requirements of this standard may be hazardous or may cause injury. To provide for personnel and environmental safety, follow the applicable plant requirements and government regulations.

1.14 Electrostatic Discharge (ESD) Protection If there are any assemblies that contain components or parts sensitive to ESD, the Manufacturer **shall [D1D2D3]** implement a documented ESD control program in accordance with ANSI/ESD-S20.20, IEC-61340-5 or as otherwise specified. Documentation necessary for an effective program **shall [D1D2D3]** be available for review.

When processing ESD sensitive assemblies, the Manufacturer **shall [N1D2D3]** verify that electrostatic discharge control is adequate when humidity decreases to a level of 30% or lower.

Note: This includes selection and use of devices such as connector covers, etc.

1.15 Tools and Equipment

1.15.1 Control Each Manufacturer **shall [D1D2D3]**:

- Select tools to be used for crimping, cabling, wiring, measuring, soldering, inspecting and in work preparation areas appropriate to the intended function.
- Clean and properly maintain all tools and equipment.
- Examine all elements of tools for physical damage.
- Prohibit unauthorized, defective, or uncalibrated tools in the work area.
- Document detailed operating procedures and maintenance schedules for tools and equipment requiring calibration or set-ups.
- Maintain records of tool and equipment calibration and functional testing.
- Assure test fixtures, test adapters, and test equipment are maintained to assure the integrity of the test.
- Assure process tooling and process equipment are maintained to assure acceptability of the product.
- Assure lead/wire cutting tools do not impart shock that causes damage.

Soldering irons, equipment, and systems **shall [D1D2D3]** be chosen and employed to provide temperature control and isolation from electrical overstress or ESD when ESD sensitive parts or assemblies are involved.

See Appendix C Guidelines for Soldering Tools and Equipment for guidelines on tool selection and maintenance.

1.0 General (cont.)

1.15.2 Calibration Torque tools, measuring equipment, and mechanical and electrical test equipment (including contact retention testers) **shall [N1D2D3]** be calibrated.

Crimping tools **shall [N1D2D3]** be calibrated or validated using a documented process.

The Manufacturer **shall [N1D2D3]** have a documented calibration system in accordance with the current revision of ISO/IEC 17025 or other National or International standard. The minimum standard **shall [N1D2D3]** assure:

- a. Measurement standards used for calibrating tools are traceable to National Institute of Standards and Technology (NIST) or other National or International standard. Calibration of tools is performed in an environment compatible with the environmental requirements of the tools.
- b. Calibration intervals are based on the type of tool and records of the tool's calibration. Intervals may be lengthened or shortened on the basis of stability demonstrated over previous calibration periods.
- c. Procedures are generated and utilized for the calibration of all tooling stated herein. Procedures include, as a minimum, standards to be used, parameters to be measured, accuracy, tolerances, environmental factors, and steps in the calibration process. The procedures may be the Supplier's specifications if judged adequate, and need not therefore be rewritten, but are documented.
- d. Records are maintained that document calibration.
- e. Tools are labeled to indicate, as a minimum:
 - 1) Date of calibration.
 - 2) Calibration due date.
 - 3) Any limitation of use. If not practical to place the label directly on the tool, then the label is affixed to the tool container or other location as documented in the procedures.
 - 4) Tool identification.

1.16 Materials and Processes The materials and processes used to assemble/manufacture cable and wire harness assemblies **shall [D1D2D3]** be selected such that their combinations produce products acceptable to this standard. When major elements of the proven processes are changed, e.g., flux, cleaning media or system, soldering system, tooling, marking, etc., validation of the acceptability of the change(s) **shall [N1N2D3]** be performed and documented.

Limited shelf life items **shall [D1D2D3]** be stored and controlled in accordance with material suppliers' recommendations, or in accordance with the Manufacturer's documented procedures for controlling shelf life and shelf life extensions. The material manufacturer's instructions or other documented procedure **shall [N1D2D3]** be followed for mixing and curing. Material **shall [D1D2D3]** be used within the pot life (working time) specified by the material supplier or used within the time period indicated by a documented system. When curing conditions (temperature, time, infrared (IR) intensity, etc.) vary from the material supplier's recommended instructions, they **shall [D1D2D3]** be documented and available for review.

Equipment used for measuring viscosity, mixing, applying and curing silicone material **shall not [D1D2D3]** be used for processing other material.

The electrical and mechanical integrity of components and assemblies **shall [D1D2D3]** be retained after exposure to processes employed during manufacture and assembly, e.g., handling, baking, fluxing, soldering, and cleaning.

1.17 Electrical Clearance Violation of minimum electrical clearance **shall [D1D2D3]** be a defect. For the definition of Electrical Clearance, see Appendix A Terms and Definitions.

1.18 Contamination Assemblies produced in accordance with this standard **shall [D1D2D3]** be free of FOD/contamination (including but not limited to, wire clippings, insulation slugs, strands of shielding braid, green residue or any other item not required to be present). See 4.2 Cleanliness for cleanliness criteria specific to soldered assemblies.

Note: The four common sources for green residue on electronics are Copper Abietate, Copper (II) Chloride, Copper Fluoride, and Copper Phthalate. The appearance of green residue is a possible indicator of material breakdown, contamination, or corrosion, and the effect on performance and reliability may be benign or serious, depending on the chemical makeup and hardware service environment.

Handling of cleaned assemblies **shall [N1N2D3]** preclude recontamination.

1.0 General (cont.)

FOD control program documents such as IPC-WP-116, AS9146, or other User approved documents may be used as guidelines for implementing FOD control.

1.19 Rework/Repair In the event a rework or repair action takes place, any tests/inspections that were previously performed **shall [D1D2D3]** be repeated in their entirety for the portion of the product that was affected by the rework or repair.

1.19.1 Rework Rework is the act of reprocessing in a manner that assures full compliance to applicable engineering documentation. Rework **shall [N1N2D3]** be documented. Rework **shall [D1D2D3]** meet all applicable requirements of this standard. Rework does not include a second application of a soldering iron during a hand soldering operation on a single connection.

Proper soldering technique, including limiting the time on the connection and the amount of heat applied, is critical in preventing damage to the assembly. Control of hand soldering **shall [N1N2D3]** include operator training and process controls. See 1.10 Personnel Proficiency.

1.19.2 Repair Repair is the act of restoring the functional capability of a defective article in a manner that does not assure compliance of the article with applicable engineering documentation. Repairs **shall [N1D2D3]** be conducted in accordance with a documented procedure. The repair method **shall [N1D2D3]** be determined by agreement between the Manufacturer and the User.

