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Industry Session #: Reliability

IPC-9592B: What is it? What isn't it?

Presented By –

Eric Swenson, Power Development Engineer
IBM Corporation
ebswensn@us.ibm.com

Contributors: Matt Kelly, Chief Technologist IPC, MattKelly@ipc.org
Rick Fishbune, IBM, fishbune@us.ibm.com

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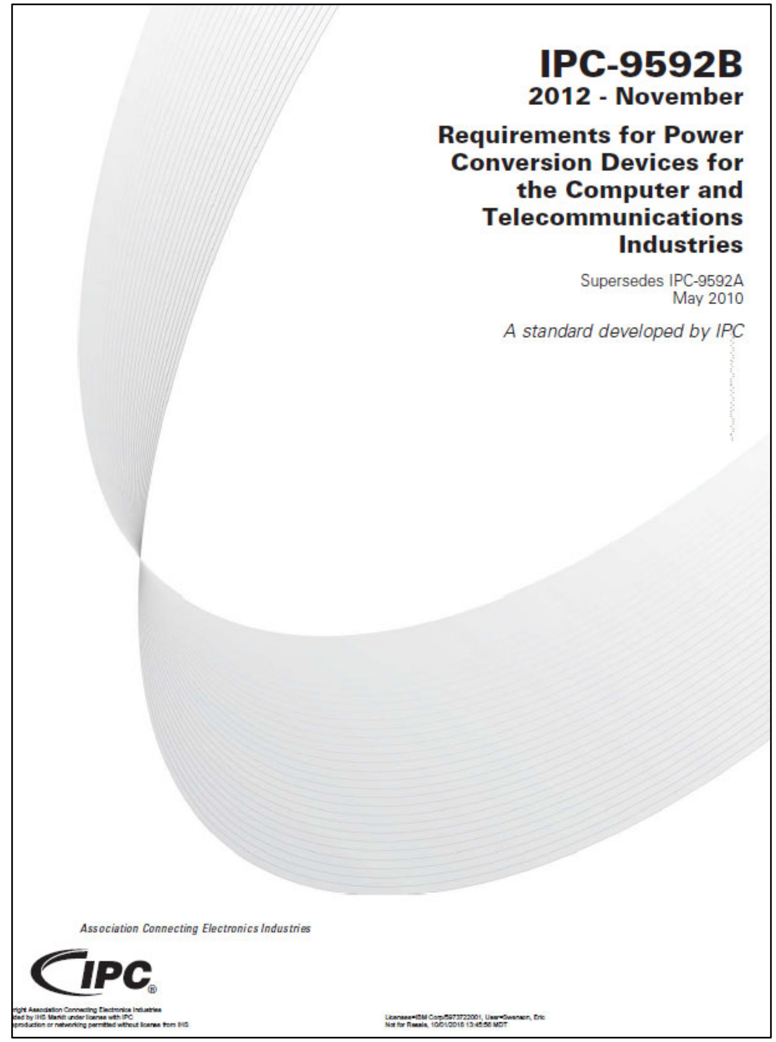
OVERVIEW

- **IPC-9592B Overview**
- **Coverage Summary by Section**
  - Topics addressed
  - Topics needing improvement
  - Topics not covered
- **Initial Plans for IPC-9592C**
- **What Next? ...A Call to Action**


IPC-9592B
2012 - November

Requirements for Power Conversion Devices for the Computer and Telecommunications Industries

Supersedes IPC-9592A
May 2010

A standard developed by IPC

Association Connecting Electronics Industries

IPC-9592B Coverage Summary

Specifies best practices for power assembly design, qualification, and manufacturing processes based on product class and category

- The main emphasis in this document is the definition of test methods used for design verification / qualification

Defines common and unique requirements for three product categories

- Assemblies providing DC output with AC or DC input
- Board mounted DC / DC converters
- AC / DC adaptors or chargers

Reviews differences in design, test, and manufacturing requirements for two product classes

- Class I: Standard grade product with life expectancy of 5 years or less
- Class II: High reliability product with life expectancy greater than 5 years

Section 3: Specification and Documentation

Topics Included

- Class and Category definitions
- Test reports required
- Data sheet requirements – covers input, output and mechanical
  - Appendix C provides example data sheet examples for an AC/DC converter and DC/DC converter of different classes
- Product labeling and material control requirements

Topics Needing Improvement

- Defining a custom design specification for external design and build
- Defining unique functional or qualification test requirements

