IPC-9151D
2012 - May

Process Capability, Quality, and Relative Reliability (PCQR²) Benchmark Test Standard and Database

Supersedes IPC-9151C
May 2010

A standard developed by IPC
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Printed Board Process Capability, Quality, and Relative Reliability (PCQR²) Benchmark Test Standard and Database

Developed by the PCQR² Subcommittee (D-36) of the Rigid Printed Board Committee (D-30) of IPC

Supersedes:
IPC-9151C - May 2010
IPC-9151B - February 2007
IPC-9151A - May 2003
IPC-9151 - June 2002

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

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Acknowledgment

Any document involving a complex technology draws material from a vast number of sources. While the principal members of the IPC PCQR² Subcommittee (D-36) of the Rigid Printed Board Committee (D-30) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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1 SCOPE

1.1 Purpose The purpose of this document is to define the Process Capability, Quality, and Relative Reliability (PCQR²) Benchmark Test Standard and Database Program used for the evaluation of printed board manufacturing processes. This is in accordance with The National Technology Roadmap for Electronic Interconnections 2000/2001 published by IPC, which states that “For a company to efficiently manage its supply chain it must identify the capability of its suppliers and make certain that their capability for manufacturing a product is consistent with the needs of the customer.”

1.2 Documentation Hierarchy All other IPC documents take precedence over this document. This document was developed by the IPC D-36 Subcommittee of the Rigid Printed Board Committee (D-30) of IPC, and describes the process to evaluate the manufacturing process capability of printed board fabricators for certain key features.

1.3 Definition of Terms The definition of all terms used herein shall be as specified in IPC-T-50 and as defined below.

Analysis Report Detailed statistical data on each fabricator’s database submission.

Comparison Report Comparative statistical data of each fabricator participating in the database.

Conductor Analysis Technologies, Inc. (CAT) The company providing and controlling the intellectual property associated with the process capability panel designs, test methods, data analysis techniques, and the database.

Database Submission A set of process capability panels submitted by a fabricator for testing, data analysis, and inclusion in the database.

Database Subscriber A company or an organization, or division(s) thereof, associated with the electronics industry that obtains access to the database through an annual subscription from IPC.

Database Supplier A fabricator who submits a set of process capability panels for testing, data analysis, and inclusion in the database.

Design Requirements File The file used to detail the specifications and manufacturing requirements of each process capability panel design.

Design Library The family of process capability panel designs developed by the IPC D-36 Subcommittee.

Fabricator A specific company’s or organization’s facility that manufactures printed boards.

PCQR² Database The electronic storage medium for the data and reports generated from the testing of process capability panels.

Peer Report Comparative data showing participating fabricator performance with respect to peers.

Process Capability Data The data generated from the testing of process capability panels.

Process Capability Panel A parametric test panel that is comprised of test modules designed to evaluate specific features of printed boards.

Submission Form The information provided by fabricators upon submitting a set of process capability panels to the database.

Subscription License Agreement The method used by subscribers to gain access to the database which is available at www.pcbquality.com.

Test Module The individual element of a process capability panel.
1.4 **Applicable Documents**  The following specifications of the revision in effect at the time of order form a part of this document to the extent specified herein.

**IPC-TM-650**  Test Methods Manual\(^1\)

2.6.27  Thermal Stress, Convection Reflow Assembly Simulation

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

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### 2 PROCESS SUMMARY

#### 2.1 Introduction

Many printed board users have developed internal processes to evaluate the capabilities of their printed board fabricators. As a result, fabricators often receive requests from multiple customers to manufacture test panels as part of qualification procedures. The PCQR\(^2\) database program provides an industry standard for the design of these test panels. The resulting data provides subscribers with the ability to review detailed results from individual fabricators, to compare the capabilities of multiple fabricators, and to eliminate multiple or redundant requests to fabricators.

#### 2.2 Process Steps

1. At the request of a database subscriber(s) or on their own behalf, fabricators **shall** download the appropriate process capability panel designs, associated requirements files, and submission forms from the design library at www.pcbquality.com.

2. The fabricator manufactures the process capability panels using their standard processes per the specifications and requirements outlined in the design requirements file and AABUS.

3. The fabricator completes the submission form as instructed in the requirements file, and ships all panels at one time. Testing will not begin until all panels and the submission form have been received.

4. CAT or a third party facility licensed by IPC performs the required testing of the process capability panels. All data analysis and report generation **shall** be performed by CAT.

5. Reports and summary information are posted to the database at www.pcbquality.com.

6. Current subscribers are informed of the posting and of the fabricator’s identity within the database.

7. The fabricator is provided with a copy of their analysis report and an applicable “peer report” for their submission.

8. The process capability panels are not the property of CAT or IPC, and if requested will be returned to the owner when the testing and data analysis has been completed. The panels will be stored for a period of two months from the posting of the data, after which time CAT may dispose of the panels. Unclaimed panels may be used by CAT and/or IPC for other committee-approved activities.

