
Specification for

**Printed circuits of assessed quality:
Generic data and methods of test
Capability approval procedure and rules**

Spécification des circuits imprimés de qualité assurée:
Données génériques et méthodes d'essai :
Procédure d'approbation de la compétence et règles

Spezifikation für gütebestatigte Druckschaltungen:
Generische Daten und Prüfmethoden :
Leistungsvermögen – Genehmigungsverfahren und Vorschriften

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Specification for printed circuits of assessed
quality: Generic data and methods of test:
Capability approval procedure and rules

Corrections

AMD 7352
December 1992

Clause 3.2 Customer's detail specification

In paragraph 5, after item (d), insert the following.

' (e) conductor design width and spacing, with tolerances;'

Renumber the existing items (e) to (j) as (f) to (k) accordingly.

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Foreword

This British Standard, which has been prepared under the direction of the Electronic Components Standards Committee, is the generic specification for printed circuits in the system of standards for electronic parts of assessed quality.

The standard, first published in 1976, has been revised by extending section two, on capability approval requirements, to overcome problems encountered by the National Supervising Inspectorate (NSI) in implementing the standard for approval purposes.

The schedule of tests for capability approval and the test patterns contained in the first edition have been deleted, and these have been incorporated where appropriate in the particular sectional specification.

Printed circuits are among those components which are made in considerable quantities but, because of numerous variations in circuit pattern, they are frequently ordered in small numbers of a particular pattern. Approval procedures for this type of component are therefore different from those applied to most components dealt with in the BS 9000 series and have been designated 'capability approval' (see section two).

Printed circuit capability is proved by manufacturing specified composite test patterns as standards of reference. These are assessed using appropriate test methods (section one) and requirements (sectional specifications).

BS 9670 prescribes tests that are suitable for printed circuits and provides a quality assurance scheme for printed circuits. It establishes the primary stage of manufacture and subsequently lists the test methods and procedures for visual, electrical, mechanical and environmental conditions. It has been prepared in accordance with the general requirements of BS 9000 and in particular with the capability approval procedures of section three of BS 9000 : Part 1. Clauses follow the same numbering sequence and fulfil the requirements of section one of BS 9000 : Part 2.

There are four sections:

Section one	Principles and mandatory procedures
Section two	Capability approval and maintenance of of capability for printed circuits. Requirements and procedures
Section three	Draft rules for the preparation of a customer's detail specification
Section four	Rework

The complete capability quality assessment system requires the following documents.

- (a) A generic specification containing principles, mandatory procedures and test methods (this document).

- (b) Sectional specifications defining the minimum requirements for capability approval, maintenance of capability and quality conformance.

- (c) A customer's detail specification which has to be prepared for each design of printed circuit ordered. (See 3.2.) The customer selects a manufacturer from those listed in PD 9002 with the appropriate capability approval. A customer's detail specification can be used only within the limits of a manufacturer's capability.

The associated sectional specifications prescribe the minimum mandatory requirements for printed circuits of assessed quality to BS 9760.

Capability approval

The operation of the capability system is outlined in the flow diagram shown as figure 1.

Section two dealing with capability approval was developed so that the disciplines required by BS 9000 could be applied to the production of printed circuits and to overcome the variants of artwork and production lots. The approval of manufacturers is based on their ability to demonstrate their capability to produce one or all of the following types of board to the stated minimum mandatory requirement, using test patterns as listed in the sectional specification. The types of board covered by the sectional specifications include:

- (a) single- and double-sided boards without plated through holes;
- (b) double-sided boards with plated through holes;
- (c) multilayer boards;
- (d) flexible base printed circuits with or without plated through holes.

Application for capability approval

A manufacturer seeking capability approval for the manufacture of printed circuits to BS 9760 shall apply to BSI, stating the type(s) of board(s) for which approval is required. BSI will then inform the National Supervising Inspectorate who will ascertain that the manufacturing organization and facilities of the firm are in accordance with sections one and two of BS 9000 : Part 1 (i.e. manufacturing approval) and that the requirements of section three of BS 9000 : Part 1 and BS 9760 for capability approval are met. After a successful completion of these requirements approval will be granted and reference made in PD 9002.

