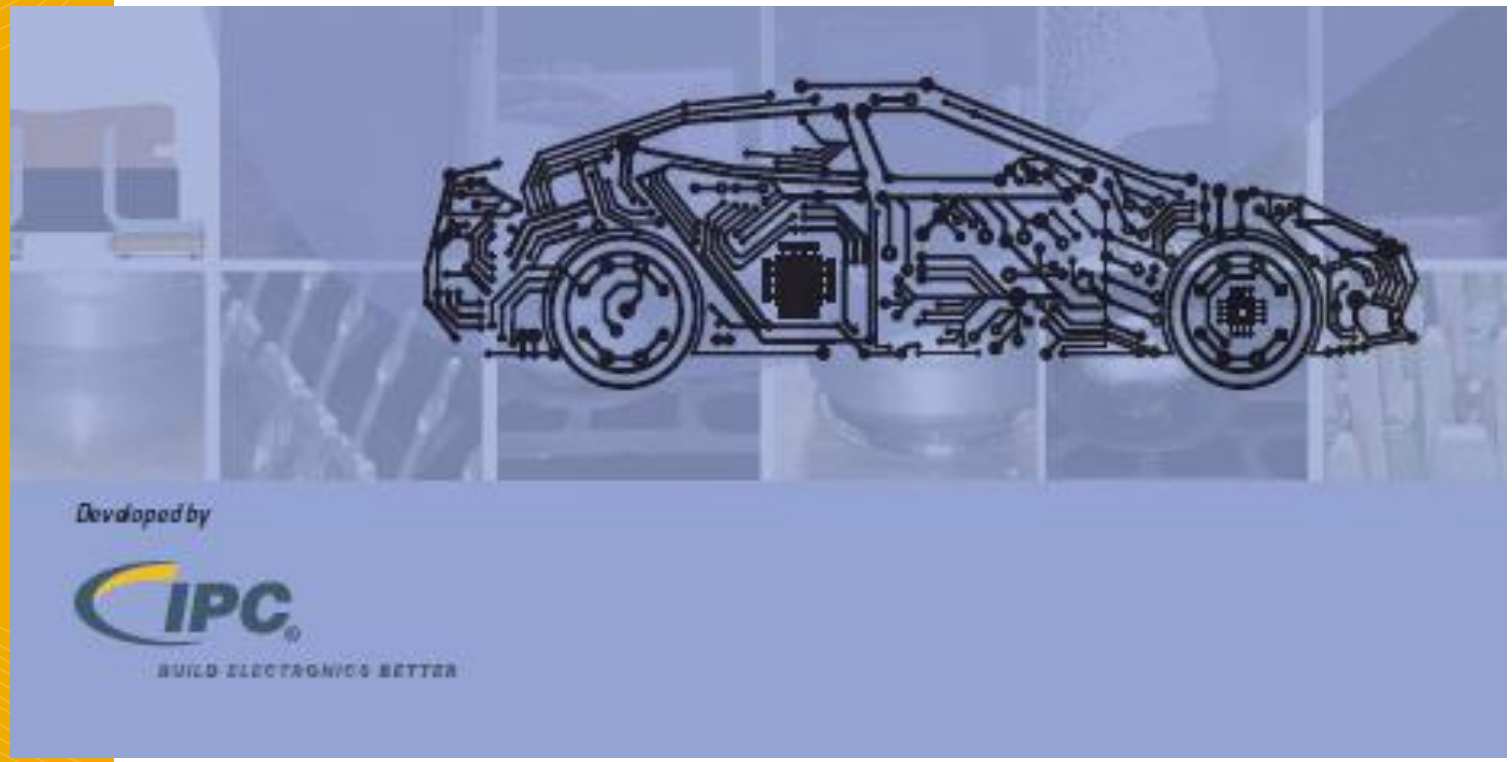
Driving to Success with IPC Standards

Teresa Rowe, IPC Sr. Director,
Assembly & Standards Technology



About IPC International Standards

- More than 300 IPC standards.
- Represent collective knowledge and best practices.
- Used worldwide for designing and manufacturing electrical and electronic products and their materials.
- Developed by committees of volunteers from around the globe.
- Serve as basis for IPC training and certification programs.
- Available in multiple languages.

Help the industry build electronics better.

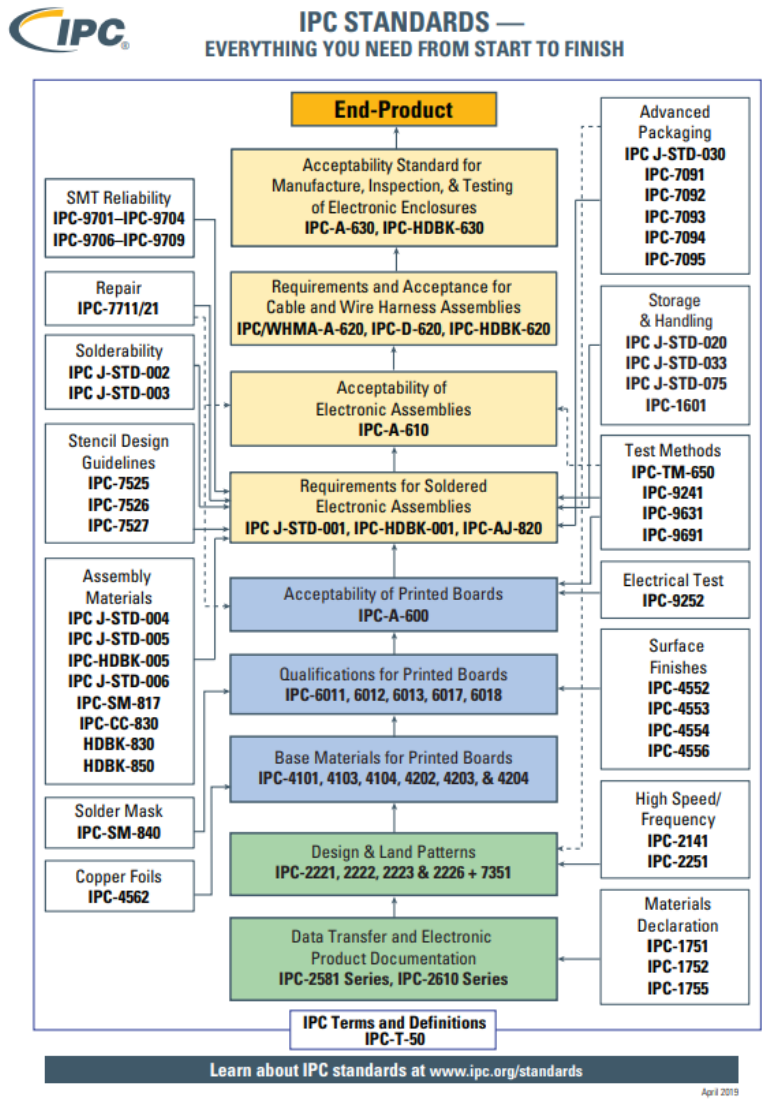
How IPC Standards are Developed

- Written and maintained by volunteers from the global electronics industry.
- Procedures accredited by American National Standards Institute.
- Standardization process ensures openness, fairness and antitrust protection.
- Limited prerequisites to develop a new international standard.
- Anyone can participate and at no cost – *not "pay to play".*
- Regional working groups can form in any part of the world.

Why Addendums?

