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**TRAVAUX SOUS TENSION
– DÉTECTEURS DE
TENSION – PARTIE 1:
TYPE CAPACITIF POUR
USAGE SUR DES
TENSIONS ALTERNATIVES
DE PLUS DE 1 kV**

ICS 29.240.99

**LIVE WORKING –
VOLTAGE DETECTORS –
PART 1: CAPACITIVE
TYPE TO BE USED FOR
VOLTAGES EXCEEDING 1
kV a.c.**

ICS 29.240.99



Numéro de référence
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CEI/IEC 61243-1: 2009

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NATIONAL STANDARD OF CANADA

CAN/ULC-61243-1-10
(CEI/IEC 61243-1: 2009, MOD)

**TRAVAUX SOUS TENSION –
DÉTECTEURS DE TENSION – PARTIE
1: TYPE CAPACITIF POUR USAGE
SUR DES TENSIONS ALTERNATIVES
DE PLUS DE 1 kV**

ICS 29.240.99

CAN/ULC-61243-1-10
(CEI/IEC 61243-1: 2009, MOD)

**LIVE WORKING – VOLTAGE
DETECTORS – PART 1: CAPACITIVE
TYPE TO BE USED FOR VOLTAGES
EXCEEDING 1 kV a.c.**

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CAN/ULC-61243-1-10 **(CEI/IEC 61243-1: 2009, MOD)**

Travaux sous tension – Détecteurs de tension – Partie 1: Type capacitif pour usage sur des tensions alternatives de plus de 1 kV

PRÉFACE ULC

Ce document constitue la deuxième édition de la norme CAN/ULC-61243-1-10 (CEI/IEC 61243-1: 2009, MOD), Travaux sous tension – Détecteurs de tension – Partie 1: Type capacitif pour usage sur des tensions alternatives de plus de 1 kV. Il s'agit de l'adoption avec les exigences propres au Canada de la norme internationale de la Commission Électrotechnique Internationale, CEI/IEC 61243-1 (Édition, 2009-06).

Cette édition de la norme a été approuvée par le Comité ULC sur les travaux sous tension et a été approuvée en tant que Norme nationale du Canada par le Conseil canadien des normes.

Une grande partie du financement nécessaire au processus d'adoption de ce rapport technique national a été assurée par l'Association canadienne de l'électricité (ACE) que nous tenons à remercier.

Decembre 2010

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CAN/ULC-61243-1-10 **(CEI/IEC 61243-1: 2009, MOD)**

Live Working – Voltage Detectors – Part 1: Capacitive Type to be Used for Voltages Exceeding 1 kV a.c.

ULC PREFACE

This is the Second Edition of CAN/ULC-61243-1-10 (CEI/IEC 61243-1: 2009, MOD), Live Working – Voltage Detectors – Part 1: Capacitive Type to be Used for Voltages Exceeding 1 kV a.c., which is an adoption with Canadian deviations of the International Standard by the International Electrotechnical Commission, CEI/IEC 61243-1 (Edition 2.1, 2009-06).

This Edition of the Standard has been formally approved by the ULC Committee on Live Working and has been approved as a National Standard of Canada by the Standards Council of Canada.

Major funding in support of the adoption process of this National Standard of Canada was provided by the Canadian Electricity Association (CEA), whose assistance is acknowledged with thanks.

December 2010

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Exigences propres au Canada

4.5 Marquages

[Supprimer la 11e item sous "Chaque indicateur doit posséder au moins les marquages suivants:" at révisé la 12e item comme suit:]

« - le numéro de la norme CAN/ULC applicable, avec l'année de publication (CAN/ULC-61243-1-10) »

[Révisé la 4e et 5e paragraphes comme suit:]

«Pour être marqué du numéro de la présente norme CAN/ULC, le produit doit satisfaire à toutes les exigences qui y sont spécifiées.

Avec chaque détecteur de tension ou avec chaque lot de détecteurs de tension à être livré, le fabricant doit fournir l'information relative au numéro de la norme CAN/ULC avec l'année de publication. »

Annexe A (normative) Appropriate aux travaux sous tension

[Supprimer Annexe A]

Canadian Deviations

4.5 Markings

[Delete the 11th item under “Each indicator shall have at least the following markings:” and revise the 12th item to read:]

“ - number of the relevant CAN/ULC standard with year of publication (CAN/ULC-61243-1-10)”

[Revise the 4th and 5th paragraphs to read:]

“To be marked with the number of this CAN/ULC standard, the product shall satisfy all the requirements specified herein.

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 CAN/ULC standard with the year of publication.”

