

Harmonized system of quality assessment for electronic components — Potentiometers for use in electronic equipment — Generic specification

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Committees responsible for this British Standard

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- British Telecommunications plc
- Electronic Components Industry Federation
- Electronic Engineering Association
- Ministry of Defence
- National Supervising Inspectorate
- Society of British Aerospace Companies Ltd.
- Telecommunication Engineering and Manufacturing Association

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National foreword

This British Standard has been prepared under the direction of the Electronic Components Standards Policy Committee. It is identical with IEC Publication 393-1 [QC 410000] “*Potentiometers for use in electronic equipment. Part 1: Generic specification*” published in 1989, as amended by Amendment 1 (1992), by the International Electrotechnical Commission (IEC).

This standard is a harmonized specification within the IECQ system of quality assessment for electronic components.

Cross-references. The British Standard harmonized with QC 001001 and QC 001002 is BS 9000 “*General requirements for a system for electronic components of assessed quality*” Part 3:1987 “*Specification of IECQ basic rules and rules of procedure for national implementation*”.

International Standard	Corresponding British Standard
ISO 3:1973	BS 2045:1965 <i>Preferred numbers</i>
ISO 497:1973	(Technically equivalent)
ISO 1000:1981	BS 5555:1981 <i>Specification for SI units and recommendations for the use of their multiples and of certain other units</i>
	(Identical)
IEC 62:1974	BS 1852:1975 <i>Specification for marking codes for resistors and capacitors</i>
	(Identical)
IEC 63:1963	BS 2488:1966 <i>Schedule of preferred numbers for the resistance of resistors and the capacitance of capacitors for telecommunication equipment</i>
	(Technically equivalent)
IEC 68	BS 2011 <i>Environmental testing</i>
IEC 68-1:1978 ^a	Part 1.1:1980 <i>General and guidance</i>
	(Identical)
IEC 68-2-1:1974	Part 2.1A:1977 <i>Tests A. Cold</i>
	(Identical)
IEC 68-2-1A:1976	Amendment 1
	(Identical)
IEC 68-2-2:1974	Part 2.1B:1977 <i>Tests B. Dry heat</i>
IEC 68-2-2A:1976	(Identical)
IEC 68-2-3:1969	Part 2.1Ca:1977 <i>Test Ca. Damp heat, steady state</i>
	(Identical)
IEC 68-2-6:1982	Part 2.1Fc:1983 <i>Test Fc. Vibration (sinusoidal)</i>
	(Identical)
IEC 68-2-13:1966	Part 2.1M:1977 <i>Test M. Low air pressure</i>
	(Identical)
IEC 68-2-14:1974	Part 2.1N:1977 <i>Test N. Change of temperature</i>
	(Identical)
IEC 68-2-17:1968	Part 2.1Q:1981 <i>Test Q. Sealing</i>
	(Identical)
IEC 68-2-20:1979	Part 2.1T:1981 <i>Test T. Soldering</i>
	(Identical)
IEC 68-2-21:1975	Part 2.1U:1977 <i>Test U. Robustness of terminations and integral mounting devices</i>
IEC 68-2-27:1972	Part 2.1Ea:1977 <i>Test Ea. Shock</i>
	(Identical)
IEC 68-2-29:1968	Part 2.1Eb:1977 <i>Test Eb. Bump</i>
	(Identical)

^a Now superseded by IEC 68-1:1982, the corresponding identical British Standard for which is BS 2011-1.1:1983 “*General and guidance*”.

International Standard	Corresponding British Standard
IEC 68-2-30:1980	Part 2.1Db:1981 <i>Test Db and guidance. Damp heat, cyclic (12 + 12 hour cycle)</i> (Identical)
IEC 68-2-45:1980	Part 2.1XA:1981 <i>Text XA and guidance. Immersion in cleaning solvents</i> (Identical)
IEC 410:1973	BS 6001:1972 <i>Sampling procedures and tables for inspection by attributes</i> (Technically equivalent)

There are no corresponding British Standards for IEC 27-1:1971, IEC 50 and IEC 117 which are all referred to in clause 2. As the standards are referred to for information only, the validity of this British Standard is not affected.

British Standards related to IEC 27-1:1979 and IEC 117 are, respectively, BS 5775 Specification for quantities, units and symbols and BS 4727 Glossary of electrotechnical, power, telecommunications, electronics, lighting and colour terms.

Foreword

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

Preface

This standard has been prepared by IEC Technical Committee No. 40: Capacitors and Resistors for Electronic Equipment.

The text of this standard is based upon the following documents:

Six Months' Rule	Report on Voting	Two Months' Procedure	Report on Voting
40(CO)506	40(CO)583	40(CO)600 40(CO)679	40(CO)660 40(CO)687

Further information can be found in the relevant Reports on Voting indicated in the table above.

This standard replaces the first edition of IEC Publication 393-1 (1973) and the first supplement, IEC Publication 393-1A (1977); the second supplement, IEC Publication 393-1B (1978) and the third supplement, IEC Publication 393-1C (1979).

The QC number that appears on the front cover of this publication is the specification number in the IEC Quality Assessment System for Electronic Components (IECQ).

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 vi, pages 1 to 64, an inside back cover 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. Scope

1 Scope

This standard is applicable to all types of resistive potentiometers, including lead-screw actuated types, presets, multi-turn units, etc. to be used in electronic equipment.

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications for Qualification Approval and Quality Assessment Systems for electronic components.

It has been mainly written, and the test methods described, to conform with the widely used single turn rotary potentiometer with a control spindle.

For other types of potentiometers:

- the angle of rotation may be several turns;
- the reference to a control spindle shall apply to any other actuating device;
- the angular rotation shall be taken to mean mechanical travel of the actuating device;
- a value for force shall be prescribed instead of a value for torque if the actuating device moves in a linear instead of a rotary manner.

These alternative prescriptions will be found in the sectional or detail specification.

When a component is constructed as a variable resistor, i.e. as a 2-terminal device, the detail specification shall prescribe the modifications required in the standard tests.

Section 2. General

2 General

2.1 Related documents

IEC Publications:

Publication 27-1 (1971)	Letter Symbols to be Used in Electrical Technology. Part 1: General.
Publication 50	International Electrotechnical Vocabulary (I.E.V.).
Publication 62 (1974)	Marking Codes for Resistors and Capacitors.
Publication 63 (1963)	Preferred Number Series for Resistors and Capacitors. Amendment No. 1 (1967) Amendment No. 2 (1977)
Publication 68	Basic Environmental Testing Procedures.
Publication 68-1 (1978)	Part 1: General.
Publication 68-2-1 (1974) 68-2-1A (1976)	Tests A: Cold First supplement.
Publication 68-2-2 (1974) 68-2-2A (1976)	Tests B: Dry heat First supplement.
Publication 68-2-3 (1969)	Test Ca: Damp Heat, Steady State. Amendment No. 1 (1984).
Publication 68-2-6 (1970)	Test Fc: Vibration (sinusoidal). Amendment No. 2 (1985).
Publication 68-2-13 (1966)	Test M: Low Air Pressure.
Publication 68-2-14 (1974)	Test N: Change of Temperature.
Publication 68-2-17 (1968)	Test Q: Sealing.
Publication 68-2-20 (1979)	Test T: Soldering.
Publication 68-2-21 (1983)	Test U: Robustness of Terminations and Integral Mounting Devices. Amendment No. 1 (1985)
Publication 68-2-27 (1972)	Test Ea: Shock.
Publication 68-2-29 (1968)	Test Eb: Bump.
Publication 68-2-30 (1980)	Test Db: Damp Heat, Cyclic (12 + 12-hours cycle).
Publication 68-2-45 (1980)	Test XA and guidance: Immersion in cleaning solvents.
Publication 117	Recommended Graphical Symbols.
Publication 390 (1972)	Dimensions of Spindle Ends for Manually Operated Electronic Components.
Publication 410 (1973)	Sampling Plans and Procedures for Inspection by Attributes.
Publication QC 001001 (1986)	Basic Rules for the IEC Quality Assessment System for Electronic Components (IECQ).
Publication QC 001002 (1986)	Rules of Procedure for the IEC Quality Assessment System for Electronic Components (IECQ).

