

Specification for

Fixed capacitors of assessed quality: Generic data and methods of test —

Section 1: Principles and mandatory
procedures —

Section 2: General rules for drafting
detail specifications

Co-operating organizations

The Telecommunication Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- British Broadcasting Corporation*
- British Electrical and Allied Manufacturers' Association
- British Radio Equipment Manufacturers' Association*
- British Radio Valve Manufacturers' Association
- British Railways Board
- Cable and Wireless Ltd.
- Crown Agents for Oversea Governments and Administrations
- Department of Employment and Productivity
- Electrical Contractors' Association (Incorporated)
- Electrical Research Association*
- Electricity Council, the Generating Board and the Area Boards, in England and Wales*
- Electronic Engineering Association*
- Electronic Valve and Semiconductor Manufacturers' Association
- Institution of Electrical Engineers*
- Institution of Electronic and Radio Engineers*
- Institution of Production Engineers
- Ministry of Defence
- Ministry of Defence, Army Department
- Ministry of Defence, Navy Department*
- Ministry of Technology*
- Post Office*
- Radio and Electronic Component Manufacturers' Federation
- Relay Services Association of Great Britain
- Science Research Council — Radio and Space Research Station*
- Society of British Aerospace Companies*
- Telecommunication Engineering and Manufacturing Association*

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- Radio Society of Great Britain
- United Kingdom Atomic Energy Authority

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Contents

	Page
Co-operating organizations	Inside front cover
Foreword	iv
Section 1. Principles and mandatory procedures	
1.1 General matters	1
1.1.1 Scope	1
1.1.2 Related documents	1
1.1.3 Terminology	1
1.1.4 Letter symbols, signs and abbreviations	4
1.1.5 Graphical symbols	4
1.1.6 Marking of the component and package	4
1.1.7 Eligibility for qualification approval	4
1.1.8 Structurally similar components	5
1.1.9 Delayed delivery	5
1.1.10 Supplementary procedure for qualification approval	5
1.1.11 Certified test records	5
1.1.12 Standard ratings and characteristics	5
1.1.13 Unchecked parameters	6
1.1.14 Procedure to be followed in the event of failures at Group C inspection	6
1.1.15 Ordering information	6
1.1.16 Release before completion of Group B inspection	6
1.2 Test procedures	6
1.2.1 Measurement conditions	6
1.2.2 Visual inspection	7
1.2.3 Dimensioning and gauging procedure	7
1.2.4 Electrical test procedures	9
1.2.4.1 Preliminary drying	9
1.2.4.2 Voltage proof	9
1.2.4.3 Capacitance	11
1.2.4.4 Tangent of the loss angle	11
1.2.4.5 Leakage current	11
1.2.4.6 Impedance	11
1.2.4.7 Insulation resistance	11
1.2.4.8 Inductance	12
1.2.4.9 Outer foil termination	12
1.2.4.10 Temperature coefficient and cyclic drift	12
1.2.4.11 Temperature characteristic of capacitance	14
1.2.4.12 <i>Text deleted</i>	14
1.2.4.13 Charge/discharge test	14
1.2.4.14 D.C. surge voltage test	15
1.2.4.15 Pressure relief test	16
1.2.4.16 Insertion loss test	16
1.2.5 Mechanical test procedures	16
1.2.6 Environmental test procedures	16
1.2.6.1 Robustness of terminations	16
1.2.6.2 Soldering	17
1.2.6.3 Rapid change of temperature	17
1.2.6.4 Bump	17

