

System of quality assessment —

Generic specification —

Printed boards

ICS 31.180

Committees responsible for this British Standard

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- Association of Contract Electronics Manufacturers
- Federation of the Electronics Industry
- GAMBICA
- Ministry of Defence
- National Supervising Inspectorate
- Printed Circuit Interconnection Federation
- Surface Mounting and Related Technologies (Smart Group) Ltd.

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Foreword

This British Standard has been prepared by Technical Committee EPL/501, Electronic assembly technology.

The BS 123000:2001 series of British Standards is based on draft proposals to revise the EN 123000 series originally dated 1991. These were circulated and voted on in CENELEC, but the CENELEC Technical Board decided not to approve them for publication. Following repeated attempts by the British National Committee to get them published, the Technical Board agreed to grant derogation from standstill to the British National Committee to publish national standards on the basis of the prEN 123000 series (Technical Board decision D106/092).

These standards are published to complement the BS EN 123000 series, which remains current. They will be withdrawn only if they are replaced by revised EN standards. They have been published because they are considered to be an improvement upon the EN series, for the following reasons.

- a) Requirements for modern materials and surface finishes required by the electronics industry have been incorporated.
- b) Reference is made to ANSI/IPC A-600F for many of the inspection criteria. This has been undertaken in response to industry requests.
- c) References to obsolete CECC regulatory documents have been replaced.
- d) Tests and requirements that are no longer considered relevant have been removed.
- e) The UK electronics industry requires standards that are subject to ongoing revision, in order to take account of new European Eco-Directives.

The BS 123000 series of standards is based upon the following hierarchy of specifications for the capability of manufacturers to produce printed boards:

- 1) generic specification (BS 123000 is a generic specification);
- 2) sectional specification;
- 3) capability detail specification;
- 4) customer detail specification.

Each sectional specification covers a printed board technology type, e.g. rigid multilayer etc. For each sectional specification, further capability detail specifications and customer detail specifications are produced as needed.

The BS 123000 series of standards differentiates between “basic capability” and “additional capability”. Attention is particularly drawn to **5.1**, **5.3.2** and **5.3.3**.

Printed boards differ from most other electronic components in a number of important factors, e.g.:

- there are few standard boards with standard patterns and dimensions, but an infinite variety of shapes and circuit configurations;
- they are “custom built”, i.e. all details must be agreed between the customer and the manufacturer.

Therefore, the Qualification Approval procedures detailed in BS QC 001002-3:1997, clause 3 (BS CECC 00114-2) are unsuitable, and the Capability Approval procedures detailed in BS QC 001002-3:1997, clause 4 (BS CECC 00114-3) apply. The relationship between IECQ and CECC regulatory publications is shown below:

Organization approval	BS QC 001002-3:1997, clause 2	BS EN 100114-1
Qualification approval	BS QC 001002-3:1997, clause 3	BS CECC 00114-2
Capability approval	BS QC 001002-3:1997, clause 4	BS CECC 00114-3
Process approval	BS QC 001002-3:1997, clause 5	BS CECC 00114-5
Technology approval	BS QC 001002-3:1997, clause 6	BS EN 100114-6
Mark of attestation	No publication	BS CECC 00108
Ad hoc guidance to NSIs	No publication	ECQAC Permanent Documents

Capability approval of printed board manufacturers is based upon the use of composite test patterns used as capability qualifying components with an appropriate selection of test methods and requirements for each type of printed board. Capability approval requirements for each type of printed board are published as a separate British Standard, as follows:

Rigid single-sided and double-sided with plain holes	BS 123100
Rigid double-sided with plated-through holes	BS 123200
Rigid multilayer	BS 123300
Flexible single-sided and double-sided without through-connections	BS 123400
Flexible single-sided and double-sided with through-connections	BS 123500
Flex-rigid multilayer with through-connections	BS 123600
Flex-rigid double-sided with through-connections	BS 123700
Flexible multilayer with through connections	BS 123800

Annex A, Annex B, Annex C, Annex D, Annex E, Annex F, Annex G, Annex H and Annex I are informative.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 35 and a back cover.

