BRITISH STANDARD

BS EN
61243-1:2005

Live working — Voltage detectors —

Part 1: Capacitive type to be used for voltages exceeding 1 kV a.c.

The European Standard EN 61243-1:2005 has the status of a British Standard

ICS 29.240.99

BSI
British Standards

National foreword

This British Standard is the official English language version of EN 61243-1:2005. It is identical with IEC 61243-1:2003. It supersedes BS EN 61243-1:1998 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/78, Tools for live working, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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EUROPEAN STANDARD **EN 61243-1**

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English version

Live working – Voltage detectors Part 1: Capacitive type to be used for voltages exceeding 1 kV a.c.

(IEC 61243-1:2003, modified)

Travaux sous tension – Détecteurs de tension Partie 1: Type capacitif pour usage sur des tensions alternatives de plus de 1 kV (CEI 61243-1:2003, modifiée)

Arbeiten unter Spannung – Spannungsprüfer Teil 1: Kapazitive Ausführung für Wechselspannungen über 1 kV (IEC 61243-1:2003, modifiziert)

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CENELEC

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Foreword

The text of the International Standard IEC 61243-1:2003, prepared by IEC TC 78, Live working, together with the common modifications prepared by the Technical Committee CENELEC TC 78, Equipment and tools for live working, was submitted to the formal vote and was approved by CENELEC as EN 61243-1 on 2005-03-01.

This European Standard supersedes EN 61243-1:1997 + A1:1997 + corrigendum June 1999.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2006-03-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2008-03-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61243-1:2003 was approved by CENELEC as a European Standard with agreed common modifications.

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INTRODUCTION

This International Standard has been prepared according to the requirements of IEC 61477, where applicable.

LIVE WORKING – VOLTAGE DETECTORS –

Part 1: Capacitive type to be used for voltages exceeding 1 kV a.c.

1 Scope

This part of IEC 61243 is applicable to portable voltage detectors, with or without built-in power sources, to be used on electrical systems for voltages of 1 kV to 765 kV a.c., and frequencies of 50 Hz and/or 60 Hz.

This part applies only to voltage detectors of capacitive type used in contact with the part to be tested, as a complete device including its insulating element or as a separate device, adaptable to an insulating stick which, as a separate tool, is not covered by this standard (see 4.4.1 for general design).

Other types of voltage detectors are not covered by this part of the standard.

Some restrictions on their use are applicable in the case of factory-assembled switchgear and on overhead systems of electrified railways (see Annex B, instructions for use).

NOTE Except where otherwise specified, all the voltages defined in this standard refer to values of phase-to-phase voltages of three-phase systems. In other systems, the applicable phase-to-phase or phase-to-earth (ground) voltages should be used to determine the operating voltage.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060-1:1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-1, *Environmental testing -Part 1: General and guidance*

IEC 60068-2-6:1995, *Environmental testing – Tests – Test Fc and guidance: Vibration (sinusoidal)*

IEC 60068-2-14:1984, *Environmental testing – Tests – Test N: Change of temperature*
Amendment 1 (1986)

IEC 60068-2-32:1975, *Environmental testing – Tests – Test Ed: Free fall*
Amendment 2 (1990)

IEC 60071-1:1993, *Insulation co-ordination – Part 1: Terms, definitions, principles and rules*

IEC 60417-DB:2002[1], *Graphical symbols for use on equipment*

IEC 60942, *Electroacoustics – Sound calibrators*

IEC 61260:1995, *Electroacoustics – Octave-band and fractional-octave-band filters*

IEC 61477:2001, *Live working – Minimum requirements for the utilization of tools, devices and equipment*
Amendment 1 (2002)[2]

IEC 61672-1:2002, *Electroacoustics – Sound level meters – Part 1: Specifications*

ISO 286-1:1988*, ISO system of limits and fits – Part 1: Bases of tolerances, deviations and fits*

ISO 286-2:1988*, ISO system of limits and fits – Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*

ISO 3744:1994, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering method in an essentially free field over a reflecting plane*

CIE (International Commission on Illumination) 15.2:1986*, Colorimetry*

3 Terms and definitions

For the purposes of this part of IEC 61243, the following terms and definitions apply.

3.1
voltage detector
portable device used to detect the presence or the absence of the operating voltage (high and low voltage at a.c. or d.c.) and used to verify that the installation is ready for earthing

NOTE These devices are generally described as either capacitive type or resistive type.

[Definition 11.2.5 of IEC 60743]

3.2
voltage detector of capacitive type
device whose operation is based on the current passing through the stray capacitance to earth (ground)

NOTE The term voltage detector is used in this document for voltage detector of capacitive type.

[1] "DB" refers to the IEC on-line database.

[2] There exists a consolidated edition 1.1 (2002) that includes edition 1 and its amendment.

3.3
designs of voltage detectors
different constructions of voltage detectors, either as a complete device with or without contact electrode extension, or as a separate device intended to be equipped with an insulating stick, with or without contact electrode extension

NOTE Some parts such as the contact electrode, the contact electrode extension (if existing), or the insulating element of a voltage detector as a complete device may be dismantled.

3.4
family of voltage detectors
voltage detectors that are identical in terms of design and dimensions and only differ by their nominal voltages (or nominal voltage ranges). A family of voltage detectors is limited by a minimum and a maximum voltage within which the nominal voltages (or voltage ranges) of the voltage detectors will be selected

3.5
contact electrode
bare conductive part of the conductive element which establishes the electric connection to the component to be tested

[IEV 651-10-09]

3.6
contact electrode extension
externally insulated conductive element between the indicator and the contact electrode, intended to achieve the correct position of the indicator relative to the installation being tested

3.7
indicator
part of the voltage detector which indicates the presence or absence of the operating voltage at the contact electrode

[IEV 651-10-08, modified]

3.8
adaptor
part of a voltage detector as a separate device which permits attachment of an insulating stick

3.9
insulating element
part of a voltage detector as a complete device that provides adequate safety distance and insulation to the user

3.10
insulating stick
separate tool attached to a voltage detector as a separate device in order to provide the length to reach the installation to be tested and adequate safety distance and insulation to the user

3.11
limit mark
distinctive location or mark to indicate to the user the physical limit to which the voltage detector may be inserted between live parts or may touch them

3.12
hand guard
distinctive physical guard separating the handle from the insulating element

NOTE Its purpose is to prevent the hands from slipping and passing into contact with the insulating element.

3.13
testing element
built-in or external device, by means of which the functioning of the voltage detector can be checked by the user

[IEV 651-10-11, modified]

3.14
accessories
items used to lengthen the handle or the contact electrode, to improve the efficiency of the contact electrode or to enable the contact electrode to reach the part to be tested

3.15
nominal voltage
U_n
suitable approximate value of voltage used to identify a system or device

[IEV 601-01-21, modified]

NOTE The nominal voltage of the voltage detector is the parameter associated with its clear indication. A voltage detector may have more than one nominal voltage, or a nominal voltage range. Limit values of the nominal voltage range are named U_n min and U_n max.

3.16
operating voltage (in a system)
value of the voltage under normal conditions, at a given instant and a given point of the system

NOTE This value may be expected, estimated or measured.

[IEV 601-01-22]

3.17
threshold voltage
U_t
minimum voltage between the live part and earth (ground) required to give a clear indication corresponding to specific conditions as defined in the corresponding test

NOTE As defined in this part of IEC 61243, threshold voltage is related to specific test conditions. Users should be aware that their requirements for threshold voltage for field operation need to be related to the test conditions in the standard.

3.18
rated voltage
U_r
value of voltage generally agreed upon by manufacturer and customer, to which certain operating specifications are referred. The rated voltage of the voltage detector is the voltage selected from IEC 60071-1, Tables 2 and 3, column 1, which should either be equal to the nominal voltage (or the highest nominal voltage of its nominal voltage range), or the next higher voltage selected from those tables

3.19
interference voltage
voltage picked up inductively or capacitively by the part to be tested

3.20
interference field
superposed electric field which may affect the indication. It may result from the part to be tested or other adjacent parts, and may have any phase relationship

NOTE The extreme cases for the tests are:

– an in-phase interference field exists when a small change of potential in the direction of the voltage detector axis results in an incorrect indication. This occurs as a result of the dimensions and/or configuration of the part of installation to be tested (or of adjacent parts of the installation having voltages in the same phase);

– an interference field in phase opposition exists when a strong change of potential in the direction of the voltage detector axis results in an incorrect indication. This occurs as a result of the adjacent parts of the installation having voltages in phase opposition.

3.21
active signal
audible or visual phenomenon whose presence, absence or variation is considered as representing information on the condition “voltage present” or “voltage not present”

[IEV 101-12-02, modified]

NOTE A signal indicating that the voltage detector is ready to operate is not considered an active signal.

3.22
clear indication
unambiguous detection and indication of the voltage state at the contact electrode

[IEV 651-10-10]

3.23
clear perceptibility
case where the indication is unmistakably discernible by the user under specific environmental conditions when the voltage detector is in its operating position

3.24
response time
time delay between sudden change of the voltage state on the contact electrode and the associated clear indication

3.25
protection against bridging
protection against flashover or breakdown, when the insulation between the parts of installation to be tested, at different potentials, is reduced by the presence of the voltage detector

3.26
stand-by state
state at which the voltage detector is ready to work without manual switching on

3.27
indoor type
voltage detector designed for use in dry conditions, normally indoors

3.28
outdoor type
voltage detector designed for use in wet conditions, either indoors or outdoors

3.29
type test
test performed on one or more items representative of the production, made to show that the product meets certain specifications

[IEC 61318, definition 3.10 and IEV 151-16-16 modified]

3.30
routine test
test performed on each item during or after manufacture to ascertain whether it complies with certain criteria

[IEC 61318, definition 3.11 and IEV 151-16-17 modified]

3.31
sampling test
test on a sample

[IEC 61318, definition 3.12 and IEV 151-16-20]

3.32
acceptance test
contractual test to prove to the customer that the item(s) or product in question meet(s) certain conditions of its specification

[IEC 61318, definition 3.13 and IEV 151-16-23 modified]

3.33
maintenance test
test carried out periodically on a device or equipment to ascertain and, if necessary, make certain adjustments to ensure that its performance remains within specified limits

[IEV 151-16-25 modified]

4 Requirements

4.1 General requirements

4.1.1 Safety

The voltage detector shall be designed and manufactured to be safe for the user, provided it is used in accordance with safe methods of work, and the instructions for use.

4.1.2 Indication

The voltage detector shall give a clear indication of the state "voltage present" and/or "voltage not present", by means of the change of the status of the signal. The indication shall be visual and/or audible.

4.2 Functional requirements

4.2.1 Clear indication

The voltage detector shall clearly indicate the presence and/or the absence of the system operating voltage as a function of the nominal voltage or nominal voltage range of the voltage detector, and its nominal frequency or nominal frequencies.

4.2.1.1 Threshold voltage

The indication “voltage present” shall appear if the voltage to ground on the part to be tested is within 45 % to 63 % of the nominal voltage.

The indication "voltage present" shall not appear if the voltage to ground on the part to be tested is less than 10 % of the nominal voltage.

To fulfil the above requirements, the threshold voltage U_t shall satisfy the following relationship:

$$0{,}10\ U_n\ \text{max} \leq U_t \leq 0{,}45\ U_n\ \text{min}$$

NOTE 1 45 % of the nominal voltage corresponds to $0{,}78 U_n/\sqrt{3}$ and 63 % corresponds to $1{,}1 U_n/\sqrt{3}$. 10 % of the nominal voltage corresponds to $0{,}17 U_n/\sqrt{3}$ and is the maximum phase to earth induced voltage normally encountered in the field.

NOTE 2 It may happen that the induced voltage level or the variations of the nominal voltage network are higher than these values. In this case, manufacturer and user should reach an agreement to set the appropriate value.

The user shall not have access to the threshold voltage setting.

4.2.1.2 Continuous indication

The voltage detector shall give continuous indication when in direct contact with a live part. It may not indicate in the vicinity of large conductive parts which create equipotential zones.

When the voltage detector is used in accordance with instructions for use, the presence of an adjacent live or earthed part shall not affect its indication.

When used in accordance with instructions for use, the voltage detector shall not indicate "voltage present" for usual values of interference voltages.

4.2.2 Clear perceptibility

The voltage detector shall give a clear indication under normal light and noise conditions.

The types of indications of voltage detector are divided into three groups:

– group I: Indication with at least two distinct active signals, which give an indication of the condition "voltage present" and "voltage not present". The "stand-by" state is not necessary;

– group II: Indication with at least one active signal, which gives an indication of the condition "voltage not present" and is activated by manually switching "on", and is suppressed when the contact electrode is put into contact with a live part;

– group III: Indication with at least one active signal, which gives an indication of the condition "voltage present", and shall have a stand-by state.

4.2.2.1 Visual indication

The indication shall be clearly visible to the user in the operating position and under normal light conditions.

When two visual signals are used, the indication shall not rely solely on lights of different colours for perceptibility. Additional characteristics, such as physical separation of the light sources, distinctive form of the light signals, or flashing light shall be used.

4.2.2.2 Audible indication

The indication shall be clearly audible to the user when in the operating position, and under normal noise conditions.

When two audible signals are used, the indication shall not rely solely on sounds of different sound pressure level for perceptibility. Additional characteristics, such as tone or intermittence of the audible signals shall be used.

4.2.3 Temperature and humidity dependence of the indication

There are three categories of voltage detectors according to climatic conditions of operation: cold (C), normal (N), and warm (W).

The voltage detector shall operate correctly in the temperature range of its climatic category, according to Table 1.

The voltage detector shall operate correctly in case of sudden change of temperature in the temperature range of its climatic category.

In these cases, the threshold voltage shall satisfy 4.2.1.1.

Table 1 – Climatic categories

Climatic categories		Climatic conditions ranges (operation and storage)	
		Temperature °C	Humidity %
(C)	Cold	–40 to +55	20 to 96
(N)	Normal	–25 to +55	20 to 96
(W)	Warm	–5 to +70	12 to 96

4.2.4 Frequency dependence

A voltage detector shall operate between 97 % and 103 % of its nominal frequency or of each of its nominal frequencies.

4.2.5 Response time

The response time shall be less than 1 s.

4.2.6 Power source dependability

A voltage detector with a built-in power source shall give a clear indication until the source is exhausted, unless its usage is limited by an indication of non-readiness or automatic shut-off,

as mentioned in the instructions for use.

4.2.7 Testing element

The testing element, whether a built-in or separate item, shall be capable of testing all the electrical circuits, including energy source and the functioning of the indication. When all circuits cannot be tested, any limitation shall be clearly stated in the instructions for use. These circuits shall be constructed with high reliability. When there is a built-in testing element, the voltage detector shall give an indication of "ready" or "not ready".

4.2.8 Non-response to d.c. voltage

The voltage detector shall not respond to a d.c. voltage.

4.2.9 Time rating

The voltage detector shall be able to perform without failure when subjected to the operating voltage for 5 min.

4.3 Electrical requirements

4.3.1 Insulating material

The insulating materials shall be adequately rated (nature of material, dimensions) for the nominal voltage (or the maximum nominal voltage of the voltage range) of the voltage detector.

NOTE When tubes of insulating material with circular cross section are used in the design of voltage detectors, they should meet the requirements of IEC 60855 or IEC 61235.

For a voltage detector as a complete device the user shall be provided with adequate insulation by means of an insulating element.

NOTE For a voltage detector as a separate device, the user should be provided with adequate insulation by means of an adaptable insulating stick.

4.3.2 Protection against bridging

Protection shall be such that the voltage detector cannot cause flashover or breakdown between live parts of an installation or between a live part of an installation and earth.

4.3.3 Resistance against sparking

The voltage detector shall be constructed so that the indicator cannot be damaged or shut off as a result of a low energy electric arc.

4.4 Mechanical requirements

For a voltage detector as a complete device the user shall be provided with adequate distance by means of an insulating element.

NOTE For a voltage detector as a separate device, the user should be provided with adequate distance by means of an adaptable insulating stick.