	Page
1.2.6.5 Shock	17
1.2.6.6 Acceleration	18
1.2.6.7 Vibration	18
1.2.6.8 Climatic sequence	18
1.2.6.9 Damp heat (steady state)	19
1.2.6.10 Container sealing	19
1.2.6.11 Storage	19
1.2.6.12 Mould growth	20
1.2.6.13 Salt mist (metal cased styles only)	20
1.2.7 Endurance test procedures	20
1.2.8 Dielectric absorption test	20
Section 2. General rules for the preparation of detail specifications	
2.1 Basic information relating to all detail specifications	21
2.2 Inspection requirements	23
2.3 Certified test records	24
2.4 Instructions for ordering components	24
Appendix A Table of measuring points for insulation resistance and voltage proof	33
Appendix B Typical layout of capacitance and voltage table for electrolytic capacitors	34
Appendix C <i>Text deleted. See Note</i>	35
Appendix D <i>Text deleted. See Note</i>	35
Appendix E Typical method of determination of impedance, resonant frequency or inductance of fixed capacitors	35
Appendix F Conditioning of aluminium electrolytic capacitors	41
Appendix G Recommended scheme for the inspection of structurally similar parts	41
Appendix H Measurement of temperature coefficient and cyclic drift	41
Appendix J <i>Text deleted. See Note</i>	44
Appendix K Allocation of numbers to detail specifications	44
Figure 1 — Relationship between defined voltages and temperatures	3
Figure 2 — Gauge plate for components having axial wire terminations	8
Figure 3 — Gauge plates for components with a diameter of 5 mm and over having axial terminations and with glass-metal seals or with discontinuities in the wire terminations	9
Figure 4 — An example of a suitable test circuit	10
Figure 5 — Circuit for checking the outer foil termination	13
Figure 6 — Relay circuit	15
Figure 7 — Silicon controlled rectifier circuit	15
Figure 8 — Typical outline drawing	22
Figure E.1 — Inductance of straight round wire, 0.2 mm diameter	37
Figure E.2 — Method of determination of impedance resonant frequency or inductance of capacitors	38
Figure E.3 — Resonant frequency as a function of inductance and capacitance	39
Figure E.4 — Typical capacitor impedance/frequency characteristic	40
Figure H.1 — Measurement of temperature coefficient and cyclic drift	43
Table 1A — Summary of test sequences contained in Table 1B, Table 1C and Table 1D	25

	Page
Table 1B — Inspection procedure for fixed capacitors: full assessment	26
Table 1C — Inspection procedure for fixed capacitors: preferred basic plus additional assessment	29
Table 1D — Inspection procedure for fixed capacitors: basic assessment	30
Table 2 — Tests applicable to specific types of non-electrolytic fixed capacitors: full assessment	31
Table 3 — Tests applicable to specific types of electrolytic fixed capacitors: full assessment	32
Table H.1 — Typical data	41

Foreword

This British Standard, which has been prepared under the authority of the Telecommunication Industry Standards Committee, is the generic specification for fixed capacitors in the system of standards for electronic parts of assessed quality.

This publication covers Sections 1 and 2 of the generic specification. Further sections will be published as necessary to prescribe the test incidence, the selected test procedures and the general requirements appropriate to the different dielectric materials used in fixed capacitors.

This standard has been issued in the United Kingdom where it is urgently required but if a similar procedure is adopted in other countries changes will be considered for the purposes of harmonization.

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 44 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.

Section 1. Principles and mandatory procedures

1.1 General matters

1.1.1 Scope. This specification prescribes the essential test requirements and other general information relating to fixed capacitors of assessed quality. It is intended to be used in conjunction with BS 9000¹⁾ and with the relevant detail specifications in which are stated the dimensions, ratings, tests and requirements which are applicable to the various specific ranges of fixed capacitors covered by such detail specifications. The rules necessary for the preparation of these detail specifications are contained in Section 2 of this specification.

1.1.2 Related documents

BS 204, *Glossary of terms used in telecommunication (including radio) and electronics.*

BS 1852, (IEC 62) *Marking codes for values and tolerances of resistors and capacitors.*

BS 1991, *Letter symbols, signs and abbreviations.*

BS 2011, (IEC 68) *Basic methods for the environmental testing of electronic components and electronic equipment.*

BS 2045, (ISO/R 3) *Preferred numbers.*

BS 2488, (IEC 63) *Schedule of preferred numbers for the resistance of resistors and the capacitance of capacitors for telecommunication equipment.*

BS 2564, *Control chart technique when manufacturing to a specification.*

BS 3939, (IEC 117) *Graphical symbols for electrical power, telecommunications and electronics diagrams.*

BS 4000, (ISO/R 101) *Sizes of papers and boards.*

BS 9000, *General requirements for electronic parts of assessed quality.*

BS 9001, *Sampling procedures and tables for inspection by attributes for electronic parts of assessed quality.*

NOTE When reference to an IEC Recommendation is given in parenthesis the British Standard is identical in technical content with the IEC Recommendation except where deviation(s) are indicated in the British Standard.

1.1.3 Terminology. The terms and their definitions which are employed in all documents applicable to electronic parts covered by this specification shall, whenever possible, be in accordance with BS 204²⁾.

In addition to the terms in BS 204²⁾ the following specific terms and their definitions are applicable:

1.1.3.1

style

(Under consideration.)

1.1.3.2

pattern

(Under consideration.)

1.1.3.3

rated capacitance of a capacitor

the value which is indicated upon the capacitor

1.1.3.4

D.C. Capacitor

a capacitor designed essentially for application with a direct voltage

NOTE D.C. capacitors may not be suitable for use on a.c. supplies. For other applications, e.g. pulse or a.c., the operating voltages will be prescribed in the detail specification.

