IEC TR 61243-6

Edition 1.0 2017-03

TECHNICAL REPORT

colour inside

Live working – Voltage detectors –
Part 6: Guidelines on non-contact voltage detectors (NCVD) for use at nominal voltages above 1 kV AC

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INTERNATIONAL
ELECTROTECHNICAL
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LIVE WORKING – VOLTAGE DETECTORS –

Part 6: Guidelines on non-contact voltage detectors (NCVD) for use at nominal voltages above 1 kV AC

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IEC TR 61243-6, which is a Technical Report, has been prepared by IEC technical committee 78: Live working.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
78/1143/DTR	78/1162A/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

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

Terms defined in Clause 3 are given in *italic* print throughout this standard.

A list of all parts of the IEC 61243 series, published under the general title *Live working – Voltage detectors*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

With the aim of ensuring the safety of the users the purpose of a *voltage detector* is to give a *clear indication* of the presence or absence of the operating voltage, without any need for interpretation or analytical evaluation by the user.

IEC 61243-1, IEC 61243-2 and IEC 61243-3 apply to portable voltage detectors designed to work correctly when they are in direct contact with the bare part of the installation to be tested.

At HV and UHV, large distances between the user and the bare parts to be tested make the handling of a very long *insulating element* or *insulating stick* an ergonomic and safety concern. In such situations, it may become convenient to avoid any contact with the bare part to be tested and to perform voltage detection at a distance.

This document provides considerations and performance guidelines for portable “non-contact” *voltage detectors* and it can be used as a reference for the development of national, industry or manufacturer's standard(s) or for the selection of a product by users.

This document has been prepared taking into consideration the provisions given in IEC 61477.

LIVE WORKING – VOLTAGE DETECTORS –

Part 6: Guidelines on non-contact voltage detectors (NCVD) for use at nominal voltages above 1 kV AC

1 Scope

This part of IEC 61243, which is a Technical Report, is applicable to portable *non-contact voltage detectors* (NCVD) with built-in power source, to be used to indicate the presence or the absence of the *operating voltage* on electrical systems for *nominal voltages* above 1 kV AC and frequencies of 16 2/3 Hz, 50 Hz and/or 60 Hz.

NOTE 16,7 Hz is often referenced.

This document applies only to devices that are not designed to be used in contact with the bare part of the installation on which the presence or the absence of the *operating voltage* has to be tested.

This document describes only devices, and their behaviour, using electric field and voltage gradient detection principles even if other principles could be used. It provides performance guidelines, recommendations for use and recommended minimum criteria for selection.

Devices like personal safety distance *voltage detectors*, distance *voltage detectors* for emergency responders or machine operators are not covered by this document.

Except when otherwise specified, all the voltages defined in this document refer to 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 61318, *Live working – Conformity assessment applicable to tools, devices and equipment*

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:

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

3.1
adaptor
part of an NCVD as a separate device which permits attachment of an *insulating stick*

3.2
application mark
mark on the NCVD to show to the user where to put the NCVD at the application point for *clear indication*

Note 1 to entry: An *application mark* may or may not be present.

3.3
application point
specific point of the installation where the *application mark* (if present) of the NCVD should correspond

Note 1 to entry: An *application point* may or may not be needed.

3.4
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 only that the NCVD is ready to operate is not considered as an *active signal*.

3.5
clear indication
unambiguous detection and indication of the voltage state of the part to be tested

3.6
clear perceptibility
case where the indication is unmistakably discernible by the user under specific environmental conditions when the NCVD is in its operating position

3.7
contact electrode
bare conductive part of a *voltage detector* which establishes the electric connection to the component to be tested

3.8
design of NCVD
different constructions of NCVDs, either as a complete device with or without an *insulating element* or as a separate device intended to be equipped with an *insulating stick*

3.9
directional property
property whereby an NCVD detects an electrical field relative to a specific position

3.10
electrode
metallic part of an NCVD combined with one or more other metallic parts that allows to pick up the electric field

3.11
expected voltage
maximum voltage value of the part of the installation that will or could be touched by the NCVD

3.12
far electric field
far field
in free space, region where the distribution of the electrical field is almost independent of the distance to the source

3.13
hand guard
distinctive physical guard separating the handle of an NCVD as a complete device from the *insulating element*

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

3.14
indicator
part of the NCVD that indicates the presence or absence of the *operating voltage* for the part of the electrical equipment or installation to be tested

3.15
indoor type
NCVD designed for use in dry conditions, normally indoors

3.16
insertion depth
distance between the *limit mark* and the top of the NCVD as a complete device

3.17
insulating element
part of an NCVD as a complete device that provides adequate safety distance and insulation to the user

3.18
insulating stick
insulating tool made essentially of an insulating tube and/or rod with end fittings

Note 1 to entry: For voltage detection, an *insulating stick* is intended to be attached to the NCVD 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.

[SOURCE: IEC 60050-651:2014, 651-22-01, modified – Note 1 to entry has been added.]

3.19
interference field
<created by the network> electric field due to the configuration of the installation that may affect the electric field of the part to be tested

3.20
interference voltage
<created by the network> voltage picked up inductively or capacitively by the part to be tested

3.21
limit mark
distinctive visible location or mark on the NCVD to indicate to the user the physical limit to which the NCVD could be inserted between live parts

Note 1 to entry: A *limit mark* may or may not be present.

3.22
medium electric field
medium field
in free space, region where the distribution of the electric field is slightly dependent on the distance to the source

3.23
near electric field
near field
in free space, region where the distribution of the electrical field is strongly dependent on the distance to the source

3.24
nominal distance
D_n
suitable value of distance, between the bare part of the installation to be tested and the NCVD, associated with the *nominal voltage* of the NCVD for *clear indication*

Note 1 to entry: The *nominal distance* of the NCVD is a parameter associated with its *clear indication*. The manufacturer can identify the *nominal distance* directly linked to the corresponding discrete *nominal voltage*.

Note 2 to entry: An NCVD may have more than one *nominal distance* when having more than one *nominal voltage*, or one or more than one *nominal voltage* range. In this case, for each *nominal voltage* or each *nominal voltage* range the manufacturer can identify at least one characteristic discrete *nominal voltage*. The manufacturer can then identify the *nominal distance* directly linked to each corresponding discrete *nominal voltage*.

Note 3 to entry: For some devices, the *nominal distance*(s) could be defined by the NCVD *reference points*.

3.25
nominal voltage
U_n
suitable approximate value of voltage used to identify a system or device

Note 1 to entry: The *nominal voltage* of the NCVD is a parameter associated with its *clear indication*. An NCVD 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 $U_{n\ max}$

[SOURCE: IEC 60050-601:1985, 601-01-21, modified – The definition has been modified to fit the specific context of device or equipment and Note 1 to entry has been added.]

3.26
non-contact voltage detector
NCVD
voltage detector that does not require making physical contact with the bare part of the installation (e.g. conductor, bus bar, capacitive tap for a cable elbow or switchgear) on which the presence or the absence of the *operating voltage* has to be tested

3.27
operating distance range
range of distances to the bare part to be tested declared by the manufacturer where the NCVD will function properly when used according to the instructions for use

Note 1 to entry: For some devices, the operating distance could be defined by the NCVD *reference points*.

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

3.29
operating voltage
<in a system> system voltage under normal conditions at a given instant and location

Note 1 to entry: This value may be calculated or measured.

3.30
protection against bridging
protection against flashover or breakdown, when the insulation between the parts of the installation to be tested, at different potentials, is reduced by the presence of the NCVD

3.31
rated voltage
U_r
value of voltage to which certain operating specifications are referred

Note 1 to entry: The *rated voltage* of the NCVD is the voltage selected from IEC 60071-1:2006+AMD1:2010, Table 2 and Table 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.