Health and safety warning. Some of the test procedures given in this standard require the use of substances that may be injurious to health unless adequate safety precautions are taken. The standard refers only to technical suitability and in no way absolves either the supplier or the user from statutory obligations relating to health and safety at any stage of manufacture or use.

Printed circuits of assessed quality :
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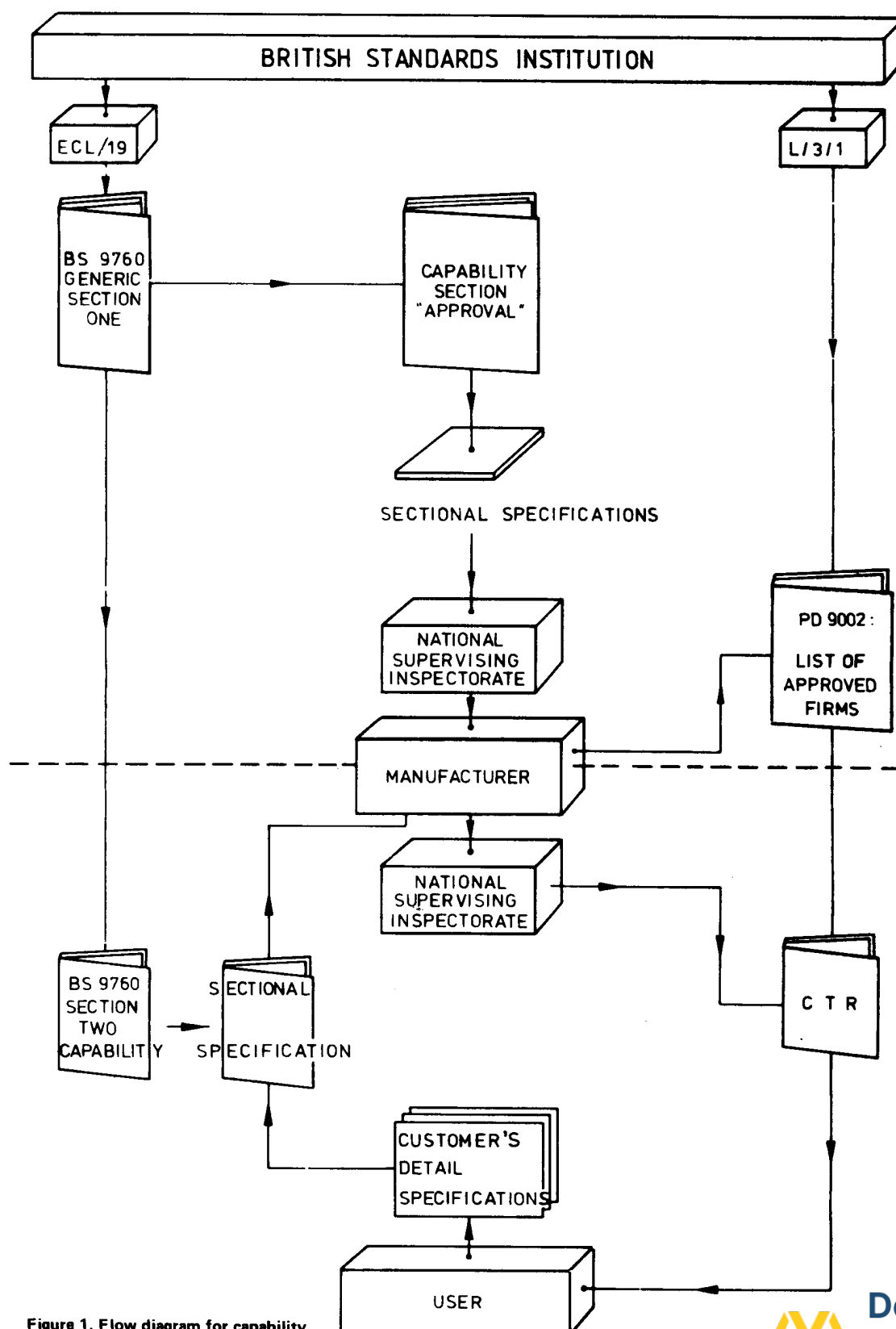