4.4.1 Design

4.4.1.1 General design

a) The voltage detector as a complete device shall include at least the following elements: handle, hand guard, insulating element, limit mark, indicator and contact electrode (see Figure 1a).

b) The voltage detector as a separate device shall include at least: adaptor, indicator, and contact electrode (see Figure 1b).

NOTE The insulating stick used in conjunction with the voltage detector as a separate device should fulfil the requirements of 4.3.1 and 4.4.2 even if not provided with the voltage detector.

The voltage detector shall not have any external conductive connection, or any other device to make such connection, except for the contact electrode.

4.4.1.2 Category

– The voltage detector without contact electrode extension shall have category marking L.

NOTE It is used mainly on overhead lines.

– The voltage detector with contact electrode extension shall have category marking S.

NOTE It is mainly used in indoor substations.

4.4.2 Dimensions, construction

The minimum length of the insulating element of a voltage detector as a complete device shall be in accordance with Table 2.

Table 2 – Minimum length of the insulating element (L_i)

U_r kV	L_i mm
$1 < U_r \leq 36$	520
$36 < U_r \leq 72,5$	830
$72,5 < U_r \leq 123$	1 300
$123 < U_r \leq 170$	1 700
$170 < U_r \leq 245$	2 300
$245 < U_r \leq 420$	3 600
$420 < U_r \leq 525$	4 300
$525 < U_r \leq 765$	6 600

NOTE 1 The nominal voltage U_n is used when the parameters to be specified are related to the installation dimensioning or to the functional performance of the voltage detector, while the rated voltage U_r is used when insulation performance of the voltage detector is concerned.

NOTE 2 The L_i values of Table 2 correspond to the minimum distance in air (obtained from Tables 1 and 2 of IEC 61936-1) plus an additional safety distance.

Conductive parts not exceeding 200 mm (in total), measured from the limit mark towards the handle, are allowed within the minimum length of the insulating element if they are completely externally insulated.

The limit mark shall be about 20 mm wide, permanent, and clearly recognisable by the user.

If there is no limit mark on a voltage detector as a separate device, the end of the adaptor shall act as the limit mark (Figure 1b).

For a voltage detector as a complete device, the handle shall be at least 115 mm in length.

NOTE The handle may be made longer for two-hand operation.

For a voltage detector as a complete device, the hand guard shall be permanently fixed and have a minimum height (h_{HG}) of 20 mm.

In order to adapt the voltage detector to different uses, the contact electrode readily may be interchangeable or completed with other types of contact electrodes depending on the type of installation and instructions for use.

4.4.3 Grip force and deflection

The voltage detector shall be designed to facilitate reliable operation with reasonable physical effort by the user.

The voltage detector shall be designed to allow a safe approach toward the installation to be tested. The deflection under its own weight shall be as low as possible.

The weight of the indicator shall be minimal and compatible with the performance requirements.

NOTE In case of a voltage detector as a separate device, the user should be aware that its choice of an insulating stick may greatly influence the grip force and deflection.

4.4.4 Vibration resistance

The indicator and the contact electrode extension shall be vibration resistant.

4.4.5 Drop resistance

The voltage detector shall be drop resistant in working conditions.

4.4.6 Shock resistance

The indicator and the contact electrode extension shall withstand mechanical shocks.

4.5 Markings

Each indicator shall have at least the following markings:

– nominal voltage and/or range of nominal voltage;
– indication group;
– nominal frequency or nominal frequencies;
– name and/or trademark of the manufacturer;
– type reference, serial number;
– indication of type "indoor" or "outdoor";
– indication of category (S or L);
– climatic category (C, N or W);
– year of production;

– symbol IEC 60417–5216(DB:2002-10) – Suitable for live working; double triangle (see Annex A);

NOTE The exact ratio of the height of the figure to the base of the triangle is 1,43. For the purpose of convenience, this ratio can be between the values of 1,4 and 1,5.

– number of the relevant European Standard immediately adjacent to the symbol (EN 61243-1).

In addition, the voltage detector shall provide the user or the testing laboratory an area permitting the marking of the date of periodic testing.

In case of a voltage detector with a built-in energy source, the type of power supply shall be indicated, either on the indicator or inside the compartment designed to house it, and the polarity when required.

These markings shall be legible and permanent. The characters shall be at least 3 mm high. The markings shall not impair the quality of the voltage detector.

4.6 Instructions for use

Each voltage detector shall be accompanied by the manufacturer's instructions for use (see Annex B). These instructions shall be prepared in accordance with the general provisions given in IEC 61477.

5 Specific requirements

5.1 For insulating element of a voltage detector as a complete device

5.1.1 Dielectric strength

The insulating element shall be rated so that no flashover or breakdown occurs in use.

5.1.2 Leakage current

The insulating element of the indoor type voltage detector shall be so rated that leakage current shall be limited under dry conditions.

The insulating element of the outdoor type voltage detector shall be so rated that leakage current shall be limited under dry and wet conditions.

5.2 For indicator casing of voltage detector as a separate device

The indicator casing shall be rated so that no flashover or breakdown occurs in use.

6 Tests

6.1 General

Tests shall be performed on a voltage detector which has been completely assembled, including the contact electrode extension when required, in accordance with the instructions for use.

When several contact electrodes or contact electrode extensions are used, the following electrical and mechanical tests shall be performed with each contact electrode or contact electrode extension:

– measurement of threshold voltage (see 6.2.1.2),

– influence of in-phase interference field (see 6.2.1.3),
– influence of phase opposition interference field (see 6.2.1.4),
– influence of interference voltage (see 6.2.1.5),
– protection against bridging for indoor/outdoor type voltage detector (see 6.3.1),
– protection against bridging for outdoor type voltage detector (see 6.3.2) and
– spark resistance (see 6.3.3).

If the insulating stick is not provided by the manufacturer (in case of a voltage detector as a separate device), an insulating stick complying with 4.3.1 and 4.4.2 shall be used for the tests.

Atmospheric conditions shall be in accordance with IEC 60068-1.

Except when otherwise stated:

– tests are carried out under the following standard atmospheric conditions:
  1) ambient temperature: 15 °C to 35 °C;
  2) relative humidity: 25 % to 75 %;
  3) atmospheric pressure: 86 kPa to 106 kPa.
– tolerances for dimensions below 3 150 mm shall comply with Js18 level according to ISO 286-1 and ISO 286-2. For larger dimensions, tolerance shall be ±1%.

The voltage detector shall be subjected to atmospheric conditions for at least 4 h before being submitted to the group of tests.

6.1.1 Tests under wet conditions

Before the electrical tests, each voltage detector shall be cleaned with isopropanol and then dried in air for 15 min.

The tests shall be conducted in accordance with 9.1 of IEC 60060-1 (standard wet test procedure), with the following exception: the openings in the collecting vessel designed to measure the wetting rate shall be less than, or equal to, the horizontal cross-section of the indicator.

6.1.2 Type test

The type test shall be performed on three complete voltage detectors. Tests shall be performed in the sequence defined in Annex C. If more than one voltage detector does not pass, the test has failed. If only one voltage detector fails, the entire sequence for the type test shall be repeated on three other voltage detectors. If, again, any of the voltage detectors does not pass, the type test is considered to have failed.

In case of voltage detectors of the same family the following applies.

– The type tests shall be performed at the lowest and at the highest nominal voltages limiting the family of voltage detectors. Within the limits of the family, bridging tests (6.3.1 and 6.3.2) shall be performed for each distance d_1 of Table 8 under the highest voltage of each voltage range. Mechanical tests shall be done only once covering the worst conditions.

– The test for clear indication (see 6.2.1) shall be carried out at each nominal voltage or each nominal voltage range. Each time the test set-up changes within the range of the nominal voltages of the voltage detector the corresponding test shall be carried out.

6.1.3 Routine test

Routine test shall be performed according to Annex C. It is not necessary to use the same set-up as in the corresponding type test, but the result shall be equivalent.

6.1.4 Sampling test

Sampling test shall be performed according to Annex C. The sampling plan shall be in accordance with Annex D.

6.1.5 Test methods

Tests shall be carried out using an a.c. power source in accordance with the requirements given in IEC 60060-1.

Unless otherwise specified;

– tests shall be performed in dry conditions for all types of voltage detectors;
– a tolerance of ±3 % is allowed for all required values;
– tests shall be carried out at frequencies of 50 Hz and/or 60 Hz;
– additional tests applicable to outdoor voltage detectors shall be performed under wet conditions.

No correction factor due to climatic conditions shall be applied to test voltages.

6.2 Function tests

6.2.1 Clear indication

6.2.1.1 General

The floor of the test room shall be conductive or laid out with conductive mattings and connected to earth.

The tests shall be conducted in a room which is free from unwanted foreign interference field.

No objects shall be situated between the test set-up and the floor (ground) within a distance H and within a distance W in any direction from the test set-up according to Figures 2 and 3.

6.2.1.2 Measurement of threshold voltage

The test set-up used for the measurement of the threshold voltage is of the ball and ring type, as given in Figure 2.

The electrode arrangement is selected according to the category of the voltage detectors. Figure 2a gives the arrangement for voltage detector of category S and Figure 2b for voltage detector of category L.

For voltage detectors with a nominal voltage range the test set-up shall be selected according to the highest nominal voltage.

The ball and ring electrodes shall be connected as shown in Figure 4a.

The voltage detector shall be installed in such a manner that its contact electrode touches the ball electrode and the indicator is approximately concentrically located in relation to the ring electrode (in the horizontal axis).

The threshold voltage shall be measured by increasing the test voltage until the status of the signal changes according to its type of indication.

The test shall be considered as passed if the measured threshold voltage is within the limits specified in 4.2.1.1.

6.2.1.3 Influence of in-phase interference field

The test set-up used for the influence of in-phase interference field is either of the ball and ring type or of the bars type, according to the nominal voltage U_n and the category of the voltage detector and as given in Table 3.

Table 3 – Selection of the test set-up for the influence of in-phase interference field

Nominal voltages	$U_n \leq 52$ kV	52 kV < $U_n \leq 245$ kV	$U_n > 245$ kV
Type of the test set-up	**Ball and ring** Category S: Figure 2a Category L: Figure 2b	**Ball and ring** Category S: Figure 2a Category L: Figure 2b or alternatively **Bars** Categories S and L: Figure 3	**Bars** Categories S and L: Figure 3

Voltage detectors with a nominal voltage range shall be checked using a same type of test set-up.

The ball and ring electrodes shall be connected as shown in Figure 4b. The bars shall be connected as shown in Figure 4d.

The voltage detector shall be installed in such a manner that its contact electrode touches the ball electrode and the indicator is approximately concentrically located in relation to the ring electrode (in the horizontal axis).

When the test set-up with bars is used, the contact electrode of the voltage detector shall touch initially the bar A at the point E_1, within a tolerance of ± 3 % of L_2. The voltage detector shall be inclined in two positions with a minimum angle of 30°, as shown in Figure 4d. The voltage detector, being returned in vertical position, shall then be moved to point E_2 (Figure 4d) in vertical position. The distance G between point E_2 and the double corona ring is given in Table 4.

Table 4 – Distance *G* (see Figure 4d)

U_n kV	*G* mm
52 < U_n 82,5	$75^{\ 0}_{-5}$
82,5 < U_n 145	$135^{\ 0}_{-5}$
145 < U_n 245	$210^{\ 0}_{-5}$
245 < U_n 420	$255^{\ 0}_{-5}$
420 < U_n 525	$315^{\ 0}_{-5}$
525 < U_n 765	$450^{\ 0}_{-5}$

The test voltage shall be 0,45 times the nominal voltage. For voltage detectors with a nominal voltage range the tests shall be performed for the lower and the higher nominal voltages. For voltage detectors with more than one nominal frequency the tests shall be performed for each nominal frequency.

The test shall be considered as passed if, according to its type of indication, the status of the signal corresponding to the indication “voltage present” appears.

6.2.1.4 Influence of phase opposition interference field

The test set-up used for the influence of phase opposition interference field is either of the ball and ring type or of the bars type, according to the nominal voltage and the category of the voltage detector and as given in Table 5.

Table 5 – Selection of the test set-up for phase opposition interference field

Nominal voltages	**U_n 52 kV**	**52 kV < U_n 245 kV**	**U_n > 245 kV**
Type of the test set-up	**Ball and ring** Categories S and L: Figure 2a Category L: Figure 2b	**Ball and ring** Categories S and L: Figure 2b or alternatively **Bars** Categories S and L: Figure 3	**Bars** Categories S and L: Figure 3

Voltage detectors with a nominal voltage range shall be checked using the same type of test set-up.

The ball and ring electrodes shall be connected as shown in Figure 4c. The bars shall be connected as shown in Figure 4e.

The voltage detector shall be installed in such a manner that its contact electrode touches the ball electrode and the indicator is approximately concentrically located in relation to the ring electrode (in the horizontal axis).

When the test set-up with bars is used, the contact electrode of the voltage detector shall touch the grounded bar A at the point E_1, within a tolerance of ± 3 % of L_2. The voltage detector shall be inclined in two positions with a minimum angle of 30°, as shown in Figure 4e.

The test voltage shall be 0,6 times the nominal voltage. For voltage detectors with a nominal voltage range the test shall be performed at the highest nominal voltage. For voltage detectors with more than one nominal frequency the test shall be performed at the highest nominal frequency.

NOTE 0,6 times the nominal voltage corresponds to 105 % of the nominal voltage divided by 1,732.

The test shall be considered as passed if, according to its type of indication, the status of the signal corresponding to the indication “voltage present” never appears.

6.2.1.5 Influence of interference voltage

The test set-up used for the influence of interference voltage is either of the ball and ring type or of the bars type, according to the nominal voltage and the category of the voltage detector and as given in Table 6.

Table 6 – Selection of the test set-up for the influence of interference voltage

Nominal voltages	**$U_n \leq 52$ kV**	**52 kV < $U_n \leq 245$ kV**	**$U_n > 245$ kV**
Type of the test set-up	**Ball and ring** Category S: Figure 2a Category L: Figure 2b	**Ball and ring** Category S: Figure 2a Category L: Figure 2b or alternatively **Bars** Categories S and L: Figure 3	**Bars** Categories S and L: Figure 3

Voltage detectors with a nominal voltage range shall be checked using the same type of test set-up.

The ball and ring electrodes shall be connected as shown in Figure 4a. The bars shall be connected as shown in Figure 4f.

The voltage detector shall be installed in such a manner that its contact electrode touches the ball electrode and the indicator is approximately concentrically located in relation to the ring electrode (in the horizontal axis).

When the test set-up with bars is used, the contact electrode of the voltage detector shall touch the energised bar A at the point E_1, within a tolerance of ± 3 % of L_2**.** The voltage detector shall be inclined in two positions with a minimum angle of 30°, as shown in Figure 4f.

The test voltage shall be 0,10 times the nominal voltage. For voltage detectors with a nominal voltage range, the test shall be performed at the highest nominal voltage. For voltage detectors with more than one nominal frequency the test shall be performed at the highest nominal frequency.

The test shall be considered as passed if, according to its type of indication, the status of the signal corresponding to “voltage present” never appears.

6.2.2 Clear perceptibility of visual indication

The test set-up is given in Figure 5.

The intensity of the light striking an unpolished grey screen with a reflectivity index of 18 % and the signal source of the indicator shall be:

– 50 000 lux ± 10 % for outdoor type voltage detector with standard light D_{55} according to CIE 15.2 corresponding to colour temperature of 5 500 °K ± 10 %;
– 1 000 lux ± 10 % for indoor type voltage detector with standard light A according to CIE 15.2 corresponding to colour temperature of 3 200 °K ± 10 %.

The voltage detector is positioned in the direction of axis A – B, and its signal source part is centered on the axis A – B in normal use, according to Figure 5a.

The visual perceptibility test shall be performed in energizing the voltage detector by any relevant means corresponding to the application of the threshold voltage plus 10 %.

By switching the voltage "on" and "off", the voltage detector is set to respond in such a manner that the indications "voltage present" and "voltage not present" alternate several times in conditions unknown to the observer.

Three observers with average sight look towards the voltage detector, through the 5 mm holes in the front plate (see Figure 5b).

