भारतीय मानक

Indian Standard

IS 16619 (Part 1) : 2023
IEC 61243-1 : 2021

लाइव वर्किंग — वोल्टेज डिटेक्टर

भाग 1 1 केवी ए.सी. से अधिक वोल्टेज के लिए उपयोग किए जाने वाले संधारित्र के प्रकार

(पहला पुनरीक्षण)

Live Working — Voltage Detectors

Part 1 Capacitive Type to be Used for Voltages Exceeding 1 kV a.c.

(First Revision)

ICS 13.260; 29.240.20; 29.260.99

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

November 2023 **Price Group 16**

Tools and Equipment for Live Working Sectional Committee, ETD 36

NATIONAL FOREWORD

This Indian Standard (Part 1) (First Revision) which is identical with IEC 61243-1 : 2021 'Live working — Voltage detectors — Part 1: Capacitive type to be used for voltages exceeding 1 kV a.c.' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on recommendation of the Tools And Equipment For Live Working Sectional Committee and approval of the Electrotechnical Division Council.

This standard was originally published in 2018. The first revision of this standard has been undertaken to align it with the latest version of IEC 61243-1 to make pace with the latest developments that have taken place at International level.

The text of the IEC standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and
b) Comma (,) has been used as a decimal marker, while in Indian Standards the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60060-1 : 2010 High-voltage test techniques — Part 1: General definitions and test requirements	IS 2071 (Part 1) : 2016/IEC 60060-1 : 2010 High-voltage test techniques: Part 1 General definitions and test requirements (*third revision*)	Identical
IEC 60068-1 Environmental testing — Part 1: General and guidance	IS/IEC 60068 (Part 1) : 2013 Guidance for environmental testing: Part 1 General	Identical
IEC 60068-2-31 Environmental testing — Part 2-31: Tests — Test Ec: Rough handling shocks, primarily for equipment-type specimens	IS 9000 (Part 7/Sec 3) : 2019/IEC 60068-2-31 : 2008 Environmental testing: Part 7 Tests, Sec 3 Test Ec: Rough handling shocks, primarily for equipment-types specimens (*first revision*)	Identical
IEC 60068-2-75 Environmental testing — Part 2-75: Tests — Test Eh: Hammer tests	IS 9000 (Part 7/Sec 7) : 2020/IEC 60068-2-75 : 2014 Environmental testing: Part 7 Tests, Sec 7 Test Eh: Hammer tests (*first revision*)	Identical
IEC 60071-1 Insulation co-ordination — Part 1: Definitions, principles and rules	IS/IEC 60071 (Part 1) : 2006 Insulation co-ordination: Part 1 Definitions, principles and rules	Identical
IEC 60942 Electroacoustics — Sound calibrators	IS 15059 : 2018/IEC 60942 : 2017 Electroacoustics — Sound calibrators (*first revision*)	Identical

IEC 61000-6-2 : 2016 Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity standard for industrial environments	IS 14700 (Part 6/Sec 2) : 2019/IEC 61000-6-2 : 2016 Electromagnetic compatibility (EMC): Part 6 Generic standards, Sec 2 Immunity standard for industrial environments (*first revision*)	Identical
IEC 61318 Live working — Conformity assessment applicable to tools, devices and equipment	IS 16155 : 2014/IEC 61318 : 2007 Live working — Conformity assessment applicable to tools, devices and equipment (*first revision*)	Identical
IEC 61672-1 Electroacoustics — Sound level meters — Part 1: Specifications	IS 15575 (Part 1) : 2016/IEC 61672-1 : 2013 Electroacoustics — Sound level meters: Part 1 Specifications (*first revision*)	Identical
IEC 62271 (All parts) High-voltage switchgear and controlgear	IS/IEC 62271 (All parts) High-voltage switchgear and controlgear	Identical
ISO 286-1 Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 1: Basis of tolerances, deviations and fits	IS 919 (Part 1) : 2014/ISO 286-1 : 2010 Geometrical product specifications (GPS) — ISO code system for tolerances on linearsizes: Part 1 Basis of tolerance, deviation and fits (*third revision*)	Identical
ISO 286-2 Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts	IS 919 (Part 2) : 2014/ISO 286-2 : 2010 Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes: Part 2 Tables of standard tolerance classes and limit deviationf or holes and shafts (*second revision*)	Identical

The Committee has reviewed the provisions of the following International Standards referred to in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60068-2-6	Environmental testing — Part 2-6: Tests — Test Fc: Vibration (sinusoidal)
IEC 60068-2-14	Environmental testing — Part 2-14: Tests — Test N: Change of temperature
IEC 60417	Graphical symbols for use on equipment
IEC 61260 (All parts)	Electroacoustics — Octave-band and fractional-octave-band filters
IEC 61326-1	Electrical equipment for measurement, control and laboratory use — EMC requirements — Part 1: General requirements
EC 61477	Live working — Minimum requirements for the utilization of tools, devices and equipment

ISO 3744 : 2010	Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering method for an essentially free field over a reflecting plane
CISPR 11	Industrial, scientific and medical equipment — Radio-frequency disturbance characteristics — Limits and methods of measurement
CIE 015.2	Colorimetry

Only the English language text has been retained while adopting it in this Indian Standard, and as such, the page numbers given here are not the same as in the IEC Publication.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding of numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

CONTENTS

INTRODUCTION

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

Indian Standard

LIVE WORKING — VOLTAGE DETECTORS

PART 1 CAPACITIVE TYPE TO BE USED FOR VOLTAGES EXCEEDING 1 KV AC

(First Revision)

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 800 kV AC, and frequencies of 50 Hz and/or 60 Hz.

This document applies only to *voltage detectors* of capacitive type used in contact with the bare 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 document (see 4.4.2.1 for general design).

Other types of *voltage detectors* are not covered by this document.

NOTE Self ranging *voltage detectors* (formally "multi range *voltage detectors*") are not covered by this document.

Some restrictions or formal interdictions on their use are applicable in case of switchgear of IEC 62271 series design, due to insulation coordination, on overhead line systems of electrified railways (see Annex B) and systems without neutral reference. For systems without neutral reference, the insulating level is adapted to the maximum possible voltage to the earth (ground).

Products designed and manufactured according to this document contribute to the safety of users provided they are used by persons trained for the work, in accordance with the hot stick working method and the instructions for use.

Except where otherwise specified, all the voltages defined in this document 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 are used to determine the *operating voltage*.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60060-1:2010, *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, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60071-1:2019, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60417, *Graphical symbols for use on equipment* (Available from: http://www.graphical-symbols.info/equipment)

IEC 60942, *Electroacoustics – Sound calibrators*

IEC 61000-6-2:2016 *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 61260 (all parts), *Electroacoustics – Octave-band and fractional-octave-band filters*

IEC 61318, *Live working – Conformity assessment applicable to tools, devices and equipment*

IEC 61326-1, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61477, *Live working – Minimum requirements for the utilization of tools, devices and equipment*

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

IEC 62271 (all parts), *High-voltage switchgear and controlgear*

ISO 286-1*, Geometrical product specifications (GPS) – ISO code system for tolerances on linear sizes – Part 1: Basis of tolerances, deviations and fits*

ISO 286-2*, Geometrical product specifications (GPS) – ISO code system for tolerances on linear sizes – Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

ISO 3744:2010, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering method for an essentially free field over a reflecting plane*

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CIE 015.2, *Colorimetry*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61318 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

3.1
accessory
item used to lengthen the handle or the *contact electrode* or *contact probe*, to improve the efficiency of the *contact electrode* or *contact probe* or to enable the *contact electrode* or *contact probe* to reach the part to be tested

3.2
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"

Note 1 to entry: A signal indicating that the *voltage detector* is ready to operate is not considered as an *active signal*.

[SOURCE: IEC 60050-101:1998, 101-12-02, modified – The term "signal" has been replaced by "*active signal*". In the definition, "physical" has been replaced by "audible or visual" and "on the condition "voltage present" or "voltage not present"" has been added.]

3.3
adaptor
part of a *voltage detector* as a separate device which permits attachment of an *insulating stick*

3.4
clear indication
unambiguous detection and indication of the voltage state at the *contact electrode* or *contact probe*

3.5
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

3.6
contact electrode
bare conductive part of the conductive element which establishes the physical electric connection to the component to be tested

Note 1 to entry: The task of the *contact electrode* is to give the user the feedback that he or she is in touch with the part to be tested.

3.7
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

3.8
contact probe
part which establishes the physical contact with the bare part to be tested

Note 1 to entry: The contact of the *contact probe* with the part to be tested is conductive, all the other part of the *contact probe* is non-conductive.

Note 2 to entry: The *contact probe* with non-conductive part establishes the mechanical positioning of the detector in order to guarantee the contact between the component to be tested and the *contact electrode*.

3.9
design
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*

3.10
exclusively outdoor type
<*voltage detector*> designed for outdoor use exclusively in wet and dry conditions

Note 1 to entry: It is a special type of *voltage detector* designed for outdoor installations when large *contact electrodes* are required.

3.11
family of voltage detectors
for testing purposes, a group of *voltage detectors*, delimited by a minimum and a maximum *rated voltage*, that are identical in design (including dimensions) and only differ by their *nominal voltages* or *nominal voltage* ranges

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

Note 1 to entry: Its purpose is to prevent the hands from slipping and passing into contact with the *insulating element*.

3.13
indicator
part of the *voltage detector* which indicates the presence or absence of the *operating voltage* at the *contact electrode* or *contact probe*

3.14
indoor type
<*voltage detector*> designed for use in dry conditions, normally indoors

3.15
insulating element
part of a *voltage detector* as a complete device that provides adequate safety distance and insulation to the user

3.16
insulating stick
insulating tool essentially made of an insulating tube and/or rod with end fittings

[SOURCE: IEC 60050-651:2014, 651-22-01]

3.17
interference field
superposed electric field which may affect the indication

Note 1 to entry: It may result from the part to be tested or other adjacent parts and may have any phase relationship.

Note 2 to entry: The extreme cases for the tests areas follows.

– 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 the 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.

3.18
interference voltage
voltage picked up inductively or capacitively by the part to be tested

3.19
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

3.20
maintenance test
test carried out periodically on a *voltage detector* or parts of it to ascertain and ensure that its performance remains within specified limits, after having made certain adjustments, if necessary

[SOURCE: IEC 60050-151:2001, 151-16-25, modified – In the definition, "an item" is replaced by "a *voltage detector* or parts of it", "to verify" is replaced by "to ascertain and ensure".]

3.21
nominal voltage
U_n
suitable approximate value of voltage used to designate or identify a system or device

Note 1 to entry: The *nominal voltage* of the *voltage detector* is the parameter associated with its *clear indication*.

[SOURCE: IEC 60050-601:1985, 601-01-21, modified – "or device" has been added at the end of the definition.]

3.22
operating voltage
<in a system> value of the voltage under normal conditions, at a given instant and a given point of the system

Note 1 to entry: This value is measured (normally), estimated or expected.

[SOURCE: IEC 60050-601:1985, 601-01-22, modified – The domain <in a system> has been added.]

3.23
outdoor type
<*voltage detector*> designed for use in wet conditions, either indoors or outdoors

3.24
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*

3.25
rated voltage
U_r
value of voltage generally agreed upon by manufacturer and customer, to which certain operating specifications are referred

Note 1 to entry: The *rated voltage* of the *voltage detector* is the voltage selected from IEC 60071-1:2019, 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.

3.26
ready to operate state
state at which the *voltage detector* has been switched on and tested on the live part or external tester, or tested with built-in self-test and gives the ready to operate indication

3.27
response time
time delay between sudden change of the voltage state on the *contact electrode* or *contact probe* and the associated *clear indication*

3.28
selector
mechanical or electronic switch or means to change the range of the *nominal voltage* and/or the nominal frequency

3.29
stand-by state
permanent state in which the *voltage detector* will indicate "voltage present" automatically when put in contact with operational voltage

3.30
testing element
built-in or separate device, by means of which the functioning of the *voltage detector* can be checked by the user

[SOURCE: IEC 60743:2013, 11.3.7, modified – The terms "element" and "diagnostic device" have been deleted.]

3.31
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 1 to entry: As defined in this document, *threshold voltage* is related to specific test conditions. It is important that users are aware that their requirements for *threshold voltage* for field operation need to be related to the test conditions in this document.

3.32
voltage detector
diagnostic device used to provide clear evidence of the presence or absence of an *operating voltage*

Note 1 to entry: These diagnostic devices are generally described as either capacitive type or resistive type.

Note 2 to entry: Clear evidence is a YES or NO indication with no interpretation needed.

Note 3 to entry: According to the performance, in some parts of the world a capacitive type is named unipolar and resistive type is named bipolar.

[SOURCE: IEC 60050-651:2014, 651-24-02, modified – In Note 2 to entry, the second sentence has been deleted. Note 3 to entry has been replaced.]

3.33
voltage detector of capacitive type
device whose operation is based on the current passing through the stray capacitance to earth (ground)

Note 1 to entry: The term *voltage detector* is used in this document for *voltage detector of capacitive type*.

Note 2 to entry: For voltage detection, an *insulating stick* is intended to be 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.

4 Requirements

4.1 General requirements

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

4.2.1.1 General

If *voltage detectors* have more than one *nominal voltage* or a *nominal voltage* range, the limiting values are named $U_{n\ min}$ and $U_{n\ max}$.

The *voltage detector* shall give an unambiguous indication of the presence and/or the absence of any *operating voltages* related to the *nominal voltage* or *nominal voltage* range of the *voltage detector*, and its nominal frequency or nominal frequencies only or almost when in contact with the bare part to be tested.

NOTE 1 A *voltage detector* can indicate the presence of voltage just before touching a bare part to be tested. The distance for which a *voltage detector* is able to indicate the presence of voltage depends, among various parameters, on the *operating voltage* and on the configuration of the installation.

Indication may not be reliable in the vicinity of large conductive parts that create equipotential zones.

When the *voltage detector* is used in accordance with instructions for use, the presence of an adjacent live or earthed (grounded) part shall not affect its indication of in-phase or phase opposition situation.

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

NOTE 2 Annex H presents some information for the next maintenance of this document.

4.2.1.2 Continuous indication

The *voltage detector* shall give permanent indication when in direct contact with a live part.

4.2.1.3 Threshold voltage

4.2.1.3.1 General

The indication "voltage present" shall appear if the voltage to earth (ground) on the part to be tested is greater than 45 % of the *nominal voltage*.

NOTE 1 45 % of the *nominal voltage* corresponds to $0,78U_n / \sqrt{3}$.

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

NOTE 2 10 % of the *nominal voltage* corresponds to $0,17U_n / \sqrt{3}$ and is the maximum phase to earth (ground) induced voltage normally encountered in the field.

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

$$0,10\ U_{n\ max} < U_t \leq 0,45\ U_{n\ min}$$

For *voltage detectors* with only one *nominal voltage*, $U_{n\ max}$ equals $U_{n\ min}$.

NOTE 3 There is a theoretical limit of 4,5 to the ratio between $U_{n\ max}$ and $U_{n\ min}$ to achieve *clear indication* of the *voltage detector*. This value corresponds to the division of 0,45 by 0,1.

NOTE 4 In some cases the induced voltage level on a specific network is higher than 10 % of the *nominal voltage* or of the maximum *nominal voltage* of the range. In this case, a special marking is the result of an agreement between the manufacturer and the client to identify the compatible devices

In some cases the variations of the nominal voltage network are such that 0,45 U_{n} or 0,45 $U_{n\ min}$ is not the lowest possible value.

Moreover, when it is expected that the *voltage detector* will be used in the vicinity of large conductive parts that create equipotential zones (see 4.2.1), customers can agree with the manufacturer on a low value of the *threshold voltage*.

In all these cases, an agreement is necessary between manufacturer and customer to set the appropriate value for the *threshold voltage*, while keeping the ratio of $U_{n\ max}$ and $U_{n\ min}$ below or equal to 4,5. The setting of the *threshold voltage* is further limited by the requirements and tests for *clear indication* which shorten the range of possible values.

4.2.1.3.2 Particular case of voltage detectors to be used on networks with low values of interference voltage

In some cases, the customer may wish to take advantage of a network with low values of *interference voltage* by reducing the lower limit of the *threshold voltage* below 0,10 $U_{n\ max}$.

This particular case allows the application of the *voltage detector* in the vicinity of large conductive parts. Changing the *threshold voltage* to a lower value, the theoretical limit of 4,5 for the ratio between $U_{n\ max}$ and adapted $U_{n\ min}$ still remains valid, and the relevant tests (*clear indication*) shall be passed, with adapted lower value of the *threshold voltage* for the *interference voltage* test.

In such case, the *voltage detector* shall have a special marking and a warning shall be included in the instructions for use to inform the users of the modification brought to the *threshold voltage*.

4.2.1.3.3 Indication on overhead lines

Voltage detectors of category L (see 4.4.2.2) shall give a *clear indication* on overhead lines and fulfil the requirement of 4.2.1.3.1.

NOTE This additional test assures, that *voltage detectors* of category L will give a *clear indication* on overhead lines except when they are used in equipotential zones. *Voltage detectors* of category S (see 4.4.2.2) do not have these problems due to the *contact electrode extension*.

4.2.1.3.4 Settings

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

A *selector* (possible for voltage and frequency, see 3.28) is allowed, but for each position of the *selector* the user shall not have access to any *threshold voltage* settings.

If the *voltage detector* has a *selector*, the theoretical limit of 4,5 for the ratio between $U_{n\ max}$ and $U_{n\ min}$ is valid for each position of the *selector*.

4.2.2 Clear perceptibility

4.2.2.1 General

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 (see also Table 1).