Figure 1. Flow diagram for capability

Section one. Principles and mandatory procedures

1.1 General matters

1.1.1 Scope

This specification gives details of the essential test procedures and other general requirements and information relating to all forms of printed circuit.

NOTE. It should be read in conjunction with BS 6001, BS 9000, PD 9002 and any other relevant specification. Such general details and definitions given in those standards as are appropriate to this specification will be held to be part of this specification.

General rules for drafting a customer's detail specification for use by BSI Technical Committees or by components manufacturers are given in section three.

The limiting conditions under which rework is permitted and the procedures necessary for demonstrating the subsequent quality of reworked printed circuits are given in section four.

1.1.2 Related specifications and documents

The following publications are referred to in this standard:

BS 441	Rosin-cored solder wire, 'activated' and 'non-activated' (non-corrosive)
BS 1133	Packaging code Section 14 Adhesive closing and sealing tape:
BS 1991	Letter symbols, signs and abbreviations
BS 2011	Basic environmental testing procedures
BS 2782	Methods of testing plastics
BS 3924	Pressure-sensitive adhesive tapes for electrical purposes
BS 3939	Graphical symbols for electrical power, telecommunications and electronics diagrams
BS 4292	Electroplated coatings of gold and gold alloy
BS 4487	Inhibited 1,1,1-trichloroethane (methylchloroform)
BS 4584	Metal-clad base materials for printed circuits
BS 4849	1,1,2-trichlorotrifluoroethane (R 113)
BS 6001	Sampling procedures and tables for inspection by attributes
BS 9000	General requirements for electronic components of assessed quality
BS 9761/2/3 etc.	Sectional specifications for printed circuits
PD 9002	BS 9000 component selection guide
IEC 194	Terms and definitions for printed circuits

1.1.3 Terminology

A British Standard giving terms and definitions for printed circuits is in course of preparation and will be based on the corresponding IEC Publication 194 : 1975.

1.1.4 Letter symbols, signs and abbreviations

The letter symbols, signs and abbreviations shall be in accordance with BS 1991 where applicable.

1.1.5 Graphical symbols

The graphical symbols shall be in accordance with BS 3939 where applicable.

1.1.6 Marking of the board and package

Board. As far as practicable each printed circuit shall be clearly marked with the information required under (a) and (b) below. The markings required under (c) and (d) may be required by the customer and the manufacturer.

(a) Drawing reference code (e.g. drawing number and issue).

(b) Manufacturer's identification code or name.

(c) BS number of the sectional specification.

(d) Date code (see 2.6.8 of BS 9000 : Part 1).

The marking may be included in the copper pattern or may be overprinted with a suitable marking ink.

Package. The package shall be marked with the above information and any special marking required by the customer's detail specification (e.g. customer's identification number).

1.1.7 Eligibility for capability approval

The primary stage of manufacture is defined as the inspection of the base material prior to processing.

The stage or a subsequent process shall be carried out under the direct surveillance of an approved Chief Inspector.

Where this first and subsequent stage of processing are carried out by a sub-contractor, capability approval may be granted provided that in each case the supervising inspectorate is satisfied that the equivalent disciplines apply.

1.1.8 Structurally similar components and common production processes

1.1.8.1 Structurally similar components. Reference should be made to 1.3(23) and 2.4.6 of BS 9000 : Part 1.

All of the following common features will normally apply for the purpose of aggregation:

(a) the same type of metal-clad base material, e.g. as specified in BS 4584 : Part 2;

(b) the same type of conductor finish, e.g. tin-lead or gold or etched copper;

(c) the same type of circuit, e.g. single-sided and double-sided without through-hole plating, or double-sided with through-hole plating, or multilayer.