3.32
reference point
point of an installation which is different from the bare part to be tested and which needs to be touched in order to give an electrical reference according to the principle of functioning of some NCVD

3.33
response time
time delay between sudden change of the voltage state on the part to be tested and the associated *clear indication*

3.34
testing element
built-in element or separate device by means of which the functioning of the NCVD can be checked by the user

[SOURCE: IEC 60743:2013, 11.3.7, modified – The definition has been modified to apply specifically to NCVD.]

3.35
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 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.

3.36
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.

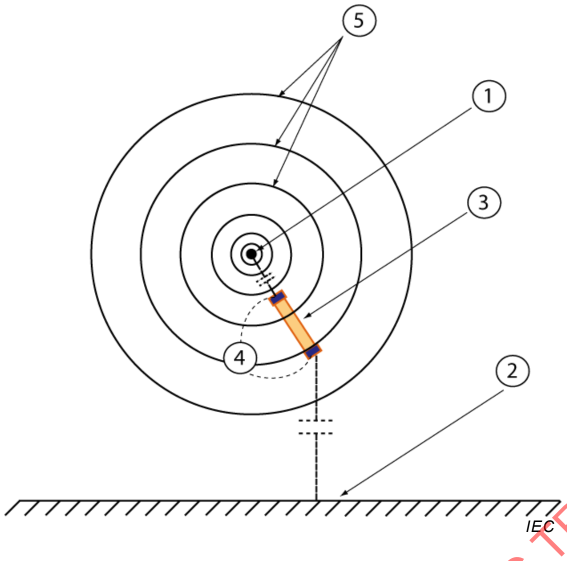
Note 2 to entry: Clear evidence is a YES or NO indication with no interpretation needed. Sometimes, *voltage detectors* also have supplementary function(s) such as the display of voltage values.

[SOURCE: IEC 60050-651:2014, 651-24-02]

4 The principles of an NCVD

4.1 NCVD designed to work at a distance without any contact

A *non-contact voltage detector* working at a distance operates by detecting the AC electric field generated in free air by the energized part of the installation to be tested. This detection is typically carried out via the use of a minimum of two internal metallic *electrode*s positioned at some distance apart. It is possible to represent the electric configuration as being equivalent to two stray capacitances. One is measured between the part to be tested and the first (internal) *electrode* of the *voltage detector*. The other is measured between the second (internal) *electrode* and the surrounding space (including earth) as shown in Figure 1. It should be noted that the closer an NCVD approaches the part to be tested, the more similar it becomes to a unipolar capacitive type (see Annex A).



Key

1 part to be tested

2 earth

3 *non-contact voltage detector* with its two internal *electrodes*

4 potential difference between the two *electrode*s of the *voltage detector*

5 electric field equipotential lines

Figure 1 – NCVD working at a distance without any contact

For this design of detector, the voltage detection is mainly based on the evaluation of an electric field associated with a potential difference between the two floating *electrode*s. As the electric potential at the floating *electrode*s is a function of the electric field distribution, the distribution of the electric field will consequently affect the detection. In most of the installation configurations, the electric field around a line or piece of equipment is not uniform. The electrical field strength and the gradient of field are normally higher near the live part and the strength and the gradient of field decreases as the distance from the live part increases. The relative positioning of the NCVD with respect to the part to be tested is then a parameter that may affect the correct indication of this type of NCVD. As illustrated in Figure 2, the voltage difference developed between its two floating electrodes will depend on the gradient of the electric field at and near the location of the NCVD. When the *voltage detector* is close to the part to be tested (Position P1 of Figure 2a), the electric field changes rapidly with the distance and a voltage difference will be easily detectable between the two floating *electrode*s. Alternatively, if the *voltage detector* is too far from the part to be tested (Position P2 of Figure 2a), the electric field will change only slightly with distance and the voltage difference across the two *electrode*s could be too small for a correct detection.

If the position of the *voltage detector* is such that the electric field is practically independent of location (i.e. nearly constant) at the position of the *voltage detector* (Position P3 of Figure 2b), no significant voltage difference will be developed between the two floating *electrode*s. This may result in an incorrect indication of the *voltage detector* (e.g. absence of voltage instead of voltage present).

The shape of the part to be tested and the distance between this part and adjacent parts at different potential will also affect the electric field distribution which consequently may affect the indication of the device. The strength of the electric field at the surface of an energized part will decrease with the height of that part above earth, and will also decrease as the size of the part increases. Also, adjacent parts at the same potential as the energized part will generally reduce the strength of the electric field distribution locally (in-phase *interference field*). Conversely, an adjacent part at the earth potential will increase the strength of the electric field distribution near the energized part (out-of-phase *interference field*). Finally, live parts in the vicinity of a de-energized part to be tested may create locally electric field that could affect the correct indication of the device. In this case the indication "voltage present" can appear although the part is de-energized.

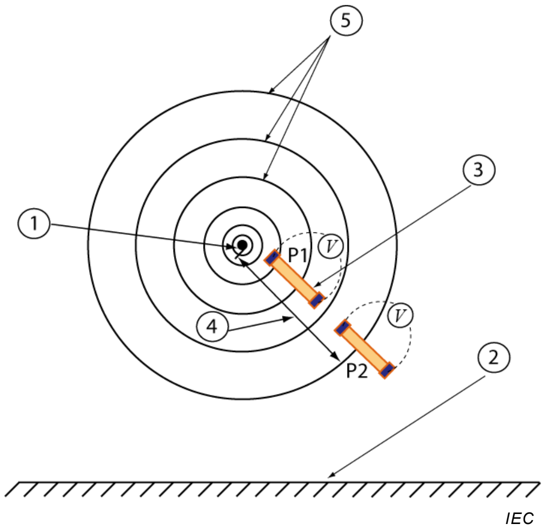


Figure 2a – Effect of the distance to the part to be tested

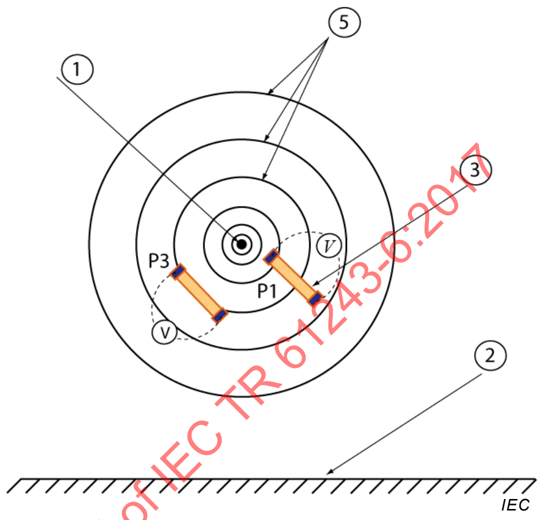


Figure 2b – Effect of the position relative to the equipotential lines

Key

1 part to be tested

2 earth

3 *non-contact voltage detector* with its two internal *electrodes*

V potential difference between the two internal *electrodes* of the *voltage detector*

5 electric field equipotential lines

P1 position of the *voltage detector* close to the part to be tested

P2 position of the *voltage detector* far from the part to be tested

P3 position of the *voltage detector* where no equipotential lines are crossed

Figure 2 – Effect of the relative position of the non-contact voltage detector

As stated previously, application of the NCVD is a very important consideration in order to obtain a reliable detection.

Like capacitive *voltage detectors* (IEC 61243-1), NCVDs may be affected by electrostatic discharges, especially in cases of low voltage and/or *far field* applications where high sensitivity is required. Electrostatic charges are typically generated by mechanical friction. This friction causes displacement of electrons in insulating materials and accumulation of charges. As static charges do not vary over time, AC *voltage detectors* should not be affected. However, in case of discharges of the static charges the frequency spectrum of these discharges contain signals that vary over a certain time for a short period and may cause random triggering of the detecting circuit.