ISO Standards:

ISO 3 (1973)	Preferred Numbers — Series of Preferred numbers.
ISO 497 (1973)	Guide to the Series of Preferred Numbers and of Series Containing more Rounded Values of Preferred Numbers.
ISO 1000 (1973)	SI Units and Recommendations for the Use of their Multiples and of Certain Other Units.

NOTE The above references apply to the current editions except for IEC Publication 68, for which the referenced edition shall be used.

2.2 Units, symbols and terminology

2.2.1 General

Units, graphical symbols, letter symbols and terminology shall, whenever possible, be taken from the following publications:

- ISO Standard 1000
- IEC Publication 27
- IEC Publication 117
- IEC Publication 50

When further items are required they shall be derived in accordance with the principles of the documents listed above.

2.2.2 Type

A group of components having similar design features and the similarity of whose manufacturing techniques enables them to be grouped together either for qualification approval or for quality conformance inspection.

They are generally covered by a single detail specification.

NOTE 1 Components described in several detail specifications may, in some cases, be considered as belonging to the same type and may therefore be grouped together for qualification approval and for quality conformance inspection.

NOTE 2 Mounting accessories are ignored provided they have no significant effect upon the test results.

2.2.3 Style

A sub-division of a type, generally based on dimensional factors.

A style may include several variants, generally of a mechanical order.

2.2.4 Grade

A term to indicate additional general characteristics concerning the intended application e.g. long life applications.

The term “grade” may only be used in combination with one or more words (e.g. long-life grade) and not by a single letter or number.

Figures to be added after the term “Grade” should be arabic numerals.

2.2.5 Variant

A sub-division within a style having specific dimensions for some part of its construction, e.g. terminations, spindle flats or length.

2.2.6 Family (of electronic components)

A group of electronic components which predominantly displays a particular physical attribute and/or fulfils a determined function.

2.2.7 Sub-family (of electronic components)

A group of components within a family manufactured by similar technological methods.

2.2.8 Category temperature range

The range of ambient temperatures for which the potentiometer has been designed to operate continuously; this is defined by the temperature limits of its appropriate category.

2.2.9 Upper category temperature

The maximum ambient temperature for which a potentiometer has been designed to operate continuously at that portion of the rated dissipation which is indicated in the category dissipation (See Sub-clause 2.2.14).

2.2.10 Lower category temperature

The minimum ambient temperature for which a potentiometer has been designed to operate continuously.

2.2.11 Critical resistance

That resistance value at which the rated voltage is equal to the limiting element voltage. Below the critical resistance the maximum voltage which may be applied across the terminations of a potentiometer is the rated voltage. Above that value the maximum voltage is the limiting element voltage (See Sub-clauses 2.2.13, 2.2.15 and 2.2.16).

2.2.12 Rated resistance

The rated resistance is the resistance value marked upon the potentiometer.

2.2.13 Rated dissipation

The maximum allowable dissipation between terminations a and c (see Sub-clause 2.2.30) of a potentiometer at an ambient temperature of 70 °C under the conditions of the electrical endurance test at 70 °C which will result in a change in resistance not greater than that specified for that test.

NOTE In practice the dissipation is modified by the following conditions:

- For high values of resistance the limiting element voltage (Sub-clause 2.2.16) may prevent the rated dissipation being attained.
- For the dissipation at temperatures other than 70 °C, reference should be made to the rating graphs in the relevant detail specification.
- For situations where only terminations a and b or b and c are being used and the control spindle is set at an angle less than 100 % of the effective electrical travel. In this case the limiting moving contact current (Sub-clause 2.2.18) should also be taken into account.

2.2.14 Category dissipation

The maximum allowable dissipation under continuous load at an ambient temperature equal to the upper category temperature and is normally expressed as a percentage of the rated dissipation.

NOTE The category dissipation may be zero.

2.2.15 Rated voltage

That d.c. or a.c. r.m.s. voltage calculated from the square root of the product of the rated resistance and the rated dissipation.

NOTE At high values of resistance, the rated voltage may not be applicable because of the size and construction of the potentiometer (see Sub-clauses 2.2.11, 2.2.13 and 2.2.16)

2.2.16 Limiting element voltage

The maximum d.c. or a.c. r.m.s. voltage which may be applied across the element of a potentiometer.

When the term “a.c. r.m.s. voltage” is used in this specification the peak voltage shall not exceed 1.42 times the r.m.s. value.

NOTE This voltage shall only be applied to potentiometers when the resistance value is equal to or higher than the critical value.

2.2.17 Isolation voltage

The maximum peak voltage under continuous operating conditions which may be applied between the potentiometer terminations and other external conducting parts connected together.

The value of the isolation voltage shall be not less than 1.42 times the limiting element voltage at normal air pressure. Under conditions of low air pressure the value of the isolation voltage will be less and shall be given in the detail specifications.

2.2.18 Limiting moving contact current

The maximum current that may be passed between the resistive element and the moving contact.

2.2.19 Variation of resistance with temperature

The variation of resistance with temperature can be expressed either as a temperature characteristic or as a temperature coefficient as defined below:

2.2.19.1 Temperature characteristic of resistance

The maximum reversible variation of resistance produced over a given temperature range within the category temperature range. It is expressed normally as a percentage of the resistance related to a reference temperature of 20 °C.

Temperature characteristic of resistance = $\frac{\Delta R}{R}$

where:

ΔR is the change in resistance between the two specified ambient temperatures.

R is the resistance value at the reference temperature.

2.2.19.2 Temperature coefficient of resistance (α_R)

The relative variation of resistance between two given temperatures (mean coefficient), divided by the difference in temperature producing it. It shall preferably be expressed in parts per million per °C. ($10^{-6}/^\circ\text{C}$).

$$\alpha_R = \frac{R_2 - R_1}{R_1 \cdot \Delta\theta}$$

where:

$\Delta\theta$ is the algebraic difference, in degrees Celsius, between the reference temperature and the specified ambient temperatures.

NOTE It should be noted that use of the term does not imply any degree of linearity for this function, nor should any be assumed.

2.2.19.3 Temperature coefficient of output ratio (α_o)

The relative variation of voltage output ratio between two given temperatures (mean coefficient) at fixed values of setting and load of the moving contact, divided by the difference in temperature producing it. It shall be preferably be expressed in parts per million per °C.

$$\alpha_o = \frac{(U_{ab2}/U_{ac2}) - (U_{ab1}/U_{ac1})}{(U_{ab1}/U_{ac1}) \times \Delta\theta}$$

where $\Delta\theta$ is the algebraic difference, in degrees Celsius, between the reference temperature and the specified ambient temperature.

NOTE 1 The value of α_o may be different for different setting of the output ratio.

NOTE 2 It should be noted that the use of the term does not imply that the function exhibits any degree of linearity, nor should any be assumed.

2.2.20 Visible damage

Visible damage which reduces the usability of the potentiometer for its intended purpose.