1.1.8.2 Common production processes. Reference should be made to 2.4.7 of BS 9000 : Part 1.

Where a production process is common to a number of types of printed circuit, e.g. edge connector gold plating, sampling may be based on the aggregated output from that particular process for the common features, e.g. plating thickness, adhesion and porosity. The chief inspector shall satisfy the supervising inspectorate that these requirements in the specification would have been satisfied had samples been tested on completion of manufacture.

1.1.8.3 In-process testing. Reference should be made to 2.6.3.1 of BS 9000 : Part 1.

Where tests, which are specified in the sectional specification, have already been performed during the production process, the results of such production tests may, at the request of the manufacturer, be accepted in lieu of those called for in the sectional specification. The chief inspector shall satisfy the supervising inspectorate that the tests being performed are such that those requirements in the specification would have been satisfied had samples been tested on completion of manufacture.

1.1.9 Delayed delivery

Completed printed circuits held by the manufacturer for a period of more than six months after acceptance testing shall be visually inspected prior to delivery.

1.1.10 Supplementary procedure for qualification approval

Not applicable.

1.1.11 Certified test records

Certified test records shall be prepared by the manufacturer as specified in BS 9000 : Part 1. An example of a certified test record is given in appendix C.

1.1.12 Standard rating and characteristics: climatic category

The climatic category may be defined in the customer's detail specification (if required) and shall be given in accordance with appendix A of BS 2011 : Part 1.1 : 1977.

1.1.13 Unchecked parameters

Parameters for properties not included in the list of tests for performance under special conditions outside the listed categories may be given in the customer's detail specification.

1.1.14 Procedure to be followed in the event of failure of group C inspection

In the event of failures in a group C inspection the procedure laid down in 2.6.4.1(2) of BS 9000 : Part 1 is to be followed.

1.1.15 Ordering information

Printed circuits shall be ordered by quoting the customer's detail specification. (See section three.) The customer's detail specification shall contain all the information necessary to define the printed circuit clearly and completely. It can be prepared by either the customer or the manufacturer.

1.1.16 Reduced inspection

1.1.16.1 Release prior to completion of group B tests.

When the conditions of BS 6001 for reduced inspection have been satisfied for all group B tests, the manufacturer is permitted to release components before the completion of such tests.

1.1.16.2 Supplementary procedures for reduced inspection.

If the conditions of 2.6.3.1 or 2.6.3.2 of BS 9000 : Part 1 for reduced inspection and for special reduced inspection are met, then these procedures may be invoked for individual subgroups.

1.2 Test procedures

This section comprises test procedures and requirements for testing printed circuits under capability approval and production testing.

1.2.1 Test and measurement conditions

1.2.1.1 General. Unless otherwise specified in the sectional specification, all tests shall be carried out under the standard atmospheric conditions for testing as specified in clause 5 of BS 2011 : Part 1.1 : 1977.

Before the measurements are made, the printed circuit and/or test patterns shall be stored at the measuring temperature for a time sufficient to allow the entire specimen to reach temperature stability. The temperature and relative humidity at which the measurements are made shall be stated in the test report.

In the event of a dispute between the manufacturer and the purchaser the measurements shall be repeated under the standard referee conditions specified in BS 2011 : Part 1.1 : 1977.

1.2.1.2 Measurement test patterns. The measurement test patterns consist of the standard composite test patterns and the production boards.

The specimens used for capability approval tests shall be taken from the relevant test patterns as follows.

For single- and double-sided boards without plated through holes the standard composite test pattern described in BS 9763 shall be used.

For double-sided boards with plated through holes the standard composite test pattern described in BS 9762 shall be used.

For multilayer boards the standard composite test pattern described in BS 9761 shall be used.