Topics Not Covered

- Manufacturing expectations / requirements

Appendix C Excerpt

Datasheet Example

APPENDIX C-2 for Category 2

dc to dc BMP and POL Functional Test Requirements

Test Name	Test Condition All tests to be performed on DVT samples	Units	Production MTR
Start up Input Current	Maximum input voltage, minimum dc load, Start Up	Amps	Yes
Worst Case Input Current	Minimum input voltage, maximum dc load	Amps	No
PSU Turn-On Voltage	Minimum and maximum input voltage, minimum and maximum dc load	Vdc	No
PSU Turn-Off Voltage	Minimum and maximum input voltage, minimum and maximum dc load	Vdc	No
Efficiency	Minimum and maximum input voltage, maximum dc load, Start Up/hot	%	Note 1,2
	Other defined energy efficiency requirement (example: Energy Star)		As Required
Output Load Regulation	Nominal input voltage, minimum and maximum dc load (various loading combinations need to be considered for multiple output supplies to assure there are no cross-regulation issues)	%	Yes
Line Regulation	Minimum and maximum input voltage, maximum dc load	%	Yes
Vout adjustment Range - Trim Up/Trim Down (as applicable)	Nominal input voltage, open, trim low, trim high	Pass/ Fail	Yes
dc Output Startup Monotonic	Minimum and maximum input voltage, minimum and maximum dc load, minimum and maximum output capacitance	Pass/ Fail	No
Output Ripple	Minimum and maximum input voltage, minimum and maximum dc load	mV pk-pk & mV rms	Note 1
Transient Response	Nominal input voltage, step load from 50% to 100%, minimum and maximum capacitance	Pass/ Fail	No
Output Overcurrent (Current Limit Inception)	Minimum and maximum input voltage, Start Up/Steady State	A	Note 1
Output Short Circuit	Minimum and maximum input voltage, minimum and maximum load	Pass/ Fail	Note 1
Output Overvoltage Protection (OVP)	Minimum and maximum input voltage, minimum and maximum dc load	V	Note 1 & Note 3
Output Sequencing (as applicable)	Test per Electrical Requirements Document	Pass/ Fail	No
Thermal Protection	Test per Electrical Requirements Document	Pass/ Fail	No
Logic Signals	Test per Electrical Requirements Document	Pass/ Fail	Yes

Note 1: After supplier completes required DVT test matrix, the supplier identifies and selects the worst case condition for the Production MTR. It is not required that all conditions be tested in production.

Example: If worst case condition for OVP (Overvoltage Protection) is maximum input voltage and minimum dc load, then that is the test condition to be used.

Note 2: Use Nominal Input Voltage if Maximum/Minimum input voltage not specified.

Note 3: Where feasible.

Section 4: Design for Reliability

Topics Included

- Reliability prediction
  - Appendix A-1 has excellent information on converting between MTBF, AFR, and FIT
- Component selection and derating
  - Appendix A covers derating requirements for each product class
- Failure Modes Effects Analysis (FMEA) for Development (DFMEA)
- Corrosion testing and mitigation
- Spacing Guidelines
- Defining Moisture Sensitivity Level (MSL) for board mounted devices

Topics Needing Improvement

- Recommendations on corrosion requirements for different product classes
  - Sulfur resistant resistors, PCB finishes, connector gold plating, conformal coating, etc.
- Some derating parameters not included for several component types

Topics Not Covered

- Firmware design best practices
- No mention of training expectations for Design for Excellence (DfX) or similar methods
- Simulation tools, methods, and best practices

Section 4.5 (Figure 4-2) Excerpt

DFMEA Severity Rating Example

Severity			Occurrence			Detection		
Ranking	Description	Interpretation	Ranking	Description	Interpretation	Ranking	Description	Interpretation
5*	Hazardous	Safety related catastrophic failure*	5	Very High	Failure is almost inevitable, <1 in 3	5	Absolute Uncertainly	Undetectable until catastrophic failure occurs, or there is no design control
4	High	Product is totally inoperable	4	Frequent	Repeated failure, <1 in 8	4	Remote	Remote chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode
3	Moderate	Product is operable, but at a reduced level of performance	3	Moderate	Occasional failure, <1 in 80	3	Low	Low chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode
2	Low	Product is operable, but comfort or convenience item(s) are inoperable or at a reduced level of performance	2	Infrequent	Relatively few failures, <1 in 150,000	2	Moderate	Moderate chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode
1	None	No effect	1	Rare	Failure is unlikely, <1 in 1,500,000	1	High	High chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