2.2.21 Potentiometer

A component for use as a voltage divider with three terminations of which two are connected to the ends of a resistive element and the third to a moving contact which can be moved mechanically along the resistive element.

2.2.22 Pre-set or trimmer potentiometer

A potentiometer designed for relatively infrequent adjustment.

2.2.23 Lead-screw actuated potentiometer

A potentiometer having a lead-screw as multi-turn actuating device.

2.2.24 Ganged potentiometers

Potentiometers consisting of two or more sections operated by a common spindle. The number of sections shall be included in the description, e.g. 2-ganged potentiometer or 4-ganged potentiometer.

2.2.25 Dual concentric potentiometers

Potentiometers consisting of two sections operated independently by concentric spindles.

2.2.26 Spindle sealed potentiometer

A potentiometer in which a spindle seal is provided to prevent particles and fluid from passing from the exterior of the potentiometer to the interior by way of the spindle bearing. (see Figure 1).

2.2.27 Spindle sealed and panel sealed potentiometer

A potentiometer in which a spindle seal and a panel seal is provided to prevent particles and fluid from entering any equipment in which this potentiometer is mounted. (see Figure 2).

2.2.28 Container sealed potentiometer

A potentiometer in which a spindle seal is provided and the container housing of the potentiometer is designed to prevent particles and fluid from passing from the exterior of the potentiometer to the interior. (see Figure 3).

In some cases a panel seal may additionally be provided.

Such a potentiometer is called a “fully sealed potentiometer” (see Figure 4).

2.2.29 Direction of rotation

Rotation is defined as clockwise or anti-clockwise when viewing the face of the potentiometer which includes the means of actuation. When doubt exists, the reference face shall be marked in accordance with the detail specification.

2.2.30 Designation of terminations

The preferred designation of the three terminations of the potentiometer is:

- a is the end termination electrically nearest to the moving contact with the spindle set fully anticlockwise as defined in Sub-clause 2.2.29;
- b is the termination of the moving contact;
- c is the other end termination.

The numerals 1, 2 and 3 or colours yellow, red and green, may be used as alternatives to a, b and c respectively. When terminations are marked the marking shall be in accordance with this clause. Additional letters, numbers or colours for other terminations shall be allocated in the relevant specification.

2.2.31 Variable resistor

A resistor with a permanent contact at one end of the resistive element and a second contact which can be moved along the resistive element, causing a change in resistance.

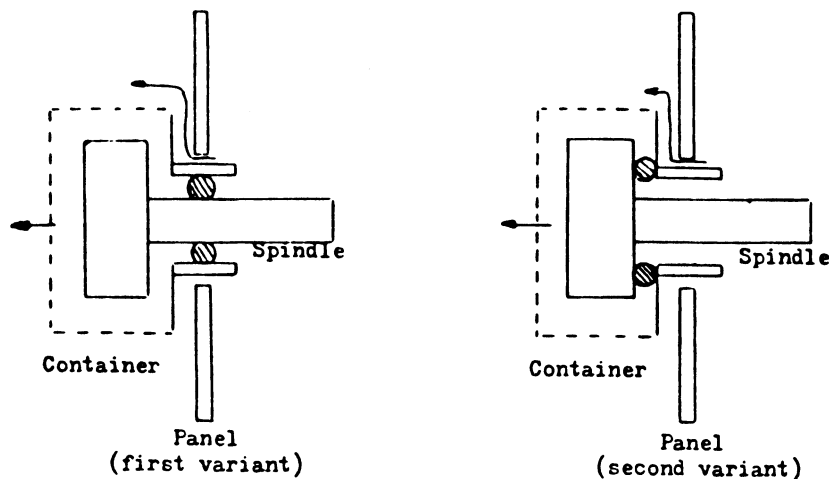
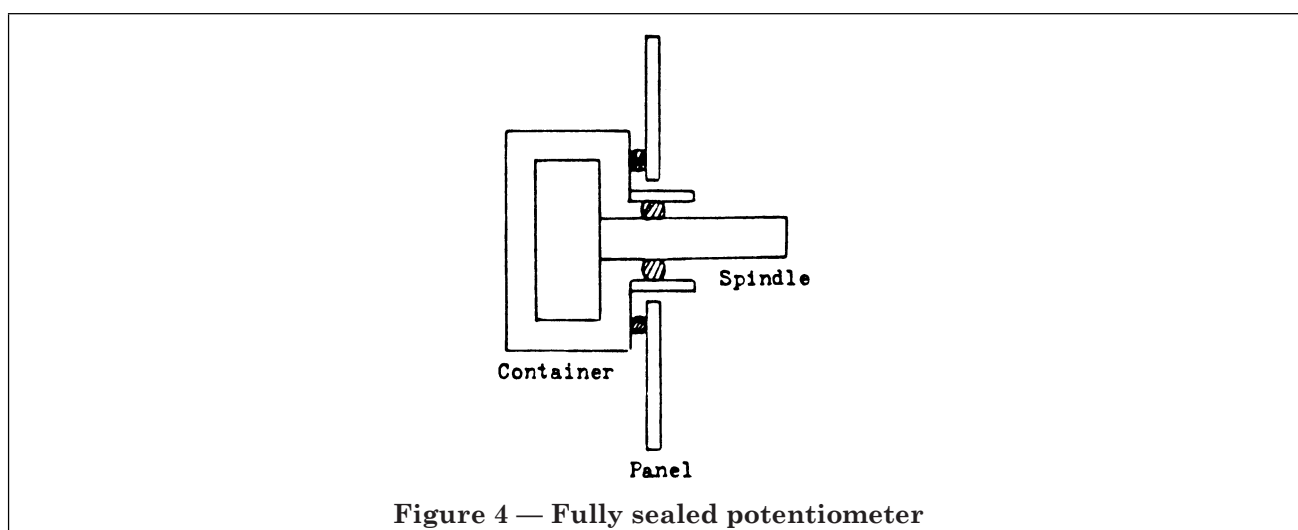
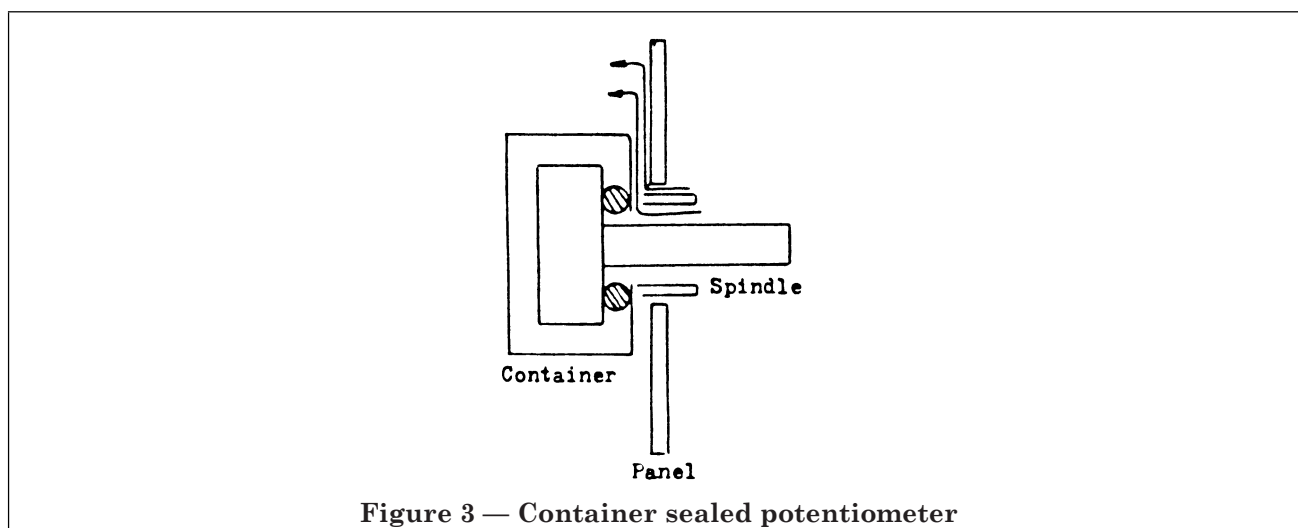
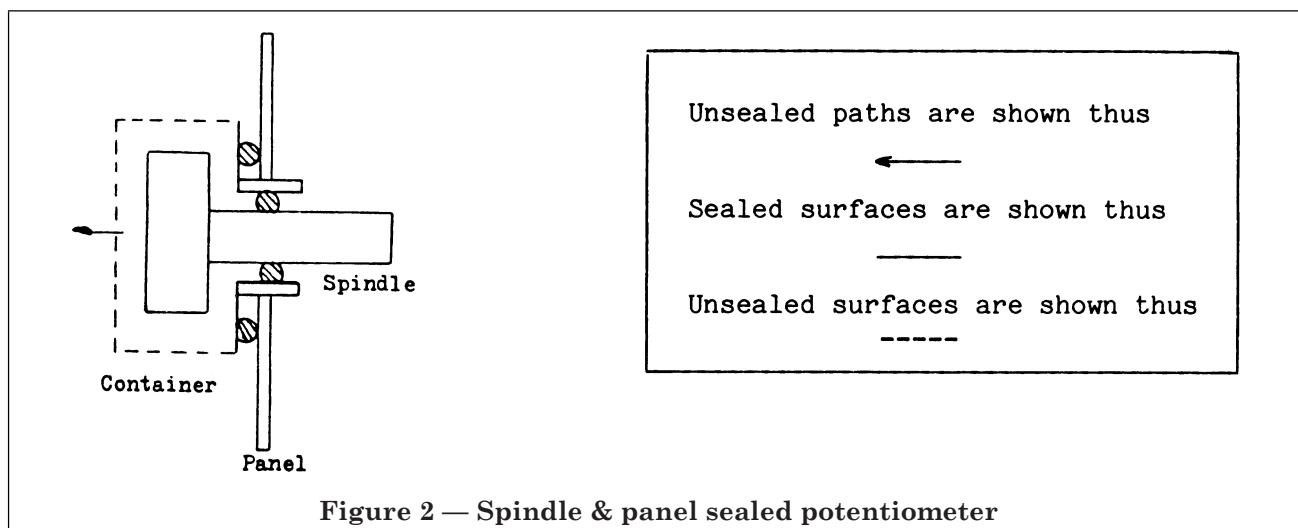


