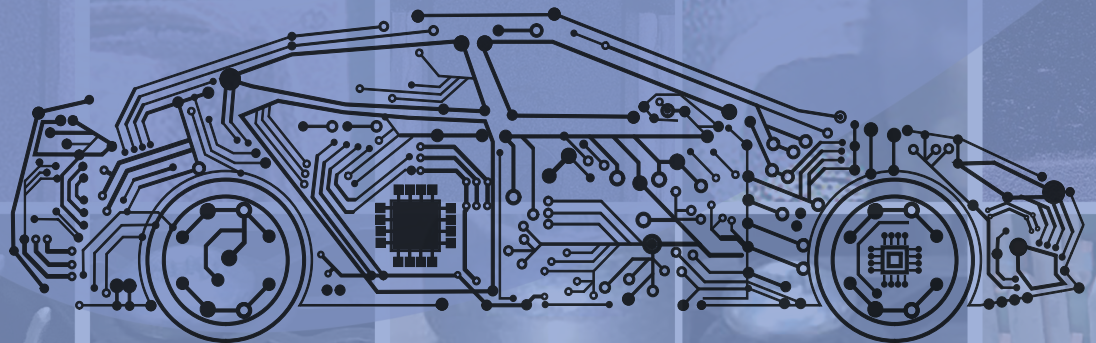


IPC J-STD-001HA/IPC-A-610HA

October 2021

**Automotive Addendum to IPC J-STD-001H
Requirements for Soldered Electrical and
Electronic Assemblies and IPC-A-610H
Acceptability of Electronic Assemblies**



Developed by



Full document details: IPC J-STD-001HA-2021 (IPC A-610HA)



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Automotive Addendum to IPC J-STD-001H Requirements for Soldered Electrical and Electronic Assemblies and IPC-A-610H Acceptability of Electronic Assemblies

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

Developed by the J-STD-001 and IPC-A-610 Automotive Addendum Task Group of the Product Assurance Committee (7-30) of IPC

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Users of this publication are encouraged to participate in the development of future revisions.

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0.1 Scope This Addendum provides requirements to be used in addition to, and in some cases, in place of, those published in J-STD-001H to ensure the reliability of mission-critical soldered automotive electrical and electronic assemblies in the field under harsh environments, considering the conditions of automated high-volume production.

0.2 Purpose When required by procurement documentation/drawings, this Addendum supplements or replaces specifically identified requirements of J-STD-001H.

0.3 Existing or Previously Approved Designs This Addendum **shall not** constitute the sole cause for the redesign of previously approved designs. When drawings for existing or previously approved designs undergo revision, they should be reviewed and changes made that allow for conformance with the requirements of this Addendum.

0.4 Use This Addendum is not to be used as a standalone document.

Where criteria are not supplemented, the Class 3 requirements of J-STD-001H **shall** apply. Where J-STD-001H criteria are supplemented or new criteria are added by this Addendum, the clause is listed in J-STD-001HA, and the entire J-STD-001H clause is replaced by this Addendum except as specifically noted.

The clauses modified by this Addendum do not include subordinate clauses unless specifically stated, e.g., 1.4 does not include 1.4.1. Clauses, Tables, Figures, etc., in J-STD-001H that are not listed in this Addendum are to be used as published. J-STD-001HA must be used with J-STD-001H.

This Addendum **shall** be used only in conjunction with the corresponding automotive addendum pertaining to IPC-A-610H.

In the context of this Addendum, IPC-A-610 **shall** be used as a companion document to J-STD-001. The revisions of J-STD-001 and IPC-A-610 **shall** correspond, e.g., J-STD-001H and IPC-A-610H. The likelihood of criteria not aligning increases when different revisions are used together.

If there is a conflict between the documents referenced in this section, the order of precedence is documented in 1.7 Order of Precedence.

1.1 Scope This standard describes materials, methods and acceptance criteria for producing soldered electrical and electronic assemblies. The intent of this document is to rely on process control methodology to ensure consistent quality levels during the manufacture of products. It is not the intent of this standard to exclude any procedure, such as for component placement or for applying flux and solder used to make the electrical connection.

Use of this Addendum implies that the product belongs to Class 3.

The soldering operations, equipment, and conditions described in this document are based on electrical/electronic circuits designed and fabricated in accordance with the specifications listed in Table 1-1HA.

Table 1-1HA Design, Fabrication and Acceptability Specifications

Board Type	Design Specification	Fabrication/Acceptability Specification
Generic Requirements	IPC-2221	IPC-6011
Rigid Printed Boards	IPC-2222	IPC-6012, IPC-6012 Automotive Addendum, IPC-A-600
Flexible Circuits	IPC-2223	IPC-6013
Rigid Flex Board	IPC-2223	IPC-6013

1.3.1 Inspection Personnel and Product Requirements The inspector **shall not** select the Product Class for the product under inspection. The selection of the product class **shall** be given by the engineering documentation. Documentation **shall** be available to the inspector, i.e., inspection instructions, process build requirements, customer specification, for the product under inspection.

1.6 Process Control Requirements 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 User requirements. Statistical Process Control documentations such as IPC-9191, JESD557 or other User-approved system may be used as guidelines for implementing statistical process control.

Manufacturers of Class 3 products **shall** develop and implement a documented process control system.

A documented process control system, if established, **shall** define process control and corrective action limits. This may or may not be a statistical process control system. 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 Manufacturer, see 1.6.2 Statistical Process Control.

Process control methodologies **shall** be used in the planning, implementation and evaluation of the manufacturing processes used to produce soldered electrical and electronic 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. The manufacturer **shall** maintain objective evidence of a current process control/continuous improvement plan that is available for review.

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** be grounds for disapproval of the process and associated documentation.

1.7 Order of Precedence The contract **shall** take precedence over this Addendum, referenced standards and User-approved drawings.

1.7.2 Conflict In the event of a conflict between this Addendum and the applicable documents cited herein, this Addendum takes precedence. Where referenced criteria of this Addendum differ from J-STD-001H, this Addendum takes precedence. In the event of conflict between the requirements of this Addendum and the applicable assembly drawing(s)/documentation, the applicable User approved assembly drawing(s)/documentation take precedence.

In the event of conflict between the requirements of the J-STD-001H and the applicable assembly drawing(s) and documentation, the applicable User approved assembly drawing(s) and documentation govern. Some examples of documentation include the contract, purchase order, technical data package, engineering specification or performance specification. In the event of conflict between the requirements of the J-STD-001H and assembly drawing(s) and documentation that have not been User approved, the J-STD-001H governs.

In the case of a conflict between this Addendum and IPC-A-610HA, this Addendum takes precedence. See below for a summary of the order of precedence for using this Addendum.

User approved drawings → J-STD-001HA → J-STD-001H → IPC-A-610HA → IPC-A-610H

1.8 Terms and Definitions

1.8.8 Manufacturer The individual, organization, or company responsible for the assembly process and verification operations necessary to ensure full compliance of assemblies to this Addendum.

1.8.9 Objective Evidence Documentation in the form of hard copy, computer data, video, or other media that demonstrates requirements have been met (for examples, see J-STD-001H Appendix C Guidance on Objective Evidence or Material Compatibility). Such documentation may include, but is not limited to:

- Work instructions.
- Procedures and records required by the quality management system.
- Chemical and physical test data.
- Reliability calculations based on recognized industry reliability standards.
- Manufacturer data sheets/reports, now acceptable record of performance by selected suppliers.
- External and/or internal audit reports.
- Test/inspection reports including actual measured values.
- Training records.
- Soldering temperature versus time profiles.
- Technical basis for changes in materials and/or processes, e.g., see Appendix C J-STD-001 Guidance on Objective Evidence or Material Compatibility.
- Historical data, e.g., 0 kilometer failures, field failures/warranties, product/process validation, pilot runs, safe launch data.
- Competency Matrix, i.e., skills checklist.

Note: Objective evidence is used to demonstrate or validate process control.

1.8.17 User The individual, organization, company, or agency responsible for the procurement of electrical/electronic hardware, and having the authority to define any variation or restrictions to the requirements of this Addendum, i.e., the originator/custodian of the contract detailing these requirements.

1.8.20 Design Authority The individual, organization, company, contractually designated authority, or agency responsible for the design of electrical/electronic hardware, having the authority to define variations or restrictions to the requirements of this Addendum, i.e., the originator/custodian of the applicable design standard and the approved or controlled documentation.

1.8.21 Solder Coverage The solder coverage is obtained by dividing the overlapping area between parallel and wettable surfaces of printed board and component termination covered with a vertically continuous layer of solder by the total overlapping area between parallel and wettable surfaces of printed board and component termination. Voids and empty space are not part of the vertically continuous layer of solder and therefore do not contribute to the solder coverage.