– Group I: Indication with at least two distinct *active signals*, which give an indication of the condition "voltage present" and "voltage not present". The ready to operate indication is given by the *active signal* "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* or *contact probe* 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". A ready to operate indication shall be available and shall have a *stand-by state*.

The *ready to operate state* is the situation in which the detector will be able to pass all the tests of the functional requirements.

"Passive" *voltage detectors* without a built-in energy source are included in group III, because the "ready to operate indication" is the performed test on operational voltage with an *active signal* before and after the voltage detection.

Table 1 – Indication group

Group	Active indication of "voltage present"	Active indication of "voltage not present"	"Ready to operate" indication
I	X	X	
II	–	X	
III	X	–	X

4.2.2.2 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.

4.2.2.3 Audible indication

The indication shall be clearly audible to the user 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 2.

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 4.2.1.3.1.

Table 2 – 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 device, 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 to operate", if the self-test was successfully passed. Any indication of a failure shall be described in the instructions for use.

4.2.8 Non-response to DC voltage

The *voltage detector* shall not respond to a DC voltage.

The AC detector shall reject DC voltage in order to be able to apply portable earthing equipment on the remaining capacitive load.

4.2.9 Time rating

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

4.2.10 Electromagnetic compatibility (EMC)

Voltage detectors shall comply with the requirements according to IEC 61000-6-2.

NOTE In some countries additional requirements are mandatory to fulfil EMC regulations.

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 1 When tubes of insulating material with circular cross section are used in the design of *voltage detectors*, this requirement is fulfilled by meeting the requirements of IEC 60855-1 or IEC 61235 or the requirements of 5.1 for voltage detectors as a complete device.

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

NOTE 2 For a *voltage detector* as a separate device, the user is 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 (ground).

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

4.4.1 General

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 is provided with adequate distance by means of an adaptable *insulating stick*.

4.4.2 Design

4.4.2.1 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).

   For 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, dismantling is allowed.

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

   The *insulating stick* used in conjunction with the *voltage detector* as a separate device shall fulfil the requirements of 4.3.1 and 4.4.3 even if not provided with the *voltage detector*.

Voltage detectors are designed for indoor use (see 3.14), for outdoor use (see 3.23) or exclusively outdoor use (see 3.10).

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

4.4.2.2 Category

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

– The *voltage detector* with *contact electrode extension* shall have category marking S. The length of the *contact electrode extension* shall be at least a_e according to Figure 3a.

NOTE *Voltage detectors* of category S can also be applied for category L use.

4.4.3 Dimensions, construction

The minimum length of the *insulating element* of a *voltage detector* as a complete device shall be in accordance with Table 3.

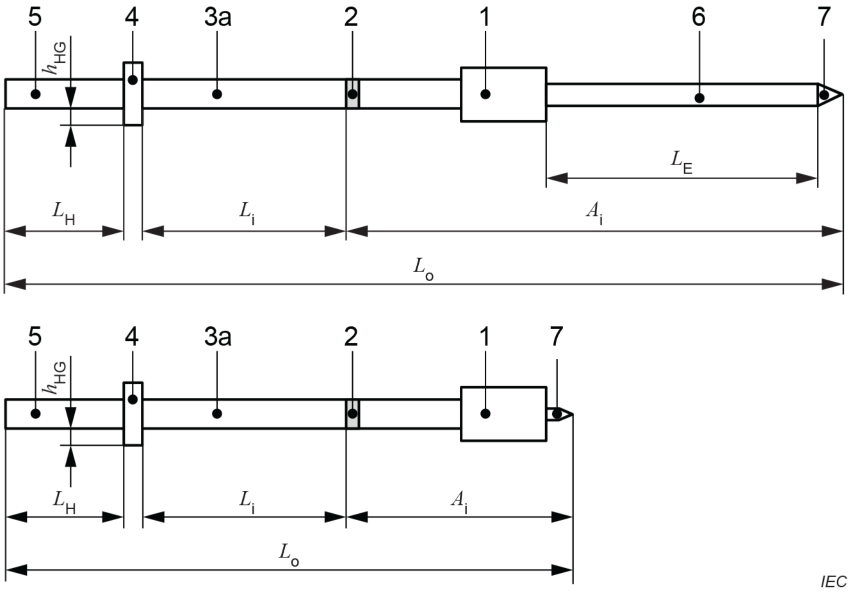


Figure 1a – Voltage detector as a complete device (including its insulating element)

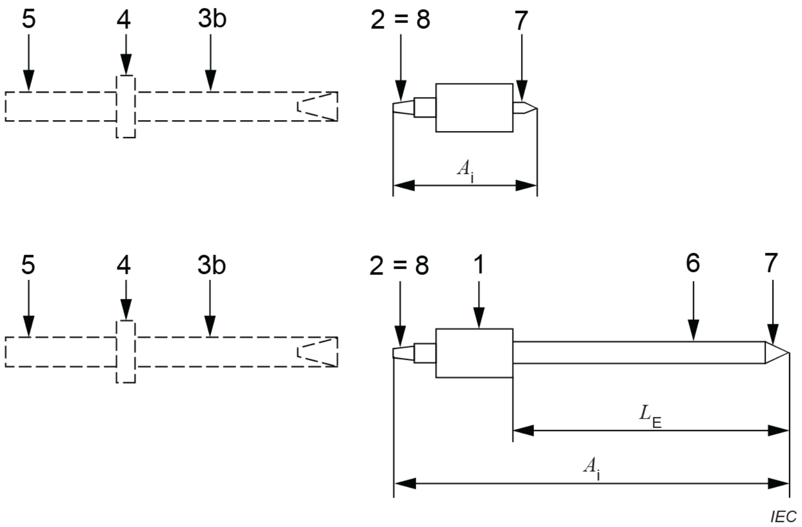


Figure 1b – Voltage detector as a separate device (with an adaptable insulating stick)

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* or *contact probe*		
8	*Adaptor*		

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

Table 3 – Minimum length of the insulating element (L_i) of a voltage detector as a complete device

U_r kV	L_i mm
$1 < U_r \leq 7,2$	320
$7,2 < U_r \leq 12$	360
$12 < U_r \leq 17,5$	370
$17,5 < U_r \leq 24$	470
$24 < U_r \leq 36$	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
$420 < U_r \leq 550$	4 300
$550 < U_r \leq 800$	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 3 correspond to the minimum distance in air (obtained from Tables 1 and 2 of IEC 61936-1:2010 and IEC 61936-1:2010/AMD1:2014) plus an additional safety distance.

NOTE 3 The L_i values of Table 3 are a guidance to determine the length of the *insulating stick* used with a *voltage detector* as a separate device. However, the length of the *insulating stick* for live working can be shortened for *voltage detectors* as a separate device taking into account the minimum approach distances or in accordance with national or regional regulations.

In the case of a *voltage detector* as a complete device and for L_i equal to or greater than 520 mm, conductive parts are allowed within the minimum length of the *insulating element*, if they are completely externally insulated and are located immediately adjacent to the *limit mark,* in one section of the *insulating element* not exceeding 200 mm.

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* to be fixed to the adaptable stick 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 4 It is possible to make the handle 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* may be readily interchangeable or supplemented with other types of *contact electrodes* depending on the type of installation and instructions for use.

4.4.4 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.

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

4.4.5 Vibration resistance

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

4.4.6 Drop resistance

The *voltage detector* shall be drop resistant in working conditions.

4.4.7 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 (I, II or III);
– special marking for low or high *interference voltage* (e.g. "LI" low *interference voltage*, "HI" high *interference voltage*), when relevant;
– nominal frequency or nominal frequencies;
– name and/or trademark of the manufacturer;
– type reference, serial number;
– indication of type "indoor", "outdoor" or "exclusively outdoor";
– indication of category (S or L);
– climatic category (C, N or W) or temperature and humidity range;
– year of production;
– symbol IEC 60417–5216:2002-10 – 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, the range is 1,4 to 1,5.

– number of the relevant IEC standard immediately adjacent to the symbol (IEC 61243-1).

In addition, the *voltage detector* shall provide the user or the testing laboratory with 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*.

To be marked with the number of this IEC standard, the product shall satisfy all the requirements specified herein.

4.6 Documents for the user

With every *voltage detector* or with every batch of *voltage detectors* to be delivered, the manufacturer shall provide information related to the number of the IEC standard with the year of publication.

4.7 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.

4.8 Requirements in case of reasonably foreseeable misuse of the selector

4.8.1 Initial position of the selector

In case of incorrect position of the voltage or frequency *selector*, if any, the *voltage detector* could give an incorrect indication. For safety reasons, the *voltage detector* shall only switch to the *ready to operate state* in the most sensitive position.

4.8.2 Voltage indication at an incorrect low position of the selector (where relevant)

In case of an incorrect low position of the *selector*, the *voltage detector* shall not be damaged and shall give the indication "voltage present" up to the highest *rated voltage* of the *voltage detector*.

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 is limited under dry conditions.

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

5.2 Insulation of the indicator casing of voltage detector as a separate device

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

5.3 Stand-by state

A device equipped with a *stand-by state* shall indicate the *ready to operate state* below the *threshold voltage*, when available, and presence of voltage at and above the *threshold voltage*.

5.4 Ready to operate state

The *ready to operate state* of the *voltage detector* shall be a visual and/or audible indication and apply after having successfully passed the self-test, if relevant.

A signal indicating that the voltage detector is ready to operate can be used as an indication of "voltage not present".

NOTE *Voltage detectors* without a built-in power source do not have a ready to operate indication.

6 Tests

6.1 General

6.1.1 Testing provisions

This document provides testing provisions to demonstrate conformance of the product with the requirements of Clauses 4 and 5. These testing provisions are primarily intended to be used as type tests and following Table C.1 order, for validation of the design input. Where relevant, alternative means (calculation, examination, tests, etc.) are specified within the test subclauses for the purpose of *voltage detectors* having completed the production phase.

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.

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 4.4.3 shall be used for the tests.

6.1.2 Atmospheric conditions

Except when otherwise stated, tests shall be carried out under the following standard atmospheric conditions of IEC 60068-1 for measurements and tests:

– ambient temperature: 15 °C to 35 °C;
– relative humidity: 25 % to 75 %;
– atmospheric pressure: 86 kPa to 106 kPa.

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

6.1.3 Tests under wet conditions

Before the electrical tests, each *voltage detector* shall be cleaned with isopropanol (CH_3-$CH(OH)$-CH_3) and then dried in air for 15 min.

The tests shall be conducted in accordance with 9.1 of IEC 60060-1:2010 (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*.

6.1.4 Type test

6.1.4.1 Type test on basic configuration

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.

6.1.4.2 Type test on additional contact electrodes and contact electrode extensions

The use of different *contact electrodes* or *contact electrode extensions* may affect the performance of the *voltage detector*.

When several *contact electrode extensions* or several *contact electrodes* are provided according to the instructions for use, the following tests shall be performed with each *contact electrode extension*, each *contact electrode* and each combination of them:

- measurement of *threshold voltage* (see 6.2.1.2.1);
- overhead line configuration test (see 6.2.1.6);
- 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 type/outdoor type voltage detector* (see 6.3.2);
- *protection against bridging for outdoor type voltage detector* (see 6.3.3);
- spark resistance (see 6.3.4);
- vibration resistance (see 6.4.3);
- drop resistance (see 6.4.4).

These type tests can be done

- with the same set of *voltage detectors*, these being equipped successively with the different *contact electrodes* and *contact electrode extensions* or combination of them, or
- with different sets of *voltage detectors*, each set being equipped with a different *contact electrodes* and *contact electrode extensions* or combination of them.

In case of different sets of *voltage detectors*, for each set if more than one *voltage detector* does not pass the test the set has failed. For each set if only one *voltage detector* fails, the entire sequence for the relevant type test (see 6.1.4.1) shall be repeated on a new set of three *voltage detectors*. If any one of these three new *voltage detectors* fails, the type test of this configuration is considered to have failed.

6.1.4.3 Type test for family of voltage detectors

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* delimiting the *family of voltage detectors*. Within the limits of the family, bridging tests (6.3.2 and 6.3.3) shall be performed for each distance d_1 of Table 9 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.

6.1.5 Test methods

Tests shall be carried out using an AC 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;
- 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 %;
- 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 (ground).

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 Figure 3 and Figure 4.

6.2.1.2 Measurement of threshold voltage

6.2.1.2.1 Type test

The test set-up used for the measurement of the *threshold voltage* is of the ball and ring type, as shown in Figure 3.

The electrode arrangement is selected according to the category of the *voltage detectors*. Figure 3a gives the arrangement for *voltage detectors* of category S and Figure 3b for *voltage detectors* 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 5a.

The electrical connection shall consist of a high voltage cable with a conductor cross section up to 5 mm^2, inserted in an insulating tube to provide mechanical support and additional electrical insulation. The connection shall be such that there is minimal influence on the test results, for example by fixing the voltage connection concentrically to the ring electrode as shown in Figure 3 or the corona ring as shown in Figure 4.

A suitable means shall be used for ensuring a good electrical connection as well as a mechanical pressure between the *contact electrode* or *contact probe* of the *voltage detector* and the ball electrode without disturbing the local electric field. An example of such means is illustrated in Figure 2a. Likewise it is possible to modify the ball electrode without disturbing the local electric field. An example of such a modified ball electrode is illustrated in Figure 2b.

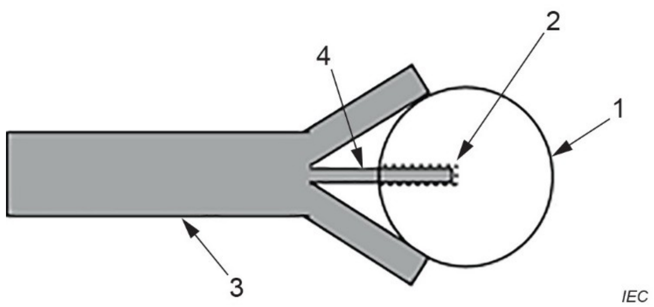


Figure 2a – Modification of a contact electrode used for testing

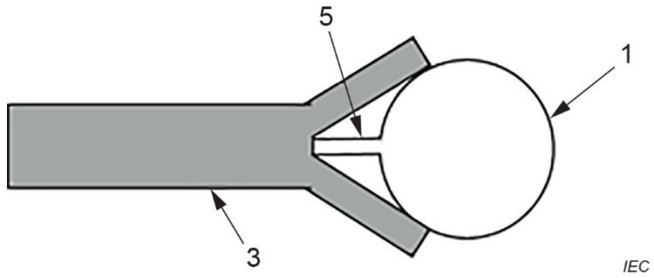


Figure 2b – Modification of the ball electrode

Key

1 ball electrode
2 circular hole drilled in the ball electrode
3 Y shape *contact electrode*
4 cylindrical rod fixed to a Y shape *contact electrode* of a dimension to fit tightly into the hole of the ball electrode
5 cylindrical rod fixed to the ball electrode

Figure 2 – Examples of suitable means for ensuring appropriate contact between a contact electrode and the ball electrode

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

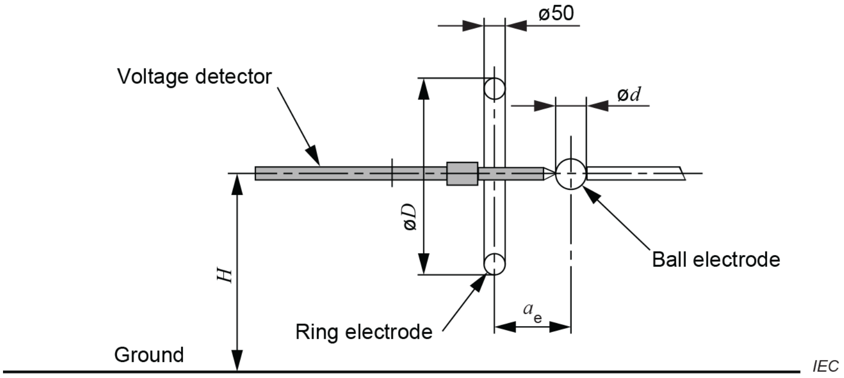
The *threshold voltage* shall be measured by increasing the test voltage until the status of the signal changes according to its type of indication.

The test shall be considered as passed if the measured *threshold voltage* is within the limits specified in 4.2.1.3.1.

6.2.1.2.2 Alternative test for voltage detectors having completed the production phase

The alternative test consists of checking that the *threshold voltage* of a manufactured *voltage detector* is within ±5 % of the *threshold voltage* of a *voltage detector* that has successfully passed the type tests according to 6.2.1.2.1. This test can be performed by means of an alternative high voltage test set-up.