Figure 1 — Spindle sealed potentiometer



2.2.32 Moving contact

The contact of the potentiometer which moves along the resistive element.

2.2.33 Tap

A fixed electrical connection made to the resistive element.

2.2.34 Track

The contact path of the moving contact on the resistive element.

2.2.35 Declutching device

That device which allows continuous rotation of the actuating device after the moving contact has reached either end of the resistive element.

2.2.36 Number of turns (of an actuating device)

The total number of times the actuating device completes (or nearly completes) 360° of movement in covering the total mechanical travel.

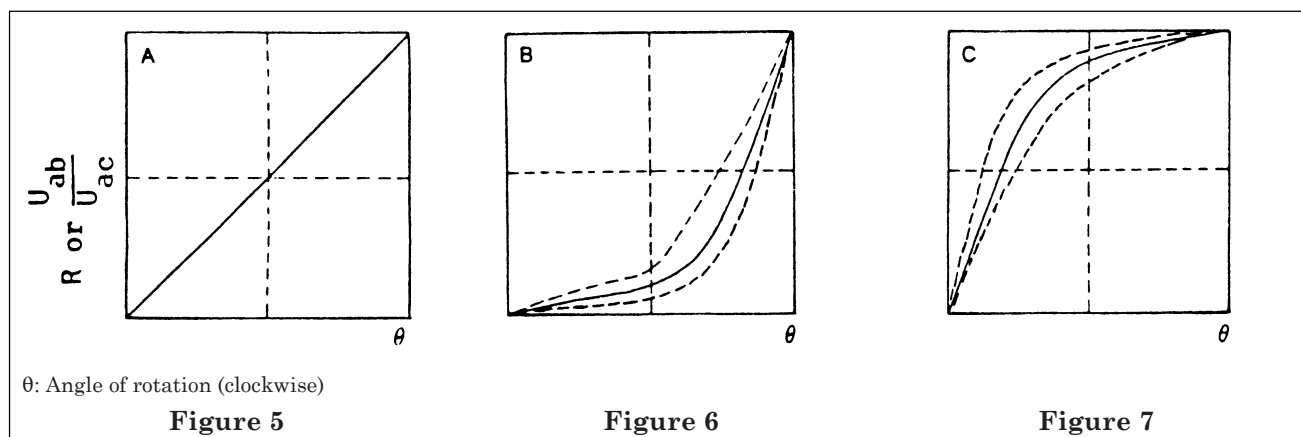
2.2.37 Resistance law

The relationship of the measured resistance value between terminations a and b or of the output ratio $\frac{U_{ab}}{U_{ac}}$ of the mechanical position of the moving contact.

2.2.37.1 Common potentiometer laws are classified as follows

- 1) Linear law: Law A (Figure 5)
- 2) Logarithmic law: Law B (Figure 6)
- 3) Inverse logarithmic law: Law C (Figure 7)

The sectional or detail specifications may permit, and prescribe the tolerances for, a rate of change of resistance near to the end of the effective travel less than that required by the prescribed law. It may also permit, and prescribe the tolerances for, approximations to the law of the form shown dotted in Figure 6 and Figure 7.



2.2.37.2 Laws other than the widely used Laws A, B and C listed in **2.3.37.1** (for example sine or co-sine) may be required for special applications. The law will then be prescribed in the sectional or detail specification.

2.2.38 Cycle of operation

For single and multi-turn potentiometers, a cycle of operation is defined as the travel of the moving contact from one end of the resistive element to the other and back.

For continuously rotating potentiometers, a cycle of operation is defined as two revolutions of 360° , in the same direction, of the moving contact.

2.2.39 Shorted-segment

A portion of the resistive element over which the output ratio remains constant within specified limits as the moving contact traverses the segment with a specified load resistance.

2.2.40 Terminal resistance

Terminal resistance is the minimum resistance which can be obtained between the termination connected to the moving contact b, and any other termination (see Sub-clause 2.2.30).

2.2.41 Residual resistance

The residual resistance is the resistance obtained between the end termination, a or c, and the termination of the moving contact b, when the moving contact is set against the relevant end stop (see Sub-clause 2.2.30).

NOTE When there is no sharp change of resistance between the end stop and the point where the minimum effective resistance is observed the residual resistance, the terminal resistance and the minimum effective resistance become the same. The lowest resistance value need not correspond with the mechanical end stop.

2.2.42 Load resistance (R_L) (see Figure 9)

The external resistance as seen by the output voltage (connected between the moving contact and either termination a or c).