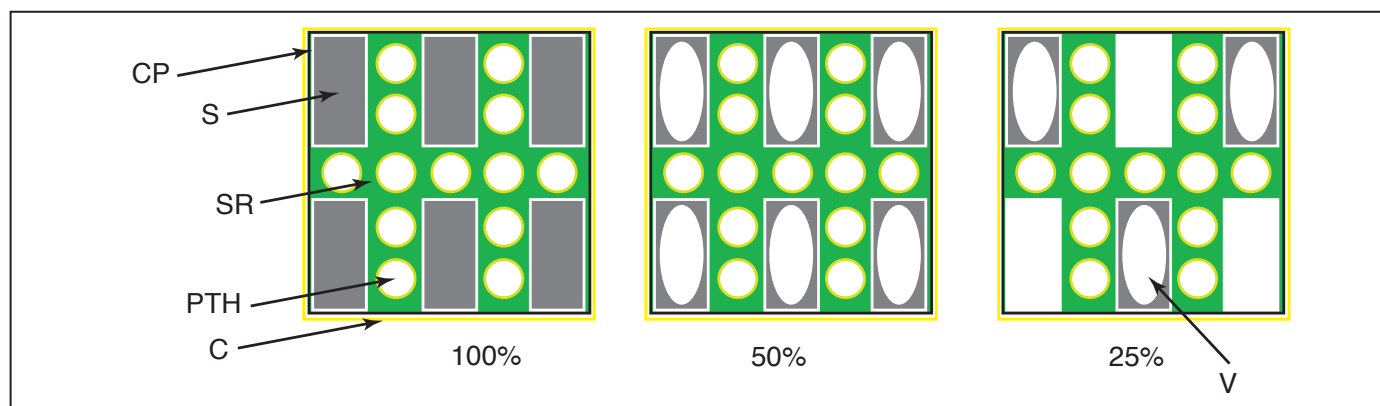


Figure 1-1HA Solder Coverage, example of a thermal pad solder connection

C. Copper
 CP. Component Pad
 SR. Solder Resist
 PTH. Plated Through-Hole
 S. Solder
 V. Void

1.8.22 Voiding (Percentage) The ratio of the area exhibiting voids divided by the total area of a solder joint in a two-dimensional x-ray image taken with the direction of projection oriented perpendicular to the printed board. In case of multiple voids, the areas of all voids detected within one solder joint is added to determine voiding. In the case that overlapping of voids occurs in the image, the area concerned by overlapping is only considered once. If a tomographic system providing three-dimensional images is used for inspection, voiding values analogous to the two-dimensional image are calculated from the three-dimensional information available.

1.9 Requirements Flowdown When this Addendum is contractually required, the applicable requirements of this Addendum **shall** be imposed on all applicable subcontracts, assembly drawing(s), documentation and purchase orders. Unless otherwise specified, the requirements of J-STD-001H are not imposed on the procurement of commercial-off-the-shelf (COTS or catalog) assemblies or subassemblies.

When a part is adequately defined by a specification, then the requirements of J-STD-001H should be imposed on the Manufacturer of that part only when necessary to meet end-item requirements. When it is unclear where flowdown should stop, it is the responsibility of the Manufacturer to establish that determination with the User.

When an assembly, e.g., daughterboard, is procured, that assembly should meet the requirements of J-STD-001H. The connections from the procured assembly to the manufactured assembly **shall** meet the requirements of J-STD-001H. If the assembly is manufactured by the same Manufacturer, the solder requirements are as stated in the contract for the entire assembly.

The design and workmanship of COTS items **shall** be evaluated by User and Manufacturer and modified as required to ensure the end-item meets contract performance requirements to the end product. Modifications to COTS items **shall** meet the applicable requirements of J-STD-001H.

1.10 Personnel Proficiency All personnel using this Addendum **shall** be proficient in the tasks to be performed and in the content, use and application of J-STD-001H and J-STD-001HA, IPC-A-610H and IPC-A-610HA. Objective evidence, e.g., records of training to the applicable job functions being performed, work experience, testing to the requirements of this Addendum, or results of periodic reviews of that proficiency **shall** be maintained and be available for review. Supervised on-the-job training is acceptable until proficiency is demonstrated.

1.11 Acceptance Requirements All products **shall** meet the requirements of the assembly drawing(s)/documentation and the applicable requirements for Class 3.

Manufacturers **shall**:

- 1) Perform 100% inspection, or
- 2) Perform sampling inspection if defined as part of a documented process control plan, see 1.6.2 Statistical Process Control, or
- 3) Provide documented objective evidence, see 1.8.9 Objective Evidence.

The User and the Design Authority have the shared responsibility to specify acceptance criteria not stated in this Addendum. If no criteria are specified, required, or cited, then 1.11.1 Conditions Not Specified applies.

1.11.1 Conditions Not Specified Conditions that are not documented by the User or the Design Authority as defective or as a process indicator **shall** be considered acceptable unless it can be established that the condition affects user-defined form, fit or function. Such conditions **shall** be documented and agreed between User, Design Authority and Manufacturer for future considerations.

1.12.1 Process Verification Inspection

Process verification inspection shall include:

- a. Surveillance of the operation to determine that practices, methods, procedures and a written control plan are being applied, per AIAG CQI-17 or equivalent.
- b. Inspection of the product to validate compliance with the requirements of J-STD-001H, J-STD-001HA, IPC-A-610H and IPC-A-610HA. For order of precedence in case of conflict, see 1.7 Order of Precedence.

1.12.1.1 Visual, Automated Optical and Automated X-ray Inspection

Manufacturers shall:

- Perform 100% inspection, or
- Sampling inspection, if defined as part of a documented process control plan, see 1.6 Process Control Requirements, or
- Provide objective evidence, see 1.8.9 Objective Evidence, to validate compliance with requirements per J-STD-001H, J-STD-001HA, IPC-A-610H and IPC-A-610HA. For order of precedence in case of conflict, see 1.7 Order of Precedence.

Inspection of soldering and post solder cleanliness may be performed in the same operations using magnifications as given in Tables 1-2, 1-3, and 1-4. Inspection of soldering and cleanliness **shall** be performed prior to conformal coating, staking or encapsulation. Inspection for damage may be combined with solder and/or cleanliness inspections. Inspection for damage should be performed prior to conformal coating and as part of the final inspection process.

The use of any non-visual electrical inspection methods, e.g., in-circuit testing (ICT), functional testing (FT), etc., is not specifically covered by J-STD-001H and this Addendum. The use of these methods **shall** be the responsibility of the Manufacturer.

1.12.2.2 Magnification Aids Magnification power for visual human inspection with microscope/magnification or not, **shall** be in accordance with Tables 1-2, 1-3, and 1-4. The magnification power requirement **shall** be based on the size of the land or wire being inspected. Any magnification power within the applicable inspection range may be used. For assemblies with mixed land sizes, the greater magnification power may be used for the entire assembly. For assemblies with mixed wire sizes, the greater magnification power may be used. If the presence of a defect cannot be determined at the appropriate magnification power defined in Tables 1-2, 1-3 or 1-4, 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. Supplemental lighting may be necessary to assist in visual assessment, see 1.12.2.1 Lighting.

1.12.3 Process Verification Methodologies The use of automated optical inspection (AOI) and automated x-ray inspection (AXI) **shall** be the responsibility of the Manufacturer. Tables 1-2, 1-3 and 1-4 do not apply to AOI/AXI image inspection. X-ray equipment not intended for electronic assemblies or not properly set up can damage sensitive components. J-STD-001H Appendix D provides guidance on x-ray inspection and radiation dosage.

1.14 Electrostatic Discharge (ESD) If there are any assemblies that contain components or parts sensitive to ESD, the Manufacturer **shall** implement a documented ESD control program in accordance with ANSI/ESD S20.20, IEC 61340-5-1, MIL-STD-1686, or as agreed between User and Supplier. Documentation necessary for an effective program **shall** be available for review.

Verification of ESD compliance of individuals in ESD Protected Areas (EPA) **shall** be done at the point of entry to these areas.

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-HDBK-001 Requirements for Soldered Electrical Electronic Assemblies Handbook

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

IPC-D-279 Design Guidelines for Reliable Surface Mount Technology Printed Board Assemblies

IPC-A-600 Acceptability of Printed Boards

IPC-A-610 Acceptability of Electronic Assemblies

IPC-OI-645 Standard for Visual Optical Inspection Aids

IPC-SM-785 Guidelines for Accelerated Reliability Testing of Surface Mount Attachments

IPC-TM-650 Test Methods Manual²

2.3.25 Detection and Measurement of Ionizable Surface Contaminants

2.3.27 Cleanliness Test Residual Rosin

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2.6.9.1 Test to Determine Sensitivity of Electronic Assemblies to Ultrasonic Energy and Test Method

2.6.9.2 Test to Determine Sensitivity of Electronic Components to Ultrasonic Energy

2.6.25 Conductive Anodic Filament (CAF) Resistance Test: X-Y Axis

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

IPC-AJ-820 Assembly and Joining Handbook

IPC-CC-830 Qualification and Performance of Electrical Insulating Compound for Printed Board Assemblies

IPC-2221 Generic Standard on PWB Design

IPC-2222 Sectional Standard on Rigid PWB Design

IPC-2223 Sectional Design Standard for Flexible Printed Boards

IPC-5704 Cleanliness Requirements for Unpopulated Printed Boards

IPC-6011 Generic Performance Specification of Printed Boards

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-6012xA Automotive Applications Addendum to IPC-6012

IPC-6013 Qualification and Performance for Flexible Printed Boards

IPC-7093 Design and Assembly Process Implementation for Bottom Termination Components (BTC)

IPC-7095 Design and Assembly Process Implementation for BGAs

IPC-7530 Guidelines for Temperature Profiling for Mass Soldering Processes (Reflow & Wave)

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

IPC-7711/7721 Rework, Modification and Repair of Electronic Assemblies

IPC-9201 Surface Insulation Resistance Handbook

IPC-9202 Material and Process Characterization/Qualification Test Protocol for Assessing Electrochemical Performance

IPC-9203 Users Guide to IPC-9202 and the IPC-B-52 Standard Test Vehicle

IPC-9261 In-Process DPMO and Estimated Yield for PWAs

IPC-9691 User Guide for the IPC-TM-650, Method 2.6.25, Conductive Anodic Filament (CAF) Resistance Test (Electrochemical Migration Testing)

IPC-9701 Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments

¹ www.ipc.org
² www.ipc.org/test-methods.aspx

2.2 JEDEC³

JESD557 Statistical Process Control Systems

JESD471 Symbol and Label for Electrostatic Sensitive Devices

2.3 Joint Industry Standards⁴

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

J-STD-003 Solderability Tests for Printed Boards

J-STD-004 Requirements for Soldering Fluxes

J-STD-005 Requirements for Soldering Paste

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

IPC/JEDEC J-STD-020 Moisture/Reflow Sensitivity Classification for Plastic Integrated Circuit Surface Mount Devices

IPC/JEDEC J-STD-033 Standard for Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices

ECA/IPC/JEDEC J-STD-075 Classification of Non-IC Electronic Components for Assembly Processes

