REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	Added para. 1.5 and marginal notations for differences from RB-276. Revised qualification requirements to use QPL-P-55110 suppliers, para. 3.3.2; deleted para. 6.0 Vendor Qualification Program. Added para. 3.4.1.1, no pink ring allowed. Revised numerous sentences for clarity and typographical corrections. Page count changed from 11 to 9 pages.	7/18/95	J.J.S.
B	Revised entire specification to conform to IPC-6011 and -6012, which supercede RB-276. Revised para. 2.3 Order of Precedence. Qualified suppliers changed to include MIL-PRF-31032. Added exposed weave as not-allowed defect. Added requirement for solder coating in accordance with -6012/3.2.6.4. Added requirement for no tented vias (3.6.7). Changed para. 3.10 Coupon Requirements for clarity and to require prior approval for using production boards in lieu of coupons. Para. 3.10.2 Coupon Design changed for clarity. Added 3.10.5 no lifted lands allowed on as-received boards. 3.10.7 Plating Voids revised. 3.12 Drilling revised for clarity. Revised para. 4.4 by allowing sampling quality conformance inspection only for Types 1 and 2. Added 4.7 requiring prior notification for contract services.	7/16/97	JJ

SHEET REVISION STATUS:

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Title: Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses

Spec. No.: S312-P-003 Rev: B

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

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Procurement Specification for Rigid Printed Boards for Space Applications and other High Reliability Uses

1.0 SCOPE

1.1 **Scope** This specification establishes requirements for rigid printed boards. The boards may be single-sided, double sided with or without plated-through holes, multilayer with or without buried/blind vias, and metal core boards. These requirements are generally in accordance with IPC-6011 and -6012 with additional construction, inspection and product assurance requirements specified.

1.2 **Purpose** This specification provides general requirements and quality assurance provisions for rigid printed boards procured for use in spacecraft and scientific instruments for space applications and other high reliability uses.

1.3 **Type** Printed boards shall be of the following types, as specified:

Type 1 - Single-sided board
Type 2 - Double-sided board
Type 3 - Multilayer board without blind or buried vias
Type 4 - Multilayer board with blind and/or buried vias
Type 5 - Multilayer metal core board without blind or buried vias
Type 6 - Multilayer metal core board with blind and/or buried vias

1.4 **Applicability** This specification is applicable to all NASA Goddard Space Flight Center (GSFC) programs and contracts using printed boards for space flight applications and critical ground support equipment. It shall be invoked on all procurements for flight and critical ground support equipment (see note below) printed wiring boards. It shall apply to both in-house and contractor procurements and also to any sub-tier vendor manufacturing printed boards for GSFC programs or contracts.

NOTE: Critical ground support equipment is mission-peculiar ground support equipment that interfaces with the flight system which, in any way through its malfunction, can damage or functionally impair the flight system.

1.5 **Notation** Requirements which vary from IPC-6011 and -6012 are denoted by " ⇨ " for emphasis and ease of interpretation.

2.0 APPLICABLE DOCUMENTS

2.1 **Government/Military specifications and standards.** The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the applicable issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS), and the applicable supplement thereto, in effect on the date of the procurement.

SPECIFICATIONS:

MIL-P-55110 *Printed Wiring Boards, General Specification for*

MIL-P-13949 *Plastic Sheet, Laminated, Metal-Clad (For Printed Wiring Boards), General Specification for*

MIL-PRF-31032 *Performance Specification, Printed Circuit Board/Printed Wiring Board, General Specification for*

(Federal and Military specifications and standards are available from the Standardization Documents Order Desk, Building 4, Section D, 700 Robbins Avenue, Philadelphia, Pennsylvania 19111-5094.)

2.2 **Other publications** The following documents form a part of this specification to the extent specified herein. The applicable issues of these documents shall be that or those in effect by the responsible industry association or society on the date of the procurement document.