- Addendums:
  - Have access to technical information from hundreds of hours of discussions across the electronics industry.
  - Provide modified and additional requirements over those published in the base documents to ensure the performance of the product that must survive the identified environment.
  - Written for a specific revision.
  - Are released after the base documents to ensure information meets industry needs.
  - Not stand-alone documents.

IPC Simplified Standards Tree



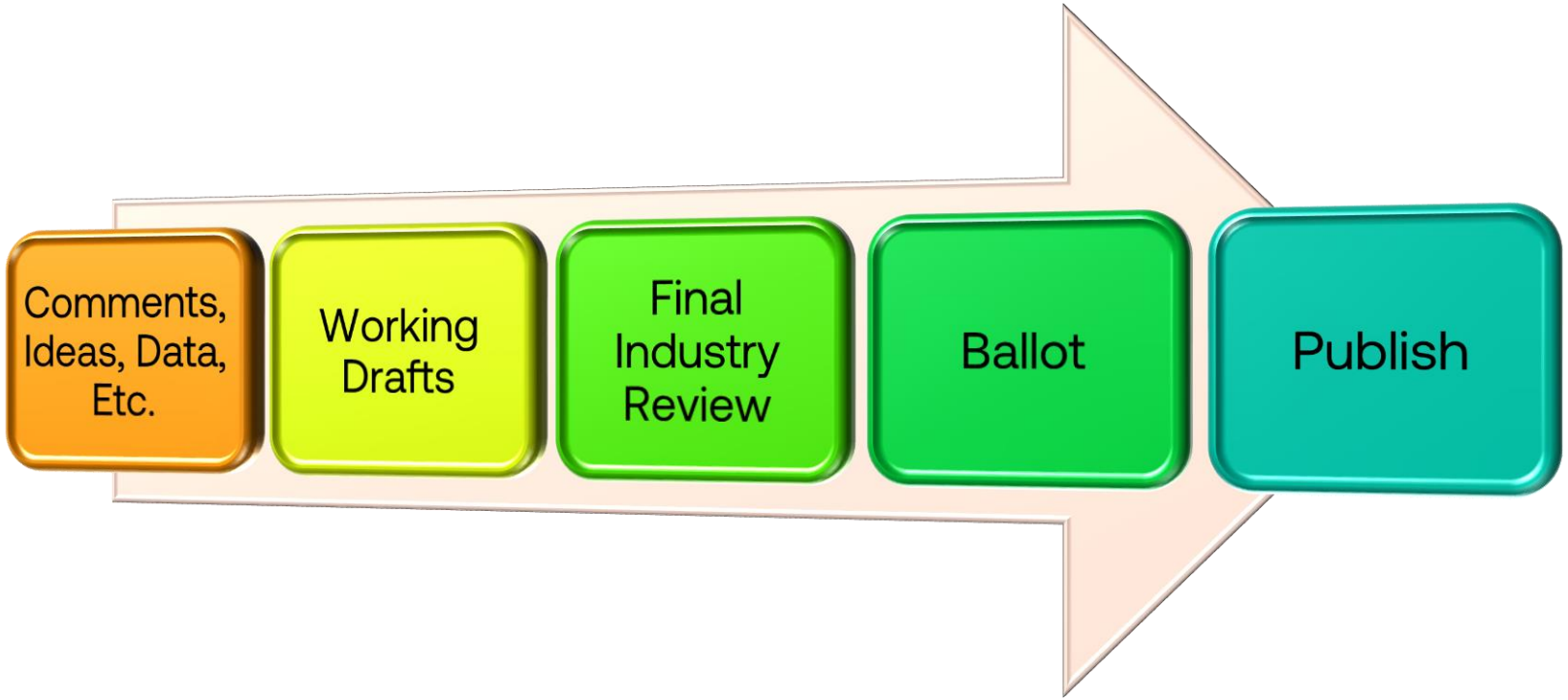
IPC Simplified Standards Tree provides an opportunity to see key standards as a process flow from design to end-product.

Documents in the “branches” can be shared between boards and assemblies.

Each standard can be used independently of the others.

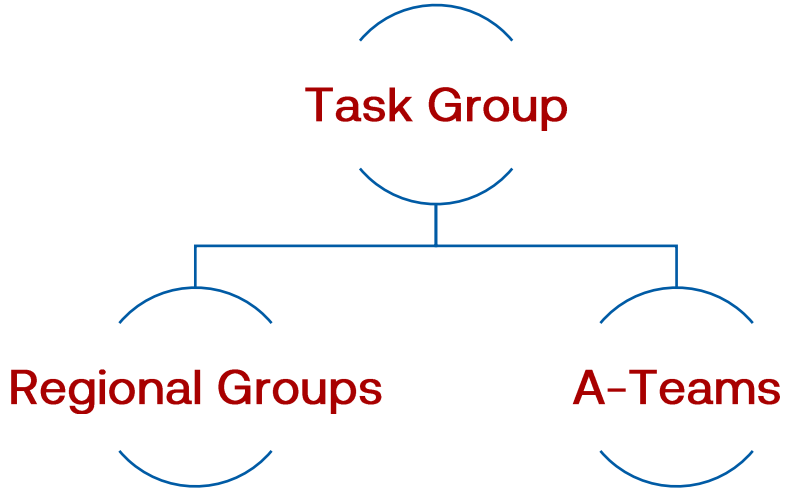
Development Process

Volunteers from industry work together to develop content for industry consensus documents using IPC's Rules of Standardization.



By Industry – For Industry

- IPC Standards are industry consensus documents.
- Development process utilizes expertise from around the world.
- Task Group – responsible for document development
  - Regional Groups – provide input from subject matter experts in a particular region; meetings are held in the local language.
  - A-Teams – Small working groups that focus on a particular topic or subject to complete action items and provide input to the task group in order to make the most effective use of time.
- Each group has a staff liaison assigned.



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Automotive Addendums

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Automotive-Focused Documents

Board Fabrication	IPC-6012 Automotive Applications Addendum to IPC-6012E Qualification and Performance Specification for Rigid Printed Boards
Assembly	J-STD-001 and IPC-A-610 Automotive Addendum to IPC J-STD-001H Requirements for Soldered Electrical and Electronic Assemblies and IPC-A-610H Acceptability of Electronic Assemblies IPC-9797, Press-Fit Standard for Automotive Requirements and Other High-Reliability Applications IPC-HDBK-9798, Handbook for Press-fit Standard for Automotive Requirements and other High-Reliability Applications
Planned	HV Cable Addendum to IPC/WHMA-A-620 Requirements and Acceptance for Cable and Wire Harness Assemblies

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IPC-A-6012EA

Automotive Applications Addendum to IPC—6012E, Qualification and Performance Specification for Rigid Printed Boards