4.2 NCVD designed to work with reference points

4.2.1 General

Another category of *non-contact voltage detectors* consists of those that require an electrical reference by contacting one or two parts of the installation other than the bare part to be tested.

4.2.2 NCVD designed to work with one reference point

The functioning of devices with one *reference point* is generally based on capacitive coupling or electric field detection. In some cases the *reference point* is connected to earth (for example, enclosed switchgear), while in other cases the *reference point* is in contact with the cable insulation covering of an insulated conductor.

When the *reference point* is the electric earth, the functioning is based on the evaluation of the potential difference (electric field) between the *reference point* and the floating *electrode* (see Figure 3).

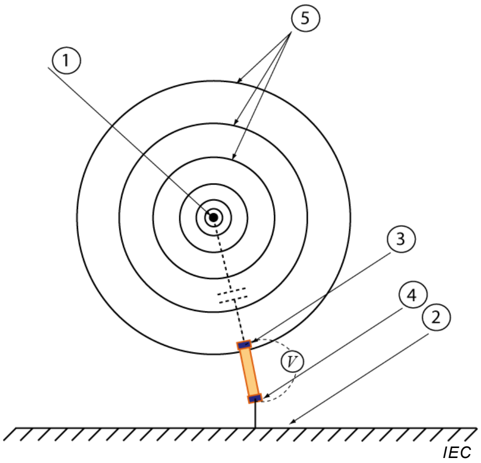


Figure 3a – NCVD with one reference point at the electric earth

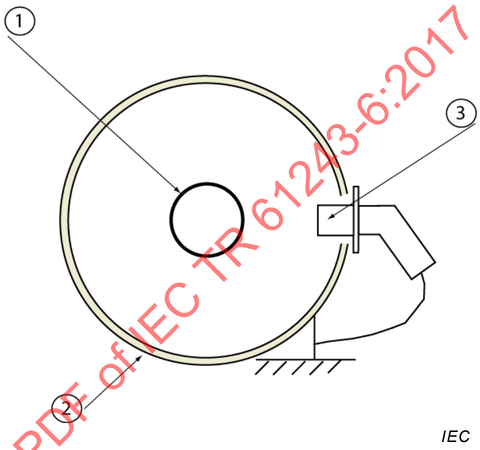


Figure 3b – NCVD used on metal enclosed equipment

Key

1 part to be tested

2 earth

3 floating *electrode* of the *voltage detector*

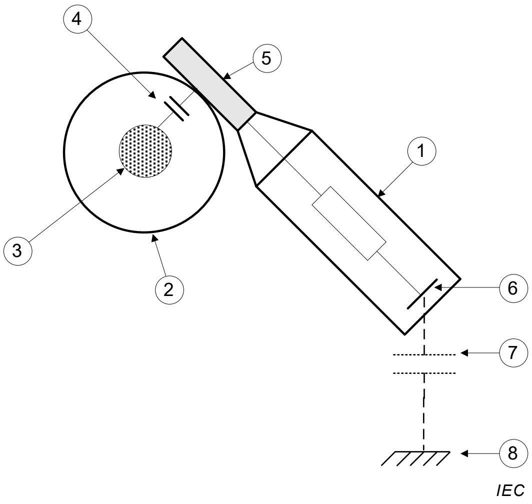
4 *reference point* of the *voltage detector* (electric earth)

5 electric field equipotential lines

V potential difference between the floating *electrode and the electric earth*

Figure 3 – NCVD working at a distance with one reference point

When the *reference point* is the cable insulation covering of an insulated conductor, the functioning is based on capacitive coupling between the *contact electrode* of the *voltage detector* and the conductor, and the stray capacitance between the floating *electrode* of the *voltage detector* and earth (see Figure 4).



Key

1 *non-contact voltage detector*

2 insulating covering

3 part to be tested (conductor)

4 capacitive coupling between the *contact electrode* of the *voltage detector* and the conductor

5 *contact electrode* of the *voltage detector*

6 floating *electrode* of the *voltage detector*

7 stray capacitance between the floating *electrode* of the *voltage detector* and earth

8 earth

Figure 4 – Non-contact voltage detector with a reference point making contact with the cable insulation covering an insulated conductor

4.2.3 NCVD designed to work with two reference points

Devices with two *reference point*s rely on the detection of a potential difference.

The first example refers to a device designed to be used on a single insulator of an insulator string where the two *reference point*s are respectively the cap and the pin of an insulator. The insulator string is considered to be a series of capacitors connected between the live part and earth. The last few insulators at the earth side of the insulator string may be considered as the low side of a voltage divider. The *voltage detector* operates by detecting the voltage across the cap and pin of one insulator closest to the earthed side of an insulator string, see Figure 5.

The second example refers to a device designed to be used on certain types of underground cable. It operates by detecting the voltage across the semi-conductive layer and the concentric neutral of the cable (Figure 6). When the cable is energized, a displacement of electrons in the insulating materials creates an accumulation of charges at the interface of the insulating material and the semi-conductive layer. This generates a voltage polarization between the semi-conductive layer and the concentric neutral of the cable.

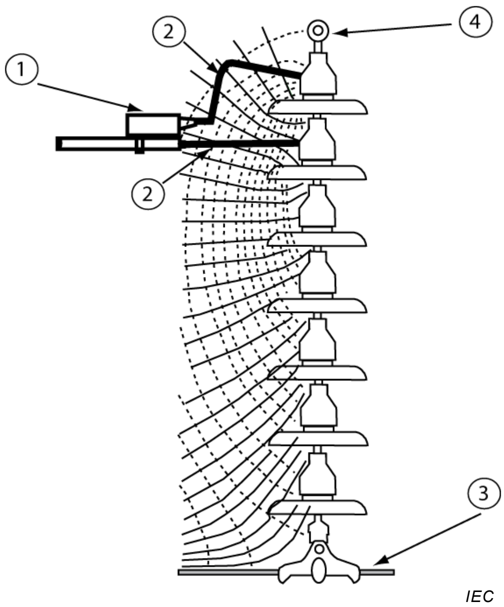


Figure 5a – NCVD used on a unit of an insulator string

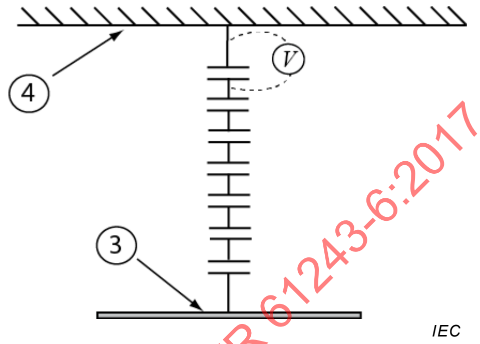


Figure 5b – Equivalent electrical circuit of an insulator string

Key

1 *non-contact voltage detector*

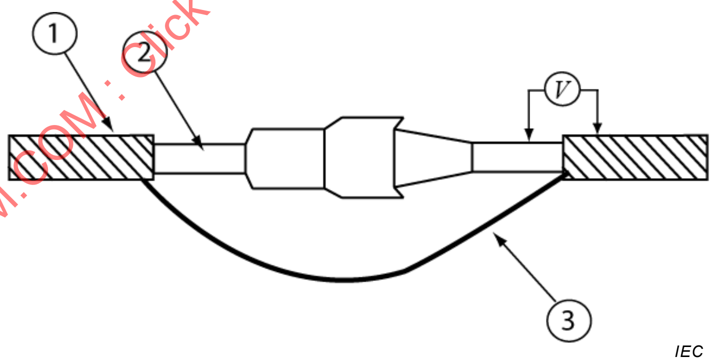
2 *contact electrodes*

3 part to be tested (conductor)

4 earth

V voltage across the cap and pin of one insulator (capacitance) on the earthed side of the insulator string

Figure 5 – Non-contact voltage detector working with two reference points making contact with the cap and pin of an insulator



Key

1 concentric neutral

2 semi-conductive layer

3 neutral wire

V voltage between the semi-conductive layer and the concentric neutral

Figure 6 – Non-contact voltage detector working with two reference points on an underground cable

5 Different designs of non-contact voltage detectors

The various types of NCVD are presented in Table 1. NCVDs are classified in five types according to their design.