* When there is a safety hazard as a result of a failure, the failure mode MUST be eliminated

Figure 4-2 DFMEA Severity, Occurrence and Detection Ranking Chart Used by Many Companies

Section 4.6 (Figure 4-3) Excerpt

Spacing Requirements

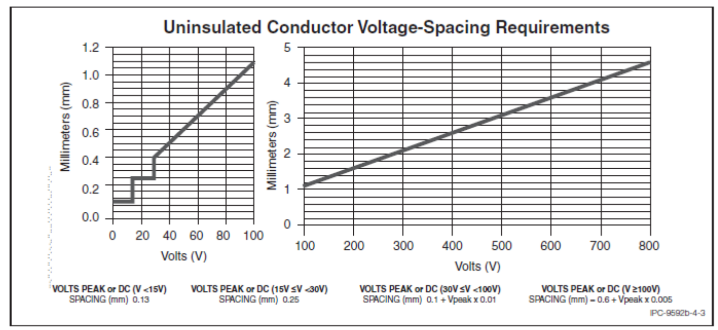


Figure 4-3 Uninsulated Conductor Voltage Spacing Requirements

Section 5: Design / Qualification Testing

Topics Included

- Design verification testing
  - Includes information on sample size, tests and test conditions, reports, etc.
- Environmental stress testing
  - Includes requirements for HALT (Appendix D)
  - Descriptions for THB, HTOB, temperature cycle, and temperature/power cycle tests
  - Mechanical test descriptions including vibration, shock, free fall, and drop
- Electromagnetic Susceptibility (EMS) tests including PLD

Topics Needing Improvement

- Design verification test conditions could be better organized
  - Need to flip between Section 5 and Appendix A
- Additional emphasis on the HALT and other test processes needed
  - Root cause analysis is critical independent of the failure point

Topics Not Covered

- Firmware quality has no unique items
  - Several tests will give an indication of firmware capability, but not quality (see the "2019 PSMA Power Supply Software / Firmware Reliability Improvement Report")
- References to physical analysis techniques such as cross section, dye and pry, ionic contamination, etc.

Sections 5.2.6.2 – 5.2.6.5 Excerpt

Temperature Cycle Test Definition

5.2.6.2 Applicability This test is applicable to Class I and Class II products.

5.2.6.3 Sample Size The minimum sample size for this test **shall** be as per Table 5-4.

Table 5-4 Sample Sizes for Temperature Cycling Tests

	Category 1 (Power Supplies)	Category 2 (BMPMs)	Category 3 (Adapters/Chargers)
Class I	3	5	3
Class II	6	30	6

5.2.6.4 Procedure The temperature cycling test **shall** be performed under the following conditions:

- Units **shall** be unpowered.
- The rate of change of ambient temperature **shall** be 5 °C/min to 20 °C/min.
- The dwell time at either temperature limit for devices with lead-based or lead-free solder **shall** be 30 minutes.
- The dwell time starts when the assembly reaches thermal equilibrium, not when the chamber reaches the final set point.
- Thermocouples on high mass components may need to be used to determine the time needed for the assembly to reach thermal equilibrium.
- The minimum number of cycles **shall** be as per Table 5-5.
- The temperature limits **shall** be as per Table 5-6.

Table 5-5 Minimum Number of Cycles for Temperature Cycling Tests

	Category 1 (Power Supplies)	Category 2 (BMPMs)	Category 3 (Adapters/Chargers)
Class I	300	300	300
Class II	700	700	700

Table 5-6 Temperature Limits for Temperature Cycling Tests

	Category 1 (Power Supplies)	Category 2 (BMPMs)	Category 3 (Adapters/Chargers)
Class I or Class II	Minimum Rated Storage Temperature to Maximum Rated Storage Temperature	-40 °C ± 3 °C to +125 °C ± 3 °C	Minimum Rated Storage Temperature to Maximum Rated Storage Temperature

5.2.6.5 Monitoring Assemblies under test **shall** be removed at the following intervals as seen in Table 5-7.

Table 5-7 Inspection Cycles for Temperature Cycling Test

Inspection Cycle	Class I	Class II
1	150 cycles	150 cycles
2	300 cycles	300 cycles
3	n/a	450 cycles
4	n/a	600 cycles
5	n/a	700 cycles