American Society for Testing and Materials (ASTM):

ASTM E-595 *Test Method for Outgassing*

(Copies can be obtained from ASTM, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

Institute for Interconnecting and Packaging Electronic Circuits (IPC):

IPC-6011	*Generic Performance Specification for Printed Boards*
IPC-6012	*Qualification and Performance Specification for Rigid Printed Boards*
IPC-MF-150	*Metal Foil for Printed Wiring Applications*
IPC-D-275	*Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies*
IPC-D-325	*Documentation Requirements for Printed Boards*
IPC-A-600	*Acceptability of Printed Boards*
IPC-TM-650	*Test Methods Manual*

(Applications for copies should be addressed to IPC, 2215 Sanders Road, Northbrook, Illinois 60062-6135 Tel 847 509-9700)

National Aeronautics and Space Administration:

RP-1161	*Evaluation of Multilayer Printed Wiring Boards by Metallographic Techniques* (Reference Publication), Jane Jellison, May 1986.
NHB 5300.4(1G)	*NASA Assurance Terms and Definitions*, Reliability, Maintainability, and Quality Assurance Publication, May 1993.

(Copies can be obtained through or as directed by the procurement activity.)

2.3 **Order of precedence** In the event of conflict between the procurement document(s), text of this specification, or other document(s) referenced herein, the following order of precedence shall apply:

1. Contract or purchase order,
2. Printed Board Master Drawing,
3. This Specification,
4. IPC-6011, *Generic Performance Specification for Printed Boards*, and IPC-6012, *Qualification and Performance Specification for Rigid Printed Boards*,
5. Other documents referenced herein.

However, nothing in this document shall supersede applicable laws and regulations unless a specific exemption has been made.

3.0 REQUIREMENTS

3.1 **General Requirements** Printed boards furnished to this specification shall conform to the requirements of the master drawing, this specification and IPC-6011 and -6012. The detailed requirements contained in this section, although determined by examining specific quality conformance test circuitry (test coupons) and sample printed boards, shall apply to all coupons, sample boards, and delivered printed boards. Defects or anomalies noted on coupons or sample boards (or both) when performing the specified inspections shall be recorded and the proper corrective actions shall be initiated to eliminate the defects or anomalies.

3.2 **Deviations and Waivers** Deviations and waivers to the contract or purchase order, Printed Board Master Drawing or this specification shall be submitted to the procuring activity for approval. *Written approval of any deviation or waiver shall be obtained prior to delivering product.*

3.3 **Qualification of Printed Board Manufacturers** All printed boards shall be procured from qualified manufacturers. Qualification requirements are specified in this section.

3.3.1 **Selection of Qualified Manufacturers** Printed board manufacturers considered for qualification to this specification shall be selected from the Qualified Products List (QPL) for MIL-P-55110 or from the Qualified Manufacturers List (QML) for MIL-PRF-31032. The procuring activity shall procure boards from manufacturers listed on this QPL or QML.

If a non - QPL or non - QML manufacturer is considered or selected, the procuring activity shall provide written justification for using a non-qualified (non - QPL or - QML) manufacturer. This justification shall include a history of the manufacturer's satisfactory

performance supplying boards to space quality (Class 3) or equivalent requirements. Written approval by the Goddard Space Flight Center (GSFC) shall be required *before* printed boards *are delivered* for flight hardware fabrication.

3.4 **Performance Specification** All printed boards shall be procured to the requirements of IPC-6011 and -6012 and this specification. Procured boards shall be Classes 3-6 High Reliability Electronic Products, per paragraph 1.2 of IPC-6011.

3.4.1 ⇨ The following printed board defect(s), permitted under IPC-6012, 3.0 REQUIREMENTS, are *not allowed* for product supplied to this specification:

3.4.1.1 ⇨ **Pink Ring** - Pink ring (ref. IPC-6012, para. 3.3.2.6) is *not allowed.*

3.4.1.2 ⇨ **Exposed Weave** - Exposed weave *shall not be allowed* in as-received boards.

3.5 **Documentation Requirements** Documentation supplied to the printed board manufacturer shall be in accordance with IPC-D-325 *Documentation Requirements for Printed Boards*. The documentation shall be Class C Full Documentation per paragraph 1.2 of that specification.

3.6 **Material Requirements** Material requirements shall be as specified in the master drawing, this specification and IPC-6012 paragraphs 3.2.1 through 3.2.13.

3.6.1 **Solder Coating** Solder coating shall be in accordance with IPC-6012 paragraph 3.2.6.4, unless otherwise specified in the procurement documentation.