Annex A (normative) Suitable for live working; double triangle

[Delete Annex A]

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Travaux sous tension – Détecteurs de tension –
Partie 1: Type capacitif pour usage sur des tensions alternatives de plus de 1 kV**

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IEC 61243-1

Edition 2.1 2009-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Travaux sous tension – Détecteurs de tension –
Partie 1: Type capacitif pour usage sur des tensions alternatives de plus de 1 kV**

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LIVE WORKING – VOLTAGE DETECTORS –

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

FOREWORD

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International Standard IEC 61243-1 has been prepared by IEC technical committee 78: Live working.

This edition includes the following major technical changes from the previous edition:

- a) the Scope has been extended to cover the use on electrical systems for voltages up to 765 kV a.c.;
- b) the notion of family of voltage detectors which are identical in terms of design and dimensions and only differ by their nominal voltages (or nominal voltage ranges) has been included;
- c) the classification in terms of the setting of the threshold voltage to give a clear indication has been eliminated;
- d) a new test set-up with bars has been introduced. Depending on the nominal voltage of the voltage detector, it is required or becomes an alternative test set-up for checking the influence of interference fields, the influence of interference voltages, the protection against bridging and the spark resistance;

- e) the revision of specific dielectric tests has been included;
- f) some test procedures (clear perceptibility of audible indication, drop resistance, climatic dependence) have been improved and completed.

This consolidated version of IEC 61243-1 consists of the second edition (2003) [documents 78/527/FDIS and 78/537/RVD], its amendment 1 (2009) [documents 78/751/CDV and 78/794/RVC] and its corrigendum of October 2005.

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 2.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 61243 consists of the following parts, under the general title *Live working – Voltage detectors*:

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

Part 2: Resistive type to be used for voltages of 1 kV to 36 kV a.c.

Part 3: Two-pole low-voltage type

Part 5: Voltage detecting systems (VDS)

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

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

LIVE WORKING – VOLTAGE DETECTORS –

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

1 Scope

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

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

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

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

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

2 Normative references

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

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

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

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

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

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

IEC 60071-1:2006, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60417-DB:2002¹, *Graphical symbols for use on equipment*

IEC 60942, *Electroacoustics – Sound calibrators*

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

¹ “DB” refers to the IEC on-line database.

IEC 61318:2007, *Live working – Conformity assessment applicable to tools, devices and equipment*

IEC 61477:2001, *Live working – Minimum requirements for the utilization of tools, devices and equipment*

Amendment 1 (2002)²

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

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

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

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61318:2007 and the following apply.

3.1

voltage detector

device used to provide clear evidence of the presence or the absence of the operating voltage

NOTE For example, voltage detectors can be described as capacitive type or resistive type.

[Definition 11.2.5 of IEC 60743, modified, and IEC 651-10-04, modified]

3.2

voltage detector of capacitive type

device whose operation is based on the current passing through the stray capacitance to earth (ground)

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

3.3

designs of voltage detectors

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

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

3.4

family of voltage detectors

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

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

3.5**contact electrode**

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

[IEV 651-10-09]

3.6**contact electrode extension**

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

3.7**indicator**

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

[IEV 651-10-08, modified]

3.8**adaptor**

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

3.9**insulating element**

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

3.10**insulating stick**

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

[Definition 2.5.1 of IEC 60743 and IEV 651-02-01]

NOTE 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.

3.11**limit mark**

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

3.12**hand guard**

distinctive physical guard separating the handle from the insulating element

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

3.13**testing element**

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

[IEV 651-10-11, modified]

3.14**accessories**

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

**Documents**

Document Sharing Hub

3.15 nominal voltage

U_n

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

[IEV 601-01-21, modified]

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

3.16 operating voltage (in a system)

value of the voltage under normal conditions, at a given instant and a given point of the system

NOTE This value may be expected, estimated or measured.

[IEV 601-01-22]

3.17 threshold voltage

U_t

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

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

3.18 rated voltage

U_r

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

3.19 interference voltage

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

3.20 interference field

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

NOTE The extreme cases for the tests are:

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

3.21**active signal**

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

[IEV 101-12-02, modified]

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

3.22**clear indication**

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

[IEV 651-10-10]

3.23**clear perceptibility**

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

3.24**response time**

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

3.25**protection against bridging**

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

3.26**stand-by state**

state at which the voltage detector is ready to work without manual switching on

3.27**indoor type**

voltage detector designed for use in dry conditions, normally indoors

3.28**outdoor type**

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

3.33**maintenance test**

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

[IEV 151-16-25 modified]

4 Requirements

4.1 General requirements

4.1.1 Safety

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

4.1.2 Indication

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

4.2 Functional requirements

4.2.1 Clear indication

The voltage detector shall give an unambiguous indication of the presence and/or the absence of the system operating voltage as a function of the nominal voltage or nominal voltage range of the voltage detector, and its nominal frequency or nominal frequencies.