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1 Scope

This British Standard specifies a system by which manufacturers of printed boards can be granted capability approval within the IECQ system for electronic components of assessed quality. It also specifies procedures for the preparation of capability detail specifications and customer detail specifications for printed boards.

This British Standard is applicable for all printed boards, irrespective of their method of manufacture. It is applicable to printed board manufacturers when using the IECQ system for electronic components of assessed quality.

NOTE Technology approval is the preferred procedure for manufacturers who wish to implement in-process testing as an element of their IECQ approval. CECC 210003 is a technology approval schedule for printed boards.

In addition to the definitive requirements, this standard also requires the items specified in clause 8 to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 4727-1:Group 11 (IEC 60194), *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms — Part 1: Terms common to power, telecommunications and electronics — Group 11: Printed circuits.*

BS 6001-1 (ISO 2859-1), *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection.*

BS 6221-2:1991 (IEC 60326-2:1990), *Printed wiring boards — Part 2: Methods of test.*

BS CECC 00114-3:1993, *Rule of procedure 14 — Quality assessment procedures — Part 3: Capability approval of an electronic component manufacturing activity.*

BS QC 001002-3:1997, *Rules of procedure of the IEC quality assessment system for electronic components (IECQ) — Part 3: Approval procedures, including a new clause on technology approval.*

ECQAC Permanent Document 1120, *Requirements for the drafting of qualification approval and capability approval test reports*¹⁾.

3 Terms and definitions

For the purposes of this British Standard the terms and definitions given in BS 4727-1:Group 11 and the following apply.

3.1

capability

ability of a manufacturer to produce printed boards of a quality recognized by the National Supervising Inspectorate (NSI)

3.2

basic capability

capability defined in a British, CECC or IEC capability detail specification

NOTE The term “basic” is intended to indicate a minimum level of assessment, testing or requirement.

¹⁾ Available from the NSI, BSI Product Services, Maylands Avenue, Hemel Hempstead, HP2 4SQ.

3.3

additional capability

capability other than those defined as basic capabilities

NOTE Examples of additional capability include:

- maximum size of printed boards that can be processed;
- minimum diameter of plated-through holes relative to board thickness (aspect ratio);
- minimum conductor width and/or spacing;
- maximum number of layers;
- surface finish.

3.4

designated management representative

person designated by the manufacturer to ensure that work is carried out in accordance with this British Standard

3.5

structurally similar boards

printed boards having all of the following common features:

- the same type of metal-clad base material, e.g. 249-2-4-IEC-GC-Cu;
- the same type of printed board, e.g. rigid single-sided or double-sided with plain holes;
- the same type of surface finish, e.g. fused tin-lead

3.6

capability qualifying component (CQC)

component used for the demonstration of capability and the subsequent maintenance of capability

3.7

composite test pattern (CTP)

arrangement of individual specimens to form the board pattern used for the demonstration of capability

NOTE A single composite test pattern represents the smallest size panel for which approval to a sectional specification can be gained.

3.8

specimen

individual circuit pattern used to assess limits of approval

3.9

aspect ratio

ratio of the length or depth of a hole to its pre-plated diameter

NOTE In practice this should be calculated as the nominal board thickness of base material divided by the smallest drill diameter, e.g.

$$\frac{3.5 \text{ mm}}{0.4 \text{ mm}} = 8.75:1$$

Aspect ratio is used as a measure of the ability of a manufacturer to overcome the difficulties present when a small hole is to be plated through. When aspect ratio is to be evaluated for capability approval the manufacturer should choose the smallest hole diameter which can be plated through the board to achieve the requirements of the standard. A smaller drill diameter than that used to verify aspect ratio may be claimed, provided that the maximum aspect ratio is not exceeded.

4 General requirements

4.1 Claims of capability

Manufacturers shall be able to demonstrate the claimed capability of their facility and processes.