The test shall be considered as passed if the indication is seen by the three observers through each hole.

6.2.3 Clear perceptibility of audible indication

The test shall be carried out in free-field over reflecting plane conditions, in an environment following the requirements of Annex A of ISO 3744.

NOTE Such test conditions can be encountered in semi-anechoic rooms.

Averaged over the microphone positions, the level of the background noise shall be at least 6 dB(A) but preferably more than 15 dB(A) below the sound pressure level to be measured. If the difference between the sound pressure levels of the background noise and the source noise is between 6 dB(A) and 15 dB(A), a correction shall be applied as described in 8.3 of ISO 3744.

The instrumentation system, including the microphones and cables, shall meet the requirements for a class 1 instrument specified in IEC 61672-1. The filters used shall meet the requirements for a class 1 instrument specified in IEC 61260.

During each series of measurements, a sound calibrator with an accuracy of class 1 specified in IEC 60942 shall be applied to the microphone to verify the calibration of the entire instrument system.

The audible perceptibility test shall be performed in energizing the voltage detector by any relevant means corresponding to the application of the threshold voltage plus 10 %.

The voltage detector shall be arranged as shown in Figure 6a, in such a manner that the sound axis of the voltage detector is parallel to the ground and at least 1,5 m away from any sound-reflecting surfaces.

A measuring plane shall be established, perpendicular to the sound axis according to Figure 6a. The distance of 400 mm can be increased by 200 mm if this will enable higher sound intensities to be measured.

The measurements shall be carried out for the indications "voltage present" and "voltage not present", at each of the twelve microphone positions of Figure 6b. The sound pressure level shall be measured in each octave band of the frequency range 1 000 Hz to 4 000 Hz, with the A-weighting network.

The period of observation shall be at least 10 s for a continuous signal. For an intermittent signal, the integration time for the measurement shall be shorter than the signal duration.

The test shall be considered as passed, if for each microphone position, the sound pressure level, within at least one octave band of the frequency range of interest, is greater than

– 80 dB(A), (ref.: 20 µPa) for a voltage detector with continuous sound signal;
– 77 dB(A), (ref.: 20 µPa) for a voltage detector with intermittent sound signal.

When there is an additional visual indication these values may be reduced by 10 dB(A).

NOTE Other higher values may be agreed between manufacturer and customer for specific usage in very noisy areas.

6.2.4 Frequency dependence

The test shall be carried out using the test set-up and the test procedure of 6.2.1.2.

For a voltage detector with one nominal frequency, the test shall be performed at 97 % and 103 % of the nominal frequency.

For a voltage detector with more than one nominal frequency, the test shall be performed at 97 % and 103 % of each nominal frequency.

The test shall be considered as passed if the threshold voltage is within the limits specified in 4.2.1.1.

6.2.5 Response time

The test voltage applied shall be the threshold voltage plus 10 %.

NOTE For practical reasons, other equivalent means for energizing the voltage detector are allowed.

The test voltage shall be applied ON, then OFF and ON twenty times. The duration of the ON and OFF periods shall be adjusted 1 s long.

The test shall be considered as passed if each visual or audible signal is seen or heard as a rhythmical indication having a minimum frequency of 0,5 Hz. The first signal(s) shall appear during the first cycle.

6.2.6 Power source dependability

A voltage detector with a built-in power source and a nominal voltage range shall be tested for the lower nominal voltage.

The test voltage shall be the threshold voltage plus 10 %.

The voltage detector shall be switched ON and the contact electrode applied to an a.c. voltage source.

The test voltage shall be switched OFF after 1 min and ON 2 min later. The status of the signal corresponding to “voltage present” shall be checked several times at certain intervals during these cycles. The cycles shall be repeated until

– an indication is given that the voltage detector is no longer operational, or
– the voltage detector is switched off automatically for that reason.

The test shall be considered as passed if one of the above-mentioned requirements is fulfilled.

NOTE The test duration may be reduced by using other methods that give the same result (ex: the use of an unloaded built-in power source with 10 % more energy than necessary for a good functioning).

6.2.7 Check of testing element

The testing element is activated according to the instructions for use.

A visual and/or audible signal shall appear. The testing element shall be activated three times, and a signal shall appear each time.

The electric circuit (and the flow chart if a software is used) shall be checked to verify that all circuits are tested, except those mentioned in the instructions for use.

6.2.8 Non-response to d.c. voltage

For a voltage detector with a nominal voltage range, the test voltage shall be selected according to the higher nominal voltage. The test voltage shall be $U_n \sqrt{2} / \sqrt{3}$.

The voltage detector shall be placed with the contact electrode on a d.c. voltage source, in accordance with IEC 60060-1. The test shall be repeated with the polarity reversed.

The test shall be considered as passed if there is no continuous signal longer than 1 s.

NOTE For practical reasons, other equivalent means for energizing the voltage detector are allowed.

6.2.9 Time rating

The voltage detector shall be placed with the contact electrode on an a.c. voltage source, and the test voltage applied for 5 min.

The test voltage shall be 1,2 U_n for a voltage detector having a nominal voltage lower than or equal to 123 kV.

The test voltage shall be $1{,}2 U_n / \sqrt{3}$ but shall be greater than 148 kV (≈1,2 times 123 kV) for a voltage detector having a nominal voltage higher than 123 kV.

The test shall be considered as passed if the status of the signal corresponding to "voltage present" is uninterrupted for all the test period.

6.3 Dielectric tests

6.3.1 Protection against bridging for indoor/outdoor type voltage detector

This test is related to the part of the voltage detector located between the limit mark and the top of the contact electrode. If there is no limit mark on a voltage detector as a separate device, the end of the adaptor shall be regarded as the limit mark (Figure 1b).

The test set-up used for the protection against bridging test is selected according to the nominal voltage of the voltage detector and as given in Table 7.

Table 7 – Selection of the test set-up and type of test

Nominal voltages	$U_n \leq 245$ kV		$U_n > 245$ kV	
	A_i+200 mm>d_1	A_i+200 mm ≤ d_1	A_i+200 mm >d_1	A_i+200 mm ≤ d_1
Type of the test set-up	V shape Bars Figure 7a		Parallel Bars Figure 7e	
Test	Surface stress and Radial and surface stress	Surface stress	Surface stress and Radial and surface stress	Surface stress

The distance d_1 between bar A and bar B shall be adjusted according to Table 8 whatever the type of test set-up used. The distance d_2 of Figure 7a, shall be calculated as follows:

$$d_2 = A_i + d_1 + 200 \text{ (all dimensions are in mm)}$$

where A_i is the insertion depth (Figure 1).

The test voltage shall be $1{,}2U_r$ for a voltage detector having a nominal voltage lower than or equal to 123 kV.

The test voltage shall be $1{,}2U_r/\sqrt{3}$ but shall be greater than 148 kV (≈1,2 times 123 kV) for a voltage detector having a nominal voltage higher than 123 kV.

Bridging tests shall be performed within the limits of the voltage range of the voltage detector for each distance d_1 at the highest voltage of each range given in Table 8.

6.3.1.1 For voltage detector ≤ 245kV

The bars shall be connected as shown in Figure 7b. The ground clearance (H) of bars shall be at least d_1.

6.3.1.1.1 Surface stress test

The top of the contact electrode shall be placed on bar A at the narrow point d_1 and the voltage detector shall be laid on bar B for 1 min. The voltage detector still staying at the narrow point is turned and pushed forward toward bar A, until the limit mark plus 200 mm reaches the bar A (Figure 7c).

The test shall be considered as passed if no flashover or breakdown occurs.

6.3.1.1.2 Radial and surface stress test

The top of the contact electrode shall be placed on bar A at the narrow point d_1 and the voltage detector shall laid on bar B. Then the voltage detector is rolled along the bars, until the limit mark plus 200 mm reaches bar B (Figure 7d) while the top of the contact electrode remains in contact with bar A.

The test shall be considered as passed if no flashover or breakdown occurs.

6.3.1.2 For voltage detector > 245 kV

The bars shall be connected as shown in Figure 7e. The ground clearance (H) of bar A shall be at least d_1. The height of bar B is not critical to the test.

6.3.1.2.1 Surface stress test

The top of the contact electrode shall be placed on bar A and the voltage detector shall be laid on bar B for 1 min (Figure 7e, initial position). The voltage detector is then pushed forward toward bar A and rolled until the limit mark plus 200 mm reaches bar A (Figure 7e, final position).

The test shall be considered as passed if no flashover or breakdown occurs.

6.3.1.2.2 Radial and surface stress test

The top of the contact electrode shall be placed on bar A (Figure 7f, initial position) and, keeping the electrode in contact with bar A the voltage detector is angularly moved relatively to the bars and rolled until the limit mark plus 200 mm reaches bar B (Figure 7f, final position).

The test shall be considered as passed if no flashover or breakdown occurs.

Table 8 – Distance d_1 for the bridging test set-up

U_n kV	d_1 mm	
	Indoor	Outdoor
$U_n \leq 7{,}2$	50	150
$7{,}2 < U_n \leq 12$	60	150
$12 < U_n \leq 17{,}5$	85	180
$17{,}5 < U_n \leq 24$	115	215
$24 < U_n \leq 36$	180	325
$36 < U_n \leq 52$	240	520
$52 < U_n \leq 72{,}5$	330	700
$72{,}5 < U_n \leq 123$	650	1 100
$123 < U_n \leq 145$	1 100	
$145 < U_n \leq 170$	1 350	
$170 < U_n \leq 245$	1 850	
$245 < U_n \leq 300$	2 100	
$300 < U_n \leq 362$	2 500	
$362 < U_n \leq 420$	2 900	
$420 < U_n \leq 525$	3 400	
$525 < U_n \leq 765$	4 800	

6.3.2 Protection against bridging for outdoor type voltage detector

The voltage detector shall be fitted with two conductive band electrodes, which, according to the nominal voltage of the voltage detector, have a width as proposed in Table 9. These band electrodes are wound around the tube, one at the contact electrode and the other in the direction of the handle at a distance d_1 specified in Table 8.

The band electrodes may be shielded by means of concentric rings having the dimensions suggested in Table 9. In this case, the rings shall be electrically connected to the band electrodes.

Table 9 – Dimensions for the concentric rings and band electrodes

Nominal voltages	Width of band electrodes mm	Concentric rings	
		Outside diameter mm	Cross-section diameter mm
$U_n \leq 245$ kV	20	200	30
$U_n > 245$ kV	40	600	160

One band electrode shall be connected to an a.c. voltage source, and the other band electrode shall be connected to earth.

For practical reasons, the band electrode nearest to ground is generally connected to earth and the farthest is connected to the a.c. voltage source.

Precipitation shall be performed in accordance with 6.1.1.

The voltage detector shall be aligned at an angle of inclination of 20° ± 5° to the vertical, in such a way that its contact electrode points downwards, and the rain falls at an angle of roughly 45° to the vertical (i.e. at an angle of roughly 65° to the voltage detector), (see Figure 8). The precipitation on the test section should be as uniform as possible.

The voltage detector shall be wetted for 3 min. Then, it shall be turned 180°, as quickly as possible, so that the contact electrode points upwards, and wetted for an additional 2 min.

Then the test voltage shall be applied for 1 min while the rain continues.

The test voltage shall be $1{,}2U_r$ for a voltage detector having a nominal voltage lower than or equal to 123 kV.

The test voltage shall be $1{,}2U_r/\sqrt{3}$ but shall be greater than 148 kV (≈1,2 times 123 kV) for a voltage detector having a nominal voltage higher than 123 kV.

Bridging tests shall be performed within the limits of the voltage range of the voltage detector for each distance d_1 at the highest voltage of each range given by Table 8.

The band electrodes shall then be shifted section by section, always maintaining the same distance d_1, so that the sections overlap by approximately 50 %.

This test shall be repeated until the earthed electrode is at the distance d_3 from the contact electrode with

$$d_3 = A_i + d_1$$

The test shall be considered as passed if no breakdown occurs.

For a voltage detector without contact electrode extension, and for which the insertion depth is shorter than d_1, the test is only made for distance d_1 from the contact electrode.

6.3.3 Spark resistance

The test set-up for the spark resistance test shall be selected according to the nominal voltage of the voltage detector, as given in Table 10.

Table 10 – Selection of the test set-up for the spark resistance test

Nominal voltages	**$U_n \leq 245$ kV**	**$U_n > 245$ kV**
Type of the test set-up	V shape bars Figure 7a	Parallel bars Figure 7e

The distance d_1 between bar A and bar B shall be adjusted according to Table 8 whatever the type of test set-up used. The distance d_2 of Figure 7a, shall be calculated as follows:

$$d_2 = A_i + d_1 + 200 \text{ (all dimensions are in mm)}$$

The test voltage shall be $1{,}2U_n$ for a voltage detector having a nominal voltage lower than or equal to 123 kV.

The test voltage shall be $1{,}2U_n/\sqrt{3}$ but shall be greater than 148 kV (≈1,2 times 123 kV) for a voltage detector having a nominal voltage higher than 123 kV.

The contact electrode shall be placed on bar A and the voltage detector shall lay on bar B. Then the voltage detector is withdrawn from bar A until the largest continuous spark occurs. The voltage detector is kept in this position for 1 min.

Additionally, the voltage detector shall be pushed forward bar A seeking the longest possible spark between the indicator and the bar B. If a spark occurs, this position shall be kept for 1 min.

The test shall be considered as passed if there is no damage to the voltage detector and the voltage detector is not shut off.

NOTE For convenience this test may be combined with 6.3.1.

6.4 Mechanical tests

6.4.1 Visual and dimensional inspection

6.4.1.1 Visual inspection

The voltage detector shall be tested for compliance with 4.5 and the instructions for use. It shall be verified that the user does not have access to the threshold voltage setting.

6.4.1.2 Dimensional inspection

The voltage detector shall be checked for compliance with the requirements of 4.4.2 and 4.5.

6.4.2 Grip force and deflection (only applicable for voltage detector as a complete device)

The voltage detector shall be kept in an horizontal position by means of two supports. The contact end electrode support (front support) shall be located 50 mm from the hand guard, towards the end of the handle. The distance between the two supports is to simulate the distance between the user hands. For a voltage detector with a handle shorter than 1 100 mm, the rear support shall be located 50 mm from the end of the handle. For a voltage detector with a handle equal to or longer than 1 100 mm the rear support shall be placed at 1 000 mm from the front support (see Figure 9).

The grip force (F) shall be measured at the front support and shall be less than 200 N.

The voltage detector shall then be clamped at the front support location and the deflection measured. The deflection (δ) shall not exceed 10 % of the total length of the voltage detector (L_o).

6.4.3 Vibration resistance

The test method shall be in accordance with IEC 60068-2-6.

The indicator shall be fastened to the vibrator by rigid intermediate parts which shall not affect the test results.

To attenuate any large amplitude oscillations which may be induced in the contact electrode during the test, the free end of the electrode shall be fastened to the rigid part.

The assembly shall be submitted to sinusoidal rectilinear vibrations in two perpendicular directions, one of which corresponding to the long axis of the indicator.

The sweep (run of the specified frequency range once in each direction) shall be continuous and the sweeping rate shall be approximately 1 octave per min. The frequency range shall be from 10 Hz to 150 Hz.

The amplitude and acceleration shall be as follows:

– 0,15 mm peak value between 10 Hz and 58 Hz;
– 19,6 m/s^2 peak value between 58 Hz and 150 Hz.

The duration of the tests shall be set for 2 h in each direction.

The test is considered as passed if the voltage detector shows no signs of mechanical damage.

6.4.4 Drop resistance

This test shall be performed in accordance with IEC 60068-2-32, procedure 1, with the following parameters:

– the test surface shall be concrete or steel. The test surface shall be smooth, hard and rigid;
– the voltage detector shall be dropped from horizontal, and from diagonal static positions;
– the height of fall shall be 1 m from horizontal position;
– the height of fall shall be 1 m plus 20 % of the overall length of the voltage detector for diagonal position. For diagonal position, the height of fall shall be the distance between the end of the contact electrode, projected onto a vertical axis, and the floor (see Figure 10);
– the number of falls shall be one per position.