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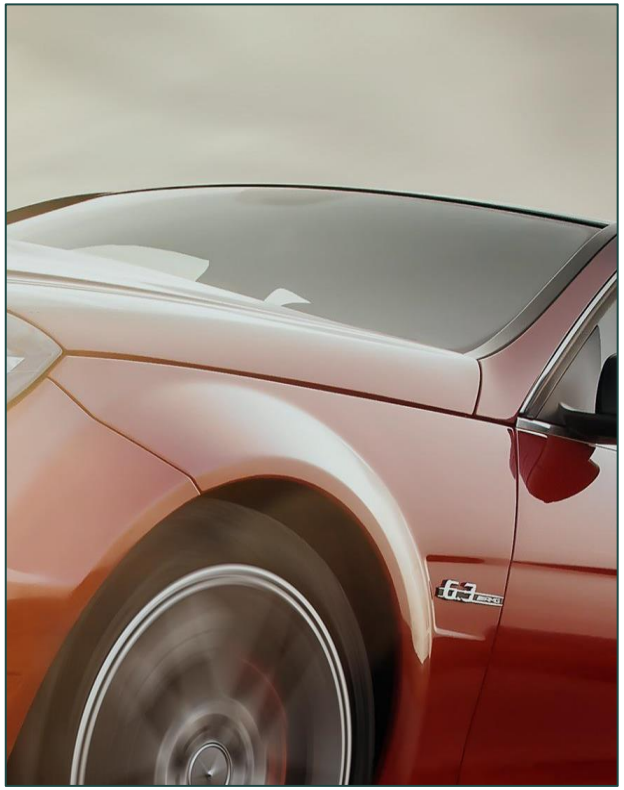
Need for an Automotive Addendum

- To consider:
  - Life Critical if Application Fails
  - Harsh Operating Environments (Automotive Under the Hood)
  - High-Volume Production

- Concern:
  - This combination of high-volume manufacturing in a Class 3 environment would result in unrealistic sampling frequencies of test samples for production lot acceptance testing where the base document sampling frequencies are built around a high-mix to low-volume model.



Key Contributors

Elmatica AS

Q-Products-Europe

Robert Bosch GmbH

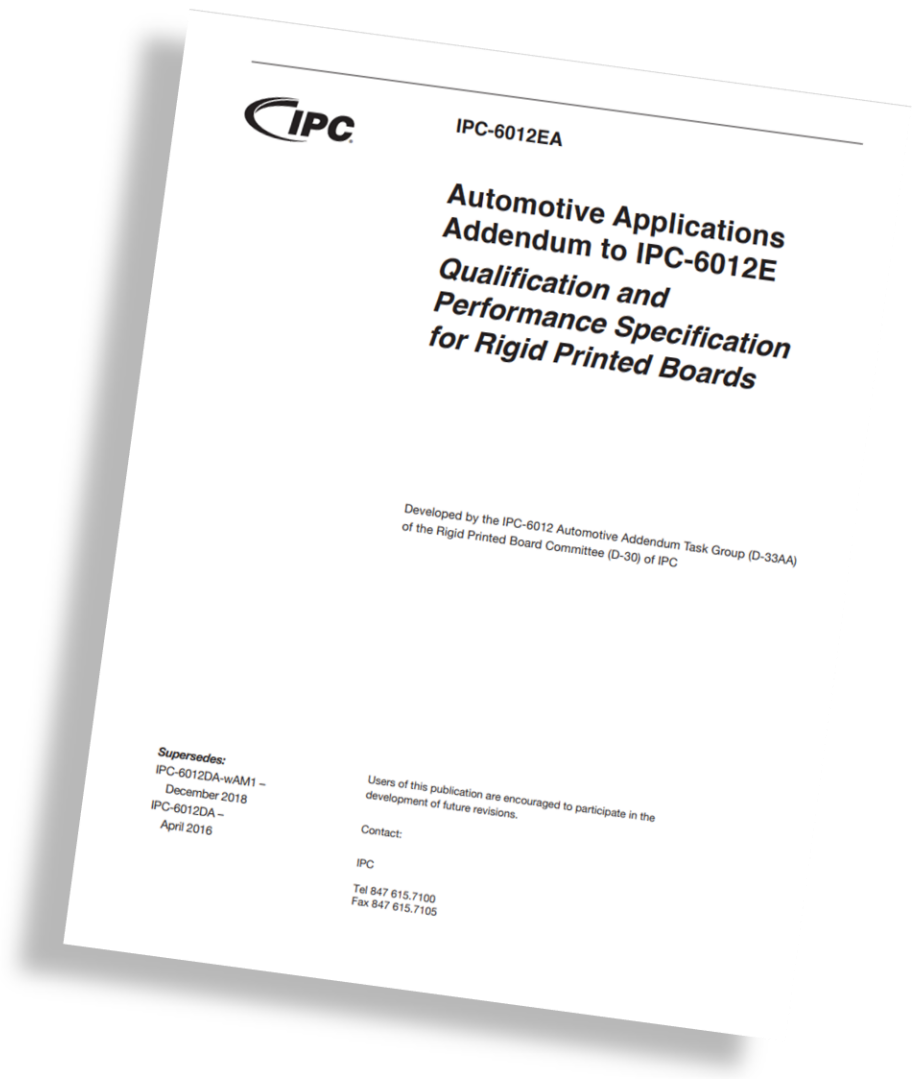
Toyota Motor North America

TTM Technologies

Content

- Released the addendum in October 2021, addresses:
  - Visual Examination
  - Lifted Lands after Thermal Stress
  - Hole Size, Pattern & Feature Accuracy
  - Preconditioning Before Bow & Twist Assessment
  - Anomalies Along the Edges of Rectangular Surface Mount Lands
  - Copper Wicking Within Internal Layers
  - Solder Mask Thickness
  - Cleanliness of the Delivered Printed Board
  - Recommended Suitability & Reliability Testing

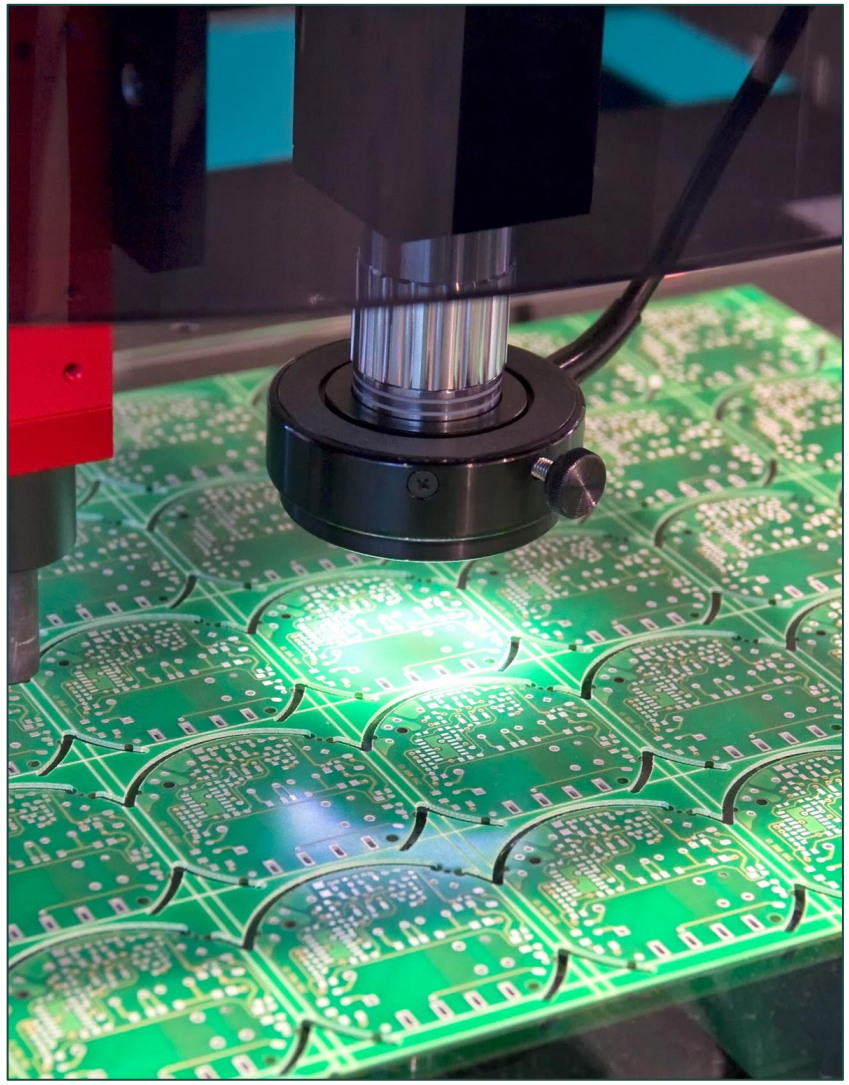
Includes additional unique criteria.



