

Methods of

Measurement on radio receivers for various classes of emission —

Part 1: General considerations and methods of measurement, including audio-frequency measurements —

(Implementation of
CENELEC HD 560.1 S1:1990)

Committees responsible for this British Standard

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- British Broadcasting Corporation
- British Educational Equipment Association
- British Radio and Electronic Equipment Manufacturers' Association
- British Telecommunications plc
- Consumers' Association
- Institution of Electrical Engineers
- International Consumer Electronics Association
- Radio, Electrical and Television Retailers' Association
- Radiocommunications Agency

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National foreword

This British Standard has been prepared by Technical Committee EPL/12. It implements Harmonization Document HD 560.1 S1:1990 which was published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 315-1:1988, Second edition, *Methods of measurement on radio receivers for various classes of emission — Part 1: General considerations and methods of measurement, including audio-frequency measurements*, published by the International Electrotechnical Commission (IEC). This Part supersedes both BS 4054-1:1980 and BS 4054-2:1980, which are withdrawn.

This Part applies to radio receivers of any kind, excluding television receivers, and to the components which they comprise or which are used as auxiliaries to such receivers, excluding those dealt with in IEC Publications 94, 98 and 268. It covers determination of performance, comparison of equipment and determination of proper practical applications by listing the characteristics which are useful for specifications, and laying down uniform methods of measurement for these characteristics. The different characteristics and the relevant methods of measurement are described. Performance requirements in general are not specified.

To facilitate reproduction, some of the figures also include the French text. It is envisaged that other Parts of IEC Publication 315 will be published as identical British Standards in due course.

Cross-references

Publications referred to	Corresponding British Standard
	BS 397: <i>Primary batteries</i>
HD 211.1 (IEC 86-1)	Part 1:1989 <i>Specification for general requirements</i>
HD 211.2 S8 (IEC 86-2)	Part 2:1989 <i>Specification sheets</i>
HD 337 S3 (IEC 98)	BS 7063:1989 <i>Specification for analogue audio disk records and reproducing equipment</i>
IEC 68	BS 2011 <i>Environmental testing</i>
IEC 94	BS 6288 <i>Magnetic tape sound recording and reproducing systems</i>
IEC 268	BS 6840 <i>Sound system equipment</i>
IEC 417	BS 6217:1981 <i>Guide to graphical symbols for use on electrical equipment</i>
IEC 617	BS 3939 <i>Graphical symbols for electrical power, telecommunications and electronics diagrams</i>

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the HD title page, pages 2 to 38, 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.

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English version

Methods of measurement on radio receivers for various classes of emission

Part 1: General considerations and methods of measurement, including audio-frequency measurements

Méthodes de mesure applicables aux récepteurs radioélectriques pour diverses classes d'émission
Première partie: Considérations générales et méthodes de mesure, y compris mesures aux fréquences audioélectriques

Meßverfahren für Funkempfänger für verschiedene Sendearten
Teil 1: Allgemeine Bedingungen und Meßverfahren einschließlich Tonfrequenz-Meßverfahren

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This Harmonization Document exists in three official versions (English, French, German).

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

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Foreword

The English and French versions of this Harmonization Document are provided by the text of the IEC Publication and the German version is the official translation of the IEC text.

According to the CENELEC Internal Regulations the CENELEC member National Committees are bound:

to announce the existence of this Harmonization Document at national level by or before 1990-12-15

to publish their new harmonized national standard by or before 1991-06-15

to withdraw all conflicting national standards by or before 1991-06-15.

Harmonized national standards are listed on the HD information sheet, which is available from the CENELEC National Committees or from the CENELEC Central Secretariat.

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Section 1. General

1 Scope

This standard applies to radio receivers of any kind, excluding television receivers, and to the parts of which they are composed or which are used as auxiliaries to such receivers, excluding those dealt with in IEC Publications 94, 98 and 268.

This standard deals with the determination of performance, the comparison of equipment and the determination of proper practical applications by listing the characteristics which are useful for specifications and laying down uniform methods of measurement for these characteristics.

This standard is confined to a description of the different characteristics and the relevant methods of measurement; it does not in general specify performance requirements.