For flexible printed circuits the standard composite test pattern described in the appropriate sectional specification shall be used.

1.2.1.3 Production testing. General inspection and relevant non-destructive testing shall be performed on the production board. Standard test patterns are normally required for destructive testing and for tests which require comparative assessment of process control.

Test specimens may be obtained by including in the board off-cut the appropriate parts of the standard composite test patterns shown in the appropriate sectional specification. Alternatively, where the panel being processed does not have sufficient area to include the appropriate test specimens, a production board or the full standard composite test patterns shall be used. Such composite test patterns shall be:

- (a) on the same base material as the production board as defined in 1.1.8, and
- (b) processed in conjunction with the production boards. They shall be evenly spaced out in production in sufficient quantity to provide the requisite number of specimens that will permit assessment of the average processing standard.

1.2.2 Visual inspection

OBJECT

The visual examination checks, identification, appearance, workmanship, finish, pattern, etc. of a printed circuit against the sectional or customer's detail specification.

SPECIMEN

Capability approval. Visual examination shall be made on the complete composite test pattern.

Production testing. Visual examination shall be made on the production board.

METHOD

The visual examination shall be carried out using optical equipment with x3 linear magnification using, where possible, transmitted light.

When specified, the visual examination shall be carried out using optical equipment with x8 to x12 linear magnification using, where possible, transmitted light.

When specified, the visual examination shall be carried out using optical equipment with higher linear magnification. This is usually required for microsection.

REQUIREMENTS

Capability approval. See appropriate sectional specification.

Production testing. As stated in the sectional or customer's detail specification.

1.2.3 Dimensioning and gauging

OBJECT

The dimensional examination is the measurement of actual dimensions with the aid of measuring tools and measuring equipment.

SPECIMEN

Capability approval. Visual examination shall be made on the complete composite test pattern.

Production testing. Visual examination shall be made on the production board.

METHOD

The measuring tools and equipment shall have an accuracy and readability suitable for the dimension and tolerance to be measured. When specified, particular measurements, e.g. on dimensions of holes and edge defects in conductors, shall be measured with an optical instrument having a measuring graticule and a calibration of 0.025 mm.

REQUIREMENTS

1.2.3.1 Board and pattern dimensions

Capability approval. As shown on the test pattern in the appropriate appendix of the sectional specification.

Production testing. As stated in the relevant drawing.

1.2.3.2 Thickness

1.2.3.2.1 Thickness for single-sided and double-sided boards. The nominal thickness and tolerances shall be in accordance with the material specification (the relevant Part of BS 4584). Where coarse and fine tolerances are given in the material specification the fine tolerances shall apply only when invoked in the customer's detail specification.

1.2.3.2.2 Thickness of multilayer boards. The nominal thickness and any general tolerance other than in the edge connector zone (see 1.2.3.2.3) shall preferably be selected from table 1. Deviations from this table shall be stated on the relevant drawing or customer's detail specification.

Table 1. Nominal thickness and tolerances

Nominal thickness	Tolerance $\pm$
mm	mm
0.8	0.15
1.6	0.20
2.4	0.25
3.2	0.30

1.2.3.2.3 Thickness in edge connector zone (for all types of printed circuits). The nominal thickness including plating and tolerance shall preferably be selected from table 2. Deviations from this table shall be stated on the relevant drawing or customer's detail specification.

Table 2. Total thickness after plating

Nominal thickness	Paper and glass-fibre base tolerances $\pm$
mm	mm
0.8	0.15
1.6	0.20
2.4	0.25
3.2	0.30

1.2.3.3 Conductor width. The design width shall be stated on the engineering drawing or customer's detail specification.

1.2.3.4 Conductor spacing. The minimum conductor spacing shall be stated in the relevant drawing or test pattern and the reduction of spacing due to metal particles shall also be stated in the sectional or customer's detail specification.

1.2.3.5 Edge connector defects. Indentations and bumps may be permitted in the zone of contact, as shown in figure 2, provided that they do not exceed the limits given in table 3.