2.4 ASTM⁵

ASTM E29 Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specification

ASTM SI10, IEEE/ASTM SI 10 American National Standard for Metric Practice

2.5 EOS/ESD Association, Inc.⁶

ANSI/ESD S8.1 ESD Awareness Symbols

ANSI/ESD-S20.20 Protection of Electrical and Electronic Parts, Assemblies and Equipment

2.6 International Electrotechnical Commission⁷

IEC 61340-5-1 Electrostatics - Part 5-1: Protection Of Electronic Devices From Electrostatic Phenomena - General Requirements

IEC 61340-5-3 Electrostatics - Part 5-3: Protection Of Electronic Devices From Electrostatic Phenomena - Properties And Requirements Classification For Packaging Intended For Electrostatic Discharge Sensitive Devices

IEC TR 61191-7 Printed board assemblies – Part 7: Technical cleanliness of components and printed board assemblies

IEC TR 61191-8 Printed board assemblies – Part 8: Voiding in solder joints of printed board assemblies for use in automotive electronic control units – Best practices

2.7 SAE International⁸

GEIA-STD-0005-1 Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder

GEIA-STD-0005-2 Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems

2.8 Military Standards⁹

MIL-STD-1686 Electrostatic Discharge Control Program For Protection Of Electrical And Electronic Parts, Assemblies And Equipment (Excluding Electrically Initiated Explosive Devices)

MIL-STD-2073 Department of Defense Standard Practice for Military Packaging

3. www.jedec.org

4. www.ipc.org

5. www.astm.org

6. www.esda.org

7. www.iec.ch

8. www.sae.org

9. quicksearch.dla.mil/qsSearch.aspx

2.10 Automotive Electronics Council (AEC)¹⁰**AEC-Q100** Failure Mechanism Based Stress Test Qualification For Integrated Circuits**AEC-Q101** Failure Mechanism Based Stress Test Qualification For Discrete Semiconductors**AEC-Q102** Failure Mechanism Based Stress Test Qualification For Discrete Optoelectronic Semiconductors in Automotive Applications**AEC-Q104** Failure Mechanism Based Stress Test Qualification For Multichip Modules (MCM) In Automotive Applications**AEC-Q200** Stress Test Qualification For Passive Components**2.11 Automotive Industry Action Group (AIAG)¹¹****AIAG CQI-17** Special Process: Electronic Assembly Manufacturing – Soldering System Assessment**2.12 American National Standards Institute (ANSI)¹²****ANSI/ASQ Z1.4** American National Standard – Sampling Procedures and Table for Inspection by Attributes**2.13 IATF¹³****IATF 16949:2016** Automotive Quality Management System

3.1 Materials The materials and processes used to assemble/manufacture electronic assemblies **shall** be selected such that their use, in combination, produces products acceptable to this standard.

When major elements of the proven processes are changed, e.g., flux, solder paste, cleaning media or system, solder alloy or soldering system, validation of the acceptability of the change(s) **shall** be performed and documented, see Appendix C J-STD-001 Guidance on Objective Evidence of Material Compatibility. They can also pertain to a change in bare boards, solder mask or metallization.

Manufacturers, when specified, **shall** have a Pb-free control plan (LFCP) established between the Design Authority and the Manufacturer.

Note: GEIA-STD-0005-1 and GEIA-STD-0005-2 constitute examples for the implementation of LFCPs/tin whisker mitigation for Aerospace and other High Performance Electronic Systems.

The electrical and mechanical integrity of components and assemblies **shall** be retained after exposure to processes employed during manufacture and assembly, e.g., handling, baking, fluxing, soldering, and cleaning. There **shall** be a documented process to control materials, including consumable materials that are subject to age degradation. Limited shelf life items **shall** be stored and controlled in accordance with the material manufacturer's recommendations or in accordance with the manufacturer's documented procedures for controlling shelf life and shelf life extensions.

Unless otherwise specified on the engineering documentation, materials **shall** be processed (mixing, curing, etc.) per the material specification or other documented procedure. Material **shall** be used within the pot life (working time) specified by the material manufacturer or used within the time period indicated by a documented system.

When curing conditions (temperature, time, infrared (IR) intensity, etc.) vary from the material manufacturer's recommended instructions, they **shall** be documented and available for review.

Items exposed to uncured silicone material **shall not** be used for processing other material. An authorized exception is allowed only in cases where equipment is used for co-curing processes and the Manufacturer has demonstrated through system tests that non-silicone material properties have not changed and design requirements are met. Objective evidence **shall** be maintained and available for review.

10. www.aecouncil.com

11. www.aiag.org

12. www.ansi.org

13. www.iatfglobaloversight.org

3.2 Solder Solder alloys **shall** be in accordance with J-STD-006 or equivalent. Solder alloys other than Sn60Pb40, Sn62Pb36Ag2, and Sn63Pb37, may be used if all other conditions of J-STD-001H and this Addendum are met and objective evidence of such is available for review.

Solder paste **shall** be in accordance with J-STD-005 or equivalent.

Flux that is part of flux-cored solder wire **shall** meet the requirements of 3.3. Flux percentage is optional.

3.2.1 Solder – Pb-Free Solder alloys **shall** be in accordance with J-STD-006 or equivalent. Solder alloys other than SnAgCu (SAC) alloys with silver content typically between 3 and 4 mass percent and copper content below 1.0 mass percent, and high reliability alloys based on SnAgCu, may be used if all other conditions of J-STD-001H and this Addendum are met and objective evidence of such is available for review. Pb-free processing **shall** be in accordance with a documented procedure that includes adequate controls to minimize the risk of cross-contamination (Pb and Pb-free products/processes).

3.2.2 Solder Purity Maintenance Solder used for preconditioning, gold removal, tinning of parts, and machine soldering **shall** be analyzed, replaced or replenished at a frequency to ensure compliance with the limits specified in Table 3-1HA.

Solder alloys other than Sn60Pb40, Sn62Pb36Ag2, Sn63Pb37 and SnAgCu alloys with silver content typically between 3 and 4 mass percent and copper content below 1.0 mass percent, and high reliability alloys based on SnAgCu, **shall** be in compliance with equivalent documented limits.

If contamination exceeds the limits, intervals between the analyses, replacement or replenishment **shall** 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** be maintained for a minimum of one year for each process/system.

SnPb alloys used for preconditioning or assembly **shall** have a tin content maintained within $\pm 1.5\%$ of the nominal alloy, e.g., $63 \pm 1.5\%$ (i.e., 61.5% - 64.5%), being used. Tin content for SnPb alloys **shall** be tested at the same frequency as testing for copper/gold contamination. The balance of the SnPb bath **shall** be Pb and/or the items listed in Table 3-1HA.

Pb-free alloys used for preconditioning or assembly **shall** have a tin content maintained within $\pm 1\%$ of the nominal alloy being used. Tin content for Pb-free alloys **shall** be tested at the same frequency as testing for copper/silver contamination. The balance of a SAC305/405 Pb-free bath **shall** be the items listed in Table 3-1HA. Use of other Pb-free solder alloy contamination limits **shall** be as agreed between Manufacturer and User.

Table 3-1HA 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 SAC305/405 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	0.01	0.065
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: limits to be 1.75% to 2.25%.

Note 2. Characterized as thick and thermally demanding may have potential plated through-hole fill and/or solder joint defects due to the impact of copper on solder flow characteristics.

3.6 Components Components, e.g., electronic devices, mechanical parts, printed boards, selected for assembly **shall** be compatible with all materials and processes, e.g., temperature ratings, used to manufacture the assembly/product. Electronic components should be qualified per applicable Automotive Electronics Council documents listed in 2 Applicable Documents or per an equivalent qualification process.

Moisture or process sensitive components (as classified by IPC/JEDEC J-STD-020, ECA/IPC/JEDEC, J-STD-075 or other documented classification procedure) **shall** be handled in a manner consistent with IPC/JEDEC J-STD-033 or other documented procedure.

3.6.1 Component and Seal Damage Minor surface flaws, discoloration, meniscus cracks, or chips in component bodies are acceptable, however, they **shall not** expose the component substrate or active element nor affect structural integrity. Components **shall not** be charred. Component damage in excess of that determined to be a minor surface flaw **shall not** degrade the component below the part specification requirements, or as otherwise determined, to meet form, fit, function and life expectancy requirements. This may be determined through documented analysis.

Component suppliers **shall** provide component terminals and terminations without any contamination or FOD that will not permit compliance with acceptance criteria stated in J-STD-001H and J-STD-001HA, e.g., burrs, flaking of the plating, non-solderable, etc.

Note: Visual aids that define minor surface flaw limits for some component/assembly types can be found in IPC-A-610.

4.1 Solderability At the start of soldering operations, components and wires to be soldered **shall** meet the solderability requirements of J-STD-002 or equivalent and printed boards **shall** meet the requirements of J-STD-003 or equivalent. Manufacturers **shall** ensure that suppliers of components and printed boards comply with J-STD-002 and J-STD-003. When a solderability inspection operation is performed as part of the documented assembly process, before or after soldering, that operation may be used in lieu of solderability testing.

4.5 Rework of Nonsolderable Parts A component lead, termination, or board not conforming to the solderability requirements of 4.1 Solderability may be reworked, e.g., by dipping in hot solder, before soldering.

A reworked part **shall** conform to the requirements of 4.3 Solderability, less steam conditioning.

Note: In times of repair of printed board, the person should be proficient in the repair of printed boards in accordance with IPC-7711/21 and functionality validation process.

4.6 Preprocessing Cleanliness Requirements Printed boards from suppliers **shall** be clean. Requirements for cleanliness can be found in IPC-5704 and/or cleanliness requirements from IPC-6012xA.

4.14.1.1.1 Wave/Selective Soldering Machine Controls The Manufacturer **shall** comply with AIAG CQI-17. Processes H & K or equivalent.

