

Specification for

**Printed circuits of
assessed quality:
sectional specification
for multilayer
flexi-rigid printed
circuits with through
hole connections**

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- Electronic Components Industry Federation
- Electronic Engineering Association
- ERA Technology Ltd.
- Institute of Circuit Technology
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Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
2 Related documents	1
3 Terminology	1
4 Base materials	2
5 Customer's detail specification	2
6 Inspection requirements	2
7 Description of capability: limits of approval	2
8 Demonstration of capability	2
9 Capability CTP allocation	3
10 Capability approval acceptance levels	4
11 Capability approval report	4
12 Abstract of description of capability	4
13 Quality conformance inspection	4
14 Certified test records	4
15 BS 9764 approval	4
Appendix A CTP materials and finishes	19
Appendix B CTP test pattern locations	20
Appendix C Layout of composite of all V layers for extension of approval for more than six layers	21
Appendix D Layout of specimens A, B, G and Y	22
Appendix E Layout of specimen C	23
Appendix F Layout of specimens D and E	24
Appendix G Layout of specimens F and K	25
Appendix H Layout of specimens L and N	26
Appendix J Layout of specimen P	27
Appendix K Layout of specimens M and H	28
Appendix L Layout of specimens J, X, Z1 and Z2	29
Appendix M CTP finished hole sizes and cover layer hole sizes in the group pattern layout	30
Appendix N CTP layout	31
Appendix P Representation of six-, eight-, ten- and twelve-layer construction	32
Appendix Q Example of abstract of description of capability for inclusion in PD 9002	33
Appendix R Customer's detail specification	34
Appendix S Examples of delamination	35
Appendix T Examples of hole defects	36
Appendix U Test method for flexural fatigue (hinge) of specimens Z1 and Z2	37
Appendix V Notes applicable to Appendix D to Appendix L	37
Figure 1 — Group pattern for 1 CTP	19
Table 1 — CTP allocation of specimens	5
Table 2 — Schedule of tests for capability approval	6
Table 3 — Quality conformance inspection	17

Foreword

This British Standard, which has been prepared under the direction of the Electronic Components Standards Committee, is one of a series dealing with printed circuits of assessed quality.

The generic standard, BS 9760, defines the test methods, procedures and rules applicable to all types of printed circuit concerning capability approval. The specific tests and requirements applicable to different types of printed circuit are contained in a series of sectional specifications, of which this standard is one. These specifications deal both with requirements for capability approval and with those for quality conformance inspection during manufacture.

This particular standard deals with multilayer flexi-rigid printed circuits with through hole connections.

A multilayer flexi-rigid printed circuit is a printed circuit consisting of rigid and flexible parts in which some interconnections are formed between the bonded layers.

WARNING NOTE. 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.

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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 37 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies tests and requirements from those listed in BS 9760 that are applicable to multilayer flexi-rigid printed circuits with through hole connections.

It also specifies the requirements for capability approval and for quality conformance inspection during manufacture.

2 Related documents

BS 2011, *Basic environmental testing procedures — Part 2.1Ca: Test Ca. Damp heat, steady state.*

BS 4584, *Metal-clad base materials for printed circuits.*

BS 6001, *Sampling procedures and tables for inspection by attributes.*

BS 9000, *General requirements for a system for electronic components of assessed quality — Part 1: Specification of basic rules of procedure.*

BS 9760, *Specification for printed circuits of assessed quality: generic data and methods of test. Capability approval procedure and rules.*

BS 9764, *Specification for printed circuits of assessed quality: sectional specification for flexible and flexi-rigid printed circuits without through hole connections.*

PD 9002, *BS 9000 component selection guide.*

3 Terminology

For the purposes of this British Standard, the following definitions apply.

NOTE The expressions “hinge” and “flying tail” are used in this specification in their meanings commonly recognized throughout industry and are illustrated on the composite test pattern (CTP) described in Appendix A.

3.1

multi-layer printed circuit

a printed circuit consisting of alternating layers of conductive patterns and insulating materials bonded together, with conductive patterns interconnected as required

3.2

multi-layer flexi-rigid printed circuit

a printed circuit consisting of rigid and flexible parts in which some interconnections are formed between the bonded layers

3.3

rigid printed circuit

that part of a printed circuit that is not intended to be flexible

3.4

flexible printed circuit

that part of a printed circuit that can be readily formed in either static or dynamic applications

NOTE In static applications the flexible printed circuit is formed only during installation and servicing; in dynamic applications the flexible printed circuit flexes repeatedly whilst in use.