The following testing and analysis is required at each inspection cycle:

1. Functional Verification: Verify operation as thoroughly as possible in the given test environment. A complete ATE or production equivalent test is strongly recommended.
2. Visual and Microscopic Inspection: 10x or greater magnification is required for visual inspection. Microscopic inspection to be performed in critical areas or as deemed necessary following visual inspection. Items to be inspected include:
   - Components for damage or delamination
   - PCB delamination (often seen as lighter areas in the PCB material)
   - Cracked solder joints

Section 6: Quality Processes

Topics Included

- Supplier quality management system
  - Key topics include Production FMEA (PFMEA), SPC, process capability assessments, CA processes, and calibration
- Sub-Tier supplier management
- Traceability
- Change authorization process and testing

Topics Needing Improvement

- All topics need additional details to be useful
  - Most topics have high level descriptions of these processes
  - No specific requirements or expectations are defined

Topics Not Covered

- Manufacturing personnel training requirements
  - No references to the use of or training to industry standards such as IPC-A-610, J-STD-001, IPC-7711/21, etc. that are applicable to all manufacturing processes
- No training to Lean Six Sigma (LSS) or similar statistical based manufacturing improvement methods

Section 6.5 Excerpt

PCN Process Requirements

6.5 Qualification of Change Suppliers **shall** provide data to support the change. Upon request, the supplier **shall** provide, a reasonable number of pieces indicated as necessary in order to qualify the new revision of the supplier product. Also, the supplier **shall** provide qualification and characterization information for each PCN as applicable. If this information is not available at the time the PCN is issued, the supplier **shall** provide a qualification plan and timeline with the initial PCN, and the final test report once it is available.

Suppliers **shall** provide samples for qualification upon request. Such samples **shall** be representative for the normal production of product to be supplied.

6.5.1 Content of each Product Change Notice (PCN)/End of Life (EOL)/Product Alert (PA) This information **shall** include the following minimum information:

- Data Supporting Change.
- Internal Tracking Number.
- Name of Supplier.
- Contact Names (address, telephone/fax numbers).
- Planned Implementation Date.
- Product Identification.
- Detailed Description of Change/Reason.
- Quantifiable Impact on Quality (positive or negative).
- Impact on Reliability.
- Supporting Data and/or Qualification Date/Plan.
- Identification Method for Product Ordering Code Changes, if known.
- Application Changes, Enhancements and/or Work-Arounds.

6.5.1.1 Product Alerts (PA) The Alert timeline notification **shall** be within 72 hours of detection of the issue and the supplier **shall** issue a written alert upon the detection of any issue adversely affecting the safety, security and/or reliability of the supplier's product. If correction of the issue requires a change to the product or related processes, the supplier **shall** issue a related PCN and explicitly note the issue being corrected as well as its impact on the safety and/or reliability of the supplier's product. The purpose of this type of notification is to provide enough information to initially ascertain the severity of an issue and involve the appropriate people, and be able to contain/quarantine the affected products.

The content requirements for a PA **shall** be the same as a PCN, except that the PA **shall** also include the shipping quantities, shipping locations and the P.O. numbers.

6.5.1.2 End of Life Suppliers **shall** accept orders up to 12 months after notification of product discontinuation. Users **shall** accept delivery within 6 months of order date.

Section 7: Manufacturing Conformance Testing

Topics Included

- Summarizes the types of testing expected during assembly processes
  - This includes AOI, ICT, X-Ray and similar types of testing
- Lists typical assembly level tests
  - This includes Functional, Burn-in/HASS, and any ORT type testing required
- States that final cosmetic / mechanical reviews should be done

Topics Needing Improvement

- All topics could be covered in greater detail
- HASS/HASA test definition in Appendix D need additional details to explain the test better

Topics Not Covered

- Identification of process sensitive devices (J-STD-075)
- Minimum test coverage levels for each product class should be defined
- Detection of outliers and Maverick lots
  - High Cpk values can allow a significant shift in measured parameters to be missed
- Best practices for test fixture and test card design should be defined
  - This is especially important for parallel mode / redundancy testing