Table 3. Imperfections in zones of contact

Type	Size (length unless otherwise stated)		Number of imperfections permitted in contact zone of each conductor
Indentations	above mm	not above mm	As stated in the sectional specification
Bumps	0.25	1.25	
	0.01	4.0 (or height 0.01)	

1.2.3.6 Holes/registration. Hole sizes and positional tolerance shall be as stated on the drawing.

The registration of inner layers with respect to holes shall be as stated in the sectional or customer's detail specification.

Determination of such registration shall be by microsection at a minimum of four points, one on each corner of the printed circuit board or by X-ray.

1.2.3.7 Plating thickness. The minimum thickness shall be as stated on the customer's drawing and shall be measured using one of the following methods (A or B).

SPECIMEN

Capability approval. Measurement of the thickness of plated metals shall be made on specimens having the appropriate test patterns shown in the sectional specification.

Production testing. Measurement of the thickness of plated metals shall be made on appropriate points on the production board or on a test specimen included in the board off-cut.

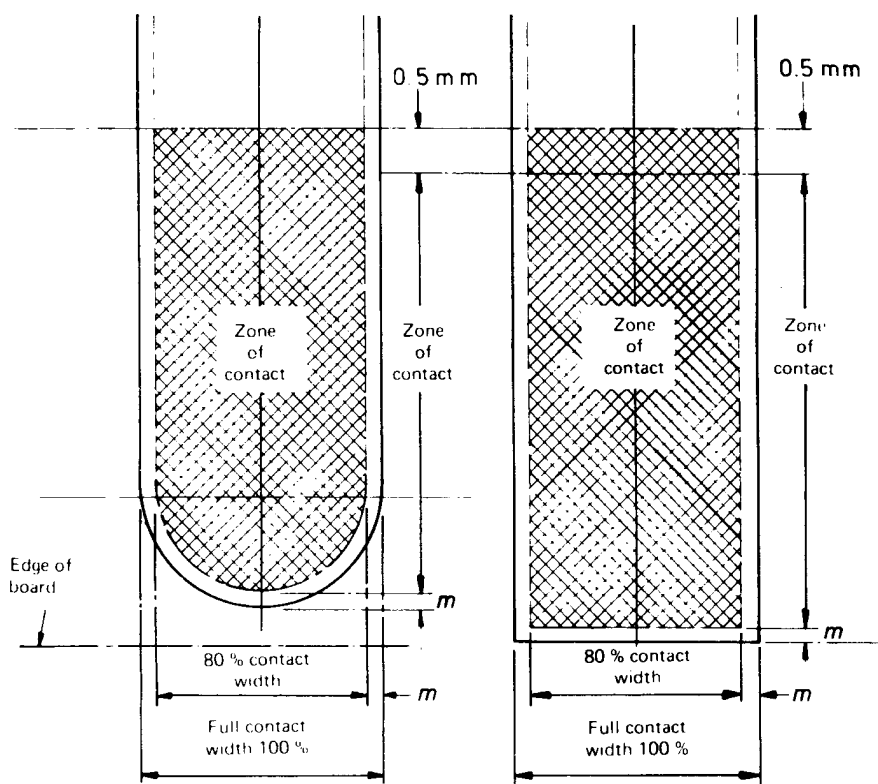
METHODS

Method A: microsection (referee method). This method is suitable for determining the thickness of copper-nickel, tin-nickel, gold and tin-lead plating more than 1 μm thick.

The thickness of plating is checked by examination of a microsection prepared by the following method. The selected portion of the printed wiring board is cut at right angles to the plated surface, degreased and may be overplated with approximately 10 μm of a suitable metal. The section is mounted by moulding in a suitable plastic material so that the plated surface is perpendicular to the face which is to be prepared for examination. The required face of the moulding is ground with progressively finer grades of abrasive paper and finally polished on a cloth pad impregnated with a suitable compound of particle size up to 1 μm , until a uniform well-defined surface is produced.