Types 1, 2 and 3 are NCVD working at a distance (without any contact). These are the most commonly used types worldwide.

A Type 1 NCVD (T1a in Table 1) is designed to be used far from the live working zone and therefore is not considered as a "live working device". As such it does not fall under the scope of IEC TC 78. Therefore, this document does not recommend indications or/and requirements for this type of NCVD. However, Type 1 could be used from the ground (T1b in Table 1) or a tower as a “pre-diagnostic” device whose indication should be later confirmed by another type of *voltage detector* with more reliability.

A Type 2 NCVD (T2a in Table 1) is designed to be used from a tower near an insulator string or from the ground near an insulator column or from any identifiable location and may penetrate the live working zone. This type of NCVD falls within the scope of IEC TC 78. T2b in Table 1 shows an example of the device in use from a tower.

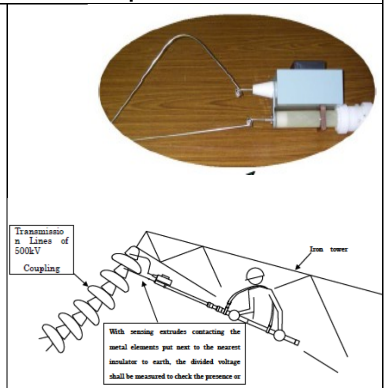
A Type 3 NCVD (T3a in Table 1) is designed to be used inside the live working zone with an adaptable *insulating stick* (T3b in Table 1). This type of NCVD falls within the scope of IEC TC 78.

Types 4 and 5 are NCVDs with at least one *reference point*. They are designed for specific applications.

Type 4a is designed for use on metal enclosed switchgear and penetrates the live working zone (T4a in Table 1). This type of NCVD falls within the scope of IEC TC 78. Type 4b is only designed to be used on insulated conductors (T4b in Table 1) and is never used within the live working zone, therefore, it is not considered as a "live working device". As such it does not fall under the scope of IEC TC 78. Therefore, this document does not recommend indications or/and requirements for this type of NCVD.

Type 5a is designed to be used on cap and pin insulator string (T5a in Table 1). This type of NCVD falls within the scope of IEC TC 78. Type 5b is only designed to be used on an underground network and is never used within the live working zone (T5b in Table 1), therefore, it is not considered as a "live working device". As such it does not fall under the scope of IEC TC 78. Therefore, this document does not recommend indications or/and requirements for this type of NCVD.

Table 1 – Types of non-contact voltage detector

Type 1 Far electric field Outside the LW zone	Type 2 Medium electric field (Mostly) outside the LW zone	Type 3 Near electric field Inside the LW zone	Type 4 One reference point	Type 5 Two reference points
Designed for use from ground or from the tower	Designed for use near an insulator string or insulator column	Designed for use near the bare part to be tested	Designed for use on metal enclosed switchgear or covered conductor	Designed for use on cap and pin insulator string or on certain design of underground power cable
Without any reference point			**With one or more reference points**	
 IEC	 IEC	 IEC	 IEC	 IEC
T1a – example of type 1	T2a – example of type 2	T3a – example of type 3	T4a – Type 4a for switchgear application	T5a – Type 5a for insulator string for aerial transmission line
 IEC	 IEC	 IEC	 IEC	 IEC
T1b – example of use of a type 1	T2b – example of use of a type 2	T3b – example of use of a type 3	T4b – Type 4b for insulated conductor application	T5b – Type 5b for underground cable application

6 Limitations and recommendations of use for each type of NCVD

6.1 Principal limitations

Since the functioning principle of most of the NCVD is based on the detection of the electric field generated in free air by the energized part of the installation to be tested, the reliability of the indication may be influenced by in-phase or out-of-phase *interference fields*. Depending on the type of NCVD this results in specific limitations.

In general NCVD working at distance should be used only where the configuration of the electric circuit is simple in structure and is not influenced by other adjacent circuits and equipment.

Table 2 gives specific limitations for each type of NCVD.

Table 2 – Limitations for use

Type 1 **Far electric field**	**Type 2** **Medium electric field**	**Type 3** **Near electric field**	**Type 4** **One reference point**	**Type 5** **Two reference points**
– Impossible to discriminate different circuits on the same structure if in a vertical configuration.	– Calibrated for one type of installation configuration and may not work properly elsewhere.	– Requires a long *insulating stick*. – Difficult to control the position of the NCVD relative to the part to be tested, which may compromise the accuracy of the indication and the safety of the operation.	– Requires a *reference point*. – Designed for a specific type of installation. – In case of Type 4a NCVD with one *reference* (e.g. metal enclosed switchgear use), it may be affected by *interference field*. – Type 4b does not work on shielded conductors.	– Requires *reference point*(s). – Designed for a specific type of installation. – In a case of cap and pin *reference points* (for Type 5a), the indication relies on the good electrical condition of the insulator unit. – The NCVD may be affected by the level of pollution and humidity on the insulator unit. – In case of an underground power cable the NCVD (Type 5b) may be affected by pollution level on the semi-conductive layer. – Type 5b does not work on the shielded conductor part.

6.2 Recommendations for the selection, calibration and use of NCVD

6.2.1 Selection of the appropriate type of NCVD

Due to possible hazardous situations associated with an incorrect indication of voltage absence or presence by a voltage detector, one should make sure that the selected NCVD is the most appropriate for the configuration being tested. Usually, *voltage detectors* are identified by a *nominal voltage* or a *nominal voltage* range, but one type of NCVD may not be appropriate everywhere on a network at a given voltage because its function is influenced by the local electric field configuration and field interference. When an NCVD is considered, one should take great care selecting the type that will work properly in the given field conditions without interpretation from the user (see Table 2 and Table 3).

6.2.2 Calibration of the selected device

To take into account the possible effect of electric field interference and to increase the reliability of *clear indication*, it may be appropriate to perform an on-site calibration. This may result in “customizing” a device for only one location or only one network configuration.

Users and manufacturers should discuss this issue and agree on the best solution. Once a device has been calibrated on-site, it is recommended to clearly identify the device accordingly, so that misuse is avoided.

6.2.3 Use of the selected device

In terms of operating a contact *voltage detector* correctly (IEC 61243-1, IEC 61243-2 and IEC 61243-3), the procedure is quite simple and is as follows; the user brings its *contact electrode* in contact with the bare part to be tested and looks at (or listens to) the indication. In contrast, in case of an NCVD, parameters like the positioning of the device relative to the part to be tested, the presence of earthed objects close by, the possible use of a selector, etc. should be explained clearly to the user to avoid incorrect indication or an unsafe situation.

As a general recommendation, the indication should be checked on *operating voltage* before every use.

Table 3 summarizes the recommendations specific for each type of NCVD to be included in the instructions for use and to be taken into consideration when training the users.