1.19.3 Post Rework/Repair Cleaning After rework or repair, assemblies **shall [N1N2D3]** be cleaned as necessary. A process **shall [N1N2D3]** be established for post rework/repair cleanliness validation.

2.0 Applicable Documents

The following documents, of the issue in effect on the invitation for bid, form a part of this specification to the extent specified herein.

2.1 IPC¹

IPC-9191 General Guidelines for Implementation of Statistical Process Control (SPC)

IPC-A-610 Acceptability of Electronic Assemblies

IPC-AJ-820 Assembly and Joining Handbook

IPC-CH-65 Guidelines for Cleaning of Printed Boards and Assemblies

IPC-OI-645 Standard for Visual Optical Inspection Aids

IPC-SM-817 General Requirements for Dielectric Surface Mounting Adhesives

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC-WP-116 Guidance for the Development and Implementation of a Foreign Object Debris (FOD) Control Plan

2.2 Joint Industry Standards²

J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

J-STD-002 Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

J-STD-004 Requirements for Soldering Fluxes

J-STD-006 Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications

2.3 Society of Automotive Engineers (SAE)³

SAE ARP 914A Glossary of Electrical Connection Terms

SAE ARP 1931A Glossary of Terms with Specific Reference to Electrical Wire and Cable

SAE AS50881 Wiring Aerospace Vehicle

SAE AS567 Safety Cable, Safety Wire, Key Washers, and Cotter Pins for Propulsion Systems, General Practices for Use of

SAE AS9146 Foreign Object Damage (FOD) Prevention Program – Requirements For Aviation, Space, and Defense Organizations

SAE AS22759 Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy

2.4 American National Standards Institute (ANSI)⁴

ISO/IEC 17025 General Requirements For The Competence of Testing And Calibration Laboratories

¹ www.ipc.org

² www.ipc.org

³ www.sae.org

⁴ www.ansi.org

2.5 International Organization for Standardization (ISO)⁵

ISO 8815 Aircraft Electrical Cables and Cable Harnesses – Vocabulary

2.6 ESD Association (ESDA)⁶

ANSI/ESD-S20.20 ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment

2.7 United States Department of Defense (DoD)⁷

MIL-DTL-17 General Specification for Cables, Radio Frequency, Flexible and Semirigid

MIL-STD-1130 Department of Defense Standard Practice: Connections, Electrical, Solderless, Wrapped

2.8 International Electrotechnical Commission (IEC)⁸

IEC 61340-5 Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements

2.9 Aerospace Industries Association (AIA/NAS)⁹

NASM33540 Safety Wiring, Safety Cabling, Cotter Pinning, General Practices For

NAS412 Foreign Object Damage/Foreign Object Debris (FOD) Prevention

2.10 Electronics Industries Alliance¹⁰

EIA-557-1 Guidance for the Selection of Critical Manufacturing Operations for Use in Implementing an SPC System for Passive Components

2.11 ASTM International¹¹

IEEE/ASTM SI 10 American National Standard for Metric Practice

2.12 Institute of Electrical and Electronics Engineers¹²

IEEE/ASTM SI 10 American National Standard for Metric Practice

⁵ www.iso.org

⁶ www.esda.org

⁷ <https://assist.daps.dla.mil/quicksearch>

⁸ www.iec.ch

⁹ www.aia-aerospace.org

¹⁰ www.eia.org

¹¹ www.astm.org

¹² www.ieee.org

3.0 Wires

3.0 Wires

The requirements and acceptance criteria in this section apply to wires regardless of when they occur during manufacturing, installation and/or testing.

3.1 Stripping

Wire insulation may be removed using chemical, thermal (including laser) or mechanical strippers using a manual, semi or fully automated process.

Chemical insulation stripping agents **shall** [D1D2D3]:

- Be used only for solid wires.
- Be neutralized or removed prior to tinning or soldering.

Note: To prevent continuing degradation of the wire surface, the residue of chemical insulation stripping products should be removed within three hours of the completion of chemical stripping.

3.2 Strand Damage and End Cuts

Strand damage can lead to degraded performance. The number of damaged (scraped, nicked or severed) strands in a single wire **shall not** [D1D2D3] exceed the limits of Table 3-1.

As an exception to Table 3-1:

- Partial or incomplete cuts of strand groups **shall not** [A1A2D3] be in the crimp contact area.
- Partial cuts of a strand group **shall not** [A1A2D3] prevent contact of the strand group for the full length of a required wrap.

Conductors **shall not** [N1D2D3] be cut or modified in any manner to reduce circular mil area (CMA) to fit a termination.

Damaged wires that do not exceed the limits specified in Table 3-1 are considered process indicators for Classes 2 & 3.

Note: See 13.1 Stripping and 15.1 Braided for shield strand damage criteria.

3.2 Strand Damage and End Cuts (cont.)

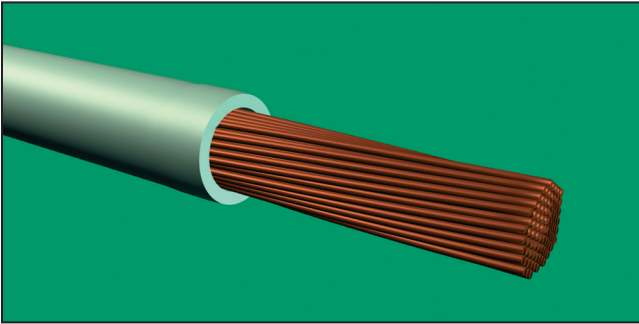


Figure 3-1

Acceptable – Class 1,2,3

- Attached burrs that will not be dislodged during process or operation.

Acceptable – Class 1

Process Indicator – Class 2,3

- Strands cut, broken, scraped or severed if the number of damaged or broken strands in a single wire does not exceed the limits in Table 3-1.