### 3 PROCESS CAPABILITY PANEL DESIGNS

#### 3.1 Design Library

The PCQR\(^2\) process capability panel designs are provided under license to IPC by CAT for use by its members and the printed board community. The designs are to be used exclusively for the support of the PCQR\(^2\) database and related activities. The most current process capability panel designs are posted at www.pcbquality.com.

#### 3.2 Panel Layouts

The process capability panels consist of an array of 25.4 x 25.4 mm [1.0 x 1.0 in] test modules, several test coupons within this array, and a 25.4 mm [1.0 in] border that includes nomenclature and alignment features. An individual design layout map is included in each set of design files posted at www.pcbquality.com. The test modules and coupon types include conductor/space, via registration, via formation, via reliability, solder mask registration, controlled impedance, conductive anodic filament and cross-section.

#### 3.3 Test Modules and Coupons

The test modules/coupons are designed to allow evaluation of detailed information on a range of feature types and sizes. Table 3-1 details the information that is obtained from each of the modules/coupons.

#### 3.4 Manufacturing Requirements

Each of the designs has an accompanying requirements file that describes its specific features and manufacturing requirements.

---

\(^1\) Current and revised IPC Test Methods are available on the IPC Web site (www.ipc.org/html/testmethods.htm)
TEST AND ANALYSIS

4.1 Testing and Data Analysis

The panels shall be tested by CAT or by a third-party licensed by CAT and approved by the IPC D-36 Subcommittee. All data analysis, report generation, and posting to the database shall be performed by CAT. The type of measurement performed on each module is detailed in Table 4-1.

<table>
<thead>
<tr>
<th>Module/Coupon</th>
<th>Capability</th>
<th>Quality</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor/Space</td>
<td>Conductor and space yield</td>
<td>Conductor width and height control</td>
<td>–</td>
</tr>
<tr>
<td>Via Registration</td>
<td>Probability of breakout</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Via Formation</td>
<td>Via yield</td>
<td>Resistance control</td>
<td>–</td>
</tr>
<tr>
<td>Via Reliability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solder Mask Registration</td>
<td>Probability of encroachment</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Controlled Impedance</td>
<td>Impedance control</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Conductive Anodic Filament</td>
<td>–</td>
<td></td>
<td>Time to failure</td>
</tr>
</tbody>
</table>

Table 4-1 Measurements

<table>
<thead>
<tr>
<th>Module/Coupon</th>
<th>Measurement Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor/Space</td>
<td>Precision resistance</td>
</tr>
<tr>
<td>Via Registration</td>
<td>Resistance</td>
</tr>
<tr>
<td>Via Formation</td>
<td>Precision resistance</td>
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<tr>
<td>Via Reliability</td>
<td>Precision resistance</td>
</tr>
<tr>
<td>Solder Mask Registration</td>
<td>Resistance</td>
</tr>
<tr>
<td>Controlled Impedance</td>
<td>Time Domain Reflectometry (TDR)</td>
</tr>
<tr>
<td>Conductive Anodic Filament</td>
<td>Voltage</td>
</tr>
</tbody>
</table>

4.2 Via Reliability and Conductive Anodic Filament Testing

4.2.1 Assembly Simulation

After initial capability and quality testing, representative reliability and conductive anodic filament coupons shall be subjected to six cycles of a convection solder reflow profile. The conditioning and reflow profiles shall be in accordance with IPC-TM-650, Method 2.6.27. The reflow profile used will be AABUS.

4.2.2 Via Reliability Testing

The via reliability coupons that are subjected to the assembly simulation process shall be thermal-cycled using the Highly Accelerated Thermal Shock (HATS) reliability test methodology, which was developed for the IPC-PCQR² program. The temperature extremes and the number of cycles are detailed in Table 4-2.

Table 4-2 HATS Cycle

<table>
<thead>
<tr>
<th>Lower Temperature</th>
<th>Upper Temperature</th>
<th>Number of Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40 °C</td>
<td>+145 °C</td>
<td>500 or until open</td>
</tr>
</tbody>
</table>

4.2.3 Conductive Anodic Filament Testing

The conductive anodic filament coupons that are subjected to the assembly simulation process shall be subjected to temperature, humidity and bias conditions as detailed in Table 4-3.

Table 4-3 Conductive Anodic Filament Test Conditions

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Humidity</th>
<th>Bias</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 °C</td>
<td>85% RH</td>
<td>48 volts</td>
<td>500 hours or until failure</td>
</tr>
</tbody>
</table>
5 DATABASE

5.1 Data  The data collected from each submission is compiled into the database that details the process capability, quality, and reliability demonstrated by fabricators. The data shall remain active for a period of thirty-six months from the posting date after which time it will be removed and archived.

5.2 Database Access  Access to the database is provided only through an annual subscription from IPC, and is based on the subscribers’ annual electronics revenues. Subscribers are allowed access to all database reports, summary information and fabricator identities during the term of their subscription.