The test shall be considered as passed if the voltage detector shows no signs of mechanical damage even if the contact electrode is bent without destruction.

If the insulating stick is not provided, the test shall be performed with an insulating stick having the minimum constructive dimensions specified in 4.4.2.

6.4.5 Shock resistance

The test is designed to check the sturdiness of the indicator and the contact electrode extension. The test method shall be in accordance with Annex E. The most fragile part of the indicator and of the contact electrode extension shall be submitted to shock five times.

The same location shall be shocked only once.

The test is considered as passed if the voltage detector shows no signs of mechanical damage and the voltage detector is still working properly.

6.4.6 Climatic dependence

Before this test, each voltage detector shall be cleaned with isopropanol and then dried in air for 15 min.

The test is performed on the indicator and the contact electrode extension, if so equipped, in accordance with IEC 60068-2-14 except for the temperature cycles and time relative to humidity. In this case, the test cycle shall be in accordance with the following (see Figure 11).

The test piece shall be placed in a climatic chamber. The temperature of the chamber is lowered from the ambient temperature to the required low value according to the climatic category of the voltage detector (see Table 1). The temperature of the chamber shall be maintained for 2 h.

The test piece shall then be removed from the climatic chamber and within 5 min to 10 min following the withdrawal, the measurement of the threshold voltage shall be carried out at ambient temperature according to 6.2.1.2. Wiping of external parts is allowed.

The voltage detector shall then be kept at ambient temperature for 2 h.

The test piece shall next be placed in the climatic chamber and the temperature shall be increased 2°K/min until it reaches the high value according to the climatic category of the voltage detector (see Table 1). The relative humidity shall be maintained at 50 %.

The chamber shall be kept at the high temperature for 3 h. During the first hour and half, the relative humidity shall be increased from 50 % to 96 %.

The test piece shall then be removed from the climatic chamber and within 5 min to 10 min following the withdrawal, the measurement of the threshold voltage shall be carried out according to 6.2.1.2 at ambient temperature. Wiping of external parts is allowed.

The test shall be considered as passed if the two measured threshold voltages satisfy the limits specified in 4.2.1.1.

NOTE This test procedure combines conditions of steady extreme temperatures and sudden change of temperature, since it is not practical to perform high voltage tests in a climatic chamber.

6.4.7 Durability of markings

The markings shall be rubbed successively with a rag soaked in water for at least 1 min, then with another rag soaked in isopropanol for another minimum of 1 min.

The test shall be considered as passed if the markings remain legible, the letters do not smear, and the stickers remain attached. The surface of the voltage detector may change. No signs of loosening shall be present for labels.

7 Specific tests

7.1 Leakage current for voltage detector as a complete device

This test is related to the part of the voltage detector as a complete device located between the limit mark and the hand guard.

The voltage detector shall be fitted with two conductive band electrodes which, according to the nominal voltage of the voltage detector, have a width specified in Table 9. These band electrodes are wound around the voltage detector, one adjacent to the hand guard in the direction of the contact electrode and the other, directly adjacent to the limit mark in the direction of the handle.

The band electrodes shall be shielded by means of concentric rings having the dimensions given in Table 9. The band electrodes and the concentric rings shall be insulated from each other.

A test voltage of $1{,}2U_r$ shall be applied for a voltage detector having a nominal voltage lower than or equal to 123 kV. A test voltage of $1{,}2U_r/\sqrt{3}$, but greater than 148 kV (≈1,2 times 123 kV), shall be applied for a voltage detector having a nominal voltage higher than 123 kV.

For voltage detectors with a nominal voltage range, the test shall be conducted at the higher value of the nominal voltage.

Leakage currents shall be measured according to the following procedure.

7.1.1 Leakage current under dry conditions

In a first step the leakage current (rms value) shall be measured under dry conditions while the test voltage is applied for 1 min.

The band electrode at the hand guard shall be connected to earth through an ammeter by means of a grounded screen cable. The adjacent concentric ring shall be connected to earth directly. The band electrode and the concentric ring at the limit mark shall be connected to the test voltage (see Figure 12a).

The test shall be considered as passed if the leakage current never exceeds 50 μA.

7.1.2 Leakage current under wet conditions (for outdoor type only)

For outdoor type voltage detector, a wet test is also required. The test shall be performed in accordance with 6.1.1.

The rain shall fall at an angle of roughly 45° to the vertical. The precipitation on the test section covering the complete insulating length shall be as uniform as possible.

The voltage detector shall be placed on a grounded plane and shall be aligned at an angle of inclination of 20° ± 5° to the vertical, with its contact electrode downward (i.e. an angle of roughly 65° between rainfall and voltage detector). The band electrode near the limit mark shall be connected to earth through the ammeter. The contact electrode and the concentric ring near the limit mark shall be grounded. The band electrode and the concentric ring near the handle shall be connected to the test voltage (see Figure 12b).

The voltage detector shall be wetted for 15 min. While the rain continues, the test voltage shall be applied for 1 min and the leakage current shall be measured. The maximum value of the leakage current shall be recorded.

NOTE In order to avoid the measurement of current spikes due to water drops and stream, the ammeter should give at least an averaging time of 1 s and its input should be equipped with an appropriate RC filter cutting frequencies above 240 Hz.

The voltage detector shall then be turned 180°, so that the contact electrode points upwards. The band electrode near the handle shall be connected to earth through the ammeter and its adjacent concentric ring shall be grounded. The contact electrode, the band electrode and the concentric ring near the limit mark shall be connected to the test voltage (see Figure 12c).

The voltage detector shall be wetted for an additional 15 min. While the rain continues, the test voltage shall be applied for 1 min and the leakage current shall be measured. The maximum value of the leakage current shall be recorded.

The test shall be considered as passed if the leakage current under wet conditions never exceeds 0,5 mA.

8 Quality assurance plan and acceptance test

8.1 General

The quality assurance plan shall ascertain that the voltage detectors meet the requirements of this standard.

In the absence of an accepted quality assurance plan as specified above, Annex D provides pieces of information related to the quality assurance plan.

8.2 Records

Acceptance test results shall be available to the customer according to the customer requirements or for at least two years (see Annex F).

The tests results shall be made available in accordance with the manufacturer’s quality control procedure.

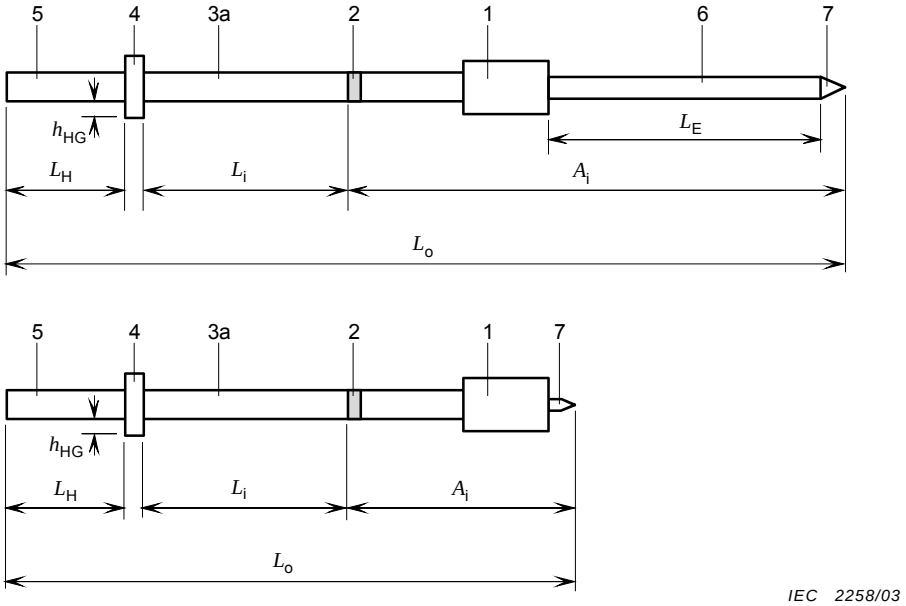


Figure 1a – Voltage detector as a complete device (including its insulating element)

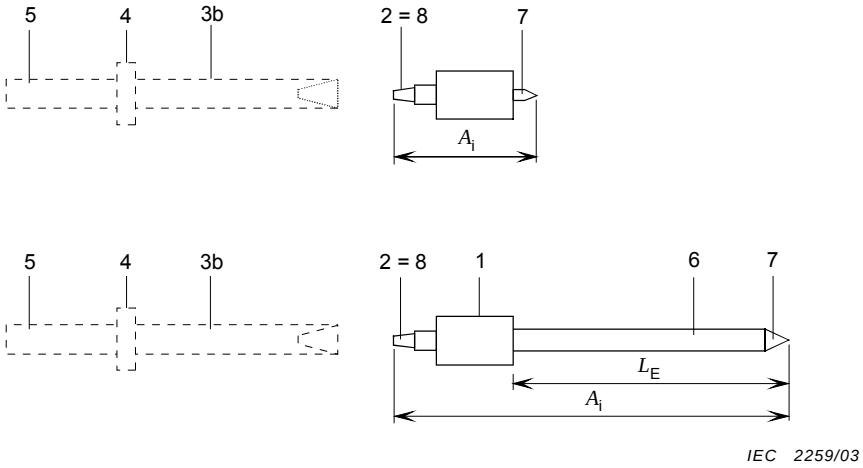
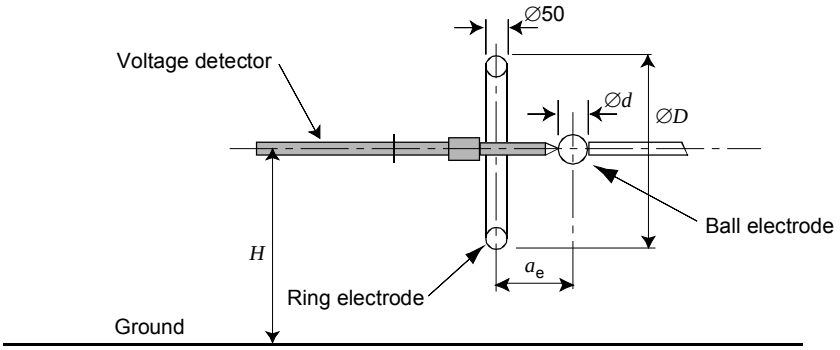


Figure 1b – Voltage detector as a separate device (with an adaptable insulating stick)

Key

1	Indicator	h_{HG}	Height of hand guard
2	Limit mark	L_H	Length of handle
3a	Insulating element	L_i	Length of insulating element
3b	Adaptable insulating stick	L_E	Length of contact electrode extension
4	Hand guard	L_o	Overall length of voltage detector
5	Handle	A_i	Insertion depth (length)
6	Contact electrode extension		
7	Contact electrode		
8	Adaptor		

Figure 1 – Examples of designs of voltage detectors of capacitive type

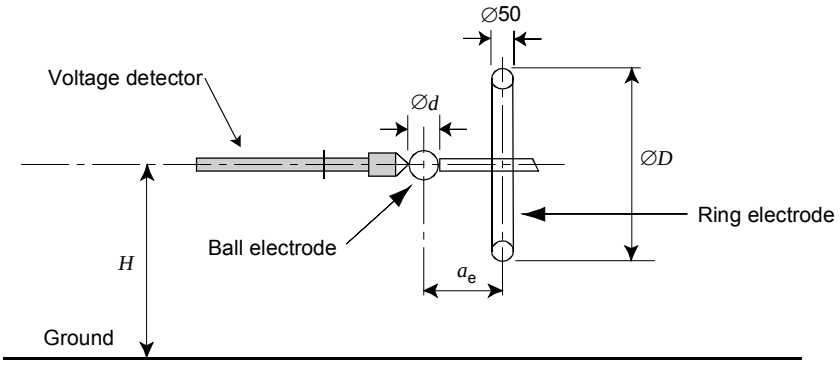


IEC 2260/03

Dimensions in millimetres

U_n kV	Electrode separation distance a_e mm	H mm	D Ring diameter mm	d Ball diameter mm	W (3 times D) Wall and ceiling clearances mm
$1 < U_n \leq 12$ $12 < U_n \leq 24$ $24 < U_n \leq 52$	100 270 430	1 500	ϕ 550	ϕ 60	> 1 650
$52 < U_n \leq 170$ $170 < U_n \leq 245$	650 850	2 500	ϕ 1 050	ϕ 100	> 3 150
$245 < U_n \leq 525$ $525 < U_n \leq 765$	850 1 200	2 500 3 500	ϕ 1 050 ϕ 1 600	ϕ 100 ϕ 150	> 3 150 > 4 800

Figure 2 a – Test set-up with the ball electrode behind the ring electrode



IEC 2261/03

Dimensions in millimetres

U_n kV	Electrode separation distance a_e mm	H mm	D Ring diameter mm	d Ball diameter mm	W (3 times D) Wall and ceiling clearances mm
$1 < U_n \leq 12$ $12 < U_n \leq 24$ $24 < U_n \leq 52$	300	1 500	ϕ 550	ϕ 60	> 1 650
$52 < U_n \leq 170$ $170 < U_n \leq 245$	1 000	2 500	ϕ 1 050	ϕ 100	> 3 150
$245 < U_n \leq 525$ $525 < U_n \leq 765$	1 000 1 000	2 500 3 500	ϕ 1 050 ϕ 1 600	ϕ 100 ϕ 150	> 3 150 > 4 800

Figure 2b – Test set-up with ball electrode in front of the ring electrode

Figure 2 – Ball and ring test set-up (see 6.2.1 and 6.2.4)

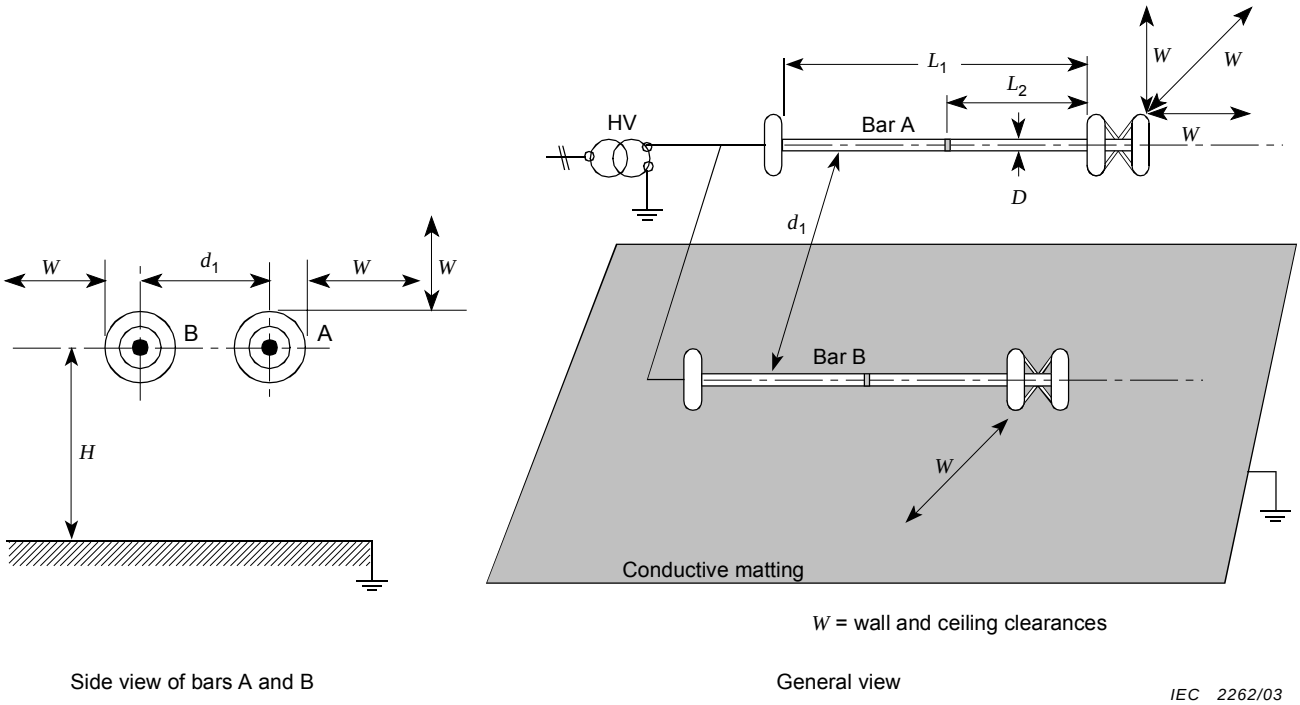


Figure 3a – General arrangement

U_n kV	H mm	W mm	d_1 mm	L_1 mm	L_2 mm	D conductor mm
52 < U_n ≤ 82,5	3 500	750	750	1 000	525	12,4 ± 5 %
82,5 < U_n ≤ 145	3 500	900	900	1 700	945	25,2 ± 5 %
145 < U_n ≤ 245	3 500	1 500	1 500	2 700	1 470	39 ± 5 %
245 < U_n ≤ 420	3 500	2 400	2 400	3 200	1 785	64,5 ± 5 %
420 < U_n ≤ 525	4 100	2 900	2 900	3 900	2 205	87,5 ± 5 %
525 < U_n ≤ 765	6 400	4 100	4 100	5 300	3 150	126 ± 5 %