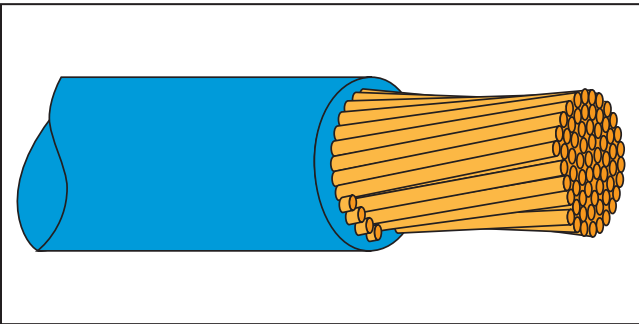


Figure 3-2

3.0 Wires

3.2 Strand Damage and End Cuts (cont.)

Table 3-1 Allowable Strand Damage^{1,2,3}

Number of Strands	Maximum allowable strands scraped, nicked or severed for Class 1,2	Maximum allowable strands scraped, nicked or severed for Class 3 for wires that will not be tinned before installation	Maximum allowable strands scraped, nicked or severed for Class 3 for wires that will be tinned prior to installation
1 (solid conductor)	No damage in excess of 10% of conductor diameter		
2–6	0	0	0
7–15	1	0	1
16–25	3	0	2
26–40	4	3	3
41–60	5	4	4
61–120	6	5	5
121 or more	6%	5%	5%

Note 1: No damaged strands for wires used at a potential for 6 kV or greater.

Note 2: For plated wires, a visual anomaly that does not expose basis metal is not considered to be strand damage.

Note 3: Nicks or scrapes less than 10% of the individual strand diameter are not considered to be strand damage.

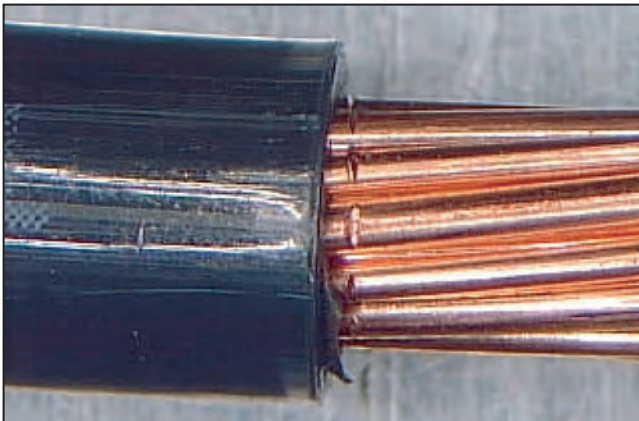


Figure 3-3

Defect – Class 1,2,3

- Attached burrs may be dislodged during process or operation.
- Variation in strand length within a strand group that prevents installation to the full depth of the crimp contact area or solder cup.
- Damaged strands exceed the limits specified in Table 3-1.

3.3 Conductor Deformation/Birdcaging

Disturbed wire strands should be restored to approximate their original lay. Strands are not flattened, untwisted, buckled, kinked or otherwise deformed.

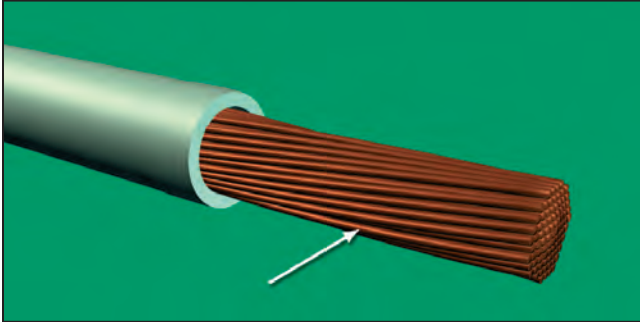


Figure 3-4

Acceptable – Class 1,2,3

- Wire strands have separation (birdcaging, shown by arrow in Figure 3-4) but:
 - do not exceed one strand diameter.
 - do not extend beyond wire insulation outside diameter.
- Where strands were straightened during the wire insulation removal, they have been restored to approximate the original spiral lay of the wire.
- Conductor strands are not kinked.

3.3 Conductor Deformation/Birdcaging (cont.)

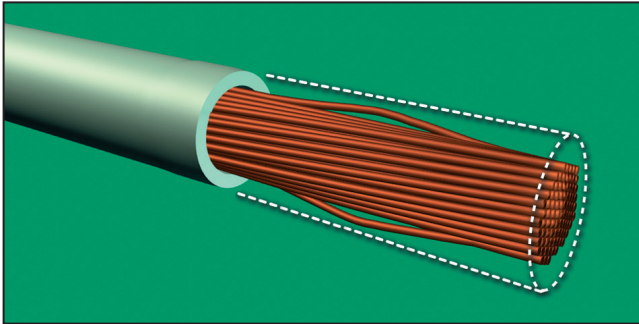


Figure 3-5

Acceptable – Class 1

Process Indicator – Class 2

Defect – Class 3

- Wire strands have separation exceeding one strand diameter but do not extend beyond wire insulation outside diameter.

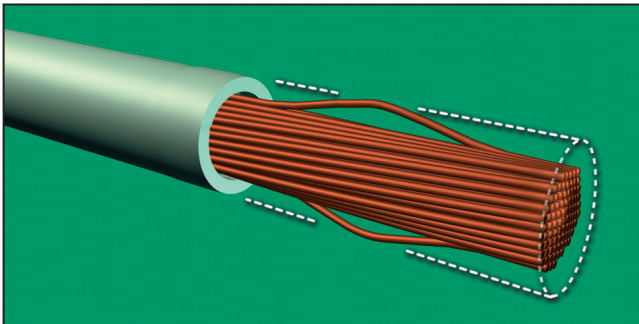


Figure 3-6

Acceptable – Class 1

Defect – Class 2,3

- The general spiral lay of the strands has not been maintained.
- Wire strands extend beyond wire insulation outside diameter.

Defect – Class 1,2,3

- Wire strands are kinked.

3.4 Twisting of Wires

When twisting is required, these criteria apply to all cable or harness bundles, whether they are twisted pairs of the same wire type and size, or cables incorporating various wire types and sizes. The length of lay (or “twist”) as measured from the midpoint of wire’s crossover through a complete spiral to the next crossover midpoint of the same wire **shall [D1D2D3]** be 8 to 16 times the outer diameter of the bundle (see Figure 3-7).

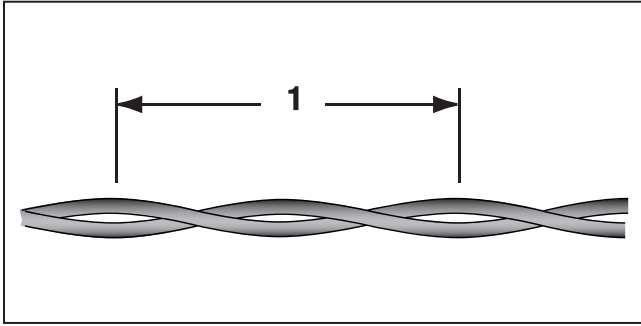


Figure 3-7

Acceptable – Class 1,2,3

- The length of lay for each twist is 8 to 16 times the outer diameter of the bundle.