2.2.43 Total applied voltage (U_{ac}) (see Figure 8)

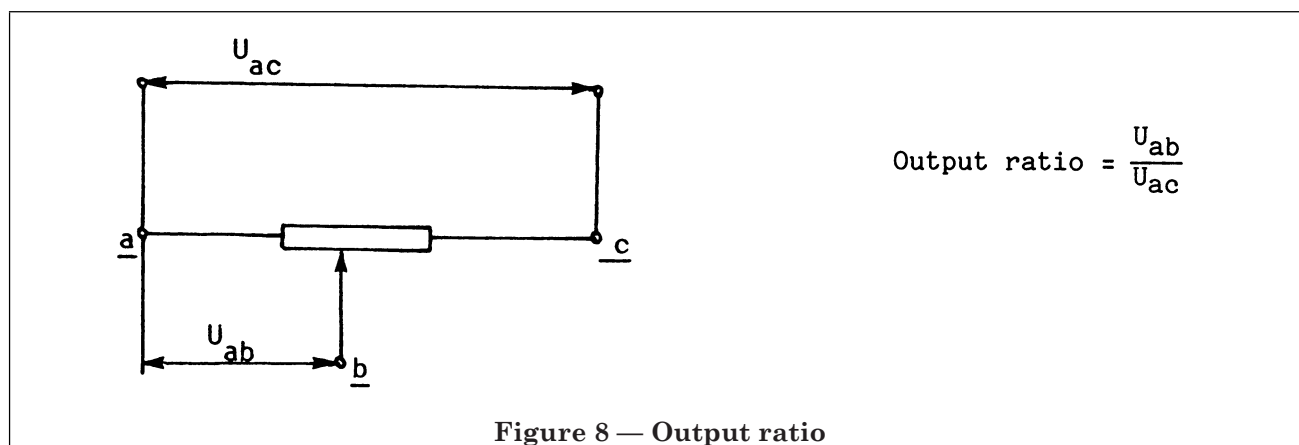
The voltage applied between input terminations, e.g. the voltage applied between input terminations a and c.

2.2.44 Output voltage (U_{ab}) (see Figure 8)

The voltage between termination b and the specified reference point. Unless otherwise specified, the specified reference point is termination a.

2.2.45 Output ratio (see Figure 8)

The ratio of the output voltage U_{ab} to the total applied voltage U_{ac} .



It is normally expressed as a percentage of the total applied voltage.

2.2.46 Minimum output ratio

The ratio of the minimum voltage value which can be obtained between the moving contact termination and one or other of the end terminations to a fixed voltage applied between the end terminations.

2.2.47 Attenuation

The reciprocal of the output ratio. It is normally expressed as $20 \log \frac{U_{ac}}{U_{ab}}$ dB.

2.2.48 Loading error (see Figure 9)

The difference between the output ratio with an infinite load resistance and the output ratio with a specified finite load resistance at any spindle position as long as it is the same position for both output ratio measurements.

NOTE Minimizing the loading error, by compensating the resistance element to give the desired output with a specified load resistance, is referred to as "load compensation".

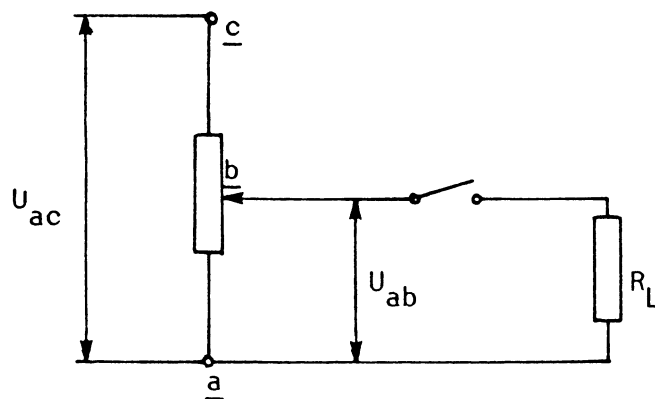


Figure 9 — Loading error

2.2.49 Resistance/travel relationships

The following definitions apply to two general constructions:

- 1) Potentiometers fitted with end stops or with declutching devices.
- 2) Single turn rotary potentiometers not fitted with end stops or declutching devices.

The amount of travel may be expressed in degrees, number of turns or millimetres.

For other constructions the detail specification shall redefine the terms or definitions.

NOTE The alternative terms given in parentheses in Sub-clauses 2.2.49.1, 2.2.49.3 and 2.2.49.4 are included for information only.

2.2.49.1 Total mechanical travel (total mechanical rotation) (see Figure 10)

In 1) above, the total mechanical travel is the value of the movement of the actuating device while the moving contact traverses the whole of its function between the two end stops or, the two positions at which the declutching device operates.

In 2) above, the total mechanical is travel 360° .

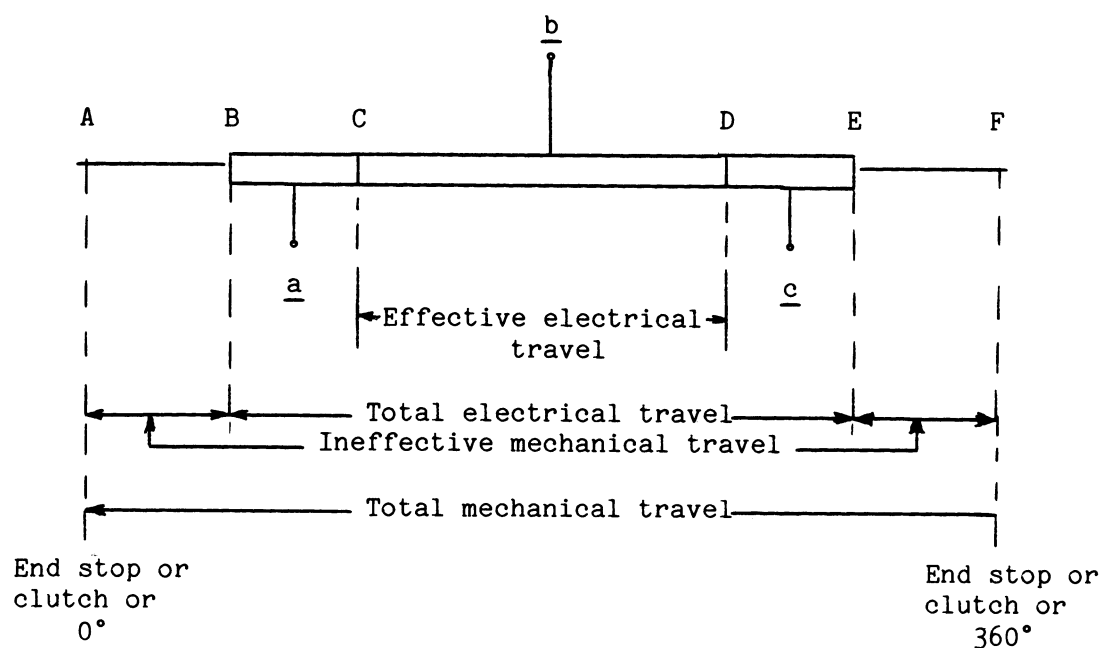


Figure 10

2.2.49.2 Total electrical travel (see Figure 10)

The amount of travel of the actuating device between two end positions during which there should not normally be any interruption in contact between the moving contact and the resistive element.

NOTE In 1) above, the end positions usually coincide with the end stops or the positions at which the declutching device operates, and the total electrical travel is therefore the same as the total mechanical travel.

2.2.49.3 Effective electrical travel (angle of effective electrical rotation)

The amount of travel of the actuating device necessary to move the moving contact in such a manner that the resistance changes as prescribed by the specified resistance law.