U_n kV	D_1 mm	D_2 mm	Z mm	Y mm
52 < U_n ≤ 82,5	200	50	50	150
82,5 < U_n ≤ 145	360	90	90	270
145 < U_n ≤ 245	560	140	140	420
245 < U_n ≤ 420	680	170	170	510
420 < U_n ≤ 525	800	210	210	630
525 < U_n ≤ 765	1 000	300	300	900

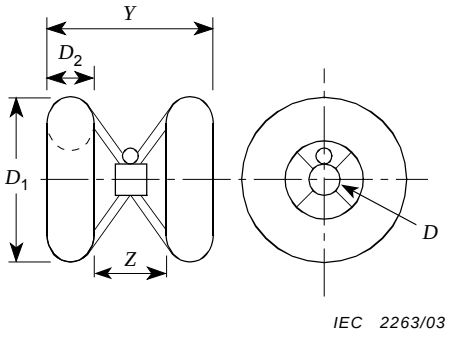


Figure 3b – Dimensions of the double corona rings (conductive material)

U_n kV	D_1 mm	D_2 mm
52 < U_n ≤ 82,5	120	30
82,5 < U_n ≤ 145	210	54
145 < U_n ≤ 245	350	90
245 < U_n ≤ 420	400	100
420 < U_n ≤ 525	480	126
525 < U_n ≤ 765	600	160

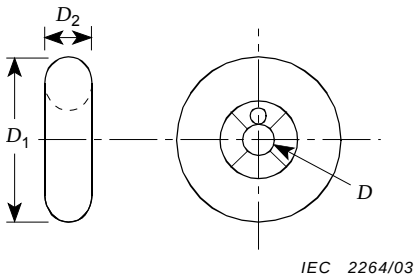


Figure 3c – Dimensions of the corona rings (conductive material)

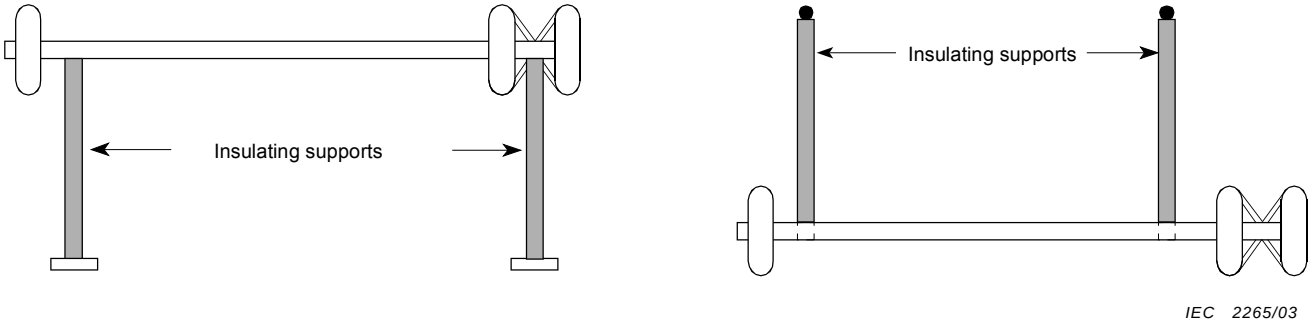


Figure 3d – Example of support arrangement for the test bars

Figure 3 – Test set-up with bars (see 6.2.1)

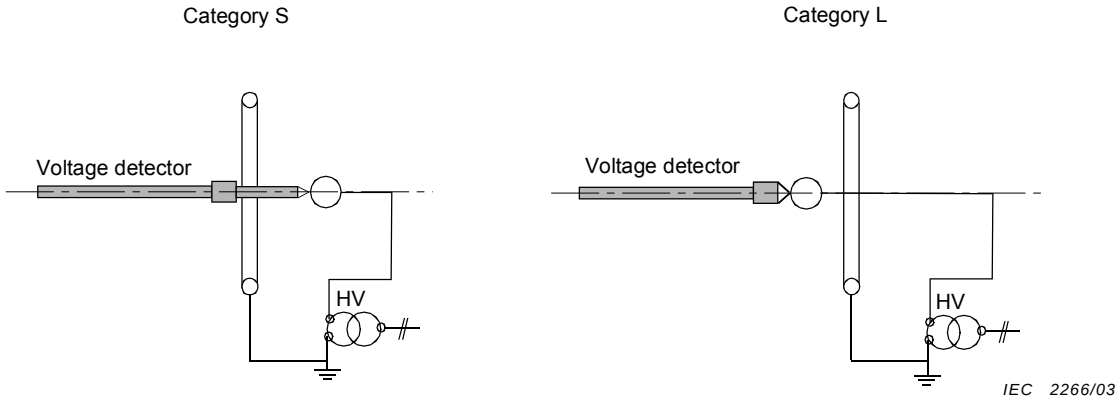


Figure 4a – Measurement of the threshold voltage and the influence of interference voltage with the ball and ring test set-up (see 6.2.1.2 and 6.2.1.5)

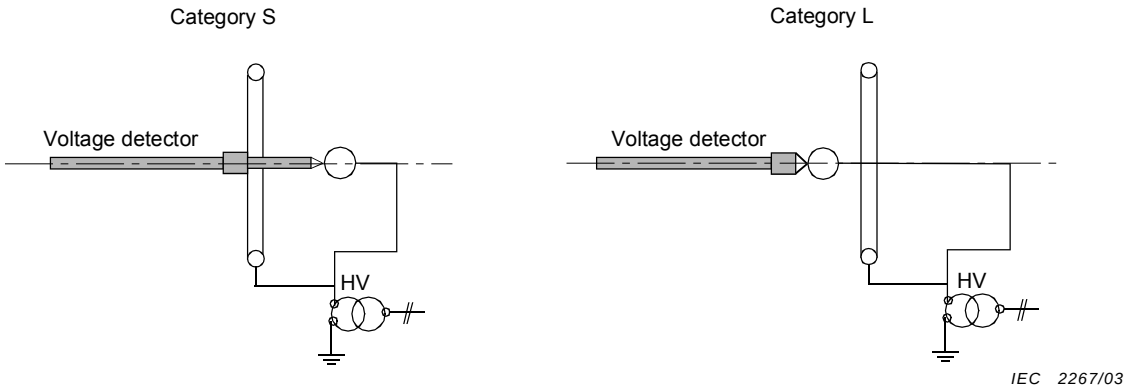


Figure 4b – Influence of in-phase interference field with the ball and ring test set-up (see 6.2.1.3)

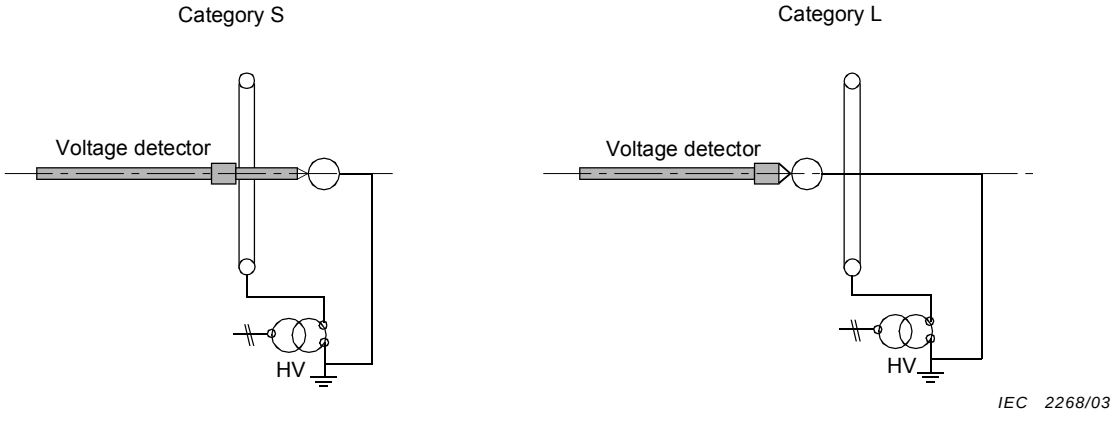


Figure 4c – Influence of phase opposition interference field with the ball and ring test set-up (see 6.2.1.4)

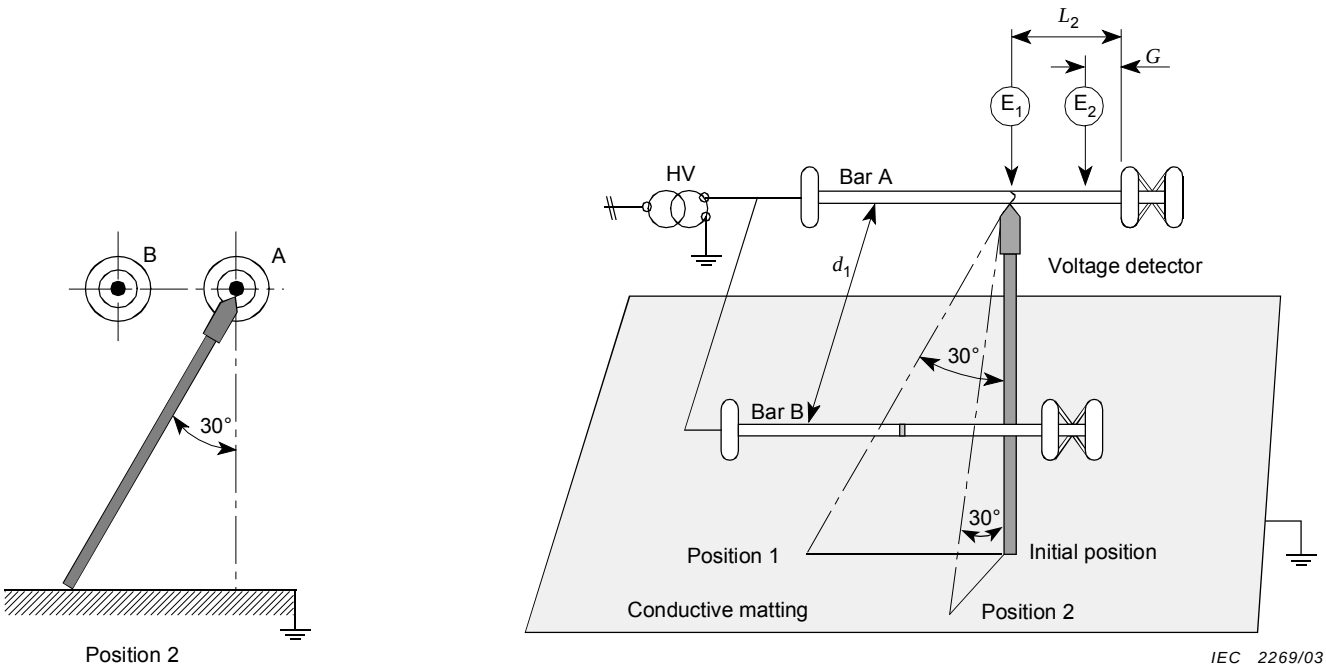


Figure 4d – Influence of in-phase interference field with the bars (see 6.2.1.3)

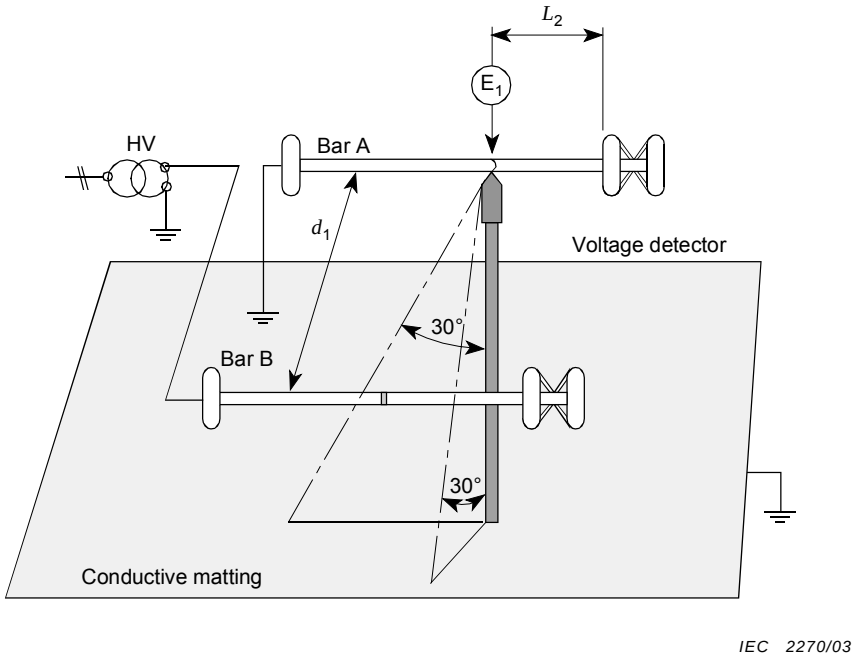


Figure 4e – Influence of phase opposition interference field with bars (see 6.2.1.4)