3.5

through hole connection

a hole in which an electric connection is made between internal or external conductive patterns or both

3.6

layer

a conductive pattern either internal or on the surface of a printed circuit board

3.7

cover layer

an outer layer of flexible insulating material applied over the conductive patterns on the surface of a printed circuit board

3.8

thickness

the distance between the faces of the completed circuit, including the cover layer where applicable

3.9

core thickness

the thickness of the dielectric between layers

3.10

resin flow

the flow of adhesive on to the pad

3.11

cover layer access hole

an aperture in the cover layer enabling electrical contact to be made to the lands

3.12

layer numbering

the numbering of layers following the sequence of artworks extending over the complete circuit area. Conductor layers are numbered serially, commencing at a chosen reference side, numbered 1. Each layer is marked such that, when in correct sequence and orientation and when viewed from the reference side, layer markings read correctly

NOTE Certain areas may not include all layers.

3.13

delamination

the separation of materials at a previously bonded interface

3.14**air entrapment**

an inclusion of air between laminated material during bonding, e.g. between cover layer and base material adjacent to conductors

4 Base materials

The base materials used shall either comply with BS 4584 or shall be other suitable materials for which an approved manufacturer or user specification is available (see 2.3.4 of BS 9760:1977).

For base materials other than epoxide glass (rigid) and polyimide or fluorinated ethylene propylene (FEP) (flexible), the printed circuit manufacturer shall define the test requirements for Table 2 in his capability manual. This test information shall also be available to the customer.

5 Customer's detail specification

A customer's detail specification (see section 3 of BS 9760:1977) shall be supplied for the purchase of printed circuits covered by capability approval.

NOTE A suitable form for a customer's detail specification for multilayer flexi-rigid printed circuits with through hole connections is shown in Appendix R.

6 Inspection requirements

Release of printed circuits complying with this specification (i.e. a certificate of conformity to the specification) shall be permitted only after the following inspection requirements have been complied with.

- a) Capability approval shall be obtained by complying with the tests given in Table 2 of this standard and with section 2 of BS 9760:1977.
- b) A customer's detail specification shall be prepared and agreed (see section 3 of BS 9760:1977).
- c) Production quality conformance inspection shall be carried out in accordance with Table 3 of this standard.

7 Description of capability: limits of approval

7.1 The description of the capability shall comply with 2.2 of BS 9760:1977.

NOTE Capability should be chosen so that it encompasses all printed circuits that require release in accordance with BS 9760.

7.2 The manufacturer shall describe his capability in terms of active board size (excluding borders), number of layers, minimum conductor width and spacing, minimum diameter of plated through hole (PTH), aspect ratio (board/hole), finishes, and additional features (see 8.6).

7.3 The basic level of capability permitted shall be as follows:

maximum active board size for a limiting process operation	310 mm × 180 mm
minimum conductor width and spacing	0.4 mm
maximum aspect ratio (board/hole)	2 : 1
minimum diameter of plated through hole	0.7 mm
minimum number of layers, rigid part	6
minimum number of layers, hinge	1
length of hinge	18 mm ± 2 mm
minimum number of layers, tail	2

7.4 If extension of capability approval is required (e.g. in respect of a flying tail with a non-plated through hole rigidizing component), the test schedule given in section 3 of BS 9764:1979 shall apply.

7.5 The abstract of approval shall be in tabular form, as shown in Appendix Q, for inclusion in PD 9002.

8 Demonstration of capability

8.1 **General.** The manufacturer shall demonstrate the boundary limits of the claimed capability in accordance with clause 7.

Since the general style of the composite test patterns (CTPs) is not intended to represent specific circuits, the demonstration of capability shall apply to rigidized plated-through areas in any position on the overall CTP.

8.2 Size

8.2.1 *Minimum size for capability approval.* The minimum pattern for capability approval shall be one complete CTP as shown in Appendix A and Appendix N.

8.2.2 *Maximum size for capability approval.* Capability larger than the CTP shall be demonstrated by printing the CTPs in a double composite as shown in Appendix N. Capability approval above this size shall be subject to assessment on production circuits.

8.3 Minimum conductor width and spacing

NOTE 1 Two sizes of conductor width and spacing are shown in specimen F in Appendix G. These sizes are repeated on internal layers of specimen K in Appendix G and specimen B in Appendix D.