1.1.3.5

polar capacitor (for electrolytic capacitors)

a capacitor designed essentially for application with the positive polarity of a direct voltage on the identified terminal

1.1.3.6

bi-polar capacitor (for electrolytic capacitors)

a capacitor designed to withstand reversal of the applied voltage

¹⁾ BS 9000, "General requirements for electronic parts of assessed quality".

²⁾ BS 204, "Glossary of terms used in telecommunication (including radio) and electronics".

1.1.3.7**A.C. capacitor**

a capacitor designed essentially for application with alternating voltages of stated frequency

1.1.3.8**pulse capacitor**

a capacitor designed essentially for application with intermittent charges or discharges at high values of the charge or discharge current

1.1.3.9**rated voltage (U_R)³⁾**

the maximum direct voltage or the maximum r.m.s. alternating voltage, which may be applied continuously to the terminals of a capacitor at any temperature between the lower category temperature and the rated temperature

1.1.3.10**category voltage (U_C)³⁾**

the voltage which may be applied to a capacitor in use at its upper category temperature

1.1.3.11**temperature derated voltage³⁾**

for any temperature between the rated temperature and the upper category temperature, the maximum voltage that may be applied continuously to the terminals of a capacitor

NOTE The information for the voltage at temperatures between the temperature specified for rated voltage and the upper category temperature will be given in the detail specification.

1.1.3.12**surge voltage ratio (of an electrolytic capacitor)**

the quotient of the maximum instantaneous voltage which may be applied to the terminals of the capacitor for a specified time at any temperature within the operating temperature range and the rated voltage or the temperature derated voltage as appropriate

the number of times per hour that this voltage may be applied should be specified

1.1.3.13**rated ripple voltage³⁾**

the r.m.s. value of the maximum allowable alternating voltage of a specified frequency superposed on the d.c. voltage at which the capacitor may be operated continuously at a specified temperature

NOTE The sum of the direct voltage and the peak value of the alternating voltage applied to the capacitor should not exceed the rated voltage.

1.1.3.14**rated ripple current**

the r.m.s. value of the maximum allowable alternating current with a frequency of 50–60 Hz or 100–120 Hz, whichever is stated, at which the capacitor may be operated continuously at its upper category temperature

1.1.3.15**lower category temperature³⁾**

the minimum ambient temperature for which a component has been designed to operate continuously

1.1.3.16**upper category temperature³⁾**

the maximum ambient temperature for which a component has been designed to operate continuously

1.1.3.17**category temperature range³⁾**

the range of ambient temperatures for which a component has been designed to operate continuously; this is defined by the temperature limits of the appropriate category

1.1.3.18**rated temperature³⁾**

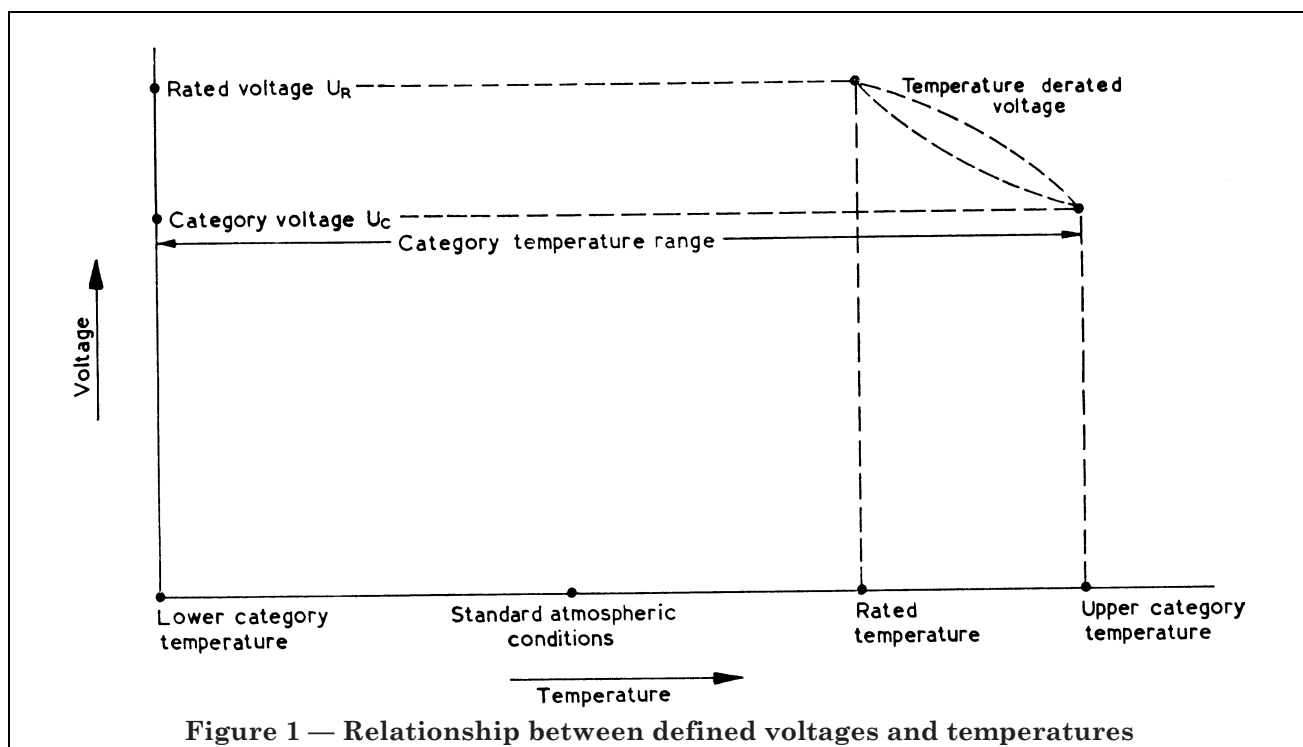
the maximum temperature at which the rated voltage is applicable continuously