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 part shall not affect its indication.

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

4.2.1.1 Continuous indication

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

4.2.1.2 Threshold voltage

4.2.1.2.1 General

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

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

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

The indication "voltage present" shall not appear if the voltage to earth 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 $0,17 U_n / \sqrt{3}$ and is the maximum phase to earth 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 It may happen that 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.

It may also happen that the variations of the nominal voltage network are such that the 0,45 U_n or 0,45 U_n max. is not the lowest possible value.

Moreover, when is it expected that the voltage detector will be used in the vicinity of large conductive parts that create equipotential zones (see 4.2.1), the customer may specify a low value of the threshold voltage.

In all these cases, manufacturer and customer should reach an agreement to set the appropriate value for the threshold voltage, while keeping it within the range specified above. The setting of the threshold voltage is further limited by the requirements for clear indication which shorten the range of possible values, and the relevant tests (clear indication) have to be passed.

4.2.1.2.2 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.

NOTE 1 This particular case could help to deal with the use of the voltage detector in the vicinity of large conductive parts. In spite of this change of the threshold voltage for a lower value, the theoretical limit of 4,5 for the ratio between U_n max. and U_n min. still remains valid, and the relevant tests (clear indication) have to be passed.

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.

NOTE 2 The special marking should be the result of an agreement between the manufacturer and the client.

4.2.2 Clear perceptibility

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

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

- group I: Indication with at least two distinct active signals, which give an indication of the condition "voltage present" and "voltage not present". The "stand-by" state is not necessary;
- group II: Indication with at least one active signal, which gives an indication of the condition "voltage not present" and is activated by manually switching "on", and is suppressed when the contact electrode is put into contact with a live part;
- group III: Indication with at least one active signal, which gives an indication of the condition "voltage present", and shall have a stand-by state.

4.2.2.1 Visual indication

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

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

4.2.2.2 Audible indication

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

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

4.2.3 Temperature and humidity dependence of the indication

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

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

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

In these cases, the threshold voltage shall satisfy 4.2.1.2.

Table 1 – Climatic categories

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

4.2.4 Frequency dependence

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

4.2.5 Response time

The response time shall be less than 1 s.

4.2.6 Power source dependability

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

4.2.7 Testing element

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

4.2.8 Non-response to d.c. voltage

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

4.2.9 Time rating

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

4.3 Electrical requirements

4.3.1 Insulating material

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

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

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

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

4.3.2 Protection against bridging

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

4.3.3 Resistance against sparking

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

4.4 Mechanical requirements

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

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

4.4.1 Design

4.4.1.1 General design

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

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

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

4.4.1.2 Category

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

NOTE It is used mainly on overhead lines.

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

NOTE It is mainly used in indoor substations.

4.4.2 Dimensions, construction

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

Table 2 – Minimum length of the insulating element (L_i) 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
$420 < U_r \leq 525$	4 300
$525 < U_r \leq 765$	6 600

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

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

NOTE 3 The L_i values of Table 2 can be used as 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.

For L_i equal to or greater than 520 mm, conductive parts not exceeding 200 mm (in total), measured from the limit mark towards the handle, are allowed within the minimum length of the insulating element if they are completely externally insulated.

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

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

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

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

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

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

4.4.3 Grip force and deflection

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

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

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

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

4.4.4 Vibration resistance

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

4.4.5 Drop resistance

The voltage detector shall be drop resistant in working conditions.

4.4.6 Shock resistance

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

4.5 Markings

Each indicator shall have at least the following markings:

- nominal voltage and/or range of nominal voltage;
- indication group;
- special marking for low interference voltage, when relevant;
- nominal frequency or nominal frequencies;
- name and/or trademark of the manufacturer;
- type reference, serial number;
- indication of type "indoor" or "outdoor";
- indication of category (S or L);
- climatic category (C, N or W);
- year of production;
- symbol IEC 60417-5216(DB:2002-10) – Suitable for live working; double triangle (see Annex A);

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

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

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

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

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

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

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.

4.6 Instructions for use

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

5 Specific requirements

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

5.1.1 Dielectric strength

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

5.1.2 Leakage current

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

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

5.2 For indicator casing of voltage detector as a separate device

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

6 Tests

6.1 General

This standard provides testing provisions to demonstrate compliance of the product to the requirements of Clauses 4 and 5. These testing provisions are primarily intended to be used as type tests 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.

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

- measurement of threshold voltage (see 6.2.1.2),
- influence of in-phase interference field (see 6.2.1.3),
- influence of phase opposition interference field (see 6.2.1.4),
- influence of interference voltage (see 6.2.1.5),
- protection against bridging for indoor/outdoor type voltage detector (see 6.3.1),
- protection against bridging for outdoor type voltage detector (see 6.3.2) and
- spark resistance (see 6.3.3).