The complete standard consists of the following parts, in which the characteristics of various types of receiver and their methods of measurement are specified; some parts include preferred values:

- *Part 1: General considerations and methods of measurement, including audio-frequency measurements* [IEC Publication 315-1 (1988)].
- *Part 3: Radio-frequency measurements on receivers for amplitude-modulated emissions* [Publication 315-3 (1973)].
- *Part 4: Radio-frequency measurements on receivers for frequency modulated sound-broad-casting emissions* [Publication 315-4 (1982)].
- *Part 5: Specialized radio-frequency measurements. Measurements on frequency-modulated receivers of the response to impulsive interference* [Publication 315-5 (1971)].
- *Part 8: Radio-frequency measurements on professional receivers for frequency-modulated telegraphy systems* [Publication 315-8 (1975)].

The standard does not deal with safety, for which reference is required to IEC Publication 65 or other appropriate IEC safety standards, nor with radiation and immunity, for which reference is required to C.I.S.P.R. Publication 13.

2 Units and system of measurement

The International System of Units (SI-units) as indicated in IEC Publication 27 is used exclusively in this standard.

3 Frequencies of measurement

3.1 Audio-frequencies

If measurements are to be made at discrete frequencies, then these shall be the frequencies specified as preferred frequencies for acoustical measurements in ISO Standard 266, reproduced in Table I of this part. If a measurement relates to a reference audio-frequency, then, in the absence of a clear reason to the contrary, this shall be the standard reference frequency of 1 000 Hz.

If a measurement is to be made using only one signal frequency, the signal frequency shall be the chosen reference frequency. If measurements are to be made at a number of different frequencies, the chosen reference frequency shall be included, the other frequencies being so chosen that the results of the measurements give an adequate representation of the behaviour of the characteristics over the whole of the effective frequency range.

If measurements are to be made in frequency bands of constant relative bandwidth, preference shall be given to the one octave and one-third octave bands mentioned in Sub-clause 6.1.

3.2 Radio-frequencies

3.2.1 General

Where applicable, frequencies shall be chosen which are decimal multiples of those given in Table I. For some purposes it is necessary to use other frequencies, such as the intermediate frequency of the receiver, and frequencies at which spurious responses or other phenomena occur.

3.2.2 Measurements on receivers with restricted tuning range

Measurements at, or near, the extremes of the tuning range together with one or more frequencies in the middle of the range are normally adequate.

Further information is given in Clause 17 and Parts 3 and 4 of this standard.

4 Quantities to be specified and their accuracy

Unless otherwise stated, the terms “voltage”, “current”, etc, when used in this standard, refer to r.m.s. quantities. For most purposes it is sufficient to measure electrical quantities with an accuracy of ± 0.15 dB. The accuracy of measurement required depends only on the purpose for which the results are to be used.

5 Marking and symbols for marking

5.1 Marking

Terminals and controls shall be adequately marked to give information regarding their function, characteristics and polarity.

The marking shall be such that it is possible to adjust the controls and to identify their positions with sufficient accuracy in connection with the information given in the user instructions.

5.2 Symbols for marking

Marking should preferably be composed of letter symbols, signs, numbers and colours, which are internationally intelligible. Reference should be made to IEC Publications 27, 617 and 417.

Markings not included in the above-mentioned standards shall be clearly explained in the user instructions.

6 Filters, weighting curves and meters for noise specification and measurement

A specification of noise or signal-to-noise ratio shall refer to noise measured by one of the following methods:

6.1 Wide band measurement

The filter shall be a band-pass filter having a frequency response within the limits shown in Figure 1. (This is identical to the wide-band filter specification in CCIR Recommendation 468-4). A band-pass filter which has a substantially constant transmission factor between 22.4 Hz and 22.4 kHz, decreasing outside this frequency band at the rates specified for octave band filters having mid-band frequencies of 31.5 Hz and 16 000 Hz specified in IEC Publication 225, has a response falling within the limits of this specification.

NOTE Care should be taken when there may be strong signals just above or below the band-limits since in this case the results will depend, to some degree, on the individual frequency response of the filter actually used.