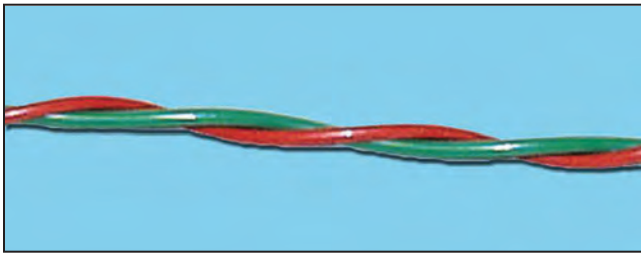


Figure 3-8

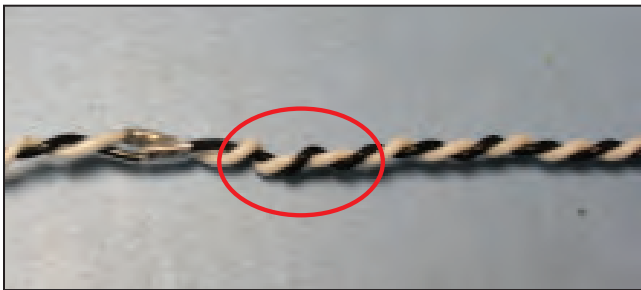


Figure 3-9

Defect – Class 1,2,3

- The length of lay for each twist is less than 8 or more than 16 times the outer diameter of the bundle.
- There is residual twist (over-twist, kinking) in individual wires (see Figure 3-9).

3.5 Insulation Damage – Stripping

Coatings added over insulation base material such as resin coatings over polyimide are not considered to be part of the insulation and these criteria are not intended to be applicable to those coatings.

The cut ends of some insulation materials, particularly those with a fiberglass barrier, may show fraying beyond the defect criteria in this document. Acceptability of this fraying beyond the defect criteria should be agreed upon between the User and Manufacturer.

These criteria are also applicable to post-assembly acceptance. Additional criteria for insulation damage as a result of soldering operations are provided in 4.5.2 Wire Insulation – Postsolder Damage.

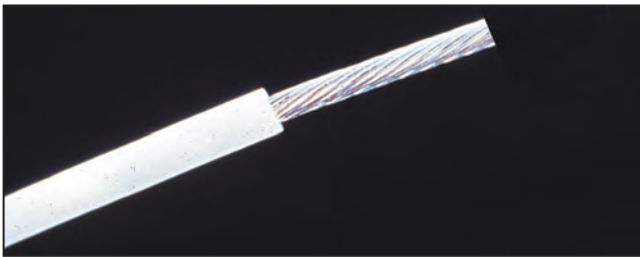


Figure 3-10

Acceptable – Class 1,2,3

- A slight, uniform impression in the insulation from the gripping of mechanical strippers.
- Chemical solutions, paste, and creams used to strip solid wires do not cause degradation to the wire.
- Discoloration of insulation resulting from thermal processing is permissible, provided it is not charred, cracked or split.

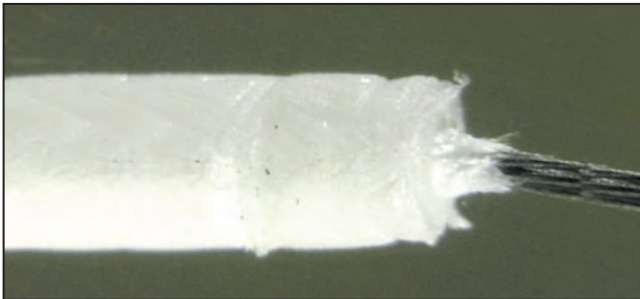


Figure 3-11

3.5 Insulation Damage – Stripping (cont.)

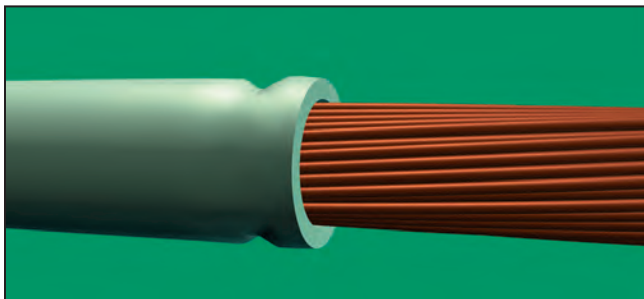


Figure 3-12

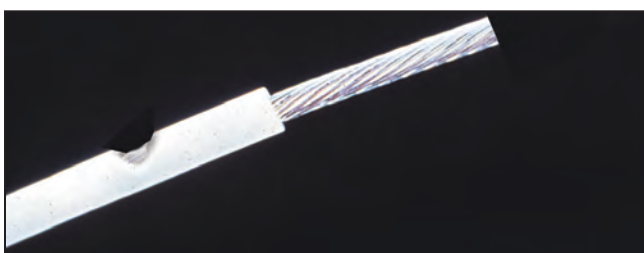


Figure 3-13

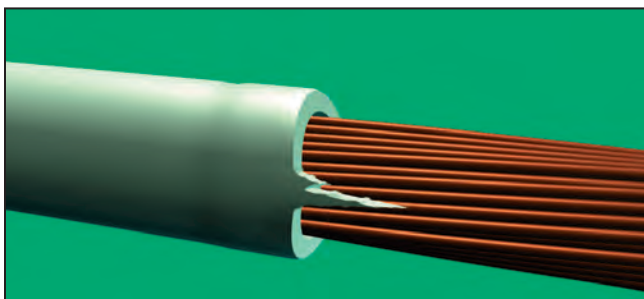


Figure 3-14

Defect – Class 1,2,3

- Insulation thickness is reduced by more than 20% (see Figures 3-12, 3-13).
- Uneven or ragged pieces of insulation (frays, tails, and tags) are greater than 50% of the wire diameter or 1 mm [0.039 in], whichever is more (see Figure 3-14).
- Insulation is charred (see Figure 3-15).
- Insulation is melted into the wire strands (see Figure 3-16).
- Any cuts, breaks, cracks or splits in insulation (see Figure 3-17).



Figure 3-15



Figure 3-16



Figure 3-17

4.0 Soldered Terminations

Criteria for forming soldered splices are provided in 8.0 Splices.

Criteria for heat shrinkable solder devices are provided in 8.0 Splices and 15.0 Harness/Cable Electrical Shielding.

4.1 Materials and Components

4.1.1 Materials and Components – Materials

See 1.16 Materials and Processes.