³⁾ A diagram showing the relationship between the defined voltages and temperatures is given in Figure 1.

1.1.3.19**maximum temperature of a capacitor**

the temperature at the hottest point of its external surface

NOTE The terminations are considered to be part of the external surface.

**1.1.3.20****minimum temperature of a capacitor**

the temperature at the coldest point of its external surface

NOTE The determinations are considered to be part of the external surface.

1.1.3.21**tangent of the loss angle ($\tan \delta$)**

the power loss of the capacitor divided by the reactive volt-amps of the capacitor at a sinusoidal voltage of specified frequency

1.1.3.22**leakage current**

the conduction current flowing through the capacitor with a direct voltage applied

1.1.3.23**insulation resistance**

the ratio of the applied voltage to the leakage current; it is normally expressed in megohms

1.1.3.24**self healing**

a process whereby the electrical properties of a capacitor after a local breakdown of its dielectric are instantaneously and essentially restored to their values before the breakdown

1.1.3.25**time constant**

the product of the insulation resistance and the capacitance of a capacitor, normally expressed in seconds

1.1.3.26 Catastrophic failure

A failure which results in the capacitor being unable to perform the function for which it was designed. Such failures may be permanent or intermittent, and result in the capacitor exhibiting open circuit or short circuit characteristics, as defined below.

1.1.3.26.1

open circuit

failure such as to cause complete lack of the required function, resulting from the capacitance value falling below 10 % of its lower rated capacitance value

1.1.3.26.2

short circuit

failure such as to cause complete lack of the required function, resulting from the current measured during the leakage current or insulation resistance tests rising above 10 % of the current passing when the test terminals of the measuring equipment are joined together

1.1.3.26.3

intermittent open circuit

an open circuit failure of duration 0.5 ms or greater, following which the capacitor recovers its ability to perform its required function without being subjected to any external corrective action. Such a failure is usually recurrent

1.1.3.26.4

intermittent short circuit

a short circuit failure of duration 0.5 ms or greater, following which the capacitor recovers its ability to perform its required function without being subjected to any external corrective action. Such a failure is usually recurrent

1.1.4 Letter symbols, signs and abbreviations. The letter symbols, signs and abbreviations which are employed in all documents applicable to electronic components covered by this specification shall be in conformity with BS 1991 or shall be derived in accordance with the principles of that standard.

1.1.5 Graphical symbols. The graphical symbols which are employed in all documents applicable to electronic components covered by this specification shall be in conformity with BS 3939 or shall be derived in accordance with the principles of that standard.

1.1.6 Marking of the component and package

1.1.6.1 Each capacitor shall be marked with 1) and 2) and with as many of the remaining items, in the order given below, as is practicable.

- 1) Polarity (electrolytic capacitors only)
- 2) Rated capacitance and tolerance (these values may be in code form according to BS 1852 [IEC 62])
- 3) Rated voltage (d.c. or a.c.)
- 4) Date code and lot identification (see 2.6.8 of BS 9000-1)
- 5) Manufacturer's name or trade mark
- 6) Number of the detail specification and (where necessary) pattern number
- 7) Any additional marking required by the detail specification.

1.1.6.2 All the information required by 1.1.6.1 shall be marked on the package of the components.

NOTE Where a transparent package is used, the information may be marked on a label which may be read without opening the package.