Manufacturers shall ensure that any additional capability is claimed, proven and recognized by NSI as an additional capability.

4.2 Eligibility for capability approval

Manufacturers of printed boards shall be deemed to be eligible for approval under this series of specifications if they are capable of conducting at least three of the following processes in-house:

- hole formation;
- imaging;
- interlayer connection;
- etching;
- bonding.

4.3 Sub-contracting

All production processes shall be carried out under the surveillance of the designated management representative.

If a sub-contractor is used to carry out processing, the manufacturer shall be able to demonstrate that disciplines are maintained by the sub-contractor that are equivalent to those applied at the approved manufacturer's facility.

4.4 Delayed delivery

When printed boards are held by the manufacturer for a period of more than 6 months (or as defined in the capability detail specification) after the quality conformity inspection (see clause 6), the following tests shall be carried out, in the following order, prior to delivery:

- a) visual examination of the appearance, as specified for quality conformity inspection in sub-group A1 of the relevant sectional specification;
- b) preconditioning for 2 h at the nominal glass transition temperature (T_g) of the substrate or 120 °C, whichever is the lower;
- c) evaluation in accordance with BS 6221-2:1991, test 14a (solderability) as specified for quality conformity inspection in sub-group B2 of the relevant sectional specification.

4.5 Resubmission of rejected lots

Where a sample fails to meet the requirements of a periodic test, action shall be taken in accordance with BS QC 001002-3:1997, 4.2.10.6 (BS CECC 00114-3), and BS 6001-1.

4.6 Marking of printed board and package

4.6.1 Printed board

Each printed board shall be clearly marked with a reference designated by the customer. The marking shall be formed either with the conductive pattern or by printing with a suitable marking ink.

Unless explicitly excluded by the customer, each printed board shall be marked with the following additional information:

- a) the batch code;
- b) the manufacturer's name or identification code;
- c) a date code.

Marking shall be sufficient to ensure batch traceability.

4.6.2 Package

The contents of the package shall be clearly identified.

4.7 Ordering information

Orders for release against BS 123000 shall be accepted by the manufacturer only where a customer detail specification has been provided. The manufacturer shall ensure that the customer detail specification either contains all the information necessary to define the printed board clearly and completely, or makes reference to that information in an appropriate way.

NOTE An example of a customer detail specification is shown in Annex A.

5 Capability approval and maintenance of capability approval

NOTE Basic capability is assessed using the standard test specimens detailed in the relevant sectional specification. Additional capability is assessed using test specimens suitable for demonstrating the claimed capability of the manufacturer's facilities and processes. These are either the standard test specimens detailed in the sectional specification, or production boards as agreed with the NSI.

5.1 Capability approval requirements

The general procedures specified in BS QC 001002-3:1997, clause 4 (BS CECC 00114-3) shall apply.

A manufacturer wishing to obtain capability approval for printed boards shall prepare:

- a) a capability manual;
- b) a capability approval test report (see 5.4).

NOTE A guide to the form and content of a capability manual is shown in Annex B, with additional examples given in Annex C, Annex D, Annex E, Annex F, Annex G, Annex H and Annex I.

5.2 Description of capability

The manufacturer shall describe the capability for which approval is sought, and which is to be demonstrated by the capability approval test report.

NOTE Annex C gives a suitable format for the presentation of the description of capability within the manufacturer's capability manual. A guide to the capability manual itself is given in Annex B.

5.3 Demonstration of capability

5.3.1 Test programme

The manufacturer shall be able to demonstrate the ability to produce printed boards of acceptable quality in accordance with the requirements of this British Standard, the appropriate sectional specification, and the appropriate capability detail specification.

The designated management representative shall prepare a programme for the assessment of the claimed capability that includes:

- reference to the capability detail specification to which the capability is claimed;
- details of the test specimen for any additional capability;
- details of inspection requirements and test conditions for additional capability.