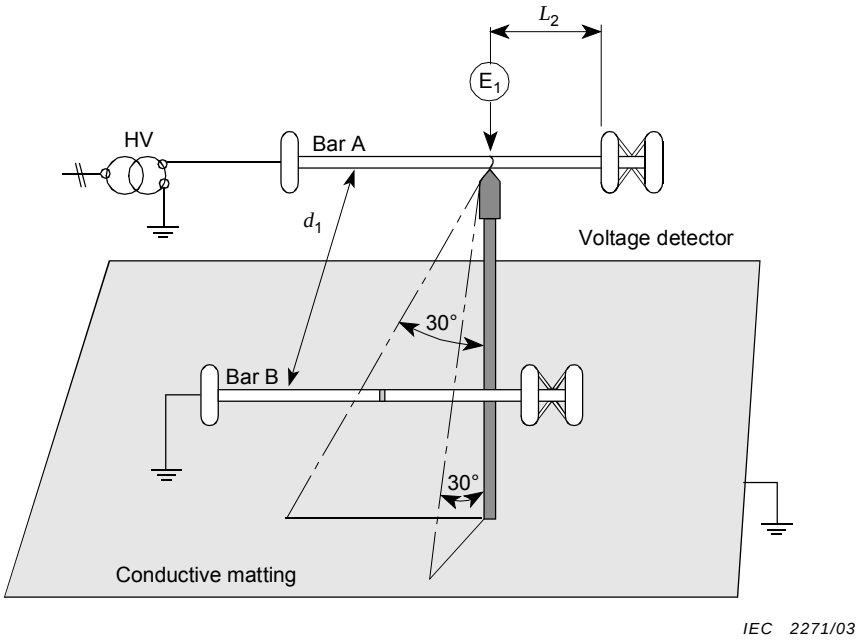
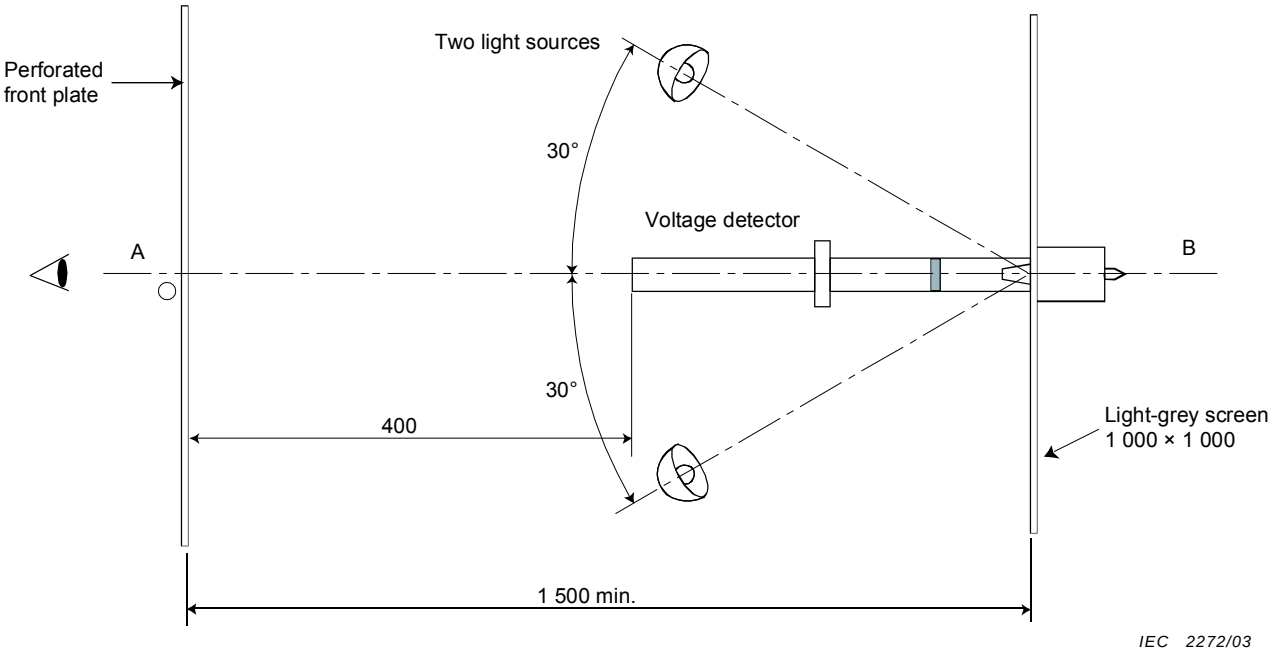


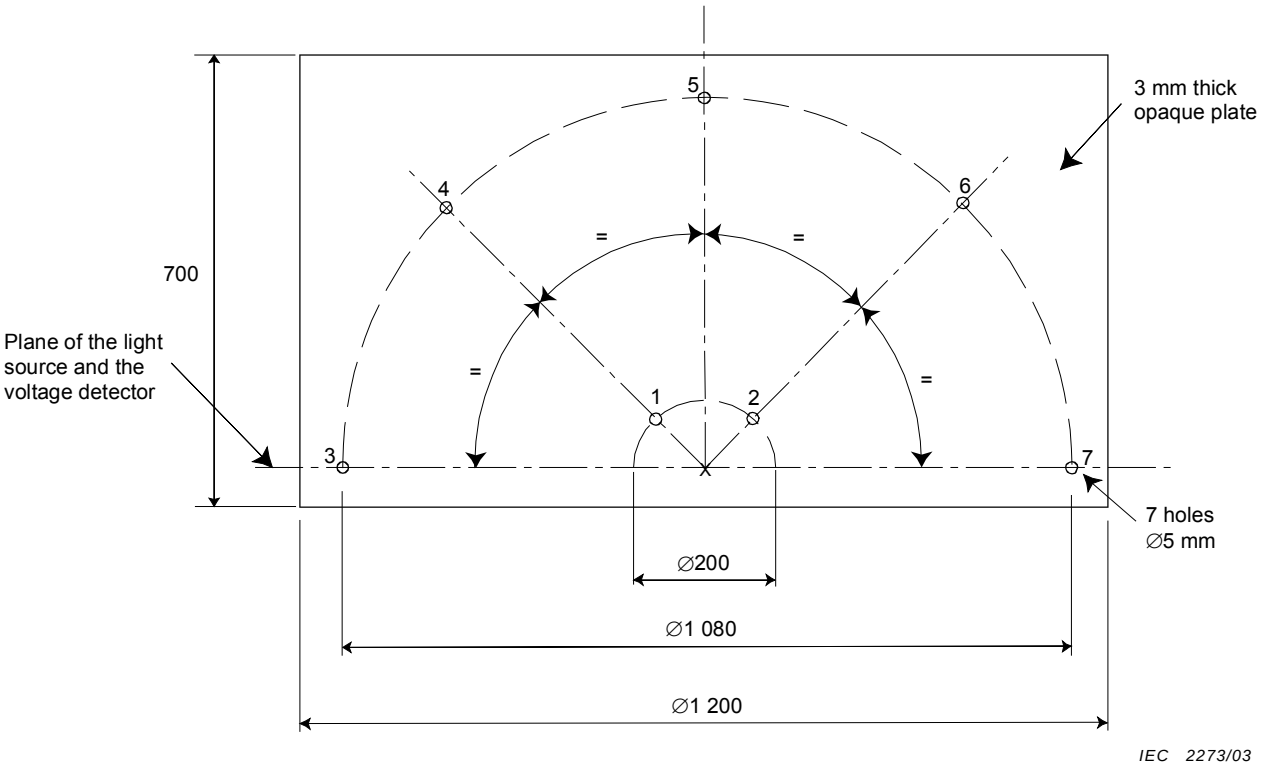
Figure 4f – Influence of interference voltage with bars (see 6.2.1.5)

Figure 4 – Circuit connections for clear indication tests (see 6.2.1)



Dimensions in millimetres

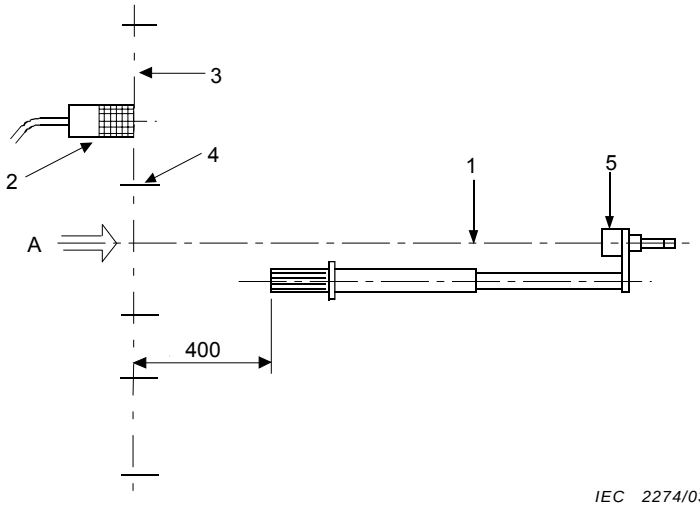
Figure 5a – Top view



Dimensions in millimetres

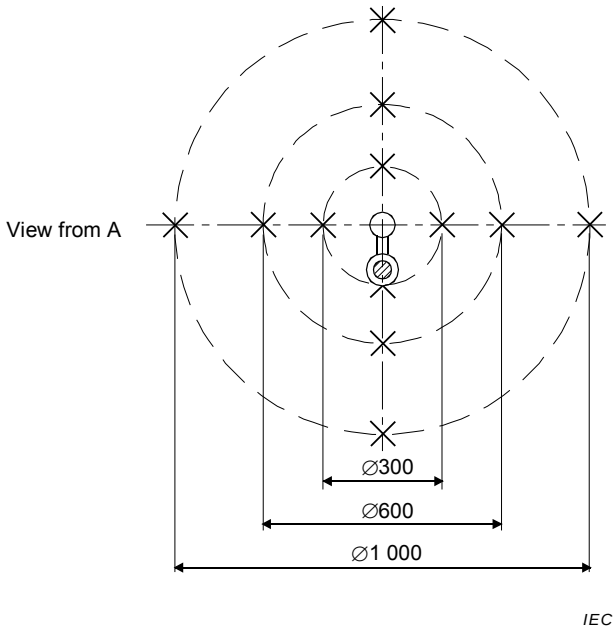
Figure 5b – Front view of the front plate

Figure 5 – Test set-up for measurement of clear perceptibility of visual indication (see 6.2.2)



Dimensions in millimetres

Figure 6a – Side view



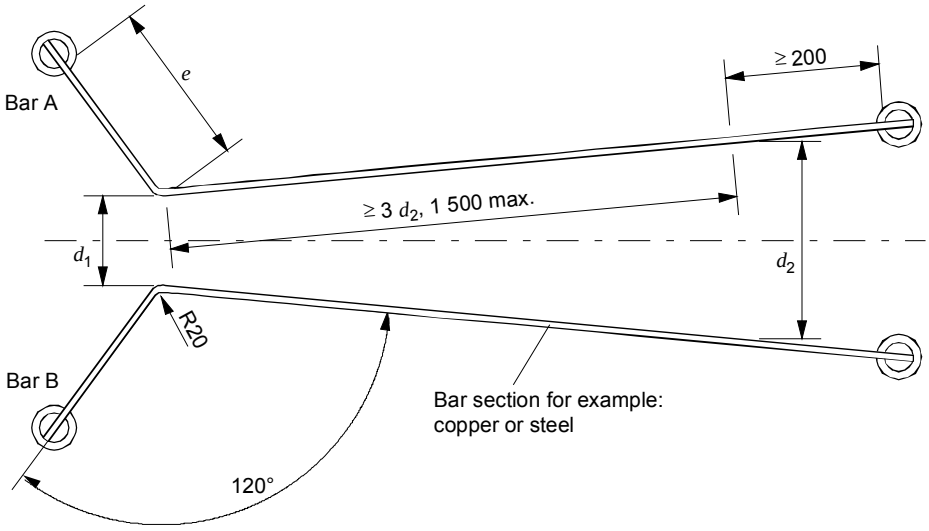
Dimensions in millimetres

Figure 6b – Front view

Key

1	Sound axis
2	Measuring microphone
3	Measuring plane
4 and X	Measuring points
5	Voltage detector

Figure 6 – Test set-up for measurement of clear perceptibility of audible indication (see 6.2.3)

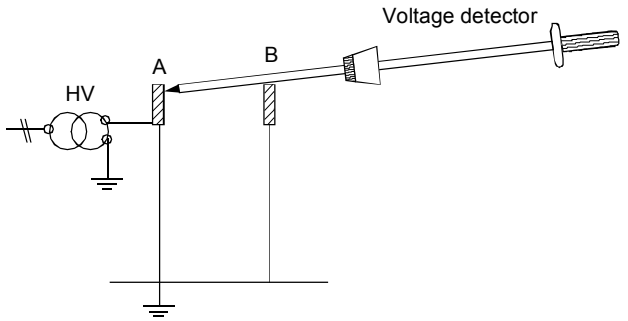


$e \geq d_1$ + 100, 1 000 max. IEC 2276/03

The bar section shall be 60 mm x 10 mm and the corners shall be rounded to a radius of 1 mm. The cut-off ends shall have the same curve as the bar.

Dimensions in millimetres

Figure 7a – Test arrangement and dimensions of the V-shape bars



IEC 2277/03

Figure 7b – Connection of the V-shape bars

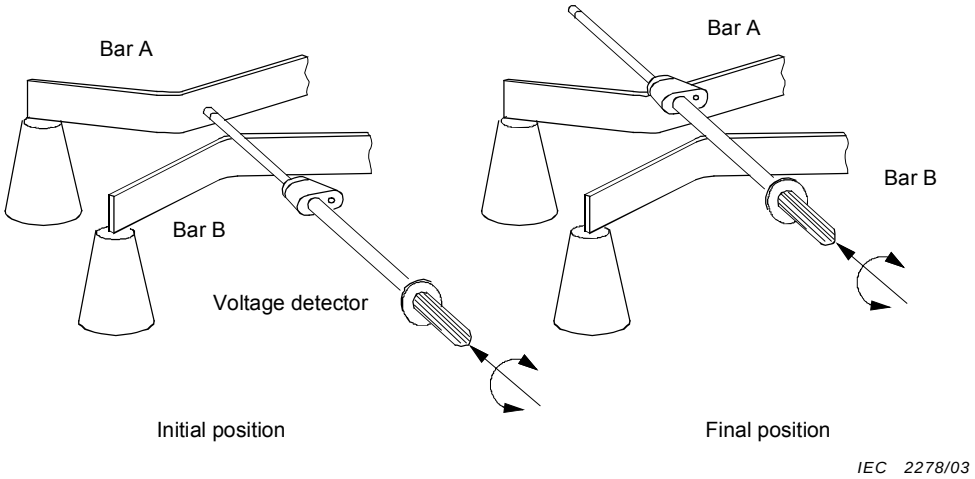


Figure 7c – Surface stress test (see 6.3.1.1.1)