The section is lightly etched with a reagent in order to improve the contrast between the deposit and the adjacent metal and to remove any soft metal which may have spread. The section is etched and polished repeatedly until no significant alteration in the thickness of the respective layers is observed under a microscope using suitable magnification.

Method B: beta backscatter. The beta backscatter method of measurement shall be carried out as recommended by equipment suppliers. Care shall be exercised to ensure that the measurement results take into consideration any possible difference in density of the equipment reference standards and the metal coating which is being measured. The effects of substrate material and thickness shall also be taken into account.



Typical dimensions include:

Contact width	Zone of contact width
mm	mm
3.56	2.8
2.5	2.0
1.9	1.5

NOTE. The above table is for example purposes only. The actual zone of contact should be determined for each design of connector.

Figure 2. Edge connector zone

REQUIREMENTS

Capability approval. See sectional specification as appropriate. For edge connector finishes, 20 % of the number of contacts presented for test shall be within $+0.5, -0 \mu\text{m}$ of the minimum claimed value. All other contacts shall be within $+100 \%$ of this minimum value.

Production testing. The minimum thickness shall be as stated in the sectional or customer's detail specification.

1.2.3.8 Landless plated through holes. Landless plated through holes shall be regarded as an additional feature. They shall be permitted for the following designs. In cases (a) and (b) the landless side of the hole shall not be electrically connected to that side of the board.

(a) *Holes, landless on one or both sides, plated through for convenience of manufacture only, e.g. to eliminate a second drilling operation.* These holes do not form any part of the electrical circuit and shall be assessed for appearance and dimensions. These holes do not require capability assessment.

(b) *Holes, with a pad on one side, which are plated to aid component mounting.* These holes require assessment for the following.

Visual inspection (1.2.2)

Dimensions (1.2.3)

Annular ring of pad side only (1.2.3.6)

Pull out strength (pulling from the pad side of the board) (1.2.5.1.2)

Solderability over the plated area (1.2.6.6 and 1.2.6.8)

(c) *Holes, landless on one or both sides providing electrical interconnection.* These holes require assessment for the following.

Visual inspection (1.2.2)

Dimensions (1.2.3)

Plating thickness (1.2.3.7)

*Pull out strength (1.2.5.1.2)

Thermal shock (1.2.6.4.2)

Change of resistance (1.2.6.4.3)

*Solderability (1.2.6.6 and 1.2.6.8)

1.2.4 Electrical test procedures

1.2.4.1 Resistance of conductors

OBJECT

To determine the resistance of conductors.

SPECIMEN

The measurement shall be made on any suitable conductors.

METHOD

The resistance of conductors shall be measured by a suitable method at two places on the board. The measuring error shall be not greater than 5 %.

The current shall be kept small enough to avoid undue heating of the specimen. In case of dispute a 4-terminal method shall be used.

REQUIREMENTS

Capability approval. No requirement.

Production testing. The customer's detail specification shall state the required value of the resistance.

1.2.4.2 Insulation resistance

1.2.4.2.1 Insulation resistance of the surface (under standard atmospheric conditions of testing)

OBJECT

To determine the insulation resistance between specified parts of a conductive pattern on the surface of a printed circuit.

NOTE. The insulation resistance gives an indication of the quality of the materials as well as the quality of the processes used in the production.

SPECIMEN

Capability approval. No requirement.

Production testing. For measurements on production boards, either specimens similar to the appropriate patterns shown in the sectional specifications may be included in the board off-cut or a suitable pair of adjacent conductors spaced a uniform distance (W) apart over a suitable length (L) may be used. The ratio W/L should be less than $1/25$.

METHOD

The specimen shall be preconditioned as required in the sectional specification. The insulation resistance shall be measured with suitable measuring equipment.