4.1.1.1 Materials and Components – Materials – Solder

Solder alloys **shall [D1D2D3]** be in accordance with J-STD-006 or equivalent. Flux that is part of flux-cored solder wire **shall [D1D2D3]** meet the requirements of 4.1.1.2 Materials and Components – Materials – Flux. Flux percentage is optional.

Solder alloys less than 0.1% Pb by weight not listed by J-STD-006 may be used when such use is agreed upon by the User and Manufacturer.

4.0 Soldered Terminations

4.1.1.1.1 Materials and Components – Materials – Solder – Solder Purity Maintenance

Solder used for preconditioning, gold removal, tinning of parts, and machine soldering **shall [N1D2D3]** be analyzed, replaced or replenished at a frequency to ensure compliance with the limits specified in Table 4-1.

Solder alloys other than Sn60Pb40, Sn62Pb36Ag2, or Sn63Pb37 **shall [N1D2D3]** be in compliance with equivalent documented limits.

If contamination exceeds the limits, intervals between the analyses, replacement or replenishment **shall [N1D2D3]** be shortened. The frequency of analysis should be determined on the basis of historical data or monthly analyses. Records containing the results of all analyses and solder bath usage, e.g., total time in use, amount of replacement solder, or area throughput, **shall [N1D2D3]** be maintained for a minimum of one year for each process/system.

SnPb alloys used for preconditioning or assembly **shall [N1D2D3]** have a tin content maintained within $\pm 1.5\%$ of the nominal alloy being used. Tin content for SnPb alloys **shall [N1D2D3]** be tested at the same frequency as testing for copper/gold contamination. The balance of the SnPb bath **shall [N1D2D3]** be Pb and/or the items listed in Table 4-1.

Pb-free alloys used for preconditioning or assembly **shall [N1D2D3]** have a tin content maintained within $\pm 1\%$ of the nominal alloy being used. Tin content for Pb-free alloys **shall [N1D2D3]** be tested at the same frequency as testing for copper/silver contamination. The balance of a SAC305 Pb-free bath **shall [N1D2D3]** be the items listed in Table 4-1. Use of other lead-free solder alloy contamination limits **shall [N1D2D3]** be as agreed between Manufacturer and User.

The limit for silver in a Sn62Pb36Ag2 solder bath **shall [N1D2D3]** be 1.75% to 2.25%.

Table 4-1 Maximum Limits of Solder Bath Contaminant

Contaminant	Preconditioning Maximum Contaminant Weight Percentage Limit SnPb Alloys	Assembly Maximum Contaminant Weight Percentage Limit SnPb Alloys	Preconditioning and Assembly Maximum Contaminant Weight Percentage Limit SAC305 Pb-Free Alloys
Copper	0.75	0.3	1.1, Note 2
Gold	0.5	0.2	0.2
Cadmium	0.01	0.005	0.005
Zinc	0.008	0.005	0.005
Aluminum	0.008	0.006	0.006
Antimony	0.5	0.5	0.2
Iron	0.02	0.02	0.02
Arsenic	0.03	0.03	0.03
Bismuth	0.25	0.25	0.25
Silver, Note 1	0.75	0.1	4.0
Nickel	0.025	0.05	0.10
Pb	N/A	N/A	0.1
Total of Copper, Gold, Cadmium, Zinc, Aluminum Contaminants	N/A	0.4	N/A

Note 1: Not applicable for Sn62Pb36Ag2.

Note 2: A maximum copper limit of 1.0% may be specified as agreed between Manufacturer and User.

4.1.1.2 Materials and Components – Materials – Flux

Flux **shall** [D1D2D3] be in accordance with J-STD-004 or equivalent. Flux **shall** [N1N2D3] conform to flux activity levels L0 or L1 of flux materials rosin (RO), resin (RE), or organic (OR), except organic flux activity level L1 **shall not** [N1N2D3] be used for no-clean soldering. When other activity levels or flux materials are used, data demonstrating compatibility **shall** [N1N2D3] be available for review.

Note: Flux or soldering process combinations previously tested or qualified in accordance with other specifications do not require additional testing.

Type H or M fluxes **shall not** [D1D2D3] be used for tinning of stranded wires.

When an external flux is used in conjunction with flux cored solders, the fluxes **shall** [D1D2D3] be compatible.

4.1.1.3 Materials and Components – Materials – Adhesives

Electrically nonconductive adhesive materials used for attachment of components should conform to an acceptable document or standard, e.g., IPC-SM-817, or as otherwise specified. The adhesives selected **shall not** [D1D2D3] be detrimental to the component or assembly they are used on. The material **shall** [D1D2D3] be cured, free of contamination, not negate stress relief, and show no visible gap or separation between the adhesive and the surface to which it is bonded.

4.1.1.4 Materials and Components – Materials – Solderability

Electronic/mechanical components (including terminals) and wires to be soldered **shall** [D1D2D3] meet the solderability requirements of J-STD-002 or equivalent. When a solderability inspection operation or pretinning and inspection operation is performed as part of the documented assembly process, that operation may be used in lieu of solderability testing.

The Manufacturer should establish procedures to minimize component solderability degradation.

A wire or terminal not conforming to the solderability requirements may be reworked, e.g., by dipping in hot solder, before soldering.

4.1.2 Materials and Components– Gold Removal

Gold **shall** [N1D2D3] be removed from the surfaces to be soldered of solder terminals plated with greater than 2.54 μm [100 μin] gold thickness. Gold **shall** [N1D2D3] be removed from the surfaces to be soldered of all solder cup terminals, regardless of gold thickness.

A double tinning process or dynamic solder wave may be used for gold removal prior to mounting the component on the assembly.

These requirements may be eliminated if there is documented objective evidence available for review that there are no gold related solder embrittlement problems associated with the soldering process being used.

4.2 Cleanliness

IPC-CH-65 and IPC-AJ-820 provide additional information about cleaning processes and materials.

4.2.1 Cleanliness – Presoldering

The assembly should be clean of any matter that will inhibit compliance to the requirements of this standard.

4.2.2 Cleanliness – Postsoldering

Solder connections required to be cleaned, e.g., rosin/resin fluxes, **shall [D1D2D3]** be cleaned in a manner that assures removal of residual flux and activators. Flux residue can degrade product performance over time based upon environmental conditions.

Methods and materials that are used to clean soldered assemblies **shall [D1D2D3]** be compatible with the product and assembly materials so that the cleaning process does not adversely affect performance characteristics.