The manufacturer shall declare which width is being offered for approval. Where the manufacturer wishes to declare a finer width and spacing than shown in specimen F of this standard, he shall provide a specially designed specimen F to demonstrate his capabilities.

NOTE 2 Different limits may be declared for the rigid and flexible parts.

8.4 Maximum diameter of PTH. The PTH diameter given for specimens A and C in Appendix M shall be the largest diameter permitted for capability approval.

NOTE Smaller diameter PTHs may be used to demonstrate any additional capability.

8.5 Number of layers. The minimum number of layers shall be six arranged as shown for the CTP in Appendix P.

NOTE Capability for more than six layers may be demonstrated using the style of CTP construction shown in Appendix P for eight-, ten- and twelve-layer construction.

8.6 Additional features. For additional features, suitable specimens shall be provided as required by 2.3.3 of BS 9760:1977.

Where limits of approval cannot be readily combined into standard CTPs (e.g. for a disproportionately long tail) production circuits shall only be used with the agreement of the NSI for demonstrating extension of capability.

Additional finishes shall be demonstrated on a minimum of one CTP for each finish as described in Appendix A. Capability approval tests and production tests shall be selected from Table 2 and shall be the subject of agreement between the manufacturer and the NSI.

Additional tests and requirements for the extension of the assessment to flying tails with rigidizing components, not having interconnections with the flying tail and bonded by a separate process, shall be covered by procedures as specified in Table 6 of BS 9764:1979 (as amended by Amendment No. 1).

The thickness of the edge connector finishes required for the basic level of capability shall be as given in Table 2.

NOTE Thinner coatings may be used to demonstrate additional capability.

9 Capability CTP allocation

9.1 Programme of capability assessment. The programme of capability assessment shall comply with 2.3 of BS 9760:1977.

9.2 Standard patterns. The standard patterns shown in Appendix B to Appendix L and Appendix N shall be used for demonstrating standard capability.

The quantities of patterns to be supplied for capability assessment shall be as follows:

- a) for single size CTP: 8 boards = 8 CTPs;
- b) for double size CTP: 4 boards = 8 CTPs;
- c) specific requirements for sizes other than those given in a) and b) shall be demonstrated, with the concurrence of the NSI, using production circuits.

9.3 Test specimen allocation

9.3.1 General. The specimens for each test shall be selected from as many complete boards and CTPs as possible.

Tests for items 1 to 9 of Table 2 shall be carried out on the complete boards before any subdivision into CTPs. The test for item 10 shall be made on the complete CTP before subdivision into specimens.

A total of 8 CTPs shall be manufactured with 6 being allocated for tests for items 11 to 23 as shown in Table 1. The specimens from each CTP shall be kept separate and identified with respect to board and position. The capability approval specimens shall be tested in accordance with the schedule shown in Table 2. Where the performance requirements of Table 2 are not applicable, the manufacturer shall specify the test limits as specified in 2.3.1 of BS 9760:1977.

The remaining two CTPs shall be used for two purposes as follows:

- a) as reserve specimens in case of accidental damage before testing (in any subdivision, note the requirement for specimens for item 25);
- b) to provide specimens for the thermal shock test (item 25).

9.3.2 Test for thermal shock (see item 25 of Table 2). For this test, one of the two reserve CTPs shall be divided as follows:

- a) specimens M, L, B2, A2, B3, C3, A3, C1 shall be contained in the same part of the CTP; and
- b) specimens P, N, B1, H, A1, C2, D1 shall be contained in the same part of the CTP.

These two parts and the flying tail shall be submitted to the thermal shock test (see item 25 of Table 2).

10 Capability approval acceptance levels

10.1 General. The level of assessment for each parameter shall be as given in Table 2, based on one of the levels given in **10.2** and **10.3**.

10.2 Acceptance level 1

Accept	0 failures
Reject	1 failure

10.3 Acceptance level 2

Accept	1 failure
Reject	2 failures

11 Capability approval report

11.1 The capability approval report shall comply with **2.5** of BS 9760:1977.

11.2 The capability approval report shall specify clearly the range of the manufacturer's approval as described in clause **7** of this standard and also **2.2** of BS 9760:1977.

12 Abstract of description of capability

The abstract of description of capability shall comply with **2.4** of BS 9760:1977.

NOTE Appendix Q gives an example of an abstract of description of capability for inclusion in PD 9002.