NOTE For some constructions of potentiometer, the effective electrical travel may be the same as the total electrical travel.

2.2.49.4 Ineffective mechanical travel (angle of ineffective mechanical rotation) (see Figure 10)

That part of the mechanical travel where the continuity between the moving contact and the resistance element cannot be guaranteed. It is equal to the difference between the total mechanical travel and the total electrical travel.

2.2.49.5 Total resistance

The total resistance is the resistance between terminations a and c (R_{ac}) when measured as described in Sub-clause 4.6.

2.2.49.6 Effective resistance

That portion of the total resistance over which the resistance changes in the manner prescribed by the specified resistance law.

2.2.49.7 Minimum effective resistance

The resistance value, at each end of the effective electrical travel, between termination b and the nearer end termination a or c (see Sub-clause 4.4.6), normally expressed as a percentage of the total resistance.

2.2.49.8 Continuity

The maintenance of electrical contact between the moving contact and the resistive element as a function of the mechanical travel of the moving contact.

2.2.49.9 Conformity (see Figure 11)

The maximum measured difference between the actual and the specified resistance law when it is expressed as a percentage of total resistance or total voltage applied.

NOTE Conformity may be expressed in different ways and must be clearly specified in the detail specification. Some methods of expressing conformity are shown in the following Sub-clauses.

2.2.49.10 Absolute conformity (see Figure 12)

The conformity measured over the specified effective electrical travel and is expressed as the maximum deviation of the actual from the specified resistance law.

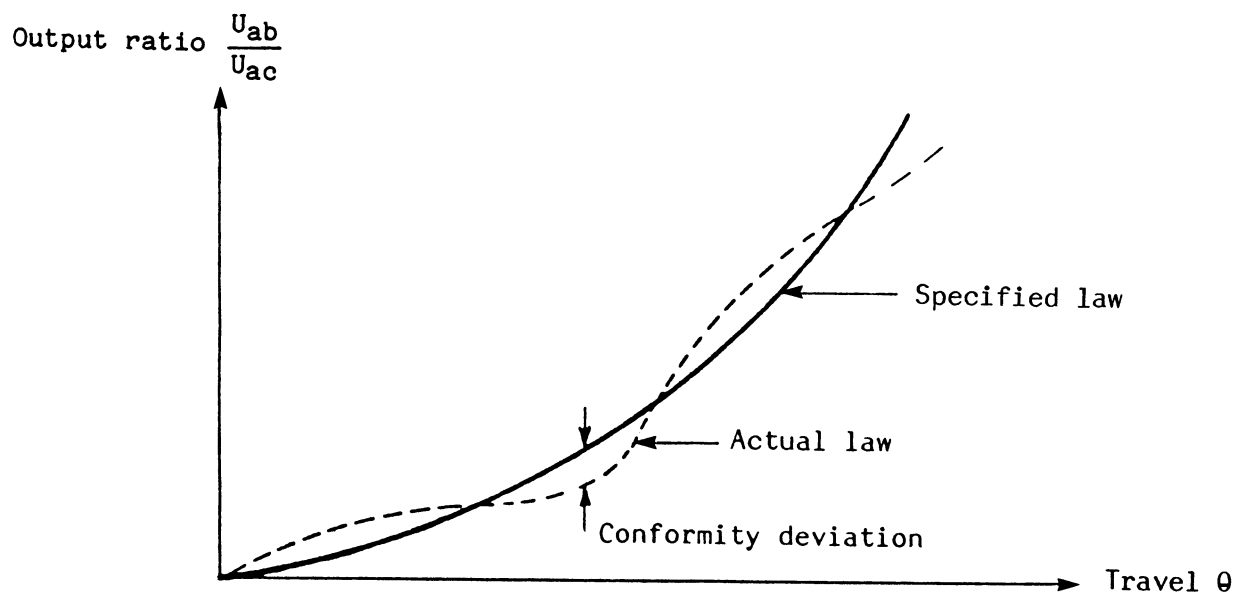


Figure 11 — Conformity

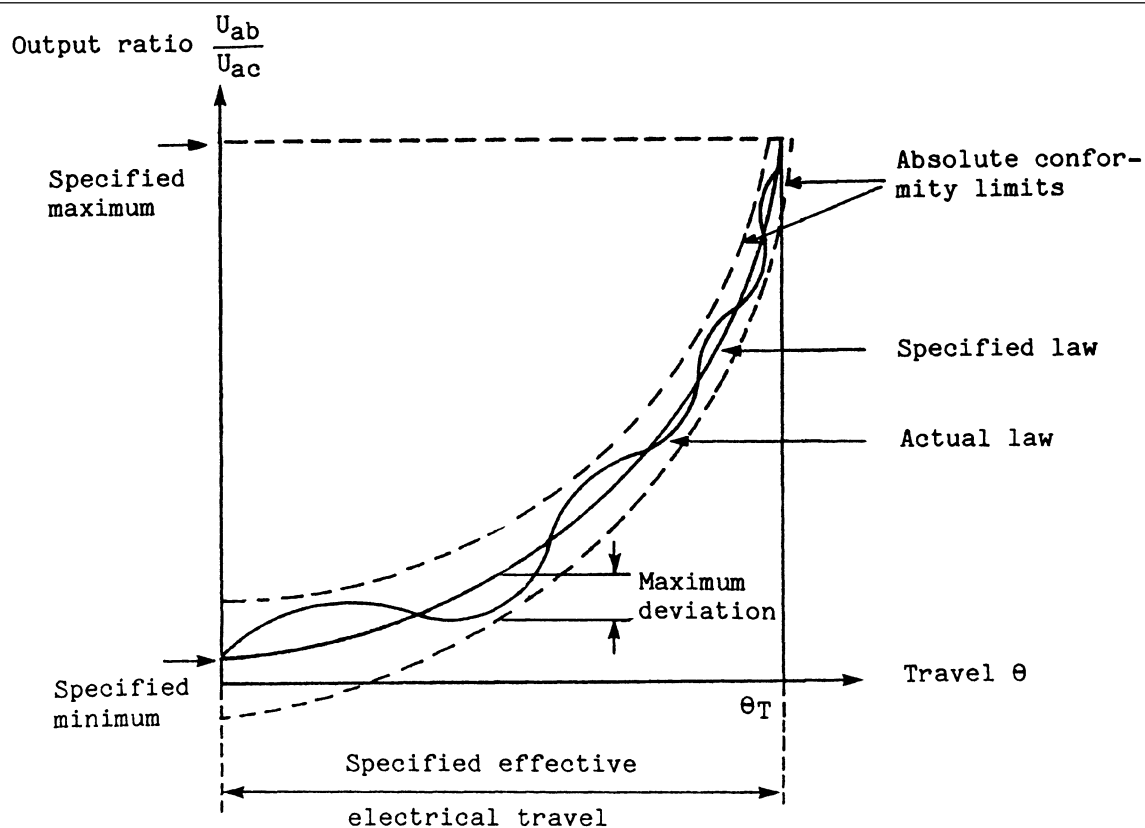
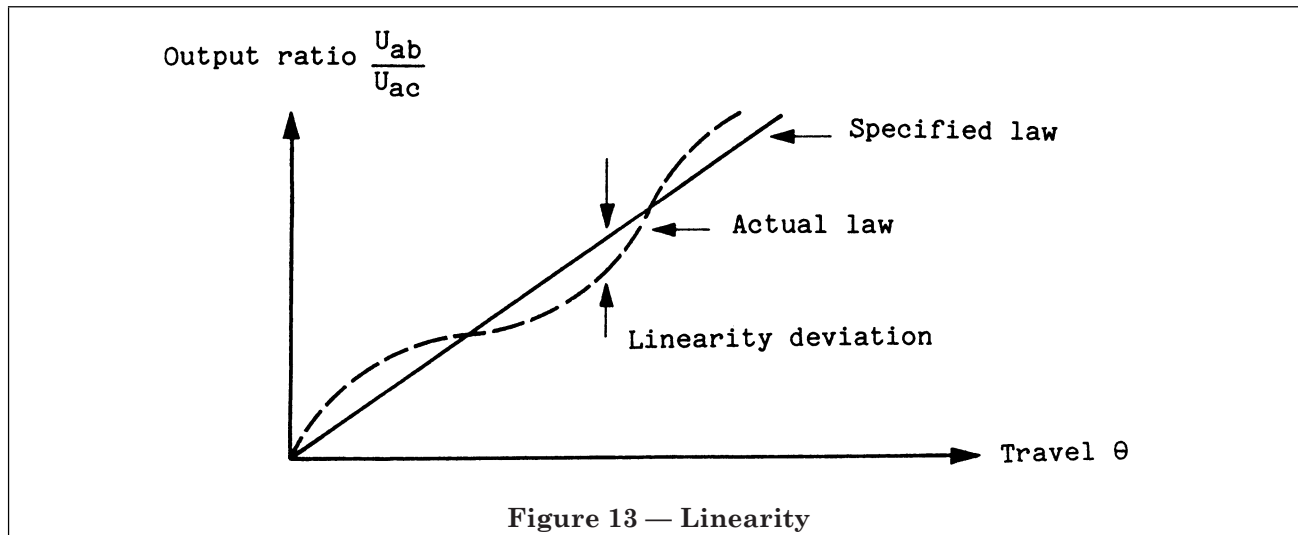