4.14.2 Reflow Soldering See IPC-AJ-820 for guidance on inert atmospheres.

The Manufacturer **shall** develop and maintain operating procedures describing the reflow soldering process and the proper operation of the equipment. These procedures **shall** include, at a minimum, a reproducible time/temperature envelope including the flux and solder paste application procedures and coverage, drying/degassing operation (when required), preheating operation (when required), controlled atmosphere (if used), solder reflow operation, and a cooling operation, see 4.13.2 Controlled Cooling. These steps may be part of an integral or in-line system or may be accomplished through a series of separate operations.

The Manufacturer **shall** comply with AIAG CQI-17 Process D or equivalent.

4.15.3 Partially Visible or Hidden Solder Connections Partially visible or hidden SMT and Through Hole Technology solder connections **shall** meet the following conditions:

- The design does not restrict solder flow to any connection element on the solder destination side lands, e.g., PTH component, of the assembly.
- The visible portion, if any, of the connection on either side of the PTH solder connection (or the visible portion of the SMT connection) is acceptable.
- Process controls are maintained, documented, and available for review, see 1.6 Process Control Requirements, in a manner to assure compliance with visual acceptability criteria per IPC-A-610H and IPC-A-610HA and acceptability requirements per J-STD-001HG and J-STD-001HA with repeatable process results.

Voiding criteria for solder joints of through-hole components are not established in this Addendum.

5.0.1 Wire and Terminal Requirements

Requirements to wire and terminal connections have not been established in this Addendum.

6.2.2 Through-Hole Component Lead Soldering When soldering component leads into PTH connections, the goal of the process is to accomplish 100% fill of the PTH with solder and good wetting to the lands, lead, and barrel top and bottom.

The solder connection **shall** meet the requirements of Table 6-6, regardless of the soldering process, e.g., hand soldering, wave soldering, intrusive soldering.

In cases where the 75% fill requirement for plated through-holes with component leads is not met or not required, the design authority and the manufacturer **shall** validate and provide documented objective evidence that a requirement for the solder fill level other than 75% is sufficient to ensure product reliability and function under field loads, e.g., thermal shock.

Less than 100% solder fill may not be acceptable in some applications, e.g., thermal shock, electrical performance.

7.0 SURFACE MOUNTING OF COMPONENTS

7.0.1 Voiding and Solder Coverage Voiding and solder coverage requirements are not visually inspectable conditions. See J-STD-001HA 4.15.3 Partially Visible or Hidden Solder Connections and 1.12.1.1 Visual, Automated Optical and Automated X-ray Inspection.

Note: Additional information on how these requirements were determined can be found in IEC TR 61191-8

Shrinkage voids, planar microvoids (champagne voids), intermetallic microvoids, pinhole microvoids, and blowholes can typically not be detected in 2D x-ray imaging under mass-production conditions and are excluded from the criteria in this section.

As voiding levels can show a considerable scatter, the average solder coverage $\bar{c}$ is also an important parameter. To calculate the average solder coverage, use a minimum of 25 solder joints of a given case size and part number from at least 5 different non-consecutive panels.

7.0.1.1 Solder Coverage Requirements for Thermal Plane Terminations Solder coverage c requirements for thermal plane terminations of components soldered directly to heat sinks (for example inlays) **shall** be agreed between user and design authority.

Solder coverage for thermal plane terminations of components soldered to thermal pads with or without thermal vias on printed boards **shall** meet the criteria in Table 7-1-1HA.

For certain designs, e.g. via in pad, it may not be possible to comply with the criteria in Table 7-1-1HA. In such cases, it **shall** be the shared responsibility of the design authority and manufacturer to provide objective evidence for thermal and electrical functionality as well as solder joint reliability.

Table 7-1-1HA – Solder Coverage Requirements for Solder Joints at Thermal Plane Terminations

Type of Component/ Solder Joint	Acceptable	Process Indicator for Average Solder Coverage $\bar{c}$	Defect
Bottom termination components – thermal plane terminations	$c \geq 35\%$	$35\% < \bar{c} \leq 50\%$ average solder coverage	$c < 35\%$
Components with gull wing solder joints as quad-flat packages – thermal plane terminations	$c \geq 35\%$	$35\% < \bar{c} \leq 50\%$ average solder coverage	$c < 35\%$
Transistors as TO-252 (D-PAK™) – thermal plane terminations	$c \geq 35\%$	$35\% < \bar{c} \leq 50\%$ average solder coverage	$c < 35\%$

7.0.1.2 Solder Coverage Requirements for I/O pins of Bottom-Termination Components Solder coverage of I/O pins of bottom-termination components **shall** meet the requirements in Table 7-1-2HA.

I/O pins are terminations not specifically designed for thermal dissipation and have a size typically equal to or smaller than 1 mm².

Table 7-1-2HA – Solder Coverage (c) Requirements of I/O Pins of Bottom-Termination Components

Type of Component/ Solder Joint	Acceptable	Process Indicator for Average Solder Coverage $\bar{c}$	Defect
Bottom termination components – I/O pins	$c \geq 50\%$	$50\% < \bar{c} \leq 65\%$ average solder coverage	$c < 50\%$

7.0.1.3 Solder Coverage Requirements for Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s)

These criteria apply to components such as Chip Resistor, Chip Capacitor, Square End MELF and network passive parts (R-NET, etc.) that have this type of termination. Solder coverage in the stand-off region of such components **shall** meet the requirements in Table 7-1-3HA. For 1-sided termination, the solderable side is the vertical end face of the component and such components with 1-sided termination are exempt from the solder coverage criteria in this section.

Table 7-1-3HA – Solder Coverage (c) Requirements for Rectangular or Square End Chip Components (2, 3 or 5 Side Terminations)

Type of Component/ Solder Joint	Acceptable	Process Indicator for Average Solder Coverage $\bar{c}$	Defect
Chip components (in stand off)	$c \geq 50\%$	$50\% < \bar{c} \leq 65\%$ average solder coverage	$c < 50\%$

7.0.1.4 Voiding Requirements for Ball Grid Array Components with Collapsing Balls

Voiding in ball grid array components with collapsing balls **shall** comply with the criteria in Table 7-1-4HA.

Table 7-1-4HA – Voiding (v) Requirements for Ball Grid Array Components with Collapsing Balls

Type of Component/ Solder Joint	Acceptable	Process Indicator	Defect
Ball grid array components with collapsing balls	$v \leq 30\%$	$30\% < v \leq 50\%$ (microvia in pad design)	$v > 30\%$ (no microvia in pad design) $v > 50\%$ (microvia in pad design)

7.0.1.5 Solder Coverage Requirements for Land Grid Array (LGA) Components

Solder coverage in land grid array components **shall** comply with the criteria in Table 7-1-5HA.

Table 7-1-5HA – Solder Coverage(s) Requirements for Land Grid Array Components

Type of Component/Solder Joint	Acceptable	Defect
Land grid array components – electrical connections	$c \geq 50\%$	$c < 50\%$
Land grid array components – thermal / ground connections	$c \geq 35\%$	$c < 35\%$

7.1.1 Plastic Components See IPC-A-610HA 8.2 SMT Leads.

7.4 Installation of Surface Mount Components See IPC-A-610HA 8.3 SMT Connections.

7.5 Soldering Requirements

Table 7-2HA Surface Mount Components

Termination	Reference
Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s)	7.5.4
Cylindrical End Cap Terminations	7.5.5
Castellated Terminations	7.5.6
Flat Gull Wing Leads	7.5.7
Round or Flattened (Coined) Gull Wing Leads	7.5.8
Flat Lug Leads and Flat Unformed Leads	7.5.11
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Bottom Termination Components (BTC)	7.5.15
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Odd-Shaped Components with Hidden Terminations	7.5.22
Half Moon Shape Ferrite Termination – Coil Terminal	7.5.23
Coil Terminals (Coated Wire)	7.5.24
“L” Type (Fuses/Shunt Resistors) Terminals	7.5.25
“C” Type Terminal with Thermal Plane Termination	7.5.26

See IPC-A-610HA 8.3 SMT Connections.

7.5.4 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) See IPC-A-610HA 8.3.2 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s).

7.5.5 Cylindrical End Cap Terminations See IPC-A-610HA 8.3.3 Cylindrical End Cap Terminations.

7.5.6 Castellated Terminations See IPC-A-610HA 8.3.4 Castellated Terminations.

7.5.7 Flat Gull Wing Leads See IPC-A-610HA 8.3.5 Flat Gull Wing Leads.

7.5.8 Round or Flattened (Coined) Gull Wing Leads See IPC-A-610H 8.3.6 Round or Flattened (Coined) Gull Wing Leads.

7.5.11 Flat Lug Leads See IPC-A-610HA 8.3.9 Flat Lug Leads.

7.5.13 Inward Formed L-Shaped Ribbon Leads See IPC-A-610HA 8.3.11 Inward Formed L-Shaped Ribbon Leads.

7.5.14 Surface Mount Area Array Packages See IPC-A-610H 8.3.12 Surface Mount Area Array.

7.5.14.1 Ball Grid Array Components with Collapsing Balls See IPC-A-610H 8.3.12 Surface Mount Area Array.

7.5.14.2 Ball Grid Array Components with Noncollapsing Balls See IPC-A-610H 8.3.12 Surface Mount Area Array.

7.5.14.3 Column Grid Array Components See IPC-A-610HA 8.3.12 Surface Mount Area Array.

7.5.15 Bottom Termination Components (BTC) See IPC-A-610HA 8.3.13 Bottom Termination Components (BTC).

For LEDs, solder coverage on heatsink pads surfaces **shall** be greater than or equal to 85%.

7.5.16 Components with Bottom Thermal Plane Terminations (D-Pak) See IPC-A-610HA 8.3.14 Components with Bottom Thermal Plane Terminations (D-Pak).

7.5.19 Vertical Cans with Outward L-Shaped Lead Terminations See IPC-A-610HA 8.3.17 Vertical Cans with Outward L-Shaped Lead Terminations.