Unique Requirement in IPC-6012EA 3.3.4

3.3.4 Lifted Lands

If observed after thermal stress when visually examined in accordance with 3.3 of IPC-6012E, separation between conductor or PTH land and laminate surface shall not be greater than one pad thickness.



Change in Requirement in IPC-6012EA 3.5

IPC-6012E:

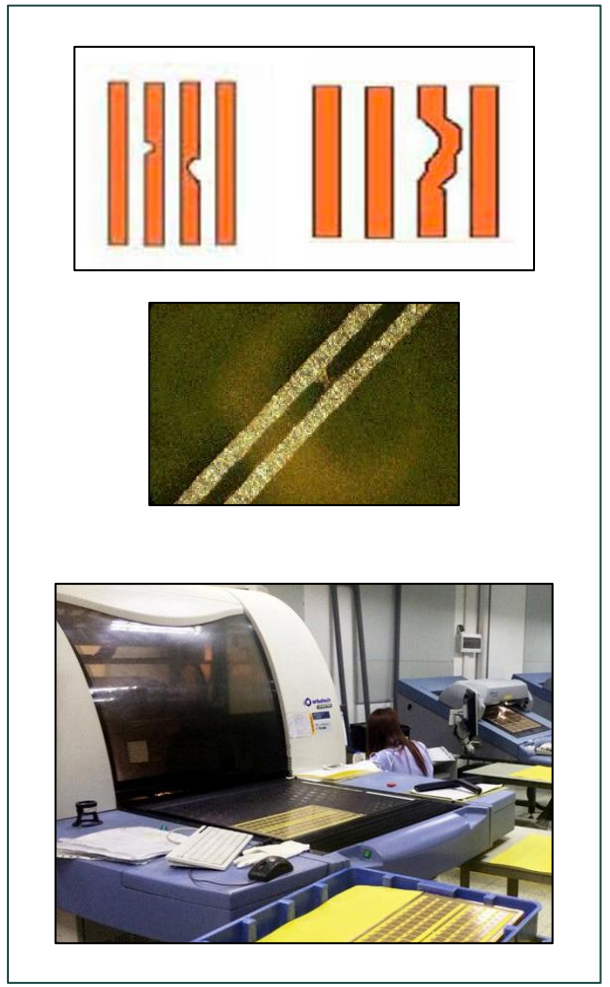
3.5 Conductor Definition

AOI inspection methods are allowed, but conductor dimensional assessment by AOI **shall** be AABUS.

IPC-6012EA:

3.5 Conductor Definition

To secure conductor definition, all layers shall be tested 100% by AOI in accordance with 3.5.1 through 3.5.4.8.



Unique Requirement to IPC-6012 EA 3.6.2.1

3.6.2.1 Wicking

IPC-6012E Table 3-10

Class 2: 100 µm

Class 3: 80 µm

IPC-6012EA: 50 µm maximum

Future Work:

Under discussion to focus on minimum insulation distance

Unique Requirement to IPC-6012EA 3.9

3.9 Cleanliness Test Methods

SIR test in accordance with IPC-TM-650 Method 2.6.3.7 should be implemented to validate the *cleanliness* levels maintained by IC and ROSE testing.

Daily Process control: IPC-TM-650, Method 2.3.25(D), (ROSE test)

Lot qualification either by ROSE test or other available test methods such as water based systems, **shall** be AABUS

Ion Chromatography* is needed periodically to test and identify which ions are present

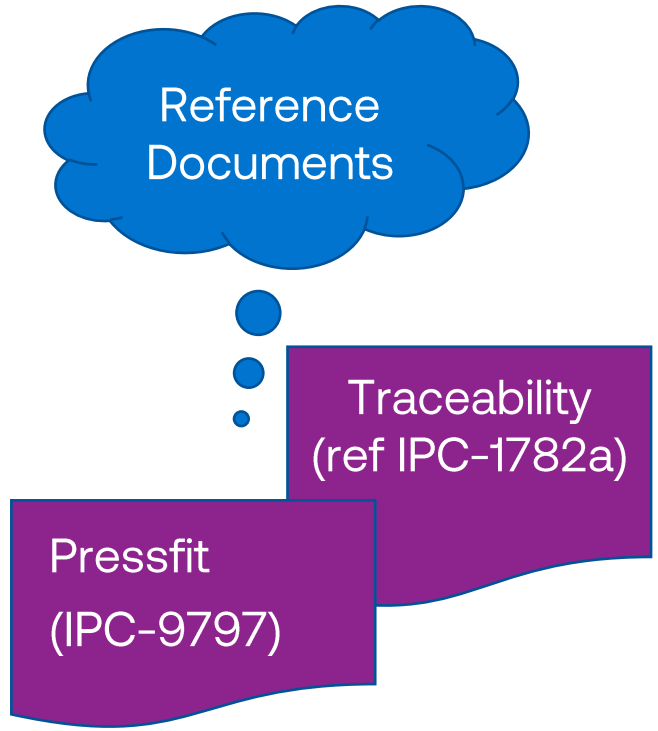
← **Define your acceptable Contamination level!**

→ **Automotive Required Process Control:**
ROSE test is required and Ion Chromatography* is recommended to be a part of the Part Production Approval Process (PPAP)

* **IPC-TM-650**, Method 2.3.28.2 (Ion Chromatography test) as described in IPC-5704 Chapter 4.1

Rev F?

- Currently working on IPC-6012FA (in conjunction with IPC-6012F)
  - **A-Teams Established to Address:**
    - Metal Base Printed Boards & Materials
    - "Technical Cleanliness"
    - High-Voltage Designs
    - Alternative Performance Tests
    - CAF/Prepreg "Buttercoat" Requirements
    - New Solder Mask Requirements