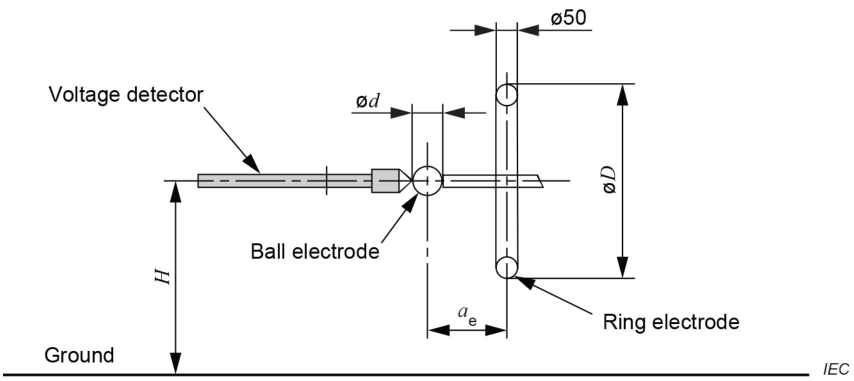
Dimensions in millimetres



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 ≤ 12 12 < U_n ≤ 24 24 < U_n ≤ 52	100 270 430	1 500	ø 550	ø 60	> 1 650
52 < U_n ≤ 170 170 < U_n ≤ 245	650 850	2 500	ø 1 050	ø 100	> 3 150
245 < U_n ≤ 550 550 < U_n ≤ 800	850 1 200	2 500 3 500	ø 1 050 ø 1 600	ø 100 ø 150	> 3 150 > 4 800

Figure 3a – Test set-up with the ball electrode behind the ring electrode

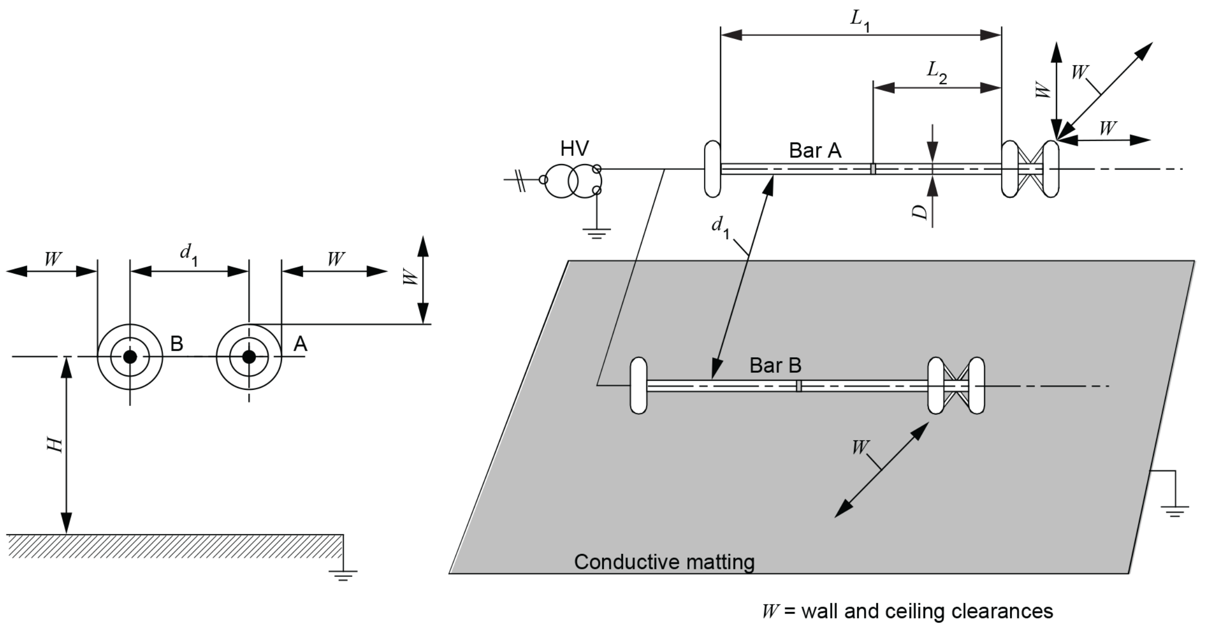
Dimensions in millimetres



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	ø 550	ø 60	> 1 650
$52 < U_n \leq 170$ $170 < U_n \leq 245$	1 000	2 500	ø 1 050	ø 100	> 3 150
$245 < U_n \leq 550$ $550 < U_n \leq 800$	1 000 1 000	2 500 3 500	ø 1 050 ø 1 600	ø 100 ø 150	> 3 150 > 4 800

Figure 3b – Test set-up with ball electrode in front of the ring electrode

Figure 3 – Ball and ring test set-up (see 6.2.1 and 6.2.5)



Side view of bars A and B

General view

IEC

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[a]	2 400[a]	3 200	1 785	64,5 ± 5 %
420 < U_n ≤ 550	4 100	2 900[a]	2 900[a]	3 900	2 205	87,5 ± 5 %
550 < U_n ≤ 800	6 400	4 800[a]	4 800[a]	5 300	3 150	126 ± 5 %

[a] The values of W and d_1 are selected from Table 2 of IEC 61936-1:2010 and IEC 61936-1:2010/AMD1:2014, "Minimum phase to earth (ground) clearance" for rod and structure N, the minimum distance taken for the highest voltage of the voltage range.

Figure 4a – General arrangement

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 ≤ 550	800	210	210	630
550 < U_n ≤ 800	1 000	300	300	900

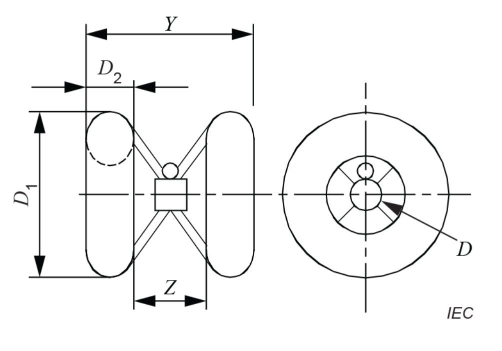


Figure 4b – Dimensions of the double corona rings (conductive material)

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 ≤ 550	480	126
550 < U_n ≤ 800	600	160

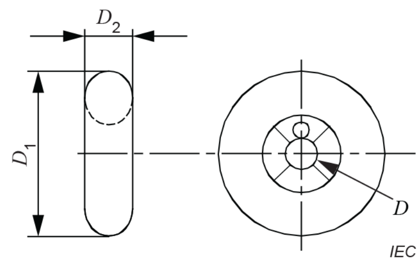


Figure 4c – Dimensions of the corona rings (conductive material)

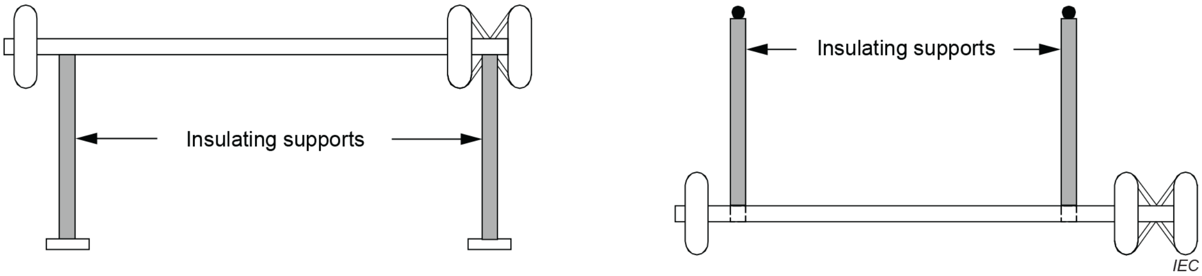


Figure 4d – Example of support arrangement for the test bars

Figure 4 – Test set-up with bars (see 6.2.1)

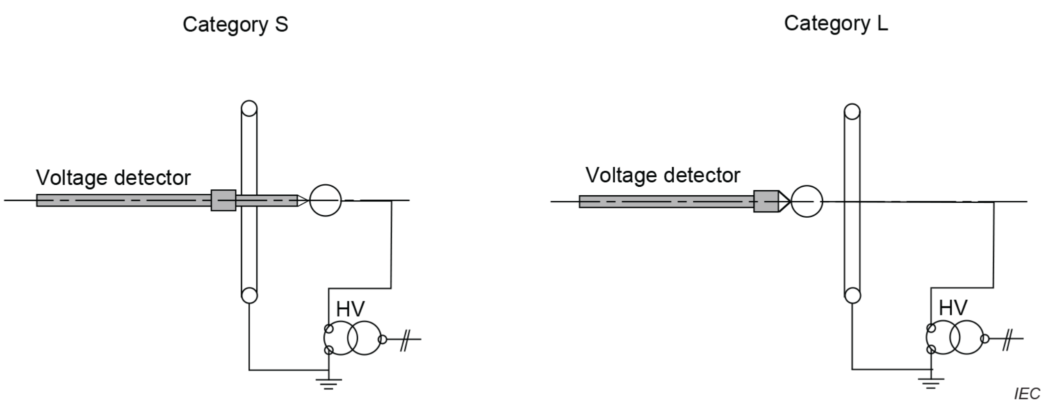


Figure 5a – Measurement of the threshold voltage and the influence of interference voltage with the ball and ring test set-up (see 6.2.1.2.1 and 6.2.1.5)

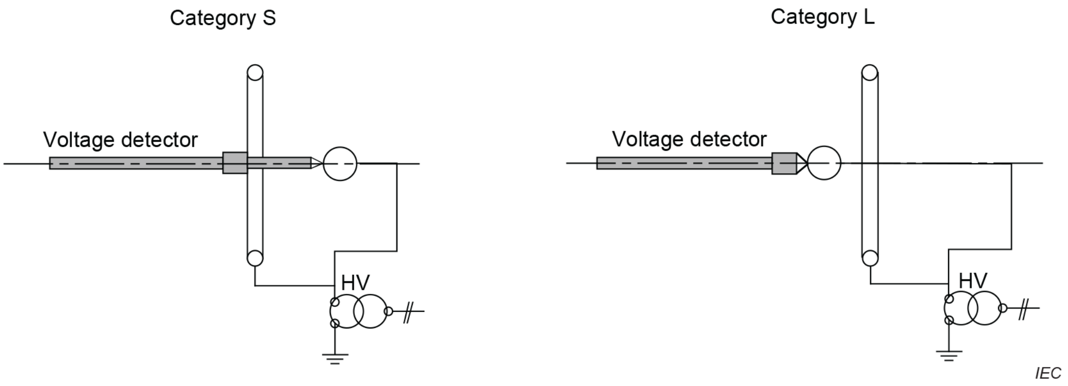


Figure 5b – Influence of in-phase interference field with the ball and ring test set-up (see 6.2.1.3)

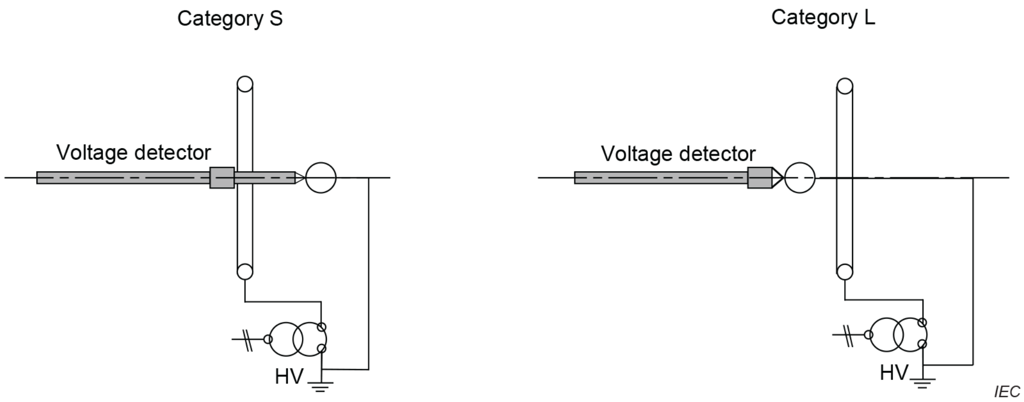


Figure 5c – Influence of phase opposition interference field with the ball and ring test set-up (see 6.2.1.4)

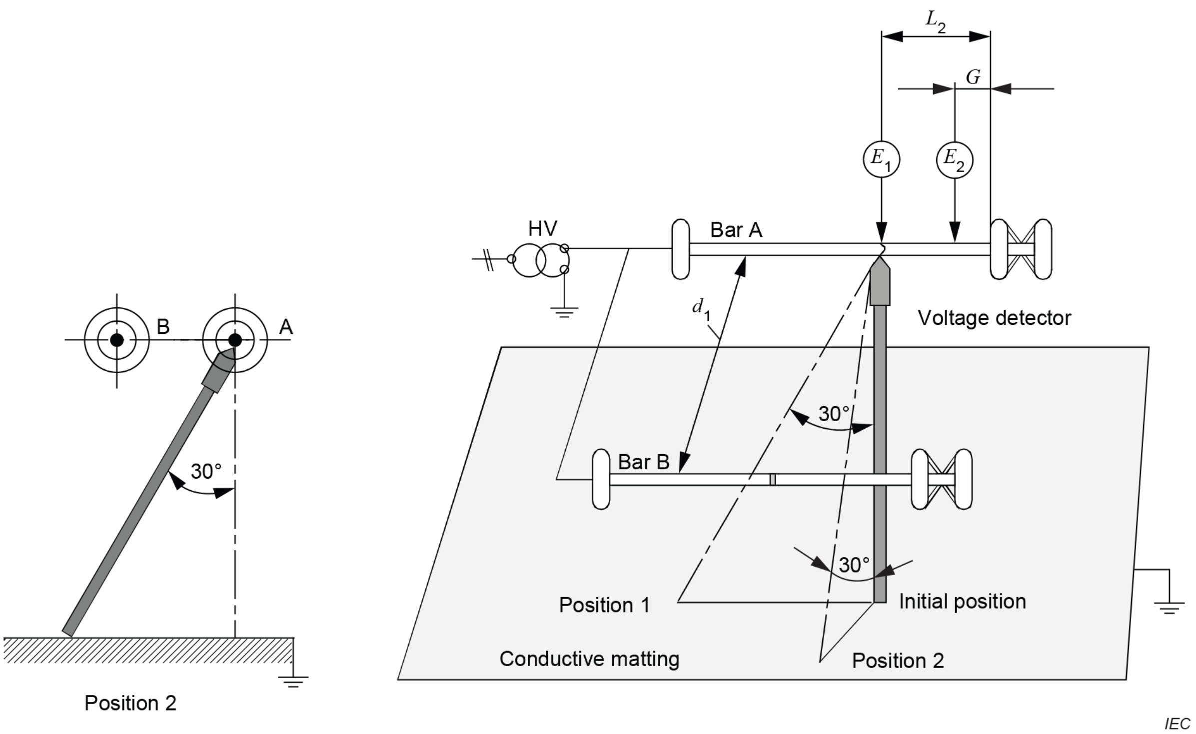


Figure 5d – Influence of in-phase interference field with the bars (see 6.2.1.3)

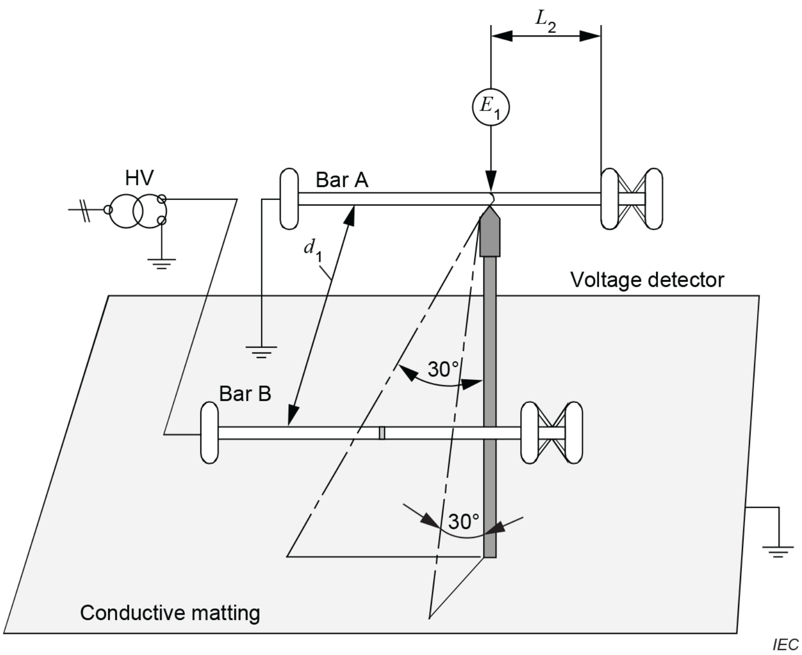


Figure 5e – Influence of phase opposition interference field with bars (see 6.2.1.4)

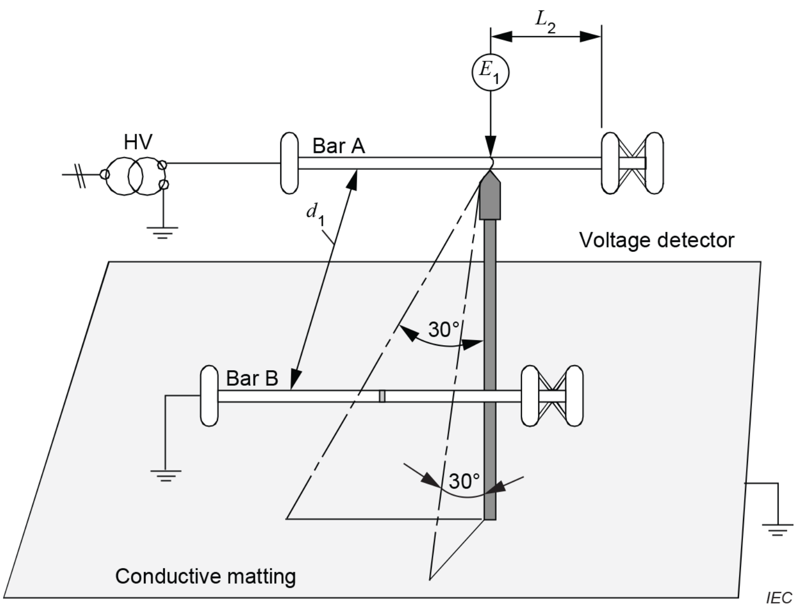


Figure 5f – Influence of interference voltage with bars (see 6.2.1.5)

Figure 5 – Circuit connections for *clear indication* tests (see 6.2.1)

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 4.

Table 4 – Selection of the test set-up for the influence of in-phase interference field

Nominal voltages	U_n **≤ 52 kV**	**52 kV <** U_n **≤ 245 kV**	U_n **> 245 kV**
Type of test set-up	**Ball and ring** Category S: Figure 3a Category L: Figure 3b	**Ball and ring** Category S: Figure 3a Category L: Figure 3b or alternatively **Bars** Categories S and L: Figure 4	**Bars** Categories S and L: Figure 4

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 5b. The bars shall be connected as shown in Figure 5d.