7.5.20 Wrapped Terminals See IPC-A-610HA 8.3.19 Wrapped Terminals.

7.5.21 Flexible and Rigid-Flex Printed Circuitry with Flat Unformed Leads See IPC-A-610HA 8.3.18 Flexible and Rigid Flex Printed Circuitry with Flat Unformed Leads.

7.5.22 Odd-Shaped Components with Hidden Terminations See IPC-A-610HA 8.3.22 Odd-Shaped Components with Hidden Terminations.

7.5.23 Half-Moon Shape Ferrite Termination-Coil Terminal See IPC-A-610HA 8.3.23 Half-Moon Shape Ferrite Termination-Coil Terminal.

7.5.24 Coil Terminals (Coated Wire) See IPC-A-610HA 8.3.22 Half-Moon Shape Ferrite Termination-Coil Terminal.

7.5.25 “L” Type (Fuses/Shunt Resistors) Terminals See IPC-A-610HA 8.3.23 “L” Type (Fuses/Shunt Resistors) Terminals.

7.5.26 “C” Type Terminal with Thermal Plane Termination See IPC-A-610HA 8.3.24 “C” Type Termination with Thermal Plane Termination.

8.4 Foreign Object Debris (FOD) Manufacturers **shall** implement measures to minimize the contamination of assemblies with metallic and non-metallic foreign particles that affect form, fit and function and are loose, e.g., could be dislodged in the normal service environment of the product.

Note: A 'zero foreign particles' (FOD) approach is not feasible, as automotive-electronics manufacturing is typically not done under clean-room conditions and a considerable fraction of the foreign-particle load on electronic assemblies results from printed circuit boards and components. Manufacturers should therefore assure requirements flowdown throughout the supply chain. For an assessment of technical cleanliness in electronics assembly manufacturing, methods of analysis of technical cleanliness recommendations for minimizing the contamination of assemblies with metallic and non-metallic foreign particles and the use of tools to provide risk assessments for technical cleanliness, manufacturers should follow IEC/TR-61191-7 or equivalent.

9.0.1 Printed Circuit Board and Assembly Damage For additional information on printed circuit boards, see IPC-6012 Automotive Addendum and IPC-A-600. For additional information on printed circuit assemblies, see IPC-A-610H.

9.3 Bow and Twist (Warpage) Bow and twist after solder should not exceed 1.5% for through-hole and 0.75% for surface mount printed board applications. IPC-TM-650 has Test Method 2.4.22 for bare boards. Component size and placement on assemblies often precludes use of that test method for populated assemblies. It may be necessary to confirm through testing that bow and twist has not created stress that will result in solder connection fracture, component damage or will otherwise cause damage during post solder assembly operations or use. Printed circuit assemblies with components with leadless terminations, e.g., LGA, may require lower bow and twist values.

12.0 REWORK AND REPAIR

Industry best practice/guidelines for rework, repair and modification of electronic assemblies can be found in IPC-7711/ 7721. The document prescribes the procedural requirements, tools, materials and methods to be used in the modification, rework, repair, overhaul or restoration of electronic products.

12.1 Rework Rework is the act of reprocessing in a manner that assures full compliance to applicable drawings/ specification. Hardware defects **shall** be documented before rework. The second application of a soldering iron during a hand soldering operation on a single connection is not considered rework.

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

Rework **shall** meet all applicable requirements of the AIAG CQI-17 Process Table S Solder Rework or equivalent procedure.

12.2 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 drawings or specifications. A hardware defect **shall not** be repaired until the discrepancy has been documented. The repair method **shall** be determined by agreement between the Manufacturer and the User.

12.3 Post Rework/Repair Cleaning After rework or repair, assemblies **shall** be cleaned per agreement between Design Authority/ User and Manufacturer.

A process **shall** be established for post rework/repair cleanliness validation.

A process **shall** be established for post rework/repair cleanliness verification on conformally coated assemblies or assemblies that cannot be submerged in a liquid for testing, e.g., unprotected vented components. This may be a visual inspection.

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Table of Contents

The following topics are addressed in this Addendum.

0.1 Scope

0.2 Use

The following reference numbers are to IPC-A-610H Clauses that are modified or added in this Addendum.

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8.3.23.7 (NEW)	Solder Fillet Thickness (G)
8.3.24 (NEW)	“C” Type Terminal with Thermal Plane Termination
8.3.24.1 (NEW)	Maximum Side Overhang (A)
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Appendix AH	Voiding Categories

0.1 Scope This Addendum provides a collection of visual acceptability criteria for electronic assemblies to be used in addition to, and in some cases, in place of, those published in IPC-A-610H intended to ensure the reliability of mission-critical soldered automotive electrical and electronic assemblies in the field under harsh environments, considering the conditions of automated high-volume production. This Addendum does not provide criteria for cross-section evaluation or evaluation of images generated by automated optical and/or x-ray inspection systems.

0.2 Use This Addendum is not to be used as a standalone document.

Where criteria are not supplemented, the Class 3 requirements of IPC-A-610H **shall** apply. Where IPC-A-610H criteria are supplemented or new criteria are added by this Addendum, the clause is listed in IPC-A-610 Automotive Addendum Acceptability section and the entire IPC-A-610H clause is replaced by this Addendum except as specifically noted.

The clauses modified by this Addendum do not include subordinate clauses unless specifically states, e.g., 1.4 does not include 1.4.1. Clauses, Tables, Figures, etc., in IPC-A-610H that are not listed in this Addendum are to be used as published IPC-A-610HA must be used with IPC-A-610H.

This Addendum **shall** be used only in conjunction with the corresponding automotive addendum pertaining to J-STD-001H, J-STD-001HA.

In the context of this Addendum, IPC-A-610 **shall** be used as a companion document to J-STD-001. The revisions of J-STD-001 and IPC-A-610 **shall** correspond, e.g. J-STD-001H and IPC-A-610H. The likelihood of criteria not aligning increases when different revisions are used together.

For the order of precedence, see clause 1.7 Order of Precedence.

1 General

1.2 Purpose The visual acceptability criteria in this document reflect the requirements of existing IPC and other applicable specifications. In order for the user to apply and use the content of this document, the assembly/product **shall** comply with other existing IPC requirements, such as IPC-7351, IPC-2220-FAM, IPC-6010-FAM and IPC-A-600 or customer unique/specified automotive standards, testing, reliability data, etc. If the assembly does not comply with these or with equivalent requirements, it **shall** be the shared responsibility of the User and the Design Authority to define, agree to, and document specific acceptance criteria.

In the case of a discrepancy, the description or written criteria, i.e., Tables, Notes addressing criteria, always takes precedence over the illustrations, e.g., photos, graphics.

Standards and Addendums may be updated at any time, including with the use of amendments. The use of an amendment or newer revision is not automatically required, unless it is agreed between customer and supplier.

Table 1-1HA is a summary of related documents.

Table 1-1HA Summary of Related Documents

Document Purpose	Spec.#	Definition
Design Standard	IPC-2220-FAM IPC-7351 IPC-CM-770	Design requirements reflecting three levels of complexity (Levels A, B, and C) indicating finer geometries, greater densities, more process steps to produce the product. Component and Assembly Process Guidelines to assist in the design of the bare board and the assembly where the bare board processes concentrate on land patterns for surface mount and the assembly concentrates on surface mount and through-hole principles which are usually incorporated into the design process and the documentation.
Printed Board Requirements	IPC-6010-FAM IPC-A-600	Requirements and acceptance documentation for rigid, rigid flex, flex and other types of substrates.
End Item Documentation	IPC-D-325	Documentation depicting bare board specific end product requirements designed by the customer or end item assembly requirements. Details may or may not reference industry specifications or workmanship standards as well as customer's own preferences or internal standard requirements.
End Item Standards	J-STD-001	Requirements for soldered electrical and electronic assemblies depicting minimum end product acceptable characteristics as well as methods for evaluation (test methods), frequency of testing and applicable ability of process control requirements.
Acceptability Standard	IPC-A-610	Pictorial interpretive document indicating various characteristics of the board and/or assembly as appropriate relating to desirable conditions that exceed the minimum acceptable characteristics indicated by the end item performance standard and reflect various out-of-control (process indicator or defect) conditions to assist the shop process evaluators in judging need for corrective action.
Training Programs (Optional)		Documented training requirements for teaching and learning process procedures and techniques for implementing acceptance requirements of either end item standards, acceptability standards, or requirements detailed on the customer documentation.
Rework and Repair	IPC-7711/7721	Documentation providing the procedures to accomplish conformal coating and component removal and replacement, solder resist repair, and modification/repair of laminate material, conductors, and plated through-holes.
Automotive Industry Action Group Standards	AIAG-CQI-17	Special Process: Electronic Assembly Manufacturing – Soldering System Assessment
Automotive Electronics Council Standards	AEC-Q100 AEC-Q101 AEC-Q102 AEC-Q104 AEC-Q200	Automotive Electronics Council – Failure Mechanism Based Stress Test Qualification

1 General (cont.)

1.3 Classification Accept and/or reject decisions **shall** be based on applicable documentation such as contracts, drawings, specifications, standards, addendums and reference documents. Criteria defined in this document reflects Class 3 visual criteria. Class 3 will not appear after the condition [Acceptable, etc.].

1.4.1 Verification of Dimensions Actual measurement of specific component placement, quantity and dimensions of the solder connection, and determination of percentages, **shall not** be used, except for referee purposes.

1.5 Definition of Requirements This document provides acceptance criteria for completed electronic assemblies. Where a requirement is presented that cannot be defined by the acceptable, process indicator, and defect conditions, the word “**shall**” is used to identify the requirement. Unless otherwise specified herein, the word “**shall**” in this document invokes a requirement for manufacturers of automotive product, and failure to comply with the requirement is a noncompliance to this Addendum.