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

A Look Inside the Addendum

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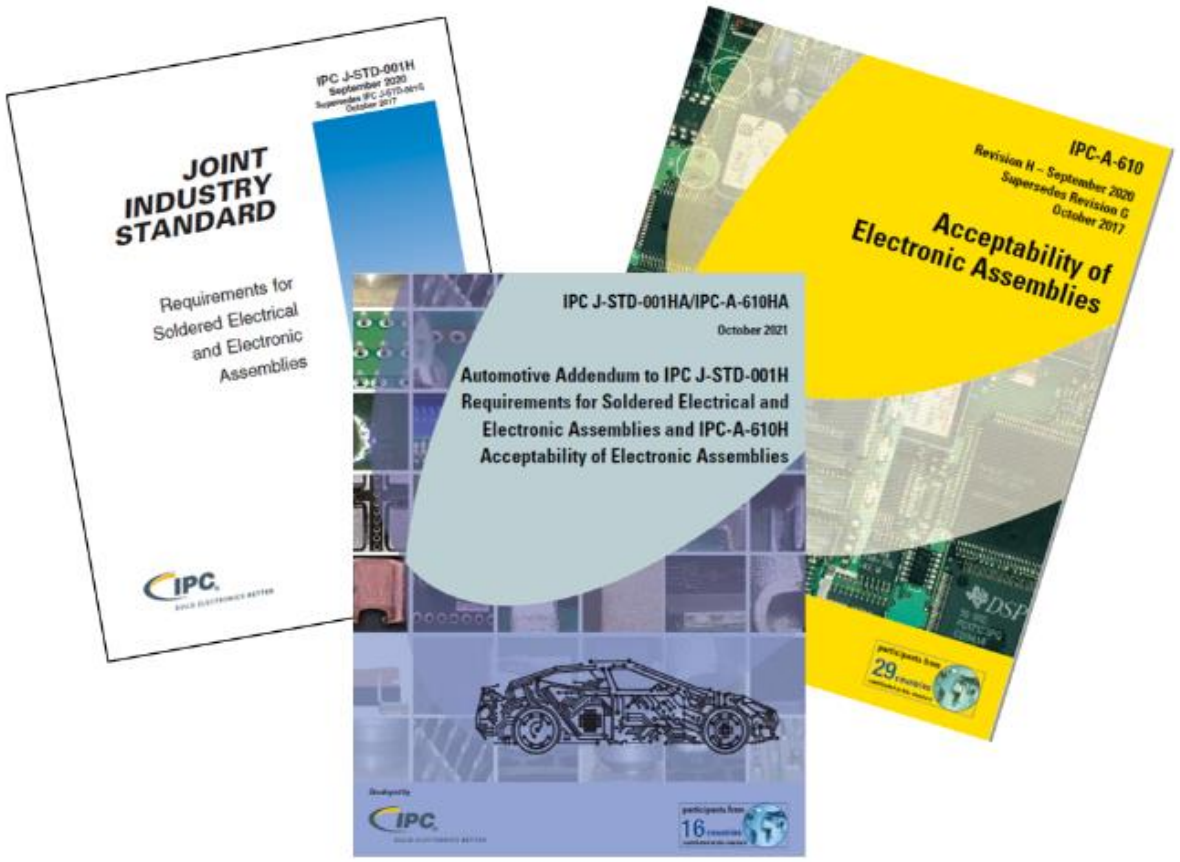
Addendums

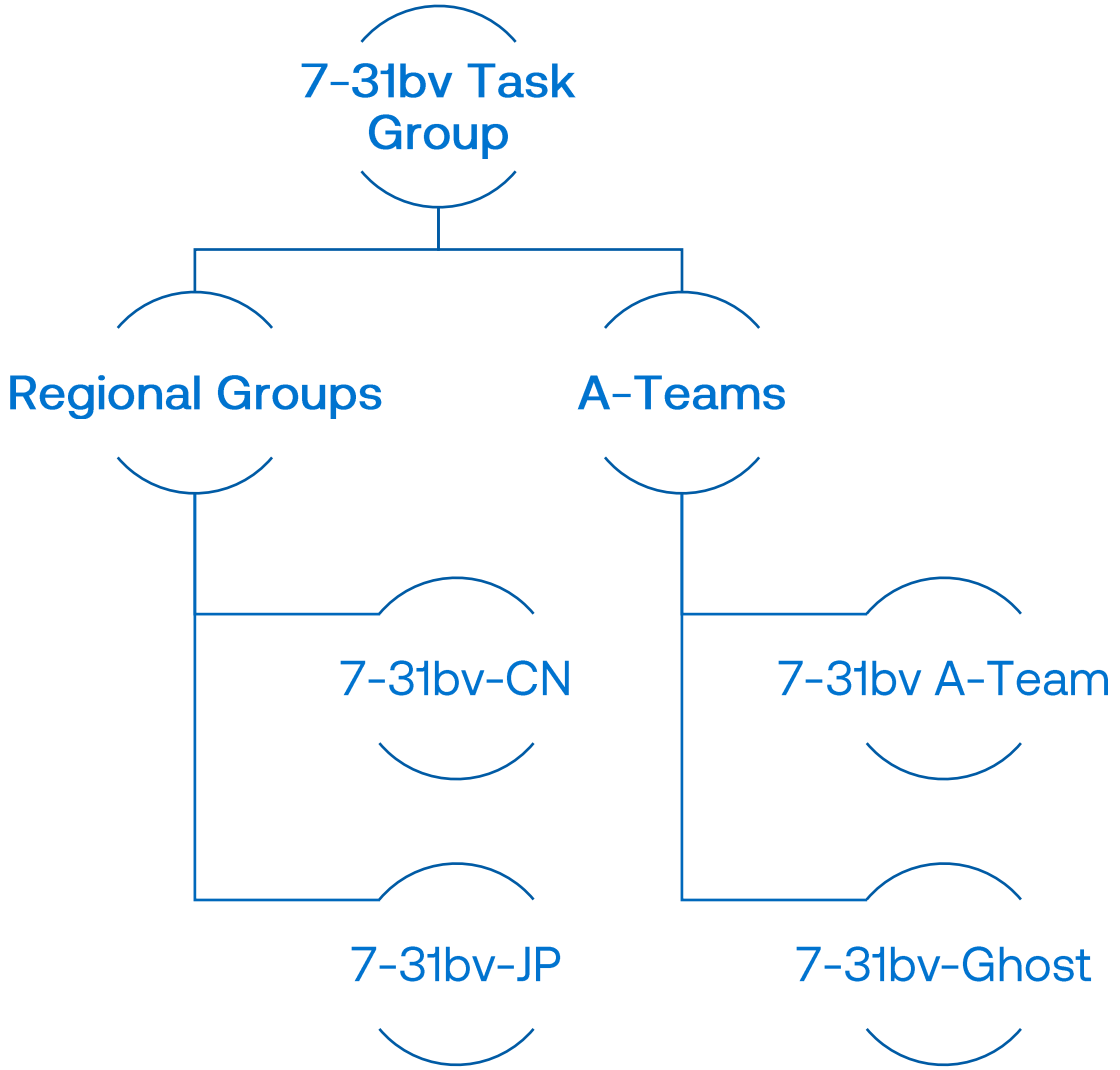


Using the J-STD-001/IPC-A-610 Automotive Addendum requires the use of three documents to determine the criteria.

Why Three Documents?

- J-STD-001
  - Describes materials, methods and acceptance criteria for producing soldered electrical and electronic assemblies.
- IPC-A-610
  - A collection of visual quality acceptability requirements for electronic assemblies.
- J-STD-001/IPC-A-610 Automotive Addendum
  - Addresses requirements to be used in addition to, and in some cases, in place of, those published in J-STD-001 and IPC-A-610 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.

IPC Groups Involved in Development



- Regional Groups
  - Provide an opportunity for groups of industry experts to come together to discuss content and make recommendations in their local language.
- A-Teams
  - Small groups of people working on a focused topic or activity.
    - 7-31bv A-Team reviews editorial content and makes decisions on changes.
    - 7-31bv-Ghost is working on a white paper providing extended coverage of voiding/solder coverage criteria and requirements.
      - White paper is nearing completion.

Key Contributors

Robert Bosch GmbH

Vitesco Technologies

Toyota Motor North America

Continental Automotive

Elmatica AS

Both Sections (J-STD-001 and IPC-A-610) have a Table of Contents

Table of Contents

The following topics are addressed in this Addendum.