The *voltage detector* shall be installed in such a manner that its *contact electrode* or *contact probe* 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* or *contact probe* 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 5d. The *voltage detector*, being returned in vertical position, shall then be moved to point E_2 (Figure 5d) in vertical position. The distance G between point E_2 and the double corona ring is given in Table 5.

Table 5 – Distance G (see Figure 5d)

U_n kV	G mm
52 < U_n ≤ 82,5	75
82,5 < U_n ≤ 145	135
145 < U_n ≤ 245	210
245 < U_n ≤ 420	255
420 < U_n ≤ 550	315
550 < U_n ≤ 800	450

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 *nominal voltage*. 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 6.

Table 6 – Selection of the test set-up for the influence of phase opposition interference field

Nominal voltages	U_n ≤ 52 kV	52 kV < U_n ≤ 245 kV	U_n > 245 kV
Type of test set-up	**Ball and ring** Category S: Figure 3a Category L: Figure 3b	**Ball and ring** Categories S and L: Figure 3b or alternatively **Bars** Categories S and L: Figure 4	**Bars** Categories S and L: Figure 4

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 5c. The bars shall be connected as shown in Figure 5e.

The *voltage detector* shall be installed in such a manner that its *contact electrode* or *contact probe* 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* or *contact probe* of the *voltage detector* shall touch the earthed (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 5e.

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 7.

Table 7 – Selection of the test set-up for the influence of interference voltage

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** Category S: Figure 3a Category L: Figure 3b	**Ball and ring** Category S: Figure 3a Category L: Figure 3b or alternatively **Bars** Categories S and L: Figure 4	**Bars** Categories S and L: Figure 4

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 5a. The bars shall be connected as shown in Figure 5f.

The *voltage detector* shall be installed in such a manner that its *contact electrode* or *contact probe* 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* or *contact probe* of the *voltage detector* shall touch the energized 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 5f.

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. For low *interference voltage detectors*, the test voltage shall be 95 % of the *threshold voltage* specified in the agreement between the manufacturer and the customer.

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.

6.2.1.6 Overhead line configuration test for voltage detectors

6.2.1.6.1 Type test

This test shall be performed for *voltage detectors* with *contact electrode extension* below a_e (see Figure 3a) for category L.

This additional test is to ensure the detector will detect in most overhead line configurations.

The test set-up is described in Figure 4a, only using one bar and its corona rings for this test. The distances and the dimensions are taken from the table of Figure 4b.

For *voltage detectors* below or equal to 52 kV the height of the bar is 1,5 m and the other distances and dimensions are taken from the table of Figure 4b line "52 < U_n ≤ 82,5".

A suitable means shall be used for ensuring a good electrical connection (similar to Figure 2) as well as a mechanical pressure between the *contact electrode* or *contact probe* of the *voltage detector* and the bar without disturbing the local electric field.

The bar shall be connected to a high voltage source in such a manner that the connection does not influence the test results (e.g. the connection is done in the axis of the bar, see 6.2.1.2.1). The floor is earthed (grounded) according to 6.2.1.1.

The *voltage detector* shall be installed horizontally for voltages below or equal to 52 kV and vertically for voltages above 52 kV in such a manner that its *contact electrode* or *contact probe* touches the bar at L2.

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 voltage is within the limits specified in 4.2.1.3.1.

6.2.1.6.2 Alternative test for voltage detectors having completed the production phase

The alternative test consists of checking that the *threshold voltage* of a manufactured *voltage detector* is within ±5 % of the voltage of a *voltage detector* that has successfully passed the type tests according to 6.2.1.6.1. This test can be performed by means of an alternative high voltage test set-up.

6.2.2 Electromagnetic compatibility (EMC)

6.2.2.1 Type test

The *voltage detector* shall be submitted to and shall fulfil the relevant tests of IEC 61326-1 for:

– immunity requirements for portable equipment powered by battery or from the circuit being measured with the test parameters given in Table 8;

Table 8 – EMC parameters

Description	Port	Reference	Parameters
Electrostatic discharge (ESD)	Enclosure	IEC 61000-6-2:2016, Table 1	8 kV (air) [a]
RF electromagnetic field immunity	Enclosure	IEC 61000-6-2:2016, Table 1	10 V/m for 80 MHz to 1 GHz (level 2) 3 V/m for 1,4 GHz to 6 GHz (level 2)
Power frequency magnetic field (Only for devices with parts sensitive to magnetic fields)	Enclosure	IEC 61000-6-2:2016, Table 1	Frequency: 50 Hz or 60 Hz Magnetic field: 30 A/m

NOTE 1 Level 2 corresponds to a moderate electromagnetic radiation environment. This happens in presence of Global System for Mobile Communications (GSM), for example fixed transceivers, like microwave antenna for cell phones, installed in transmission structures or substations.

NOTE 2 Capacitive type *voltage detectors* are magnetically non-sensitive devices.

[a] For *voltage detectors* with a *nominal voltage* equal to or above 10 kV the test for spark resistance is the more severe test, no ESD test is required.

The performance criteria for all the EMC tests are given in Table 9.

Table 9 – Performance criteria for all the EMC tests

Function	Criteria
Functioning of *voltage detector*	A
Functioning of the *testing element*	B

NOTE Criteria A and B are defined in IEC 61326-1.

– emission limit requirements for equipment intended for use in industrial locations with the test parameters given in Table 10.

Table 10 – Test parameters for emission limit

Description	Port	Test	Parameters
Radio disturbances characteristics	Enclosure	CISPR 11	Class A

NOTE For safety reasons the *voltage detector* can be activated by other means than high voltage.

For *voltage detectors* with a *selector*, it shall be set in the most sensitive position.

The test shall be considered as passed if the relevant indications are not affected.

6.2.2.2 Alternative means for voltage detector having completed the production phase

After completing the production phase, it is not practical to perform EMC tests for checking the conformity to the relevant requirements. Nevertheless, the manufacturer shall prove that it has followed the same documented assembly procedure as for the type tested device.

6.2.3 Clear perceptibility of visual indication

6.2.3.1 Type test

The test set-up is given in Figure 6.

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 ± 5 000 lux for *outdoor type voltage detector* with standard light D_{55} according to CIE 15.2 corresponding to colour temperature of 5 500 K ± 550 K;
- 1 000 lux ± 100 lux for *indoor type voltage detector* with standard light A according to CIE 15.2 corresponding to colour temperature of 3 200 K ± 320 K.

The *voltage detector* is positioned in the direction of axis A–B, and its signal source part is centred on the axis A–B in normal use, according to Figure 6a.

The visual perceptibility test shall be performed by 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 6b).

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

6.2.3.2 Alternative test for voltage detectors having completed the production phase

The alternative test consists in comparing the perceptibility of the visual indication of a manufactured *voltage detector* to that of a *voltage detector* which has passed successfully the type test according to 6.2.3.1 (reference *voltage detector*). The test shall be considered as passed if the perceptibility of both is almost identical.

Dimensions in millimetres

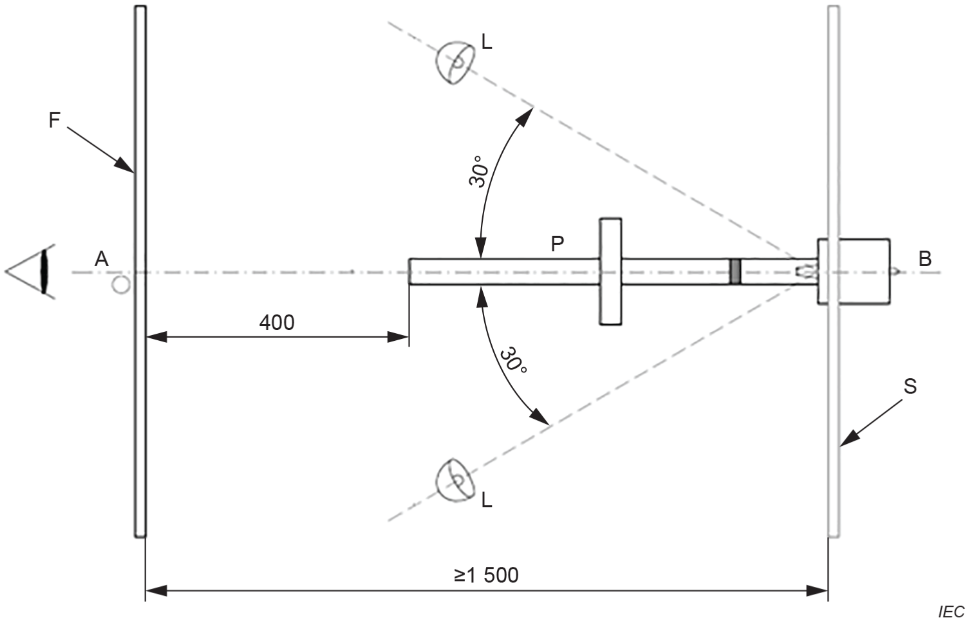


Figure 6a – Top view

Dimensions in millimetres

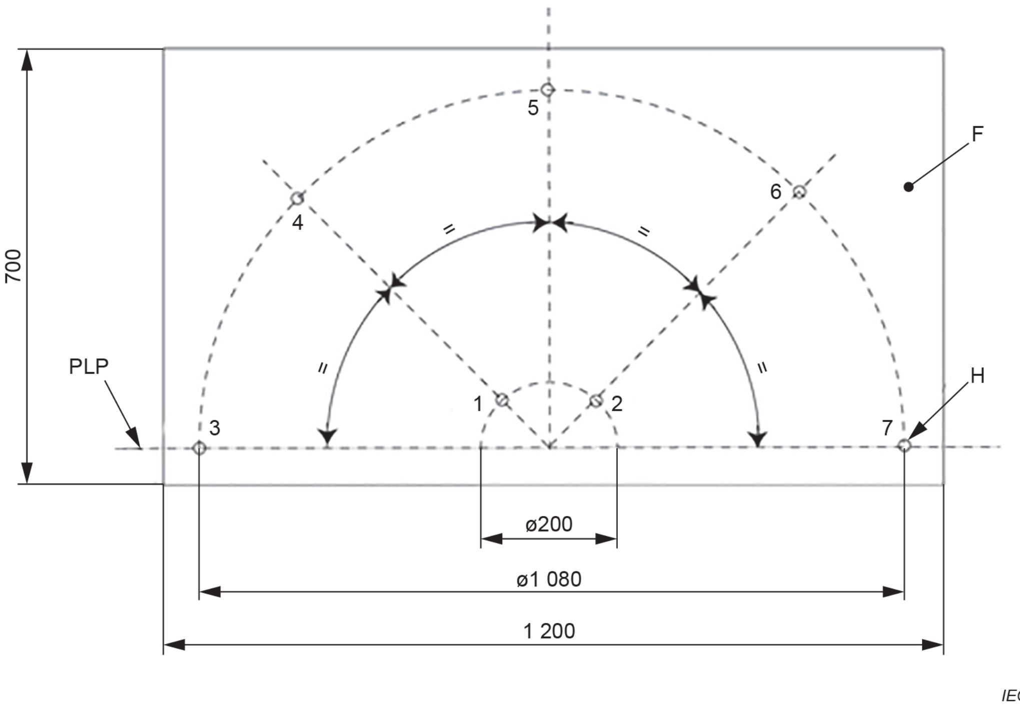


Figure 6b – Front view of the front plate

Key

P	pole of the *voltage detector*	S	light-grey screen 1 000 × 1 000
F	perforated front plate 3 mm thick	H	seven holes, 5 mm diameter
L	light source	PLP	plane of the light sources and the pole of the *voltage detector*

Figure 6 – Test set-up for measurement of clear perceptibility of visual indication (see 6.2.3.1)

6.2.4 Clear perceptibility of audible indication

6.2.4.1 Type test

The test shall be carried out in free-field over reflecting plane conditions, in an environment following the requirements of Annex A of ISO 3744:2010.

NOTE 1 Such test conditions are possible 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 8.2.3 of ISO 3744:2010.

The instrumentation system, including the microphone and cable, 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 the IEC 61260 series.

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 by 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 7a, 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 7a. The distance of 400 mm may be increased by 200 mm if this will enable higher sound intensities to be measured.

Dimensions in millimetres

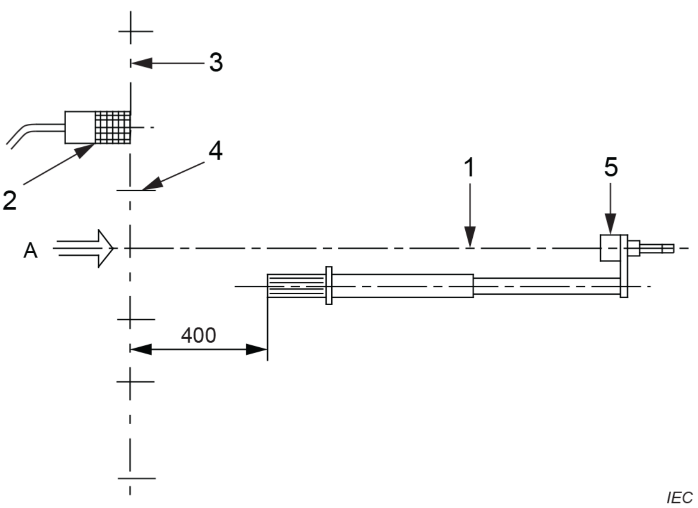


Figure 7a – Side view

Dimensions in millimetres

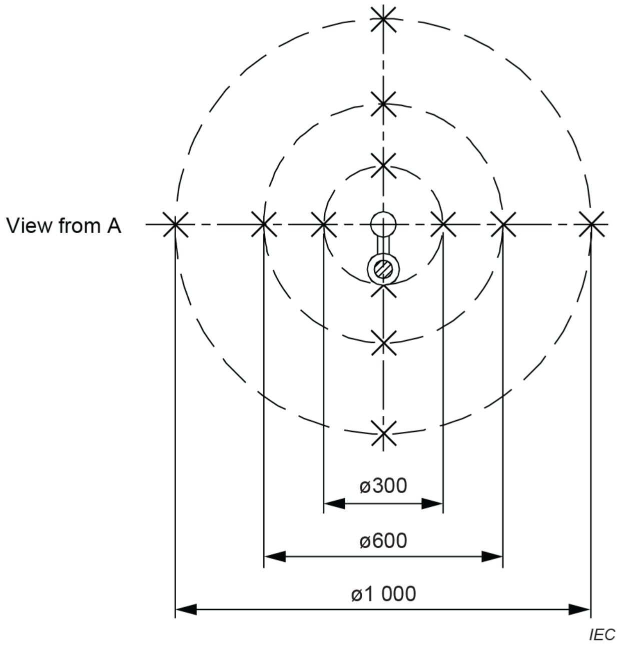


Figure 7b – Front view

Key

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

Figure 7 – Test set-up for measurement of clear perceptibility of audible indication (see 6.2.4.1)

The measurements shall be carried out for the indications "voltage present" and "voltage not present", at each of the twelve microphone positions of Figure 7b. 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 2 It is possible to agree on higher values between manufacturer and customer for specific usage in very noisy areas.

6.2.4.2 Alternative test for voltage detectors having completed the production phase

The alternative test consists in comparing the perceptibility of the audible indication of a manufactured *voltage detector* to that of a *voltage detector* which has passed successfully the type test according to 6.2.4.1 (reference *voltage detector*). The test shall be considered as passed if the perceptibility of both is almost identical.

6.2.5 Frequency dependence

6.2.5.1 Type test

The test shall be carried out using the test set-up and the test procedure of 6.2.1.2.1.

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 4.2.1.3.

6.2.5.2 Alternative means for voltage detectors having completed the production phase

The manufacturer shall prove that it has followed the same documented assembly procedure as for the type tested device. The manufacturer shall document components that affect the frequency performance.

6.2.6 Response time

6.2.6.1 Type test

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

NOTE For practical reasons, the *voltage detector* can be energized by other equivalent means.

The test voltage shall be switched on, then off and on twenty times. The duration of the on and off periods shall be adjusted to 1 s.

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.

6.2.6.2 Alternative means for voltage detectors having completed the production phase

The manufacturer shall prove that it has followed the same documented assembly procedure as for the type tested device. The manufacturer shall document components that affect the *response time*.

6.2.7 Power source dependability

6.2.7.1 Type test

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 %.

NOTE For practical reasons, the *voltage detector* can be energized by other equivalent means.

The *voltage detector* shall be switched on and the *contact electrode* or *contact probe* applied to an AC 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 according to the instructions for use 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.

The test duration may be reduced by using other methods that give the same result (for example, the use of an unloaded built-in power source with just enough energy for a good functioning or the use of an external power supply).

6.2.7.2 Alternative means for voltage detectors having completed the production phase

The manufacturer shall prove that it has followed the same documented assembly procedure as for the type tested device. The manufacturer shall document components that affect the power source dependability.

6.2.8 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.

6.2.9 Non-response to DC voltage

6.2.9.1 Type test

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* or *contact probe* on a DC 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, the *voltage detector* can be energized by other equivalent means.

6.2.9.2 Alternative means for voltage detectors having completed the production phase

The manufacturer shall prove that it has followed the same documented assembly procedure as for the type tested device. The manufacturer shall document components that affect the non-response to DC voltage.

6.2.10 Time rating

6.2.10.1 Type test

The *voltage detector* shall be placed with the *contact electrode* or *contact probe* on an AC 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 / √3 but shall be greater than 148 kV (≈ 1,2 × 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.