The test voltage, i.e. the voltage across the insulation to be measured, shall be

100 ± 15 V d.c., or

500 ± 50 V d.c.

or as specified in the sectional specification. In cases of dispute the voltage shall be 100 ± 15 V d.c. The test voltage shall be applied for 1 min before measurement. If a stable reading is not obtained within 1 min, this shall be recorded in the test report.

Capability approval. No requirement.

Production testing. The customer's detail specification shall state:

- (a) the parts of the pattern to be measured;
- (b) the test voltage;
- (c) the conditioning requirements.

REQUIREMENTS

Capability approval. No requirement.

Production testing. The customer's detail specification shall state the minimum value of insulation resistance.

1.2.4.2.2 Insulation resistance within a layer (under standard atmospheric conditions for testing)

OBJECT

To determine the insulation resistance between specified parts of a conductive pattern on an internal layer of a completed multilayer printed circuit or flexible circuit.

NOTE. Since this insulation resistance is a combination of surface resistance and volume resistance, it is not possible to correlate the values obtained with those specified in BS 4584 : Parts 11 and 12.

SPECIMEN

Capability approval. The insulation resistance measurement shall be made on the appropriate test pattern shown in the sectional specification BS 9761.

Production testing. The insulation resistance shall be measured between any two specified points of a conductor pattern on an internal layer of a multilayer printed circuit, or on test specimens included in the board off-cut and similar to the appropriate test pattern shown in the sectional specification.

METHOD

The specimen shall be preconditioned as required in the sectional specification.

The method described in 1.2.4.2.1 shall be applied.

Capability approval. See sectional specification.

Production testing. The sectional or customer's detail specification shall state:

- (a) the parts of the pattern to be measured;
- (b) the test voltage;
- (c) the conditioning requirements.

REQUIREMENTS

Capability approval. See sectional specification.

Production testing. Minimum value of insulation resistance between specified parts of the conductive patterns of adjacent layers of a completed multilayer printed circuit as specified in the sectional or customer's detail specification.

1.2.4.2.3 Insulation resistance between layers

OBJECT

To determine the insulation resistance between specified parts of the conductive patterns of adjacent layers of a completed multilayer printed circuit.

SPECIMEN

Capability approval. The insulation resistance measurement shall be made using the appropriate test pattern shown in the sectional specification BS 9761.

Production testing. The insulation resistance shall be measured between any two specified points of the conductor pattern on adjacent internal layers of the production multilayer printed circuit, or on a test specimen included in the board off-cut and similar to the appropriate test pattern shown in the sectional specification BS 9761.

METHOD

The specimen shall be preconditioned as required in the sectional specification BS 9761.

The method described in 1.2.4.2.1 shall be applied.

Capability approval. See sectional specification BS 9761.

Production testing. The sectional or customer's detail specification shall state:

- (a) the parts of the pattern to be measured;
- (b) the test voltage;
- (c) the conditioning requirements.

REQUIREMENTS

Capability approval. See sectional specification BS 9761.

Production testing. Minimum value of insulation resistance as stated in the sectional or customer's detail specification.

1.2.4.3 Interconnection continuity

OBJECT

To determine the resistance between specified interconnections on the printed circuit.

SPECIMEN

Capability approval. The interconnection continuity shall be measured using the appropriate test patterns shown in the sectional specification.

Production testing. The interconnection continuity shall be measured between any two specified points on the production boards, or on specimens included in the board off-cut and similar to the appropriate test patterns shown in the sectional specifications.

METHOD

The specimens shall be preconditioned as required in the sectional specification.

Using a 4-terminal method of measurement or equivalent, with the current not exceeding 20 mA, the resistance shall be measured between test points of the test pattern. Leads shall be soldered on to the conductor for proper connection to the four terminals of the test instrument (a suitable soldering iron for this purpose is described in BS 2011 : Part 2.1Ta : 1977).

Capability approval. See sectional specification.

Production testing. The sectional or customer's detail specification shall state:

- (a) the holes and interconnections to be measured;
- (b) the method of connection;
- (c) the conditioning requirements.