1.1.7 Eligibility for qualification approval. The first stage of factory processing is that at which the primary performance of the capacitor is determined. The first stage is defined as:

- 1) the winding of the capacitor element of a wound type
- 2) the stacking of the plates of a plate type
- 3) the formation of the oxide layer of an electrolytic type
- 4) the application of the electrodes to a single layer dielectric capacitor of plate, disc, tube or similar construction
- 5) the first common firing of the dielectric electrode assembly of a multilayer dielectric capacitor.

1.1.8 Structurally similar components. Structurally similar components are a range of styles as defined in 1.1.3.1 and are usually covered by a single detail specification (see 2.4.6 of BS 9000-1).

The procedure for the formation of lots of structurally similar components is given in Appendix G.

1.1.9 Delayed delivery. The period following manufacturer's acceptance inspection, after which re-inspection to Group A is required, shall be as follows:

- | | |
|---|---|
| 1) All other capacitors: | 36 months, unless otherwise stated in the detail specification. |
| 2) All other capacitors of climatic categories -/-/21 and -/-/56: | 24 months. |

NOTE At the discretion of the manufacturer, aluminium electrolytic capacitors may be subjected to conditioning in accordance with Appendix F prior to re-testing to Group A inspection.

1.1.10 Supplementary procedure for qualification approval. Not applicable. (Information concerning the standard qualification approval procedure is given in 2.3.2 of BS 9000-1.)

1.1.11 Certified test records. Certified test records shall be prepared by the manufacturers, only if specified in the detail specification. If required they shall be prepared as specified in 1.3 10) of BS 9000-1 for fixed capacitors of full (or full plus additional) assessment. They are not required for those of basic (or basic plus additional) assessment.

Certified test records shall be printed on international size A4 paper to BS 4000 in the format shown in Appendix C of BS 9000-1.

When the relevant section requires that attributes information shall be recorded, the following procedures shall be used:

- 1) Where a subgroup is comprised of a single conditioning test, the total number of rejected capacitors shall be recorded without reference to the parameter for which the rejection was made.
- 2) Where a subgroup is comprised of a number of conditioning tests, the relevant section shall state whether the results shall be recorded for the individual conditioning tests or for a number of them as a group. For the purposes of this specification the climatic sequence shall be deemed to form a single conditioning test.

The relevant section shall state which tests are to be reported on the certified test record as measurements information. It shall also state whether results may be aggregated, e.g. by ranges of rated capacitance, etc.

As a minimum, the results of all electrical endurance tests shall be presented as measurements information.

1.1.12 Standard ratings and characteristics. Ratings and characteristics shall, where possible, be taken from the preferred values given below.

- 1) *Capacitance.* Values of rated capacitance shall preferably be taken from the E6 series of BS 2488. Where intermediate values are required, these shall preferably be taken from the appropriate E series.
- 2) *Tolerances.* The standard tolerances given in BS 1852 shall preferably be used.
- 3) *Rated voltage.* Values of rated voltage shall preferably be taken from the R5 series given in BS 2045. Where intermediate values are required, these shall preferably be chosen from the appropriate R series.
- 4) *Terminations.* Dimensions of terminations shall be selected from the following:
 - a) *Diameters of wire terminations* (mm)
 Minimum: 0.20, 0.25, 0.35, 0.45, 0.55, 0.75 and 0.95.
 Nominal: 0.25, 0.3, 0.4, 0.5, 0.6, 0.8 and 1.0.
 Maximum: 0.28, 0.33, 0.44, 0.55, 0.66, 0.88 and 1.10.
 - b) *Length of wire terminations*
 Axial wire terminations 25 mm minimum.
 Radial wire terminations 4 mm minimum.
 - c) *Spacing of radial terminations.* The spacing of radial terminations shall be based on a 2.54 mm module.
- 5) *Environmental classification.* Combinations of the preferred values given below will be given as preferred environmental classifications in detail specifications:
 Upper category temperatures: 70, 85, 100, 125 °C

Lower category temperatures: – 55, – 40, – 25, – 10 °C

Humidity classifications: 56, 21, 04, A4.

6) *Temperature characteristic and coefficient.* Preferred values of temperature characteristic or temperature coefficient will be given in the relevant section.

1.1.13 Unchecked parameters. Detail specifications prepared in accordance with this specification do not necessarily give information on the operation of capacitors under special conditions, e.g. under pulse conditions. Unchecked parameters are not used for inspection purposes and consistent performance under such conditions cannot be relied upon.

Where a requirement exists for operation under such conditions it shall be given in a detail specification prepared by the manufacturer. The test method shall be fully described and appropriate limits, acceptable quality levels and inspection levels specified.