6.2 Weighted measurements

6.2.1 Noise (*A-weighting*) or signal-to-noise (*A-weighting*) ratio

The filter used shall have A-weighting characteristics with type I tolerances as specified for sound level measurements in IEC Publication 651. The meter shall be a true r.m.s. meter as described in Publication 651 for sound level meters type I; the dynamic characteristics designated “S” shall be used.

NOTE A-weighted measurements are particularly appropriate where the noise output from the equipment in the absence of a programme is concerned.

6.2.2 Noise (*psophometric*) or signal-to-noise (*psophometric*) ratio

The filter and meter used shall have the characteristics described in Appendix A, which are identical to those specified in CCIR Recommendation 468-4.

NOTE 1 The word “psophometric” may be abbreviated to “ps” (see CCITT Recommendation J.16), if this causes no confusion.

NOTE 2 Psophometric measurements are particularly appropriate where the disturbing effect of the noise output from the system in the presence of a programme is concerned.

6.2.3 Octave/third-octave band measurements

The filters shall have characteristics as specified for octave or third-octave band filters in IEC Publication 225. The meter shall be a true r.m.s. meter as described in IEC Publication 651 for sound level meters, type I. When measuring in narrow bands, particularly at low frequencies, it is recommended that the instruments should conform dynamically to the characteristics designated “S” for the sound level meter.

7 Rated values (see IEV 151-04-03) [IEC Publication 50 (151)]

In this standard, the word “rated” is used in a particular sense. Wherever it is used it means “the value stated by the manufacturer”. It always has this meaning even though it is used in two different kinds of technical terms, which are known as “rated conditions” and “rated values of characteristics” respectively.

7.1 Rated conditions

When an equipment is to be used or tested, it has to be operated under certain conditions which are fixed by the manufacturer. These conditions include electrical, mechanical and climatic conditions, and they cannot, by their nature, be verified by measurement.

Rated conditions for a particular type of equipment generally include some or all of the following:

— *Electrical*

- rated power supply voltage(s)
- rated power supply frequency
- rated source impedance(s)
- rated source e.m.f.(s)
- rated load impedance(s)

— *Mechanical*

- mounting position
- ventilation

— *Climatic*

- rated ambient temperature ranges for operation, and for full performance to specification
- rated humidity range
- rated air pressure range.

NOTE Ranges are defined by the extreme values, each of which may be regarded as a separate rated condition.

7.2 Rated value of a characteristic

In IEC Publication 315, methods of measurement are given for a wide range of characteristics. For each of these characteristics, the manufacturer is required or permitted to state a value in the specification of an equipment. This stated value is, by definition, the *rated* value of that characteristic (see Clause 7). The application, of the term “rated” in this sense is not restricted to a limited set of major characteristics but may be applied to *any* characteristic for which a method of measurement is given. Since the rated value is the value stated by the manufacturer, the defining title of the “characteristic to be specified” does *not*, in general, include the word “rated”; the rated value is not something which is measured but is decided by the manufacturer, taking into account measurements on many samples of the equipment and theoretical tolerance calculations.

For example, a method of measurement is referred to in this publication and described in IEC Publication 268-3 for the distortion-limited output power of an amplifier. The *rated* distortion-limited output power is the value stated by the manufacturer, usually calculated from measurements (according to the standard method) on several samples of the amplifier, supplemented by tolerance calculations.

7.3 Interdependent characteristics

It often happens that the value of one characteristic is required to be stated for a particular value of another characteristic. A prominent example is the noise-limited sensitivity of a receiver, which is stated for a particular value of signal-to-noise ratio.

In such cases, it is necessary to adopt one of the characteristics as a rated condition, and it is preferable to adopt that characteristic the rated value of which is either specified as a reference in a relevant IEC standard or is chosen by the manufacturer more or less arbitrarily within certain practical limits.

NOTE Applying the preferred criterion to the above-mentioned example, the rated signal-to-noise ratio (for which preferred values are given in Parts 3 and 4) is adopted as a rated condition, and the rated noise-limited sensitivity becomes the rated value of a characteristic.

7.4 Matching values

A knowledge of the values of certain basic characteristics of two items of equipment, which are to be connected together, is necessary in order to ensure compatibility. These values are known as matching values and are stated by the manufacturer for conditions defined in the relevant parts of the standard. Some matching values are also rated conditions.