0.1 Scope

0.2 Purpose

0.3 Existing or Previously Approved Designs

0.4 Use

The following reference numbers are to J-STD-001H Clauses that are modified or added in this Addendum.

1.1	Scope
1.3.1 (NEW)	Inspection Personnel and Product Requirements
1.6	Process Control Requirements
1.7	Order of Precedence
1.7.2 (NEW)	Conflict
1.8	Terms and Definitions

- Unique paragraphs defining use of the content.
- A table of affected clauses.
  - A paragraph reference in this table that is also referenced in the base document will be modified when the automotive addendum is used.
  - “NEW” defines a new paragraph in the addendum without a corresponding paragraph in the base document.

Use

0.4 Use

Table of Contents

The following topics are addressed in this Addendum.

The following reference numbers are to J-STD-001H Clauses that are modified or added in this Addendum.

1.1	Scope
1.3.1 (NEW)	Inspection Personnel and Product Requirements
1.6	Process Control Requirements
1.7	Order of Precedence
1.7.2 (NEW)	Conflict
1.8	Terms and Definitions

Where criteria are not supplemented, Class 3 requirements apply.

CLASS 3 High Performance/Harsh Environment Electronic Products

Includes products where continued high 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 or other critical systems.

Conflicts and Conditions Not Specified

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

- User-approved drawings always take precedence over the standards.
  - This includes inspection requirements identified on engineering documentation.
  - The inspector must have documentation, i.e., inspection instructions, process build requirements, and customer specification, for the product under inspection.

- Conditions not documented as defective or as a process indicator are considered acceptable unless it can be established that the condition affects user-defined form, fit or function.

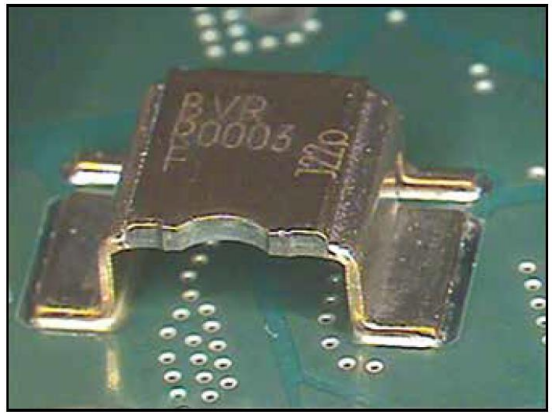
Voiding and Solder Coverage

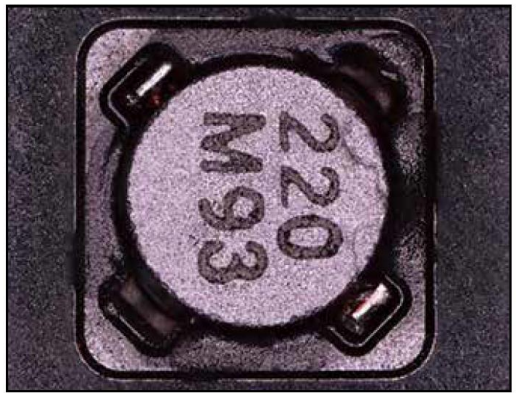
- Voiding criteria for solder joints of through-hole components are not established.

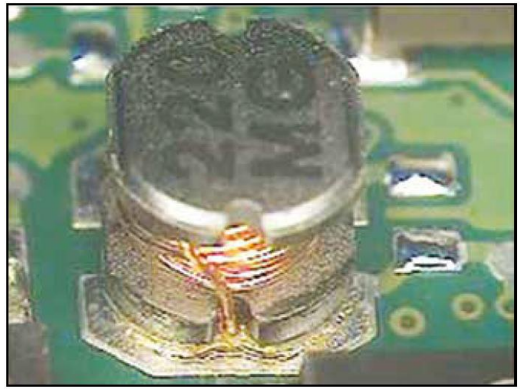
- For surface mount components:
  - Shrinkage voids, planar microvoids (champagne voids), intermetallic microvoids, pinhole microvoids, and blowholes can typically not be detected in 2D x-ray imaging under mass-production conditions and are excluded from the criteria.
  - Solder Coverage Requirements for:
    - Solder Joints at Thermal Plane Terminations
    - I/O pins of Bottom-Termination Components
    - Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s)
  - Voiding Requirements for:
    - Ball Grid Array Components with Collapsing Balls
    - Land Grid Array (LGA) Components
    - Appendix AH also provides guidance, along with pictures, on the different categories of voids.

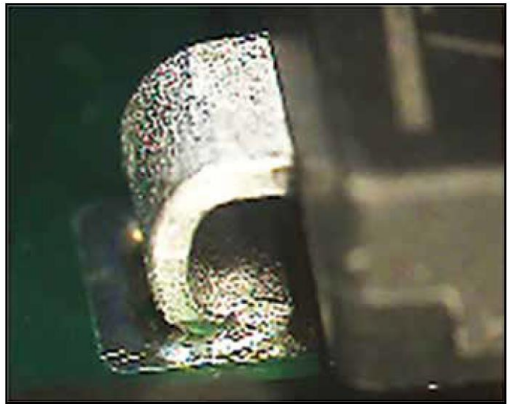
“New” Component Types

- Acceptance criteria are provided for several component types not covered in the base documents.
  - Odd-Shaped Component with Hidden Terminations
  - Half-Moon Shape Ferrite Terminations-Coil Terminal
  - Coil Terminals (Coated Wire)
  - “L” Types (Fuses/Shunt Resistors) Terminals
  - “C” Type Terminal with Thermal Plane Termination









Example of how the addendum is written is provided on the next slide.

Example of How “New” Component Types are Presented

Example of how the addendum is written

J-STD-001HA:

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

IPC-A-610HA:

8.3.20 Odd-Shaped Components with Hidden Terminations

Table 8-23HA Dimensional Criteria – Odd-Shaped Components with Hidden Terminations

Feature	Dim.	Criteria
Maximum Side Overhang	A	25% (W), Note 1
Maximum Toe Overhang	B	Note 1
Minimum End Joint Width	C	75% (W)
Minimum Side Joint Length	D	Note 5
Maximum Heel Fillet Height	E	Note 4
Minimum Heel Fillet Height	F	(G) + evidence of wetting on the vertical surface of the termination
Solder Thickness	G	Note 3
Lead Length	L	Note 2
Lead Thickness	T	Note 2
Lead Width	W	Note 2

Note 1. Does not violate minimum electrical clearance.

Note 2. Unspecified geometrical dimension of the component and/or land, or variable in size as determined by design, with no requirement to inspect per IPC-A-610HA.

Note 3. Solder dimensions of the terminal that 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 4. Solder may touch component body on the lower inside bend radius and in between bottom body and component lead.

Note 5. If “D” is visible, then D equals evidence of wetting on the visible portion.

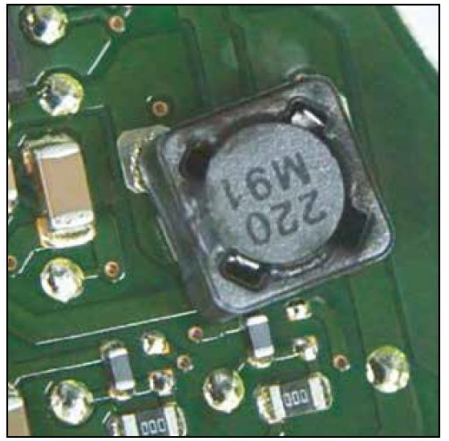


Figure 8-65HA

Defect

- Maximum overhang (A) is greater than 25% of lead width (W).