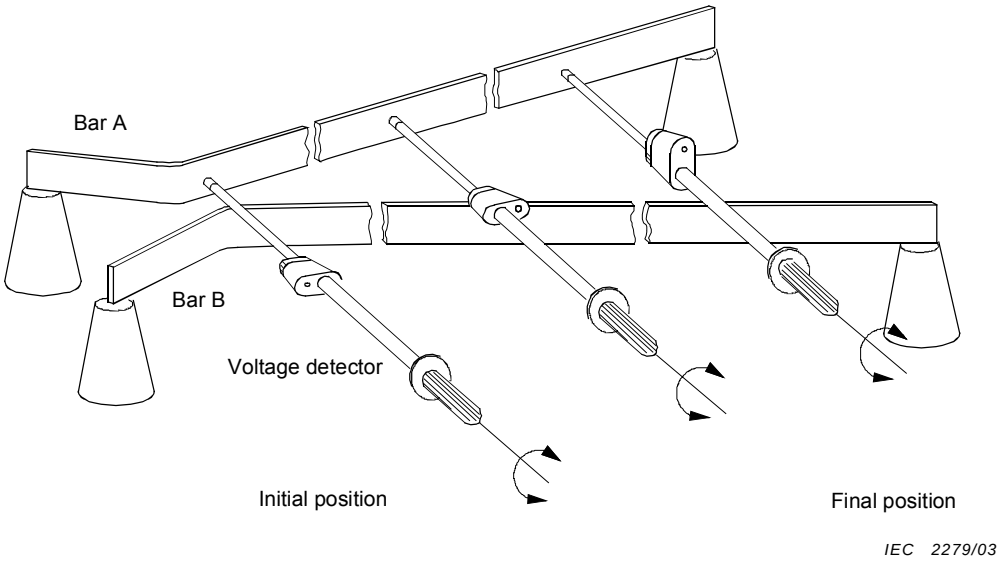
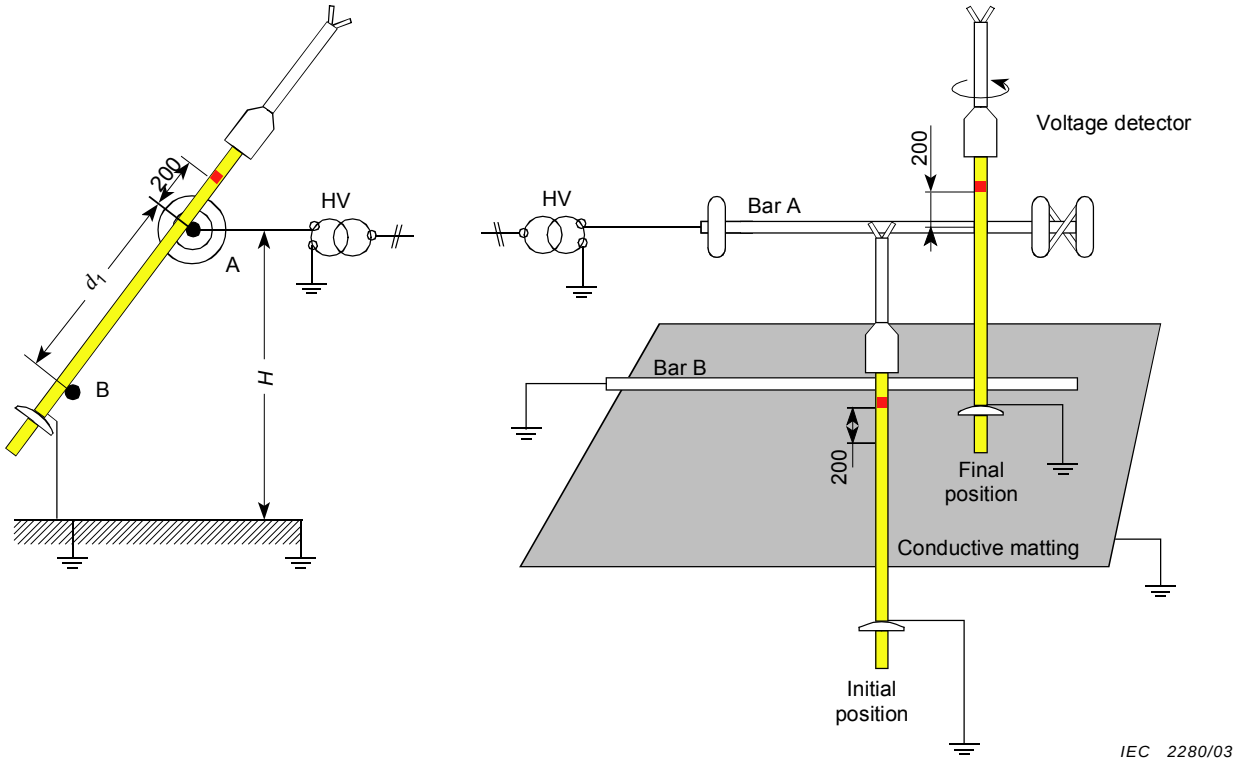
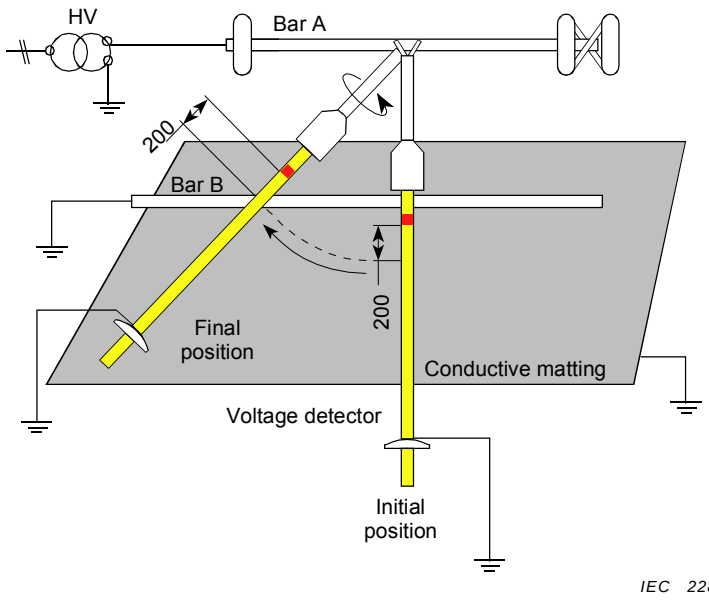


Figure 7d – Radial and surface stress test (see 6.3.1.1.2)



Dimensions in millimetres

Figure 7e – Parallel bars – Surface stress test



Dimensions in millimetres

Figure 7f – Parallel bars – Radial and surface stress test

Figure 7 – Test set-up for protection against bridging and spark resistance (see 6.3.1 and 6.3.3)

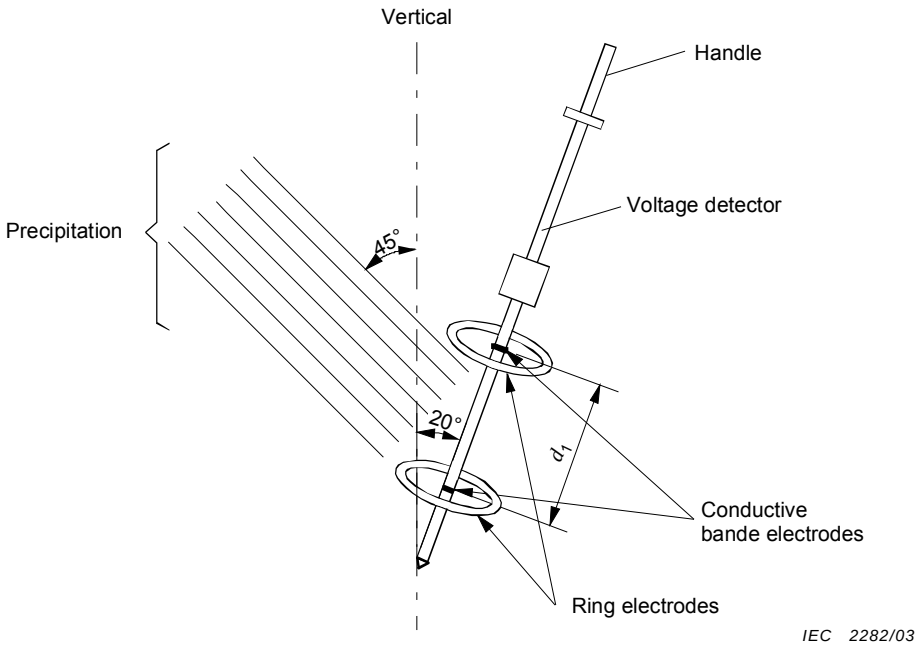
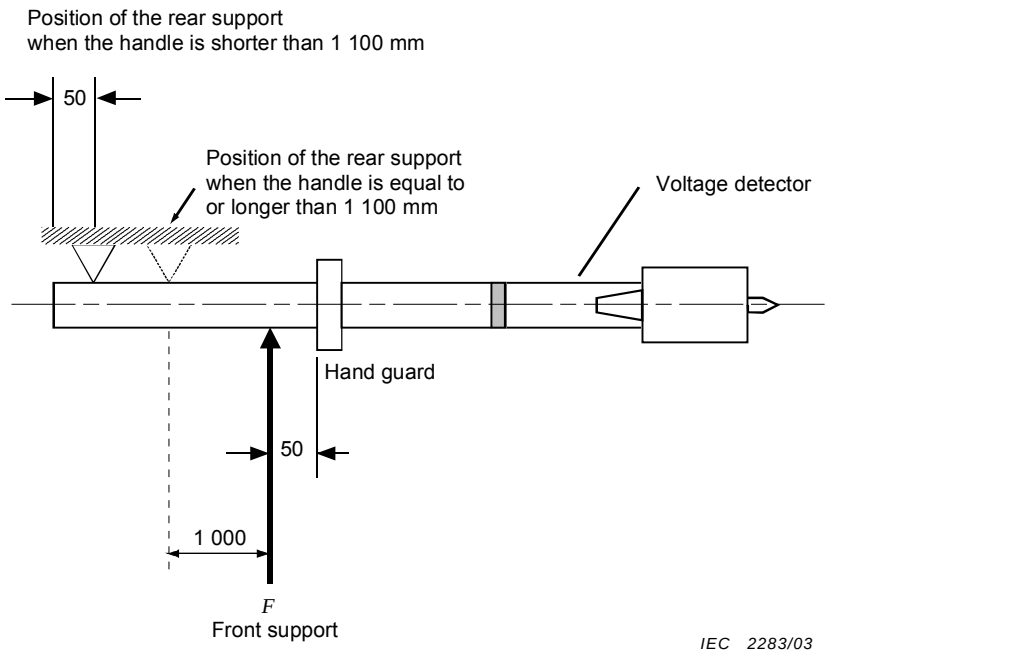


Figure 8 – Test for protection against bridging for outdoor type voltage detector (see 6.3.2)



Dimensions in millimetres

Figure 9 – Test set-up for grip force (see 6.4.2)

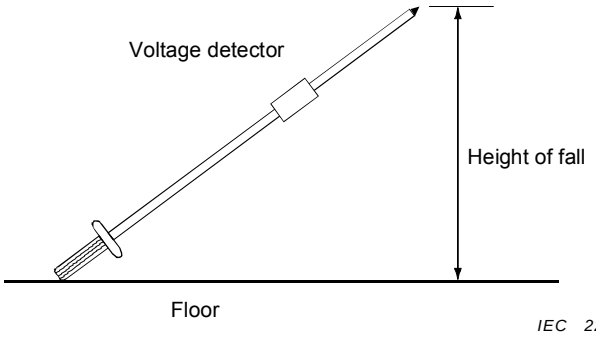


Figure 10 – Drop resistance test – Diagonal position (see 6.4.4)

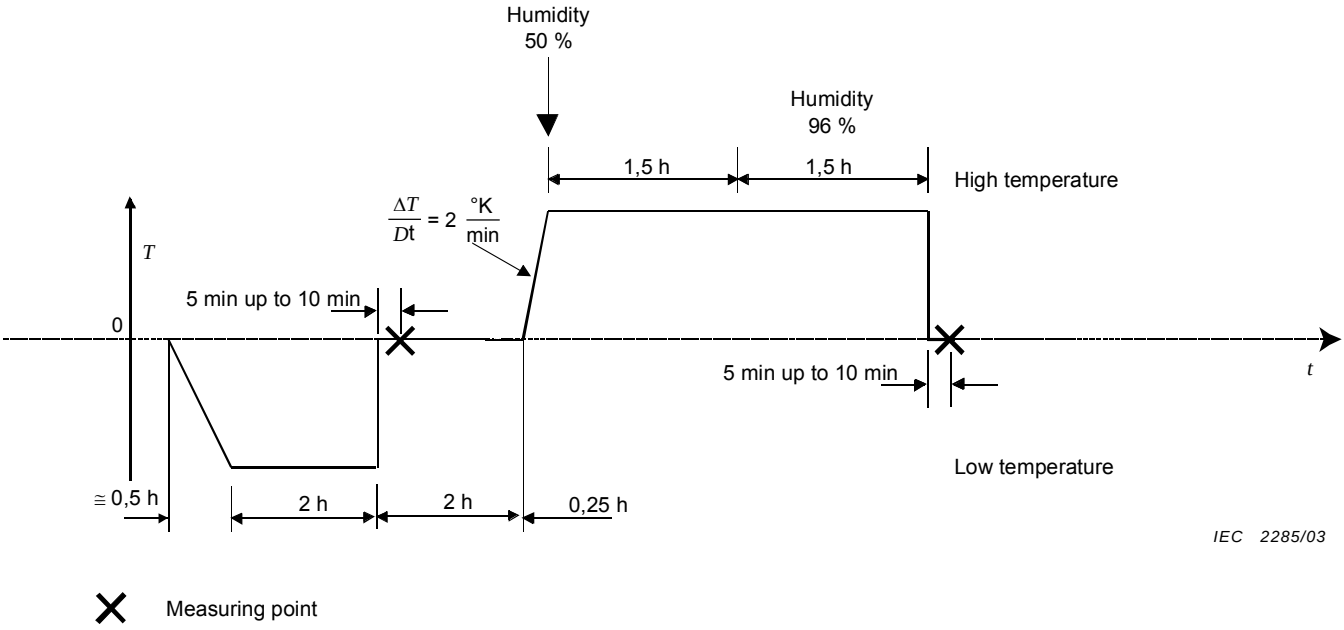


Figure 11 – Curve of test cycle for climatic dependence (see 6.4.6)

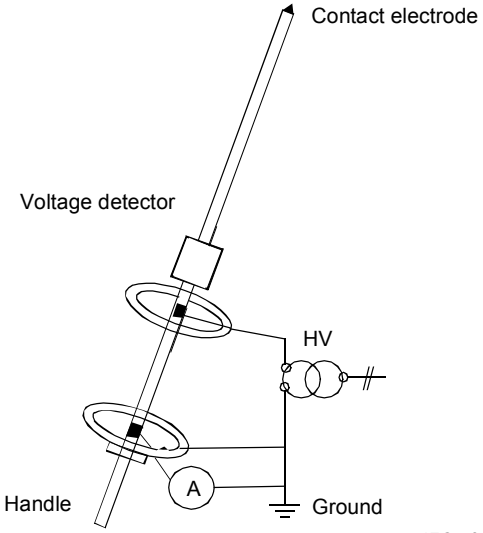


Figure 12a – Test under dry conditions (see 7.1.1)

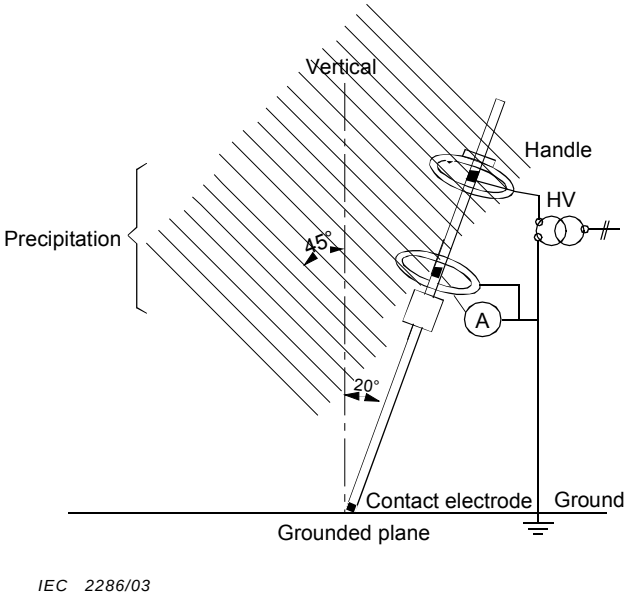


Figure 12b –Downwards position (see 7.1.2)

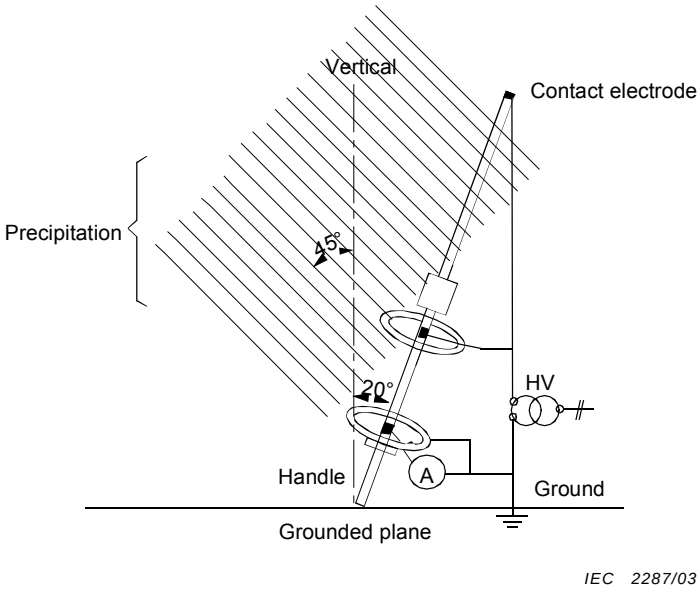


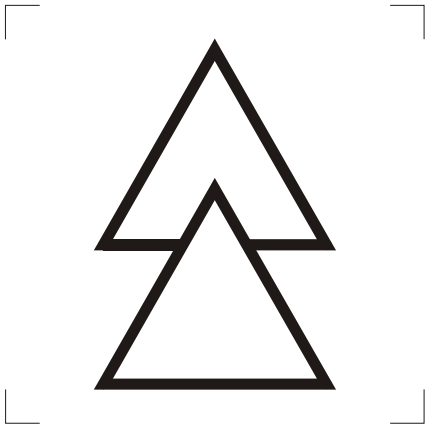
Figure 12c – Upwards position (see 7.1.2)

Test under wet conditions for outdoor type voltage detector only

Figure 12 – Arrangement for leakage current tests for voltage detector as a complete device (see 7.1)

Annex A
(normative)

Suitable for live working; double triangle (IEC-60417-5216(DB:2002-10))



Annex B
(normative)

Instructions for use

Operating instructions that contain all information necessary for the use and care of the voltage detector shall be supplied with every unit.