13 Quality conformance inspection

13.1 The requirements for quality conformance during manufacture shall be as given in Table 3.

13.2 Subgroups A0, A2 and B1 shall be applied to production boards only. Other tests shall be applied either to production boards or to special test circuits.

13.3 Production boards subjected to destructive tests marked (D) shall not be accepted for release (see **2.6.5** of BS 9000-1:1981).

14 Certified test records

Certified test records shall be prepared giving attributes information as given in subgroups A5, B8 and C6 in Table 3.

15 BS 9764 approval

Approval to this specification, i.e. BS 9766, will qualify as approval to BS 9764, which is the sectional specification for flexible and flexi-rigid printed circuits without through hole connections.

Table 1 — CTP allocation of specimens

Specimen identity		Sample quantity	Tests applied and allocation	Inspection characteristics
Rigid parts	Flexible parts			
A1, A2, A3		9	Item 20(b) 3 for wetting 6 for dewetting	Solderability: holes
		9	Item 21(b) 3 for wetting 6 for dewetting	Accelerated ageing: holes
	A4, A5	12	Item 6(a)	Holes/registration
B1, B2, B3	B4	9	Item 20(a) 3 for wetting 6 for dewetting	Solderability: conductors
		9	Item 21(a) 3 for wetting 6 for dewetting	Accelerated ageing: conductors
C1		6	Item 19	Internal short circuits
C2		6	Item 24	Adhesion of plating
C3		3	Item 11(a)	Thickness of plating
		3	Item 15	Thermal shock on PTH
	C4	3	Item 11(a)	Thickness of plating
D1		3	Item 24	Insulation resistance/Process contamination
	D2	3	Item 24	Insulation resistance/Process contamination
	E	3	Item 6(a)	Holes/registration
F1		6	Item 3, item 5 Examined on all complete CTPs	Conductor widths and defects/Conductor spacing
	F2	6	Item 3, item 5 Examined on all complete CTPs	Conductor widths and defects/Conductor spacing
G1		3	Item 12(b)	Peel strength of conductor to base
	G2	3	Item 12(a)	Peel strength of conductor to base
H		3	Item 13(b)	Pull-out strength of PTH
	J	6	Item 13(a)	Pull-off strength after soldering
K		6	<i>Subject to tests in the following sequence</i> Item 4 Item 9 Item 22 Item 23 Item 11(b)	Edge connector defects Board thickness in edge connector zone Porosity of plating Adhesion of plating Thickness of platings on edge contacts only
L		6	Item 18	Change in resistance
M		6	Item 17	Insulation resistance between layers
N		6	Item 6(a) Examined on all complete CTPs	Holes/registration
P		6	Item 16	Insulation resistance within a layer
	X	6	Item 14(a)	Flexural fatigue (flying tail)
	Y	3	Item 12(c)	Peel strength of cover layer to conductor
	Z1, Z2	6	Item 14(b)	Flexural fatigue (hinge)

Table 2 — Schedule of tests for capability approval

Item	Inspection characteristics	Clause reference in section 1 of BS 9760:1977	Test pattern (Appendix A to Appendix L)	Acceptance level (see clause 10)	Requirements	Remarks
1	Visual inspection	1.2.2	Complete board	1	Pattern, marking, identification, material and finishes shall comply with the composite test pattern	All boards before subdivision
2(a)	Appearance	1.2.2	Complete board	1	The board shall be inspected for general appearance and workmanship. There shall be no apparent defects apart from those permitted by this standard The surface of the conductors, including metallic finishes and base material, shall be of uniform appearance, free from cracks, burns, pits, nodules and blisters. There shall be no fine line cracks or breaks in the conductors	All boards before subdivision
2(b)	Plated through holes	1.2.2	Complete board	1	Plated through holes shall appear clean and free from inclusions of any sort that may affect component insertion or solderability. There shall be no apparent failure of the plating within the hole, but in materials in excess of 0.5 mm overall thickness (excluding cover layers) voids are permissible provided that their sum total does not exceed one-quarter of the hole circumference and provided that the effective length of plating through the board is not reduced by more than one-quarter at any point. Visual estimation of the void hole dimensions is sufficient in any one board; holes with plating voids shall not exceed 10 % of the total number of plated through holes	
2(c)	Edge finish (flexible part only)	1.2.2	Complete board	1	Edges shall be clean cut. There shall be no tears or nicks Inside corners shall have a radius of not less than 1 mm; anti-tear holes shall have a diameter of not less than 2 mm	