Self-Tapping Fasteners

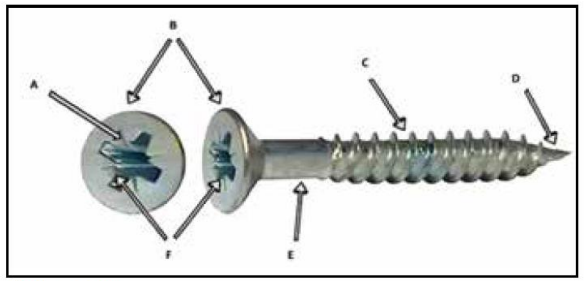


Figure 4-5HA
A. Slot
B. Head
C. Thread
D. Tip
E. Shank
F. Drive

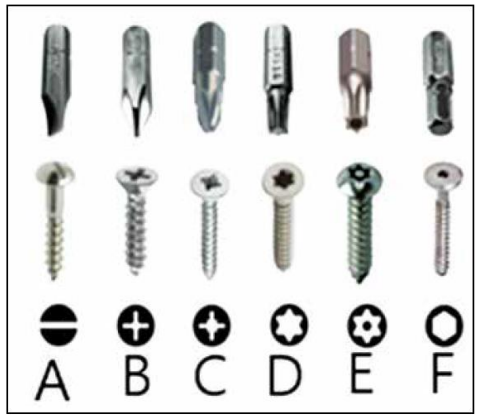


Figure 4-6HA
A. Slot Head
B. Phillips Head
C. Pozidriv
D. Torx
E. Secure Torx
F. Hex Head

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).

Additional Topics – Center/Lateral Termination(s)

- Additional topics covered in the addendum (not the base documents):
  - 3-Side Terminations – Center/Lateral Termination(s)

Table 8-2-1HA Dimensional Criteria – Rectangular or Square End Chip Components – Termination Variations – Center / Lateral Termination(s)

Feature	Dim.	Criteria
Maximum Side Overhang	As	25% (Cw) or 25% (Cp), whichever is less, Note 1
End Overhang	Bs	Not permitted
Minimum End Joint Width	Cs	75% (Cw) or 75% (Cp), whichever is less, Note 4
Minimum Fillet Height	Es	Wetting is evident on the vertical surface(s) of the component
Maximum Fillet Height	Fs	Note 6
Solder Thickness	G	Note 3
Center/Lateral Termination Width	Cw	Note 2
Center/Lateral Termination Height	Ch	Note 2
Center/Lateral Land Width	Cp	Note 2
Center/Lateral Termination	s	Note 2
Solder Coverage	Z	Note 5

Note 1. Does not violate minimum electrical clearance.

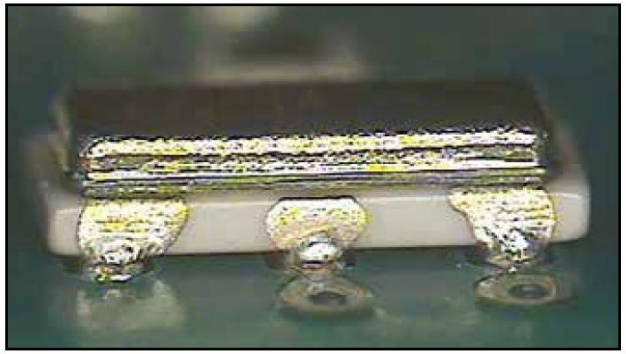
Note 2. Unspecified geometrical dimension of the component and/or land, or variable in size as determined by design, with no requirement to inspect per IPC-A-610HA.

Note 3. Wetting is evident.

Note 4. (C) is inspected at the narrowest point of the required fillet.

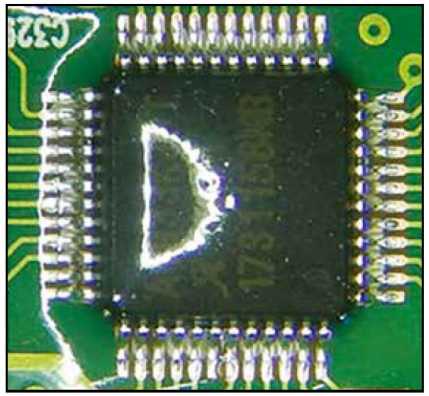
Note 5. Voiding criteria/solder coverage are not a visually-inspectable condition. See J-STD-001HA 4.15.3 Partially Visible or Hidden Solder Connections, 1.12.1.1 Visual, Automated Optical and Automated X-ray Inspection, and 7.0.1 Voiding and Solder Coverage.

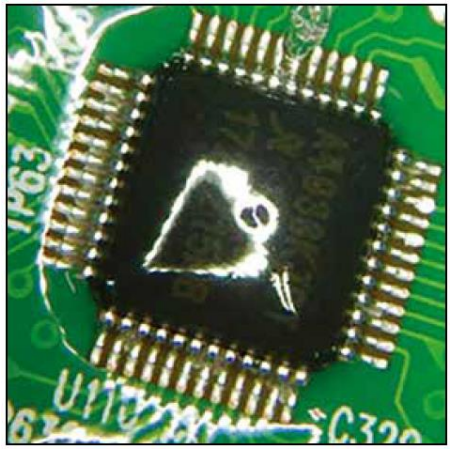
Note 6. For Cylindrical End Cap Center Termination, the fillet may overhang the land or extend onto the top metallization but does not touch the top of the component. Solder may touch the bottom half of the component body.



Additional Topics – Coverage – Silicon Base Coatings

> Coverage for Silicone Base Coatings





Process Indicator

- Silicone droplets / projections
  - Will not become dislodged.
  - Do not violate printed board maximum height requirements.
  - Near or on the component.

Defect

- Material not cured.
- Silicone droplets / projections
  - Will become dislodged.
  - Violate printed board maximum height requirements.

Revision J?

- Work is beginning on Revision J with “The Relay Race.”
  - J-STD-001J and IPC-A-610J are on track to be released on Q4 2023.
  - 7-31bv Task Group is considering:
    - Changes to the base documents on sections not covered in the addendum.
    - Criteria from the automotive addendum that was considered relevant to the entire industry and adopted into the base documents.
    - New content recommendations from industry.
    - Comments / recommendation for change from industry.