These include, where applicable, the following as a minimum:

– explanation of the labels;
– instructions for proper usage;
– explanation of the assembly in the case of multipart voltage detector;
– explanation of the limit mark and of the hand guard;
– significance of the indication signals;
– explanation of the function test and statement of any limitation (e.g. when the testing element is not testing all circuits);
– explanation of categories S or L, and its purpose concerning the proper use;
– statement that the function test must be repeated in the event of an indication "voltage not present";
– statement that the indication should be checked on operating voltage before every use;
– explanation concerning the possible use of accessories;
– statement concerning the possible restriction of their use on factory-assembled switchgear;
– statement concerning the possible restriction of their use on overhead systems of electrified railways;
– explanation concerning the limits within which the voltage of the installation to be tested may vary giving at the same time a clear indication;
– statement concerning possible effects of interference voltage and interference field;
– statement concerning the duration that the voltage detector may be in contact with installations while exposed to precipitation;
– instructions for storage and care;
– instructions for periodic maintenance tests;
– instructions for transport;
– statement concerning which parts of the voltage detector can be replaced by the user and what parameters shall be maintained in doing so;
– a note to the effect that if the voltage detector is without a built-in testing element, and no external testing device is available, the voltage detector shall be tested on a live conductor before and after use.
– statement concerning the type, the minimum length of the insulating element and the dielectric properties of the insulating stick that has to be used in conjunction with the voltage detector as a separate device (see 4.3.1 and 4.4.2).

Annex C
(normative)

Chronology of tests

Table C.1 – Sequential order for performing tests

Subclause		Tests		
		Type	Routine	Sampling
6.4.1	Visual and dimensional inspection	X	X	
6.4.7	Durability of markings	X		X
6.4.2	Grip force and deflection	X		X
6.4.3	Vibration	X		
6.4.4	Drop resistance	X		
6.4.5	Shock resistance	X		
6.2.1.2	Threshold voltage	X	X	
6.4.6	Climatic dependence	X		
6.3.1	Protection against bridging for indoor/outdoor type voltage detector	X		X
6.3.2	Protection against bridging for outdoor type voltage detector	X		X
6.3.3	Spark resistance	X		X
6.2.8	Non-response to d.c. voltage	X		
6.2.9	Time rating	X		
6.2.7	Check of testing element	X	X	
6.2.6	Power source dependability	X		
6.2.5	Response time	X		
6.2.4	Frequency dependence	X		
6.2.3	Clear perceptibility of audible indication	X		X
6.2.2	Clear perceptibility of visual indication	X		X
6.2.1	Clear indication	X		X
7.1	Leakage current for voltage detector as a complete device			
7.1.1	Under dry conditions	X	X	
7.1.2	Under wet conditions (for outdoor type only)	X	X[a]	

[a] Under dry conditions only.

Annex D
(informative)

Sampling procedure

D.1 General

Due to the safety of the personnel involved and the limited quantity of devices produced, special individual quality assurance plans shall be used. They are based on IEC 61318 and are presented in this annex.

Each lot consists of voltage detectors of the same class and category.

D.2 Classification of defects

The sampling plan and procedure are based on the type of defect likely to be found for voltage detectors covered in this part of IEC 61243. All defects are identified as minor or major (see definitions in IEC 61318).

Table D.1 gives the types of defects corresponding to each test retained for the sampling procedure.

Table D.1 – Classification of defects

Description of tests		Type of defects	
		Minor	Major
6.4.7	Durability of markings	X	
6.4.2	Grip force and deflection	X	
6.3.1	Protection against bridging for indoor/outdoor type voltage detector		X
6.3.2	Protection against bridging for outdoor type voltage detector		X
6.3.3	Spark resistance		X
6.2.3	Clear perceptibility of audible indication		X
6.2.2	Clear perceptibility of visual indication		X
6.2.1	Clear indication		X

D.3 General sampling plan

D.3.1 Plan for major defects

The number of voltage detectors undergoing the tests and the acceptance criterion shall be in accordance with Table 1 of IEC 61318.

D.3.2 Plans for minor defects

The number of voltage detectors undergoing the tests and the acceptance criterion shall be in accordance with Table 3 of IEC 61318.

D.4 Procedure when testing is carried out in a laboratory other than the manufacturer's

If during the conduct of the dielectric tests, the voltage detectors in a lot or batch fail to meet the requirements of 4.3 and Clause 5, the testing shall be terminated. If the testing is carried out in a laboratory other than the manufacturer's, the manufacturer or supplier shall be notified.

In such a case, the manufacturer or supplier may ask the customer or testing laboratory to submit proof that the test procedure and equipment conform to the applicable clauses of this standard.

When such proof has been established, the manufacturer or supplier may request that his representative witness the testing of additional voltage detectors from the shipment the lot is rejected.

All voltage detectors from rejected lots shall be identified and returned as directed by the manufacturer or supplier, but without permanent marking.

Annex E
(normative)

Mechanical shock tests – Pendulum method

The shock test shall be performed using the pendulum method (see 6.4.5). The pendulum comprises a hammer fixed at the end of an oscillating arm, and rotating around a horizontal axis (see Figure E.1).

The hammer moves by gravity in a vertical plane.

The arm of the hammer is a steel tube, of 9 mm outer diameter and 8 mm inside diameter, having

– a rotational fitting at the top to permit the adjustment of the strike. The axis of the pendulum shall always be perpendicular to the support face of the rigid frame;
– a 1,5 kg hammer fixed at the bottom end, and has a radius of swing of 1 m to give a shock of 6 J at a fall height of 400 mm.

The voltage detector shall be fastened to the rigid frame so that the point of impact for each shock coincides with the location where the trajectory of the hammer meets the vertical plane through the axis of the swing. This swing shall coincide with the tangent plane at the point of impact for a curved surface (see Figure E.1a).

The hammer details are given in Figures E.1c and E.1d.

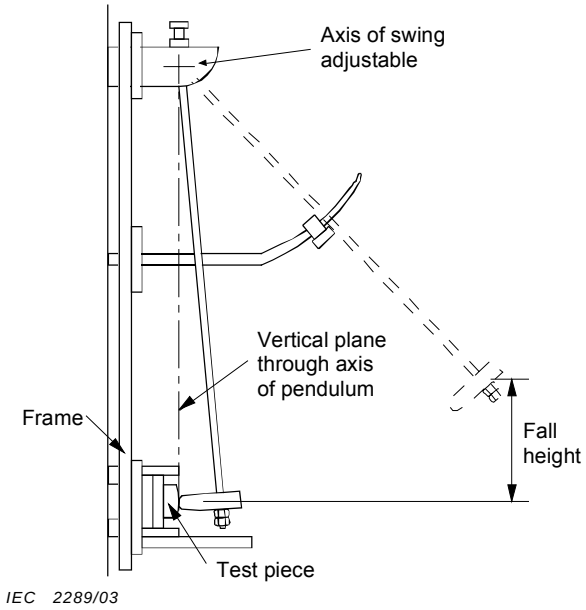
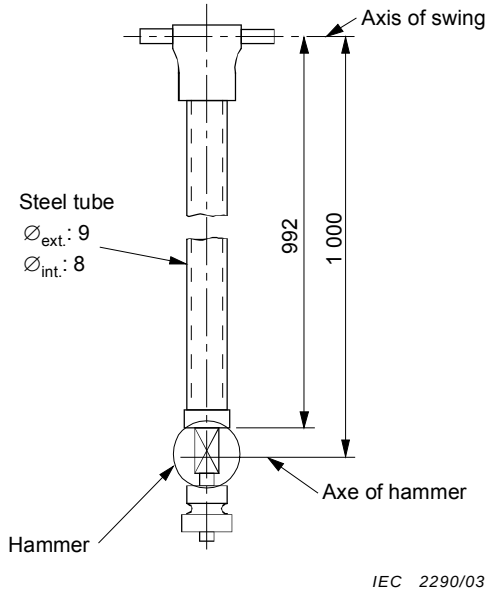


Figure E.1a – Side view



Dimensions in millimetres

Figure E.1b – Front view

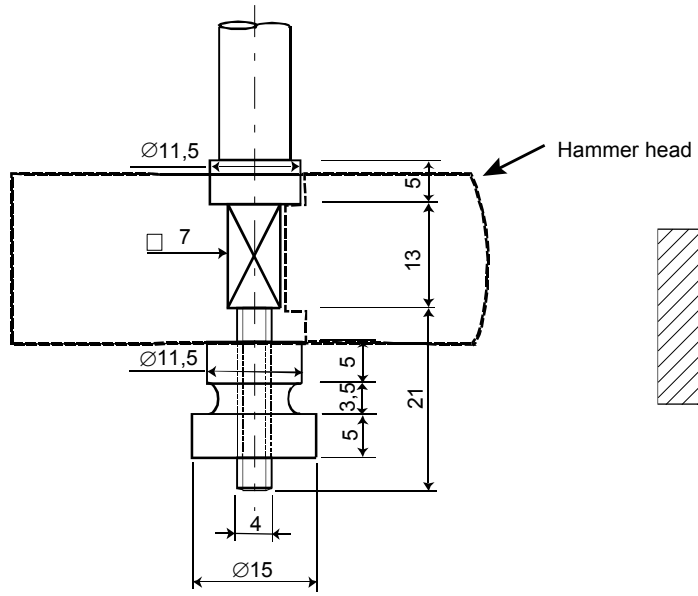
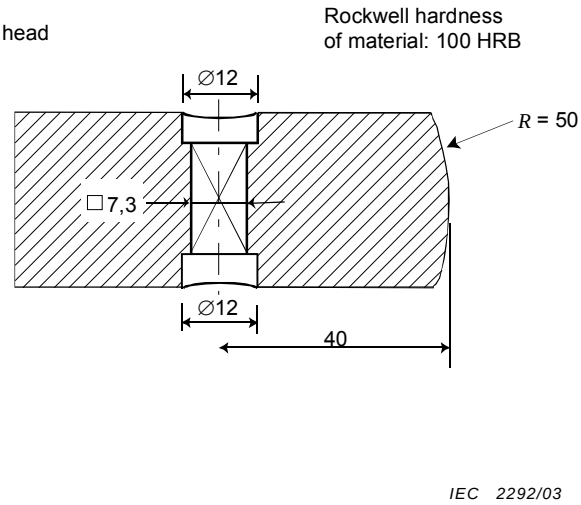


Figure E.1c – Detail of the assembly of hammer



Dimensions in millimetres

Figure E.1d – Detail of hammer head

Figure E.1 – Details of pendulum for shock test

Annex F
(informative)

Acceptance tests

An acceptance test is a contractual test to prove to the customer that the item(s) or product in question meet(s) the conditions of the customer's specification.

If the customer only requires that the product shall meet those of the governing standard the basic acceptance tests are those which are specified in the governing standard. The customer may request that they be repeated on his order.

The customer may request additional tests or increase the sampling size but shall include this in his own specification. The expansion of the acceptance testing beyond the tests required in the governing standard is subject to agreement between the customer and the supplier.

The customer shall include the acceptance test requirements in his own specification and may wish to witness the tests, have them witnessed by a third party or accept the results of the tests carried out by the manufacturer. The customer may prefer to perform the tests in his own laboratory or may specify that the tests be carried out in an independent laboratory of his choosing. This additional test expense is subject to agreement between the customer and the supplier.

Annex G
(informative)

In-service care

G.1 General

Maintenance on live equipment in service is recognised as a basis for insuring their good functioning and the safety of the user. It is the responsibility of the user to elaborate the maintenance schedule, taking into account the use conditions (storage, regular care, training of the user, etc.). However no voltage detector, even those held in storage, should be used unless re-testing within a maximum period of 6 years.

It is recommended that the maintenance be done by the manufacturer or at an agreed trained repair facility.

In any time, when a voltage detector is to be used, a visual inspection should be done. If there is a serious doubt that the device is not in a good condition, it should be discarded for testing, then returned to the manufacturer for repair or rejection.

G.2 Testing

Table G.1 lists the tests which permit to verify the physical integrity, the functioning of the voltage detector and its insulation performance.

Table G.1 – In-service testing

Subclauses	Designation
6.4.1	Visual and dimensional inspection
6.2.7	Check of testing element
7.1.1	Leakage current under dry conditions [a]
6.2.1.2	Measurement of threshold voltage
6.2.1.3	Influence of in-phase interference field
6.2.2	Clear perceptibility of visual indication [b]
6.2.3	Clear perceptibility of audible indication [c]
6.3.1	Protection against bridging for indoor/outdoor type voltage detector [d]
6.3.3	Spark resistance [e]

[a] When the test is performed as a periodic testing, the admissible leakage current may be higher than that specified in 7.1.1 but the selection of the current value should take into consideration the basic guidance given in IEC 60479-1.

[b] A comparison may be made with a voltage detector of the same type which has withstood the test according to 6.2.2. Arrangement and performance with regard to the reference voltage detector should correspond to clause 6.2.2 but the test should be carried out by means of the testing element. The voltage detector is considered to have withstood the test if at least the same accuracy of visual indication is reached.

[c] A comparison may be made with a voltage detector of the same type which has withstood the test according to 6.2.3. The sound pressure level of the voltage detector is compared to the sound pressure level of the reference voltage detector each located at the same position in the testing room. The sound pressure level of the voltage detector should reach at least the same level of the reference voltage detector.

[d] Under dry conditions only.

[e] For practical purpose this test may be combined with 6.3.1.

NOTE According to the design of the voltage detector and its fabrication process the manufacturer may specify additional tests related to particular components or characteristics. These specific tests should be noticed in the instructions for use.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE Where an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60060-1 + corr. March	1989 1990	High-voltage test techniques Part 1: General definitions and test requirements	HD 588.1 S1	1991
IEC 60068-1	- [1)]	Environmental testing Part 1: General and guidance	EN 60068-1	1994 [2)]
IEC 60068-2-6 + corr. March	1995 1995	Part 2: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	1995
IEC 60068-2-14 + A1	1984 1986	Part 2: Tests - Test N: Change of temperature	EN 60068-2-14	1999
IEC 60068-2-32 + A2	1975 1990	Part 2: Tests - Test Ed: Free fall (Procedure 1)	EN 60068-2-32	1993
IEC 60071-1	1993	Insulation co-ordination Part 1: Definitions, principles and rules	EN 60071-1	1995
IEC 60417	database	Graphical symbols for use on equipment	-	-
IEC 60942	- [1)]	Electroacoustics - Sound calibrators	EN 60942	2003 [2)]
IEC 61260	1995	Electroacoustics - Octave-band and fractional-octave-band filters	EN 61260	1995
IEC 61477 A1	2001 2002	Live working - Minimum requirements for the utilization of tools, devices and equipment	EN 61477 A1	2002 2002
IEC 61672-1	2002	Electroacoustics - Sound level meters Part 1: Specifications	EN 61672-1	2003
ISO 286-1	1988	ISO system of limits and fits Part 1: Bases of tolerances, deviations and fits	EN 20286-1	1993
ISO 286-2	1988	Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts	EN 20286-2	1993
ISO 3744	1994	Acoustics - Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free field over a reflecting plane	EN ISO 3744	1995
CIE 15.2 [3)]	1986	Colorimetry	-	-

[1)] Undated reference.

[2)] Valid edition at date of issue.

[3)] CIE = International Commission on Illumination.

Bibliography

IEC 60050-101:1998, *International Electrotechnical Vocabulary (IEV) – Part 101: Mathematics*

IEC 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*

IEC 60050-601:1985, *International Electrotechnical Vocabulary (IEV) – Chapter 601: Generation, transmission and distribution of electricity – Generation*

IEC 60050-651:1999, *International Electrotechnical Vocabulary (IEV) – Part 651: Live working*

IEC 60479-1, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC 60743:2001 *Live working – Terminology for tools, equipment and devices*

IEC 60855:1985, *Insulating foam-filled tubes and solid rods for live working*

IEC 61235:1993, *Live working – Insulating hollow tubes for electrical purposes*

IEC 61672-2:2003, *Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests*

IEC 61936-1:2002 *Power installations exceeding 1 kV a.c. – Part 1: Common rules*

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