Table 2 — Schedule of tests for capability approval

Item	Inspection characteristics	Clause reference in section 1 of BS 9760:1977	Test pattern (Appendix A to Appendix L)	Acceptance level (see clause 10)	Requirements	Remarks
2(d)	Bonding of conductor to base	1.2.2	Complete pattern	1	There shall be no separation of the conductor pattern from the base by apparent blisters and wrinkles other than those permitted in relevant material specifications	
2(e)	Bonding of cover layer to base and conductor	1.2.2	Cover layer area of test pattern	1	The bond between the cover layer and the base shall appear to be complete and uniform. Minor delaminations are permitted in the following situations a) at random locations away from the conductors b) along conductor edges Delaminations shall not infringe the design spacing between conductors by more than 20 %, by visual estimation. There shall be a minimum continuous bonding of 0.5 mm between adjacent conductors. There shall be no delamination with conductor spacings less than 0.5 mm	Typical examples are shown in Appendix S and Appendix T
2(f)	Bonding of flexible circuit to the rigid parts	1.2.2	Complete board	1	The bonding between the flexible parts and the rigid parts shall appear complete and uniform The following conditions shall be permitted at the junction between flexible and rigid parts a) Resin flow on to the flexible part shall not extend beyond 2 mm from the junction b) A non-bonded zone shall not extend on to the rigid part more than 2 mm from the junction	

Table 2 — Schedule of tests for capability approval

Item	Inspection characteristics	Clause reference in section 1 of BS 9766:1977	Test pattern (Appendix A to Appendix L)	Acceptance level (see clause 10)	Requirements	Remarks
3	Conductor widths and defects	1.2.3.3	Specimens F1 and F2 on complete board	1	a) 0.4 mm <i>conductors</i>. Except in cases of local defects, the conductor width shall not depart from the design width (0.4 mm) by more than 10 %. In any event, the effective width of the conductor, resulting from its width being less than the design width in the presence of hole or edge defects, shall be not less than 75 % of the design width b) 0.25 mm <i>conductors</i>. Inclusive of local defects, the conductor width shall not depart from the design width (0.25 mm) by more than 0.08 mm c) <i>Conductors below 0.25 mm</i>. Inclusive of local defects, the conductor width shall not depart from the design width by more than the manufacturer's claimed tolerance d) <i>All conductors</i>. The number of holes in conductors other than those in edge contacts shall not exceed one per 650 mm² of board area. Indentation in conductors other than those in edge contacts shall not be a reason for the rejection of the printed circuit board	All boards before subdivision

Table 2 — Schedule of tests for capability approval

Item	Inspection characteristics	Clause reference in section 1 of BS 9760:1977	Test pattern (Appendix A to Appendix L)	Acceptance level (see clause 10)	Requirements	Remarks				
4	Edge connector defects	1.2.3.5	Specimen K on complete board	2	The plated surface of edge board contacts shall be smooth and free from defects in the zone of contact likely to cause a reduction in either the electrical or mechanical properties of the connectors. Examples of such defects are pin holes, deep scratches, roughness or pitting The number of imperfections permitted in contact zone on each conductor shall be as follows <table><tr><td>Indentations</td><td>1</td></tr><tr><td>Bumps</td><td>1</td></tr></table>	Indentations	1	Bumps	1	All boards before subdivision (not applicable to tin-lead finish)
Indentations	1									
Bumps	1									
5	Conductor spacing	1.2.3.4	Specimens F1 and F2 on complete board	2	The spacing between adjacent conductors in the presence of any conductive particles shall be not less than 75 % of the design spacing	All boards				
6(a)	Holes/ registration	1.2.3.6	Specimens A4, A5, E and N on complete board	1	Permissible misalignment of hole and land: outer surface layers <i>Holes not plated through.</i> The width of metal at any point around the hole shall be not less than 0.15 mm <i>Plated through holes.</i> The width of metal at any point around the hole shall be not less than 0.08 mm Permissible misalignment of hole and land: inner layers The hole shall not break out of the land	All boards before subdivision				
6(b)	Cover layer access holes	1.2.3.6	Complete cover layered part only on complete board	1	Registration of an access hole in the cover layer in relation to the relevant land on the base material shall be such that any overlapping will not reduce the effective land dimensions to less than the minimum width given under item 6(a)	All boards before subdivision Typical examples are shown in Appendix S and Appendix T				