Solder connections produced using “no-clean” processes need only be cleaned when required.

4.2.2.1 Cleanliness – Postsoldering – Foreign Object Debris (FOD)

Defect – Class 1,2,3

- Dirt and particulate matter on assembly, e.g., solder splatter, solder balls, dirt, lint, dross, metallic particles, etc.

4.2.2.2 Cleanliness – Postsoldering – Flux Residue

4.2.2.2.1 Cleanliness – Postsoldering – Flux Residue – Cleaning Required

Acceptable – Class 1,2,3

- No visible flux residue.

Defect – Class 1,2,3

- Visible flux residue.

4.2.2.2.2 Cleanliness – Postsoldering – Flux Residue – No-Clean Process

Flux residue may be present if it is flux residue that is not intended to be cleaned.

Not illustrated.

Acceptable – Class 1,2,3

- Flux residue does not inhibit visual inspection.
- Flux residue does not inhibit access to test points of the assembly.

Defect – Class 1,2,3

- Wet, tacky, or excessive flux residues that may spread onto other surfaces.
- No-clean flux residue on any electrical mating surface.
- Flux residue inhibits visual inspection.

4.3 Solder Connection

These connection criteria apply regardless of which methods of soldering have been utilized.

There are specialized soldering finishes, e.g., immersion tin, palladium, gold, etc., that require the creation of special acceptance criteria other than as stated in this document. The criteria should be based on design, process capability and performance requirements.

Wetting cannot always be judged by surface appearance. The wide range of solder alloys in use may exhibit from low or near zero degree contact angles to nearly 90° contact angles. The acceptable solder connection **shall** [D1D2D3] indicate evidence of wetting and adherence where the solder blends to the soldered surface.

The solder connection wetting angle (solder to lead and solder to terminal) **shall not** [D1D2D3] exceed 90° (see Figure 4-1-A, B). As an exception, the solder connection to a termination may exhibit a wetting angle exceeding 90° (see Figure 4-1-C) when it is created by the solder contour extending over the edge of the solderable termination area.

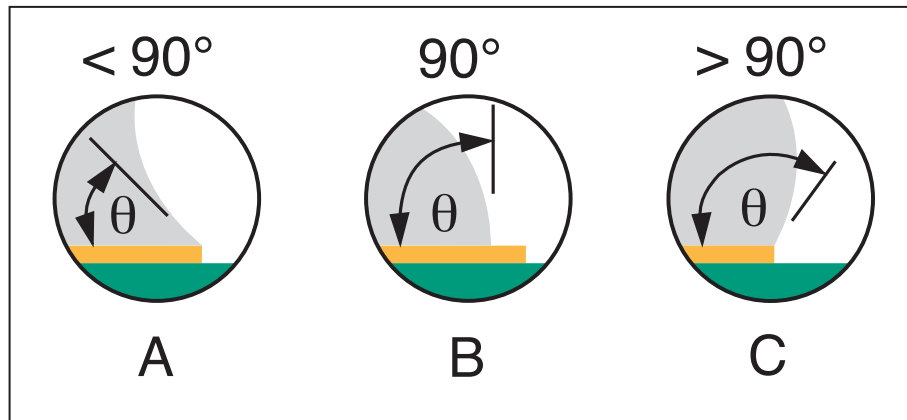


Figure 4-1

4.3 Solder Connection (cont.)

The primary difference between the solder connections created with processes using SnPb alloys and processes using Pb-free alloys is related to the visual appearance of the solder. This standard provides visual criteria for inspection of both SnPb and Pb-free connections. Figures specific to Pb-free connections will be identified with the symbol shown in Figure 4-2.



Figure 4-2

Acceptable Pb-free and SnPb connections may exhibit similar appearances but Pb-free alloys are more likely to have:

- Surface roughness (grainy or dull).
- Greater wetting contact angles.

All other solder fillet criteria are the same.

Typical SnPb connections have from a shiny to a satin luster, generally smooth appearance and exhibit wetting as exemplified by a concave meniscus between the objects being soldered. High temperature solders may have a dull appearance.

Undesirable wetting conditions are typically nonwetting and dewetting.

Nonwetting is characterized as partial adherence of solder to a surface that it has contacted and basis metal remains exposed. Dewetting is a condition where molten solder coats a surface and then recedes to leave irregularly shaped mounds of solder on the surface that are separated by areas covered with a thin film of solder and without leaving basis metal exposed.

Some solders may have a dull appearance, e.g., high temperature, some Pb-free alloys. These should not be considered defective based upon their surface appearance.

Rework (touch-up) of soldered connection defects should only be performed if required by disposition (see 1.5.1.2.1 Disposition and 1.19.1 Rework).

4.3.1 Solder Connection – General Requirements

The following general requirements are applicable to all terminals unless there is a specific requirement for a given terminal. Solder connection anomaly criteria are shown in Table 4-2.

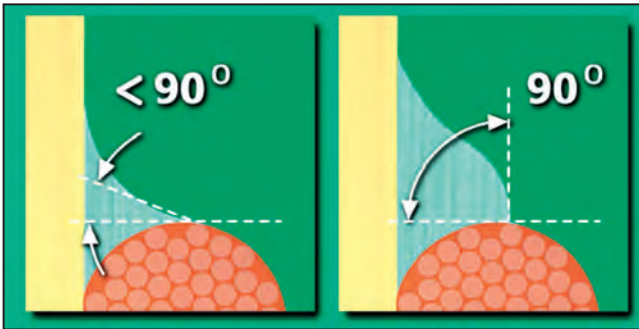


Figure 4-3

Acceptable – Class 1,2,3

- The acceptable solder connection indicates evidence of wetting and adherence when the solder blends to the soldered surface, forming a contact angle of 90° or less, except when the quantity of solder results in a contour which is limited by the edge of the attached surfaces.
- Solder wicking allows the wire to remain flexible in required areas.