6.2.10.2 Alternative means for voltage detectors having completed the production phase

The manufacturer shall prove that it has followed the same documented assembly procedure as for the type tested device. The manufacturer shall document components that affect the time rating.

6.3 Dielectric tests

6.3.1 Insulating material for tubes and rods for voltage detectors as a complete device

6.3.1.1 Type test

These tests shall only be performed for tubes and rods which are not covered by IEC 60855-1 or IEC 61235.

This test of insulating material is for *voltage detectors* or phase comparators (see IEC 61481-1 and IEC 61481-2) as a complete device and not for tubes and rods for other use.

Insulating parts which are between 60 mm and 200 mm long shall be tested over their entire length. For longer lengths, test pieces of 200 mm shall be made. The ends of the test pieces shall not be sealed for the test.

A strip, approximately 0,5 mm thick and 10 mm wide, shall be removed over the entire length of the axis of each test piece. The test piece shall be conditioned in water having a maximum resistivity of 100 Ω m at a temperature of 40 °C ± 2 °C for 96 h.

At the end of this period, adhering water shall be wiped off. A 20 mm wide band electrode of conductive material shall be immediately applied on the exterior surface, at both ends of the test piece. After a drying period of 15 min ± 1 min, in a room at a temperature of 23 °C ± 3 °C, a test voltage of 1 kV/cm for 5 min shall be applied.

The test shall be considered as passed if the current is not greater than 50 µA RMS at any time during the last 4 min.

After removal of the test pieces, the current passing through the test set-up shall not exceed 10 µA RMS with the test voltage applied.

6.3.1.2 Alternative test or means for voltage detectors having completed the production phase

The manufacturer shall prove that the tubes and rods used are of the same quality as the type tested ones.

6.3.2 Protection against bridging for indoor and outdoor type voltage detectors

6.3.2.1 Type test

6.3.2.1.1 General

This test is related to the part of the *voltage detector* located between the *limit mark* and the top of the *contact electrode* or *contact probe*. 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 11.

Table 11 – Selection of the test set-up and type of test

Nominal voltages	**U_n ≤ 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 test set-up	V-shape bars Figure 8a		Parallel bars Figure 8e	
Test	Surface stress and Radial and surface stress	Surface stress	Surface stress and Radial and surface stress	Surface stress

For *voltage detectors* marked "indoor" or "outdoor" the distance d_1 between bar A and bar B shall be adjusted according to Table 12, column "Indoor", whatever the type of test set-up used.

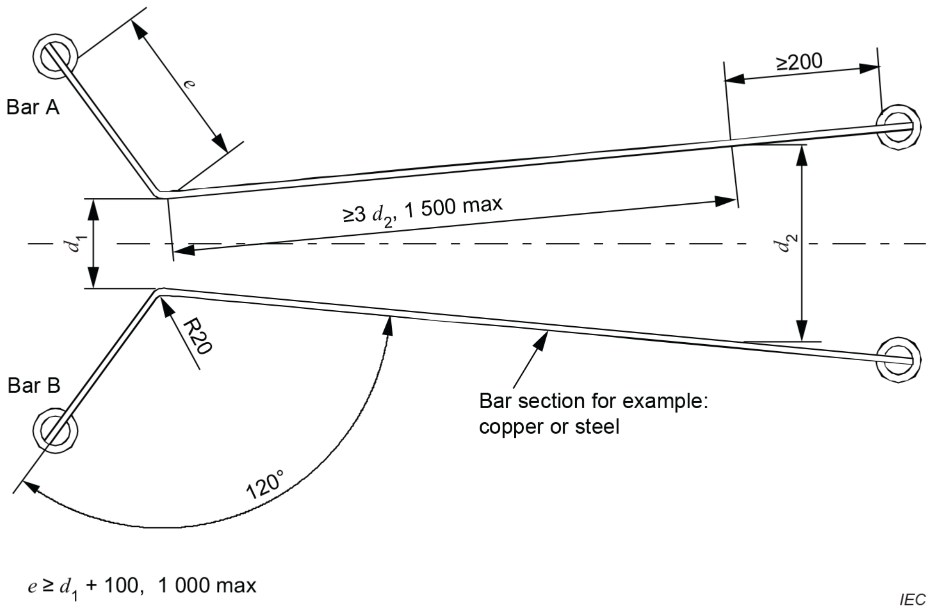
For *voltage detectors* marked "exclusively outdoor" the distance d_1 between bar A and bar B shall be adjusted according to Table 12, column "outdoor", whatever the type of test set-up used.

The distance d_2 of Figure 8a, shall be calculated as follows:

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

where A_i is the insertion depth (Figure 1).

Dimensions in millimetres



Dimensions of the bars: The bar section shall be 60 mm × 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.

Figure 8a – Test arrangement and dimensions of the V-shape bars

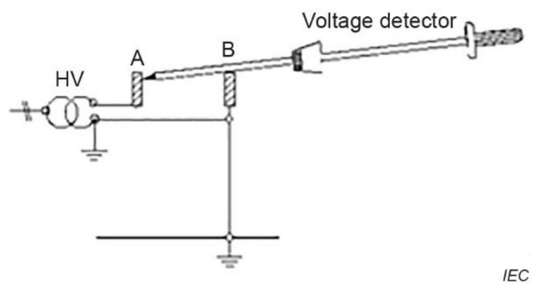


Figure 8b – Connection of the V-shape bars

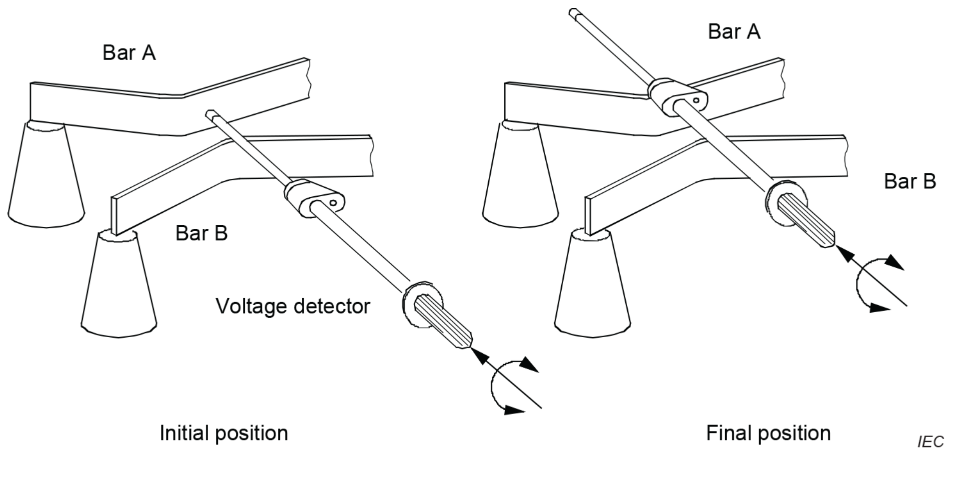


Figure 8c – Surface stress test (see 6.3.2.1.2.2)

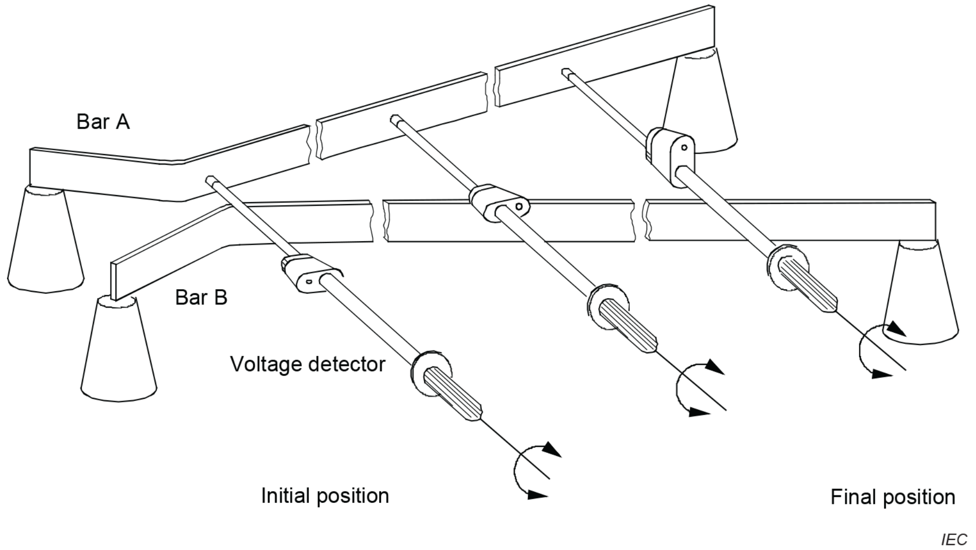


Figure 8d – Radial and surface stress test (see 6.3.2.1.2.3)

Dimensions in millimetres

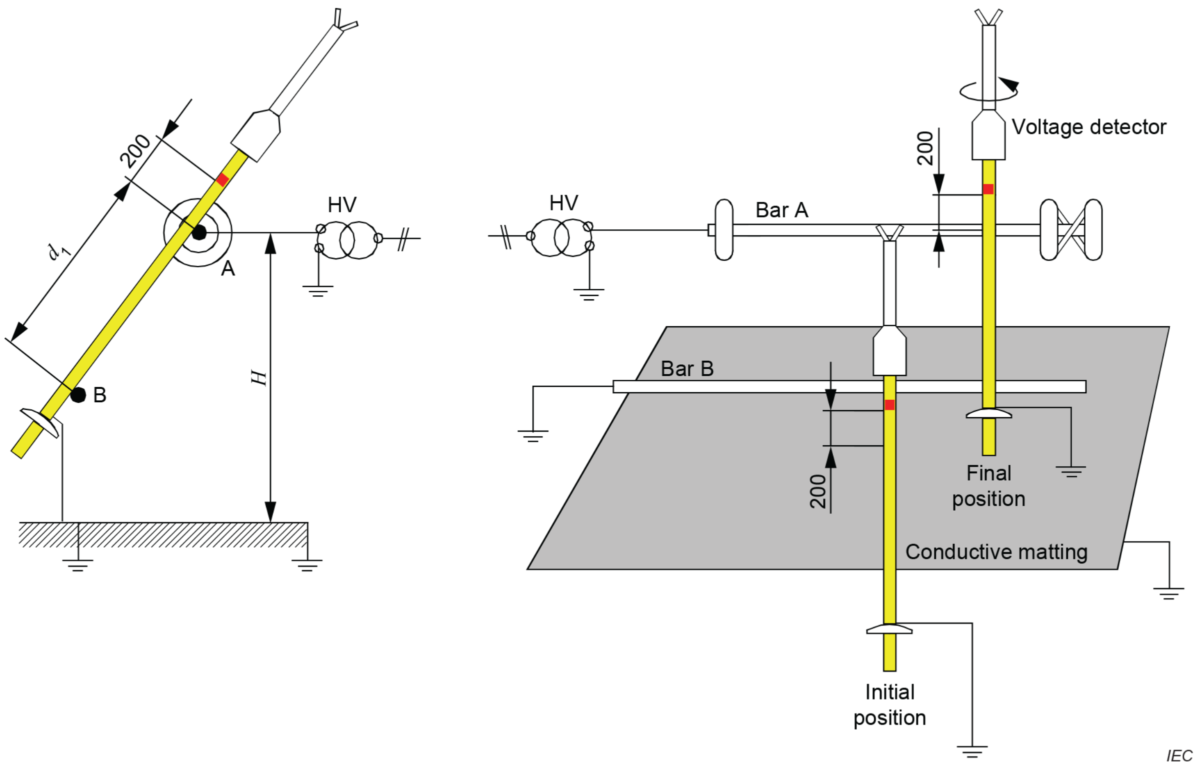


Figure 8e – Parallel bars – Surface stress test (see 6.3.2.1.3.2)

Dimensions in millimetres

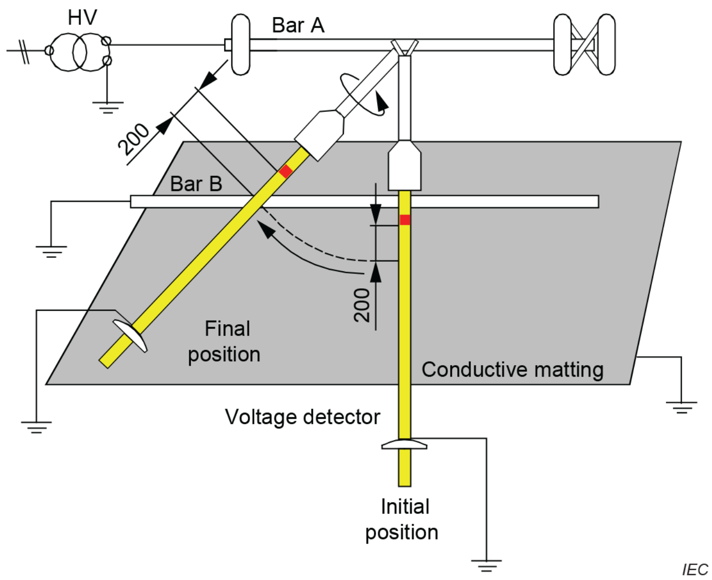


Figure 8f – Parallel bars – Radial and surface stress test (see 6.3.2.1.3.3)

Figure 8 – Test set-up for protection against bridging and spark resistance (see 6.3.2 and 6.3.4)

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 × 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 12.

Table 12 – 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	1 100
$145 < U_n \leq 170$	1 350	1 350
$170 < U_n \leq 245$	1 850	1 850
$245 < U_n \leq 300$	2 100	2 100

U_n kV	d_1 mm	
	Indoor	**Outdoor**
300 < U_n ≤ 362	2 500	2 500
362 < U_n ≤ 420	2 900	2 900
420 < U_n ≤ 550	3 400	3 400
550 < U_n ≤ 800	4 800	4 800

6.3.2.1.2 For voltage detector ≤ 245 kV

6.3.2.1.2.1 General

The bars shall be connected as shown in Figure 8b. The ground clearance (H) of bars shall be at least d_1.

6.3.2.1.2.2 Surface stress test

The top of the *contact electrode* or *contact probe* 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, shall be turned and pushed forward toward bar A, until the *limit mark* plus 200 mm reaches bar A (Figure 8c).

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

6.3.2.1.2.3 Radial and surface stress test

The top of the *contact electrode* or *contact probe* shall be placed on bar A at the narrow point d_1 and the *voltage detector* shall be laid on bar B. Then the *voltage detector* shall be rolled along the bars, until the *limit mark* plus 200 mm reaches bar B (Figure 8d) while the top of the *contact electrode* or *contact probe* remains in contact with bar A.

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

6.3.2.1.3 For voltage detector > 245 kV

6.3.2.1.3.1 General

The bars shall be connected as shown in Figure 8e. The ground clearance (H) of bar A shall be at least d_1. The height of bar B is not critical to the test.

6.3.2.1.3.2 Surface stress test

The top of the *contact electrode* or *contact probe* shall be placed on bar A and the *voltage detector* shall be laid on bar B for 1 min (Figure 8e, initial position). The *voltage detector* shall then be pushed forward toward bar A and rolled until the *limit mark* plus 200 mm reaches bar A (Figure 8e, final position).

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

6.3.2.1.3.3 Radial and surface stress test

The top of the *contact electrode* or *contact probe* shall be placed on bar A (Figure 8f, initial position) and, keeping the electrode in contact with bar A, the *voltage detector* shall be angularly moved relative to the bars and rolled until the *limit mark* plus 200 mm reaches bar B (Figure 8f, final position).

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

6.3.2.2 Alternative test for voltage detectors having completed the production phase

For *voltage detectors* having completed the production phase the test for surface stress shall be performed for 30 s.

6.3.3 Protection against bridging for outdoor type voltage detector

6.3.3.1 Type test

This test is performed for all types of outdoor *voltage detectors* (*outdoor type* and *exclusively outdoor type*).

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 13. These band electrodes are wound around the tube, one at the *contact electrode* or *contact probe* and the other in the direction of the handle at a distance d_1, column "Outdoor", specified in Table 12.

The band electrodes may be shielded by means of concentric rings having the dimensions suggested in Table 13. In this case, the rings shall be electrically connected to the band electrodes.

Table 13 – Dimensions for the concentric rings and band electrodes

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

One band electrode shall be connected to an AC voltage source, and the other band electrode shall be connected to earth (ground).

For practical reasons, the band electrode nearest to ground is generally connected to earth (ground) and the farthest is connected to the AC voltage source.

Precipitation shall be performed in accordance with 6.1.3.

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* or *contact probe* 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 9). The precipitation on the test section should be as uniform as possible.

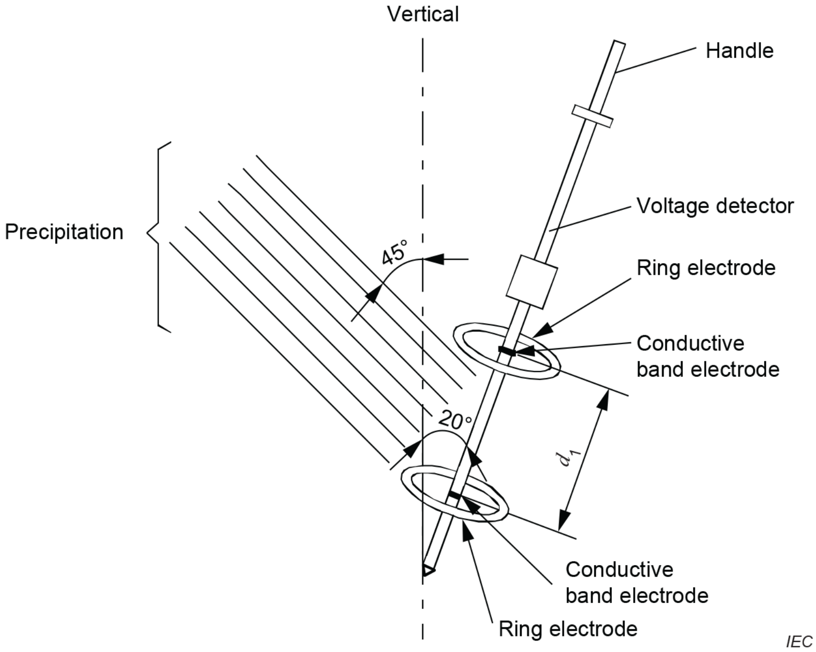


Figure 9 – Test for protection against bridging for outdoor type voltage detector

The *voltage detector* shall be wetted for 3 min. Then, it shall be turned 180°, as quickly as possible, so that the *contact electrode* or *contact probe* 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 / √3 but shall be greater than 148 kV (≈ 1,2 × 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 12.