NOTE Tables showing inspection requirements and tests for the basic capability qualifying components are given in the relevant capability detail specification.

Where the capability qualifying components are designed and produced solely for the purpose of obtaining capability approval, the manufacturer shall ensure that the same controls and disciplines are applied to the normal production.

The tests shall be carried out either in the manufacturer's laboratory, or by a test laboratory approved by IECQ or CECC.

5.3.2 Basic capability

Each manufacturer shall make the number of composite test patterns specified in the relevant capability detail specification. The test patterns required for the capability approval shall be spaced out evenly in production so that an average assessment can be made. The test specimens shall be subjected to the tests specified in the relevant capability detail specification.

NOTE The test patterns are shown in the relevant sectional specification.

5.3.3 Additional capability

COMMENTARY ON 5.3.3. *Additional capability covers features such as:*

- *the maximum size of the printed boards (active area) that can be processed, if larger than the size of the composite test pattern as specified in the sectional specification;*
- *the ratio of board thickness to diameter of plated-through holes (aspect ratio) experienced in production, if larger than the ratio included in the composite test pattern as specified in the relevant sectional specification;*
- *the smallest nominal conductor width and/or spacing experienced in production, if smaller than those included in the composite test pattern as specified in the relevant sectional specification;*
- *the maximum number of layers experienced in the production of multilayer printed boards, if larger than that included in the composite test pattern as specified in the relevant sectional specification;*
- *solderability after accelerated ageing (BS 6221-2:1991, test 20a), with the ageing conditions, packaging conditions (if applicable), and the use of non-activated flux (if applicable) being specified in the relevant capability detail specification.*

NOTE 1 Capability approval covering two or more features does not necessarily imply that each and every combination of extremes is possible.

Where possible, the test specimen for the assessment of additional capability shall be the relevant specimen of the composite test pattern as specified in the relevant sectional specification, but modified so as to be suitable for demonstrating the additional capability. If the composite test pattern does not provide for this possibility, or if the use of a modified specimen of the composite test pattern is not desirable, appropriate additional test specimens shall be used.

For the assessment of additional capability, the manufacturer shall:

- a) produce appropriate test specimens;
- b) state the test method to be used and the requirements to be fulfilled, if a standard test method (BS 6221-2) is applicable;
- c) fully define the test method, and state the requirements to be conformed to, and the acceptance level to be applied, if a special test method is necessary.

NOTE 2 Where a test for demonstrating additional capability covers the relevant test for demonstrating basic capability, only the additional capability needs to be tested.

5.3.4 Rework

When rework is carried out, the manufacturer shall:

- a) identify and record both type 1 and type 2 defects as designated in Table 1 and Table 2 respectively;
- b) inform the customer of type 2 defects and obtain written approval from the customer before commencing rework;
- c) document each method of repair;
- d) conduct trials to validate each repair method for type 2 defects, and document the evidence of validation;
- e) perform any testing that is determined by trials.

The records of type 2 defects shall form part of the manufacturer's quality records. Type 1 defects shall be recorded for process analysis only.

If type 1 defects (see Table 1) are to be reworked, they shall not be the subject of a formal validation exercise.

NOTE Type 1 defects are not limited in number.

Table 1 — Type 1 defects

Defect	Description	Comments
Reduction in conductor spacing	Residual conductive material that reduces the design spacing to less than the permitted minimum value	
External short circuit	Conductive material bridging two or more conductors	
Edge contact defects	Deep scratches, pitting, plating thickness deficiency, excess porosity	Stripping and replating of complete edge connectors is considered as reprocessing.
Defective marking and identification	Notation missing or illegible	
Scratches	Scratches in the surface over-plating or solder resist	Scratches penetrating to an under-plating or to the copper cladding are classified as type 2.

If type 2 defects (see Table 2) are to be reworked, they shall be the subject of a formal validation exercise. The number of reworked defects per batch shall be limited by agreement with the customer (see clause 8), and additionally shall not exceed the numbers specified in Table 2.