1.5.1.2 Defect Condition A defect is a condition that may be insufficient to ensure the form, fit or function of the assembly in its end use environment. Defect conditions **shall** be dispositioned by the manufacturer based on design, service, and customer requirements. In this Addendum, if the defect condition is not defined, the default condition is Defect if it affects form, fit or function.

It is the shared responsibility of the User and the Design Authority to define complimentary, unique defect categories applicable to the product.

1.5.1.4 Combined Conditions Cumulative conditions **shall** be considered in addition to the individual characteristics for product acceptability even though they are not individually considered defective. The significant number of combinations that could occur does not allow full definition in the content and scope of this specification but manufacturers should be vigilant for the possibility of combined and cumulative conditions and their impact upon product performance.

Conditions of acceptability provided in this specification are individually defined and created with separate consideration for their impact upon reliable operation for the defined production classification. Where related conditions can be combined, the cumulative performance impact for the product may be significant, e.g., minimum solder fillet quantity when combined with maximum side overhang and minimum end overlap may cause a significant degradation of the mechanical attachment integrity. The Manufacturer is responsible for identification of such conditions.

It is the shared responsibility of the User and the Design Authority to identify complimentary combined conditions where there is significant concern based upon end use environment and product performance requirements.

1.5.1.5 Conditions Not Specified See 1.11.2 Conditions Not Specified.

1.6 Process Control Methodologies Process control methodologies **shall** be used in the planning, implementation and evaluation of the manufacturing processes used to produce soldered electrical and electronic 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. The Manufacturer **shall** maintain objective evidence of a current process control/continuous improvement plan that is available for review. Also refer to 1.8.27 Objective Evidence and 1.11 Acceptance Requirements of this IPC-A-610HA Addendum for further J-STD-001 requirements.

1.7 Order of Precedence The contract **shall** take precedence over this Addendum, referenced standards and User-approved drawings. Where referenced criteria of this Addendum differ from IPC-A-610H, this Addendum takes precedence. In the event of a conflict between this Addendum and the applicable documents cited herein, this Addendum takes precedence, except for J-STD-001HA and J-STD-001H. For the latter, J-STD-001HA takes precedence.

In the event of conflict between the requirements of this Addendum and the applicable assembly drawing(s)/documentation, the applicable User approved assembly drawing(s)/documentation take precedence.

In the event of conflict between the requirements of the IPC-A-610H Standard and the applicable assembly drawing(s) and documentation, the applicable User approved assembly drawing(s) and documentation govern. Some examples of documentation include the contract, purchase order, technical data package, engineering specification or performance specification.

In the event of conflict between the requirements of the IPC-A-610H and assembly drawing(s) and documentation that has not been User approved, IPC-A-610H governs.

In the case of a conflict between this Addendum and J-STD-001H, J-STD-001HA takes precedence.

1 General (cont.)

1.7.1 Clause References The clauses modified by this Addendum do not include subordinate clauses unless specifically stated, e.g., 1.4 does not include 1.4.1. Clauses, Tables, Figures, etc. in IPC-A-610H that are not listed in this Addendum are to be used as-published.

1.7.3 Appendix AH Appendix AH in this Addendum applies.

1.8.5.1 Minimum Electrical Clearance The minimum spacing between noncommon uninsulated conductors, e.g., patterns, materials, hardware, residue, is referred to as “minimum electrical clearance” throughout this document and is defined in the applicable design standard or on the approved or controlled documentation. In the absence of a known design standard, use Appendix B (derived from IPC-2221).

1.8.5.2 Gap Clearance The minimum spacing between non-common uninsulated conductors, e.g., patterns, materials, hardware, residue, is referred to as “minimum gap clearance” throughout this document if the conductors, at the position of the minimum spacing, are separated by a gap without the presence of a potential creepage path in the immediate surroundings. An example for this gap clearance is the spacing between two solder joints (balls) of a ball grid array. It is defined in the applicable design standard or on the approved or controlled documentation. In the absence of a known design standard, use Appendix B (derived from IPC-2221).

Note: The gap clearance is a special case of the minimum electrical clearance.

1.8.25 User The individual, organization, company, or agency responsible for the procurement and having the authority to define the product class and variations or restrictions to the requirements of this Addendum, i.e., the originator/custodian of the contract detailing these requirements.

1.8.26 Design Authority The individual, organization, company, contractually designated authority, or agency responsible for the design of electrical/electronic hardware, having the authority to define the product class and variations or restrictions to the requirements of this Addendum, i.e., the originator/custodian of the contract detailing these requirements.

1.8.27 Objective Evidence

It may include, but is not limited to:

- a. Work instructions.
- b. Procedures and records required by the quality management system.
- c. Chemical and physical data.
- d. Reliability calculations based on recognized industry reliability standards.
- e. Manufacturer data sheets/reports, known acceptable record of performance by selected suppliers.
- f. External and/or internal audit reports.
- g. Test/inspection reports including actual measured values.
- h. Training records.
- i. Solder temperature versus time profiles.
- j. Technical basis for changes in materials and/or processes, e.g., see Appendix C J-STD-001 Guidance on Objective Evidence or Material Compatibility.
- k. Historical data, e.g., 0 kilometer failures, field failures/warranties, product/process validation, pilot runs, safe launch data.
- l. Competency matrix, i.e., skills checklist.

Note: Objective evidence is used to demonstrate or validate evidence of process control.

1 General (cont.)

1.9 Requirements Flowdown When this Addendum is contractually required, the applicable requirements of this Addendum (including product class, see 1.3) **shall** be imposed on all applicable subcontracts, assembly drawing(s), documentation and purchase orders. Unless otherwise specified, the requirements of this Addendum are not imposed on the procurement of commercial- off-the-shelf (COTS or catalog) assemblies or subassemblies.

When a part is adequately defined by a specification, then the requirements of this Addendum should be imposed on the Manufacturer of that part only when necessary to meet end-item requirements. When it is unclear where flow-down should stop, it is the responsibility of the Manufacturer to establish that determination with the User.

When an assembly, e.g., daughterboard, is procured, that assembly should meet the requirements of this Addendum. The connections from the procured assembly to the manufactured assembly **shall** meet the requirements of this Addendum. If the assembly is manufactured by the same manufacturer, the solder requirements are as stated in the contract for the entire assembly.

The design and workmanship of COTS items should be evaluated and modified as required to ensure the end-item meets contract performance requirements. Modifications **shall** meet the applicable requirements of this Addendum.

1.10 Personnel Proficiency All personnel involved in the acceptance decision-making **shall** be proficient in the content, use and application of the written criteria of the IPC-A-610H and IPC-A-610HA. Objective evidence of that proficiency **shall** 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** meet the requirements of the contracts, engineering documentation, applicable standards, and the requirements for Class 3 of these standards.

Manufacturers **shall**:

- 1) Perform 100% inspection, or
- 2) Perform sampling inspection if defined as part of a documented process control plan, see J-STD-001H 1.6.2 Statistical Process Control, or
- 3) Provide documented objective evidence, see 1.8.9 Objective Evidence.

The User and the Design Authority have the shared responsibility to specify acceptance criteria not stated in J-STD-001H and this Addendum. If no criteria are specified, required, or cited, then 1.11.2 Conditions Not Specified applies.

1.11.1 Missing Parts and Components Missing parts and components **shall** be a defect for all Product Classes.

1.11.2 Conditions Not Specified Conditions that are not documented by the User or the Designer Authority as defective or as a process indicator **shall** be considered acceptable unless it can be established that the condition affects user-defined form, fit or function. Such conditions **shall** be documented and agreed between User and Design Authority and Manufacturer for future considerations.

1.12 Inspection Methodology Accept and/or reject decisions **shall** be based on applicable documentation such as contract, drawings, specifications and referenced documents.

The use of any non-visual inspection methods other than those already detailed in 8.3.12 Surface Mount Area Array and 8.3.13 Bottom Termination Components (BTC) are not specifically covered by this Addendum. Automated Inspection, e.g., AOI imaging, is a viable alternative to visual inspection and complements automated test equipment. Many characteristics in this document can be inspected with an automated system. In particular, x-ray imaging inspection can be used to validate hidden solder connections, e.g., dimension "G." The use of automated inspection equipment as AOI and AXI **shall** be manufacturer responsibility. Tables 1-1, 1-2 and 1-3 do not apply to AOI/AXI image inspection.

For industry standard requirements on sampling inspection in accordance with ANSI/ASQ A1.4 and process control, see J-STD-001H and J-STD-001HA.

1.12.1 Lighting Illumination at the surface of workstations should be at least 1000 lm/m² (approximately 93 foot candles). Supplemental lighting may be necessary to assist in visual human inspection with or without magnification.

The light source **shall** provide shadowless illumination of the area being viewed unless directional or oblique lighting is specifically required.

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 printed circuit assembly features and contaminants with increased clarity.

1 General (cont.)

1.12.2 Magnification Aids Magnification power for visual inspection with or without magnification, some individual specifications may call for magnification aids for examining printed board assemblies.

The tolerance for magnification aids is $\pm 15\%$ of the selected magnification power. Magnification aids, if used for inspection, **shall** be appropriate with the item being inspected. Unless magnification requirements are otherwise specified by contractual documentation, the magnifications in Tables 1-2, 1-3, and 1-4 are determined by the item being inspected.

If the presence of an anomaly cannot be determined at the appropriate magnification power defined in Tables 1-2, 1-3 or 1-4, the item is acceptable. The referee magnification power is intended for use only after an anomaly has been determined as a defect but is not completely identifiable at the inspection power.

For assemblies with mixed land sizes, the greater magnification power may be used for the entire assembly. For assemblies with mixed wire sizes, the greater magnification power may be used.

1.13.2 Field Assembly Operations In field assembly operations on Class 3 products where the controlled environmental conditions required by J-STD-001H and this Addendum cannot be effectively achieved, precautions **shall** be taken to maximize the quality of solder connections and minimize the effects of the uncontrolled environment on the operation being performed on the hardware.