1.1.14 Procedure to be followed in the event of failures at Group C inspection. Where a batch failure occurs on long term Group C tests, the following procedure shall apply:

- 1) *Endurance tests.* A test of 48 h duration under the conditions of the endurance test shall be carried out on a lot-by-lot basis in accordance with the provisions of 1.1.14 of BS 9000-2.
- 2) *Damp heat, steady state tests.* Any damp heat, cyclic test already included in Group B shall be carried out at the next tighter AQL, in accordance with the provisions of 1.1.14 of BS 9000-2. Where there is no damp heat, cyclic test already in Group B the detail specification shall give details of an appropriate test.

1.1.15 Ordering information. The detail specification shall prescribe that the following information shall be given when ordering components:

- 1) Capacitance value and tolerance.
- 2) Rated voltage.
- 3) BS number of the detail specification and, where necessary, pattern number.

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

1.2 Test procedures

This subsection contains test methods which are applicable to fixed capacitors. Test incidence, conditions of test (including initial intermediate and final measurements) are given in Sections 3 *et seq.* of this standard.

Where measurements before and after conditioning are called for in the procedures given in this clause the following measurements shall be made in the order prescribed in the detail specification:

1) *Initial measurements:*

Leakage current	1.2.4.5
Capacitance	1.2.4.3
Tangent of loss angle	1.2.4.4
Insulation resistance	1.2.4.7
Voltage proof	1.2.4.2

2) *Final measurements:*

Visual examination	1.2.2
Leakage current	1.2.4.5
Capacitance	1.2.4.3
Tangent of loss angle	1.2.4.7
Insulation resistance	1.2.4.4
Voltage proof	1.2.4.2

1.2.1 Measurement conditions. Unless otherwise specified, all tests shall be carried out under the standard atmospheric conditions for testing as specified in BS 2111.

Before the measurements are made, the capacitors shall be stored at the measuring temperature for a time sufficient to allow the entire capacitor to reach this temperature. The recovery period called for after conditioning is normally sufficient for this purpose. Standard conditions for normal and assisted recovery are given in BS 2011.

When measurements are made under conditions other than those specified, the results shall, where necessary, be corrected using the correction graph given in the detail specification or the appropriate section of this specification. The conditions of measurement shall be stated in the test report. In the event of a dispute the measurements shall be repeated using the standard reference temperature ($20 \pm 1^\circ\text{C}$) and such other conditions as are prescribed in this specification.

NOTE During measurements the capacitor should not be exposed to draughts, direct sun-rays or other influences likely to cause error.

1.2.2 Visual inspection

1.2.2.1 Initial examination. The specimen shall be visually examined. The workmanship and finish shall be satisfactory. The marking shall be legible.

1.2.2.2 Examination after conditioning. The specimen shall be visually examined. There shall be no visible damage likely to reduce the usability of the product for its intended purpose.

1.2.3 Dimensioning and gauging procedure. The dimensions shall be checked, using the methods of 1.2.3.4 and 1.2.3.5 as appropriate, and they shall comply with those given in the detail specification.

1.2.3.1 Dimensions. Those dimensions affecting interchangeability shall be checked and they shall comply with those prescribed in the detail specification.

1.2.3.2 Text deleted.

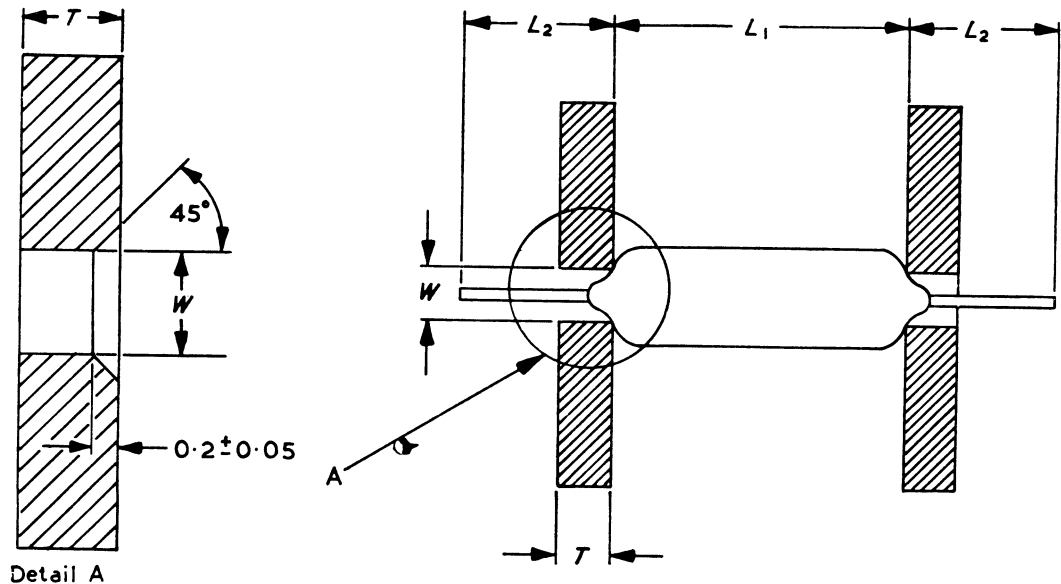
1.2.3.3 Mass. Where prescribed in the detail specification, the specimen shall be weighed. The mass shall not be greater than the maximum prescribed in the detail specification.