Table 3 – Specific recommendations for use

Type 1 **Far electric field**	**Type 2** **Medium electric field**	**Type 3** **Near electric field**	**Type 4** **One reference point**	**Type 5** **Two reference points**
– The device should be used in free space (no neighbouring objects: building, trees, no shielding structure (e.g. within the tower, …). – The user needs to determine a reference (e.g. an energized adjacent line at the same *nominal voltage*) and to compare it with the part to be tested.	– The user should know the configurations and the associated *application point* for which the device may be used to provide correct indication. – The user should control the relative position of the NCVD to the installation: to be parallel with the insulator.	– The user should know the configurations for which the device may not-provide correct indication (in-phase interference). – The *insulating stick* to be used with separate devices should provide to the user adequate distance and insulation. – The user should control the relative position of the NCVD to the part to be tested.	– In case of metal enclosed switchgear (Type 4a) the user should know the configurations for which the device can provide correct indication. – In case of insulated cable (Type 4b) the user should control the relative position of the NCVD on the insulating covering.	– In case of cap and pin reference points (Type 5a), the user should know the electrical condition of the three insulators of the insulator unit closest to the earth side of the insulating string. – In case of pollution or humidity, the three insulators of the insulator unit closest to the earth side should be cleaned (with Live Working method) before the use of an NCVD Type 5a – In case of pollution, the underground power cable unit should be cleaned before the use of an NCVD Type 5b.

7 Recommended requirements

7.1 General

This document is not intended to be used as a product standard. However, to help manufacturers and users of *non-contact voltage detectors* in the design, use and selection of the products, Clause 7 details the recommended requirements. These requirements are based on the ones associated with contact *voltage detector*s covered by IEC 61243-1, IEC 61243-2 and IEC 61243-3, which are recognized as providing adequate performance and safety. In this context, the use of “shall” indicates that a characteristic is required in order for the product to demonstrate adequate characteristics.

The following recommended requirements do not apply to Type 1, Type 4 for insulated conductors and Type 5 for underground power cables which, as stated previously, do not fall under the scope of IEC TC 78.

Because of the various designs of NCVD, this document does not describe any tests.

7.2 Recommended general requirements

7.2.1 Safety

Because an NCVD is designed to remain at a distance from the line(s) or the bare part to be tested, it results in an increase of the intrinsic safety of operation.

In the case of *near field* NCVD requiring a relatively long *insulating element* or an *insulating stick* (Type 3), the intrinsic safety of operation may be reduced because there is always a possibility, either by inadvertent movement or by an incorrect evaluation of the distance, of touching the bare live part to be tested or another live part. In all cases, the accidental contact of a *near field* NCVD with a live part shall not result in a hazardous situation for the user.

In the case of *medium field* NCVD (Type 2), an accidental contact with a part of the installation at an intermediate potential shall not result in a hazardous situation for the user.

7.2.2 Indication

An NCVD shall give a *clear indication* of the state "voltage present" and/or "voltage not present" of the system operating voltage, by means of the change of the status of the signal.

The indication shall be visual or visual and audible. In some circumstances (e.g. use of long *insulating stick*, noisy or bright environments), it is recommended to have both visual and audible indication.

To avoid any interpretation by the user, it is recommended that the visual indication of the state "voltage present" and/or "voltage not present" shall not rely on the display of a discrete voltage value.

7.2.3 Electromagnetic compatibility (EMC)

*Voltage detector*s are used generally in various locations such as power substations, power lines or in heavy industries and are subjected to various kinds of electromagnetic disturbances. NCVD shall be immune to the level of disturbances for which the NCVD is intended to operate.

It is recommended that NCVD should at least comply with the requirements of class A for portable equipment according to IEC 61326-1.

NOTE In some countries, additional requirements may need to be added to fulfil EMC regulations.

7.3 Recommended functional requirements

7.3.1 Clear indication

7.3.1.1 General

NCVD shall clearly indicate the presence and/or the absence of the system *operating voltage* as a function of its *nominal voltage* or *nominal voltage* range, its *nominal distance* or *operating distance* range or its nominal position and its nominal frequency or nominal frequencies when used according to the instructions for use.

NCVD shall indicate correctly in presence of usual values of *interference fields* (in-phase and out of phase). It shall not indicate for usual values (see NOTE 2 of 7.3.1.2) of *interference voltages*.

NCVD may indicate incorrectly or not indicate at all in the vicinity of large conductive parts that create equipotential field zones (in-phase interference).

7.3.1.2 Threshold voltage

The *threshold voltage* is a parameter to characterize the functioning of an NCVD in a specific laboratory situation. The purpose of determining and using a standard test set-up for the *threshold voltage* is to allow testing of different devices under the same conditions and also for in-service care.

When an NCVD is positioned according to the instructions for use:

– The indication “voltage present” shall appear if the voltage to earth on the bare 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 bare 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 usually encountered in the field.

To fulfil the above recommendations, the *threshold voltage* U_t should satisfy the following relationship:

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

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

Except for Type 5, the relationship should be satisfied at the *nominal distance* D_n or the *nominal distance* range ($D_{n\ min}$ and $D_{n\ max}$) of the NCVD declared by the manufacturer.

For NCVD with only one *nominal distance*, $D_{n\ max}$ equals $D_{n\ min}$.

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.

For specific applications (e.g. calibration on site), customers and manufacturers can agree on different values than the ones recommended.

7.3.1.3 Setting of the threshold voltage

The setting of the *threshold voltage* (calibration of the *voltage detector*) is normally the responsibility of the manufacturer.

In some cases, the *threshold voltage* is set by an agreement between the manufacturer and the customer. When it is expected by the customer that the *voltage detector* will be used in the vicinity of large conductive parts that create equipotential field zones, a low value of the *threshold voltage* could be selected. However, where induced voltage or out of phase *interference fields* are expected by the customer, a high value of the *threshold voltage* could be selected.

In all cases, customers should validate that the device (with its *threshold voltage*) performs correctly in the field.

Once the housing of the *indicator* is closed and sealed, the design of the device shall be such that the user does not have access to the *threshold voltage* settings.

7.3.1.4 Use of a selector

The use of voltage, frequency or other type of selector(s) is often proposed on the market and may be attractive for some users as it could eliminate the need of different devices for covering various network conditions. However, there are negative sides to selectors that the user should take into consideration. A selector being inadvertently in an incorrect position is likely to result in an incorrect indication. This incorrect indication may become a hazard for the user.

Misuse of a selector as an indirect way to “modify” the *threshold voltage* can cause hazardous situations.

In the instructions for use, the manufacturer shall give clear advice to the user concerning the setting of the selector.

When selector(s) are present, they should be as few as possible and should have a minimum number of positions.

It is recommended that the manufacturer provides means to minimize the consequence of an incorrect selection, for example by forcing the selector of the NCVD to be set at the maximum sensitivity when the NCVD is switched on.

7.3.1.5 Continuous indication

An NCVD shall give continuous indication when it is positioned relative to the live part to be tested according to the instructions for use.

In case of Type 3, if there is no way for the user to confirm that the NCVD is still working after having inadvertently contacted a bare live part (absence of an *indicator* of state "ready for use" or "in use"), it shall provide continuous indication when in contact with the live part.

7.3.1.6 Directional properties for NCVD working at a distance

The *directional properties* of an NCVD result from the combination of its sensitivity and its aperture window to the electrical field. The sensitivity of an NCVD is generally linked with its *threshold voltage* while the aperture window to the electrical field is linked with the mechanical design of the NCVD. These characteristics may cause the detector to be influenced by adjacent live parts while testing a de-energized part (too wide detection angle) or to miss the live part to be tested (too small detection angle).

The *directional properties* are a parameter to characterize the functioning of an NCVD in a specific laboratory situation. The purpose of determining and using a standard test set-up for the directional properties is to allow testing of different devices under the same conditions and later on for in-service care.