Figure 12 — Absolute conformity

2.2.49.11 Linearity (see Figure 13)

The specific type of conformity when the specified law or output ratio is shown as a straight line.



2.2.49.12 Independent linearity (best straight line) (see Figure 14)

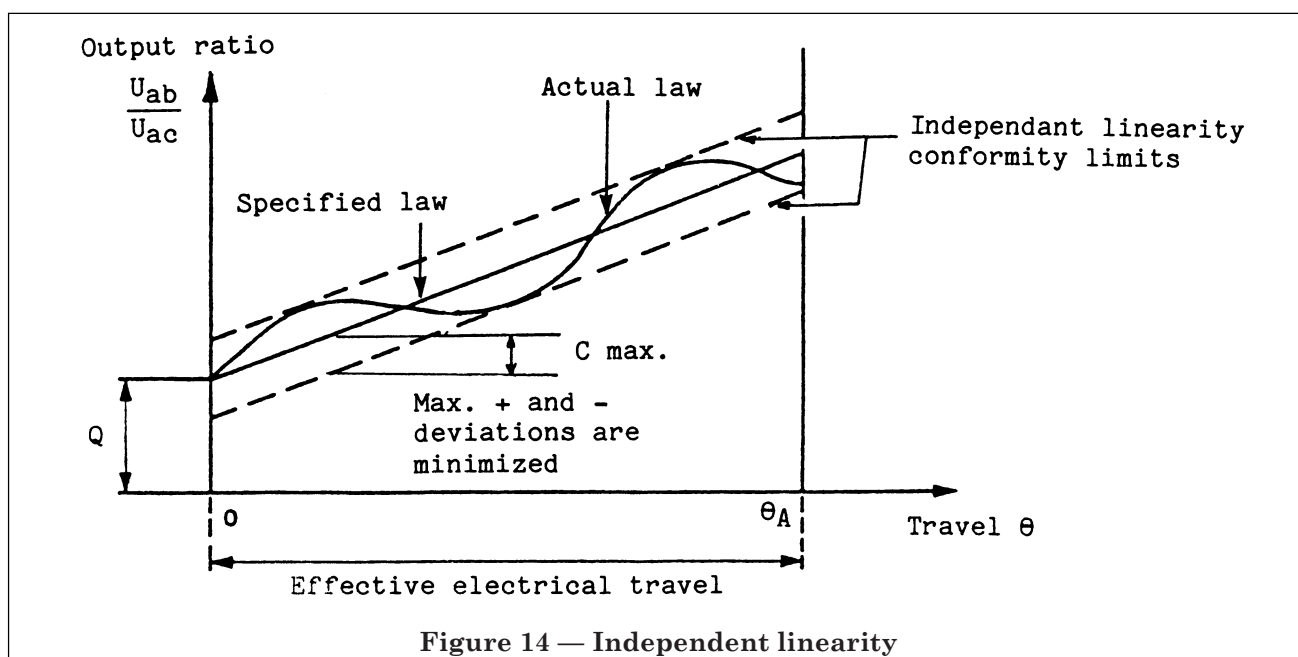
The specific type of conformity when the maximum vertical deviation, expressed as a percentage of the total applied voltage, of the actual law from a straight reference line with its slope and position is chosen to minimise deviations over the effective electrical travel, or any specified portion thereof.

NOTE Requirements for minimum and maximum output ratio, when specified, will limit the slope and position of the reference line.

$$\text{MATHEMATICALLY: } \frac{U_{ab}}{U_{ac}} = P \frac{\theta}{\theta_A} + Q \pm C$$

where:

P is the unspecified slope, Q is the unspecified intercept at $\theta = 0$, and where P and Q are chosen to minimise C but are limited by the output ratio requirement and θ_A is the amount of effective electrical travel.