1.2.3.4 Measurements of the dimensions of a cylindrical component having two axial wire terminations

1) *Length.* The length of the body shall be measured by inserting the terminations into slots (or holes) of two gauge plates and by moving these plates parallel to each other until the component body is clamped without deforming the body or the termination. The plates shall be considered sufficiently close to parallel if, allowing for the size of plate and the distance between the component and the measuring device, the error in measurement due to this cause does not exceed 0.2 mm.

Alternative methods of measurement are given in Methods 1 and 2 (see Figure 2 and Figure 3).

Method 1

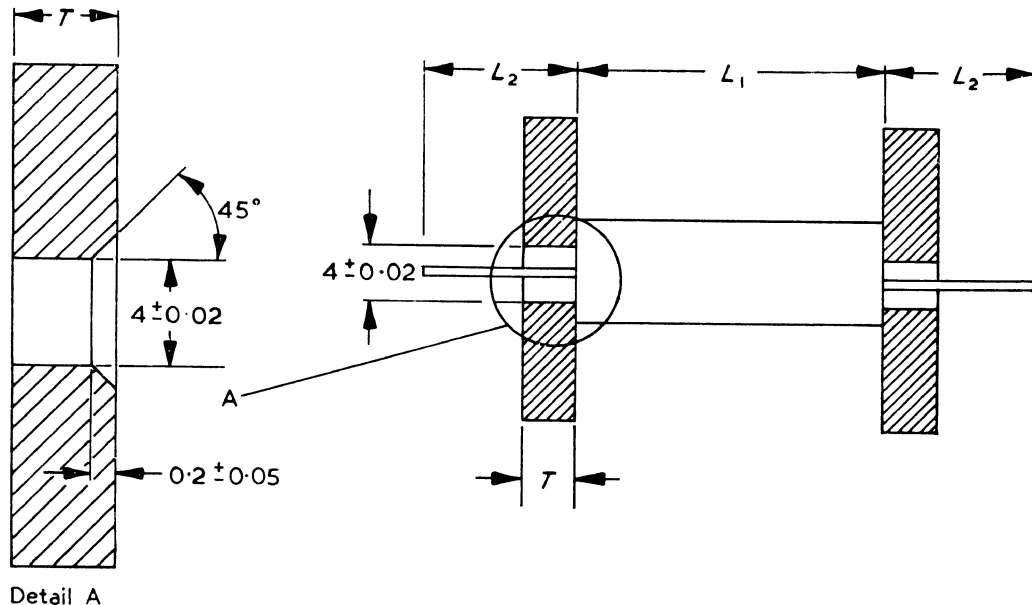


The length of the body is equal to the measured length L_1 , the length of the termination is equal to L_2 .
The width of the slot W , (or the diameter of the hole) in the gauge plate shall depend on the diameter of the wire termination in the manner given in the following table.

Nominal diameter of wire terminations (mm)	W (mm)
up to and including 0.45	0.8 ± 0.02^a
0.45 up to and including 0.7	1.0 ± 0.02^a
0.7 up to and including 0.9	1.2 ± 0.02^a
0.9 up to and including 1.15	1.5 ± 0.02^a
1.15 up to and including 1.32	1.8 ± 0.02^a
1.32 up to and including 2.0	3.0 ± 0.02^a

^a This tolerance need only be maintained in the locality of the point where the termination will lie during measurement.

Figure 2 — Gauge plate for components having axial wire terminations (except components mentioned in Method 2)

Method 2**Detail A**

If there is a discontinuity in the wire termination, e.g. on components with welded terminations outside the case and on components provided with glass seals, the thickness of the gauge has no significance in the measurement of length. The length of the component shall be taken as the distance between the inside faces of the gauge plates (L_1), the length of the terminations is equal to L_2 .

The width of the slot (or the diameter of the hole) in the gauge plate shall be 4 ± 0.02 mm.

NOTE This tolerance need only be maintained in the locality of the point where the termination will lie during measurement.