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 (grounded) electrode is at the distance d_3 from the *contact electrode* or *contact probe* 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* or *contact probe*.

6.3.3.2 Alternative test for voltage detectors having completed the production phase

For *voltage detectors* having completed the production phase the test for surface stress shall be performed for 30 s, only in dry condition.

6.3.4 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 14.

Table 14 – Selection of the test set-up for the spark resistance test

Nominal voltages	U_n **≤ 245 kV**	U_n **> 245 kV**
Type of test set-up	V-shape bars Figure 8a	Parallel bars Figure 8e

The distance d_1 between bar A and bar B shall be adjusted according to Table 12 whatever the type of test set-up used. The distance d_2 of Figure 8a, shall be calculated as follows:

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

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 × 123 kV) for a *voltage detector* having a *nominal voltage* higher than 123 kV.

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

Additionally, the *voltage detector* shall be pushed toward bar A seeking the longest possible spark between the *indicator* and 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 can be combined with test 6.3.2.

6.4 Mechanical tests

6.4.1 Visual and dimensional inspection

6.4.1.1 Visual inspection

The *voltage detector* shall be tested for conformance with 4.1, 4.2.1.3.4, 4.4.2, 4.5, 4.6 and the instructions for use (4.7). 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 conformance with the requirements of 4.4.3 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 a 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's 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 1 000 mm from the front support (see Figure 10).

Dimensions in millimetres

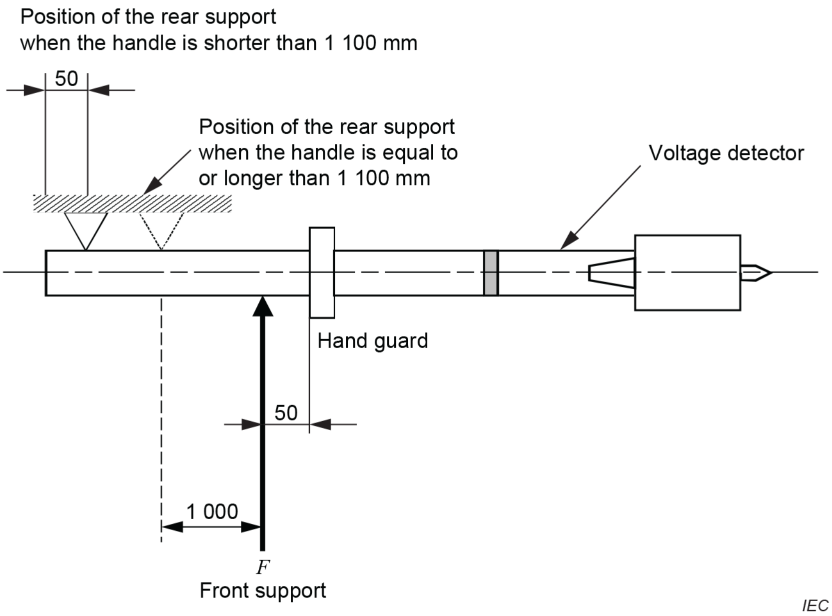


Figure 10 – Test set-up for grip force

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* or *contact probe* 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 corresponds 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 one octave per minute. 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 60068-2-31, 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* or *contact probe*, projected onto a vertical axis, and the floor (see Figure 11).
– The number of falls shall be one per position.

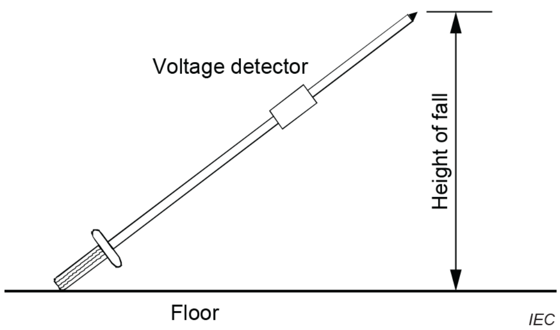


Figure 11 – Drop resistance test – Diagonal position

The test shall be considered as passed if the *voltage detector* shows no signs of mechanical damage even if the *contact electrode* or *contact probe* 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 4.4.3.

6.4.5 Shock resistance

The test is designed to check the sturdiness of the *voltage detector*. The test method shall be in accordance with the IEC 60068-2-75 pendulum method.

The most fragile part of the *voltage detector* shall be submitted to shock five times. The same location on the most fragile part shall be shocked only once.

The impact energy shall be 5 J.

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

6.4.6.1 Type test

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

The test shall be performed on the *indicator* and the *contact electrode* or *contact probe* extension, if so equipped, in accordance with IEC 60068-2-14 except for the temperature and relative humidity cycles. In this case, the test cycle shall be in accordance with the following (see Figure 12).

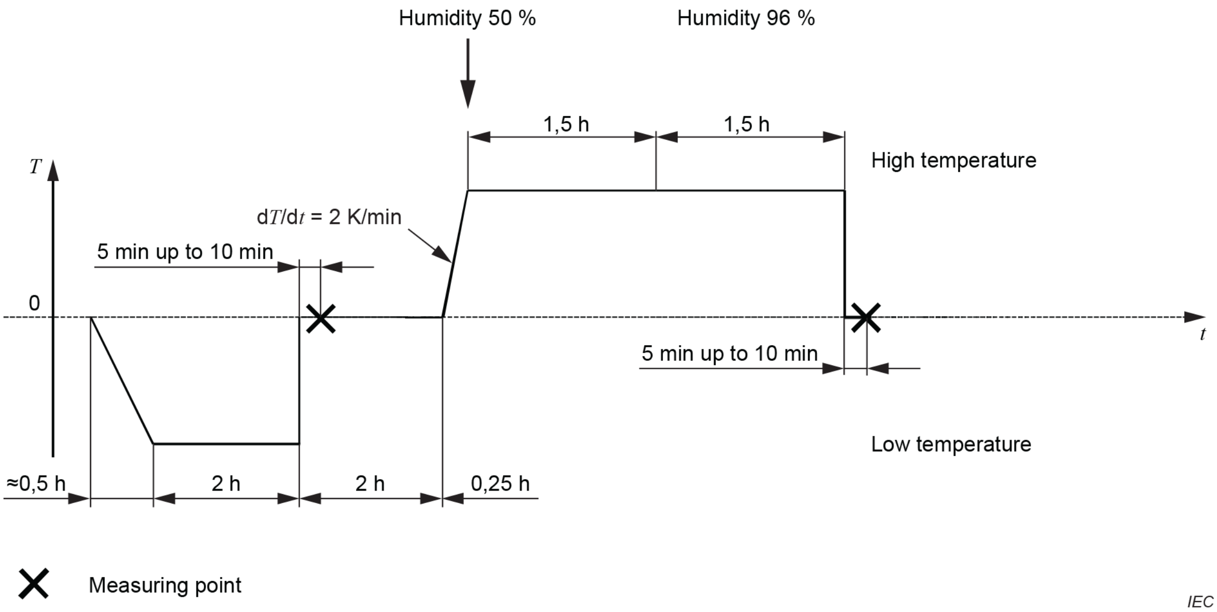


Figure 12 – Curve of test cycle for climatic dependence

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 2). 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 6.2.1.2.1. 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 2). 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 6.2.1.2.1 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 4.2.1.3.1.

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.

6.4.6.2 Alternative means for voltage detectors having completed the production phase

It is not practical to perform the test under climatic conditions after completing the production phase for checking the conformity to the associated requirements. Nevertheless the manufacturer shall prove that it has followed the same documented assembly procedure as for the type tested device. The manufacturer shall document components that affect the climatic performance.

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

7.1.1 General

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 13. These band electrodes are wound around the *voltage detector*, one adjacent to the *hand guard* in the direction of the *contact electrode* or *contact probe* 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 13. 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 × 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 7.1.2 and 7.1.3.

7.1.2 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 (ground) through an ammeter by means of a earthed (grounded) screen cable. The adjacent concentric ring shall be connected to earth (ground) directly. The band electrode and the concentric ring at the *limit mark* shall be connected to the test voltage (see Figure 13).

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

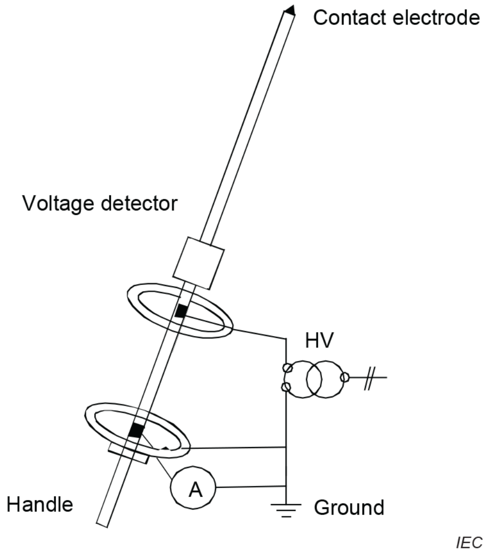


Figure 13 – Arrangement for leakage current tests under dry conditions for voltage detector as a complete device

7.1.3 Leakage current under wet conditions (outdoor type and exclusively outdoor type)

For *outdoor type voltage detector*, a wet test is also required. The test shall be performed in accordance with 6.1.3.

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 earthed (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 (ground) through the ammeter. The *contact electrode* and the concentric ring near the *limit mark* shall be earthed (grounded). The band electrode and the concentric ring near the handle shall be connected to the test voltage (see Figure 14a).

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.

In order to avoid the measurement of current spikes due to water drops and stream, the ammeter shall give at least an averaging time of 1 s and its input shall be equipped with an appropriate resistor-capacitor 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 (ground) through the ammeter and its adjacent concentric ring shall be earthed (grounded). The *contact electrode*, the band electrode and the concentric ring near the *limit mark* shall be connected to the test voltage (see Figure 14b).

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.

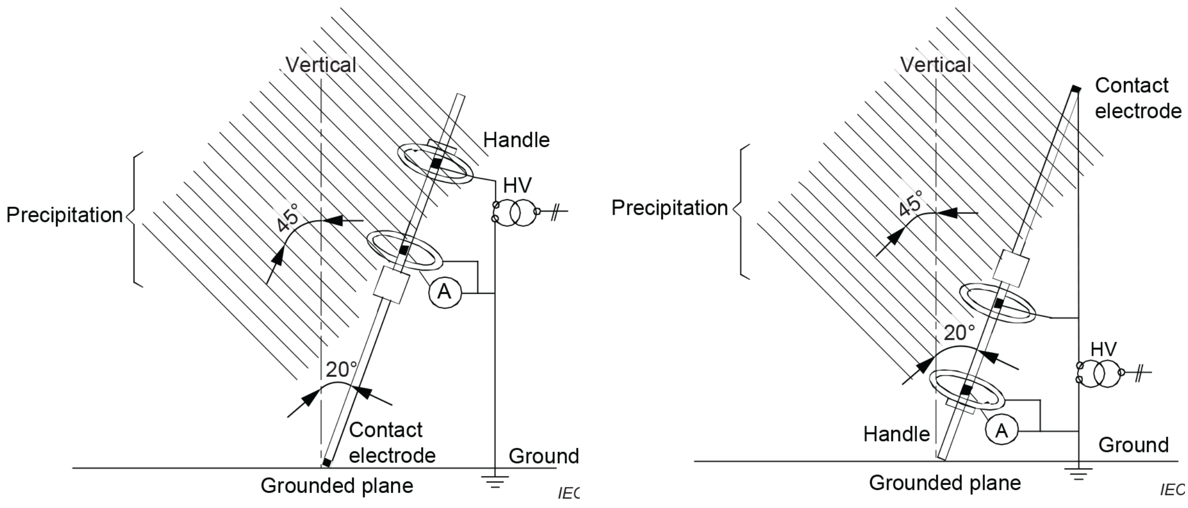


Figure 14a – Downwards position **Figure 14b – Upwards position**

Figure 14 – Arrangement for leakage current tests under wet conditions for outdoor type voltage detector as a complete device

7.1.4 Alternative test for voltage detectors having completed the production phase

The manufacturer can use any alternative test set-up to check that the leakage current does not exceed the value given in 7.1.2.

7.2 Test for stand-by state

Voltage detectors with a *stand-by state* shall be tested in the test set-ups according to 6.2.1.2.1 and 6.2.1.6.

The *voltage detector* shall be in the *stand-by state* mode to start the first test and the second test.

For the first test the test voltage is 90 % of the *threshold voltage* measured in 6.2.1.2.1.

The test shall be considered as passed if there is no indication of "voltage present".

For the second test, the test voltage is 110 % of the *threshold voltage* measured in 6.2.1.2.1.

The test shall be considered as passed if there is indication of "voltage present".

For *voltage detectors* of category L, both tests shall be repeated in the test set-up according to 6.2.1.6. The test voltages are 90 % and 110 % of the measured values of 6.2.1.6.

7.3 Test for ready to operate state

The *ready to operate state* is tested with the check of *testing element*. If relevant, according to 5.4, the indication of the *ready to operate state* shall be checked by activating the *voltage detector*.

8 Test for reasonably foreseeable misuse of the selector

8.1 Initial position of the selector

The voltage or frequency *selector* shall be switched at the least sensitive position if possible in the switched-off state. The *voltage detector* shall be switched on.

The test shall be considered as passed if the *voltage detector* does not reach the "*ready to operate state*" or the *voltage detector* switches automatically to the most sensitive range.

The test shall be repeated for every *selector* position not being the most sensitive position.

8.2 Voltage indication at incorrect low position of the selector (where relevant)

The voltage or frequency *selector* of the *voltage detector* shall be switched at the most sensitive position. The test for *threshold voltage* shall be performed at the highest *rated voltage* of the voltage ranges of the *voltage detector*.

The test shall be considered as passed if the *voltage detector* still gives a *clear indication* "voltage present", and no obvious damage of the *voltage detector* is visible.

9 Conformity assessment of voltage detectors having completed the production phase

For conducting the conformity assessment during the production phase, IEC 61318 shall be used in conjunction with this document.

Annex D, the result of a risk analysis on the performance of the *voltage detector*, provides the classification of defects and identifies the associated tests applicable in case of production follow-up.

Annex E provides classification of defects and tests to be allocated.

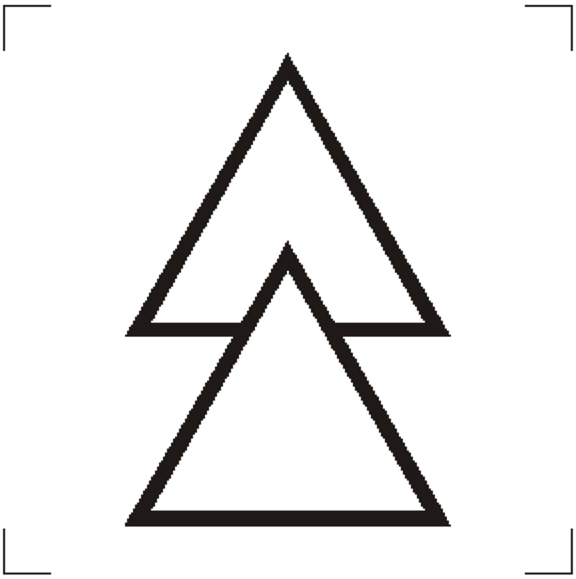
10 Modifications

Any modification of the type tested *voltage detector* shall require:

– a repeat of the type tests, in whole or in part (if the degree of modification so justifies);
– an update of the *voltage detector* reference literature.

Annex A
(normative)

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



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 and a recommendation for a training before the first use;
- 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 their purpose concerning the proper use;
- explanation of customized *voltage detectors* (e.g. for low or high *interference voltages*);
- statement that making contact on a coated part to be tested may give an incorrect indication, only contact bare metal to bare metal ensures a correct indication;
- statement that the function test shall be repeated in the event of an indication "voltage not present";
- statement that the *voltage detector* with a built-in *testing element* shall be checked before and after every use;
- statement that every *voltage detector* shall be put into the *ready to operate state* before detection;
- 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 that when the system *operating voltage* is degraded (e.g. 20 kV instead of 110 kV) the indication of a *voltage detector* according to the systems *nominal voltage* may not be correct;
- for *voltage detectors* with a *selector*, explanation of correct selection, possible misuse and its consequences;
- explanation of the purpose and limitation of use of each *accessory* supplied and type-tested;
- explanation of the usage of a *voltage detector* marked "exclusively outdoor";
- statement concerning the possible restrictions or formal interdictions on their use in case of switchgear of IEC 62271 series design;
- for systems without neutral reference, a statement that the insulating level shall be adapted to the maximum possible voltage to the earth (ground);
- statement concerning the possible restriction of their use on overhead line 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*;
- explanation that the *voltage detector* shall not be put nearby, between or along conductive parts at the same potential creating an equipotential zone, because this may lead to an incorrect indication – in the worst case indication of a dead state instead of a live state;

- explanation of the correct and incorrect positioning of a *voltage detector* between two live parts (see Annex F);
- statement concerning the duration that the *voltage detector* may be in contact with installations while exposed to precipitation;
- statement concerning *voltage detectors* with a built-in power source explaining the reaction when the power source is exhausted;
- instructions for storage and care;
- instructions for periodic *maintenance tests*; (See Annex G)
- 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;
- statement concerning the type, the minimum length of the *insulating element* and the dielectric properties of the *insulating stick* that shall be used in conjunction with the *voltage detector* as a separate device (see 4.3.1 and 4.4.3).