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2 Applicable Documents

The following documents of the issue currently in effect form a part of this document to the extent specified herein.

2.1 IPC Documents¹

IPC-HDBK-001 Handbook and Guide to Supplement J-STD-001

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

IPC-CM-770 Component Mounting Guidelines for Printed Boards

IPC-D-279 Design Guidelines for Reliable Surface Mount Technology Printed Board Assemblies

IPC-D-325 Documentation Requirements for Printed Boards

IPC-A-600 Acceptability of Printed Boards

IPC-A-610 Acceptability of Electronic Assemblies

IPC-OI-645 Standard for Visual Optical Inspection Aids

IPC-SM-785 Guidelines for Accelerated Reliability Testing of Surface Mount Attachments

IPC-TM-650 Test Methods Manual²

2.3.25 Detection and Measurement of Ionizable Surface Contaminants

2.3.27 Cleanliness Test Residual Rosin

2.3.39 Surface Organic Contamination Identification Test (Infrared Analytical Method)

2.4.22 Bow and Twist

2.6.9.1 Test to Determine Sensitivity of Electronic Assemblies to Ultrasonic Energy and Test Method

2.6.9.2 Test to Determine Sensitivity of Electronic Components to Ultrasonic Energy

2.6.25 Conductive Anodic Filament (CAF) Resistance Test: X-Y Axis

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

IPC-AJ-820 Assembly and Joining Handbook

IPC-CC-830 Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies

IPC-2220-FAM Design Standards for Printed Boards

IPC-2221 Generic Standard on Printed Board Design

IPC-2222 Sectional Design Standard for Rigid Organic Printed Boards

IPC-2223 Sectional Design Standard for Flexible Printed Boards

IPC-6010-FAM IPC-6010 Printed Board Performance Specifications

IPC-6011 Generic Performance Specification for Printed Boards

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-6013 Qualification and Performance Specification for Flexible/Rigid-Flexible Printed Boards

IPC-7093 Design and Assembly Process Implementation for Bottom Termination Components (BTC)

IPC-7095 Design and Assembly Process Implementation for Ball Grid Arrays

IPC-7351 Generic Requirements for Surface Mount Design and Land Pattern Standard

IPC-7530 Guidelines for Temperature Profiling for Mass Soldering Processes (Reflow and Wave)

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

IPC-7711/7721 Rework, Modification and Repair of Electronic Assemblies

IPC-9201 Surface Insulation Resistance Handbook

1. www.ipc.org
2. www.ipc.org/test-methods.aspx

2.1 IPC Documents (cont.)

IPC-9202 Material and Process Characterization/Qualification

IPC-9203 Users Guide to IPC-9202 and the IPC-B-52 Standard Test Vehicle

IPC-9261 In-Process DPMO and Estimated Yield for PWAs

IPC-9691 User Guide for the IPC-TM-650, Method 2.6.25, Conductive Anodic Filament (CAF) Resistance and Other Internal Electrochemical Migration Testing

IPC-9701 Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments

2.2 Joint Industry Documents³

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-003 Solderability Tests for Printed Boards

J-STD-004 Requirements for Soldering Fluxes

J-STD-005 Requirements for Soldering Pastes

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

IPC/JEDEC J-STD-020 Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices

IPC/JEDEC J-STD-033 Handling, Packing, Shipping and Use of Moisture, Reflow, and Process Sensitive Devices

ECA/IPC/JEDEC J-STD-075 Classification of Non-IC Electronic Components for Assembly Processes

2.3 Electrostatic Association Documents⁴

ANSI/ESD S8.1 ESD Awareness Symbols

ANSI/ESD-S20.20 Protection Of Electrical And Electronic Parts, Assemblies And Equipment (Excluding Electrically Initiated Explosive Devices)

2.4 International Electrotechnical Commission⁵

IEC TR 61191-7 Printed board assemblies - Part 7: Technical cleanliness of components and printed board assemblies

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

IEC 61340-5-3 Electrostatics - Part 5-3: Protection of electronic devices from electrostatic phenomena - Properties and requirements classification for packaging intended for electrostatic discharge sensitive devices

2.5 ASTM⁶

ASTM E29 Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

ASTM SI10, IEEE/ASTM SI 10 American National Standard for Metric Practice

3. www.ipc.org

4. www.esda.org

5. www.iec.ch

6. www.astm.org

2.6 Military Standards⁷

MIL-STD-1686 Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

MIL-STD-2073 Standard Practice for Military Packaging

2.7 SAE International⁸

GEIA-STD-0005-1 Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder

GEIA-STD-0005-2 Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems

2.8 JEDEC⁹

JESD557 Statistical Process Control Systems

JESD471 Symbol and Label for Electrostatic Sensitive Devices

2.9 Automotive Electronics Council (AEC)¹⁰

AEC-Q100 Failure Mechanism Based Stress Test Qualification For Integrated Circuits

AEC-Q101 Failure Mechanism Based Stress Test Qualification For Discrete Semiconductors

AEC-Q102 Failure Mechanism Based Stress Test Qualification For Discrete Optoelectronic Semiconductors in Automotive Applications

AEC-Q104 Failure Mechanism Based Stress Test Qualification For Multichip Modules (MCM) In Automotive Applications

AEC-Q200 Stress Test Qualification For Passive Components

2.10 Automotive Industry Action Group (AIAG)¹¹

AIAG CQI-17 Special Process: Soldering System Assessment

2.11 ISO-IATF¹²

ISO-IATF 16949:2016 Automotive Quality Management System

7. quicksearch.dla.mil/qsSearch.aspx

8. www.sae.org

9. www.jedec.org

10. www.aecouncil.com

11. www.aiag.org

12. www.iatfglobaloversight.org

2.12 American Society of Quality¹³

ANSI/ASQ Z1.4 American National Standard – Sampling Procedures and Tables for Inspection by Attributes

¹³. www.asq.org

3 Handling Electronic Assemblies

See 3.1 Gloves and Finger Cots, Appendix B and J-STD-001HA 4.1.

3.1 Gloves and Finger Cots Gloves, e.g., disposable, non-disposable, or finger cots **shall** be used if required under contract to prevent contamination of parts and assemblies. These gloves and cots shall not be used for handling or touching anything other than electronic components, printed circuit boards and assemblies. Gloves and finger cots must be carefully chosen to maintain EOS/ESD protection as well as non-contamination of assemblies.

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4 Hardware

This section illustrates several types of hardware used to mount electronic devices to an assembly or any other types of assemblies requiring the use of any of the following: screws, bolts, nuts, washers, fasteners, clips, component studs, tie downs, rivets, connector pins, etc. This section of this Addendum is primarily concerned with the visual assessment of press-fit contact terminals (for single pin insertion) and connector modules (housing). Visual inspection of this mechanical operation in the printed board (entry & exit) and housing, i.e., correct pins, damaged pins, bent and broken pins, damage to the substrate or conductive pattern, correct height and compliance with insertion force, see J-STD-001HA.

Visual inspection is performed in order to verify the following conditions:

- a. Correct parts and hardware.
- b. Correct sequence of assembly.
- c. Correct security and tightness of parts and hardware.
- d. No discernible damage.
- e. Correct orientation of parts and hardware.

The following topics are addressed in this section.

- 4.1.5.4 Self-Tapping Fasteners and Other Threaded Hardware
- 4.3.2 Press Fit Pins
 - 4.3.2.3 Compliant Press Fit Pins
 - 4.3.2.3.1 Standalone Press-Fit Pins Inserted into Printed Board
 - 4.3.2.3.2 Press-Fit Pins Inserted into Housing

4.1.5.4 Threaded Fasteners and Other Threaded Hardware – Self-Tapping Fasteners

Self-tapping fasteners (screws) are used to assemble printed boards in enclosures. See Figure 4-5HA.

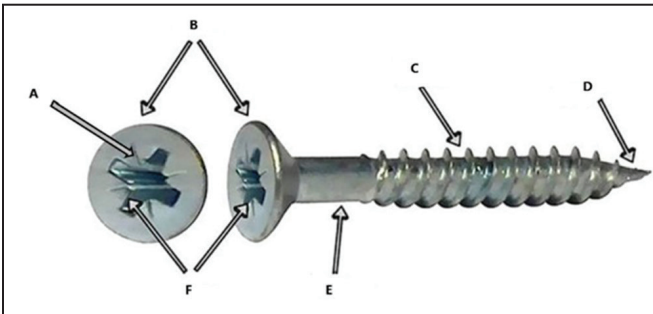


Figure 4-5HA

- A. Slot
- B. Head
- C. Thread
- D. Tip
- E. Shank
- F. Drive

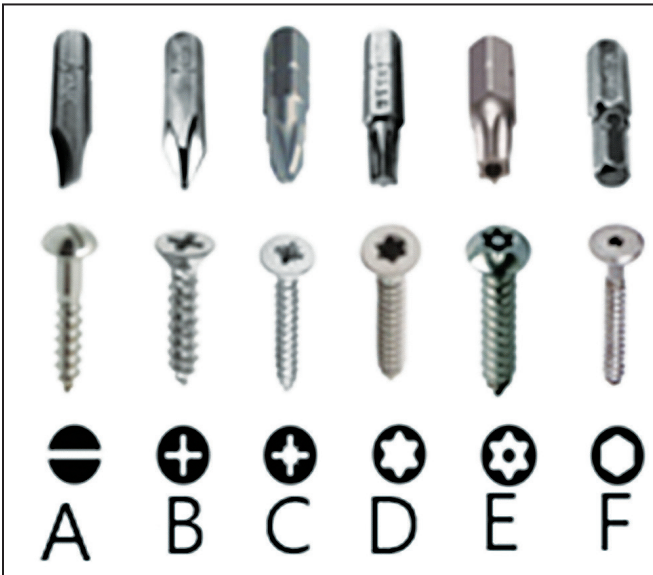


Figure 4-6HA

- A. Slot Head
- B. Phillips Head
- C. Pozidriv
- D. Torx
- E. Secure Torx
- F. Hex Head