When an NCVD is positioned according to the instructions for use:

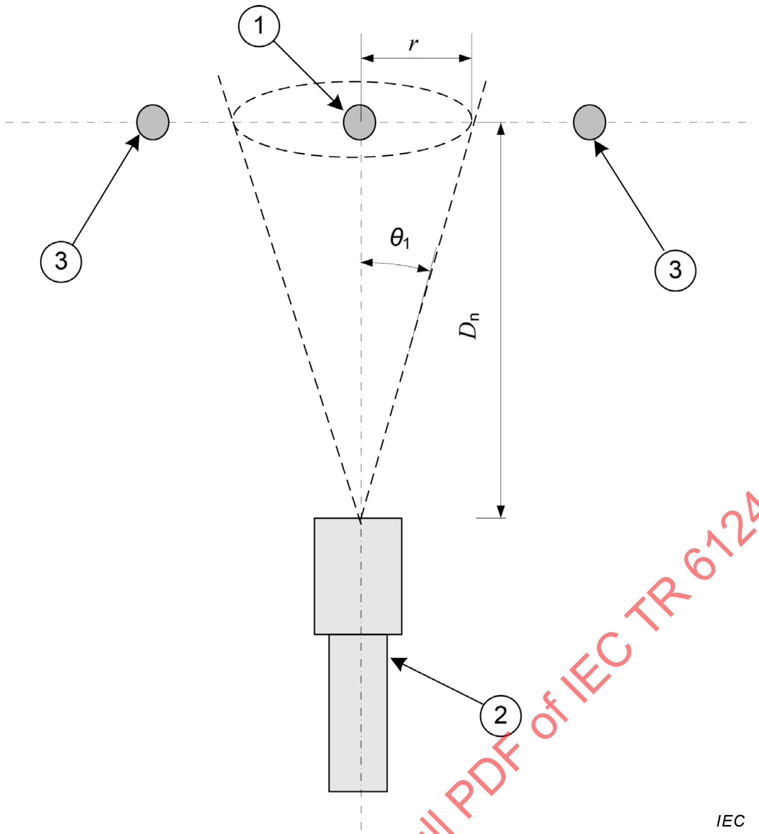
- The indication “voltage present” shall appear when the bare live part to be tested is situated inside a detection angle θ_1° specified by the manufacturer relative to a specific position of the NCVD.
- The indication "voltage present" shall not appear when the bare live part to be tested is situated outside the detection angle θ_1° relative to the position of the NCVD.

In all cases, the customer should validate that the device with its directional properties performs correctly in the field.

To guarantee a correct functioning of the NCVD for inter-phase or inter-circuit detection, the angle θ_1 should be as small as possible in relation to the configuration of the installation. As an example, Table 4 gives the radius r of the cone of detection corresponding to different values of distance D_n and angle θ_1 according to Figure 7.

Table 4 – Examples of values of the radius of the cone of detection as a function of the directional properties angle

Nominal distance, D_n m	**Radius of the cone of detection, r** m		
	θ_1 = 10°	**θ_1 = 20°**	**θ_1 = 30°**
0,5	0,088	0,182	0,288
1	0,176	0,364	0,577
2	0,352	0,728	1,154
3	0,529	1,091	1,731
4	0,705	1,455	2,308
5	0,881	1,819	2,885



Key

1 part to be tested

2 *non-contact voltage detector*

3 adjacent parts

D_n *nominal distance*

θ_1 detection angle

r radius of the cone of detection

Figure 7 – Directional properties of NCVD working at distance

7.3.2 Clear perceptibility

7.3.2.1 Visual indication

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

EXAMPLE 1 50 000 lux corresponds to normal light conditions for *outdoor type* NCVD with standard light D_{55} according to CIE 15, corresponding to a colour temperature of 5 500 K.

EXAMPLE 2 1 000 lux corresponds to normal light conditions for *indoor type* NCVD with standard light A according to CIE 15, corresponding to a colour temperature of 3 200 K.

When two visual active signals are used, it is recommended that the indication does 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(s), can be used.

7.3.2.2 Audible indication

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

When two audible *active signals* are used, it is recommended that the indication does not rely solely on sounds of different sound pressure levels for perceptibility. Additional characteristics, such as tone or intermittence of the audible signals, can be used.

7.3.3 Temperature and humidity dependence of the indication

A *voltage detector* shall operate correctly in the climatic environment for which it is intended to be used.

Extreme temperatures, sudden changes of temperature and the presence of condensation or frost on the surface of the casing of the *voltage detector* may affect its correct operation. It is important that the manufacturer and the user define the climatic conditions for which the NCVD will be used.

Three climatic conditions of operation according to Table 5 are recommended for the classification of the NCVD: cold (C), normal (N), and warm (W).

The device shall operate correctly for the selected climatic category.

Table 5 – Climatic categories

Climatic category		Climatic conditions (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

7.3.4 Frequency dependence

NCVD shall operate correctly at its nominal frequency or its nominal frequencies for which it is intended to be used.

To take into account the possible variations of the frequency of the system, it is recommended that the NCVD operates between 97 % and 103 % of its nominal frequency or for each of its nominal frequencies.

7.3.5 Response time

NCVD shall give rapid indication of any change of the status "voltage present" and/or "voltage not present" of the system operating voltage.

It is recommended that the response time is less than 1 s.

7.3.6 Power source dependability

NCVD with a built-in power source shall give *clear indication* until its power 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.

7.3.7 Testing element

To check proper functioning of an NCVD, it is recommended to have a *testing element*, whether as a built-in or as a separate item.

The *testing element* should be capable of testing all the electrical circuits, including the detecting circuit, the energy source and the indicating function. When it is not possible to test all circuits, any limitation should be clearly stated in the instructions for use. All circuits shall be constructed with high reliability.

When there is a built-in *testing element*, the NCVD shall give an indication of "ready for use" or "not ready for use", until the device is switched-off.

7.3.8 Non response to DC voltage (static electric field)

An NCVD designed for AC use shall not respond to DC voltage or when moved in presence of a DC electric field.

This recommended requirement aims to avoid random indications which may lead the user to lose confidence in the indication.

7.3.9 Immunity to electrostatic discharges

An NCVD shall not indicate when exposed to electrostatic discharges, except for self-test purpose declared by the manufacturer for a specific position of the voltage selector. This specific position of the voltage selector for the test-function shall be clearly identified as, for example, "self-test" or "test".

This recommended requirement aims to avoid random indications which may lead the user to lose confidence in the indication.

7.3.10 Time rating

The NCVD shall perform without failure for 5 min when the bare part to be tested is energized at its maximum *operating voltage* and the NCVD is positioned as stated in the instructions for use relative to the live part to be tested.

7.4 Electrical requirements

7.4.1 Insulating material

7.4.1.1 General

The insulating materials of an NCVD shall be adequately rated (nature of material, dimensions) to withstand the electrical stresses normally encountered in service.

When tubes of insulating material with circular cross section are used in the design of NCVDs, they should meet the requirements of IEC 60855-1 or IEC 61235.

7.4.1.2 Insulating element of an NCVD as a complete device

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

7.4.1.3 Leakage current of an NCVD as a complete device

Where relevant the *insulating element* shall be so rated that the leakage current is limited depending on the conditions (dry, or dry and wet) for which the NCVD has been designed (indoor, outdoor, indoor and outdoor). For dry conditions, it is recommended that the current value is limited below 50 µA at the maximum *expected voltage* in use.

7.4.2 Protection against bridging for Type 3 only

The protection shall be such that an NCVD cannot cause flashover or breakdown between live parts of an installation or between a live part of an installation and earth.

7.4.3 Resistance against sparking

Where relevant the NCVD shall be constructed so that the *indicator* cannot be damaged or shut off as a result of a low energy electric arc encountered for the maximum *expected voltage* in service.