8 Climatic conditions

Measurements and mechanical checks may be carried out at any combination of temperature, humidity and air pressure within the following limits:

Ambient temperature:	15 °C to 35 °C, preferably at 20 °C.
Relative humidity:	25 % to 75 %
Air pressure:	86 kPa to 106 kPa.

For equipment designed to be used in vehicles the ambient temperature limits are 5 °C to 45 °C.

If the manufacturer finds it necessary to specify climatic conditions differing from the above, these should be chosen from IEC Publication 68 and the measurements shall be made under these specified conditions.

The conditions mentioned above represent those under which the equipment is required to meet its specification. Over a wider range the equipment may operate but not meet all of its specifications and it may be permissible to store the equipment under much more extreme conditions. For a more complete discussion of these concepts, reference is required to IEC Publication 68.

9 Individual specification and type specification

Values may be specified either for a general type or for an individual sample of this type.

In the first case, the manufacturer shall state whether the specified values are:

- limits
- statistical “worst case” values (see note)
- average values (see note).

NOTE These values are derived from measurements on a batch and accompanied by the data required to render them significant; see ISO standards on sampling procedures.

10 Graphical presentation of data

10.1 General

The relation between two or more quantities is often more clearly presented as a graph rather than as a table.

When the results of a point by point measurement for an individual sample are presented as a continuous curve, the measured points shall be clearly indicated. Extrapolated or intermediate curves based on theoretical expectations or other information presented, but not based on direct measurement, shall be clearly distinguished from measurement curves, for example by another style of drawing.

Where appropriate, data may be presented as a line or band spectrum of constant bandwidth or constant proportional bandwidth. The bandwidth used shall be stated. Preference shall be given to one octave and one-third octave bands as mentioned in Sub-clause 6.1.

10.2 Scales

Linear or logarithmic scales are recommended for graphical presentation. Other kinds of scales, such as double logarithmic and combinations of linear and logarithmic, should be avoided. Linear decibel scales are equivalent to logarithmic scales.

Where quantities represented by abscissa and ordinate are of the same kind, the same unit length should be used for both. A remote zero point on linear scales should be avoided as far as possible. The zero reference on decibel scales should, if possible, be the rated value.

For logarithmic frequency scales and polar level diagrams used for presenting the results of audio-frequency measurements, reference is made to IEC Publication 263.

10.2.1 Logarithmic frequency scales

For graphs in which a level (in decibels) is plotted against frequency on a logarithmic scale, the scale proportions shall be those for which the length for a 10 : 1 frequency ratio is equal to the length for a level difference of 50 dB on the ordinate scale.

NOTE 1 The alternative values of level difference (10 dB and 25 dB) given in IEC Publication 263 may be used when appropriate.

NOTE 2 Logarithmic frequency scales are mostly used for plotting modulation frequency rather than carrier frequency.

10.2.2 Polar level diagrams

For polar plots in which a level in decibels is shown increasing outward along a radius on a linear scale, the maximum level shall preferably be plotted on, or within 2.5 dB of, the reference circle whose radius corresponds to a difference in level of 25 dB. The tolerance on the radius of the reference circle corresponds to ± 0.25 dB. These requirements apply for whatever length is chosen to represent 1 dB.

For an absolute level, when the radius of the reference circle corresponds to 25 dB, the level assigned to the reference circle shall be a multiple of 5 dB.

NOTE If it is necessary to plot a characteristic over a range greater than 25 dB, then a difference in level of 50 dB should be used.

11 Pre-conditioning

In order to ensure that when measurements begin the receiver characteristics do not change significantly with time, the receiver shall be operated under standard measuring conditions for a period of at least 10 min (for small battery-operated receivers) and preferably of at least 1 h (for larger receivers) before recording the results of any measurements.