4.1.5.4 Threaded Fasteners and Other Threaded Hardware – Self-Tapping Fasteners (cont.)



Figure 4-7HA

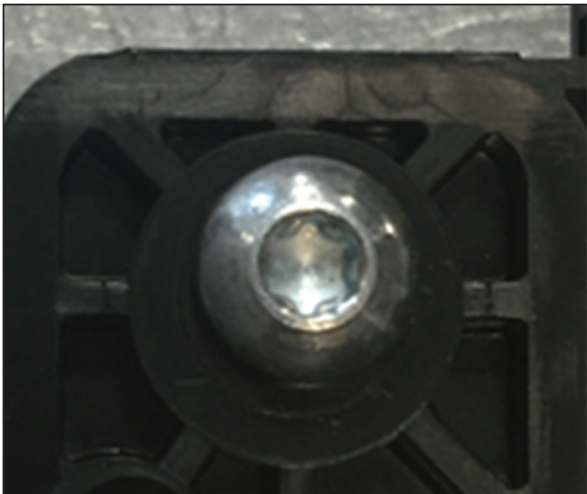


Figure 4-8HA

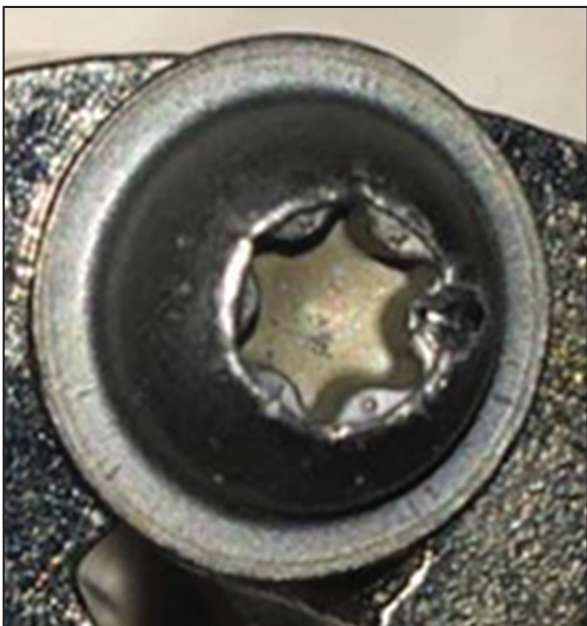


Figure 4-9HA

Acceptable

- Screw is seated in contact 360° of its circumference to the surface, see Figure 4-7HA.
- The surface of the screw drive does not have damage that affects the installation and verification of the screw's torque, see Figure 4-8HA.
- No visible damage to the surface of the enclosure, see Figures 4-7HA and 4-8HA.
- No evidence of slivers or burrs, see Figures 4-7HA and 4-8HA.
- No cracks in the screw.
- Damage to the exterior surface of the screw head does not exceed 25%, see Figure 4-9HA.

4.1.5.4 Threaded Fasteners and Other Threaded Hardware – Self-Tapping Fasteners (cont.)

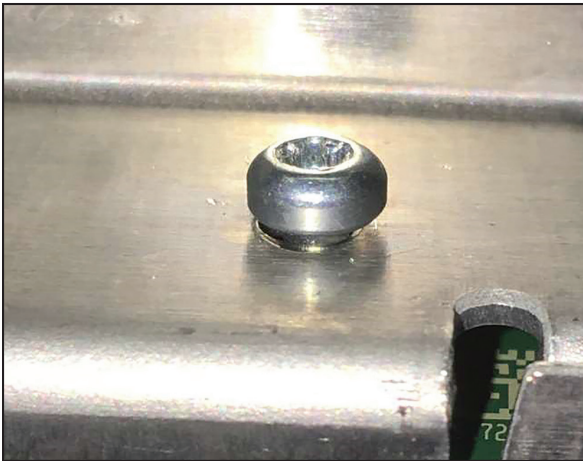


Figure 4-10HA

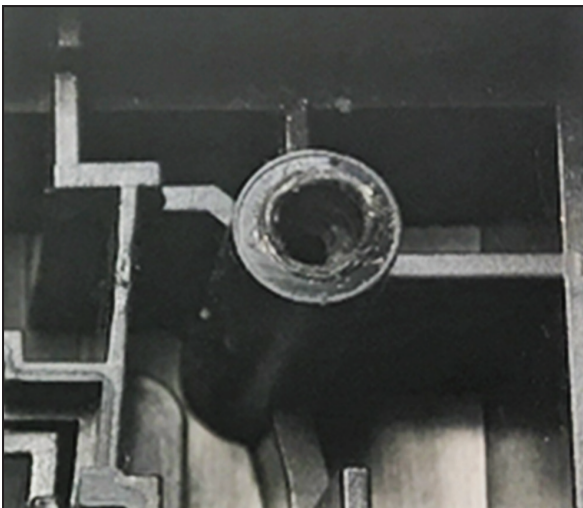


Figure 4-11HA



Figure 4-12HA

Defect

- The surface of the screw drive has damage that affects the installation and verification of the screw's torque, see Figure 4-11HA.
- Screw is not seated in contact 360° of its circumference to the surface.
- Visible damage to the surface of the enclosure.
- Evidence of slivers or burrs.
- Cracks in the screw.
- Damage to the exterior surface of the screw head exceeds 25%, see Figure 4-11HA.

Note: The lack of some additives on the surface of the screw would lead to an increase in the torque (see Figure 4-12HA).

4.3.2 Connector Pins – Press Fit Pins

See IPC-9797 for compliant press-fit connection area criteria pertaining to the compliant press-fit tail, see Figure 4-13HA, and these criteria do not address solid press-fit technology.

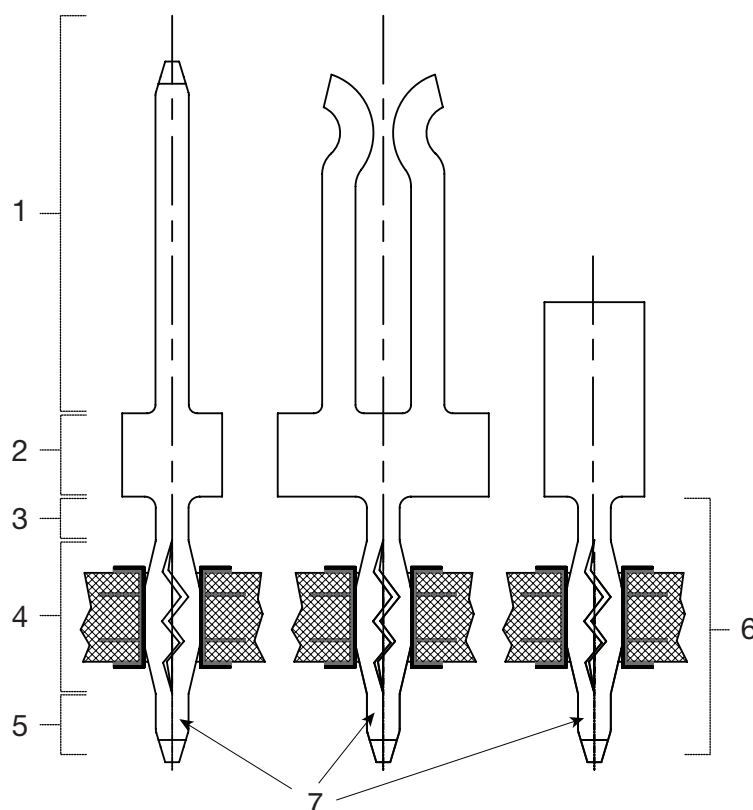


Figure 4-13HA Examples of Interface Contact, Compliant Press-Fit Zone and Plated Through-Hole

- | | |
|-----------------------------------|---------------------------------|
| 1. Examples of Interface Contacts | 5. Compliant Press-Fit Zone Tip |
| 2. Pin Shoulder | 6. Compliant Press-Fit Tail |
| 3. Pin Neck/Transitional Zone | 7. Axis |
| 4. Compliant Press-Fit Zone | |

4.3.3 Connector Pins – Standalone Pins

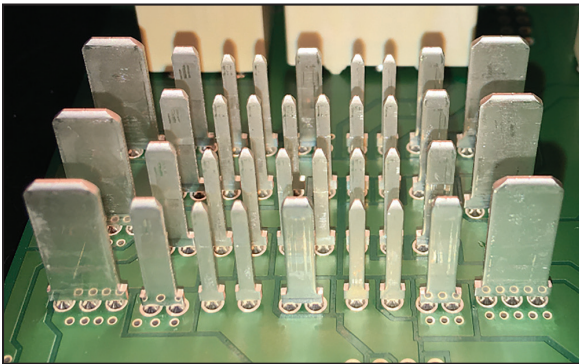


Figure 4-14HA

Acceptable

- Horizontal pin alignment is within tolerance per assembly drawing(s)/documentation.
- Pin height is within tolerance per assembly drawing(s)/documentation.
- No exposed pin base metal unless agreed between pin supplier and Manufacturer.

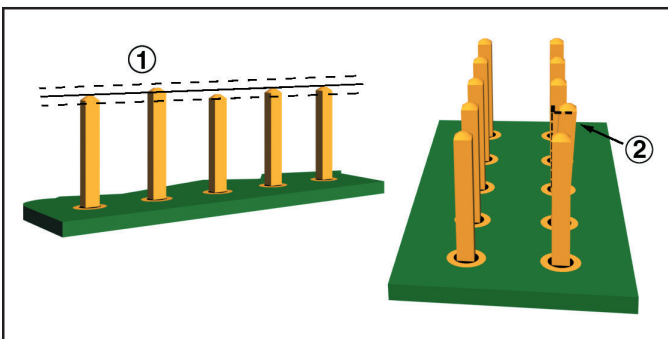


Figure 4-15HA

1. Pin height tolerance
2. Horizontal pin alignment within tolerance