6 UPDATES AND REVISIONS

The design library and database will be reviewed and updated periodically by the IPC D-36 Subcommittee. Additions, deletions, and modifications will be made to the design library and database to reflect the needs of subscribers and fabricators. These revisions must be approved by the active subscribers. In all cases, the most current revisions shall be used and are the controlling documents. Requests to support archived designs more than three months old shall not be accepted.
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This is a **NEW** term and definition being submitted.
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This is a **CHANGE** to an existing definition.

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<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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Committees affected by this term:

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<tr>
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<td>Date of Initial Review:</td>
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<tr>
<td>Comments Collated:</td>
<td>Comment Resolution:</td>
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<td>Returned for Action:</td>
<td>Committee Action:  ❑ Accepted  ❑ Rejected  ❑ Accept Modify</td>
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<tr>
<td>Revision Inclusion:</td>
<td></td>
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</table>

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**IEC Classification**

Terms and Definition Committee Final Approval Authorization:
Committee 2-30 has approved the above term for release in the next revision.

Name:  Committee:  IPC 2-30  Date:  

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- **Printed Circuit Board Manufacturer**
  
  Facility manufactures and sells printed circuit boards (PCBs) or other electronic interconnection products to other companies. What products do you make for sale? (check all that apply)
  
  - [ ] One and two-sided rigid, multilayer printed boards
  - [ ] Flexible printed boards
  - [ ] Other interconnections
  - [ ] Printed electronics

- **Electronics Manufacturing Services (EMS) Company**
  
  Facility manufactures printed circuit assemblies, on a contract basis, and may offer other electronic interconnection products for sale.

- **OEM — Original Equipment Manufacturer**
  
  Facility purchases, uses and/or manufactures printed circuit boards or other interconnection products for use in a final product, which we manufacture and sell.

  What is your company’s primary product line?

- **Industry Supplier**
  
  Facility supplies raw materials, equipment or services used in the manufacture or assembly of electronic products.

  Which industry segment(s) do you supply?

  - [ ] PCB
  - [ ] EMS
  - [ ] Both
  - [ ] Printed electronics

  What products do you supply?

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  Organization is a government agency, university, college or technical or nonprofit institution which is directly concerned with design, research and utilization of electronic interconnection devices.

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Payment Information (Purchase orders not accepted as a form of payment)

Membership Dues

Membership will begin the day the application and dues payment are received, and will continue for one or two years based on the choice indicated below. All fees are quoted in U.S. dollars.

Please check one:

<table>
<thead>
<tr>
<th>Primary facility:</th>
<th>Government agency, academic institution, nonprofit organization</th>
<th>Consulting firm (employing less than 6 individuals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ One year $1,050.00</td>
<td>☐ One year $275.00</td>
<td>☐ One year $625.00</td>
</tr>
<tr>
<td>☐ Two years $1,890.00</td>
<td>☐ Two years $495.00</td>
<td>☐ Two years $1,125.00</td>
</tr>
<tr>
<td>(SAVE 10%)</td>
<td>(SAVE 10%)</td>
<td>(SAVE 10%)</td>
</tr>
</tbody>
</table>

Additional facility: Membership for a facility of an organization that already has a different location with a primary facility membership

| ☐ One year $850.00 | ☐ One year $625.00 |
| ☐ Two years $1,530.00 | ☐ Two years $1,125.00 |
| (SAVE 10%) | (SAVE 10%) |

Company with an annual revenue of less than $5,000,000

| ☐ One year $625.00 | ☐ One year $625.00 |
| ☐ Two years $1,125.00 | ☐ Two years $1,125.00 |
| (SAVE 10%) | (SAVE 10%) |

Enclosed is a check for $________________

Bill credit card: (check one)

☐ MasterCard ☐ American Express ☐ Visa ☐ Diners Club

Card No. Expiration Date Security Code

Authorized Signature

Mail application with check or money order to:

IPC
3491 Eagle Way
Chicago, IL 60678-1349

Fax/Mail application with credit card payment to:

3000 Lakeside Drive, Suite 309 S
Bannockburn, IL 60015
Tel: +1 847-615-7100
Fax: +1 847-615-7105
www.ipc.org

*Overnight deliveries to this address only.
Contact membership@ipc.org for wire transfer details

Please attach business card of primary contact here

10/10
The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:
IPC
3000 Lakeside Drive, Suite 309S
Bannockburn, IL 60015-1249
Fax: 847 615.7105
E-mail: answers@ipc.org
www.ipc.org/standards-comment

1. I recommend changes to the following:
   ___ Requirement, paragraph number ________
   ___ Test Method number ________, paragraph number ________

   The referenced paragraph number has proven to be:
   ___ Unclear  ___ Too Rigid  ___ In Error
   ___ Other

2. Recommendations for correction:

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

3. Other suggestions for document improvement:

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

Submitted by:

Name __________________________________ Telephone ______________________

Company __________________________________ E-mail ______________________

Address __________________________________

City/State/Zip __________________________ Date __________________________