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White Papers

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White Papers

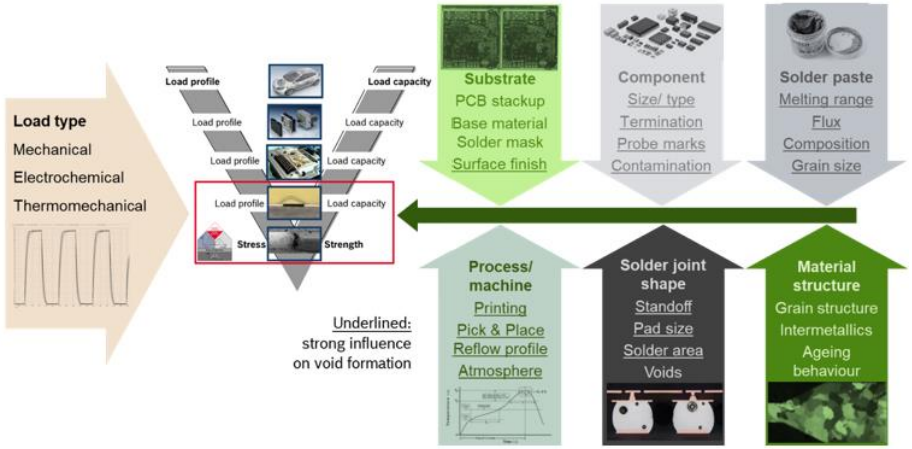
- Two new white papers developed to help industry understand and use the requirements found in J-STD-001, IPC-A-610 and automotive addendum:

  - IPC-WP-027 Understanding Control and Assessment of Voiding in SMT Connections for Automotive Applications

  - IPC-WP-028 Guidance on Objective Evidence for Validating the Acceptability of Bubbles in Conformal Coating

An Overview: IPC-WP-027

- Purpose:
  - Explain the voiding/solder coverage requirements in J-STD-001/IPC-A-610 Automotive Addendum.
  - Address the challenges of:
    - The impact of voiding on assembly reliability.
    - Typical x-ray inspection systems do not generally satisfy tight requirements on gauge repeatability and reproducibility.



Load types and load capability of solder joint reliability and voiding

Summary of voiding/solder coverage requirements in J-STD-001HA/IPC-A-610HA

Type of component/solder joint	Voiding v / solder coverage c / average solder coverage $\bar{c}$	Acceptability limit	Process indicator	Defect	Notes
Ball grid array components with collapsing balls	Voiding v	$v \leq 30$ %	30 % $\leq v \leq$ 50 % (via in pad design)	$v > 30$ % (no via in pad design) $v > 50$ % (via in pad design)	a
Bottom termination components – thermal pads	Solder coverage c / average solder coverage $\bar{c}$	$c \geq 35$ %	35 % $\leq \bar{c} \leq$ 50 % average solder coverage	$c < 35$ %	a, b, c, d, e
Bottom termination components – I/O pins	Solder coverage c / average solder coverage $\bar{c}$	$c \geq 50$ %	50 % $\leq \bar{c} \leq$ 65 % average solder coverage	$c < 50$ %	a, e
Thermal pads of components with gull wing solder joints as quad-flat packages	Solder coverage c / average solder coverage $\bar{c}$	$c \geq 35$ %	35 % $\leq \bar{c} \leq$ 50 % average solder coverage	$c < 35$ %	a, b, c, d, e
Thermal pads of transistors as TO-252 (D-PAK™)	Solder coverage c / average solder coverage $\bar{c}$	$c \geq 35$ %	35 % $\leq \bar{c} \leq$ 50 % average solder coverage	$c < 35$ %	a, b, c, d, e
Rectangular or square chip components in stand off (2, 3 or 5 side termination)	Solder coverage c / average solder coverage $\bar{c}$	$c \geq 50$ %	50 % $\leq \bar{c} \leq$ 65 % average solder coverage	$c < 50$ %	a, e

[a] Shrinkage voids, planar micro voids (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.

[b] For certain designs, e.g. via in pad (microvia), it may not be possible to comply with the above threshold values. In such cases, it is the shared responsibility of design authority and manufacturer to provide objective evidence for thermal and electrical functionality as well as solder-joint reliability.

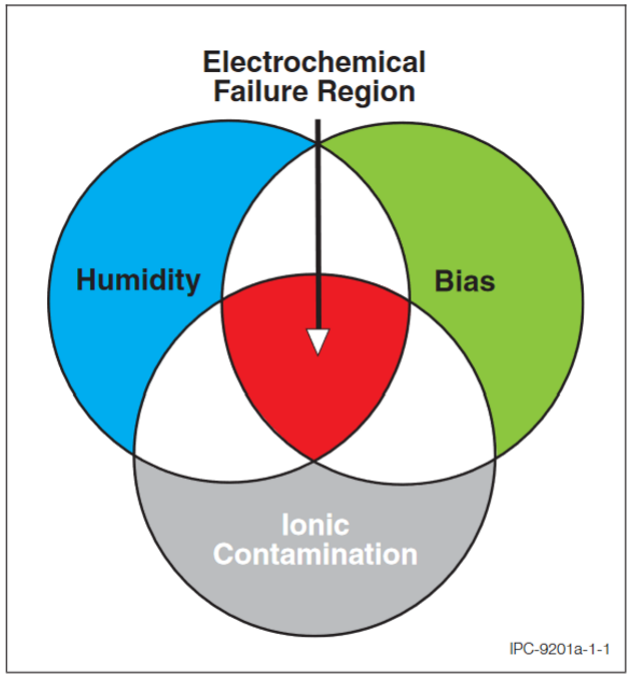
[c] If thermal planes of components are soldered directly on heat sinks, the thresholds for solder coverage are to be agreed between user and design authority.

[d] If the above defined connection area is not sufficient for thermal transfer for a particular component, it is the responsibility of the design authority to define a component-specific minimum connection area.

[e] As voiding levels can show a considerable scatter, the average solder coverage is also an important parameter. The average from a minimum sample of 25 solder joints of a given case size and part number from at least 5 different nonconsecutive panels should be analyzed.

An Overview: IPC-WP-028

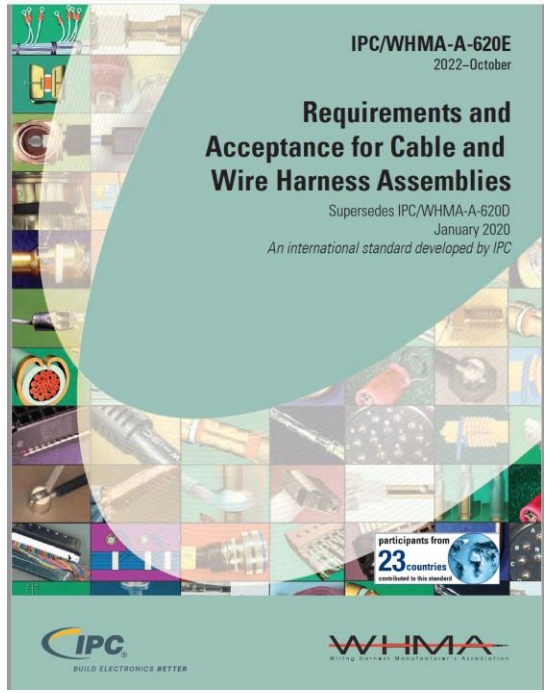
- Purpose: Provide guidance on obtaining objective evidence for validating the acceptability of bubbles in conformal coatings.
  - Experimental approach involves test boards.
    - IPC-9202 and IPC-TM 2.6.3.7 Surface Insulation Resistance
  - Field Records
  - Production Qualification Testing
- Includes new definitions found in J-STD-001J and IPC-A-610J.
  - Bubble: Air or other volatiles enclosed entirely, e.g., in a coating material of between component body and printed board surface.
  - Bridging Bubble: Air or other volatiles enclosed entirely, e.g., in a coating material or between component body and printed board surface, bridging between adjacent conductors.



Venn Diagram Illustrating the Variables Affecting Electrochemical Failure

Additional Projects

- Additional automotive-related projects in early phases of development:
  - Addendum to IPC/WHMA-A-620
    - High voltage cable applications in the electric mobility industry.
    - 7-31FHV IPC/WHMA-A-620 High Voltage Cable Task Group



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HV CABLE ADDENDUM

How to Get Involved

To sign-up for a task group or a regional group:

www.ipc.org/committee-page

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