12 Measurements in a uniform alternating low-frequency magnetic field

12.1 Method of producing a uniform alternating low-frequency magnetic field

A convenient and fairly accurate method of producing a uniform alternating magnetic field makes use of the arrangement of three square coils according to Figure 2. Dimension $a = 0.375 b$, where a is the distance between the coils and b the dimension of the side of each coil. The coils are supplied with a current at the required frequency. Between the three coils 1, 2 and 3 having turns in the ratios of

$$\frac{n_1}{100} = \frac{n_2}{36} = \frac{n_3}{100}$$

when the same current I flows through each coil in the same direction, a field is produced that may be considered to be uniform to within $\pm 2\%$, inside a spherical space having a diameter of $d = 0.5 b$, the centre of which coincides with the geometrical centre of coil 2.

The resulting magnetic field strength H and magnetic induction B will be approximately:

$$H = 1.35 \frac{n_1 I}{b} \text{ (A/m)} \quad B = 1.70 \frac{n_1 I}{b} \text{ (}\mu\text{T)}$$

The magnetic field strength shall be measured before the sample under test is placed in the magnetic field. This can be done with a search coil (see Appendix B).

12.2 Positioning the sample

The sample under test shall be placed in the magnetic field and the position of the sample relative to the pattern of the field shall be varied until the interference is at maximum.

The sample under test shall not project from the spherical space of diameter d .

13 Types of power supply and relevant measuring conditions

The following types of power supply are defined:

- Mains: any centralized a.c. or d.c. power source, usually having a rated voltage of more than 24 V.
- Batteries: accumulators, primary batteries or any similar energy sources such as solar batteries, thermo-electric cells, etc.

Batteries of the type, voltage and internal resistance specified for use with the receiver shall be employed; other sources, which essentially simulate the characteristics of those specified, may also be used and the substitute arrangements stated with the results.

Receivers intended for use on more than one type of power supply should be measured with each type of power supply.

NOTE In this respect, a.c. mains and d.c. mains are considered as different types of power supply.

To determine the influence of variations in the supply voltages on the characteristics, supplementary measurements may be carried out at overvoltages and undervoltages, these being chosen appropriately with due regard for the manufacturer's specifications.

13.1 Mains-operated receivers

13.1.1 The rated voltage at the rated frequency shall be applied to the receiver. For receivers with more than one rated operating voltage or frequency, a specified rated voltage, at a rated frequency, shall be applied.

13.1.2 Overvoltages and undervoltages

The rated voltage + 10 % and the rated voltage – 10 % at a rated frequency shall be applied.

For receivers with more than one rated operating voltage or frequency: the highest rated voltage + 10 % at the lowest rated frequency and the lowest rated voltage – 10 % at the highest rated frequency shall be applied; where tapings for a range of voltages are provided, the appropriate range shall be selected for the measurements.

13.2 Accumulator-operated receivers

13.2.1 Normal conditions

The normal operating voltage for accumulator batteries shall be 2.0 V per cell for lead batteries not under charge, 2.2 V per cell for lead batteries under charge and 2.4 V per cell for car batteries, measured at the terminals of the battery. If accumulators other than lead accumulators are used, the voltages per cell shall be chosen accordingly and stated with the results (see also Table II).

13.2.2 Overvoltages and undervoltages

The undervoltage for lead accumulators shall be 1.8 V per cell. The overvoltage for lead accumulators of motor cars shall be 2.6 V per cell. If accumulators other than lead accumulators are used, the undervoltage and overvoltage per cell shall be chosen accordingly and these stated with the results (see also Table II).

NOTE For batteries in vehicles, switching peaks of very short duration and greatly exceeding the normal operating voltage may occur, whilst at low operating temperatures higher continuous voltages may be encountered.

13.3 Primary battery-operated receivers

13.3.1 Normal conditions

The normal operating voltages for primary batteries are given in IEC Publication 86. The normal operating voltage for primary batteries of the Leclanché type is fixed at 1.5 V per cell; if other voltages apply, these shall be stated with the result.

13.3.2 Receivers with tubes — undervoltages

The undervoltage on load for primary batteries of the Leclanché type shall be 1.10 V per cell for batteries supplying filament voltage and 1.00 V per cell for batteries supplying anode voltage.

Normally, the undervoltage shall be obtained by using an adjustable resistor in series with fresh batteries or other sources of rated voltage having negligible internal resistance. The series resistor shall be adjusted once and for all, to obtain the specified undervoltage under conditions of maximum current demand by the receiver.