Figure 3 — Gauge plates for components with a diameter of 5 mm and over having axial terminations and with glass-metal seals or with discontinuities in the wire terminations

2) *Maximum length of the termination covered by coating material.* When the terminations are inserted in the gauge plates and the component is clamped as prescribed in 1.2.3.4 1) no coating material shall extend beyond the gauge plates. The thickness T of the gauge plates shall be specified in the relevant detail specification.

NOTE Recommended values for gauge plate thicknesses are 1.5 ± 0.05 mm for components for use on single sided printed wiring board and 4 ± 0.05 mm for components for other applications.

3) *Method for checking the overall diameter.* For a given diameter the component shall pass through a straight tube, of which the internal diameter is equal to the maximum prescribed body diameter + 0.1 mm with a tolerance of $-0/+0.05$ mm and the length is the maximum prescribed body length for that component. The component shall pass through the gauge by its own weight.

The maximum diameter of the component as given by the manufacturer shall take into account the irregularities in the shape of the body such as bow and wire wrapping as part of the terminations of ceramic capacitors, etc.

1.2.3.5 Measurement of a component having radial wire terminations (Under consideration.)

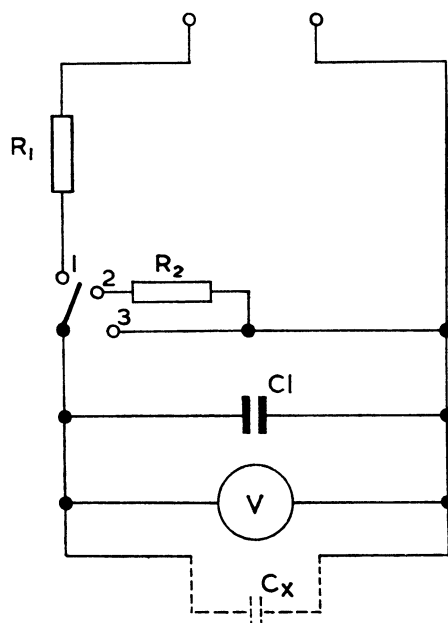
1.2.4 Electrical test procedures

1.2.4.1 *Preliminary drying.* The capacitor shall be conditioned for 96 ± 4 h by heating in a circulating air oven at a temperature of 55 ± 2 °C and a relative humidity not exceeding 20 %.

The capacitor shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and shall be kept therein from the time of removal from the oven to the beginning of the specified test.

1.2.4.2 Voltage proof

1.2.4.2.1 The test shall be made at the specified points of application, (see Appendix A).



NOTE The capacitor C_1 may be omitted for certain types of capacitors. This should be stated in the detail specification.

Figure 4 — An example of a suitable test circuit

The resistance of the voltmeter shall be not less than $10\,000\ \Omega/V$. The resistances R_1 and R_2 shall be so chosen that, in conjunction with the capacitance C_1 and the capacitance of the part under test, the charge and discharge currents do not exceed the specified value at the highest test voltage. The capacitance of C_1 shall be at least 10 times the capacitance of the part under test so that variations of this capacitance do not affect the charge or discharge current.

The switch shall be connected to R_2 . The two terminals at the top of the diagram shall be connected to a variable d.c. supply, of sufficient power, which shall be adjusted to the required test voltage. The capacitor to be tested (C_x) shall be connected as indicated in the diagram.

The switch shall then be connected to R_1 so that the capacitors C_1 and C_x are charged.

The switch shall remain in this position for the time specified after the test voltage has been reached. The capacitor shall be discharged by connecting the switch to R_2 . As soon as the voltmeter reading has fallen to zero the capacitors shall be short-circuited and C_x shall be disconnected.

Where the case of the capacitor is non-metallic, or where the capacitor has a metallic case with an insulating sleeve, the test voltage shall be applied in either of the two following ways:

- 1) A metal foil shall be closely wrapped around the body of the capacitor to within a distance from the terminations equal to approximately 1 mm per kV test voltage. The test voltage shall be applied between the terminations connected together and this foil.
- 2) The capacitor shall be mounted in its normal manner on a metal plate, which extends at least 12.5 mm beyond the mounting face of the capacitor in all directions; the test voltage shall be applied between the terminations connected together and the metal plate.

1.2.4.2.2 There shall be no sign of breakdown or flash-over during the test period.

1.2.4.2.3 The appropriate section of this specification prescribes:

- 1) the test voltage, and points of application (see Appendix A),
- 2) the method of applying the test voltage, either 1) or 2) of **1.2.4.2.1**,
- 3) the duration of the test,
- 4) the maximum charging and discharging current,
- 5) when applicable, the maximum value of the time constant $R_1 (C_1 + C_x)$