For example, in case of a Type 3, as the *voltage detector* may touch a bare live part, the maximum *expected voltage* in service is therefore equal to the maximum *nominal voltage* for which the NCVD is designed. In case of a Type 5a, the maximum *expected voltage* is the voltage across one insulator.

7.4.4 Resistive (impedance) element of Type 5 only

The resistive element (or impedance) of an NCDV of Type 5 shall be adequately rated with respect to the maximum *expected voltage* and power in service.

7.5 Recommendations for mechanical performance

7.5.1 General

For an NCVD as a complete device the user should be provided with adequate distance and insulation by means of an adequate *insulating element* designed according to the *insertion depth* into the live working zone for the *rated voltage* of the nominal voltage or the highest *rated voltage* of the nominal voltage range of the NCVD (Types 2, 3 and 5).

For an NCVD as a separate device, the user should be provided with adequate distance and insulation by means of an adequate adaptable *insulating stick* designed for the *rated voltage* of the nominal voltage or the highest *rated voltage* of the nominal voltage range of the NCVD (Type 3)

7.5.2 Design

Amongst the NCVD on the market, there are three main types of construction:

- NCVD as a complete device which includes at least a handle, a *hand guard*, an *insulating element* and an *indicator* (Figure 8a);
- NCVD as a complete device which includes at least a handle and an *indicator* but without an *insulating element* (Figure 8b);
- NCVD as a separate device which includes at least an *adaptor* and an *indicator* (see Figure 8c).

NCVD shall not have any external conductive connection, except for connections to the *reference points* in case of Types 4 and 5 (e.g. *contact electrodes*).

7.5.3 Dimensions and construction

Where relevant, the minimum length of the *insulating element* of an NCVD as a complete device or the *insulating stick* used with an NCVD as a separate device shall be in accordance with the expected maximum voltage to withstand in case of a contact with the live part (for Type 3 (*near field*)) or a part at an intermediate potential (for Types 2 and 5).

Table 6 should be used as guidance to determine this minimum length.

The length of the *insulating stick* for live working can be shortened for NCVD as a separate device taking into account the minimum approach distances or in accordance with national or regional regulations. The L_i values of Table 6 correspond to the minimum distance in air (obtained from Table 1 and Table 2 of IEC 61936-1:2010+AMD1:2014) plus an additional 200 mm safety distance. The additional safety distance allows to have conductive parts not exceeding 200 mm (in total), measured from the limit mark towards the handle, within the minimum length of the *insulating element* if they are completely externally insulated.

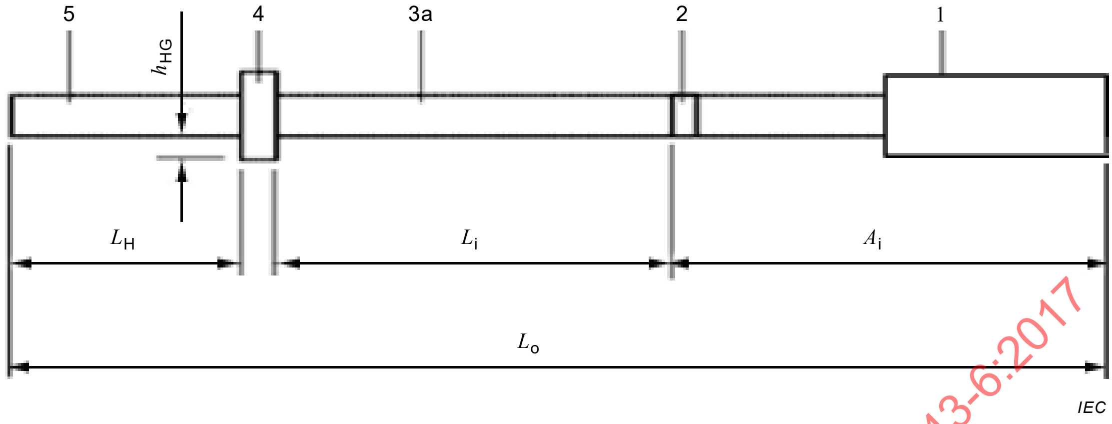


Figure 8a – NCVD as a complete device (including its insulating element)

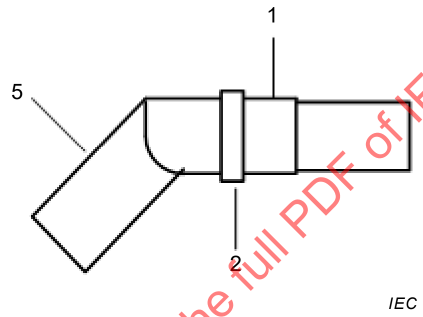


Figure 8b – NCVD as a complete device (without an insulating element)

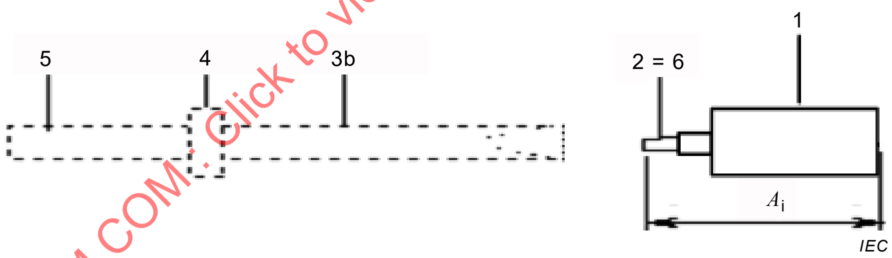


Figure 8c – NCVD as a separate device (with an adaptable insulating stick)

Key

1	*indicator*	h_{HG}	height of *hand guard*
2	*limit mark* or *application mark*	L_H	length of *handle*
3a	*insulating element*	L_i	length of *insulating element*
3b	adaptable *insulating stick*		
4	*hand guard*	L_o	overall length of NCVD
5	handle	A_i	*insertion depth* (length)
6	*adaptor*		

Figure 8 – Examples of designs of NCVDs

Table 6 – Minimum length of the insulating element or of the insulating stick (L_i)

Expected maximum voltage kV	L_i mm
$1 < U \leq 7,2$	320
$7,2 < U \leq 12$	360
$12 < U \leq 17,5$	370
$17,5 < U \leq 24$	470
$24 < U \leq 36$	520
$36 < U \leq 72,5$	830
$72,5 < U \leq 123$	1 300
$123 < U \leq 170$	1 700
$170 < U \leq 245$	2 300
$245 < U \leq 420$	3 600
$420 < U \leq 525$	4 300
$525 < U \leq 765$	6 600

If present, it is recommended that the *limit mark* shall be about 20 mm wide, permanent, and clearly recognizable by the user.

If any, it is recommended that the *application mark* shall be of a different colour than the *limit mark* but not red, shall be permanent, not repositionable and clearly recognizable by the user.

If the *application mark* and the *limit mark* are at the same position, the *limit mark* is prevalent.

If there is no *limit mark* or *application mark* on the NCVD as a separate device, the end of the *adaptor* can act as the *limit mark* or the *application mark* (Figure 8c).

For an NCVD as a complete device, it is recommended that the handle shall be at least 115 mm in length. *Hand guard* shall be permanently fixed with a minimum height (h_{HG}) of 10 mm. Other means than a *hand guard* could be used to limit the hand from slipping (e.g. the shape of the NCVD's handle).

7.5.4 Degree of protection provided by enclosure

During service life, NCVDs are likely to be exposed to dust and water. To ensure correct functioning of an NCVD, it is recommended that the degree of protection of all enclosures meet or exceed the requirements of IP44 for category 2 equipment (see IEC 60529).