Annex C
(normative)

Chronology of type tests

The chronology of type tests shall be made according Table C.1 and Table C.2.

Table C.1 – Sequential order for performing type tests

Sequential order	Type tests	Subclauses	Requirements
1	Visual and dimensional inspection	6.4.1	4.1, 4.2.1.3.4, 4.4.2, 4.4.3, 4.5, 4.6 4.7
2	Vibration resistance	6.4.3	4.4.5
2	Drop resistance	6.4.4	4.4.6
2	Shock resistance	6.4.5	4.4.7
3	*Threshold voltage*	6.2.1.2.1	4.2.1.3.1
3	Overhead line configuration test for *voltage detectors* of category L	6.2.1.6	4.2.1.3.3
3	Test for *stand-by state*	7.2	5.3
3	Test for reasonably foreseeable misuse of the *selector* – voltage indication at incorrect low position of the *selector*	8.2	4.2.1.3.4 4.8.2
4	Climatic dependence	6.4.6.1	4.2.3
4	Frequency dependence	6.2.5.1	4.2.4
4	Power source dependability (or out of sequence)	6.2.7.1	4.2.6
5	*Protection against bridging* for *indoor type/outdoor type voltage detector*	6.3.2.1	4.3.2 5.2
5	*Protection against bridging* for *outdoor type voltage detector*	6.3.3.1	4.3.2
6	Spark resistance	6.3.4	4.3.3
7	Time rating	6.2.10.1	4.2.9 4.2.1.2
8	Check of *testing element*	6.2.8	4.2.7
8	Test for *ready to operate state*	7.3	5.4
9	Influence of in-phase *interference field*	6.2.1.3	4.2.1
9	Influence of phase opposition *interference field*	6.2.1.4	4.2.1
9	Influence of *interference voltage*	6.2.1.5	4.2.1
10	Leakage current for a *voltage detector* as a complete device under dry conditions	7.1.2	4.3.1 5.1
11	Leakage current for a *voltage detector* as a complete device under wet conditions (for *outdoor type* and *exclusively outdoor type*)	7.1.3	4.3.1 5.1

NOTE Tests with the same sequential number can be performed in the most convenient order.

Table C.2 – Type tests out of sequence

Type tests	Subclauses	Requirements
Durability of markings	6.4.7	4.5
Grip force and deflection	6.4.2	4.4.4
Non-response to DC voltage	6.2.9.1	4.2.8
Clear perceptibility of visual indication	6.2.3.1	4.2.2.2
Clear perceptibility of audible indication	6.2.4.1	4.2.2.3
Response time	6.2.6.1	4.2.5
Electromagnetic compatibility (EMC)	6.2.2.1	4.2.10
Insulating material for tubes and rods	6.3.1.1	4.3.1
Test for reasonably foreseeable misuse of the *selector* – initial position of the *selector*	8.1	4.8.1
NOTE Type tests out of sequence are performed on the same three *voltage detectors*.		

Annex D
(informative)

Classification of defects and tests to be allocated

Annex D addresses the type of defects of a manufactured *voltage detector of capacitive type* (critical, major or minor) in a consistent manner (see IEC 61318). For each requirement identified in Table D.1, both the type of defect and the associated test are specified.

Table D.1 – Classification of defects and associated requirements and tests

Requirements		Type of defect			Test	Test to be performed	Documen-tation test	Sampling test
		Critical	Major	Minor				
4.1 4.2.2.2 4.2.2.3	*Clear perceptibility* of indication for *voltage detectors* with only one type of signal (visual or audible) - indication group I: - indication groups II and III:		 X X		6.2.3.2 6.2.4.2			 X X
	Clear perceptibility of indication for *voltage detectors* with two types of signals (visual and audible)			X				X
4.2.1	Influence of in-phase *interference field* (functional safety)	X			[b]			
4.2.1	Influence of phase opposition *interference field*	X			[b]			
4.2.1	Influence of *interference voltage*	X			[b]			
4.2.1.3.1	*Threshold voltage*	X			6.2.1.2.2	X		
4.2.1.3.3	Indication on overhead lines	X			6.2.1.6.2	X		
4.2.1.3.4	Setting of the *threshold voltage* (functional safety)	X			6.2.1.2.2 6.2.1.6.2	X		
4.2.3	Climatic dependence (functional safety)	X			6.4.6.2		X	
4.2.4	Frequency dependence (functional safety)	X			6.2.5.2		X	
4.2.5	*Response time* (functional safety)	X			6.2.6.2		X	
4.2.6	Power source dependability	X			6.2.7.2		X	
4.2.7	Functioning of the *testing element*		X		6.2.8			X
4.2.8	Non-response to DC			X	6.2.9.2		X	
4.2.9	Time rating (functional safety)		X		6.2.10.2		X	
4.2.10	Electromagnetic compatibility (EMC) - emission - immunity	 X		 X	6.2.2.2		 X X	

Requirements		Type of defect			Test	Test to be performed	Documen-tation test	Sampling test
		Critical	Major	Minor				
4.3.1 5.1.1	Insulating material for tubes and rods for *voltage detector* as a complete device	X			6.3.1.2		X	
4.3.1 5.1.2	Leakage current along the *insulating element* of a *voltage detector* as a complete device	X			7.1.4	X		
4.3.2 5.2	*Protection against bridging* for *indoor type /outdoor type voltage detector*	X			6.3.2.2	X		
4.3.2	*Protection against bridging* for *outdoor type voltage detector*	X			6.3.3.2 [a]	X		
4.3.3	Spark resistance (functional safety)		X		6.3.4			X
4.4.2	General design and category of the *voltage detector*	X			6.4.1.1	X		
4.4.3	Minimum length of the *insulating element* for a *voltage detector* as a complete device	X			6.4.1.2	X		
4.4.4	Grip force and deflection			X	6.4.2			X
4.4.5	Vibration resistance		X		6.4.3			X
4.4.6	Drop resistance		X		6.4.4			X
4.4.7	Shock resistance		X		6.4.5			X
4.5	Correctness of the marking of the *voltage detector*	X			6.4.1.1	X		
4.5	Durability of marking		X		6.4.7			X
4.6	Documents for the user			X	6.4.1.1 [c]			X
4.7	Instructions for use (availability)	X			6.4.1.1 [c]	X		
4.8.1	Initial position of the *selector*	X			8.1	X		
4.8.2	Voltage indication at an incorrect position of the *selector*			X	8.2			X
5.2	Insulation of the *indicator* casing of *voltage detector* as a separate device	X			6.3.2.2 6.3.3.2 [a]	X		
5.3	*Stand-by state*	X			7.2	X		
5.4	*Ready to operate state*		X		7.3			X

[a] For *outdoor type* and *exclusively outdoor type voltage detectors*, the tests are performed in dry conditions only.

[b] At the production level, there is no need to perform a test associated to this requirement. The confirmation of the *threshold voltage* value according to 6.2.1.2.2 confirms the correctness of the performance of the device to give a correct indication under *interference field* and *interference voltage*.

[c] At the production level, the test shall check the availability of the documents for the user and the instructions for use.

Annex E
(informative)

Rationale for the classification of defects

Annex E provides the rationale for the classification of defects specified in Annex D. For a brand new *voltage detector*, Table E.1 presents the justification for the type of defect associated with a lack of conformance with each of the requirements included in this document.

This analysis takes into consideration that *voltage detectors* are used by persons trained for the work, in accordance with the hot stick working method and the instructions for use.

Table E.1 – Rationale for the classification of defects

Requirement	Justification for the associated defect specified in Annex D
Critical defects	
Clear perceptibility of indication for *voltage detectors* with only one type of signal (visual or audible) - indication group I:	If one of the *active signals* does not work, the user cannot conclude if the part to be tested is live or not. This can lead to a hazardous situation for the user.
Influence of in-phase *interference field* (functional safety)	*Interference field*s may affect picking up the correct signal and so give a false indication. This can lead to a hazardous situation for the user.
Influence of phase opposition *interference field*	
Influence of *interference voltage*	
Threshold voltage	An incorrect *threshold voltage* can lead to an incorrect indication. This can lead to a hazardous situation for the user.
Indication on overhead lines (*voltage detectors* of category L)	If the *voltage detector* gives a false indication (for example "voltage not present" instead of "voltage present"), it can lead to a hazardous situation.
Setting of the *threshold voltage* (functional safety)	The user shall not have any access to the *threshold voltage* setting. Changing the setting can lead to false indication. This can lead to a hazardous situation for the user.
Climatic dependence (functional safety)	If the *voltage detector* does not work properly in its temperature range, it could give a false indication and lead to a hazardous situation for the user.
Frequency dependence (functional safety)	If the *voltage detector* does not work properly in its frequency range, it can give a false indication and lead to a hazardous situation for the user.
Response time (functional safety)	If for any reasons the *response time* becomes longer than 1 s, the user could conclude a non answer as an indication. This could lead to a hazardous situation for the user.
Power source dependability	The purpose of this requirement is to ensure that the *voltage detector* will indicate properly until the built-in power source is exhausted. If not it could give incorrect indication and lead to a hazardous situation.
Electromagnetic compatibility (EMC) - immunity	If the *voltage detector* does not fulfil the immunity requirements, it can give wrong indications.
Insulating material for tubes and rods for *voltage detector* as a complete device	The good dielectric performance of the insulating material for tubes and rods used for complete devices guarantees the protection of the user during each use of the device.
Leakage current along the *insulating element* of a *voltage detector* as a complete device	The *insulating element* of a *voltage detector* as a complete device constitutes the protection of the user during each use of the device. On a brand new device a value of leakage current above the limit is a hazard for the initial user.
Protection against bridging for *indoor type*/*outdoor type voltage detector*	It would be hazardous for the user to have the *voltage detector* initiate a fault between two parts at different potential. Of course the user would not be in the direct circuit of the arc, but may be close enough to be affected by the arc by-products.

Requirement	Justification for the associated defect specified in Annex D
Protection against bridging for *outdoor type voltage detector*	It would be hazardous for the user to have the *voltage detector* initiate a fault between two parts at different potential. Of course the user would not be in the direct circuit of the arc, but may be close enough to be affected by the arc by-products.
General design and category of the *voltage detector*	If one of the necessary elements of the design of the *voltage detector* according to its category is missing, the *voltage detector* is not complete and can lead to a hazardous situation.
Minimum length of the *insulating element* (*voltage detector* as a complete device)	A shorter length of the *insulating element* can result in an unacceptable value of leakage current and/or can lead to a hazardous situation.
Correctness of the marking of the *voltage detector*	An incorrect marking, for example a wrong *nominal voltage* or a wrong climatic class, could result in a hazardous situation.
Instructions for use (availability)	A *voltage detector* without its instructions for use is an incomplete product and could lead to a hazardous situation.
Initial position of the *selector*	If the *voltage detector* will initially work at any position of the *selector*, this may lead to an incorrect indication and cause a hazardous situation.
Indicator casing	If the material and dimensioning of the *indicator* casing are not adequately rated with respect to voltage and power, it can lead to a hazardous situation.
stand-by state	If the *stand-by state* does not function, it can lead to an incorrect indication. This can lead to a hazardous situation.
Major defects	
Clear perceptibility of indication for *voltage detectors* with only one type of signal (visual or audible) - indication groups II and III	The *voltage detector* has either to be switched on manually or has to be checked on a live part before and after checking the part to be tested. The user will notice if the *voltage detector* is not working properly and should not use it.
Functioning of the *testing element*	If the *testing element* does not function, the user will become aware of that during the test. This results in a non availability of the *voltage detector*.
Time rating (functional safety)	If a *voltage detector* does not respect the time rating, it means that an internal fault has occurred. The device does not work properly any more. That reduces significantly the functionality of the *voltage detector*.
Spark resistance (functional safety)	If a *voltage detector* does not respect this requirement, some elements could be destroyed. The device does not work any more. That reduces significantly the functionality of the *voltage detector*.
Vibration resistance	If a brand new device does not have a good mechanical performance to drop, shock and vibration, it can lead to internal defect which reduces significantly the functionality of the *voltage detector*.
Drop resistance	
Shock resistance	
Durability of marking	If the marking is not available or is impaired, the user will not use the *voltage detector*.
Ready to operate state	If the *ready to operate state* does not function, the user should not use the *voltage detector*.
Minor defects	
Clear perceptibility of indication for *voltage detectors* with two types of signals (visual and audible)	We can consider that there is always one of the two *active signals* operational and the user can conclude whether the network is energized or not. It does not affect significantly the functionality of the *voltage detector*.
Non-response to DC	If the *voltage detector* indicates DC voltage it will only give a short indication. This will not lead to a hazardous situation.
Electromagnetic compatibility (EMC): - emission	If the *voltage detector* does not fulfil the emission requirements, it will (perhaps) affect other devices in the vicinity but it will not affect the *voltage detector*.
Grip force and deflection	Even if the grip force and the deflection do not fulfil the requirements, it does not reduce significantly the functionality of the *voltage detector*.
Documents for the user	A *voltage detector* without the documents for the user is an incomplete product but it does not affect the functionality of the device.

Requirement	Justification for the associated defect specified in Annex D
Voltage indication at an incorrect low position of the *selector*	The *voltage detector* is designed to withstand the highest voltage of the voltage range. The *selector* only changes the sensivity of the electronic signal processing device in the *indicator* casing. No hazardous situation for the user can occur.

Annex F
(informative)

Information and guidelines on the use of the limit mark and of a contact electrode extension

F.1 General

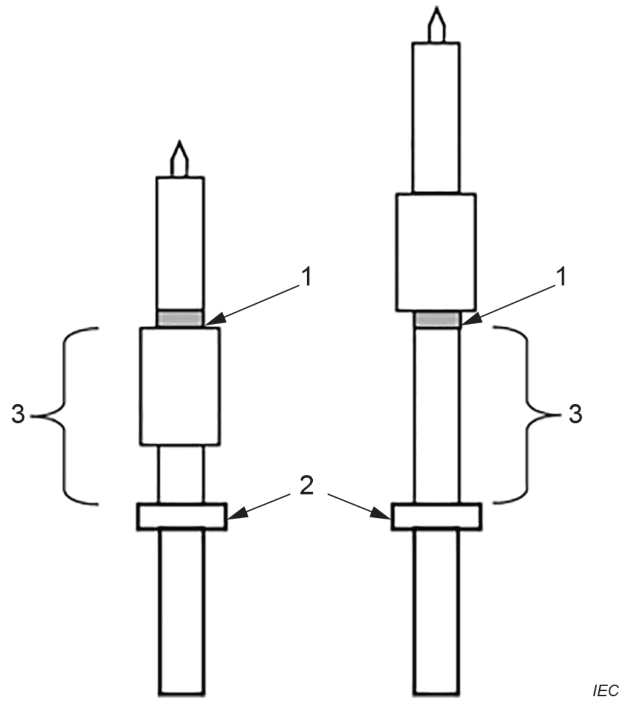
Annex F provides additional information on the purpose and use of the *limit mark*, which is a mandatory part of a *voltage detector* as a complete device and of the *contact electrode extension* to achieve the correct position of the *indicator* relative to the installation being tested.

F.2 Situation when using a voltage detector as a complete device

As defined in Clause 3, the *limit mark* is a 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.

The user handling a *voltage detector* as a complete device is provided with an adequate insulation by the *insulating element* which is defined by the distance between the *limit mark* and the *hand guard* (see Figure F.1).

This document specifies a minimum length of the *insulating element* of a *voltage detector* as a complete device (see Table 3). A user may specify a longer length.



Key

1 *limit mark*

2 *hand guard*

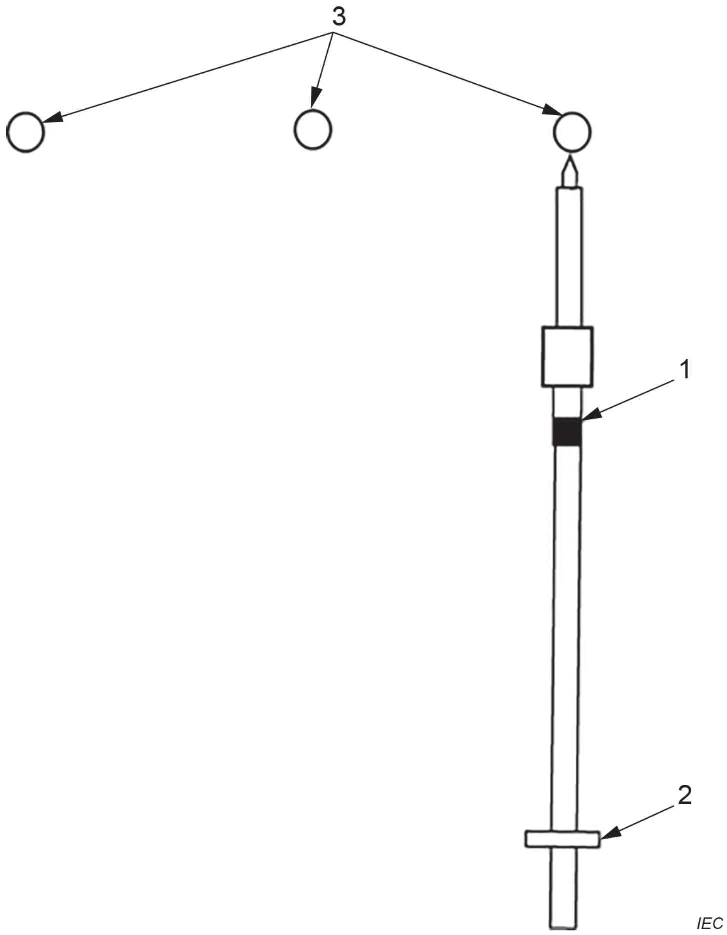
3 *insulating element*

Figure F.1 – Insulation element of a *voltage detector* as a complete device

When handling a *voltage detector* near live parts of an electrical installation, the user should always make sure that the device will approach the live parts in a way to not shorten in any unsafe manner the insulation distance between the *limit mark* and the *hand guard*.