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

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

Except when otherwise stated:

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

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

6.1.1 Tests under wet conditions

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

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

6.1.2 Type test

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

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

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

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

6.1.3 Test methods

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

Unless otherwise specified;

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

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

6.2 Function tests

6.2.1 Clear indication

6.2.1.1 General

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

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

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

6.2.1.2 Measurement of threshold voltage

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 2.

The electrode arrangement is selected according to the category of the voltage detectors. Figure 2a gives the arrangement for voltage detectors of category S and Figure 2b 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 4a.

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

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

The test shall be considered as passed if the measured threshold voltage is within the limits specified in 4.2.1.2.

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 $\pm 5\%$ 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.

6.2.1.3 Influence of in-phase interference field

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

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

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

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

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

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

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

Table 4 – Distance G (see Figure 4d)

U_n kV	G mm
$52 < U_n \leq 82,5$	$75 \begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$
$82,5 < U_n \leq 145$	$135 \begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$
$145 < U_n \leq 245$	$210 \begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$
$245 < U_n \leq 420$	$255 \begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$
$420 < U_n \leq 525$	$315 \begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$
$525 < U_n \leq 765$	$450 \begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$

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 5.

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

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

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

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

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

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

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

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

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

6.2.1.5 Influence of interference voltage

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

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

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

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

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

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

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

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

6.2.2 Clear perceptibility of visual indication

6.2.2.1 Type test

The test set-up is given in Figure 5.

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

- 50 000 lux $\pm$ 10 % for outdoor type voltage detector with standard light D₅₅ according to CIE 15.2 corresponding to colour temperature of 5 500°K $\pm$ 10 %;
- 1 000 lux $\pm$ 10 % for indoor type voltage detector with standard light A according to CIE 15.2 corresponding to colour temperature of 3 200°K $\pm$ 10 %.

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

The visual perceptibility test shall be performed 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 5b).

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

6.2.2.2 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 the one of a voltage detector which has passed successfully the type test according to 6.2.2.1 (reference voltage detector). The test shall be considered as passed if both perceptibilities are almost identical.

6.2.3 Clear perceptibility of audible indication

6.2.3.1 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 3744:1994.

NOTE 1 Such test conditions can be encountered in semi-anechoic rooms.

Averaged over the microphone positions, the level of the background noise shall be at least 6 dB(A) but preferably more than 15 dB(A) below the sound pressure level to be measured. If the difference between the sound pressure levels of the background noise and the source noise is between 6 dB(A) and 15 dB(A), a correction shall be applied as described in 8.3 of ISO 3744:1994.

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 IEC 61260.

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

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

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

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

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

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

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

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

NOTE 2 Other higher values may be agreed between manufacturer and customer for specific usage in very noisy areas.

6.2.3.2 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 the one 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 both perceptibilities are almost identical.

6.2.4 Frequency dependence

6.2.4.1 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 4.2.1.2.

6.2.4.2 Alternative means for voltage detectors having completed the production phase

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

6.2.5 Response time

6.2.5.1 Type test

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

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

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

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

6.2.5.2 Alternative means for voltage detectors having completed the production phase

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

6.2.6 Power source dependability

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

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

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

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

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

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

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

6.2.7 Check of testing element

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

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

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

6.2.8 Non-response to d.c. voltage

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

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

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

6.2.8.2 Alternative means for voltage detectors having completed the production phase

The manufacturer shall prove that he has followed the same documented assembly procedure as per the type tested device. The manufacturer shall document components that affect the non-response to d.c. voltage.

6.2.9 Time rating

6.2.9.1 Type test

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

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

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

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

6.2.9.2 Alternative means for voltage detectors having completed the production phase

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

6.3 Dielectric tests

6.3.1 Protection against bridging for indoor/outdoor type voltage detector

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

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

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

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

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

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

where A_i is the insertion depth (Figure 1).

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

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

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

6.3.1.1 For voltage detector $\leq 245 \text{ kV}$

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

6.3.1.1.1 Surface stress test

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

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

6.3.1.1.2 Radial and surface stress test

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

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

6.3.1.2 For voltage detector $> 245 \text{ kV}$

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

6.3.1.2.1 Surface stress test

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

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

6.3.1.2.2 Radial and surface stress test

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

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

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

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

6.3.2 Protection against bridging for outdoor type voltage detector

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

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

Table 9 – Dimensions for the concentric rings and band electrodes

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

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

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

Precipitation shall be performed in accordance with 6.1.1.

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

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

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

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

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

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

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

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

$$d_3 = A_i + d_1$$

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

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

6.3.3 Spark resistance

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