2.2.49.13 Zero based linearity (see Figure 15) (for wirewound potentiometers only)

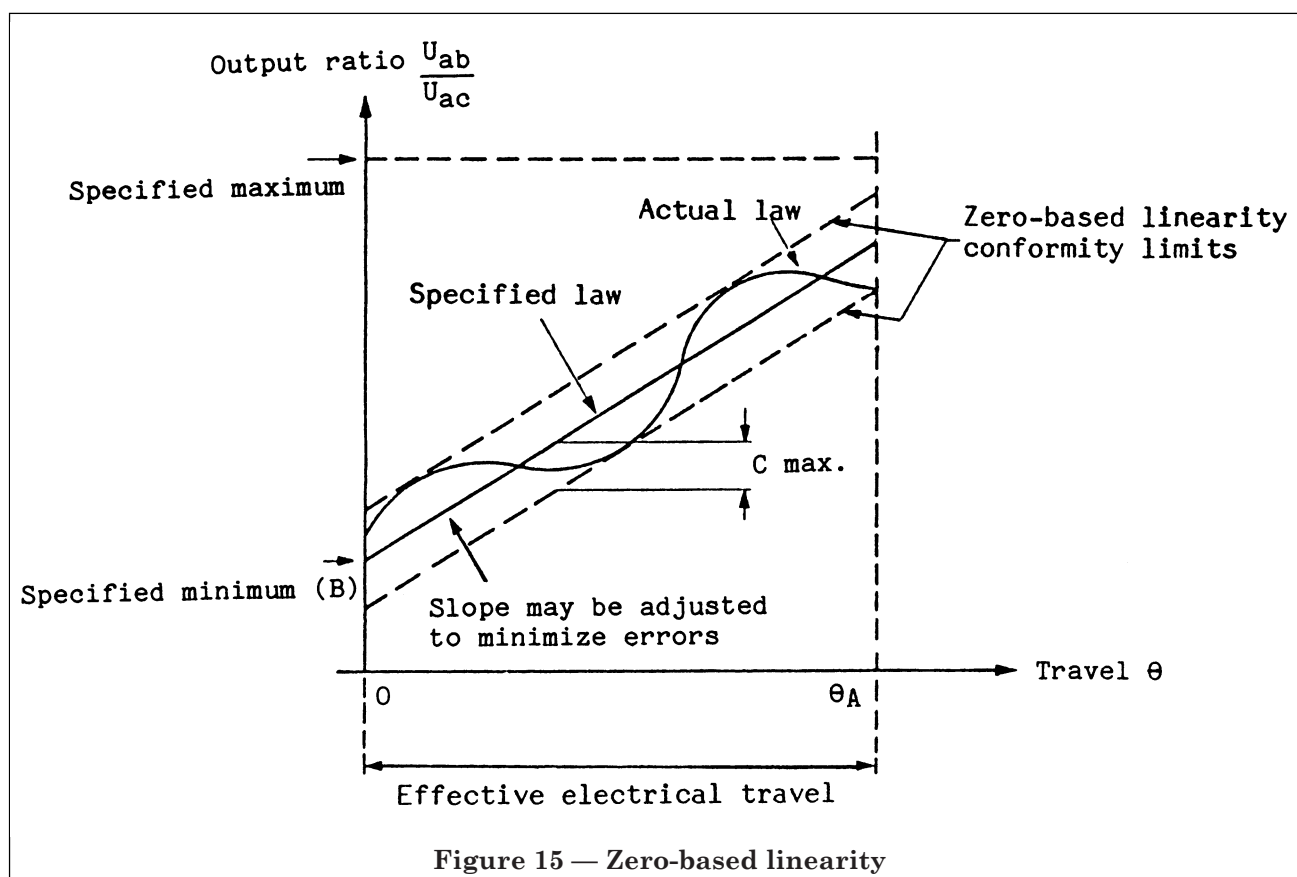
The specific type of conformity when the maximum vertical deviation, expressed as a percentage of total applied voltage, of the actual law from a straight reference line drawn through the specified minimum output ratio extended over the effective electrical travel, with its slope chosen to minimise the maximum deviations. Any specified requirement for maximum output ratio may limit the possibility to change the slope of the reference line. Unless otherwise specified, the specified minimum output ratio will be zero.

$$\text{MATHEMATICALLY: } \frac{U_{ab}}{U_{ac}} = P \frac{(\theta)}{\theta_A} + B \pm C$$

where:

P is the unspecified slope limited by the end voltage requirement at the maximum output ratio end; θ_A = amount of effective electrical travel.

Unless otherwise specified: $B = 0$

**2.2.49.14 Absolute linearity** (see Figure 16)

The specific type of conformity where the maximum vertical deviation, expressed as a percentage of the total applied voltage, of the actual law from a straight reference line drawn through the specified minimum and maximum output ratios which are separated by the specified effective electrical travel. Unless otherwise specified, minimum and maximum output ratios are respectively zero and 100 % of the total applied voltage.

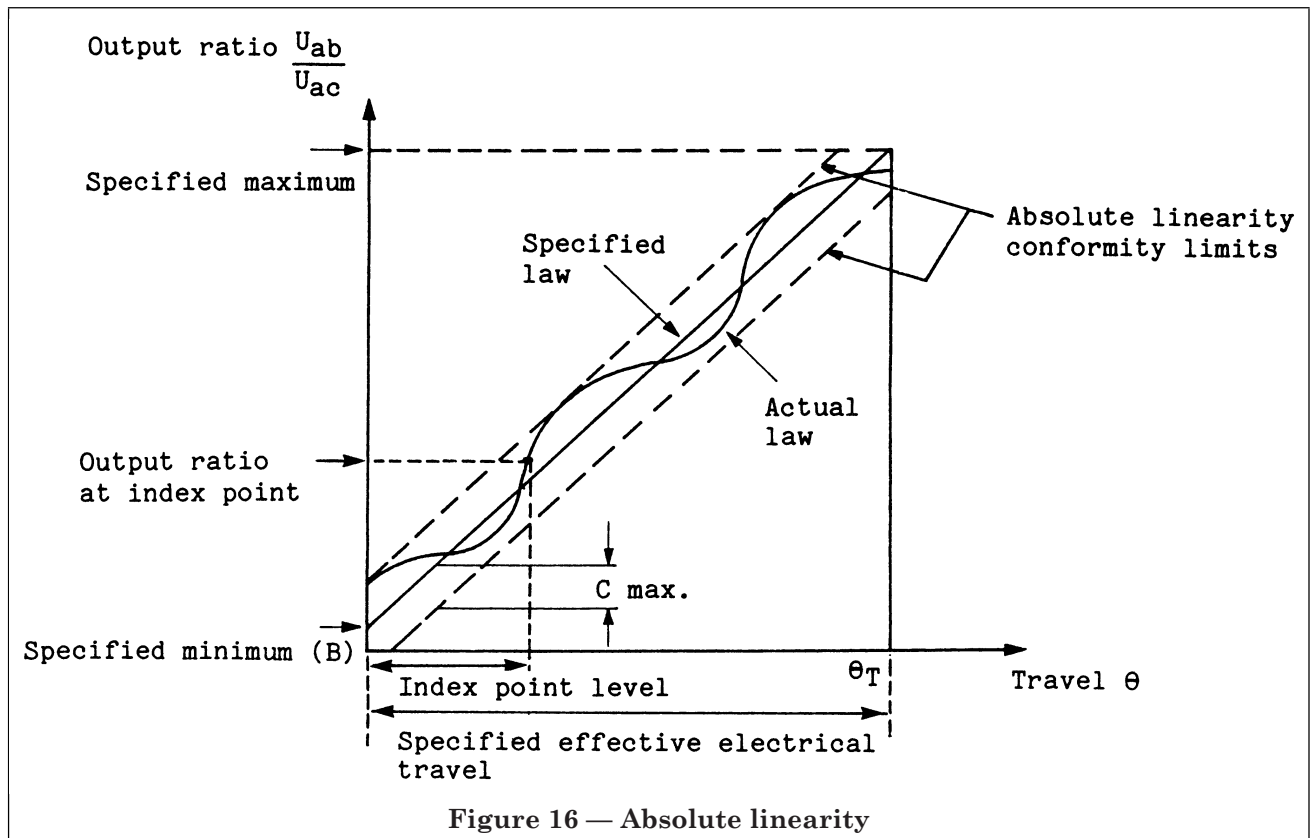
$$\text{MATHEMATICALLY: } \frac{U_{ab}}{U_{ac}} = A \frac{(\theta)}{\theta_T} + B \pm C$$

where:

A is the given slope, B is the given intercept at $\theta = 0$;

θ_T is the total specified effective electrical travel.

Unless otherwise specified $A = 1$ and $B = 0$.



2.2.49.15 Terminal based linearity (see Figure 17) (for wirewound potentiometers only)

The specific type of conformity where the maximum vertical deviation, expressed as a percentage of the total applied voltage, of the actual law from a straight reference line drawn through the specified minimum and maximum output ratios which are separated by the effective electrical travel. Unless otherwise specified, minimum and maximum output ratios are respectively, zero and 100 % of total applied voltage.

$$\text{MATHEMATICALLY: } \frac{U_{ab}}{U_{ac}} = A \frac{(\theta)}{\theta_A} + B \pm C$$

where:

A is the given slope; B is the given intercept at $\theta = 0$;

θ_A is the amount of effective electrical travel. Unless otherwise specified $A = 1$ and $B = 0$.