Alternatively, the undervoltage may be obtained in a similar way using an initial voltage source of a specified percentage, e.g. 20 %, below the rated voltage value, with an appropriately smaller value for the series resistance; the use of this method shall be explicitly stated with the results.

13.3.3 Receivers with semiconductor devices — undervoltages

The undervoltage on load for primary batteries of the Leclanché type shall generally be 0.90 V per cell. If required, additional tests at an undervoltage of 0.75 V per cell may be applied.

The undervoltage shall be obtained as indicated in Sub-clause 13.3.2.

13.4 Additional information

Table II gives a survey of the different overvoltages and undervoltages for various types of operation.

If, during operation at the extreme voltages specified in this section, the receiver is unstable or if the local oscillator fails, measurements shall be made at less extreme voltages. A clear statement of these conditions shall be added to the results.

13.5 Power and current consumption of receivers

The power and current consumption of receivers may be measured under otherwise standard measuring conditions for each of the following conditions:

- a) without a radio-frequency input signal (if the receiver is equipped with a muting circuit, this shall be in operation);
- b) with a radio-frequency input signal, modulated 30 % at the standard reference frequency, the receiver delivering one-eighth of the rated distortion limited output power.

The measurements may be repeated at overvoltages and undervoltages.

The type of power supply and the operating conditions during the measurements shall be stated.

14 Toleration of surge discharges of limited energy, applied to the antenna input circuit

14.1 Introduction

Receivers connected to an open antenna are liable to be damaged by surge discharges of limited energy to or from this antenna. Such surge discharges mainly occur during thunderstorms or, in the case of a car radio receiver, by discharging the body of the car, while the antenna is accidentally connected to earth by any means.

Direct lightning discharges are not dealt with in this section.

The ability of the input circuit of a receiver to endure surge discharges is measured by the highest surge voltage, expressed in kilovolts, or by the highest surge energy, expressed in microjoules, after which the receiver does not fail to function.

The energy that the receiver can withstand is dependent on the applied voltage. Therefore, a capacitor with a fixed value (1.5 nF) is chosen as a means of applying the surge. The value of the maximum permissible surge energy, together with the applied voltage, shall be stated by the manufacturer.

The applied voltage and the surge energy have a fixed interrelation according to the following formula:

$$E = 1/2 CU^2$$

where

E = surge energy, in joules

C = capacitance, in farads, and

U = applied voltage, in volts.

14.2 Method of test

The receiver shall be in operation, receiving any suitable signal by means of a small antenna having a capacitance of less than 10 pF, a connection to earth being applied if the receiver has an earth terminal.

A surge discharge device is also connected to the aerial and earth terminals of the receiver under test. The surge discharge device consists of a capacitor of 1.5 nF, earthed at one side, which in turn is charged by an adjustable voltage source (e.g. 0 to 10 kV), and discharged, through the input circuit of the receiver, by means of a switch or relay connected to the aerial terminal through a current-limiting resistor of 2 000 Ω . If the receiver does not have an earth terminal, it shall, in the case of a mains receiver, be operated from a supply which has one pole earthed. A battery receiver shall be placed on a metal sheet which shall be considered as earth. The receiver shall be insulated from the metal sheet by a thin (about 0.5 mm thick) dielectric material.

Figure 3 gives an example of the arrangement for measuring the toleration of surge discharges.

NOTE The switch or relay should have stray capacitances of 15 pF or less, between contacts C and D and from contact D to earth. Care is required in the design to avoid spurious effects due to contact bounce.

With the switch in the “charge” position C, the voltage source is adjusted for the specified voltage or for the voltage corresponding to the specified surge energy, whichever is applicable.

The switch (or the relay) shall then be manipulated at least ten times from the “charge” position C to the “discharge” position D and back.

If the receiver, after this series of discharges, is still in normal operating condition, it is deemed to pass the test for the applied d.c. polarity.

The test shall be repeated after reversing the polarity of the adjustable voltage source.

WARNING. — The aerial used for normal operation shall not be connected to the receiver, because its capacitance to earth would absorb part of the discharge energy.

The small aerial used for the test shall not be touched during the test and shall be discharged to earth when the measurements are completed, to avoid risk of shock.