4.0 Soldered Terminations

4.3.1 Solder Connection – General Requirements (cont.)

Table 4-2 Solder Connection Anomalies

Anomalies	Class 1	Class 2	Class 3
Insufficient Solder:			
Blowholes/pinholes/voids, etc., providing the solder connection meets minimum requirements.	Acceptable	Process Indicator	
Blowholes/pinholes/voids, etc., reduce the solder connection below minimum requirements.	Defect		
Solder coverage does not meet minimum requirements for the termination type.	Defect		
Excess Solder:			
Solder bridging except when the path is present by design.	Defect		
Solder violates minimum electrical clearance.	Defect		
Solder wicking under wire insulation inhibits flexibility where required.	Defect		
Loose solder balls, Note 1.	Defect		
Solder splash or webbing.	Defect		
Solder Wetting:			
Solder not wetted to the surface where required.	Defect		
Dewetting causes connection to not meet minimum solder fillet requirements.	Defect		
Solder Appearance:			
Fractured solder.	Defect		
Disturbed solder.	Defect		
Cold or rosin solder connection results in nonwetting or incomplete wetting.	Defect		
Probe mark or other damage degrades the integrity of the solder connection.	Defect		
Contaminated Solder:			
Flux residues, when cleaning is required.	Defect		
No-clean flux residues that are wet, tacky, or excessive.	Defect		

Note 1: "Loose" means it could be dislodged in the service environment of the product.

4.3.2 Solder Connection – Soldering Anomalies

4.3.2.1 Solder Connection – Soldering Anomalies – Exposed Basis Metal

Exposed basis metal is acceptable on conductor ends and as otherwise allowed in the standard.

4.3.2.2 Solder Connection – Soldering Anomalies – Partially Visible or Hidden Solder Connections

Partially visible or hidden solder connections **shall** [A1P2D3] meet the following conditions:

- The design does not restrict solder flow to any connection element.
- The visible portion, if any, of the connection is acceptable.
- Process controls are maintained in a manner assuring repeatability of assembly techniques.

4.4 Wire/Lead Preparation, Tinning

In this document, the term pre-tinning and tinning have the same meaning: The application of molten solder to a basis metal or surface finish.

When wires are tinned using alloys other than those listed in 4.1.1.1 Materials and Components – Materials – Solder, the solder used for tinning **shall [D1D2D3]** be the same alloy used in the subsequent soldering process.

Stranded conductors **shall [N1D2D3]** be tinned when:

- Wires will be formed for attachment to solder terminals.
- Wires will be formed into splices (other than mesh).

Stranded wires **shall not [D1D2D3]** be tinned when:

- Wires will be used in crimp terminations.
- Wires will be used in threaded fasteners.
- Wires will be used in forming mesh splices.

Tinning of stranded wires is optional when heat shrinkable solder devices are used.

Note: J-STD-002 provides additional information for assessing this requirement.

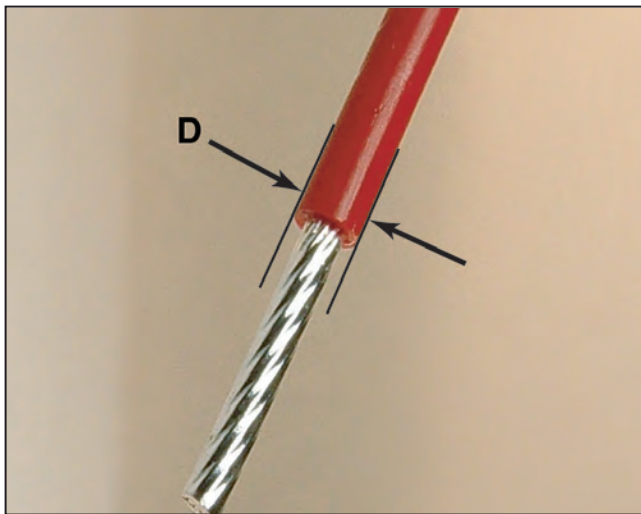


Figure 4-4

Acceptable – Class 1,2,3

- The solder wets the tinned portion of the wire and penetrates to the inner strands of stranded wire.
- Solder wicks up wire provided the solder does not extend to a portion of the wire that is required to remain flexible.
- The tinning leaves a smooth coating of solder and the outline of the strands are discernible.

Process Indicator – Class 2,3

- Strands are not discernible but excess solder does not affect form, fit or function.
- Solder does not penetrate to the inner strands of the wire.

4.4 Wire/Lead Preparation, Tinning (cont.)

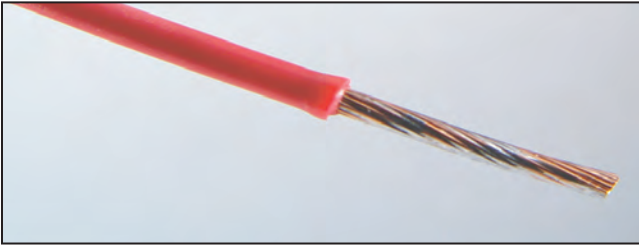


Figure 4-5

Acceptable – Class 1

Process Indicator – Class 2

Defect – Class 3

- Length of untinned strands from end of wire insulation is greater than one wire diameter (see Figure 4-4-D).

Defect – Class 2,3

- Pinholes, voids, dewetting/nonwetting exceeding 5% of the area required to be tinned.
- Solder does not wet the tinned portion of the wire.

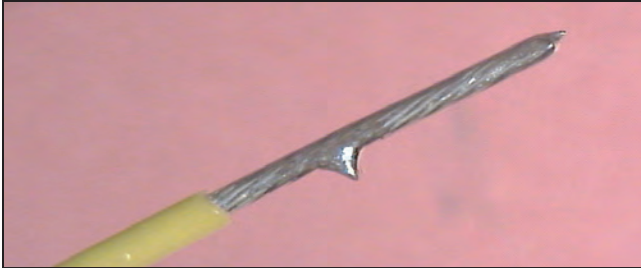


Figure 4-6

Defect – Class 1,2,3

- Solder build-up or icicles within the usable wire area that affect subsequent assembly steps.
- Solder wicking extends into the portion of wire that is required to remain flexible after soldering.

4.5 Wire Insulation

4.5.1 Wire Insulation – Clearance

Insulation clearance below is defined as the distance between the wire insulation and the solder fillet.

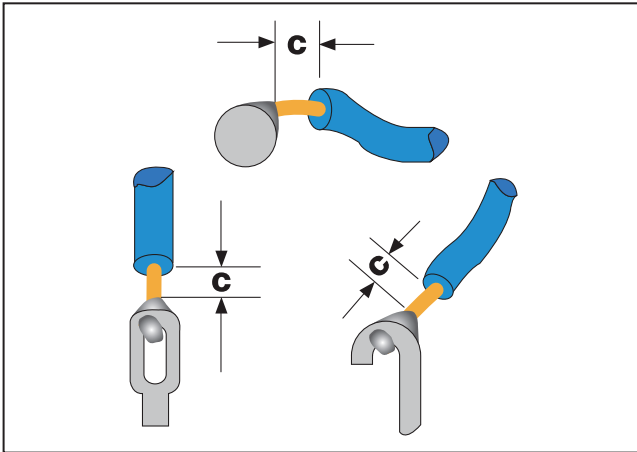


Figure 4-7

Acceptable – Class 1,2,3

- The insulation clearance (C) is two wire diameters or less including insulation or 1.5 mm [0.060 in], whichever is greater.
- Insulation clearance (C) does not permit violation of minimum electrical clearance to adjacent conductors.
- The wire insulation is in contact with the solder but does not interfere with formation of an acceptable connection.