3.6.2 **Material Handling and Storage** Material handling and storage shall be in accordance with IPC-MF-150 and any applicable manufacturer's data sheets. Raw material storage and handling shall be controlled to insure and prolong shelf life. When released from primary storage areas, material shall be handled and controlled to minimize contamination and damage.

3.6.3 ⇨ **Metal-clad Laminates** Unless otherwise specified, metal-clad laminates for Type 1 and 2 printed boards and individual layers for Type 3 through Type 6 printed boards shall be in accordance with MIL-P-13949, type GIN (polyimide). When an epoxy resin system is required, the metal-clad laminate shall be in accordance with MIL-P-13949 and have a glass transition temperature (T_g) above 150^0 C (302^0 F). Other materials shall not be used without prior GSFC approval.

3.6.4 **Bonding Material** The inner-layer bonding material for Type 3 through Type 6 printed boards shall be preimpregnated (B-Stage) and of the same type as the base laminate, in accordance with MIL-P-13949.

3.6.5 Copper Foil Unless otherwise specified the copper foil shall be Class 3 high temperature elongation (HTE) in accordance with IPC-MF-150. The thickness shall be as specified in the master drawing.

3.6.6 Electrodeposited Copper The electrodeposited copper shall have an elongation of 14% ⇨ minimum and an average tensile strength of 25.3×10^{6} kg/m^2 (36,000 psi) minimum when measured in accordance with IPC-TM-650 Method 2.4.18. Tensile strength and elongation shall be monitored bi-weekly and the data from the most recent evaluation shall be used to determine acceptability.

3.6.7 Tented Vias Tenting of via holes with solder mask is *not allowed.* ⇨

3.7 **Registration (Internal)** Registration shall be as described in paragraph 3.4.2 of IPC-601 ⇨ *except* that the minimum internal and external annular ring shall be 50 µm (0.002 in).

3.8 **Outgassing** When tested in accordance with ASTM Test Method ASTM E-595, no ⇨ material shall have a total mass loss (TML) greater than 1.0% and a collected volatile condensable material (CVCM) greater than 0.1%. Each material (for example, laminate material and solder mask) shall be tested separately. Foil shall be removed from laminate material prior to test. Certified test data provided by the material manufacturer or by an approved test laboratory is acceptable.

3.9 **Laminate Integrity** Laminate integrity shall be as described in paragraph 3.6.2.3 of IPC ⇨ 6012, for Class 2 and 3 products. Laminate voids or cracks exceeding 75 µm (0.003 inch) in the unstressed coupon are *not* acceptable. Laminate voids shall be defined to include resin recession.

3.10 **Coupon Requirements** Coupon requirements shall be as specified in IPC-6012, Table ⇨ 4-1, except that a total of six (6) "B" coupon segments per panel are required. The coupons shall not be separated from the panel prior to completing all board manufacturing processes. Using production boards in lieu of coupons shall require prior procuring activity approval. A 100% coupon evaluation is required for Types 3-6 boards. Sampling coupon evaluations in accordance with IPC-6012 paragraph 4.2.1 are allowed only for Types 1 and 2 boards.

3.10.1 Coupon Placement Coupon(s) shall be placed as specified in IPC-D-275 paragraph 7.3.1.

3.10.2 Coupon Design Coupons shall be designed in accordance with IPC-D-275 Paragraph 7.3. Each layer of the printed board shall be represented by internal annular rings at all coupon plated-through holes. When thermal relief is used in the board, the same thermal relief design shall be used in the coupon.

3.10.3 Coupon Evaluation Coupons shall be evaluated in accordance with the requirements of IPC-6012 and this specification. When clarification of requirements is necessary, IPC-A-600 shall be used. NASA-RP-1161 may be used to provide guidance in preparing and inspecting coupons. Coupon evaluation shall be performed per para. 4.5 of this specification.

3.10.4 Plating Integrity (as produced) The criteria specified in paragraph 3.6.2 of IPC-6012 shall be evaluated both before and after coupon microsection etching.