The *limit mark* is a physical way to indicate to the user the limit of insertion of the device between live parts. Any live part contacting the *voltage detector* in any location between the *limit mark* and the *hand guard* will shorten the insulation distance.

When the user positions the *voltage detector* right under a live part, with no obstacles in between (see Figure F.2), the *limit mark* has no significant use.



Key

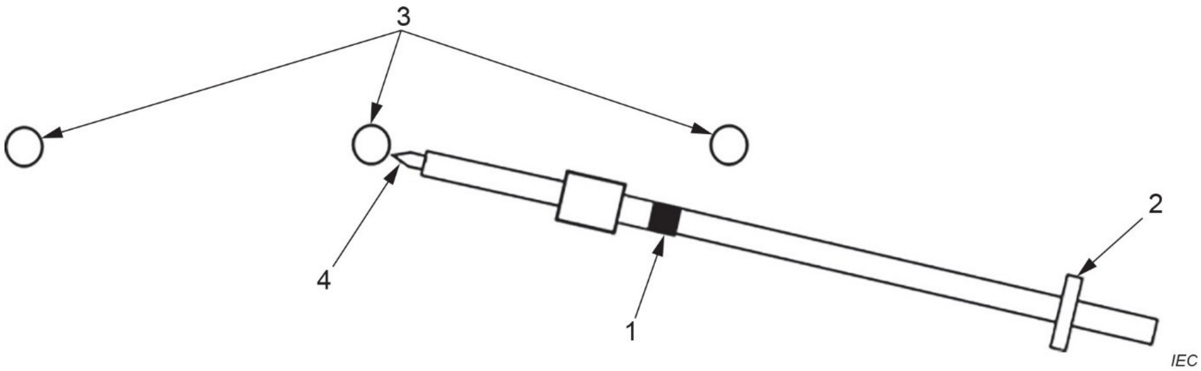
1 *limit mark*

2 *hand guard*

3 live parts

Figure F.2 – Example of positioning of a voltage detector in contact with a live part without obstacles from other live parts

However, in some installation configurations, the user may have to approach a live part by positioning the *voltage detector* close to another live part, under or over it. In such a situation, to have the *limit mark* going between the live parts would reduce the insulation distance (see Figure F.3), a situation which shall be avoided.



Key

1 *limit mark*

2 *hand guard*

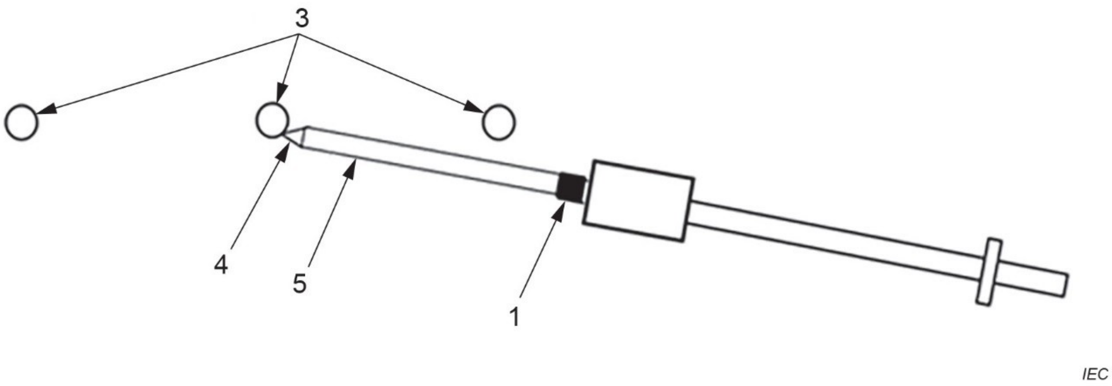
3 live parts

4 *contact electrode or contact probe*

Figure F.3 – Example of incorrect positioning of a voltage detector with the limit mark between two live parts

To avoid such situation, the distance between the *contact electrode* and the *limit mark* of the *voltage detector* shall be extended in such a way that it exceeds the usual distances between live parts for a given *operating voltage*.

A usual way for achieving that is the use of a *contact electrode extension* (see Figure F.4).



Key

1 *limit mark*

3 live parts

4 *contact electrode* or *contact probe*

5 *contact electrode extension*

Figure F.4 – Usual way of managing the use of the voltage detector for maintaining the insulation distance between the limit mark and the hand guard

F.3 Situation when using a voltage detector as a separate device

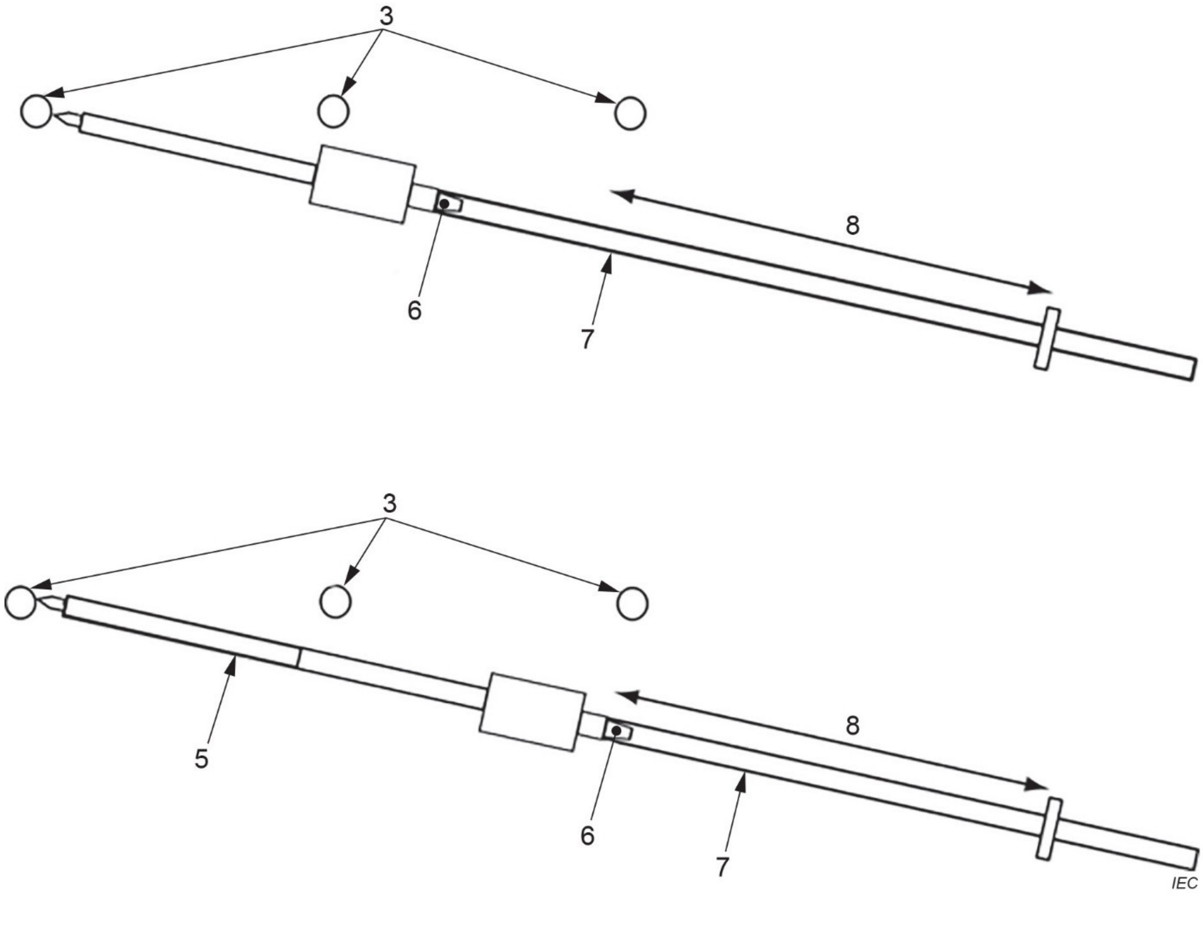
Each pole of a *voltage detector* as a separate device is equipped with an *adaptor* to permit its attachment to an *insulating stick*. The *insulating stick* is a separate tool, and its general performance, as well as its length, is the responsibility of the user.

In a certain way, the *adaptor* of a *voltage detector* as a separate device may be associated to the *limit mark* of a *voltage detector* as a complete device in the sense that the insulation of the user will be provided by the *insulating element* of the *insulating stick* that is identified as the distance between the *adaptor* and the *hand guard* of the *insulating stick*.

However, while the *insulating element* of a *voltage detector* as a complete device is of a determined length corresponding to the design of the manufacturer, the length of the *insulating stick* and the determination of the distance between the *adaptor* and the *hand guard* of the stick are the responsibility of the users and may be influenced by the working procedures.

The user has two possible ways to achieve the positioning of the *voltage detector* between live parts:

– the use of a *contact electrode extension*;
– the use of an *insulating stick* of a length longer than the minimum length of insulation towards the *hand guard* that will allow the *adaptor* of the *insulating stick* to be between live parts (see Figure F.5) taking into account the possible impact of *interference fields* for *clear indication*.



Key

3 live parts

5 *contact electrode extension*

6 *adaptor*

7 *insulating stick* of the appropriate length

8 minimum length of insulation (under the responsibility of the users and influenced by the working procedures)

Figure F.5 – Usual ways of managing the use of the voltage detector as a separate device for assuring the appropriate insulation for the user

Annex G
(informative)

In-service care

G.1 General

Maintenance on live equipment in service is recognized as a basis for ensuring their good functioning and the safety of the user. *Maintenance tests* should be carried out periodically on *voltage detectors* to ascertain that their performance remains within specified limits and, if necessary, make certain adjustments to ensure this.

It is the responsibility of the user to elaborate the maintenance schedule, based on national regulations, on manufacturer's instructions and the conditions of use (storage, regular care, training of the user, etc.). However no *voltage detector*, even those held in storage, should be used unless re-tested within a maximum period of six years.

It is recommended that the periodic maintenance be done by a competent test facility.

At any time, a visual inspection of the *voltage detector* should be made before use. If there is a doubt that the device is not in good condition, it should be excluded from further use, then returned to the manufacturer for repair or rejection.

G.2 Testing

Table G.1 lists the tests that verify the physical integrity, the functioning of the *voltage detector* and its insulation performance. It also recommends a chronological order for performing the tests. The *insulating stick* to be used with *voltage detectors* as a separate device should be covered by an IEC, regional, national or local/company standard.

Table G.1 – In-service testing

Chronological order	Designation
1	Visual and dimensional inspection
2	Check of *testing element* [a]
3	Leakage current under dry conditions [b]
4	*Protection against bridging* for *indoor type*/*outdoor type voltage detector* [c]
5	Spark resistance [d]
6	Measurement of *threshold voltage* [e]
7	Influence of in-phase *interference field*
8	*Clear perceptibility* of visual indication [f]
8	*Clear perceptibility* of audible indication [f]

[a] The check of the electrical circuits, to verify that all circuits are tested, is not necessary.

[b] When the test is performed as a periodic testing, the admissible leakage current may be higher than that specified in 7.1.2 but it should not exceed 200 µA.

[c] Under dry conditions only. The test duration for the surface stress test (6.3.2.1.2.2 and 6.3.2.1.3.2) shall be 30 s.

[d] For practical purposes, this test may be combined with the test for *protection against bridging* (number 4 of the chronological list). The test duration for spark resistance is at least 5 s.

[e] A comparison may be made with a reference *voltage detector* of the same design and using an alternative high voltage test set-up.

Since the parameters of the test set-up and the test room arrangement can influence significantly the measured value of the *threshold voltage*, it is recommended to measure and record the initial value of the *threshold voltage* as obtained with this test set-up and this testing room, and to use the same configuration at periodic intervals.

[f] A comparison may be made with a reference *voltage detector* of the same design. Tests for *clear perceptibility* may also be combined with other previous tests of the list.

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 noted in the instructions for use.

Annex H
(informative)

Information for the next maintenance

H.1 Overhead line test

H.1.1 Rationale

This test will be an item of the next maintenance of this document. Only the test for *voltage detectors* of category "L" is implemented to reduce the risk of wrong indication on overhead lines. A risk may exist for *voltage detectors* of category "S", too. Manufacturers and users should use the opportunity to do some investigations and to make improvements to the test.

H.1.2 Proposal for an improved test (will be discussed within the next maintenance)

Under consideration

H.2 Threshold deviation ratio category (deviation category) for voltage detectors of category L

H.2.1 Rationale

This requirement will be an item of the next maintenance of this document. This is the result of the new overhead line configuration test and the experience over the next years with it, to give manufacturers and users the opportunity to make improvements.

H.2.2 Proposal for a new requirement (will be discussed within the next maintenance)

The *threshold voltage* should have as little deviation as possible for different configurations of installations to ensure that the *voltage detector* shall always give a *clear indication*. According to requirements 4.2.1.3.1 and 4.2.1.3.3 the deviation category is the absolute value of

$$|1 - (U_t\ (6.2.1.2.1)\ /\ U\ (6.2.1.6))|$$

and given as percentage value.

The deviation categories are the following.

– Deviation category A: ≤ 15 %.
– Deviation category B: > 15 % to ≤ 25 %.
– Deviation category C: > 25 %.

H.3 Phase opposition test for voltage detectors of category L

H.3.1 Rationale

This requirement will be an item of the next maintenance of this document. This is the result of field experience and should give manufacturers and users the opportunity to make improvements.

H.3.2 Proposal for an improved test (will be discussed within the next maintenance)

Under consideration

H.4 Non-contact behaviour of voltage detectors of category L

H.4.1 Rationale

This requirement will be an item of the next maintenance of this document. This is the result of field experience and should give manufacturers and users the opportunity to make improvements.

H.4.2 Proposal for a new test (will be discussed within the next maintenance)

The test is under consideration.

Some distances from the former French standard C 18-311 (1986), from a study of the University of Stuttgart and from proposals during the maintenance are given in Table H.1.

Table H.1 shows the maximum distances of early detection beyond which the device cannot be considered as a contact *voltage detector*.

Table H.1 – Maximum distances for early detection

U_r kV	D_S mm
$1 < U_r \leq 36$	41,0
$36 < U_r \leq 72,5$	72,5
$72,5 < U_r \leq 123$	123,0
$123 < U_r \leq 170$	170,0
$170 < U_r \leq 245$	245,0
$245 < U_r \leq 420$	420,0
$420 < U_r \leq 550$	550,0
$550 < U_r \leq 800$	800,0
NOTE D_S corresponds to 1 kV/mm; see: Denissov et al., Dielectric strength of different gases in GIS, University Stuttgart, 2005; a tolerance of 5 mm was added.	

The test voltage should be performed with the highest voltage (U_r) of the range of Table H.1. The distances refer to "1 mm/kV × U_r + 5 mm". For *voltage detectors* below 36 kV the distance should be set at the distance for *voltage detectors* of 36 kV.

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 – General*

IEC 60050-651:2014, *International Electrotechnical Vocabulary (IEV) – Part 651: Live working*

IEC 60743:2013, *Live working – Terminology for tools, devices and equipment*

IEC 60855-1, *Live working – Insulating foam-filled tubes and solid rods – Part 1: Tubes and rods of a circular cross-section*

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

IEC 61481 (all parts), *Live working – Phase comparators*

IEC 61936-1:2010, *Power installations exceeding 1 kV a.c. – Part 1: Common rules*
IEC 61936-1:2010/AMD1:2014

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in.

This Indian Standard has been developed from Doc No.: ETD 36 (18657).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.gov.in

Regional Offices:		*Telephones*
Central	: 601/A, Konnectus Tower -1, 6th Floor, DMRC Building, Bhavbhuti Marg, New Delhi 110002	2323 7617
Eastern	: 8th Floor, Plot No 7/7 & 7/8, CP Block, Sector V, Salt Lake, Kolkata, West Bengal 700091	2367 0012 2320 9474
Northern	: Plot No. 4-A, Sector 27-B, Madhya Marg, Chandigarh 160019	265 9930
Southern	: C.I.T. Campus, IV Cross Road, Taramani, Chennai 600113	2254 1442 2254 1216
Western	: Plot No. E-9, Road No.-8, MIDC, Andheri (East), Mumbai 400093	2821 8093

Branches : AHMEDABAD. BENGALURU. BHOPAL. BHUBANESHWAR. CHANDIGARH. CHENNAI. COIMBATORE. DEHRADUN. DELHI. FARIDABAD. GHAZIABAD. GUWAHATI. HIMACHAL PRADESH. HUBLI. HYDERABAD. JAIPUR. JAMMU & KASHMIR. JAMSHEDPUR. KOCHI. KOLKATA. LUCKNOW. MADURAI. MUMBAI. NAGPUR. NOIDA. PANIPAT. PATNA. PUNE. RAIPUR. RAJKOT. SURAT. VISAKHAPATNAM.

Published by BIS, New Delhi