Figure 4-8



Figure 4-9

4.5.1 Wire Insulation – Clearance (cont.)

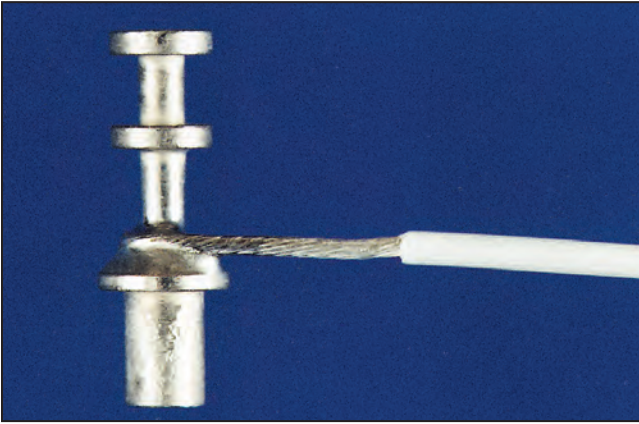


Figure 4-10

Acceptable – Class 1

- Exposed bare wire providing there is no danger of violating minimum electrical clearance to adjacent circuitry when the wire is moved.

Acceptable – Class 1

Process Indicator – Class 2

Defect – Class 3

- The insulation clearance is greater than two wire diameters or 1.5 mm [0.060 in], whichever is greater.

Defect – Class 2,3

- Insulation is embedded in or covered with solder.

Defect – Class 1,2,3

- The clearance between the end of the insulation and the connection violates minimum electrical clearance between noncommon conductors.
- Insulation interferes with formation of the solder connection.

4.5.2 Wire Insulation – Postsolder Damage

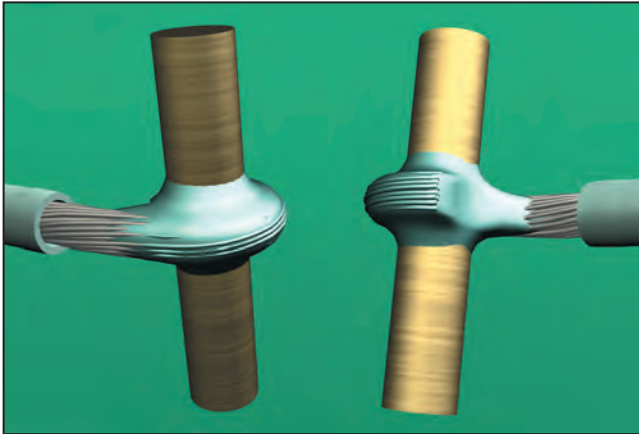


Figure 4-11

Acceptable – Class 1,2,3

- Insulation is not melted, charred or otherwise damaged from the soldering process (see Figure 4-11).

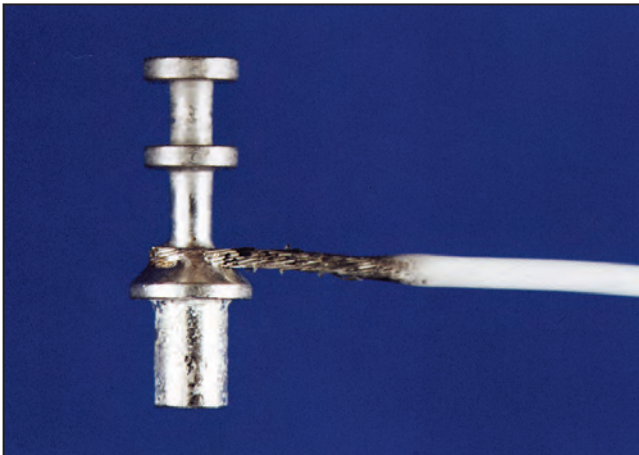


Figure 4-12

Defect – Class 1,2,3

- Insulation charred.
- Melting reduces insulation thickness by more than 20%.

4.6 Insulation Sleeving

The following criteria apply when insulation sleeving is required to be applied to any type of soldered terminal, i.e., not only soldered connector cups.

These criteria are intended for use with shrink sleeving. Criteria for other types of sleeving should be agreed upon between User and Manufacturer.

Cleaning, if required, **shall [D1D2D3]** be accomplished prior to shrinking of the sleeving.

Heating processes used to shrink sleeve insulation **shall not [D1D2D3]** damage the connector, wire, sleeving, or adjacent components, nor reflow the solder connection.

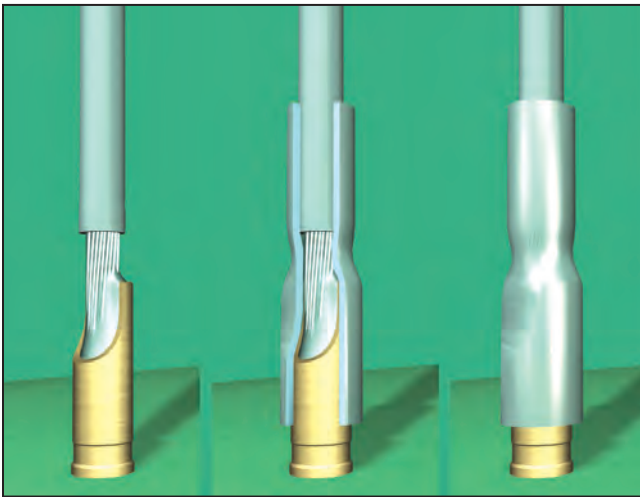


Figure 4-13

Acceptable – Class 1,2,3

- Insulation sleeving overlaps the connector terminal and the wire insulation by a minimum of two wire diameters.
- Insulation sleeving is more than 50% wire diameter and not more than two wire diameters from the point where the connector terminal enters the connector insert.
- Multiple pieces of sleeving overlap each other by at least three wire/cable diameters.

Acceptable – Class 1

- Sleeving/tubing is tight on terminal, but not tight on wire.

Acceptable – Class 2,3

- Sleeving/tubing is tight on terminal and wire.