Table 2 — Type 2 defects

Defect	Description	Comments	Maximum reworked defects per batch
Conductor width violation	Complete breaks, cracks, deep scratches, nicks or pinholes that reduce the conductor width to less than the design minimum	Inner layer defects detected after lamination shall not be reworked.	2 per inner layer (prior to lamination) 2 per outer layer
Inner layer short circuit	Conductive material bridging two or more conductors		2 per inner layer
Plated-through hole defect	Voids, other than as permitted by the capability detail specification Total absence of plating	The rework method shall not impede component mounting. Rework of plating connecting to inner layers shall be limited to replating only.	2 per panel

5.4 Capability approval test report

The manufacturer shall prepare a test report, in accordance with the requirements of ECQAC Permanent Document 1120, which shall be submitted to the NSI.

5.5 Range of capability approval

5.5.1 Range of approval of basic capability

If approval is granted for rigid multilayer boards, it shall be deemed to be granted for all other types of rigid printed boards.

If approval is granted for rigid printed boards with plated-through holes, it shall be deemed to be granted for rigid printed boards with plain holes.

If approval is granted for rigid printed boards with plain holes, it shall apply for that type of printed board only.

If approval is granted for flexible printed boards with through-connections, it shall be deemed to be granted for flexible printed boards without through-connections.

If approval is granted for flexible printed boards without through-connections, it shall apply to that type of printed board only.

If approval is granted for multilayer flexible printed boards, it shall be deemed to be granted for all other types of flexible printed board.

If approval is granted for multilayer flex-rigid printed boards, it shall be deemed to be granted for all other types of printed board, both rigid and flexible.

5.5.2 Range of approval of additional capability

If approval is granted for additional capability, it shall be deemed to be granted for all boards within the additional capability.

NOTE It may also encompass some aspects of the basic capability (5.5.1).

5.5.3 Approval to cover unique orders

If a batch of printed boards falls outside the manufacturer's limits of approval, it shall be released provided that:

- a) when all the tests unique to the unapproved feature, detailed in the appropriate capability detail specification, are conducted, the boards meet the specified requirements; and
- b) a test report demonstrating the conformity of the batch is made available to the NSI.

NOTE The test report may subsequently be used to support a modification to the approval limits. However, this clause is intended to enable manufacturers to release batches with unique or unusual requirements, without the penalty of maintenance testing, where repeat orders are not anticipated.

5.5.4 Changes to process materials or techniques

If changes to process materials or techniques are introduced that could affect the quality and/or reliability of the product, the manufacturer shall report the changes to the NSI. If significant changes (see **B.16.2**) are introduced the manufacturer shall revise the capability manual accordingly, and if necessary shall give a partial or full re-demonstration of capability.

NOTE **B.16.2** gives further information.

5.5.5 Modifications to capability approval

The manufacturer shall apply in writing to modify the range of capability approval. A revised capability manual, including the new abstract of capability, shall be submitted to the NSI for verification. In the case of an enhancement of capability, an appropriate test programme shall be agreed and conducted.

NOTE **B.16.1** gives further information.

5.6 Maintenance of capability approval

Maintenance of capability approval shall be conducted in accordance with BS QC 001002-3:1997, clause 4 (BS CECC 00114-3). The approved manufacturer shall re-demonstrate all the limits of capability at intervals not exceeding 36 months. This shall be demonstrated by one of the following techniques:

- a) an individual test programme;
- b) a rolling test programme;
- c) recording the limits of approval achieved in actual production.

NOTE Annex D and Annex E provide further information.

The approved manufacturer shall additionally make evidence of quality conformity testing (groups A, B and C as detailed in the relevant sectional specification) available to the NSI.

5.7 Suspension and withdrawal of capability approval

The procedures specified in BS QC 001002-3:1997, clause 4 (BS CECC 00114-3) shall apply.

5.8 Capability approval testing, sample size and number of failures

The sample size for each property of a composite test pattern shall be as specified in the sectional specification and/or capability detail specification.