NOTE IP44 corresponds to a protection against ingress of solid foreign objects ≥ 1,0 mm in diameter and against splashing

7.5.5 Grip force and deflection

For an NCVD the grip force and the deflection should be as low as possible (e.g. grip force below 200 N and deflection less than 10 % of the total length) to facilitate reliable operation and a safe approach towards the installation to be tested with reasonable physical effort by the user.

In case of an NCVD as a complete device, the deflection will depend only on its own weight. In case of an NCVD as a separate device, the user should be aware that the *insulating stick* may greatly influence the grip force and deflection.

It is recommended that the weight of the *indicator* shall be minimal to limit the grip force and deflection.

7.5.6 Vibration drop and shock resistance

The NCVD shall be resistant to drop, shock and vibrations expected to occur in use.

7.6 Markings

It is recommended that each NCVD have the following items of marking:

– *nominal voltage* and/or range(s) of *nominal voltage*;
– *nominal voltage*s of the selector setting (if relevant);
– nominal frequency or nominal frequencies;
– nominal frequencies of the selector setting (if relevant);
– name and/or trademark of the manufacturer;
– manufacturer reference, serial number;
– indication of type: indoor or outdoor;
– symbol for climatic category or climatic categories ("C", "N" or "W");
– symbol IEC 60417–5216:2002-10 – Suitable for live working; double triangle (see Annex D);

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.

Each NCVD could have the following additional items of marking:

– year of production;

In addition, the NCVD should provide the user or the testing laboratory an area to permit the marking of the date of periodic testing (see Annex C).

In case of an NCVD with a built-in energy source, the type of power supply and polarity should be indicated either on the *indicator* or inside the compartment designed to house it.

These markings shall be legible and permanent. The characters should be at least 3 mm high. The markings shall not impair the performance of the NCVD.

7.7 Instructions for use

Each NCVD shall be accompanied by the manufacturer's instructions for use. These instructions should be prepared in accordance with the general provisions given in IEC 61477.

The instructions for use should include as a minimum the information listed in Annex B.

Annex A
(informative)

General considerations about voltage detection

A.1 General

Annex A provides general information about voltage detection. It describes various methods of voltage detection, including those that apply to other parts of the IEC 61243 series.

IEC 61243-1, IEC 61243-2 and IEC 61243-3 apply to portable *voltage detector*s designed to work correctly when they are in direct contact with the bare part of the installation to be tested. IEC 61243-5 applies to AC *voltage detector*s coupled to the bare part of the installation to be tested through a capacitive coupling element which is considered as an integral part of the equipment (switchgear).

This document, as a Technical Report, provides considerations for *non-contact voltage detector*s. As stated in the Scope, this document is intended only for devices that have not been designed to be used in direct contact with the bare part of the installation on which the presence or the absence of the *operating voltage* has to be tested.

A.2 Principles of functioning of voltage detectors

A.2.1 Basic analysis

An energized conductor, regardless of how it is connected in a network, always exhibits the following:

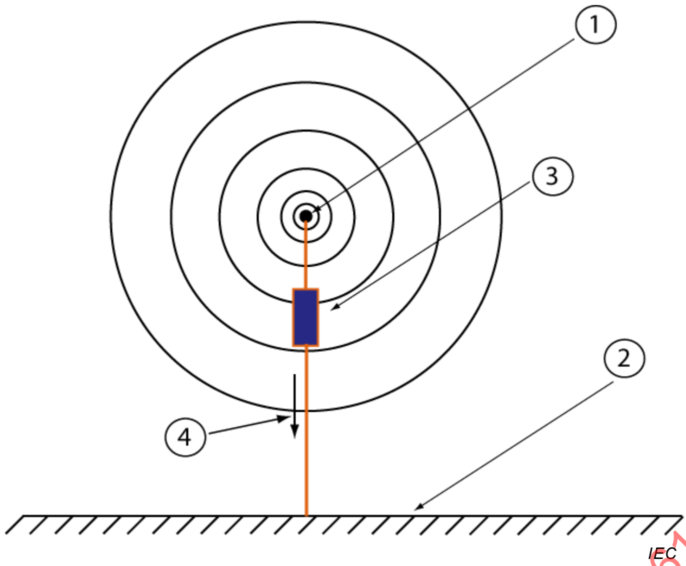
- the availability of a current that can flow through a load connected between the conductor and the electrical earth (or another point of the circuit at a different voltage);
- the presence of an electric field, having a non-linear spatial distribution. The field strength decreases with the distance to the conductor and in free space the decrease is usually in inverse proportion to the distance, but may be different.

While the value of the current passing through a certain load depends only on the voltage value across this load, the electric field strength can be influenced by the presence of other objects and the spatial distribution of electrical fields in the vicinity of the conductor.

For safe maintenance, the purpose of a *voltage detector* is to give a *clear indication* of the presence or absence of the *operating voltage* without any need for interpretation or analytical evaluation by the user. Consequently, it is important to know the status of the part to be tested even in the presence of interferences. Based on technical considerations and experience in service, the presence of the *operating voltage* (*nominal voltage*) on a part to be tested has been associated with the *threshold voltage* of the *voltage detector*. This has been found to be suitable to assure that the *voltage detector* provides correct indication.

A.2.2 Voltage detection with two contact electrodes (bi-polar detectors)

A live electrical installation has low source impedance and can supply load current without affecting the operating voltage. The best way to check for the operating voltage is therefore to evaluate the status of the installation on the basis of load current evaluation. For this purpose, it is necessary to connect an impedance of a known value between the conductor of the installation and a return path (generally the earth potential), see Figure A.1. In practice the voltage detection is based on the evaluation of a resistive current to earth. The distribution of the electric field around the conductor does not affect the detection because the current in the detecting circuit relies only on the voltage difference between the conductor and the *reference point* (usually the earth potential).



Key

1 part to be tested (where one *electrode* of the *voltage detector* makes contact)

2 earth (or point of the installation at a different potential and where the second *electrode* of the *voltage detector* makes contact)

3 bipolar *voltage detector*

4 current circulating through the *voltage detector*

Figure A.1 – Bi-polar voltage detection principle

This design of *voltage detector* is basically made of two *contact electrode*s and requires two connection points to the installation to be tested: one to the part to be tested and the other to earth or to a point at a different potential. It is called a "bi-polar type". Its components shall provide adequate distance and insulation (e.g. *insulating element*, resistive element and insulated connecting lead). This type of *voltage detector* has been described in IEC 61243-2 and IEC 61243-3. The design of such *voltage detector*s requires limiting the current through the device because the energy could become a hazard in terms of heat dissipation and insulation. Alternatively, if the impedance of the device is too high (low circulation current) it can lead to a lower certainty on the voltage detection in the presence of *interference voltage* (induced voltage). Experience indicates that the common values of current are generally in the order of a few hundreds of microamperes (μA) and can be considered appropriate for both discriminating the interferences and achieving safe use.

In several situations such as high voltage installations, bi-polar type *voltage detector*s have several limitations in terms of practical use and safety such as:

- use of connections and *insulating element*s appropriate for the large distances between connection points;
- use of insulated connecting lead(s) and high voltage impedance(s) appropriate for the voltage of the network;
- availability of a connecting point that is truly at earth potential.

A.2.3 Voltage detection with one contact electrode

In order to avoid the problems associated with bi-polar devices, often the detection is performed with a device that only requires touching the bare part to be tested, without touching a second point. In such a design and at a given operating voltage, a current still flows between the bare part to be tested (e.g. the conductor) and the earth potential but it is mainly due to the presence of a stray capacitance to earth. The stray capacitive coupling to earth is generally in air but sometimes it is through the operator handling the *voltage detector*,