3.10.5 Plating Integrity (as received) Lifted lands shall *not* be allowed in *as received* boards.

3.10.6 Plated-Through Hole Integrity after Thermal Stress Following thermal stressing per paragraph 3.6.1 of IPC-6012, coupons shall be microsectioned and examined before and after microsection etching. They shall meet the requirements of IPC-6012, paragraphs 3.6.2.1 through 3.6.2.15, Table 3-7, and Figures 3-2 through 3-6 for Class 3. Lifted lands *equal or less than* 25 μm (0.001 in.) are allowed after thermal stressing.

3.10.7 Plating Voids Any product exhibiting the criteria of IPC-6012 paragraph 3.6.2.2 for Class 3 product shall be rejected.

3.11 Etchback Etchback is required. Etchback shall meet the limits of IPC-6012 paragraphs 3.6.2.5 and 3.6.2.7.

3.12 Drilling For Type 3 through Type 6 boards, the smallest-sized drill used for a plated-
⇨ through hole shall be used for the coupons. These holes shall be microsectioned and examined in accordance with IPC-6012 paragraph 3.6 and shall meet the requirements of Table 3-7.

The manufacturer shall have a drill replacement program in use.

3.13 Repairs Bare board repairs shall *not* be permitted.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Quality Requirements The manufacturer is responsible for all inspection requirements specified in this specification and IPC-6011 and -6012.

4.2 Qualification Requirements Qualification testing shall be performed in accordance with
⇨ the requirements of IPC-6012 paragraphs 4.1.1 and 4.1.2 and Table 4-1 *except* that coupon testing shall be performed at a laboratory approved by GSFC.

4.3 **Source Inspection** The procuring activity reserves the right to verify that all the requirements of this specification have been met. Periodic surveillance and/or inspection of all phases of fabrication, testing, and inspection may be conducted.

4.4 **Quality Conformance** Quality conformance inspection shall be performed by the board manufacturer in accordance with the requirements of IPC-6012 paragraph 4.2 and Table 4-3 and this specification. Classes 3-6 product shall be subjected to a 100% coupon inspection and a 100% visual inspection for all boards. Sampling is allowed *only* for Types 1 and 2 boards.

4.5 ⇨ **Quality Verification Inspection** A coupon from each panel shall be evaluated for structural integrity before and after thermal stress in accordance with the requirements of IPC 6012 and this specification. Coupons shall be prepared and evaluated by GSFC or in a facility approved by GSFC. The government reserves the right to perform this inspection, at its discretion.

4.6 **Inspection Lot** An inspection lot shall consist of all printed boards having the same part number, fabricated from the same materials, using the same processes, produced under the same conditions, accompanied by the same routing documentation and submitted for quality conformance inspection at the same time.

4.6.1 **Traceability** The manufacturers shall establish and maintain a traceability program for all printed boards in accordance with paragraph 4.3.2.2 of IPC-6011. Each separated coupon shall be traceable to the panel from which it was separated. Each board shall be identified with a unique serial number and be traceable to its panel.

4.7 **Contract Services** If the manufacturer contracts any portion of his manufacturing operation to a contract service, he shall notify the procuring activity in writing *prior to fabricating any boards*. The manufacturer shall flow down the requirements of this specification to any contract service.

5.0 PACKAGING AND SHIPPING

5.1 **Individual Wrapping** Each printed board shall be wrapped in a suitable material and secured in groups to prevent abrasion damage during transport. The wrapping material shall be constructed from material that will not contribute to degraded solderability of the printed board for a three year storage period under ambient conditions.

5.2 **Shipping Container** The boards shall be protected adequately during shipment by using suitable packing materials and placing them in a shipping container or box to support the boards during transport.

6.0 Reserved

7.0 TRAINING

7.1 **Supplier Responsibility** The supplier shall be responsible for the following:

7.1.1 **Specification Training** All printed board manufacturing and inspection personnel who work on product procured to this specification shall be familiar with this specification, IPC-6011 and 6012 and other pertinent requirements of the engineering and procurement documents.

7.1.2 **Process Training** Training shall be provided to manufacturing and inspection personnel in the techniques of printed board fabrication and inspection to assure each individual is appropriately skilled in the processes for which they are responsible in their assigned work.

7.1.3 **Training Records** A record of training shall be maintained for each individual receiving training under paragraphs 7.1.1 and 7.1.2. This record shall be made available for review by the procuring activity upon their request.