Section 7.3.1 (Figure 7-1) Excerpt

Typical Manufacturing Conformance Test Flow

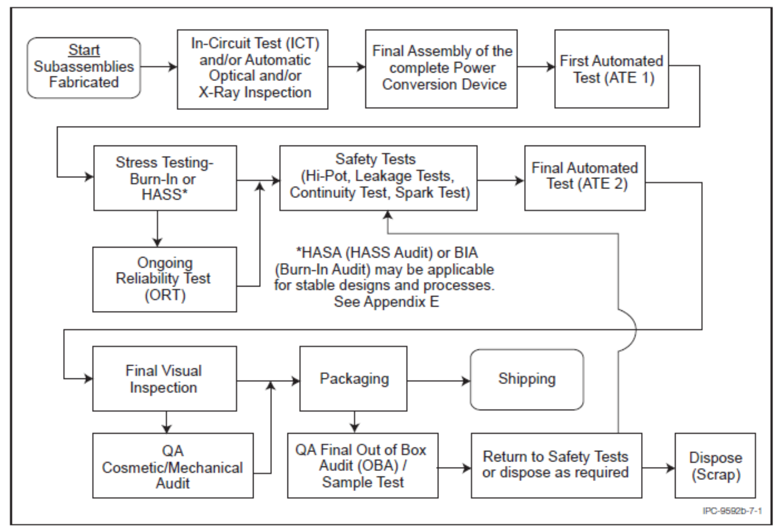


Figure 7-1 Typical Manufacturing Conformance Test Flow

IPC-9592C Planned Topics (Committee Currently Dormant)

PCB MSL Rating when Not Defined

- Define MSL based on materials, stack-up, and thickness instead of the general Class 2a now established
- Perform studies or identify sources supporting these ratings

Section 4: Design for Reliability

- Update focusing on requirements while minimizing the current guideline format
- Establish templates for worst case stress analysis for each component in the bill of materials

Section 5: Design and Qualification Testing

- Establish templates qualification test plans and reporting
- Improve temperature cycling test by adding flexibility to the stress conditions
  - Focus on temperature extremes and ranges as they relate to the number of required cycles
  - Identify test conditions for industry known problems with various SMT packages and thick PCBs

Appendix D: HASS Definitions

- Expand this section with greater detail on the test method and expectations (much as was done with HALT in the revision A)

Major Topics to Address

Firmware

- Best practices in design, implementation and verification
- Test and qualification methods in the power subsystem
  - Must include in system test
- Identification of wear-out or end-of-life

Statistical methods such as DfX, DFSS, DOX, etc.

- Training and education expectations
- Usage in manufacturing process monitoring and optimization
- Optimization of test process and limit setting
  - Reduction of test time – improved efficiency
  - Identification of outliers and Maverick lots
  - Verification of the capability of the test system

Manufacturing expectations

- Identification of process sensitive devices
- Use of industry standards
- Create a "Standards Map" directly applicable for power assemblies
- Applicable standards may differ by product category and class
- Operator / trainer / supervisor qualifications

What's Next? ...A Call to Action

Updates to IPC-9592

- Provide additional detail or clarifications to material included in the document (Rev C plans)
- Define expectations for each product class when not defined in current document
- Add new content to fill gaps in current document (other topics that need to be addressed summarized in previous slides)

New standards

- Some topics may complicate IPC-9592 due to the subject matter / required depth
  - Creating a new standard referenced by IPC-9592 may be preferable
- Subject matter that has value outside the IPC-9592 standard
- Each example from the "Major Topics to Address" slide could be a new standard including:
  - Firmware
  - Statistical methods
  - Manufacturing expectations

Combinations of both

- Reference or summarize "New Standard" in IPC-9592
- Create new standard to complement content in IPC-9592

Interested? Please contact me or Matt Kelly at IPC to get involved

Q & A

Thanks a lot for your time and attention!

Any questions and/or comments?

References

- IPC-9592B – Requirements for Power Conversion Devices for the Computer and Telecommunications Industries
- 2019 PSMA Power Supply Software / Firmware Reliability Improvement Report
- IPC-A-610x – Acceptability of Electronic Assemblies
- IPC J-STD-001x – Requirements for Soldered Electrical and Electronic Assemblies
- IPC/JEDEC J-STD-020x – Moisture / Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices
- IPC/JEDEC J-STD-033x – Handling, Packing, Shipping and Use of Moisture/Reflow and/or Process Sensitive Devices
- ECA/IPC/JEDEC J-STD-075x – Classification of Non-IC Electronic Components for Assembly Processes
- "Applying Design for Six Sigma to Software and Hardware Systems" by Dr. Eric Maass